



ASBIRES 2022

Proceeding of
14th Symposium

on

Applied Science, Bussiness & Industrial Research

24th March, 2023

**Faculty of Applied Sciences
Wayamba University Sri Lanka
Kuliyapitiya**





ASBIRES 2022

Proceedings

14th

**Applied Science, Business & Industrial Research
Symposium**

04th April 2023



Faculty of Applied Sciences

Wayamba University of Sri Lanka

Kuliyapitiya

© Faculty of Applied Sciences,
Wayamba University of Sri Lanka, 2023
Catalog in Publication Data approved by
National Library and Documentation Services Board

Symposium on applied science, business & industrial research (14th : 2023 April 04th
Kuliyapitiya, Sri Lanka)

Proceedings. - Kuliyapitiya: Wayamba University of Sri Lanka, 2023

Vol 14 – 347 p; 36 cm.

eISBN: 978-624-5564-78-1

i. 607 DDC 23

ii. Title

- Applied science – Research
- Computer and information systems – Research
- Industrial management - Research
- Mathematical sciences - Research

ISSN: 2989-0683

ISBN 978-624-5564-29-3

Typesetting, Designing and Printing
at the Department of Computing and Information Systems,
Faculty of Applied Sciences, Wayamba University of Sri Lanka, 2023

This event is proudly organized by the
Faculty of Applied Sciences, Wayamba University of Sri Lanka

EDITORIAL BOARD

Dr. (Mrs.) B Munasinghe

Editor in Chief

Department of Computing and Information Systems

Members

Prof. (Mrs.) RAR Prabodanie	<i>Department of Industrial Management</i>
Dr. (Mrs.) NADN Napagoda	<i>Department of Mathematical Sciences</i>
Dr. SPDSSK Karunarathna	<i>Department of Mathematical Sciences</i>
Dr. GVRK Vithanage	<i>Department of Mathematical Sciences</i>
Mrs. WMLN Wanninayake	<i>Department of Computing and Information Systems</i>

Editorial Assistance - Language

Department of English Language Teaching

Mr. MKSM Samaranayake
Ms. AGNK Rathnayake
Ms. KMJS Kulathunga
Ms. EMSH Ekanayake
Ms. NN Elwaladedara
Ms. WASD Wickramasinghe
Ms. AH Madhushika
Ms. AMWS Karunarathna

Editorial Assistants

Ms BI Madubhashini	Ms MAP Munasingha
Ms. DIS Hettiarachchi	Ms. MAWS Punyamali
Ms. DAPS Gunawardhana	Ms. PBWSR Kumarasinghe
Ms. IPSM Ilankoon	Ms. AST Athukorala
Ms. MVN Thejanee	Ms. E.A.D.D.D. Edirisinghe
Ms RMBPM Uduweriya	Ms. C.M. Liyanage

PANEL OF REVIEWERS

Prof. MGNAS Fernando	University of Colombo School of Computing, Sri Lanka
Prof. MMDR Deegahawature	Wayamba University of Sri Lanka, Sri Lanka
Prof. (Mrs). RAR Prabodanie	Wayamba University of Sri Lanka, Sri Lanka
Prof. RMKT Rathnayaka	Sabaragamuwa University of Sri Lanka, Sri Lanka
Prof. SR Kodituwakku	University of Peradeniya, Sri Lanka
Prof. S Vasanthapriyan	Sabaragamuwa University of Sri Lanka, Sri Lanka
Dr. AD Dharmawansa	Wayamba University of Sri Lanka, Sri Lanka
Dr. A Gunasekara	General Sir John Kotelawala Defence University, Sri Lanka
Dr. A Hewaarachchi	University of Kelaniya, Sri Lanka
Dr. A Pallegedara	Wayamba University of Sri Lanka, Sri Lanka
Dr. (Mrs.) B Munasinghe	Wayamba University of Sri Lanka, Sri Lanka
Dr. (Ms.) BS Habaragoda	Wayamba University of Sri Lanka, Sri Lanka
Dr. (Mrs.) DDM Jayasundara	University of Kelaniya, Sri Lanka
Dr. D Herath	University of Peradeniya, Sri Lanka
Dr. (Mrs.) DMKN Seneviratna	University of Ruhuna, Sri Lanka
Dr. (Mrs.) DMPV Dissanayake	University of Kelaniya, Sri Lanka
Dr. EACP Karunarathne	Wayamba University of Sri Lanka, Sri Lanka
Dr. H Abeysundara	University of Peradeniya, Sri Lanka
Dr. HA Usoof	University of Peradeniya, Sri Lanka
Dr. HL Jayetilleke	University of Ruhuna, Sri Lanka
Dr. HWB Kavinga	University of Kelaniya, Sri Lanka
Dr. (Mrs.) I Hewapathirana	University of Kelaniya, Sri Lanka
Dr. (Ms.) JABU Jayasinghe	University of Moratuwa, Sri Lanka
Dr. KD Prasangka	University of Ruhuna, Sri Lanka
Dr. KMNM Chathuranga	University of Peradeniya, Sri Lanka
Dr. K Thabotharan	University of Jaffna, Sri Lanka
Dr. L Rupasinghe	Sri Lanka Institute of Information Technology, Sri Lanka
Dr. LS Nawarathna	University of Peradeniya, Sri Lanka
Dr. (Mrs.) NV Chandrasekara	University of Kelaniya, Sri Lanka
Dr. PM Edirisinghe	University of Moratuwa, Sri Lanka
Dr. RD Nawarathna	University of Peradeniya, Sri Lanka

Dr. R Rajapaksha	University of Kelaniya, Sri Lanka
Dr. S Abeysundara	University of Peradeniya, Sri Lanka
Dr. T Kokul	University of Jaffna, Sri Lanka
Dr. (Mrs.) TMM De Silva	University of Kelaniya, Sri Lanka
Dr. VGTN Vidanagama	Wayamba University of Sri Lanka, Sri Lanka
Dr. WAC Weerakoon	University of Kelaniya, Sri Lanka
Dr. (Mrs). WGEJ Wattegama	Wayamba University of Sri Lanka, Sri Lanka
Dr. YAA Kumarayapa	Wayamba University of Sri Lanka, Sri Lanka
Ms. AW Edirisuriya	Wayamba University of Sri Lanka, Sri Lanka
Mr. AWLP Thilan	University of Ruhuna, Sri Lanka
Mr. DM Jayasena	Wayamba University of Sri Lanka, Sri Lanka
Mrs. EAC Dilrukshi	Wayamba University of Sri Lanka, Sri Lanka
Mr. JRKC Jayakody	Wayamba University of Sri Lanka, Sri Lanka
Ms. KTGP Madhusanka	University of Sri Jayewardenepura, Sri Lanka
Mrs. MGS Dilanthi	Wayamba University of Sri Lanka, Sri Lanka
Mr. M Kesavan	Wayamba University of Sri Lanka, Sri Lanka
Mrs. PAAU Jothirathna	Wayamba University of Sri Lanka, Sri Lanka
Ms. PABH Amarathunga	Wayamba University of Sri Lanka, Sri Lanka
Mr. P Gunathilake	University of Peradeniya, Sri Lanka
Mrs. RPTH Gunasekara	Wayamba University of Sri Lanka, Sri Lanka
Mr. S Ratnavale	University of Notre Dame, Australia
Mr. S Thirukumaran	University of Vavuniya, Sri Lanka
Mr. T Arudchelvam	Wayamba University of Sri Lanka, Sri Lanka

Table of Contents

A Model for Diabetes Prediction Using Machine Learning	1
AI and ML tools for quality engineering: A Comparative analysis	6
Assessing software code quality using metrics-based approach	11
Comparison of Web Applications or Websites and Mobile Applications for SME	17
Enhancement of Real-Time Object Detection for Autonomous Driving Based on YOLOv5	23
Enhancing Prediction of Heart Failure Using Feature Selection Techniques	29
Enhancing User Experience in Virtual Tours: A Systematic Literature Review	34
Factors Influencing Behavioral Intention Towards Green Computing Practices: A Systematic Literature Review	39
Forecasting Electricity Demand in Sri Lanka by Using Weather Patterns Through a Machine Learning Approach: Literature Review	44
Generative Adversarial Network Approach for the Traditional Batik Industry in Sri Lanka	50
Identifying Named Entity Recognition for Customized Corpus of Sinhala News Articles Using Deep Learning	55
Identifying People's Perception of the Sri Lankan Economy Using Twitter Sentiment Analysis	60
Literature Review on Sign Language Translation Approaches on Sinhala Sign Language – a survey	66
Preventing Ergonomic Hazards in Sri Lankan Private Sector: Identifying Incorrect Computer Posture using Deep Convolutional Neural Network and Mini Survey	73
Real-time Facial Expression Classification using ResNet-50	79
Sinhala Font Recognition Using Transfer Learning: Literature Review	85
Software Development Trend Prediction: a survey	91
Stress Detection of Employees using Image Processing and Machine Learning	96
Success Factors for the Effective Usage of an ERP System in the Post-Implementation Period; Case of Sri Lankan Firms: A Systematic Review of Literature	101
The Role of Enterprises Resources Planning Systems in Future Smart Factories - A Systematic Literature Review	107
A Time Series Analysis of Coconut Prices at the Colombo Coconut Auction	112
An Artificial Neural Network Approach for Predicting Tidal Elevation in Sri Lanka	117
Analysis of Daily Energy Consumption and Daily Peak Demand in Sri Lanka	122
Analysis of the Electricity Demand in the Matara Area	127
Application of Lean Manufacturing for Improving the Efficiency in Apparel Binding – A Case Study	133
Driver Drowsiness Detection	138
Forecasting Daily Bean Sales at ABC Supermarket Using Time Series Analysis	143
Forecasting Daily Knitting Production of ABC Garment Manufacturing Company in Sri Lanka	148
Forecasting Monthly Treated Water Production of Akuressa Area	154

Identification of Main Risk Factors for Heart Disease and Comparison of Predictive Models for the Assessment of Heart Disease Status	160
Impact of Customer Relationship on Customer Satisfaction in Marketing: A Case Study	167
Lung Cancer Diagnosis Using the Lloyd K-means Algorithm	172
Mathematical Modelling of Tumorigenesis	177
Predicting the Final Score of Twenty-Twenty International Cricket Match after the Power Play	182
Quality Control in Dyeing of Textiles: A Case Study	187
Some Properties of Fuzzy Compact Topological Space and Strong Fuzzy Metric Space	192
The Best Approach to Estimate the Extreme Quantiles of the Distribution of Fire Claims: A Case Study	199
Time Series Analysis of the Weekly Sales of Roti Flour for the Year 2022	204
A Literature Review on critical success factors in implementing big data in ERP systems in Manufacturing Industry	211
A Study on How Perceived Economic Crisis Affect on Consumer Attitudes Towards Shopping and Brand Switching for Dairy Products in Sri Lanka	217
An Analysis of Turnover Intention of Frontend and Backend Web Developers in Sri Lanka	223
Antecedents of Intention for e-HRM Adoption – A Case Study of the Sri Lankan Apparel Sector	228
Benefits and Challenges of Blockchain Integrated ERPs: A Systematic Review of Literature	233
Competitive Priorities of the Post COVID-19 Pandemic in the Sri Lankan Manufacturing Sector	238
Effect of Social Media e-WOM On Customer Influence to the Financial Services - a Case Study	244
Factors Affecting Brain Drain of Sri Lankan IT Professionals	249
Factors Affecting Consumer Post Purchase Cognitive Dissonance in Online Shopping: A Case Study of Southern Province in Sri Lanka	255
Factors influencing successful ERP usage in the Manufacturing industry in Sri Lanka: A systematic literature review	261
Human Resource Allocation in Software Projects: a Case Study	267
Identifying the Customer Segmentation for Buying Mercedes Benz Vehicles: A Phase from Sri Lanka	274
Identifying the most effective layout design for the production floor: A Case study of Apparel industry	279
Impact of e-Woms on Cosmetic Products Purchase Intention of Young and Middle-Aged Women: Evidence From Sri Lanka	286
Impact of factors of inventory management on inventory performance measures in the Sri Lankan wholesale industry: A Systematic Literature Review	293
Impact of Social Media Influencer Marketing on Making Purchase Decisions of Ready-	

to-Eat Foods - a Case Study	298
Implications of Brand Equity on Purchase Intention of Personal Care Products: A Study on University Undergraduates	302
Minimizing Defects in Sri Lankan Footwear Industry: A Case Study	308
Motivating Pro-environmental Behaviour through Green Human Resource Management Practices	314
The Influence of Job Stress, Work Environment, Salary and Benefits on Employee Job Satisfaction: Evidence from Tyre Industry Company	320
The Perceived Usefulness of (Enterprise Resource Planning) ERP System for a Productive Management System: The Case of a Glove Manufacturing Company in Sri Lanka	326
THE Simulation on the Personal Detail Collecting for License Issuing Performance of the Department of Motor Traffic – Kurunegala: A Case Study	332
Work-Activity (WA) Study to Perform Manual Work by People with Physical Disabilities	337
Analysis of One Day Passport Issuing Service Performance of the Department of Immigration and Emigration Sri Lanka Using the Arena Simulation Model: A Case Study	343



A Model for Diabetes Prediction Using Machine Learning

Gangoda GMCA¹, Wanninayake WMLN²

Department of Computing and Information Systems, Faculty of Applied Sciences, Wayamba University of Sri Lanka.^{1, 2}

chethikagangoda97@gmail.com¹

lakminiw@wvb.ac.lk²

ABSTRACT

Diabetes is an illness caused because of high glucose levels in the human body. If untreated, it may cause health issues that affect the heart, kidneys and eyesight. The early diagnosis of Diabetes helps to control these effects. To achieve this goal, an application for early Diabetes prediction with higher accuracy by applying Machine Learning Techniques is developed. A large data set collected from patients that includes attributes such as Pregnancy, Blood Pressure, Insulin, BMI, etc., was utilized to predict diabetes. After testing with a variety of popular classification approaches, including decision tree, linear discriminant analysis, support vector machines, Naive Bayes, and a few other Machine Learning algorithms, a classification model was built using Logistic regression. The model is validated using several train-test splits and several measures such as the accuracy, precision, recall, confusion matrix, classification report, and ROC Curves were used to investigate the model's robustness. The model shows an accuracy of 79.49%. Overall, the test results show that this model is capable of predicting diabetes effectively.

KEYWORDS: Diabetes, Machine Learning, Classification, Logistic Regression

1 INTRODUCTION

Diabetes is an increasingly growing health issue among people. Current practice to diagnose diabetes is relatively a slow process since, it requires to perform various tests and, suitable treatment is recommended only after the results are examined. Rather, a predictive approach based on health data such as blood pressure, insulin level, Body Mass Index (BMI) and etc., can be used as an alternative and faster method. It enables diagnosis well in advance with the best possible level of accuracy.

This study utilizes different types of machine learning (ML) algorithms and data mining techniques, to analyze data and identify patterns to build a Diabetes prediction model.

2 LITERATURE REVIEW

Many researchers have developed models to predict diabetes using various techniques. Lai, et al. (2019) has proposed a Gradient Boosting Machine (GBM) model with a performance of 84.7% and a Logistic regression (LR) model with a 84.0% performance. Further, Lyngdoh, Choudhury, & Moulik (2021) have tested five machine learning algorithms and have managed to achieve a stable and highest accuracy of 76% with the K-Nearest Neighbors (KNN) classifier.

Khanam & Fo (2021) have concluded that among all the proposed models, the Artificial Neural Network (ANN) with two hidden layers has been considered the most efficient and promising for analyzing diabetes with an accuracy rate of approximately 86% for all varying epochs (200, 400, 800).

A study conducted by Alam, et al. (2019), proposes the ANN technique has provided the best accuracy of 75.7% after comparing with random forest, and K-means clustering techniques.

Perveen, et al. (2016) have also compared prediction models to classify diabetic patients, across three age groups in the Canadian population. They have followed AdaBoost and bagging ensemble techniques using J48 (c4.5) decision tree as a base learner along with the standalone data mining technique J48 to classify patients with diabetes mellitus using diabetes risk factors. They have concluded that the Adaboost ensemble method is the best.

Nai-arun & Mounngmai (2015) have created a web application, using thirteen classification models including a combination of Bagging and Boosting techniques except for the Random Forest algorithm. The results reveal that Random Forest was ranked first in both accuracy and receiver operating characteristic (ROC) curve. Soni and Varma (2020) have also compared several classification approaches such as Support vector machines (SVM), KNN, Random Forest, Decision Tree, LR and GBM classifiers.

Mujumdar and Vaidehi (2019) have concluded that AdaBoost classifier that depicts an accuracy of 98.8% is the best model for diabetes prediction after comparing several classification techniques. Evwiekpaefe and Abdulkadir (2021) have weighed Decision tree, KNN and ANN algorithms for diabetes prediction against one another. ANN has shown the highest accuracy of 97.40%, recall of 0.97, precision of 0.97 and F1

Score of 0.97. In another study conducted by Rani (2020), Decision Tree algorithm has given the best accuracy with 98% training accuracy and 99% testing accuracy. The research of Thenabadu and Ilmini (2020) proposes the use of an ANN to predict type two diabetes. Their model has achieved 92.48% accuracy on the testing data set.

3 METHODOLOGY

Machine Learning techniques were used to implement our model to predict diabetes with higher accuracy. ML focuses on developing computer programs that learn from previous data and use this training to predict properties of a new data introduced to the computer program. Figure 1 shows the ML process carried out during this study.

3.1 Data Collection

The first step was data collection. The data set used in this study is originally taken from the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK), USA. This Diabetes data set contains 2768 records and 9 attributes. Attributes include Pregnancies, Glucose, Blood Pressure, Skin Thickness, Insulin, BMI, Diabetes Pedigree Function, Age, and Outcome.

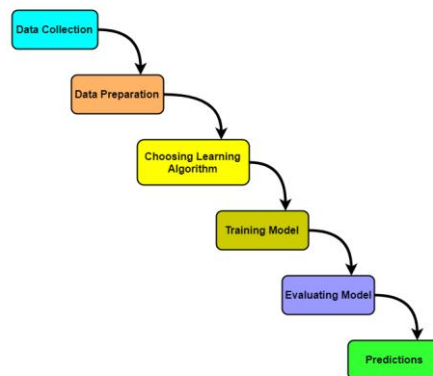


Figure 1: Machine Learning Process

3.2 Data Pre-processing

After collecting, the data set was per-processed to improve its quality and effectiveness. Duplicates, null values, and zero values were removed. Next, the input variables and the target variable were identified. Then, the data set was normalized in order to scale the attribute values to fall within a smaller range. Moreover, the standardization of attributes is required for some ML algorithms such as Support Vector Machines.

3.3 Building the Model

As the next step, several models were built using various classification and ensemble algorithms such as Logistic Regression, K-Nearest Neighbour, Gaussian Naïve Bayes, Support Vector Machine, Decision Tree, Random Forest, Gradient Boost, Multi-layer Perceptron (MLP) classifier, and Linear SVM to predict diabetes.

Next, the models were trained and evaluated. The robustness of each model was evaluated considering the accuracy, precision, recall, confusion matrix, classification report, and ROC Curve. Further, K-Fold cross-validation was used for precise use of the data set and also for calculating the most optimal accuracy results. After that, the best machine-learning algorithm was identified and the diabetes prediction model was created.

3.4 Training the Model

The diabetes data set has been split by allocating 20% of the data to the test set and 80% of the data to the training set. Furthermore, the data set has been divided according to the 70-30 train-test split. The model was trained by giving

the train data set in each of the 80-20 split and 70-30 split.

3.5 Evaluating the Model

Next, the model was evaluated considering the performance measurements such as accuracy, precision, recall and F1 score.

3.6 Using the Model for predictions

Finally, the built model was used for predicting the diabetes status of a person by providing the required input attribute values. Further, a Graphical User Interface (GUI) was created to facilitate the user to enter the input attribute values and view the prediction results.

4 RESULTS AND DISCUSSION

4.1 Results

The prediction results were evaluated using various evaluation metrics like classification accuracy, precision, recall and f1-score. Table 1 depicts the evaluation metrics of test size 0.2 and 0.3. During the experiment, Logistic Regression classifier amounted to train accuracy of 75.88%, test accuracy of 79.49%, predicted accuracy of 79.49% for test size 0.2 and a cross validation score of 0.77. The top three ROC AUC scores were depicted by MLP Classifier, SVM, and Logistic Regression which are 0.81, 0.79, and 0.78 for test size 0.2. Figure 2 shows the Confusion Matrix of Logistic Regression of test size, 0.2 and Figure 3 shows the ROC AUC Curve of Logistic Regression (test size = 0.20).

According to the model evaluation results, it is evident that Logistic regression is the best algorithm that can be used to develop the diabetes prediction model.

Table 1: Classifier Evaluation Results

		Logistic Regression	KNN	Naive-Bayes	SVM	Linear SVC	Decision Tree	Random Forest	Gradient Boosting	MLP Classifier
Test data size=0.2	Accuracy	79.49	74.36	76.28	80.77	78.21	76.92	78.21	73.72	81.41
	Precision	0.73	0.67	0.67	0.76	0.70	0.67	0.70	0.64	0.71
	Recall	0.71	0.62	0.72	0.71	0.69	0.71	0.76	0.64	0.76
	F1-Score	0.72	0.64	0.69	0.73	0.70	0.69	0.73	0.64	0.73
	ROC AUC	0.78	0.72	0.75	0.79	0.76	0.75	0.77	0.72	0.81
Test data size=0.3	Accuracy	77.35	76.07	74.79	77.35	77.35	72.22	78.21	71.79	78.63
	Precision	0.72	0.71	0.67	0.74	0.72	0.60	0.70	0.62	0.73
	Recall	0.63	0.60	0.64	0.60	0.63	0.69	0.68	0.63	0.72
	F1-Score	0.67	0.65	0.65	0.66	0.67	0.64	0.69	0.63	0.73
	ROC AUC	0.74	0.73	0.73	0.74	0.74	0.71	0.76	0.7	0.77
Cross-validation		0.77	0.73	0.74	0.75	0.76	0.7	0.75	0.74	0.75

```
In [53]: sns.heatmap(confusion_matrix(Y_test,lr_pred), annot=
Out[53]: <AxesSubplot:>
```

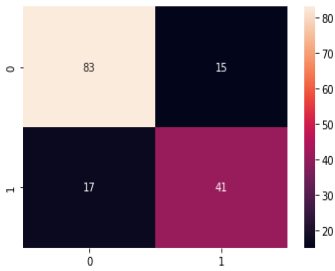


Figure 2: Confusion Matrix of Logistic Regression (test size = 0.2)

4.2 Discussion

In this research study, several machine learning algorithms were tested to identify the most suitable classifier to build a model to predict diabetes. During the analysis, data pre-processing techniques were used since the data set is imbalanced.

The prediction results were evaluated using various evaluation

metrics like classification accuracy, confusion matrix, and f1-score.

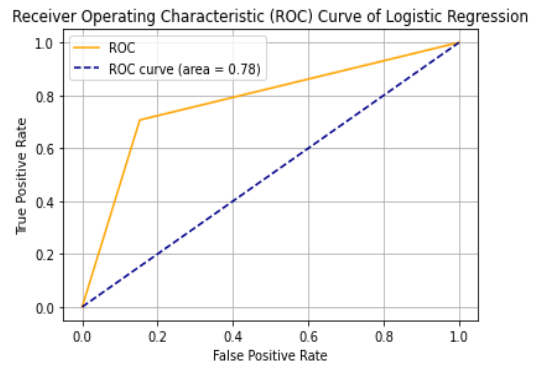


Figure 3: ROC AUC Curve of Logistic Regression (test size = 0.20)

The Logistic Regression algorithm was chosen for building the diabetes prediction model considering the evaluation results.

5 CONCLUSION

In this study, systematic efforts are made in designing a system that results in the prediction of diabetes using machine learning algorithms. During this work, nine machine learning algorithms were used to predict diabetes and evaluated the performance considering various measures. Algorithm performance measures were compared with two different train and test data set splits. Among all the tested models, the Logistic Regression is the most efficient for analyzing diabetes. Therefore, this algorithm was selected to build the diabetes risk prediction model.

This system can be used to detect if the patient has diabetes or not. Ease of use is one of the strengths of this system. Further, the result of this study could help as a Decision Support System for hospital management, which would assist them a lot in making timely and quality decisions. However, this system does not predict the type of diabetes the patient has and this model is based on a structured data set. In the future, this system can be improved to support unstructured data and to predict the type of diabetes the patient has.

REFERENCES

- Alam, T. M., Iqbal, M. A., Ali, Y., Wahab, A., Ijaz, S., Baig, T. I., Hussain, A., Malik, M. A., Raza, M. M., Ibrar, S. & Abbas, Z. (2019). A model for early prediction of diabetes. *Informatics in Medicine Unlocked*, 16.
- Evwiekpaefe, A. E., & Abdulkadir, N. (2021). A Predictive Model for Diabetes Using Machine Learning Techniques (A Case Study of Some Selected Hospitals in Kaduna Metropolis). *Master of Science in Computer Science Theses*, 41.
- Khanam, J. J., & Fo, S. Y. (2021, February). A comparison of machine learning algorithms for diabetes prediction. *ICT Express*, 7(4), 432-439.
- Lai, H., Huang, H., Keshavjee, K., Guergachi, A., & Gao, X. (2019, October 19). Predictive models for diabetes mellitus using machine learning techniques. *BMC Endocrine Disorders*, 19(1).
- Lyngdoh, A. C., Choudhury, N. A., & Moulik, S. (2021). Diabetes Disease Prediction Using Machine Learning Algorithms. *2020 IEEE EMBS Conference on Biomedical Engineering and Sciences (IECBES)*.
- Mujumdar, A., & Vaidehi, V. (2019). Diabetes Prediction using Machine Learning Algorithms. *Procedia Computer Science*, 165, 292-299.
- Nai-arun, N., & Mounngmai, R. (2015). Comparison of Classifiers for the Risk of Diabetes Prediction. *Procedia Computer Science*, 69, 132-142.
- Perveen, S., Shahbaz, M., Guergachi, A., & Keshavjee, K. (2016). Performance Analysis of Data Mining Classification Techniques to Predict Diabetes. *Procedia Computer Science*, 82, 115-121.
- Rani, K. J. (2020). Diabetes Prediction Using Machine Learning. *International Journal of Scientific Research in Computer Science, Engineering and Information Technology*, 6(4), 294-305.
- Soni, M., & Varma, S. (2020). Diabetes Prediction using Machine Learning Techniques. *International Journal of Engineering Research & Technology (IJERT)*, 9(09), 921-925.
- Thenabadu, T., & Ilmini, W. (2020). Diabetes Prediction System using Machine Learning. *13th International Research Conference*, 79-86.



AI and ML tools for quality engineering: A Comparative analysis

Bandara GRSTG¹, Vidanagama VGTN²

Department of Computing & Information Systems, Faculty of Applied Sciences, Wayamba University of Sri Lanka.

sahangamlathbandara@gmail.com¹

tharinda@wyb.ac.lk²

ABSTRACT

The use of Artificial Intelligence (AI) and Machine Learning (ML) in Quality Engineering (QE) has gained significant attention in recent years, as these technologies have the potential to significantly improve the efficiency and effectiveness of QE processes. AI and ML can be used to quickly and accurately detect defects in software by analyzing large amounts of data to identify patterns and anomalies that may indicate the presence of defects, helping to catch issues earlier in the development process and reducing the time and cost required to fix them. AI and ML can be used to automate the testing process by generating test cases and identifying the most relevant tests to run, reducing the time and effort required to manually create and execute test cases, and allowing testers to focus on more complex tasks. Despite the potential benefits, the use of AI and ML in QE still poses some challenges, such as the need for high-quality data to train machine learning algorithms and ensuring that AI and ML systems are transparent and explainable so that their decisions can be understood and trusted by professionals. This paper proposes a methodology to evaluate and compare AI and ML tools for QE based on various criteria. It compares eight popular AI and ML-based tools for QE and highlights the importance of choosing a tool that aligns with specific testing needs and goals. This paper suggests that AI and ML tools can provide significant benefits for QE, such as improved test case generation, prioritization, maintenance, and optimization, as well as enhanced accuracy, reliability, and speed, but it is important to choose a tool that aligns with testing needs and goals.

KEYWORDS: Artificial Intelligence, MACHINE Learning, Quality Engineering

1 INTRODUCTION

Web applications are becoming increasingly popular for their ability to implement spectacular User interfaces (UI). Despite advancements in technology, there are still challenges that need to be addressed in terms of software quality (Murthy & Murthy, 2020). However, quick changes in a web application's evolution can sometimes result in failures and errors in test automation scripts (Choudhary et al., 2011). Intelligent technologies such as natural language processing and machine learning have progressed to the point where scripts can learn and adapt. AI and ML techniques are used in technologies

like self-healing test automation to dynamically adjust testing to changes in an application's user interface or environment (Wilkinson, 2020). This research aims to provide a comprehensive overview of the AI and ML tools currently used in Quality Engineering (QE) and evaluate their strengths and weaknesses, as well as provide case studies of how these tools have been applied in the industry and recommendations for future research in this area.

2 PROBLEM SPECIFICATION AND LITERATURE SURVEY

2.1 *Problem specification*

In recent years, the use of AI and ML tools in software development and testing has increased significantly. These tools have the potential to improve the efficiency, effectiveness, and reliability of the software development process and to help organizations deliver better-quality products and services to their customers. However, there is a lack of comprehensive and objective information on the AI and ML tools that are being used in the field of QE.

2.2 *Literature survey*

In the field of software engineering, QE refers to the process of ensuring that software products meet the required quality standards. This can involve a wide range of activities, including designing and implementing quality control systems, testing software to identify defects, analyzing data to identify patterns and trends, and developing methods to prevent or correct defects. QE is an important part of the software development process, as it helps to ensure that software is reliable, safe, and fit for its intended use.

QE professionals may be responsible for developing and implementing test plans and protocols, conducting experiments and tests, analyzing data, and reporting on the results. They may also be involved in developing and implementing quality improvement initiatives, such as Agile, Six Sigma, or Lean software development (Tripathy & Naik, 2011).

The main challenge in QE is balancing the cost and time of quality

assurance activities with their benefits. Extensive testing may be required for reliability, but it can be expensive and time-consuming. Therefore, QE professionals need to prioritize testing activities and focus on the most important quality attributes (Chen & Miao, 2013).

AI and ML have become prevalent in recent years and have had a significant impact on software development and QE (Sogeti, 2021). However, many QE professionals are too busy to become AI specialists overnight. They are better served by grasping essential AI and ML foundations that will enable them to begin embracing new testing methodologies as soon as possible in order to maximize their time, effort, and skill set. They can use their new data science abilities to evaluate their existing software testing strategies for optimal data outputs as they gain knowledge, making their processes more efficient and facilitating the move to automated testing. With comprehensive reporting features, intelligent test automation tools are assisting QE teams in adopting a proactive approach to product quality. AI and ML, when used properly, may benefit QE teams in expanding testing to cover cross-browser, mobile web, and Application Programming Interface (API) testing without adding unsustainable quantities of test management chores (Hughes, 2022).

2.3 *Use of AI and ML in the QE process*

AI and ML can greatly enhance the QE process. By leveraging them, quality engineers can automate tasks, improve testing efficiency, and increase the accuracy and speed of defect detection

and resolution. Below are some of the several techniques used in the QE process using AI/ML algorithms.

- *Automated Test Generation*

Using AI/ML to generate test cases automatically based on code analysis and system specifications reduces the manual effort required for testing and increases test coverage.

- *Predictive Defect Analysis*

Training AI/ML algorithms on historical defect data to predict the likelihood of defects occurring in future code changes will allow quality engineers to prioritize testing efforts and improve defect detection.

- *Intelligent Test Selection*

Leveraging AI/ML to select the most relevant test cases for a given code change, taking into account factors such as code changes and test history, reduces overall testing time and increases testing efficiency.

- *Continuous Integration and Deployment*

Utilizing AI/ML algorithms to automatically validate code changes and provide feedback to developers, reduces the time and effort required for manual code review and testing.

- *Code Quality Analysis*

Using AI/ML to analyze code quality metrics such as code complexity, maintainability, and readability, quality engineers can identify areas of code that need improvement and make informed decisions about code changes.

- *Bug Localization and Diagnosis*

Implementing AI/ML algorithms to automatically localize and diagnose software defects will reduce the time and

effort required for manual defect analysis, increasing the speed of defect resolution.

- *Requirements Traceability*

Leveraging AI/ML to automatically trace requirements to code changes and test cases, will ensure that all requirements are addressed and tested, reducing the risk of software defects.

3 METHODOLOGY

The aim of this study was to evaluate and compare eight AI and ML tools for QE in software development. The tools evaluated in this study were Google OSS-Fuzz, Launchable, Appltools, Percy, Functionize, Tricentis, Testim, and TestProject.

To conduct the evaluation, the tools were compared against eight criteria: performance, ease of use, functionality, support and maintenance, cost, flexibility, scalability, and security. The evaluation was based on the information provided by the vendors and other sources.

To ensure the validity and reliability of the evaluation, the following methods were used:

- A literature review was conducted to gather information about the tools and the criteria used for the evaluation.
- The results were analyzed and compared to identify the strengths and weaknesses of each tool.

The methodology was intended to provide a comparison of the tools and identify the options for different scenarios and requirements. The results of the evaluation can be used as a reference for QE professionals to make

informed decisions about the tools to use

4 EVALUATION

In this chapter, a comparison of the features, performance, ease of use,

for QE in software development.

support and maintenance, flexibility, scalability, security, and cost of each tool is compared and contrasted.

4.1 Comparison of the tools

Table 1: Comparison of selected tools

Tool	Functionality	Performance	Ease of Use	Support and Maintenance	Flexibility	Scalability	Security	Cost
Google OSS-Fuzz	Fuzz testing for open-source projects	Scalable and efficient testing	May require some technical expertise to set up and use	Active community support and maintenance	Highly customizable and can integrate with other tools	Designed to handle large amounts of data across platforms	Built-in security features to protect data	Free and open source
Launchable	Cloud-based performance testing tool for web apps.	Optimized for speed and accuracy	Intuitive interface and easy to set up	Active technical support and regular updates	Can integrate with a variety of tools and workflows	Designed to scale for large test data	Built-in security features to protect data	Paid service with pricing plans
Applitools	Automated visual testing in mobile and web	High accuracy and fast execution time	User-friendly interface with a steeper learning curve	Community of developer support and regular updates	Customizable testing processes with various frameworks	Designed to handle large-scale visual testing	Only authorized users can access data	Paid service with pricing plans
Percy	Visual review and collaboration for web apps.	Good performance high accuracy	Straightforward approach and is easy to use	Active technical support and regular updates	Review and approve visual changes	Designed to handle large-scale visual testing	Built-in security features to protect data	Paid service with pricing plans
Testim	AI-driven testing for web and mobile applications	Optimized for efficient and accurate testing	User-friendly interface but may have a steeper learning curve	Active customer support and regular updates	Highly customizable and can integrate with other tools	Designed to handle large-scale testing	Built-in security features to protect data	Paid service with pricing plans
TestProject	Free and open-source End-to-end testing	Good performance in functional, security, and performance testing	Easy to use with a straightforward interface	Large community support and maintenance	Can integrate with a variety of frameworks	Designed to handle large-scale testing	Built-in security features to protect data	Free and open source
Functionize	Cloud-based tool that can automate the process of QE	Excellent results in automating QE process	Feature-rich but may have a steeper learning curve	Active customer support and regular updates	Highly customizable and can integrate with other tools	Designed to handle large-scale testing	Built-in security features to protect data	Paid service with pricing plans
Tricentis	Test automation platform for QE	Optimized for functional, security, and performance testing	Straightforward approach and easy to use	Active customer support and regular updates	Highly customizable and can integrate with other tools	Can handle large-scale testing for enterprise spaces	Built-in security features to protect data	Paid service with pricing plans

5 RESULTS

The key results of the comparison show that,

Google OSS-Fuzz is a great option for finding security and stability issues in open-source software, with excellent results in identifying bugs and vulnerabilities in the code. Launchable is a good option for measuring the speed, scalability, and reliability of web applications.

Testim is a great option for AI-driven test automation, with excellent results in automating testing with high accuracy and a fast execution time. TestProject is a good option for functional, security, and performance testing and is a cost-effective solution as it's free and open-source.

Applitools is a good option for automated visual testing of web and mobile applications, with excellent results in automating visual testing. Percy is a good option for visual review and collaboration.

Functionize would be good for a cloud-based, AI-driven test automation platform that automates the process of quality engineering in software development. Tricentis is a good option for a test automation platform that allows teams to automate functional, security, and performance testing of web and mobile applications.

6 CONCLUSION

This research paper discusses the use of AI and ML tools in QE, highlighting their capabilities and benefits such as improved test case generation, maintenance, and optimization, as well as enhanced accuracy, reliability, and speed.

However, it is important to consider compatibility, cost, and support when selecting a tool that aligns with testing needs and goals. Future work may include a continued exploration of the capabilities and limitations of AI and ML tools, case studies, and user studies to understand practical usage and integration with other testing approaches and technologies.

REFERENCES

- Chen, R., & Miao, H. (2013, June). A Selenium based approach to automatic test script generation for refactoring JavaScript code. In *2013 IEEE/ACIS 12th International Conference on Computer and Information Science (ICIS)* (pp. 341-346). IEEE.
- Choudhary, S. R., Zhao, D., Versee, H., & Orso, A. (2011, July). Water: Web application test repair. In *Proceedings of the First International Workshop on End-to-End Test Script Engineering* (pp. 24-29).
- Hughes, B. (2022, May 5). AI and Machine Learning Skills for Quality Engineering. *Mabl*. Retrieved December 22, 2022, from <https://www.mabl.com/blog/ai-and-machine-learning-skills-for-quality-engineering-mabl>
- Murthy T. & Murthy C. R. (2020). A Selenium Based Approach to Automate Software Testing. *International Journal of Mechanical and Production Engineering Research and Development*, 10(3), 4361-4374.
- Sogeti. (2021). State of AI applied to Quality Engineering 2021-22. In *www.sogeti.com*. <https://www.sogeti.com/ai-for-qe>
- Tripathy, P., & Naik, K. (2011). *Software testing and quality assurance: theory and practice*. John Wiley & Sons.
- Wilkinson, J. (2020, August 20). Why self-healing test automation is the next big thing. *Accenture*. Retrieved December 25, 2022, from <https://www.accenture.com/us-en/blogs/software-engineering-blog/wilkinson-self-healing-test-automation>



Assessing software code quality using metrics-based approach

Shyamal DKK¹, Dinesh Asanka PPG², Wickramaarachchi Dilani³

Department of Industrial Management, Faculty of Science, University of Kelaniya, Sri Lanka^{1,2,3}

shyamald_im17073@stu.kln.ac.lk¹

dasanka@kln.ac.lk²

dilani@kln.ac.lk³

ABSTRACT

The primary objective of software development is to deliver technological solutions that address human requirements and issues that arise in the business context. Consequently, software engineering is one of the most demanding jobs in the contemporary world, and the expansion of the software development environment and the analysis and comprehension of emerging needs contribute to the growth of the software engineering sector. Software engineers are primarily responsible for maintaining the quality of the code, and the term "Quality Coding" has gained significant attention in software quality assurance and is one of the trendiest subjects on which the industry focuses most of its time, energy, and resources. Maintaining software development quality is necessary to maintain high demand, and code quality is one of the critical factors behind software quality. Code quality refers to the overall level of excellence and maintainability of software. It encompasses a wide range of factors, including readability, scalability, performance, and adherence to industry standards. High-quality code is easy to understand, modify, and test, making it more reliable and less prone to bugs. The current quality models for measuring code quality present several challenges that must be addressed to ensure accuracy and efficacy in evaluating and enhancing code quality. This study aims to identify the most relevant code quality models within the current software industry and determine the most critical code quality attributes and their respective metrics for developing an appropriate quality model.

KEYWORDS: Code Quality, Quality Metrics, Quality Attributes, Quality Models, Software Metrics

1. INTRODUCTION

The software engineering sector has made great strides thanks to the current software industry's explosive growth. The complexity of the modern world has created a multitude of opportunities for professionals in the business sector, encompassing both technical and non-technical roles in software development. This is essential to meet society's increasing demands and expectations

Technological advancements result in increased workload and complexity for developers, leading to decreased product quality in some cases. One reason for this is the decrement in source code quality.

There have been attempts to improve it through quality models and methodologies. However, there needs to be more study on programming languages and their specifications, and the existing quality models have received intense criticism for their completeness and soundness.

2. LITERATURE REVIEW

The quality of a software product's source code is assessed based on various qualitative factors, and these are defined differently by researchers. It is important to keep studying and incorporating new trends and technologies to maintain the

quality of the code, as it is critical for the overall quality of the program.

The ISO/IEC 25010:2011 System and Software Quality Model outlines the specifications for software quality. This model encompasses eight crucial characteristics, including functional suitability, reliability, usability, compatibility, performance efficiency, maintainability, portability, and security. (ISO - ISO/IEC 25010:2011 - Systems and Software Engineering — Systems and Software Quality Requirements and Evaluation (SQuaRE) System and Software Quality Models, n.d.) To ensure software adheres to these standards, code quality rules are generated and aligned with the relevant quality characteristics, as described in the quality model (Forouzani, Chiam & Forouzani, 2016; Fang, 2001; Software Metrics, n.d).

Typically, problem-solving and planning for a software solution go into software design. Early-stage development non-functional requirements are commonly referred to as quality attributes. The ability to understand source codes is crucial for easy adaptation (Singh & Gautam, 2016).

A well-defined quality model with specific qualities and metrics is necessary for measuring software quality (Forouzani et al., 2016). There are established metrics for evaluating products, and various metrics have been proposed for measuring source code quality based on discussions and research. Choosing metrics to measure software quality is challenging because only some metrics can provide a complete representation of quality. As a result, many people have criticised

metrics. Most of this criticisms is on the accuracy and soundness of the content (Sharma & Spinellis, 2020). Quality metrics are grouped into four main categories, with the categories and their respective metrics displayed in Table 1.

Table 1: Categories of code quality metrics

Category	Metrics
Defect	Defects' quantity, Defects' density
Complexity	Cyclomatic Complexity, Halstead Complexity
Traditional	Size, Comment percentage, Code duplications
Object-Oriented Specific	Weighted Methods per Class, Lack of Cohesion of Methods, Coupling Between Object Classes, Depth of Inheritance Tree, Response for a Class, Number of Children

The quantity and severity of defects significantly impact the overall quality of the source code. Factors such as the number of open defects, the stage of development when the defect is discovered, and the defect density are all considered in evaluating the quality of the source code.

Another category of software metrics referred to as "Control Metrics/Complexity Metrics," is based on the principle that the complexity of a program increases as the control flow becomes more intricate. There are

various types of complex metrics available.

However, "Cyclomatic Complexity" and "Halstead Complexity" are the most used control metrics. Cyclomatic complexity measures how many linearly independent routes are there through the source code, and when the complexity drops, the developer must deal with fewer control pathways in the code. (Zakariya & Belal, 2015; Rosenberg & Hyatt, n.d.)

Halstead metrics analyse a program as a series of operators and the operands that go with them. According to Halstead, "A computer program is an implementation of an algorithm considered a collection of tokens which can be classified as either operators or operands." (Software Engineering | Halstead's Software Metrics - GeeksforGeeks, n.d.)

From a commercial perspective, maintenance costs make up a significant portion (40-80%) of the total project cost, which is a result of code quality. To reduce these costs, the software industry has developed various techniques to improve the coding process (Abrahamsson et al., 2017.). A 2016 study on creating maintainable software provided ten recommendations for writing future-proof code and addressing the challenges of working with someone else's code. The recommendations include writing code once, keeping unit interfaces small, avoiding large classes, balancing the number and size of components, keeping the code base small, and automating tests to keep the code clean (Serban et al., 2020)

3. METHODOLOGY

For the literature, the process was analysed, and the publications were reviewed in the following procedure. Various academic websites, including Google Scholar, Research Gate, Z-Library, Science Direct, IEEE, and Scopus were searched and used to gather the literature.

Initially, 46 papers that related to research keywords were downloaded. Considering those papers, snowball sampling was executed, and 8 more papers were added during this process. Only recent papers were examined and chosen for analysis using keyword searches, index identification, and publication year sorting.

A preliminary list of quality attributes and metrics was established by reviewing past literature. Participants were then selected for interviews based on the research objectives. Interview questions were developed, and informed consent was obtained before the interviews. The interviews were conducted in a semi-structured manner and recorded. The transcripts were generated promptly after the interviews took place. The transcribed data were analysed to draw conclusions based on the information gathered from the interviews.

4. DATA COLLECTION AND ANALYSIS

4.1 *Quality Attributes and Metrics Identification*

The ISO/IEC 25010:2011 System and Software Quality Model's quality characteristics were evaluated to identify relevant quality attributes. However, considering the wide range of attributes

within this model, it was determined that a direct application of these attributes was inappropriate. As a result, alternative quality attributes were analysed. The following four were determined to be the most pertinent regarding source code quality.

Values that can evaluate source code numerically or statistically were selected as the quality metrics. A comprehensive review of past literature led to the identification of 51 potential quality metrics. After thorough analysis, 8 of these metrics were chosen to form the basis of the quality model.

4.2. Quality management procedure

An extensive examination of existing quality models and management procedures revealed that PMD is a widely utilised tool in various organisations. The rules integrated with this tool were thoroughly evaluated to gain a clear understanding of the quality metrics involved.

4.3. Conduct Interviews

A comprehensive analysis of industry-standard practices and tools was conducted prior to the initiation of the interview process to ensure efficient and effective interviews. Four industry experts were interviewed, and their opinions were utilised to analyse the quality attributes and metrics. The final quality model was constructed through a comprehensive analysis of the literature review, PMD rule set, and the insights and perspectives of industry experts.

5. RESULTS

Quality is a subjective and abstract concept that can be challenging to define precisely. However, in the context of

conducting research related to code quality, it is important to have a clear and specific definition in place to provide a basis for comparison and evaluation.

In this research, code quality is defined as the “Capability of reading, maintaining and testing reliable source code to satisfy the stated and implied needs for the current software project”. Selected attributes from the past literature and conducted interviews are used to define the code quality.

The quality model was developed by mapping selected attributes to the quality metrics with their threshold values. The developed quality model is shown in Table 2. Determining threshold values for code quality metrics is a challenging task due to various factors, including subjectivity, the specific context of each project, ever-evolving requirements, a lack of consensus within the industry, and the limitations of the metrics themselves. This research endeavors to establish threshold values through a comprehensive review of past literature and consultation with industry experts.

6. DISCUSSIONS AND RECOMMENDATIONS

Code quality is a broad and complex topic that requires a multi-disciplinary and holistic approach for understanding and evaluation. In addition, code quality is a dynamic concept that can change over time as the software evolves, the technology, programming languages, frameworks, design patterns and development practices change, and the requirements of the software change. Since the definition of code quality was finalized considering quality model attributes, it is essential to keep in touch

with the industry behaviours and continue adaptations based on new trends.

To address challenges related to code quality, a flexible and adaptive code quality assessment approach was designed.

Code quality metric	Attribute				Threshold Values
	Maintainability	Readability	Testability	Reliability	
Lines of code		x			60-100 (Individual function/method)
Code duplications	x				0
Cyclomatic complexity	x				1-10
Comment percentage		x			(10-20) %
Depth of inheritance tree	x				≤ 5
Coupling between objects				x	0
Number of children			x		No more than (7-10)
Lack of Cohesion of Methods (LCOM)				x	0

Table 2: Code quality metrics and associate characteristics with threshold values

This approach consists of two key components such as a set of rules and structural elements. These rules can be customised to align with the specific development environment. This research identifies the appropriate structural elements to incorporate in developing a quality model.

7. CONCLUSION

Quality coding is a critical aspect of software development. It ensures the software is reliable, maintainable, readable, and testable. However, there are several common issues and limitations related to quality coding that developers need to address to enhance software development processes. This study is conducted to examine quality management procedures and practices to

identify existing code quality attributes and metrics that impact source code quality. The findings of this investigation provide a clearer understanding of code quality by examining current industry best practices and management procedures. Additionally, a quality assessing approach has been developed by identifying the most critical code quality attributes and metrics with their threshold values that impact source code quality.

REFERENCES

- Abrahamsson, P., Salo, O., Ronkainen, J., & Warsta, J. (2017). Agile software development methods: Review and analysis. *arXiv preprint arXiv:1709.08439*.
- Fang, X. (2001, December). Using a coding standard to improve program quality. In *Proceedings Second Asia-Pacific Conference on Quality Software* (pp. 73-78). IEEE.
- Forouzani, S., Chiam, Y. K., & Forouzani, S. (2016, December). Method for assessing software quality using source code analysis. In *Proceedings of the Fifth International Conference on Network, Communication and Computing* (pp. 166-170).
- ISO (n.d.). *ISO/IEC 25010:2011 Systems and software engineering — Systems and software Quality Requirements and Evaluation (SQuaRE) — System and software quality models*. Retrieved from <https://www.iso.org/standard/35733.html>
- Rosenberg, L.H. & Hyatt, L.E. (n.d) Software quality metrics for object-oriented environments, *Software Quality Metrics for Object-Oriented Environments*.
- Serban, A., van der Blom, K., Hoos, H., & Visser, J. (2020, October). Adoption and effects of software engineering best practices in machine learning. In *Proceedings of the 14th ACM/IEEE International Symposium on Empirical Software Engineering and Measurement (ESEM)* (pp. 1-12).
- Sharma, T., & Spinellis, D. (2020). Do We Need Improved Code Quality Metrics? *ArXiv [Cs.SE]*. Retrieved from <http://arxiv.org/abs/2012.12324>
- Singh, B., & Gautam, S. (2016, December). The impact of software development process on software quality: a review. In *2016 8th international conference on computational intelligence and communication networks (CICN)* (pp. 666-672). IEEE.
- Software Engineering | Halstead's Software Metrics - GeeksforGeeks. (n.d.). Retrieved from <https://www.geeksforgeeks.org/software-engineering-halsteads-software-metrics/>
- Software Metrics. (n.d.). Retrieved from [https:// www.perforce.com.html](https://www.perforce.com.html).
- Zakariya, S., & Belal, M. (2015). Software quality management measured based code assessments. *International Journal of Computer Science Trends and Technology*, 3(4), 263-26



Comparison of Web Applications or Websites and Mobile Applications for SME

Caldera HPSM¹, Premarathna WCC²

Department of Computing & Information Systems, Faculty of Applied Sciences, Wayamba University of Sri Lanka^{1, 2}

sasinimadushika23@gmail.com¹

chamidu@wyb.ac.lk²

ABSTRACT

Small and medium-sized enterprises (SME's) are the foundation of both developed and emerging economies worldwide. Technology development has made significant progress in terms of hardware and software capabilities, opening up new opportunities for SME's. It might be claimed that one of the main objectives of businesses is to create applications that are useful and, more significantly, user-friendly so they can provide the best user experience to their clients. web and mobile applications both contain data aimed at assisting small businesses. The main outcome of this study is to examine data to choose an appropriate internet platform from a web application or a mobile application in order to run various types of businesses. A Google form was used to collect data on many people's preferences for web and mobile applications for SME's. The odds ratio of males' preference for web applications for clothing products versus females. The researcher then divides the frequency of application preference for essential products into age groups. Finally, the Chi-square test was used to determine the independence of essential and non-essential products. Further, a correspondence analysis was performed to explore more about the relationships among the variables.

KEYWORDS: SME, Website, Mobile application, Web application

1. INTRODUCTION

1.1 Background

There has been a lot of research about the mobile application to SMEs, web application to SME and this research suggests is a strong linkage between web and mobile applications to SME success. SME s form the economic backbone of many countries and this is especially true in the context of developing nations.

SME's are increasingly finding new opportunities in both local and foreign markets as they are acknowledged as significant contributors to the economies of many nations. Though websites and mobile applications both are equally useful, but still there exist differences that set them apart. This research paper compares websites with mobile

applications specifically in the context of small and medium enterprises.

1.2 Motivation

The due current situation in the county There is a resin artifact business started and currently running by myself as a side hustle named S&N Crafts with two co-owners. SME's acquire and participate in a large part of Sri Lanka's economy, accounting for 80 percent of all businesses. Internet platforms offer far better benefits when compared to social media business channels Hence there is a good opportunity for small enterprises to use internet platforms like web applications and mobile applications to reach out to customers directly and provide finer customer service.

1.3 Problem Statement

SMEs, which account for 80% of all enterprises in Sri Lanka, is a significant component of the country's economy. Nowadays Sri Lankan adults, teenagers, and the majority use the web and mobile applications for buying products, especially due to the covid situation and inflation. Small business owners can use this to increase their profits and customer base. For this, there are many viable options but it can be single web applications and mobile applications as the more favorable options. Both these types have their own qualities that can help businesses to grow. But the main problem is that even though they help them to grow. Both of these options cost a business heavily so business owners should be careful when selecting either one of these options. This research aim is to research to select what is a suitable internet platform between mobile applications and web applications for small businesses to grow.

2. RELATED WORKS

Amaradiwakara and Gunatilake (2017) has researched Factors Affecting the Growth of Small and Medium Enterprises in Sri Lanka. The main objective of this research was to recognize the factors that affect the growth of SMEs in Sri Lanka. The researcher selected a suitable sample of SMEs using a stratified sampling technique, and the study employed correlation analysis and the Chi-square test. The chi square test was also used by the researcher in this study to analyze the data set.

Bentley, Fisher and Craig (2003) have done a study on the importance of

information design for small business websites. The study presents research that inspected the effectiveness of small firms' websites from the outlook of users. As a result, the study was extremely beneficial in gaining an understanding of the web and SME's for this research.

Polkowski, Dutta, Savulescu and Shtefanitsa (2016) have done a study on the problem of using and implementing mobile solutions in SME's. An important part of the study is a presentation of the study on mobile solutions which can be used to control the business activities in SMEs and concerns the study on using mobile solutions in SMEs. As a result, the study was extremely beneficial in obtaining solutions for SME's using mobile applications for this study.

There are numerous studies on SMEs and web applications, mobile applications. However, there is no comparison study for SME web and mobile applications. This research study primarily focused on comparing web applications and mobile applications in various ways and determining which internet platform is best suited for small and medium-sized businesses based on their business types.

3. METHODOLOGIES

To collect research papers for this study, a keyword filter phase and an abstract filter phase were used. Data were gathered using a survey, which was discovered to be the most difficult part of the study. Data was collected using Google Form 1046, with the majority of data coming from the 20-30 and 30-40 age groups.

Table 1: Two-way table for gender and web/mobile application preference for clothing

	Male	Female	Total
Web applications	221	337	558
Mobile applications	192	296	488
Total	413	633	1046

First, the researcher categorizes product types as essential or non-essential. The researcher must determine which internet platform is preferred by business types based on the data sample collected. The odd ratio of males' preference for web applications for clothing products versus females was then calculated. Then divides the frequency of application preference for essential products into age groups. Finally, the Chi-square test of independence was used to determine whether the preference for web/mobile applications among different types of products is independent of one another for essential products and non-essential products. Further, a correspondence analysis was performed to explore more about the relationships among the variables.

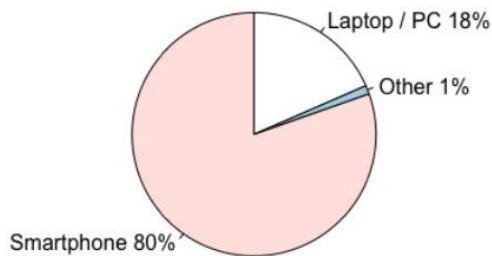


Figure 2: Preferred device to buy goods from online small businesses

4. RESULTS AND DISCUSSION

According to the sample data gathered, 80% of individuals prefer to use a smartphone to make purchases from online merchants in general figure 1. But it not says that customers always use mobile phones for purchases.

Food, transportation, clothing, medicines, and kitchen supplies are considered essential products by the researcher, while stationary, electric products, furniture, and arts and crafts are considered non-essential products. According to the data collected, the vast majority of people prefer mobile applications for transportation and eating, while web applications are preferred for all non-essential products and kitchen, and medical items. People want web and mobile applications for roughly equal amounts of different types of apparel. The odds ratio 1.01 with a 95% confidence level (0.79,1.30) of preference for web applications for apparel products among males as opposed to females was determined from the two-way table 1 to draw additional conclusions for clothing products. Based on that odd ratio, females are more likely than males to make purchases through mobile applications.

Following that, divide the frequency of application preference for essential products by age group. The majority of people between the ages of 20 and 40 prefer mobile apps for food and transportation, and web apps for purchasing kitchen supplies and medicine. Again, web and mobile apps are roughly equal for online clothing purchases.

Table 2: p-values from Chi-square test of independence -essential products

	Food	Transport	Cloths	Medicines	Kitchen Suppliers
Food		1.65×10^{-12}		0.94	0.73
Transport			0.02	0.33	1.00
Cloths		0.02		0.28	3.62×10^{-6}
Medicines	0.94	0.33	0.28		$< 2.2 \times 10^{-16}$
Kitchen suppliers	0.73	1.00	3.62×10^{-6}	$< 2.2 \times 10^{-16}$	

Then a chi-square test was performed. The p-values from each Chi-square test for essential products are listed in Table 2. Any p-value less than 0.05 provide strong evidence to state that the preferences are not independent. The researcher can confirm that the choice of web/mobile applications for necessities like food, transportation, and clothing is significantly associated based on the p-values shown in table 2. It means the desire for buying food can have some bearing on the preference for buying clothes, transportation, or both, and vice versa. The p-values from the Chi-square test for independence are relatively tiny, as seen in Table 3, indicating that the preferences for non-essential goods purchases can impact on one another.

A correspondence analysis was also performed to learn more about the relationship between all variables in this

study. In figure 2 symmetric bi plot, the rows are represented by blue points and columns by red triangles and the distance between any row points or column points measures the similarity (or dissimilarity). Row points with similarities are closed on the factor map. Electric items and clothing are grouped with web applications suggesting those purchases are made more often through web applications whereas, for food and transportation, mobile applications are more often used. For kitchen items, furniture, and for medicine, people seem to prefer other purchasing methods such as in-store purchases. However, the magnitude of distances between any row and column items in figure 2 is not interpretable. To interpret the distances between column and row points, the column profiles must be presented in row space.

Table 3: p-values from Chi-square test of independence -a non-essential product

	Stationaries	Electric items	Furniture	Art and crafts
Stationaries		$< 2.2 \times 10^{-16}$	$< 2.2 \times 10^{-16}$	$< 2.2 \times 10^{-16}$
Electric items	$< 2.2 \times 10^{-16}$		1.86×10^{-13}	8.64×10^{-7}
Furniture	$< 2.2 \times 10^{-16}$	1.86×10^{-13}		$< 2.2 \times 10^{-16}$
Art and crafts	$< 2.2 \times 10^{-16}$	8.64×10^{-7}	$< 2.2 \times 10^{-16}$	

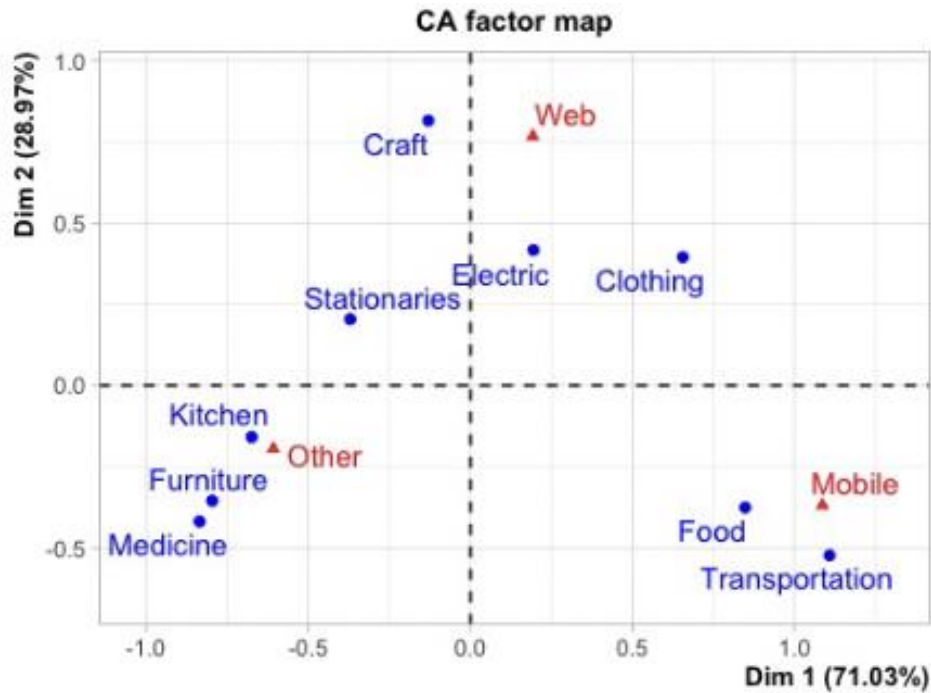


Figure 2: Symmetric bi-plot

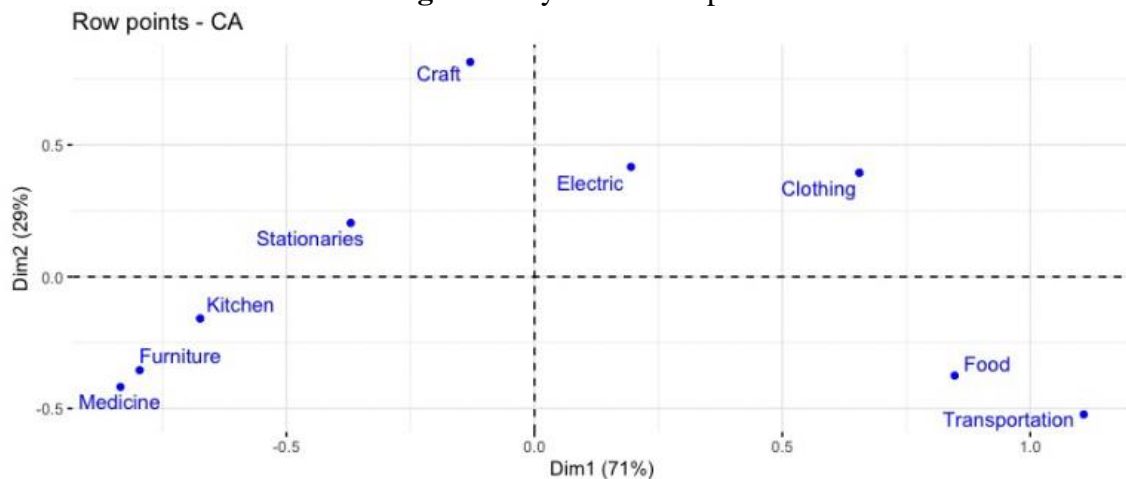


Figure 3: Asymmetric bi-plot

Thus, the researcher can see that preference for food and transportation are strongly related. Electric items and clothing products are related. Negatively correlated rows are grouped on opposite sides of the plot origin (opposed quadrants).

5. CONCLUSIONS

In conclusion, according to the sample data gathered, 80% of individuals prefer to use a smartphone to make

purchases from online small businesses. The majority of individuals like to purchase food and transportation using mobile applications. Also, most people like to purchase medicines and kitchen supplies using web applications or websites. An odd ratio of preference of web applications for clothing products of males compared to females was calculated. Then researcher breakdown frequencies of preference of applications

for essential products based on age groups. Then performs the Chi-square test of independence for essential and non-essential products separately. Further, a correspondence analysis was performed to explore more about the relationships among the variables.

Finally, the findings of this study show that mobile applications are an appropriate internet platform for food and transportation businesses. And it's a good idea to keep a website for medicine, kitchen suppliers, art and crafts, electrical items, and stationery businesses. A website or a mobile application are both suitable for clothing products.

REFERENCES

- Amaradiwakara A.U. and Gunatilake M. M. (February 2017). *Factors affecting growth of small and medium enterprises in Sri Lanka*. Article in International Journal of Advanced Research.
- Bentley J, Fisher J, Craig A. (2003). *The importance of information design for small business web sites*. A paper for the Small Enterprise Association of Australia and New Zealand 16th Annual Conference, Ballarat.
- Polkowski Z, Dutta N, Savulescu N, Shtefanitsa M. (2016). *Mobile Solutions in Small and Medium Enterprises*. ECAI 2016 - International Conference – 8th Edition



Enhancement of Real-Time Object Detection for Autonomous Driving Based on YOLOv5

Batuwangala MT¹, Wanninayake WMLN²

Department of Computing and Information Systems, Faculty of Applied Sciences, Wayamba University of Sri Lanka.^{1,2}

mudithatharuka@outlook.com¹

lakminiw@wyb.ac.lk²

ABSTRACT

Object detection is a critical factor in autonomous driving systems. Many inspiring methods for improving object detection have been proposed in various studies by altering the internal structure of deep learning models. This research reveals several aspects that improve the speed and accuracy of object detection in autonomous driving. Based on the YOLOv5 one-stage deep learning framework, two models with different settings are constructed to evaluate the effectiveness of the considered factors, using a minimum amount of resources. Compared with YOLOv5, the algorithms derived in this paper improve the average accuracy by 9.1% and inference speed by 6.7% on a comparatively selected validation block from the BDD100k dataset.

KEYWORDS: Object Detection, Convolutional Neural Networks, Autonomous Drivin

1. INTRODUCTION

The object detection algorithm of self-driving vehicles should meet two major requirements: first, the high detection accuracy, and second, real-time speed. Recent studies on improving object detection performance based on deep learning algorithms have shown a rapid growth in the suggested approaches (Ahmad, Abdullah, & Han, 2020; Xiao et al., 2020). However, most of these studies have focused on modifying the deep learning models' underlying architecture to improve the detection performance (Cai et al., 2021; Dong et al., 2018; Huang et al., 2022; Liu et al., 2016). Only a few researchers have examined alternate methods based on two-stage models (Carranza et al., 2021). Based on a one-stage detection model, YOLOv5s (Jocher, 2020), this paper presents several factors that considerably improve the speed and accuracy of object detection in autonomous driving (AD)

even with varying environmental conditions. Therefore, the novelty of this study was to focus on factors affecting on improving object detection performance with minimal resources and without changing the architecture of a one-stage deep learning model. Section 2 presents the experiment's methods, and Section 3 reviews on the result of the method. Section 4 concludes the paper.

2. METHOD DESCRIPTION

This study is inspired by the YOLOv5s framework (Jocher, 2020). To estimate each bounding box, this network takes data from the full image.

2.1. Data acquisition and pre-processing

In deep learning model training, the dataset can be thought of as the main building block for an accurate result. This section describes the process of obtaining and pre-processing the dataset for optimal model output.

Table 1: Class distribution through the image in bdd100k dataset

		Class								
	Person	Rider	Car	Truck	Bus	Train	Motor bike	Bicycle	Traffic light	Traffic sign
Train	22076	3586	69072	18890	8993	105	2284	4343	39237	57154
Val.	3220	515	9879	2689	1242	14	334	578	5653	8221

Table 2: Class distribution through the instances in the images of bdd100k dataset

		Class								
	Person	Rider	Car	Truck	Bus	Train	Motor bike	Bicycle	Traffic light	Traffic sign
Train	91349	4517	713211	29971	11672	136	3002	7210	186117	239686
Val.	13262	649	102506	4245	1597	15	452	1007	26885	34908
Priority	7	3	10	6	5	1	2	4	8	9

Table 3: Final number of images allocations for train and validation sets

Total images	Bg. ratio	Split percentage	Train set				Validation set			
			Train images	Bg. imgs.	Actual images	Max imgs. per class	Validation images	Bg. imgs.	Actual Images	Max imgs. per class
1350	5%	80%	1080	54	1026	102	269	13	256	25
		70%	944	47	897	89	405	20	385	38

2.1.1. Data Acquisition

For this study, the well-known BDD100k open-source image dataset (Berkeley DeepDrive ,(n.d.)) was used. It contains 100000 (100K) 1280x720 dimension road/driving images with labels in PASCAL VOC format. Objects in the images in this dataset have been divided into twelve categories as person, rider, car, truck, bus, train, motorbike, bicycle, traffic light, traffic sign, lane and drivable area.

2.1.2. Data Pre-Processing

Despite the fact that the BDD100k dataset comprises 100k images, the size of the dataset must be reduced in order to include these resources within the scope

Table 4: Final number of images allocations for test set

Total images	Bg. ratio	Test set			
		Test imgs.	Bg. imgs.	Actual imgs.	Max imgs. per class
100	0.05	100	5	95	9

of this research. As a result, a total of 1350 images were chosen as the training and validation datasets. The lane and drivable area classes were excluded from consideration since they are not in the norm of object detection but rather in lane detection. The images were chosen with a strong emphasis on decreasing class imbalance on pre-processed data,

because the BDD100k dataset suffers from significant class and instance imbalance issues, as demonstrated in Tables 1 and 2, respectively. Further, considerations such as obtaining images in different environmental circumstances and acquiring background images to reduce the likelihood of false positives (FP) were taken into account. To improve the accuracy of the results, the image selection procedure was carried out under two scenarios using two split percentages 80% (0.8) and 70% (0.7) to distribute a varied amount of images to train and validation sets (80% signifies 80% of the images for the train and 20% for the validation). Moreover, a 5% (0.05) background image percentage was chosen in both divisions based on the standard of 1%-10% for total images. To eliminate the class imbalance problem, the remaining space of the sets was equally allocated to all the 10 classes. As shown in Table 2, a list of priority classes was identified in order to minimize the instance imbalance problem. According to this list, the class train has the highest priority and the class car has the lowest priority, which implies that when assigning images to train and validation sets, images with train labels are assigned first and images with car labels are allocated last. Images were selected for a test set for the visual evaluation of all three models using the same approach as the train and validation sets, but only 100 images overall. Tables 3 and 4 depict the final image allocation for each collection. Several difficulties, however, had to be handled during the image pre-processing

phase. The first and most serious fault was that it attempted to create a class imbalance while assigning images based on environmental factors. Nonetheless, after correcting the other concerns stated and constructing the pre-processed dataset, the train, validation, and test image sets comprised a sufficient number of images for various environmental attributes. The second was that the final number of images for each set after image pre-processing was somewhat fewer than the initial allotted number. This was caused by the floor function that was used to remove the decimal points from the calculation's number of images. The PASCAL VOC labels of the selected BDD100k frames were turned to YOLO format as the final phase of data pre-processing.

2.2. *Experiment Setup*

Using a set of 1280x720 dimension images taken from an accurate pre-processing phase, two models with 80% and 70% split percentages were trained and evaluated in an effective manner. Computation was carried out in a virtual environment (VENV) made available by Google Colab, using a Tesla T4 GPU built with the CUDA 11.2 computational kernel. By mounting with the VENV, Google Drive was utilized to store the data and model outputs. The final pre-processed dataset contained 10 classes. The batch size was set to 16 images in each batch, for a total of 100 epochs. With a small number of images in the dataset, a large epoch count might lead to an overfitting of the model was the reason for choosing a small epoch count.

Table 5: Performance evaluation of the models

Image set	Model	Parameters (M)	mAP50 (%)	FPS	Model size (MB)
Val. set of 80% split	YOLOv5s	7.2	35.0	68.49	14.1
	Proposed mod. 1 (80% split)	7.0	44.1	72.99	14.0
Val. set of 70% split	YOLOv5s	7.2	35.8	70.42	14.1
	Proposed mod. 2 (70% split)	7.0	43.0	75.18	14.0

3. RESULTS AND DISCUSSION

This evaluation used both the validation and test image set data. In order to retain all of the classes studied in the proposed models in the original YOLOv5 model, the rider and traffic sign classes were excluded from the results to enable an unbiased evaluation.

3.1. Evaluation with Validation Data

Mean Average Precision (mAP) as depicted in (1) can be used to measure the model performance across all categories and mAP50 denotes the mAP computed at the IOU threshold of 0.5.

$$\text{mAP} = \frac{\sum_{i=1}^N \text{AP}_i}{N} \quad (1)$$

Where; AP Average precision
N – Number of classes

Table 5 illustrates the performance

75.18FPS, which is 7.2% and 6.75% increase in accuracy and speed respectively. Similarly, in comparison to the original YOLOv5s model, which has 35.0% mAP50 and 68.49FPS using data from the 80% validation set, the suggested model has a mAP50 of 44.1% and 72.99FPS, which is 9.1% and 6.57% increase in accuracy and speed respectively.

According to results in Table 5, it can be concluded that both the proposed models with 80% and 70% split percentages can fully enhance object detection accuracy and speed in AD. Furthermore, the mAP50 value of 44.1% for the model with 80% split percentage is higher than that for the model with 70% split percentage, indicating that

Predicted \ Actual	Person	Car	Truck	Bus	Train	Motorbike	Bicycle	Traffic light	Background
Person	62	0	0	0	0	0	1	0	4
Car	0	655	3	1	0	0	0	0	9
Truck	0	14	20	3	1	0	0	0	4
Bus	0	4	0	7	0	0	0	0	0
Train	0	0	0	0	1	0	0	0	0
Motorbike	0	1	0	0	0	6	0	0	1
Bicycle	0	0	0	0	0	0	7	0	0
Traffic light	0	0	0	0	0	0	0	117	5
Background	37	354	15	6	1	12	21	111	5

Figure 1.a: Inference results from the original YOLOv5s

Predicted \ Actual	Person	Car	Truck	Bus	Train	Motorbike	Bicycle	Traffic light	Background
Person	75	1	0	0	0	1	4	0	20
Car	2	758	10	0	0	3	3	0	24
Truck	0	6	11	5	0	1	0	0	5
Bus	0	1	0	8	0	0	0	0	1
Train	0	0	0	1	1	0	0	0	2
Motorbike	0	0	0	0	0	6	2	0	0
Bicycle	0	1	0	0	0	0	14	0	3
Traffic light	0	0	0	0	0	0	0	148	15
Background	22	164	17	3	2	7	6	80	5

Figure 1.b: Inference from the model with 70% split.

Predicted \ Actual	Person	Car	Truck	Bus	Train	Motorbike	Bicycle	Traffic light	Background
Person	63	0	0	0	0	0	0	0	8
Car	0	755	14	1	0	2	3	0	44
Truck	8	3	10	4	0	1	0	0	3
Bus	0	1	0	5	1	0	0	0	2
Train	0	0	0	1	1	0	0	0	0
Motorbike	0	0	0	0	0	5	1	0	0
Bicycle	1	0	0	0	0	2	12	0	3
Traffic light	0	0	0	0	0	0	0	151	6
Background	27	139	14	6	1	8	13	77	5

Figure 1.c: Inference from the model with 80% split.

of each. Compared with the original YOLOv5s model which has 35.8% mAP50 and 70.42FPS using data from the 70% validation set, the proposed model has mAP50 of 43.0% and

putting more data into the train set than the validation can improve the detection accuracy.

3.2. Evaluation with Test Data

Fig 1.a to Fig 1.c show the confusion matrixes generated for all models to evaluate the detection results obtained with the visual evaluation from the test images. With the detection results from the confusion matrix of the original model, as shown in Fig. 1.a, it has not been able to detect many objects on the

3.3. Discussion

Considering all the results obtained from both procedures performed on the validation and test sets, both proposed models have improved the accuracy and speed of object detection in AD. Those aspects identified that improved the detection can be clearly stated as follows.

- Choosing a significantly larger number of images for the training set than for the validation set.
- Eliminating class imbalance problems in the dataset.
- Minimizing instance imbalance problems of the dataset.
- Adding background images to the training and validation sets at a rate of 1% to 10%.
- Picking an epoch value that will not lead the model to overfit.

4. CONCLUSION

Object detection is a vital part of AD systems. This research finds and verifies aspects that affect the object detection performance by managing limited resources using YOLOv5s one-stage algorithm and boosting the accuracy and speed of object detection for AD without altering the model architecture. With the results from the validation set, compared to the original YOLOv5s model, the mAP50 and inference speed of the model of 80% split are increased by 9.1% and

road. This is clearly seen in the bottom row of its confusion matrix, which represents the detection as background, i.e. no detection. Considering the confusion matrices of the proposed models, most of the matrix values in both models are on the diagonal of the matrix representing the correct detection.

6.57%, respectively, while the model of 70% split is increased by 7.2% and 6.75%. This proves the viability of the factors explored in this work for enhancing object detection for AD.

REFERENCES

- Ahmad, M., Abdullah, M., & Han, D. (2020). Small object detection in aerial imagery using RetinaNet with anchor optimization. *2020 International Conference on Electronics, Information, and Communication (ICEIC)*.
- Berkeley DeepDrive (n.d.). *University of California, Berkeley*. Retrieved from <https://bdd-data.berkeley.edu/> (Accessed: August 20, 2022)
- Cai, Y., Luan, T., Gao, H., Wang, H., Chen, L., Li, Y., Li, Z. (2021). Yolov4-5D: An effective and efficient object detector for autonomous driving. *IEEE Transactions on Instrumentation and Measurement*, 70, 1–13.
- Carranza-García, M., Lara-Benítez, P., García-Gutiérrez, J., & Riquelme, J. (04 2021). Enhancing Object Detection for Autonomous Driving by Optimizing Anchor Generation and Addressing Class Imbalance. *Neurocomputing*, 449. doi:10.1016/j.neucom.2021.04.001
- Dong, E., Zhu, Y., Ji, Y., & Du, S. (2018, August). An improved convolution neural network for object detection using YOLOv2. In *2018 IEEE International Conference on Mechatronics and Automation (ICMA)* (pp. 1184-1188). IEEE.
- Huang, T., Cheng, M., Yang, Y., Lv, X., & Xu, J. (2022). Tiny object detection based on Yolov5. *2022 The 5th International Conference on Image and Graphics Processing (ICIGP)*(pp. 45-50).
- Jocher, G., Chaurasia, A., Stoken, A.,

- Borovec, J., NanoCode012, Kwon, Y., ...
Jain, M. (2022). ultralytics/yolov5: v7.0 -
YOLOv5 SOTA Realtime Instance
Segmentation (Version v7.0). *Zenodo*.
doi:10.5281/zenodo.7347926.
- Liu, W., Anguelov, D., Erhan, D., Szegedy,
C., Reed, S., Fu, C. Y., & Berg, A. C.
(2016). Ssd: Single shot multibox detector.
In *Computer Vision–ECCV 2016: 14th
European Conference, Amsterdam, The
Netherlands, October 11–14, 2016,
Proceedings, Part I 14* (pp. 21-37). Springer
International Publishing.
- Xiao, Y., Wang, X., Zhang, P., Meng, F., &
Shao, F. (2020). Object Detection Based on
Faster R-CNN Algorithm with Skip Pooling
and Fusion of Contextual Information.
Sensors, 20(19), 5490.
doi:10.3390/s20195490.



Enhancing Prediction of Heart Failure Using Feature Selection Techniques

Vijayakanthan Ganesalingam¹, Alagiah Suthakaran², Vaishali Ravi³
Department of Physical Science, Faculty of Applied Science, University of Vavuniya^{1,3}

g.vijayakanthan@vau.ac.lk¹
rvaishali@vau.ac.lk³

Department of Computer Science, Faculty of Applied Science, Trincomalee Campus, Eastern University of Sri Lanka²

suthakarana@esn.ac.lk²

ABSTRACT

One of the leading causes of death and morbidity among the global population is cardiovascular disease. The prediction of cardiovascular disease is the most crucial topic among the topics in the area of clinical data analysis. The healthcare sector generates a tremendous amount of data. A vast amount of unstructured healthcare data are transformed through data mining into knowledge that may be used to make predictions and educated decisions. There are some researchers that have already used data mining techniques to predict cardiac disease. The goal of this study is to find important characteristics and data mining methods that can increase the precision of cardiovascular disease prediction. In this research, we attempted to select the features by using feature selection methods such as forward selection and backward selection. Subsequently, the features were utilized to analyze the performance by using the classification algorithms: Logistic Regression (LR), Decision Tree (DT), Logistic Regression SVM (LR-SVM), and Naive Bayes (NB). Finally, this paper produces a comparison model that was built to analyze the classification performances with feature selection and without feature selection methods.

KEYWORDS: Classification, Data mining, Feature selection, Heart disease

1. INTRODUCTION

The heart is a vital organ in the human body that pumps blood throughout the body to maintain blood circulation. Its health must be protected for a healthy lifestyle in today's demanding world. Numerous things can have an impact on a human heart on a daily basis. Our survival depends on the healthy operation of the heart because it is such a vital organ to our bodies. The illness known as heart disease impairs the ability of heart to beat. The chance of developing heart disease is raised by a number of variables. The experiences of a person's life and their personal and professional habits play a significant role in determining the health of their heart. Due to a variety of hereditary variables, a

particular form of heart disease may also be handed down across generations.

The World Health Organization claims that, various forms of heart disease, generally known as cardiovascular disease, cause more than 12 million deaths annually. By 2030, this number will rise to over 23.6 million (Dangare & Apte, 2012) Depending on the pains, the symptoms of the heart disease can be varied significantly. For a typical person, recognizing some signs can be challenging. The most typical symptoms, though, are chest pain, shortness of breath, and heart palpitations. The heart's inability to pump blood after a heart attack might result in heart failure as well.

2. LITERATURE REVIEW

The leading three data mining techniques were used by (Amin, Chiam & Varathan, 2019) to propose a prediction model with an experiment on the UCI Cleveland dataset to identify the significant features, and their features were assessed on the UCI Statlogth dataset. By combining the methods of Vote, Naive Bayes, and Support Vector Machine, they have chosen nine important features for the classification. Finally, the precision of the proposed model was compared to the precision of the models proposed in previous studies.

(Pratiksha & Aswale, 2021) used the UCI heart disease dataset to predict heart disease using three different classification techniques: Decision Tree, Neural Network, and Naive Bayes. In their comparative research, the Decision Tree performed better, with an accuracy of 98.54% using the UCI dataset. They also attempted to assess Naive Bayes' accuracy by excluding specific qualities, but the findings were not significantly different because the Naive Bayes algorithm was unaffected by the remaining attributes.

An automated classifier for separating high-risk patients from low-risk patients was introduced by (Melillo et al., 2013). The classification and regression tree (CART) performed better than the other methods in their study, with a sensitivity of 93.3% and a specificity of 63.5%. There were only 12 low-risk patients and 34 high-risk patients studied. The efficacy of their proposed method must be tested on a larger dataset.

In order to conduct their research, (Alizadehsani et al., 2013) used 303 cases from the Rajaie Cardiovascular Medical and Research Centre. They employed an ensemble-based learning technique. The conventional C45 ensemble learning method was employed by the authors to forecast cardiovascular illness. They had 68.96% accuracy in diagnosing stenosis in the Right Coronary Artery (RCA), 61.46% accuracy in the Left Circumflex Artery (LCX), and 79.54% accuracy in the Left Anterior Descending Artery (LAD).

In (Takci, 2018) the authors utilized four feature selection approaches and twelve machine learning classifiers from different categories to predict cardiac attacks. The ROC analysis findings, processing time, and model accuracy were all taken into consideration when assessing the models. Without feature selection, the highest accuracy value was 82.59%, and with feature selection, it rose to 84.81%. Using naive Bayes and linear SVM, the model accuracy was 84.81%. The authors (Ishaq et al., 2021) discovered significant features and effective data mining techniques that can increase the precision of cardiovascular patient survival prediction by combining nine classification models with feature selection. A thorough analysis of the literature showed that existing methods accurately predicted heart failure on a variety of datasets. Various optimization techniques, however, have been used to improve metrics such as accuracy, precision, and recall. The primary goal of this study is to compare various machine learning methods and select the one that will be most accurate in predicting cardiovascular disease survival.

3. MATERIALS AND METHODS

The proposed study aims to improve classification accuracy by reducing the number of features in a cardiac disease dataset. Preprocessing and feature selection procedures were used once the dataset has been verified. The following methods are employed to analyze the data: Logistic Regression, Decision Tree, Logistic Regression SVM, and Naive Bayes. Following the application of algorithms and techniques, we compared the findings and discussed the implications. The framework for classifying heart diseases is shown in Fig. 1. The proposed framework's key elements include data collection, data preprocessing, feature selection, data splitting, classifier-based model training, and model evaluation. The suggested framework is further explained in the ensuing subsections.

3.1 Data Collection

In this study, we have collected Cleveland heart disease datasets from the UCI (University of California, Irvine) repository (Ayon, Islam & Hossain, 2020). When this dataset was created, there were 303 instances and 75 features. This dataset contains 14 features, including biographic, clinical, habitual, and output features, which were used in the earlier studies (Takci, 2018) (Aggrawal & Pal, 2020) There are two types (diseased: 1, alive: 0) of output feature labels.

3.2 Feature Selection

The selection of features is a process of a subset of original features so that the feature space is optimally reduced according to some evaluation criterion. Here, we employed feature selection

methods including forward selection and backward selection to analyze their effects on a few common datasets. The number of input feature sets that are evaluated during the Forward and Backward procedure varies and depends on the initialization of the input feature set, the stopping criteria, and the type of problem being solved. However, there is no guarantee that this selection approach will always identify the global optimal input set.

4. EXPERIMENTAL SETUP AND RESULTS

This section evaluates our feature selection strategy and compares it to the best results in the literature. We mainly focused on the Cleveland heart disease datasets from the repository for machine learning at UCI in comparing the various classification techniques such as Logistic Regression, Decision Tree, Logistic Regression SVM, and Naive Bayes. All experiments were carried out in a Python environment using various libraries on a 2 GB NVIDIA GeForce MX330 graphical processing unit on an Intel(R) Core(TM) i7 2.80GHz computer with 8

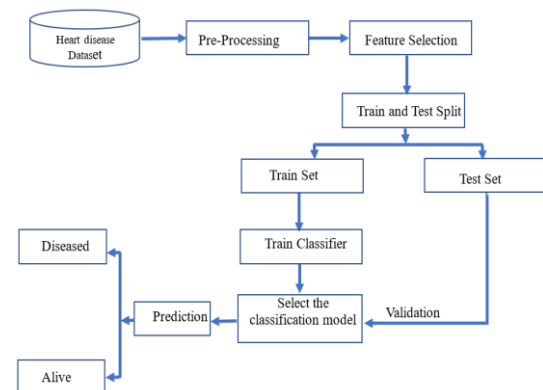


Figure 1: Proposed framework

GB DDR4 Random Access Memory (RAM).

The UCI dataset was broken up into three sets, each of which contained training and testing data from all classes. The training (80%) and testing (20%) are performed respectively. The training phase of the classification algorithm was validated using a 5-fold cross-validation method.

Two feature selection techniques were shown. The best feature in the training set is chosen by the machine learning classifiers using one technique called forward selection. The experimental setup of this method involved choosing features one by one from each training set in order to build the best classifier model for a given class using machine learning classifiers. The second method is backward selection.

Table 1: Classification accuracy with full feature set

Classifier	Precision	Recall	F-Score
DT	0.81	0.83	0.82
LR	0.82	0.91	0.86
LR-SVM	0.87	0.86	0.86
NB	0.80	0.86	0.82

The experimental setup of this method was such that we deleted features one by one from each training set and constructed the best classifier model for a particular class with the machine learning classifiers. Using learning techniques, we evaluated the classification accuracy of datasets that had all available features. Then we reorganized the datasets using selected (reduced) features by each method and evaluated each method by the same process.

4.1 Classification Performance

We calculated the performance metrics of full-featured datasets by the

standard machine learning models. Table 2 shows our results. A comparative analysis of supervised machine learning classifiers has been performed on full-featured datasets. Some classifiers performed well on evaluation metrics, while others performed poorly. This study used tree-based, regression-based, and statistical-based models to predict heart failure survival. One of the ensemble models based on trees is the decision tree.

Table 2: Number of selected features by feature selection methods

Classifier	Forward selection	Backward selection	Full Features (13)
DT	0.8525(5)	0.8851(6)	0.8241
LR	0.8362(6)	0.8195(9)	0.8650
LR-SVM	0.8195(6)	0.8196(6)	0.8568
NB	0.7378(4)	0.8362(6)	0.8243

Based on the results in Table 1, the Logistic Regression classifier performed well, with an accuracy of 0.8650, a precision of 0.82, a recall of 0.91, and an F-Score of 0.86. The second-best classifiers were SVM and G-NB, which had an accuracy of 0.8568 and an F-Score of 0.86.

4.2 Number of selected features

We considered the number of features obtained from feature reduction using feature selection methods. Reducing the number of features in a dataset is important because it reduces complexity and learning time. Table 2 compares accuracy for selected and full feature set. All techniques worked well to decrease the number of characteristics, as is evident.

5. CONCLUSION

Medical diagnostic methods are generally effective at forecasting heart

failure. In addition to that, computer-aided technologies help medical professionals to predict heart failure more efficiently and accurately. To enhance the performance of heart failure prediction using computers, this research compared models developed by four classifiers from three various categories and two feature selection techniques that were used to predict heart failure.

Moreover, experiments with and without feature selection were carried out to evaluate the impact of feature selection in a classification. From the experiment, it is visible that Decision Tree and Naïve Bayes achieved better accuracy with feature selection method while regression models performed better for full features. Comparatively, Decision tree produced a better model with an accuracy of 88.51%. It was therefore shown that feature selection in heart failure prediction studies has a significant impact when it comes to the appropriate combinations.

REFERENCES

- Aggrawal, R., & Pal, S. (2020). Sequential Feature Selection and Machine Learning Algorithm-Based Patient's Death Events Prediction and Diagnosis in Heart Disease. *SN Computer Science*, 344. doi:10.1007/s42979-020-00370-1
- Alizadehsani, R., Habibi, J., Alizadeh Sani, Z., Mashayekhi, H., Boghrati, R., Ghandeharioun, A., Khozeimeh, F., & Alizadeh-Sani, F. (2013). Diagnosing Coronary Artery Disease via Data Mining Algorithms by Considering Laboratory and Echocardiography Features. *Research in cardiovascular medicine*, 2(3), 133–139. doi: 10.5812/cardiovasmed.10888
- Amin, M. S., Chiam, Y. K., & Varathan, K. D. (2019). Identification of significant features and data mining techniques in predicting heart disease. *Telematics and Informatics*, 36, 82–93. doi:10.1016/j.tele.2018.11.007
- Ayon, S., Islam, & Hossain, R. (2020). Coronary Artery Heart Disease Prediction: A Comparative Study of Computational Intelligence Techniques. *IETE Journal of Research*, 68, 2488–2507. doi:10.1080/03772063.2020.1713916
- Dangare, C., & Apte, S. (2012). A data mining approach for prediction of heart disease using neural networks. *International Journal of Computer Engineering and Technology (IJ CET)*, Volume 3. Retrieved from <https://ssrn.com/abstract=2175569>
- Ishaq, A., Sadiq, S., Umer, M., Ullah, S., Mirjalili, S., Rupapara, V., & Nappi, M. (2021). Improving the Prediction of Heart Failure Patients' Survival Using SMOTE and Effective Data Mining Techniques. *IEEE Access: Practical Innovations, Open Solutions*, 9, 39707–39716. doi:10.1109/ACCESS.2021.3064084.
- Melillo, P., De Luca, N., Bracale, M., & Pecchia, L. (2013). Classification tree for risk assessment in patients suffering from congestive heart failure via long-term heart rate variability. *IEEE journal of biomedical and health informatics*, 17(3), 727–733. doi:10.1109/jbhi.2013.2244902
- Pratiksha Shetgaonkar , Dr. Shailendra Aswale. (2021). Heart Disease Prediction using Data Mining Techniques. *International Journal of Engineering Research & Technology (IJERT)*, Volume 10, doi : 10.17577/IJERTV10IS020083
- Takci, H. (2018). Improvement of heart attack prediction by the feature selection methods. *Turkish Journal of Electrical Engineering and Computer Sciences*, 26(1). doi: 10.3906/elk-1611-235



Enhancing User Experience in Virtual Tours: A Systematic Literature Review

Aluthge ADTA¹, Chathura Rajapakse²

Department of Industrial Management, Faculty of Science, University of Kelaniya, Sri Lanka^{1, 2}

aluthgethilina@gmail.com¹

chathura@kln.ac.lk²

ABSTRACT

Virtual tours are simulations of real-world environments. Users can go through and learn about the environment without physically visiting it. These virtual tours are commonly used in the tourism industry to provide tourists with information about a location before visiting it. Nowadays, most virtual tours are developed based on 360 panoramic images. However, there is a huge user experience gap between real and virtual visits to a location. One of the main issues with 360 panoramic tours is limited navigation. Users have to be satisfied with the images that they provide. Users cannot communicate with other visitors. The user is always alone inside the virtual environment. Similarly, there are few user experience gaps between existing virtual tours. This paper presents a constructive review of the literature with the goal of identifying factors that influence the user experience of virtual tour systems. In order to identify pertinent publications on the subject for the review presented in this paper, a set of keyword-based search strings was used on Google Scholar and other research publication websites. Interaction, navigation, guidance, and realism were identified as the main key factors in the review. The paper finally presents detailed insights about the above factors, and it would be helpful to virtual tour developers to enhance their system's user experience.

KEYWORDS: Virtual Tour, Virtual Events, Virtual Environments, 3D, Game Technology, User Experience, VR

1. INTRODUCTION

A virtual tour is a recreation of a real place and is typically made out of a series of videos or still photos (Thobias, & P4Panorama, n.d.). Nowadays, virtual tours are used in different industries. Among them are tourism, education, hotels, and hospitality. In the tourism industry, there are a lot of virtual tours that help increase the popularity of a given place.

However, these virtual tours have very limited interaction. Users can only view the scene from a static location. Users cannot navigate due to the 2D implementation of the virtual tour. Therefore, the lack of navigation

experience affects the overall user experience of the virtual tour. Other than navigation, there are many user experience factors that are limited in existing virtual tours.

2. METHODOLOGY

For the literature, publications were reviewed and analyzed in the following procedure: Various academic websites, including Google Scholar, Research Gate, Z-Library, Science Direct, IEEE, and Scopus, were searched and used to gather the literature.

Initially, all papers related to research keywords were downloaded. Considering those papers, snowball sampling was executed, and more papers

were added during this process. Only recent papers were examined and chosen for analysis using keyword searches, index identification, and publication year sorting.

3.LITERATURE REVIEW

Virtual tours are useful to promote destinations, and they directly affect the destination's image (Zhou & Lin, 2012). One of the most important applications of these technologies is cultural heritage (Bastanlar et al., 2008). Still image galleries and video galleries are two of the most common approaches. Video galleries are more effective and include much richer content (Maines & Tang, 2016). However, one of the few solutions that provide a "genuine" tour experience is 360° interactive virtual tours. In comparison to the image and video galleries, the 360° image tour gives a considerably superior experience, allowing viewers to engage with the environment rather than simply seeing it. The virtual environment should be realistic. More realistic means a more realistic experience can be achieved inside the virtual environment. Realism is how realistic the virtual world feels to the user (Ahn et al., 2017). However, the feeling of being in the real world cannot be achieved by only using 360 images. Users can view sites from various angles, but they always do so from a fixed location. (Maines & Tang, 2016). Within the limitations of the interaction, it is important to keep the user immersed during the experience. And that is the main objective (Routhier, 2016).

In a virtual tour, users can experience a 360-degree view of the location. One of the researchers tried to evaluate their virtual tour (Li, Nie, & Ye,

2022). They developed a virtual tour of a museum and received feedback from the users. Using high-quality 360-degree panoramic images, users can easily zoom in and have a look at the content. However, since panoramic images retain their two-dimensional format, they do not permit the spectator to interact with the scene in the same way that a live visit would. Some interviewees complained that the virtual tour didn't allow them to interact with the museum more during their visits. For instance, some respondents expressed the desire to observe the show from various perspectives and focus on more minute elements. This may indicate that people desire a greater level of engagement with the virtual tour.

When it comes to navigation, feedback was very poor, and this significantly impacts the user experience of the virtual tour. Visitors can only navigate through the different views by clicking the arrow button on the tour screen. And that is not enough to have a good navigation experience. There are a lot of things to be improved in navigation in virtual tours (Li et al., 2022).

Another thing that user expects from the virtual tour is guidance. They had good feedback for learning. People said that they had the opportunity to grab more information about the location using this tour. However, some users pointed out that there was not much detailed information about some items and some descriptions were too academic (Li et al., 2022).

Another study explained how they handled the guidance in their virtual world. For that, they developed a 3D character that can navigate through the virtual world using the A* algorithm.

This character can communicate with the user and guide them. They used around 300 questions and 70 answers for this character to communicate with the user (Jan et al., 2009).

In virtual worlds, the sense of being surrounded by people is also an important user experience factor. In the real world, people feel connected to the people around them since they are sharing and enjoying the same experience with them. Crowds in virtual environments can foster a nice mood because this tribal behavior is a major sign of communities. Informants said that crowds provided them with social and enjoyment opportunities (Wreford, Williams, & Ferdinand, 2019).

Another main factor that affects the user's experience of the virtual environment is sound. Researchers have identified that there is a difference between real-world sounds and virtual reality sounds. They were saying that, could be a limitation of the recording device or the user's headphones, or a combination of these two (Wreford et al., 2019). Audio is just as significant as video (Martins et al., 2017).

A research group tried to enhance the navigation experience by creating a 3D environment. They developed a floor of a building at a university using 3D models and the Unity game engine. Since this is a 3D experience, users can freely navigate by walking. And the feedback was also good for navigation (Maines & Tang, 2016). They had to model 3D objects on the floor (desks, chairs, doors, walls, etc.) manually. Using Autodesk 3Ds Max to model the 3D components and Adobe Photoshop to produce the textures is how they have decided to approach this project. They developed

the tour with two navigation methods. Manual navigation using keyboard and mouse and automatic navigation in automatic navigation, the camera automatically moves each location in the environment. They used 1st person camera view for their method. When it comes to virtual worlds, 1st person camera can give a more immersive experience than 3rd person camera (Shafer, Carbonara, & Korpi2019).

Another 3D design of a university was made in 2016 using SketchUp computer software (Moloo et al., 2016). They modeled the buildings, trees, cars, and paths. Since this is a 3D tour, users can freely navigate using the keyboard and look at whatever they want in the environment. All the 3D models were manually modeled and textured. Therefore, the natural look of the environment was poor.

The Zamani Project spatially documented the ancient city of Polonnaruwa in 2019. Structures documented include Gal Vihara, Kiri Vihara, Lankatilaka Vihara, and the 11 structures of the Quadrangle: The Vatadage, Hatadage, Atadage, Recumbent House, Chapter House, Gal Pota, Satmahal Prasada, Bodhisattva Shrine, Latha Mandapaya, Bodhi Tree Shrine, and Thuparama Gedige They used high-quality real images to develop the 3D models. The end result was absolutely perfect. All the 3D models were of very good quality and looked like real ones (The ZAMANI Team, n.d.). Other than that, they have created Medirigiriya Vatadage using more than 20,000 images. They used "Reality Capture" software to extract the 3D model from images (Zamani & Capturing Reality, 2020).

4. RESULTS AND DISCUSSION

The literature review identified several key gaps in the user experience of virtual tours, including issues with realism, interactivity, navigation, and user engagement. Specifically, many virtual tours rely on 360-degree panoramic images, which can lack the realism and navigation needed to fully engage users. Additionally, there is often a lack of user engagement in virtual tours, as users are limited in their ability to interact with the environment and with other users.

The present study draws attention to the shortcomings of 360-degree image-based tours in terms of improving the user experience, particularly with regard to navigation. The study offers the creation of 3D environments as a superior solution for a better user experience to address this. It is difficult to create 3D environments for real-world locations, though. However, the study suggests making use of the cutting-edge "Reality Capture" technology, which makes it possible to recreate real-world locations in 3D. With this strategy, virtual tours should become more realistic and immersive.

Guidance is one of the key elements that affect the user experience in virtual tours, and it can be enhanced by offering accurate and pertinent information throughout the tour. All users should be able to understand the information presented; it should be delivered in an easy-to-understand manner, and it shouldn't cause any distraction to the participants.

A chat system can be incorporated into virtual tours to further improve the guidance component. Such systems can

promote interaction and information sharing by facilitating participant discussion, which enhances the user experience. The use of a chat system closely resembles the interactive component of a real-world visit and can greatly enhance virtual tours' overall success.

The sense of people in virtual tours has a significant impact on the user experience. Given that all existing tours are based on a single client, it is beneficial to develop tours where multiple users can join. In video games, non-player characters (NPCs) are used to bring the feeling of life to the game. Similarly, this method can be employed to enhance the sense of people inside the tour, thus augmenting the overall user experience.

Sounds also play a crucial role in enhancing the user experience of virtual tours. It should be given equal importance to visuals during the tour's development. Sound can be used to create a realistic environment that helps to immerse the user in the tour. Properly placed sound effects and background music can make the tour more engaging and enjoyable. Therefore, it is essential to consider sound as an integral part of virtual tour development.

5. CONCLUSION

Overall, this literature review emphasizes the importance of taking user experience into account when creating and implementing virtual tours. Developers and designers can produce efficient and interesting virtual tours that better mimic actual environments by addressing the user experience gaps found in this review. The suggestions made in this review can be used as a

manual for enhancing users' virtual tour experiences and making them more convenient and enjoyable.

REFERENCES

- Ahn, J., Choi, S., Lee, M., & Kim, K. (2017). Investigating key user experience factors for virtual reality interactions. *Journal of the Ergonomics Society of Korea*, 36(4), 267-280.
- Bastanlar, Y., Grammalidis, N., Zabulis, X., Yilmaz, E., Yardimci, Y., & Triantafyllidis, G. (2008). 3D reconstruction for a cultural heritage virtual tour system. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, 37-B5, 1023-1036.
- Jan, D., Roque, A., Leuski, A., Morie, J., & Traum, D. (2009). A virtual tour guide for virtual worlds. In *Intelligent Virtual Agents: 9th International Conference, IVA 2009 Amsterdam, The Netherlands, September 14-16, 2009 Proceedings 9* (pp. 372-378). Springer Berlin Heidelberg.
- Li, J., Nie, J. W., & Ye, J. (2022). Evaluation of virtual tour in an online museum: Exhibition of Architecture of the Forbidden City. *PloS one*, 17(1), e0261607.
- Maines, C.L., & Tang, S. (2015). An Application of Game Technology to Virtual University Campus Tour and Interior Navigation. *2015 International Conference on Developments of E-Systems Engineering (DeSE)*, 341-346.
- Martins, J., Gonçalves, R., Branco, F., Barbosa, L., Melo, M., & Bessa, M. (2017). A multisensory virtual experience model for thematic tourism: A Port wine tourism application proposal. *Journal of destination marketing & management*, 6(2), 103-109.
- Moloo, R. K., Pudaruth, S., Ramodhin, M., & Rozbully, R. B. (2016, March). A 3D Virtual Tour of the University of Mauritius using WebGL. In *2016 International Conference on Electrical, Electronics, and Optimization Techniques (ICEEOT)* (pp. 2891-2894). IEEE.
- Routhier, P. (2016, October). Virtually perfect: Factors affecting the quality of a VR experience and the need for a VR content quality standard. In *SMPTE 2016 Annual Technical Conference and Exhibition* (pp. 1-20). SMPTE.
- Shafer, D. M., Carbonara, C. P., & Korpi, M. F. (2019). Factors affecting enjoyment of virtual reality games: a comparison involving consumer-grade virtual reality technology. *Games for health journal*, 8(1), 15-23.
- The ZAMANI Team. (n.d.). *The monuments of an ancient monumental garden-city polonnaruwa, Sri Lanka*. Zamaniproject. <https://www.zamaniproject.org/site-sri-lanka-Polonnaruwa.html>
- Thobias, L. & P4Panorama. (n.d.). *Galle, Sri Lanka 360 Virtual Tour*. P4panorama. <https://p4panorama.com/gallery-item/galle-sri-lanka>
- Wreford, O., Williams, N. L., & Ferdinand, N. (2019). Together alone: An exploration of the virtual event experience. *Event Management*, 23(4-5), 721-732.
- Zamani & Capturing Reality. (2020, March 12). *CRhub: Sri Lanka's monuments preserved in 3D by Zamani* [Video]. YouTube. <https://www.youtube.com/watch?v=EPhU4qRuZE8>
- Zhou, L., & Lin, Q. (2012, November). Virtual tour's impact on destination image. In *2012 International Symposium on Management of Technology (ISMOT)* (pp. 641-643). IEEE.



Factors Influencing Behavioral Intention Towards Green Computing Practices: A Systematic Literature Review

Halgahagama SS¹, Kavirathna CA²

Department of Industrial Management, Faculty of Science, University of Kelaniya, Sri Lanka^{1, 2}

halgahag_im17028@stu.kln.ac.lk¹

chathumi@kln.ac.lk²

ABSTRACT

The environmentally responsible and eco-friendly use of computers and their resources is known as green computing. The main aim of green computing is to reduce the carbon footprint generated by the Information Technology and Systems related business and industries. Different types of practices in both organizational and individual level have been paired with the concept of go with green computing. Behavioral intention towards green computing has been identified as a main factor when adopting green computing practices at the individual or organizational level. This study aims to investigate previous studies on behavioral intentions towards green computing and theories related to them. Among the studies on the green computing perspective, very few have focused on conducting a systematic literature review on behavioral intention towards a green computing practices standpoint. Therefore, this study contributes to the theory by fulfilling that knowledge gap.

KEYWORDS: green computing, green Information Technology, behavioral intention, green Information and Communication Technology, green Information Systems

1. INTRODUCTION

The Information and Communication Technology sector consumes 6% of global electricity consumption, which includes the electricity consumption of various network devices, computers and their peripherals, data centers, and so on. Even electricity generation, computers, peripherals, network devices, and data centers emit a significant amount of greenhouse gases, such as CO₂, into our environment. ICT accounts for nearly 2% of global CO₂ emissions (Sen & Chowdhury, 2016).

Green computing is the practice of making better use of computing resources while maintaining or improving overall performance. To meet sustainability requirements, sustainable IT services must incorporate green computing practices such as power management, virtualization, improved cooling technology, recycling, electronic waste disposal, and IT infrastructure

optimization (Harmon & Auseklis, 2009). Cloud computing and green data Centre have become effective green computing practices among organizations (Salama, 2012). Along with those organizational practices, individual green computing practices such as turning off the monitor when it's not in use, adjusting the brightness, previewing before printing, avoiding using a screen server, and energy-efficient device usage also can be identified.

There are very few studies that have been conducted in Sri Lanka on green computing practices, and even fewer studies have been conducted in the area of behavioral intention toward green computing practices. Hence, it's necessary to review the factors that affect behavioral intention toward green computing practices.

With this consideration, this paper mainly aims to understand the factors that affect behavioral intention toward

green computing practices.

2. METHODOLOGY

The systematic literature review focused on identifying the current work that has been performed on green computing, green computing practices, factors affecting behavioral intention toward green computing practices, and theories related to those studies. The method utilized in this systematic literature review was content analysis to compile the most recent findings in chosen areas of green computing and behavioral intention towards green computing. The initial phase of this analysis was to look for papers related to the topic. The authors employed databases such as Emerald Insight, Semantic Scholar, Science Direct, and Google Scholar to find relevant information. Keywords such as "Green computing," "Green IT," "Green ICT," "Behavioral intention toward green computing," and others were included in the search criteria. This search method was required since independent studies on behavioral intention and green computing appeared in various publications across several fields. Papers on Green IT and Green ICT are also taken into consideration as they are similar to green computing. A total of 33 papers were selected for analysis.

A comprehensive literature review was done to discover the knowledge available in the related fields. The articles selected featured a wide spread of knowledge across multiple industries.

3. FINDINGS AND DISCUSSION

3.1 *Green computing*

Green computing can be traced back to 1992, when the United States Environmental Protection Agency (EPA) started the Energy Star program with the goal of reducing the energy consumption of computing products. Simultaneously, the Swedish group, the Swedish

Confederation of Professional Employees(TCO), launched the TCO Certification effort to reduce toxic emissions from computer materials and encourage the implementation of ecologically sustainable computing (Ahmed, 2018). Factors driving green computing can be recognized as the rapid growth of the internet, increasing equipment power density, increasing energy costs, restrictions on energy supply and access, and growing awareness of the impact of IT on the environment (Harmon & Auseklis, 2009).

Four key domains of green computing can be identified as green design, green manufacturing, green use, and green disposal (Ahmed, 2018). Green Use can be described as reducing the power consumption of computers, information systems, and their peripheral subsystems in an environmentally friendly manner. Green disposal is about refurbishing and repurposing existing obsolete computers and electronic equipment. IT providers employ their "take back" policy to recycle unwanted, used computers and other electronic debris in order to take responsibility for the entire lifecycle of the items they generate (Pazowski, 2015). Green design is about designing various components, such as computers, servers, and cooling equipment, to be energy efficient and environmentally friendly. Manufacturing various electronic components, computers, and associated subsystems in such a way that the environmental impact is zero or minimal is called green manufacturing (Sen & Chowdhury, 2016).

3.2 *Green computing practices*

Green computing practices can be divided into two sections: organizational-level green computing practices and individual-level green computing practices. Virtual technologies, Cloud

computing, Computer Waste management, and Data center reconfiguration can be considered some of the organizational-level green computing practices. Virtualization has emerged as a significant technique for meeting the expanding computing needs of businesses. Virtualization is primarily concerned with IT optimization in terms of energy efficiency and cost savings. It maximizes the use of current IT resources while lowering energy use, capital expenditure, and human resource expenses (Harmon & Auseklis, 2009). Data centers produce the most GHG emissions, and if measures to reduce emissions are not taken, emissions will continue to rise. Reconfiguring data centers with green computing practices such as Sharing architectures, Server Consolidation, Multicore processors, and Efficient Software and Algorithms can achieve energy efficiency compared to traditional data centers (Ahangama & Gunawardana, 2012). Cloud computing is a high-performance computing model that is accessible over the internet and can be further subdivided into services such as utility computing as a service (SaaS), platform as a service (PaaS), and infrastructure as a service (IaaS). Cloud Computing is able to reduce the excessive or redundant use of modern computers through sharing the same resources (Su, Chen & Widjaja, 2012).

Turning off the monitor when it's not in use, adjusting the brightness, previewing before printing, avoiding the use of a screen server, and energy-efficient device usage can be considered as some individual-level green computing practices. According to an analysis, usage of a desktop computer takes approximately 100 watts for 5 hours, but a laptop only consumes about 60 watts. And in sleep mode, a desktop computer consumes about 35 watts for 3 hours, while a laptop only consumes 16 watts (Sen & Chowdhury, 2016). The use

of PC power management techniques can be considered another green computing practice. PC power management techniques can be called a set of actions and mechanisms for controlling the power use of personal computer hardware, mainly turning off the power or switching the system to the low-power state when inactive (Pazowski, 2015). Power down the CPU and all peripherals during extended periods of inactivity, try to do computer-related tasks during contiguous, intensive blocks of time, leaving hardware off at other times, and power up and power down energy-intensive peripherals such as laser printers according to need can be considered as more ways that each individual can contribute towards a sustainable earth by the responsible use of computers and related applications (Agarwal & Nath, 2011).

3.3 Behavioral intention toward green computing practices

Taking behavioral intention into consideration, most researchers have tried to find answers at the organizational level, firm level, or industry level. Lack of business leadership on green IT, the extent of IT sophistication in the organization, and inadequate skills and training can be considered organizational factors that affect behavioral intention towards green IT.

Most earlier studies have taken well-established theories to analyze the relationship between factors and behavioral intention toward green computing practices. A study on the IT industry in South Africa has shown that attitudes towards green computing, media influence, and perceived behavioral control have a direct positive effect on green computing intentions (Du Buisson & Naidoo, 2014). An investigation on the Malaysian manufacturing industry has found that awareness of consequences and accepting responsibility should be

primarily considered by organizations when adopting Green Information Technology (Asadi et al., 2019). So it has been said that manufacturing organizations should direct and support their decision-makers, as well as consider strategies to increase their awareness of environmental issues and attract their moral obligation to perform in a sustainable and ecological manner. And it shows that the awareness of consequences and the ascription of responsibility by the managers are the crucial factors that should be considered by organizations (Asadi et al., 2019). Similar to the manufacturing industry, an earlier study shows that IT individuals with more awareness of the environmental effect of IT usage intend to adopt GIT more often (Mishra, Akman & Alok, 2014).

3.4 Theoretical Models

According to Ajzen (1991), the Theory of Planned Behavior (TPB) evolved from the Theory of Reasoned Action (TRA), which states that actions are entirely under volitional control and that individual behavior is the result of the intent to do a behavior. The norm activation model (NAM) (Schwartz, 1977) has been widely used to predict altruistic and prosocial behavior in people (De Groot & Steg, 2009). Davis's Technology Acceptance Model (TAM) is one of the most widely used models for understanding and predicting the process of user acceptance or adoption of information technologies (Akman & Mishra, 2015).

4. CONCLUSION

Based on the number of published studies identified in this review, green computing as a research area has evolved relatively in the last decade. However, studies are likely to increase as all human endeavors pay more attention to environmental sustainability and energy-saving practices. Many researchers have

focused on the notion of green computing, related practices, drivers, and obstacles in green computing. However, there has been little research in the domain of behavioral intention toward green computing.

The analysis revealed that most studies on behavioral intentions toward green computing have relied on established theories. Some researchers have chosen to combine multiple theories to gain a better understanding of the elements that influence behavioral intention toward green computing. This study also has its own limitations. This literature review has mainly focused on the area of behavioral intention toward green computing. More reviews should be done to find the theories and factors related to green computing adoption.

REFERENCES

- Agarwal, S., & Nath, A. (2011). Green Computing - A New Horizon of Energy Efficiency and Electronic Waste Minimization: A Global Perspective. *2011 International Conference on Communication Systems and Network Technology, Katra, India, CSNT 2011*, 688-693. doi:10.1109/CSNT.2011.148
- Ahangama, N., & Gunawardana, K. D. (2012). An Empirical Investigation into the Extent of Green It Practices in Sri Lanka's Data Centers – A Case Study Approach. *SSRN Electronic Journal*. doi:10.2139/ssrn.2171519
- Ahmed, A. I. (2018). Understanding the factors affecting the adoption of green computing in the Gulf universities. *International Journal of Advanced Computer Science and Applications (ijacsa)*, 9(3), 304–311. doi:10.14569/IJACSA.2018.090342
- Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, 50(2), 179–211. doi:10.1016/0749-5978(91)90020-T
- Akman, I., & Mishra, A. (2015). Sector diversity in Green Information Technology practices: Technology Acceptance Model perspective. *Computers in Human Behavior*,

FACTORS INFLUENCING BEHAVIORAL INTENTION TOWARDS GREEN COMPUTING
PRACTICES: A SYSTEMATIC LITERATURE REVIEW

- 49, 477–486. doi:10.1016/j.chb.2015.03.009
- Asadi, S., Nilashi, M., Safaei, M., Abdullah, R., Saeed, F., Yadegaridehkordi, E., & Samad, S. (2019). Investigating factors influencing decision-makers' intention to adopt Green IT in Malaysian manufacturing industry. *Resources, Conservation and Recycling*, 148, 36–54. doi:10.1016/j.resconrec.2019.04.028
- De Groot, J. I. M., & Steg, L. (2009). Morality and Prosocial Behavior: The Role of Awareness, Responsibility, and Norms in the Norm Activation Model. *The Journal of Social Psychology*, 149(4), 425–449. doi:10.3200/SOCP.149.4.425-449
- Du Buisson, W., & Naidoo, R. (2014). Exploring factors influencing it workers' green computing intention at a South African firm. *Proceedings of the Southern African Institute for Computer Scientist and Information Technologists Annual Conference 2014 on SAICSIT 2014 Empowered by Technology*, 148–156. doi:10.1145/2664591.2664609
- Energy-efficient Cloud Computing Application Solutions and Architectures. *Publication Server of the University of Stuttgart (OPUS) University of Stuttgart*. doi:10.18419/OPUS-2989
- Harmon, R. R., & Auseklis, N. (2009). Sustainable it services: Assessing the impact of green computing practices. *PICMET: Portland International Center for Management of Engineering and Technology, Proceedings*, 1707–1717. doi: 10.1109/PICMET.2009.5261969.
- Mishra, D., Akman, I., & Alok, M. (2014). Theory of Reasoned Action application for Green Information Technology acceptance. *Computers in Human Behavior*, 36, 29–40. doi:10.1016/j.chb.2014.03.030
- Pazowski, P. (2015). Green Computing: Latest Practices and Technologies for ICT Sustainability. *Managing Intellectual Capital and Innovation, Proceedings of the MakeLearn and TIIM Joint International Conference*. 1853–1860. Retrieved from <https://ideas.repec.org/h/tkp/mk1p15/1853-1860.html>
- Schwartz, S. H. (1977). Normative influences on altruism. *Advances in Experimental Social Psychology*, 10(C), 221–279. doi:10.1016/S0065-2601(08)60358-5
- Sen, D., & Chowdhury, D. R. (2016). Green Computing: Efficient Practices and Applications. *International Journal of Computer Sciences and Engineerin*, 04 pp. 38-47 (02). doi:10.5281/zenodo.5226613
- Su, B., Chen, J. V., & Widjaja, A. E. (2012). It Leaders Intention in Supporting Green It Initiatives Through the Use of Cloud Computing in Organizations : Integration of Theory of Planned Behavior and Technology Organization-Environment Framework. *Proceeding of 22nd Annual Meeting of International Conference on The Pacific Rim ManagementAt: Rosemead, CA, USA*. Retrieved from <https://www.researchgate.net/publication/300166313>



Forecasting Electricity Demand in Sri Lanka by Using Weather Patterns Through a Machine Learning Approach: Literature Review

Abeywickrama S¹, Asanka PPGD²

Department of Industrial Management, Faculty of Science, University of Kelaniya, Sri Lanka^{1,2}
shaniabeywickrama294@gmail.com¹
dasanka@kln.ac.lk²

ABSTRACT

Sri Lanka's electricity demand will grow day by day. Planning to increase the electricity supply to meet future demand is difficult. Therefore, knowing the future demand for an uninterrupted power supply is essential. Many past studies have considered the correlation between weather factors and electricity demand to predict accurate demand value. Therefore, the objective of this study is to review papers that have been done related to forecasting electricity demand, considering the influence of weather patterns. Collected full articles from various sources such as Science Direct and Research Gate. Searches based on keywords such as electricity demand, weather patterns, forecasting, and machine learning. The review focused on i) different types of electricity demand forecasting approaches, ii) the impact of weather patterns on electricity demand, and iii) the specificity of machine learning approaches for accurate electricity demand forecasting using weather patterns. However, the findings showed that the machine learning algorithms chosen differ among researchers based on different scenarios. Most studies in foreign countries have used at least one weather feature along with electricity demand. It shows ample evidence for clear correlations between weather parameters and electricity demand. But it can be seen in the Sri Lankan context as no special attention has been paid to historical weather data to forecast electricity demand in the context of Sri Lanka.

KEYWORDS: Electricity Demand, Weather Patterns, Forecasting, Machine Learning

1. INTRODUCTION

The Ceylon Electricity Board (CEB) is controlled centrally by a System Control Centre (SCC), the nerve center of operational activities. One of the fundamental prerequisites of operations planning is the forecasts for short-term demand. There is still no comprehensive forecasting mechanism for SCC. Also, region-wise demand forecasting is not currently manipulated by the CEB, although there is such a requirement (Priyadarshana et al., 2021). The world has moved with various methodologies in forecasting techniques such as Multiple Regression (MRA), Exponential Smoothing, Iterative Reviewed Least Squares, Stochastic Time Series, Fuzzy

Logic, Artificial Neural Networks (ANN), and Expert Systems. However, Sri Lanka hasn't used such techniques for predicting electricity consumption. In Sri Lanka, system engineers decide the next day's demand according to the previous electricity consumption data on their experience (Karunathilake & Nagahamulla, 2017). Furthermore, the current long-term electricity demand forecasting studies of the CEB are conducted by considering possible explanatory variables with linear regression. It has also expressed the

importance of developing an AI-based non-linear forecasting approach with explanatory variables, including climate conditions, that will justify and compare the performance of official forecasts (Hapuarachchi, Hemapala & Jayasekara, 2018). Therefore, this study aims to review papers on electricity demand forecasting, considering the impact of weather patterns and why machine learning approaches are best suited for demand forecasting.

2. METHODOLOGY

This section discusses the methodology used to complete this review paper. This section describes more about machine learning approaches used for electricity demand forecasting. In that way, the literature review mainly discussed different types of electricity forecasting approaches and the impact of weather patterns on electricity demand. In the search phase, articles from the Institute of Electrical and Electronics Engineers (IEEE), Science Direct, Google Scholar, and ResearchGate were collected using research keywords. Several keywords were mainly used in the selection of articles. Those are machine learning, electricity, forecasting, energy demand, predicting, and weather patterns. Papers were then reviewed based on three categories. That is, different types of electricity demand forecasting approaches, the impact of weather patterns on electricity demand, and the specificity of the machine learning approach for accurate electricity demand forecasting using weather patterns. Only recent papers were screened during the selection process.

3. LITERATURE REVIEW

3.1 Different Types of Electricity Demand Forecasting Approaches

Many studies have been done on electricity forecasting approaches. Popular forecasting methods for energy supply and demand can be divided into two categories. The first category is statistical or mathematical methods, and the second is modern statistical learning-based methods, also known as machine learning (Vivas, n.d.). Commonly used methods for Medium-term load forecast (monthly, weekly) are the neural network, regression models, support vector machine, and time series models (Shao et al., 2017). The chosen machine learning algorithm and metric evaluation are different among the researchers, and dataset size may influence the accuracy of the model generated has been mentioned (Salleh, Suliman & Jørgensen, 2020).

Table 1 describes the different methods for conducting demand forecasting. Researchers have used other techniques, based on those techniques, they have concluded the best approach. But among them, one researcher compared multiple models and based on that, the multivariate LSTM model was selected as the most suitable model.

Table 1: Machine Learning Algorithm Used

Reference	ML algorithms	Features and Area
(Al-Musaylh, Adamowski, & Li, 2018)	MARS (Multivariate Adaptive Regression Splines), SVR(Support Vector Regression), ARIMA	Electricity Demand Data of Queensland, Australia

FORECASTING ELECTRICITY DEMAND IN SRI LANKA BY USING WEATHER PATTERNS
THROUGH A MACHINE LEARNING APPROACH: LITERATURE REVIEW

	(Autoregressive Integrated Moving Average)	
(Samarawickrama, Hemapala & Jayasekara 2016).	SVMR (Support Vector Machine Regression)	the energy demand of commercial buildings of Sri Lanka
(Panklib, Prakasvudhisa & Khummongkol, 2015)	ANN, Regression	Economic data, electric demand, and climate data recorded for 20 years of Thailand
(Hapuarachchi et al., 2018)	ANN	GDP, Population, GDP per capita, Avg. Annual Temperature, No. of Consumer Accounts, the electricity demand of Sri Lanka
(Sahay, Sahu & Singh, 2016; Houimli, Zmami & Ben-Salha, 2020)	ANN	half-hourly electric load demand, temperature
(Salam & El Hibaoui, 2018)	Random Forest, Linear regression, Decision tree SVM(Support Vector Machine), ANN	historical consumption energy data of Tetouan city, weather data Morocco
(Nichiforov et al., 2017)	(Nonlinear Autoregressive Neural Networks) NAR, ARIMA	Energy consumption data of a small production area of a company
(Goswami & Kandali, 2020)	SARIMA (Seasonal Autoregressive Integrated Moving Average), ARIMA (Autoregressive Integrated	daily electricity load data in Assam Pakistan

	Moving Average)	
(Abbasimehr, Shabani & Yousefi, 2020)	ARIMA, ANN, KNN, RNN (Recurrent Neural Networks), SVM, and single-layer LSTM (Long Short-Term Memory)	demand data of a furniture company, Other correlated factors
(Manowska, 2020)	LSTM	Energy consumption data of Poland
(Liu, Roberts, & Sioshansi 2018)	VAR (Vector Auto Regression)	electricity supply and demand data and weather data of 61 cities around the United States

3.2 The Impact of Weather Patterns on Electricity Demand

Many studies have been conducted internationally on electricity demand, electricity consumption, or electricity load forecasting using the influence of the weather. Such studies have raised the importance of considering the impact of weather patterns on electricity demand data.

The study has proposed an Autoregressive Distributed Lag (ARDL) model incorporating weather patterns to forecast monthly electricity consumption in Sri Lanka. This study has confirmed the importance of awareness of weather impacts on electricity demand (Priyadarshana et al., 2021). This paper has explored the importance of using historical weather data (temperature, humidity) to forecast electricity loading in Sydney and New South Wales, Australia (Dehalwar et al., 2016). The

annual temperature is strongly positively correlated with the electricity demand and Relative Humidity (%) is moderately negatively correlated, while average rainfall is not associated with electricity demand (Hapuarachchi et al., 2018). The study was done to forecast growing electricity demand and analyze weather impacts on electricity demand in Saudi Arabia until 2040, using a weather-based long-term electricity demand forecasting model following a hybrid approach using end-use and econometric methods (Alabbas & Nyangon, 2016). It has been pointed out that a temperature rise causes an increase in electric power consumption in Thailand (Panklib et al., 2015).

A comprehensive analysis on an annual and seasonal basis reveals that meteorological parameters, especially air temperature and dew point temperature, have influenced electricity consumption in Muzaffarabad, Pakistan (Jawad et al., 2020). According to the above studies, a clear relationship can be seen between weather parameters and electricity demand.

3.3 *The specificity of machine learning approaches for accurate electricity demand forecasting using weather patterns*

Many studies on electricity demand forecasting have been conducted internationally using different techniques. Several researchers have shown evidence of machine learning methods' importance in forecasting electricity demand.

The study has shown different time granularities. The results have shown that the electricity demand can be forecasted with high accuracy using machine learning algorithms such as linear

regression, decision trees and publicly available data (Camurdan & Ganiz, 2017). Machine learning models have better forecasting accuracy than traditional forecasting models (Vivas, n.d.). It was concluded that the ANN model is more suitable than conventional time series models for forecasting the monthly electricity demand in Turkey using the effects of seasonal trends (Hamzaçebi & Çakmak, 2019). From the above evidence, it can be concluded that Machine Learning (ML) models often provide more accurate results for demand forecasting than other forecasting models.

4. CONCLUSION

This paper reviews forecasting models for electricity demand from recent years. All researchers intend to ensure that the produced model can predict electricity demand. However, the scope of demand forecasting studies starts from a small building to a country. According to the summarized table, it can be seen that most studies have used at least one weather feature along with electricity demand data. Based on the articles reviewed, ML models provided more accurate predictions than other methods. Since many ML algorithms and tools exist, many researchers implemented training with one or more ML algorithms to see the changes in the model created. Finding the best-fitting model varies with the size of the data set and the time horizon.

REFERENCES

- Abbasimehr, H., Shabani, M., & Yousefi, M. (2020). An optimized model using LSTM network for demand forecasting. *Computers & industrial engineering*, 143, 106435.

- Alabbas, N., & Nyangon, J. (2016, October). Weather-Based Long-Term Electricity Demand Forecasting Model for Saudi Arabia: A Hybrid Approach Using End-Use and Econometric Methods for Comprehensive Demand Analysis. In *34th USAEE/IAEE North American Conference*.
- Al-Musaylh, M. S., Deo, R. C., Adamowski, J. F., & Li, Y. (2018). Short-term electricity demand forecasting with MARS, SVR and ARIMA models using aggregated demand data in Queensland, Australia. *Advanced Engineering Informatics*, 35, 1-16.
- Camurdan, Z., & Ganiz, M.C. (2017). Machine learning based electricity demand forecasting. 2017 International Conference on Computer Science and Engineering (UBMK), 412-417.
- Dehalwar, V., Kalam, A., Kolhe, M. L., & Zayegh, A. (2016, October). Electricity load forecasting for Urban area using weather forecast information. In *2016 IEEE International Conference on Power and Renewable Energy (ICPRE)* (pp. 355-359). IEEE.
- Goswami, K., & Kandali, A. B. (2020, July). Electricity demand prediction using data driven forecasting scheme: ARIMA and SARIMA for real-time load data of Assam. In *2020 International Conference on Computational Performance Evaluation (ComPE)* (pp. 570-574). IEEE.
- Hamzaçebi, C., Es, H. A., & Çakmak, R. (2019). Forecasting of Turkey's monthly electricity demand by seasonal artificial neural network. *Neural Computing and Applications*, 31, 2217-2231.
- Hapuarachchi, D. C., Hemapala, K. T. M. U., & Jayasekara, A. G. B. P. (2018, October). Long term annual electricity demand forecasting in Sri Lanka by artificial neural networks. In *2018 IEEE PES Asia-Pacific Power and Energy Engineering Conference (APPEEC)* (pp. 290-295). IEEE.
- Houimli, R., Zmami, M., & Ben-Salha, O. (2020). Short-term electric load forecasting in Tunisia using artificial neural networks. *Energy Systems*, 11(2), 357-375.
- Jawad, M., Nadeem, M. S. A., Shim, S. O., Khan, I. R., Shaheen, A., Habib, N., ... & Aziz, W. (2020). Machine learning based cost effective electricity load forecasting model using correlated meteorological parameters. *IEEE Access*, 8, 146847-146864.
- Karunathilake, S. L., & Nagahamulla, H. R. (2017, September). Artificial neural networks for daily electricity demand prediction of Sri Lanka. In *2017 Seventeenth International Conference on Advances in ICT for Emerging Regions (ICTer)* (pp. 1-6). IEEE.
- Liu, Y., Roberts, M. C., & Sioshansi, R. (2018). A vector autoregression weather model for electricity supply and demand modeling. *Journal of Modern Power Systems and Clean Energy*, 6(4), 763-776.
- Manowska, A. (2020). Using the LSTM network to forecast the demand for electricity in Poland. *Applied Sciences*, 10(23), 8455.
- Nichiforov, C., Stamatescu, I., Făgărășan, I., & Stamatescu, G. (2017, October). Energy consumption forecasting using ARIMA and neural network models. In *2017 5th International Symposium on Electrical and Electronics Engineering (ISEEE)* (pp. 1-4). IEEE.
- Panklib, K., Prakasvudhisarn, C., & Khummongkol, D. (2015). Electricity consumption forecasting in Thailand using an artificial neural network and multiple linear regression. *Energy Sources, Part B: Economics, Planning, and Policy*, 10(4), 427-434.
- Priyadarshana, A. D. A. D., Lokupitiya, R. S., Kuruppuarachchi, D., & Lokupitiya, E. Y. K. (2021). Using weather patterns to forecast electricity consumption in Sri Lanka: An ardl approach.
- Sahay, K. B., Sahu, S., & Singh, P. (2016, March). Short-term load forecasting of Toronto Canada by using different ANN algorithms. In *2016 IEEE 6th International Conference on Power Systems (ICPS)* (pp. 1-6). Ieee.
- Salam, A., & El Hibaoui, A. (2018, December). Comparison of machine learning algorithms for the power consumption prediction:-case study of tetouan city-. In *2018 6th International Renewable and Sustainable Energy Conference (IRSEC)* (pp. 1-5). IEEE.

- Salleh, N. S. M., Suliman, A., & Jørgensen, B. N. (2020, August). A systematic literature review of machine learning methods for short-term electricity forecasting. In *2020 8th International conference on information technology and multimedia (ICIMU)* (pp. 409-414). IEEE.
- Samarawickrama, N. G. I. S., Hemapala, K. T. M. U., & Jayasekara, A. G. B. P. (2016, April). Support Vector Machine Regression for forecasting electricity demand for large commercial buildings by using kernel parameter and storage effect. In *2016 Moratuwa Engineering Research Conference (MERCon)* (pp. 162-167). IEEE.
- Shao, Z., Chao, F., Yang, S. L., & Zhou, K. L. (2017). A review of the decomposition methodology for extracting and identifying the fluctuation characteristics in electricity demand forecasting. *Renewable and Sustainable Energy Reviews*, 75, 123-136.
- Vivas, E. A.-C. (n.d.). A systematic review of statistical and machine learning methods for electrical power forecasting with reported mape score. *Entropy*, 22(12), 141



Generative Adversarial Network Approach for the Traditional Batik Industry in Sri Lanka

Gamlath OGYN¹, Premarathna WCC²

Department of Computing and Information Systems, Faculty of Applied Sciences, Wayamba University of Sri Lanka^{1,2}

yuganinavodya@gmail.com¹

chamidu@wyb.ac.lk²

ABSTRACT

These days the Sri Lankan batik fashion industry has a high demand all around the world. Most foreigners like to buy batik dresses and some materials when they are traveling and enjoying our country. This batik industry can make a huge influence on the Sri Lankan economy in this crisis period as well. Because of that most of the batik factory owners try to hire more fashion designers to create a lot of new batik styles. This study examined the method to create new batik images without any human interaction using Unsupervised Deep Learning related Generative Adversarial Network (GAN) concept. This Deep Convolutional Generative Adversarial Network (DCGAN) model was given unique, attractive batik images without any fashion designers' thoughts. Some Python libraries and modules like TensorFlow, and Keras were used and the model was trained in the Google Colab cloud environment. A simple Batik Fashion Generator user interface was created using this trained GAN model. A Python Tkinter module was used for it. This generator was given various types of unique GAN-related batik images as well. Another important fact is that accuracy curves and loss curves (generator loss and discriminator loss) were plotted using python libraries for the performance evaluation process.

KEYWORDS: Batik, Generative Adversarial Network (GAN), Model, Python

1 INTRODUCTION

Batik arts have a high demand from foreigners. This batik industry can make a significant volume of foreign exchange to the Sri Lankan economy. Because of that batik sellers continuously introduce new batik arts for their customers. They want to hire a lot of qualified fashion designers and talented artists to sketch brand-new and unique designs to improve their business quality. Because of the above reason, the GAN-related research idea was proposed for generating new batik designs. GAN can be introduced as an exciting recent innovation in Deep Learning. GAN was designed by Ian Goodfellow and his colleagues in June 2014 (Goodfellow et al., 2014). In this research, a lot of

existing batik images were used to train the GAN model, and finally, it was optimized and trained to generate unique batik arts. After that, this model will automatically generate new batik images.

This research study is most significant because it generates unique and attractive styles without any kind of manpower. According to that, fashion designers do not waste their time, brain power, and money to generate new batik styles. This research can be introduced as the most appropriate idea for the growth of today's batik fashion industry.

2 LITERATURE REVIEW

2.1 Generative Adversarial Nets

The very first paper related to the GANs was published by Ian J

Goodfellow and his colleagues in the year 2014. A new deep learning framework was proposed by them for estimating generative models via an adversarial process. Simultaneously two models were trained and named as generative model G and discriminative model D. The generative model can capture the data distribution, and also the discriminative model estimates the probability that the sample came from the training data rather than the generator G. The training process of the generator is to maximize the probability of the discriminator making a mistake. This framework corresponds to a minimax two-player game (Goodfellow et al., 2014). This paper demonstrates the potential of the framework through quantitative and qualitative evaluation of the generated outputs.

They trained adversarial nets using the MNIST handwritten digits dataset, the Toronto Face Database (TFD), and the CIFAR-10 dataset (Goodfellow et al., 2014). According to the paper, the generator used a mixture of ReLU and Sigmoid activations. The discriminator network used max out activation. Dropout was applied to train the discriminator. The theoretical explanation of the architecture, GAN training algorithm, and the challenges of various approaches to generative modeling were explained in this paper.

2.2 *Unsupervised Representation Learning With Deep Convolutional Generative Adversarial Networks*

Alec Radford and his team tried to bridge the gap between the success of Convolutional Neural Networks (CNN) for supervised and unsupervised learning in the year 2015. It was introduced by

them as Deep Convolutional Generative Adversarial Network (DCGAN) architecture. A model was trained using Large-scale Scene Understanding (LSUN), Imagenet-1k, and a newly assembled Faces dataset (Radford, Metz & Chintala, 2015). Finally, a more stable architecture and some guidelines for training DCGANs were proposed. According to the paper, some little instabilities that were in this model were identified. As the future works, is to extend this framework to tackle this form of instabilities. Other than that they hope to explore some other domains like video frame prediction and audio speech synthesis.

2.3 *Image Generation for Real-Time Application using DCGAN*

Dr. V. Vijeya Kaveri and his team tried to generate different types of images that will be useful in animations and designing. According to the paper published in the year 2021, the DCGAN was used to generate new images that were not visible in a real dataset. They used MNIST and anime face image datasets (Vijeya Kaveri et al., 2021). According to them, DCGAN is the best solution, because this architecture was previously proposed well with unlabelled data samples.

3 METHODOLOGY

DCGAN was selected as the suitable GAN type for this research work. Because DCGANs are more powerful and give the best results according to the literature. First of all, some batik images were collected. After that those collected images were pre-processed (images were resized to the same size, and BGR

images were converted to RGB images) using Python modules.

After those main tasks, there were some main steps followed. The first step was to implement the discriminator model. It had one input layer and 4 hidden layers. It consisted of Convolutional 2D layers, Flatten layer, Dropout layer, Dense layer, and Leaky ReLU activation (alpha=0.2). The second step was to implement the generator model. It consisted of Convolutional 2D Transpose layers, Dense layer (input layer), Convolutional 2D layer, and Leaky ReLU activation (alpha=0.2). The last layer of the generator used Tanh activation. The third step was to implement the DCGAN model using both of the previous models. The optimizer was set as the Adam optimizer (lr=0.0002, beta_1=0.5) and the loss function was set as the Binary Cross Entropy. The following figure shows the structure of both models.

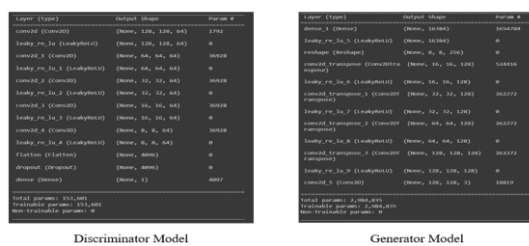


Figure 1: Structure of the Discriminator and Generator Models.

The next step was to train the DCGAN model for the relevant number of epochs and to test the DCGAN and analyze the output results. After summarizing the performance using the accuracy of both models, the generative loss and discriminative loss, the final step was to visualize the output results of the trained DCGAN model using the Batik Fashion Generator user interface.

3.1 Software Platforms and Libraries

Google Colab was used as the GAN model training environment. It supports most of the machine learning libraries. The key feature of this environment is free cloud service with free GPU. And also some open-source machine learning-related libraries (TensorFlow, Keras) were used. Python language and its libraries (Matplotlib, Numpy, OpenCV, Tkinter) were used throughout this research.

Batik Fashion Generator's graphical user interface was created using the Python Tkinter module. It was implemented in the Python IDE environment. Using this interface, new batik images could be generated according to the relevant batik style. These new styles were selected with some different models that were saved in 10 epochs in the DCGAN training process. Here testing for each saved model and the most suitable models were selected for the user interface generation purpose.

4 DATA COLLECTION & ANALYSIS

A data set of 999 batik images was used to train the GAN model in this research. The main resource can be mentioned as the Indonesian Batik Motifs Kaggle dataset. This dataset contains 983 (.jpg) images of twenty designs of Indonesia's Signature Crafts. Some suitable images were selected from this Kaggle dataset and the other remaining images were selected from the internet.

5 RESULTS AND DISCUSSION

This GAN model training takes more hours to train the number of

epochs. First of all this model was trained for the 100 epochs using Google Colab GPU. Around 30 minutes were taken to the training process. After that, the model was set to train for the 1000 epochs. However, in this scenario, the model was trained only up to 859 epochs. It took around 4 hours to train. Finally, the model was set to train for the 2000 epochs. At this stage, the model was trained to the 1449 epochs. It was the best effort of the training process. Around 6 hours were taken to the training process. The following figure represents some resultant batik images in some random intermediate epochs.

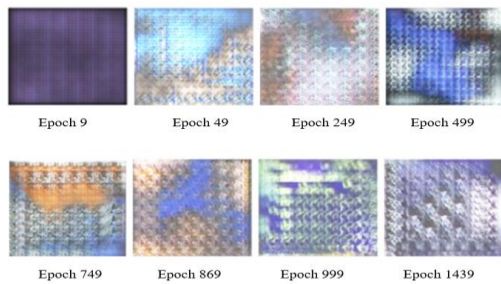


Figure 2: Resultant Batik Images in Some Intermediate Epochs.

This DCGAN model gave better results than the original Vanilla GAN (Bermano et al., 2022). Because the DCGAN used a convolutional layer with stride instead of an upsampling layer and another convolution layer instead of a fully connected layer. The following figure shows some best resultant images to prove the best performance of the DCGAN model.

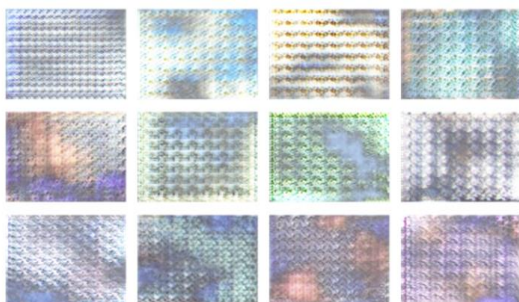


Figure 3: Best Batik GAN Images.

The Batik Fashion Generator user interface can be used to demonstrate the above results. Using the Batik Fashion Generator, the user can select a relevant batik style by clicking on the relevant button, and then the new batik image is visualized. And also the generated batik image can be saved or downloaded to the local computer. The following figure shows the functional results of the Batik Fashion Generator user interface.

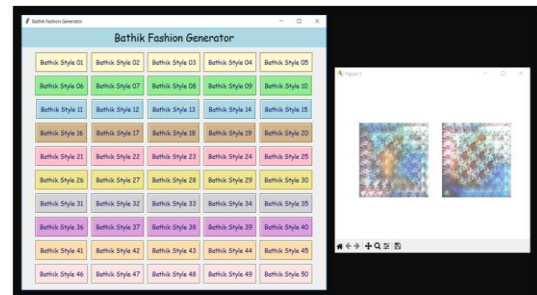


Figure 4: Functional Results of the Batik Fashion Generator UI.

5.1 GAN Performance Summarization

GAN performance evaluation is an important task. Because the generator was trained using unsupervised learning algorithms. Because of that, objective errors of generated images cannot be calculated. The quality of the GAN should be manually evaluated. That means nobody knows when to stop training the model without looking at the examples of generated images. For that classification accuracy of the discriminator real and the fake images were periodically evaluated. And the generator models were periodically saved for every 10 epochs. And also while training the GAN model for every epoch, it will print the number of epochs count, generator loss, and discriminator loss.

5.2 Loss and Accuracy Curves

In this research loss curves and accuracy curves were drawn using the

matplotlib plotting library during the training epochs. The following figure represents the variations of both generative loss and discriminative loss according to each training epoch.

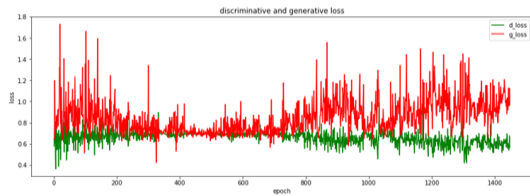


Figure 5: Generative and Discriminative Loss Curves.

The performance of the GAN model was manually evaluated. For that classification accuracy of the discriminator real and the fake images were periodically evaluated while training the GAN model. The following accuracy curves were plotted, according to the above periodic evaluation details. The following figure represents the accuracy curves on real and fake images according to each epoch.

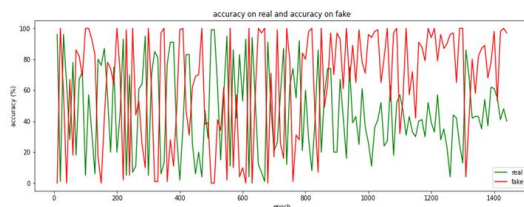


Figure 6: Accuracy Curves on Real and Fake Images.

6 CONCLUSION

There were several limitations of this study. The training process was suddenly stopped because of the GPU usage limits of the Google Colab free trial version. Then training processes could not continue from the relevant stopped point. Therefore, around 24 hours were passed to continue the work. Another thing is that the training process was stopped at a considerable number of an epoch. These are the major difficulties

that were found in the research. However, the GAN model was trained for the 1449 number of epochs successfully.

As future works, it can be suggested to train the model with a huge number of epochs like 10,000 or above. Another suggestion is that other GAN types (like StyleGAN) (Hitawala, 2018) can be used for the batik dataset and check the results. Then anyone can do the comparison about the results from each type of GANs as another research idea.

REFERENCES

- Bermano. Amit H., Gal, Rinon, Alaluf, Yuval, Mokady, Ron, Nitzan, Yotam, Tov, Omer, Patashnik, Or, Cohen-Or, Daniel. (2022). State-of-the-Art in the Architecture, Methods and Applications of StyleGAN. *arXiv: e-prints. arXiv: 22202.14020v1 [cs.CV]. doi:10.48550/arXiv.2202.14020*
- Goodfellow, Ian J., Pouget-Abadie, Jean, Mirza, Mehdi, Xu, Bing, Warde-Farley, David, Ozair, Sherjil, Courville, Aaron C., and Bengio, Yoshua. (2014). Generative Adversarial Networks. *arXiv e-prints. arXiv: 1406.2661. doi:10.48550/arXiv.1406.2661*
- Hitawala, S. (2018). Comparative Study on Generative Adversarial Networks. *arXiv e-prints. arXiv: 1801.04271v1 [cs.LG]. doi:10.48550/arXiv.1801.04271*
- Radford, A., Metz, L., & Chintala, S. (2015). Unsupervised Representation Learning with Deep Convolutional Generative Adversarial Networks. *arXiv e-prints. arXiv: 1511.06434 [cs.LG]. doi:10.48550/arXiv.1511.06434*
- Vijeya Kaveri, V., Meenakshi, V., Deepan, T., Dharnish, C.M., & Haarish, S.L. (2021). Image Generation for Real-Time Application Using DCGAN (Deep Convolutional Generative Adversarial Network). *Turkish Journal of Computer and Mathematics Education (TURCOMAT). Vol.12 No. 11 (2021), 617 – 621. doi:10.17762/turcomat.v12i11.593*



Identifying Named Entity Recognition for Customized Corpus of Sinhala News Articles Using Deep Learning

Hiripitiya KK¹, Dinesh Asanka PPG²

Department of Industrial Management, Faculty of Science, University of Kelaniya, Sri Lanka^{1,2}

hiripiti_im17031@stu.kln.ac.lk¹

dasanka@kln.ac.lk²

ABSTRACT

Sinhala is used by the majority of Sri Lankans for their daily activities, and in activities that involve text, efficient information extraction plays a significant role. To address this problem, we can use text-processing techniques. Named Entity Recognition (NER) is one of the important text processing techniques, and it is used to extract important information like persons, organizations, and locations from texts automatically. Developing NER systems requires manually annotated data, including text with manually located and classified named entity tags. Many studies have been done for languages like English, Russian, and Spanish to develop NER systems. But when it comes to the Sinhala language, there is a handful of research done so far because of limited resources. Most of this research have not used the latest technologies available for NER. Therefore, it becomes necessary to assess the effects of deep learning techniques on Named Entity Recognition for the Sinhala language. Hence, this study aims to develop a Sinhala news article-specific NER system using deep learning models XLM-RoBERTa and Spacy CNN and to create a comprehensive Sinhala news corpus. Multiple experiments were executed to evaluate the outcome of this system using different feature combinations. The combination of Gazetteer Matcher, Fuzzy Matcher, Spacy Model, and XLM-RoBERTa gave the highest Precision, Recall, F1 score, and Accuracy when considering all experiments with 76% F1 score and 66% Accuracy. The research has also demonstrated the significant impact of using deep learning models for Sinhala NER, and the results can be applied to various real-world applications.

KEYWORDS: NER, Sinhala, NLP, XLM-RoBERTa, Spacy

1. INTRODUCTION

About 16 million people in Sri Lanka speak Sinhala. Most Sri Lankans use the Sinhala language for daily activities, including media, education, communication, and health. This research mainly focuses on Sinhala news articles in the media domain. Natural Language Processing (NLP) technologies can be used to extract information and insights contained in the documents. There are multiple NLP approaches as Rule-based, Statistical and Neural NLP. NLP can be broken down into multiple tasks, one of them is Named Entity Recognition (NER). NER is used to extract important information from texts

automatically. This information includes named entities, like person name, country name, organization, location. Developing NER systems requires manually annotated data which is necessary for training models with machine learning techniques and evaluating system performances (Ruokolainen, Kauppinen, Silfverberg, & Lindén, 2020). Many studies have been done on languages like English, Russian, and Spanish. But, there is a handful of research done so far in Sinhala language, because of limited resources. Most of this research have not used the latest deep learning technologies available. Hence the main purpose of this research is to develop a Sinhala news

article domain-specific NER system using XLM-RoBERTa and Spacy CNN deep learning models.

2. LITERATURE REVIEW

2.1 Sinhala Rule Based NER Systems

In Rule-Based NER, information is extracted based on a set of pre-defined rules. Few studies have been conducted using a purely Rule-Based approach for Sinhala Named Entity Recognition. However, a study was conducted in 2015 to propose the construction of a hybrid NER system that uses Conditional Random Fields (CRF) as the data-driven technique in combination with a Rule-Based post-processor. (Udayangi, K. A. I., 2015).

2.2 Sinhala Statistical NER Systems

In statistical NER, statistical modelling methods are applied for machine learning to tackle NER problems. In 2020, research was conducted to implement a comprehensive NER system for Sinhala. This research presented a novel fine-grained Named Entity (NE) tag set, and an NE annotated Sinhala corpus of 70k word tokens and trained a custom NER model for Sinhala based on Conditional Random Fields (CRF). (Azeez & Ranathunga, 2020).

In 2016, a study focused on identifying the effectiveness of using data-driven techniques and possible combinations of language features in detecting Named Entities in Sinhala text. Research is done using Conditional Random Fields (CRF) and Maximum Entropy (ME) statistical modeling methods. Based on the results obtained from the experiments, the most critical observation made is that the Conditional Random Fields method outperforms the

Maximum Entropy method when it comes to Indic languages such as Sinhala.

In 2021 study was done to present a novel NER system using Support Vector Machine (SVM) for the Sinhala language. Researchers observed that performance is increasing with the increase in the training data size, performance is increasing. As prior literature has shown the effect of language features, researchers have observed different behaviors for different language feature combinations. As the data sample for training purposes, they used 100,000 Sinhala tokens. Researchers identified a considerable effect of using gazetteers with SVM to improve the model (Mallikarachchi, Lorensuhewa, & Kalyani, 2021).

In 2018 research was done to present a comparative evaluation of Parts-of-Speech (POS) using Support Vector Machines (SVM), Hidden Markov Models (HMM) and Conditional Random Fields (CRF). Also, this study evaluated the usage of corpora of two domains in the training and testing phases of Sinhala POS tagging. Five experiments were designed using the two corpora News and Official Documents with different combinations for training and testing datasets for 3 POS tagger models. A corpus of news articles of 200,000 words has been used for training. From the five experiments using individual taggers, SVM based tagger has given the highest overall accuracy for two tests, while CRF based tagger has outperformed the other two taggers in three trials. HMM-based tagger has not achieved the highest accuracy in any tests. (Fernando & Ranathunga, 2018).

2.3 Sinhala Neural NER Systems

In neural NER, neural networks and deep learning techniques are used to tackle NER problems. In 2019, research was done to solve Named Entity Recognition as a Reinforcement Learning problem. The researchers proposed a basic Reinforcement Learning model that can be used as an essential foundation for future research by providing a learning algorithm and a simple and customizable implementation of the learning algorithm. The data set contained about 66000 Non-Named Entities and about 7562 Named Entities. The accuracy yield of the learning algorithm is around 90% (Anuruddha, 2019).

In 2021 research was done to implement a novel system for nested NE boundary detection for the Sinhala language considering unhealthy religious statements in social media. A corpus of more than 100,000 Sinhala hates speech contents has been extracted, preprocessed, and annotated by an expert panel to train the model. A deep neural approach using BiLSTM has been applied to capture the corpus's complexity indexes, matrices, and other related elements. (Priyadarshana, et al, 2021).

3. METHODOLOGY

3.1 Corpus Development and Manual Annotation

The first step of developing this NER system was extracting news articles to build the corpus. News article collection was limited to online websites containing peer-reviewed news articles to

avoid grammatically incorrect and misspelt sentences and words, leading to confusion when training the NER model. In this study, Roar Media and BBC Sinhala news websites were used as the sources of data collection. News articles were extracted from various categories to increase the diversity of data.

After extracting the news articles, they were manually annotated according to five entity classes, namely PERSON, LOCATION, ORGANIZATION, DATE and TIME. Tecoholic NER Text Annotator was used as the annotation tool. After annotating and developing the corpus, the next step was developing training data for the Spacy Model and XLM-RoBERTa Model. A Python tool was created to convert corpus data into Spacy and XLM-RoBERTa training data.

3.2 System Architecture

An illustration of the system's overall view is presented in Figure 1. The system was developed as an API service in that the user can send a Sinhala text through the API and receive the tagged entities in the given text as a JSON output. Check Entities request handler resolves incoming text and sends it to Spacy, XLM-RoBERTa, Fuzzy Matcher and Gazetteer Matcher services. Gazetteer Matcher was used to extract entities from pre-populated gazetteers with exact string matching. In this study, multiple gazetteers have been used for all the entity classes. The gazetteer containing LOCATION entity values contained more than 45K location names worldwide. The Fuzzy Matcher feature extracts entities by near-string matching with gazetteers.

A threshold of 0.75 out of 1 was set for the confidence of extracting entities to avoid the extraction of mismatching entities. When building the gazetteers, English references were also kept for all the Sinhala entity values for better practical usage of results. In this study, stemming and lemmatization for Sinhala are handled by adding synonyms in the gazetteer. Various forms of the words are added as synonyms in the gazetteer, along with English references.

The user-given text was also passed into the trained Spacy and XLM-RoBERTa models to run the predictions. Training data generated from the previous stage was used to train these two models. As the base model for XLM-RoBERTa, the xlm-roberta-base model was used.

Once all the matches and model predictions were generated, a result combination mechanism was used to generate the final entity list. Union is used to combine all the entities coming

from the Spacy model, XLM-RoBERTa model, Fuzzy matcher and Gazetteer matcher. If different entities were tagged for the same start and end character position of the text, priority was given to the Gazetteer matches. Finally, this combined result was returned to the user as the API response.

4. RESULTS AND DISCUSSION

Multiple experiments were executed to evaluate the outcome of this system using different feature combinations. Individual performance is assessed for the Spacy model, XLM-RoBERTa model, Gazetteer matcher and Fuzzy matcher. Finally, the combination of these four features representing the final NER system is evaluated. The test dataset contains around 20K word tokens, and the training dataset contains around 100K. The evaluation used macro averaged Precision, Recall, F1 score, and Accuracy to measure performance. The combination of Gazetteer Matcher, Fuzzy Matcher, Spacy Model, and XLM-

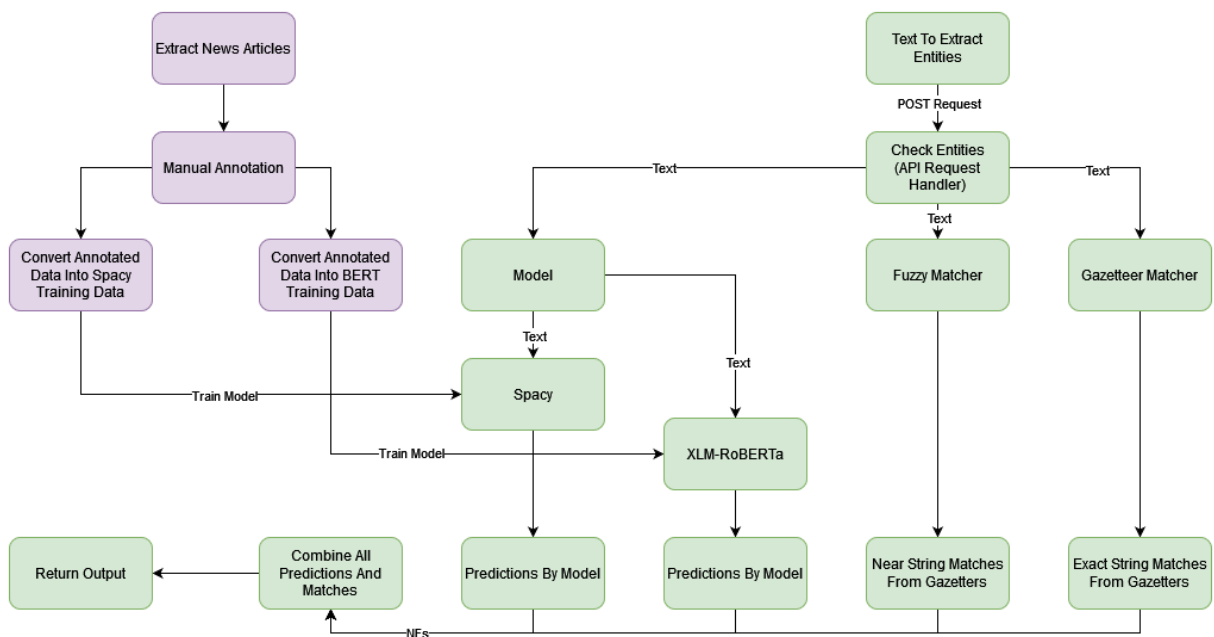


Figure 3: System Architecture

RoBERTa gave the highest Precision, Recall, F1 score, and Accuracy when considering all experiments with 76% F1 score and 66% Accuracy. The results of each experiment are shown in Table 1.

E1 - Spacy Model

E2 - XLM-RoBERTa Model

E3 - Combination of Gazetteer Matcher + Fuzzy Matcher + Spacy Model + XLM-RoBERTa Model

Table 4: Experiment results

Measure	E1	E2	E3
F1 score	64 %	60 %	76 %
Accuracy	65 %	61 %	66 %
Precision	61 %	58 %	74 %
Recall	67 %	63 %	78 %

5. CONCLUSION

This study presented a novel NER system for the Sinhala language using deep learning models trained by a customized corpus of Sinhala news articles. The system has shown promising results in accurately identifying and classifying named entities in Sinhala text, which significantly contributes to the field of natural language processing for the Sinhala language. The results of this research can be applied to various real-world applications, such as information extraction, text summarization, and sentiment analysis. There are still several future works that we can consider. Expanding the dataset, to additional entity types like events, products, and quantities and combining more Sinhala language features will also help to improve the accuracy.

REFERENCES

- Anuruddha, H. M. S. (2019). *Reinforcement learning for sinhala named entity recognition*.
- Azeez, R., & Ranathunga, S. (2020). *Fine-grained named entity recognition for sinhala*. 295–300. IEEE
- Fernando, S., & Ranathunga, S. (2018). *Evaluation of different classifiers for sinhala pos tagging*. 96–101. IEEE.
- Mallikarachchi, P. S., Lorensuhewa, S. A. S., & Kalyani, M. A. L. (2021). *Support Vector Machine based Named Entity Recognition for Sinhala*.
- Priyadarshana, Y. P., Ranathunga, L., Amalraj, C. R. J., & Perera, I. (2021). *HelanER: A Novel Approach for Nested Named Entity Boundary Detection*. 119–124. IEEE..
- Ruokolainen, T., Kauppinen, P., Silfverberg, M., & Lindén, K. (2020). *A Finnish news corpus for named entity recognition*. *Language Resources and Evaluation*, 54(1), 247–272. doi:10.1007/s10579-019-09471-7
- Udayangi, K. A. I. (2015). *A Hybrid Approach for Named Entity Recognition in Sinhala Language*.



Identifying People's Perception of the Sri Lankan Economy Using Twitter Sentiment Analysis

Liyanage TLU¹, Dinesh Asanka PPG²

Department of Industrial Management, Faculty of Science, University of Kelaniya, Sri Lanka^{1,2}

liyanage_im17044@stu.kln.ac.lk¹

dasanka@kln.ac.lk²

ABSTRACT

With the development of modern technology and the internet, social media has become a norm for everyone. Social media platforms like Twitter, Facebook, and Instagram have changed the way people connect with each other. Since most people are expressive in some way, they use social media platforms like Twitter to express their opinions. This makes Twitter a rich source of opinions, beliefs, and emotions toward different topics. Sentiment analysis has become a popular research topic among researchers due to the high availability of opinionated data from social media platforms like Twitter. They use this data to discover valuable information about emerging trends, human behavior, etc. When it comes to Sri Lanka, many Twitter users express their opinions on different topics such as politics, products, movies, etc. With the country's economic collapse, people use social media platforms to express their opinions about economy-related topics. So, the main purpose of this research is to identify people's perceptions about the economy of Sri Lanka using a machine learning approach. Due to the unavailability of a proper economic-related dataset, this research also focuses on constructing a corpus of economic-related tweets. Another aim of this research is to identify the impact of different feature extraction techniques on model performance. Also, using different supervised machine learning algorithms, the best model will be identified to perform sentiment analysis on the economic domain.

KEYWORDS: Sentiment Analysis, Twitter, Feature Extraction, Economy

1. INTRODUCTION

Social media plays a massive role in our modern day-to-day lives. People frequently use online platforms like Twitter to express their emotions, beliefs, and opinions toward any entity, including a product, person, event, etc. (Hota & Pathak, 2018).

This makes Twitter a rich source of opinions. Although the availability of a vast amount of data and opinions is beneficial, it isn't easy to analyze and make sense of this data. So, to address this problem, sentiment analysis techniques can be used.

The existing sentiment analysis techniques are beneficial in a variety of

applications. While sentiment analysis has been used in various applications, such as product and movie reviews, political polls, and healthcare, it has not been widely explored in the economic domain, especially in Sri Lanka.

Accordingly, this study aims to fill this gap by conducting sentiment analysis on tweets related to the economic domain in Sri Lanka. Our goal is to identify a method to classify tweets into positive, negative, and neutral categories using different machine learning and feature extraction techniques. Here, the impact of feature extraction techniques will be explored in an economic context. This research has the potential to benefit the general public by providing a platform

for their voices to be heard when making economic-related decisions. Additionally, it can assist the government and relevant authorities in determining public sentiment toward economic decisions and policies.

2. LITERATURE REVIEW

2.1 *Lexicon-based Approaches*

The COVID-19 pandemic has persuaded researchers to conduct their studies by analyzing the sentiments of people at that time. A lexicon-based method to analyze the emotions behind the tweets regarding COVID-19 worldwide was carried out by researchers (Mathur, Kubde & Vaidya, 2020). Twitter data was collected from a website called TweetBinder, and R language was used in the preprocessing process. They have used the NRC Word-Emotion Association Lexicon to do the analysis.

Medical-related sentiment analysis was carried out to improve the quality of healthcare and decision-making in the medical domain (Mammadova, Jabrayilova & Shikhaliyeva, 2022). For this research, a dataset from Kaggle was used, and researchers utilized a lexicon-based method to do the analysis. VADER lexicon-based approach was used to classify the data into positive, negative, and neutral categories. The results of the research showed that the majority of the opinions expressed by the patients were positive, and both neutral and negative opinions were much less common compared to the positive ones.

2.2 *Machine Learning Approaches*

Survey studies in sentiment analysis were carried out by different researchers

to identify the impact of machine learning. According to the findings, Support Vector Machines and Naïve Bayes were the most commonly employed algorithms for sentiment classification, and machine learning approaches were generally preferred over other methods (Aydogan & Akcayol, 2016).

The political domain is also mostly employed in sentiment analysis. Many researchers have used machine learning methods to analyze the sentiments of political tweets. A machine learning-based method to analyze the sentiment of Indian people towards the political situation and issues in India was carried out by researchers (Jain & Katkar, 2015). They used Twitter data for the research, and the experiment was carried out using classifiers K-Nearest Neighbors, Random Forest, Naive Bays, and BaysNet. The results from the experiments showed that the K-Nearest Neighbors classifier gave the highest predictive accuracy over other classifiers.

Economic-related sentiment analysis was carried out to analyze the sentiment toward the tourism industry in Saudi Arabia (Alrashidi et al., 2022). For this research, tweets were collected using the Twitter API from both the English and Arabic languages. The labeling of the dataset was done manually into positive, negative, and neutral classes. Support Vector Machines and Naïve Bayes machine learning models were trained using the labeled dataset to carry out the analysis. According to the results, Support Vector Machines performed better than Naïve Bayes in all the evaluation matrices.

IDENTIFYING PEOPLE'S PERCEPTION OF THE SRI LANKAN ECONOMY USING TWITTER SENTIMENT ANALYSIS

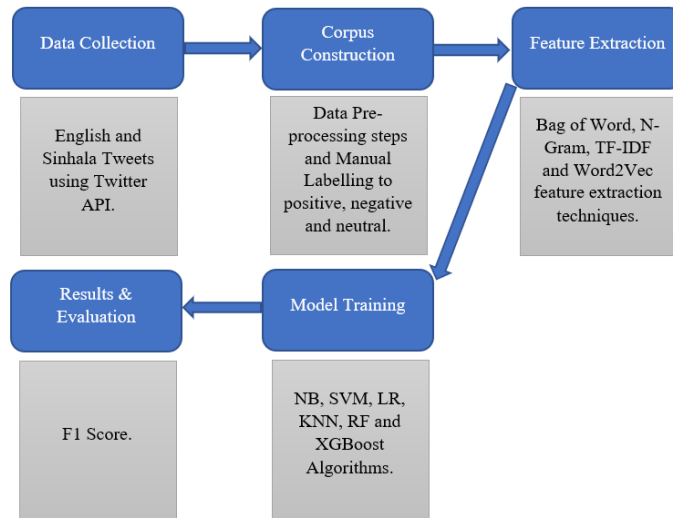


Figure 1: Sentiment analysis process

3. METHODOLOGY

The overall methodology is shown in Fig. 1. For this research, we have used tweets published by different users who expressed their opinion on the Sri Lankan economy. After collecting the tweets in both Sinhala and English, a corpus of economic-related tweets was created. Then we carried out different pre-processing steps to clean the data. One of the main objectives of this research is to identify the impact of different feature extraction techniques on sentiment analysis in the economic domain. To accomplish that, we have utilized many feature extraction techniques like Bag of Word, N-Gram, TF-IDF, and Word2Vec. After the feature extraction step, machine learning models like Multinomial Naïve Bayes, Support Vector Machines, Logistic Regression, Random Forest, K-Nearest Neighbors, and XGBoost were trained to identify the best model to do the sentiment analysis. We considered the F1-Score when selecting the best model,

as it gives the harmonic mean between precision and recall.

4. DATA COLLECTION & ANALYSIS

The main and most important step of this research was to find a proper dataset that expresses opinions about the Sri Lankan economy. To accomplish this task, we have used the Twitter API v2 collection. We were able to collect around 20,000 tweets from July 2021 to February 2022 about the economy of Sri Lanka. After removing the retweets, duplicate tweets, and irrelevant tweets, the size of the data set was reduced to 1851. The collected tweets were manually labeled into three sentiment classes: positive, negative, and neutral. After labeling, there were 338 positive tweets, 862 negative tweets, and 651 neutral tweets in total.

Since the collected data were raw, the following data pre-processing steps were carried out in order to build the models.

Table 1: F1-Scores of different models

	MNB	SVM	RF	LR	KNN	XGB
BoW	60.82	57.58	61.24	57.47	48.43	59.53
N-Gram (bi)	54.91	47.47	52.88	51.01	42.16	49.09
N-Gram (tri)	48.87	47.33	48.13	48.80	46.15	40.44
N-Gram(uni+bi)	60.86	57.00	61.18	57.39	48.73	58.99
TF-IDF (uni)	55.84	61.30	57.05	57.29	55.47	59.03
TF-IDF (bi)	50.37	49.73	51.53	50.28	49.61	48.55
TF-IDF (uni+bi)	60.43	61.01	55.50	59.41	49.27	58.26
Word2Vec	58.59	59.04	58.94	58.6	57.57	57.86

- Converting the words into lowercase.
- Removing the hashtag symbol and account ids.
- Removing the URLs, hyperlinks, and emoticons.
- Removing the stops from words like am, is, are, etc.
- Removing all the punctuation marks and symbols.
- Using lemmatization to return words to their original form.

Before applying the data to machine learning models, feature extraction techniques were carried out. For this research, several feature extraction techniques were used. Bag of Word, N-Gram techniques like bigram, trigram, and combination of both unigram and bigram features, TF-IDF with unigram, bigram, and collection of both unigram and bigram features, and Word2Vec features were used in this step.

There are various sentiment analysis techniques, like lexicon-based methods and machine learning methods. In this

study, machine learning methods were preferred over lexicon-based methods, as the existing lexicons were not relevant to the economic domain of Sri Lanka. Multinomial Naïve Bayes, Support Vector Machines, Logistic Regression, Random Forest, K-Nearest Neighbors, and XGBoost classifiers were trained using the training dataset in this research, and the F1-Score was calculated in order to determine the best model along with the feature extraction technique.

4. RESULTS & DISCUSSIONS

Table 1 shows the calculated F1-Scores of each model with different feature extraction techniques. Hyperparameter tuning was done for every model to increase the F1-Score further. Since this is a multi-class classification, an averaging of the F1-Score had to be done. In this research, macro averaging is considered over micro and weighted averaging in order to emphasize the performance of each individual class as it calculates the

average F1-Score over each class regardless of its size.

The calculated F1-Scores for all the models did not exceed 62 percent. According to the results, we can see that all the machine learning models have a high F1-Score except K-Nearest Neighbor. When it comes to the Support Vector Machine classifier, it can handle non-linearly separable data well. We can see that from the results, as it performed well with different feature extraction techniques. Multinomial Naïve Bayes also performed well in this context, as it can handle large data sets with sparse features. The Random Forest classifier also performed well with this dataset as it can handle imbalanced classes.

The results clearly showed that different feature extraction techniques have an impact on the model's performance. Feature extraction techniques that use unigram features and a combination of unigram and bigram features have better performances with classification models compared to other techniques in this context. Bag of Words, TF-IDF with unigram features, N-Gram, and TF-IDF with a combination of unigram and bigram features performed well according to the results of this research. Unigrams work well in a sentiment classification task as they capture the presence of individual words in a text. When it comes to bigrams and trigrams, they can also perform well in sentiment classification as they capture adjacent words in a text and provide more context for the sentiment. According to the results, the bigram and trigram features underperformed compared to other features. This may be a result of overfitting since the size of the training dataset is limited and these

features increase the feature space. The usage of both unigram and bigram features also performed well in this context, as they provided a good balance between individual words and pairs of words. Results also indicate that Word2Vec features perform equally well with every classification model. The reason for this observation is that they capture the semantic meaning of words in the context of the training dataset.

5. CONCLUSION

The objective of this research was to develop a model for identifying people's perceptions of the economy of Sri Lanka using Twitter data. In this process, feature extraction techniques play a major role. So, another objective of this research is to identify the best feature extraction technique in an economic context.

The first challenge we faced was developing a corpus consisting of tweets with economic relevance. We utilized the Twitter API to collect tweets regarding the economy of Sri Lanka, and manual labeling was used. In developing the model, we considered eight feature extraction techniques and six supervised machine learning models. F1-Score was calculated in order to determine the best model along with the feature extraction technique.

Among those feature extraction techniques and models, the Support Vector Classifier with TF-IDF unigram features showed the highest F1-Score of 61.3% when compared with other models. The relatively small size of the dataset has contributed to the low F1-Score observed in this study. Specifically, due to the economic context of Sri Lanka, a large portion of the tweets

collected were retweets, leading to a reduced dataset size after filtering out irrelevant content. Despite this challenge, the results obtained are still indicative of the impact that different feature extraction techniques can have on sentiment analysis of economic-related tweets.

This model can be useful mainly to policymakers and the government to identify the people's perceptions before making decisions. Also, this model can be useful for a variety of other stakeholders, like businesses, as they can understand how their products and services are perceived by customers in the context of the Sri Lankan economy. This model will be helpful to researchers as they can explore public opinion in different time periods. Another party that can utilize this model will be the media. This model will be helpful to journalists and media organizations to stay up-to-date on public sentiment towards the Sri Lankan economy and report on economic issues more accurately and objectively.

To improve this model, future work could involve adding more data, such as Facebook posts. This will make the model more relevant to the Sri Lankan context since many individuals in Sri Lanka use Facebook rather than Twitter to express their opinions.

REFERENCES

- Alrashidi, S., Alanazi, F., Albalawi, H., Albalawi, O., & Awadelkarim, A. (2022). Machine Learning Based Sentiment Analysis for Tweets Saudi Tourism. *Journal of Theoretical and Applied Information Technology*, 5096-5109.
- Aydogan, E., & Akcayol, A. (2016). A Comprehensive Survey for Sentiment Analysis Tasks Using Machine Learning Techniques. *2016 International Symposium on Innovations in Intelligent Systems and Applications (INISTA)* (pp. 1-7). Sinaia, Romania: IEEE.
- Hota, S., & Pathak, S. (2018). KNN Classifier Based Approach for Multi-Class Sentiment Analysis of Twitter Data. *International Journal of Engineering & Technology*, 1372-1375.
- Jain, A., & Katkar, V. (2015). Sentiments Analysis of Twitter Data Using Data Mining. *2015 International Conference on Information Processing (ICIP)* (pp. 807-810). Pune, India: IEEE.
- Mammadova, M., Jabrayilova, Z., & Shikhaliyeva, N. (2022). Lexicon-based Sentiment Analysis of Medical Data. *Technology transfer: fundamental principles and innovative technical solutions*, (pp. 7-10).
- Mathur, A., Kubde, P., & Vaidya, S. (2020). Emotional Analysis using Twitter Data during Pandemic Situation: COVID-19. *5th International Conference on Communication and Electronics Systems (ICCES)* (pp. 845-848). Coimbatore, India: IEEE



Literature Review on Sign Language Translation Approaches on Sinhala Sign Language – a survey

Munasinghe NK¹, Yapa CS², Jayalal SV³, Wijayasiriwardhane TK⁴
Department of Industrial Management, Faculty of Science, University of Kelaniya^{1, 2, 3, 4}
munasing_im17047@kln.ac.lk¹
yapacs_im17094@stu.kln.ac.lk²
shantha@kln.ac.lk³
thareen@kln.ac.lk⁴

ABSTRACT

Sign language was introduced to bridge the communication gap between deaf or hearing-impaired communities and ordinary communities. But even with sign language, the learning factor was crucial when using this bridge. More than 70 000 within Sri Lanka use sign language, but only a few human interpreters are available island-wide. Hence the study of computerized sign language interpreters is highly needed. This paper assesses using the most up-to-date sensor-based and vision-based technologies to interpret Sinhala Sign Language. It aims to Compare the published journals and give a general meaning to the reader of the existing technologies and their impact. We have used the standard literature review method to search journals manually. Only three research studies have used sensor-based and five vision-based for sign language recognition in Sri Lankan contexts. The accuracy of sign detection does not guarantee a system that will work in every practical scenario. All the studies have been done with limited conditions and a limited number of signs. Therefore, the accuracy is limited to tested scenarios. Vision-based approaches are susceptible to the background color, light variations, etc., while sensor-based methods can be more accurate but costly.

Keywords: Sri Lankan sign language translation survey, Gesture Recognition, Sinhala Sign Language

1. INTRODUCTION

Human interaction is mainly done through communication; verbal communication is the most widely used and common method. Some people may have hearing problems or disabilities in speaking, so they can't understand or convey the message correctly. It has been estimated that 72 million people worldwide have hearing disabilities (Rishan, Jayalal & Wijayasiriwardhane, 2022) and about 300,000 of the total population in Sri Lanka. (Department of Census & Statistics, 2012) For the hearing-impaired community, sign language was introduced based on physical movements and gestures of the body parts.

Though verbal language can be used in different countries and regions, sign language is unique country-wise. In some cases, a specific sign language may have additional distinctive signs region-wise. (Stone & Rego, 2007) They may have the same meanings for particular signs, but the intentions of the signs will be mainly based on the community using them. Their different approaches have been made in other regions associated with their community. This paper will review studies done on Sri Lankan Sign Language (SSL) Translation with the primary objective of supporting future improvements in this area and discuss the main methodologies used, Differences and similarities with parallel studies, limitations of each study, and future

improvements. The main element that separates our review from other studies is the Unavailability of a systematic review of the approaches for translating Sri Lankan Sign Language into Sinhala Text.

Though Sri Lankan sign language is based on British sign language, there are many key differences in SSL, such as,

- Using both hands to perform signs
- Using facial expressions to differentiate meanings shown by the hand gestures etc.

When translating Sri Lankan sign language into an understandable format for ordinary individuals, the focus should be on hand gestures and facial expressions; otherwise, performing a meaningful sentence will be difficult, and the proper message will not be delivered to the end user.

In this review, we have classified the previous work according to the primary approach the study was taken.

1. Sensor-Based Approaches
2. Vision-Based Approaches

So far, approaches that will be categorized under the above categories have failed to cover all the signs in SSL, and few can translate signs in real-time. Since the context is narrowed down to Sri Lanka, the available studies related to the mentioned area are very limited.

2. METHOD

This study has been undertaken as a systematic literature review based on the original guidelines. In this case, the goal of the evaluation is to assess systematic literature reviews (which are referred to as secondary studies), so this study is categorized as a tertiary literature review.

The steps in the systematic literature review method are documented below.

2.1 Research questions

The research questions addressed by this study are:

- How much research have done using sensor-based and vision-based sign language recognition in Sri Lankan context?
- What are the limitations of current research?

We have recognized that no systematic literature review (SLR) has been done regarding SSL recognition. To address research question 1, we identified the research papers published regarding SSL recognition by year and based methodology (vision or sensor).

2.2 Search process

First, we searched through four major electronic databases, namely, IEEE Xplore, SpringerLink, Wiley Interscience, and Google Scholar, for publications related to Sinhala Sign language interpretation using a Boolean search string given below:

((((Sinhala) OR (Sri Lankan Sign Language*) OR (SSL)) AND ((Gesture) AND ((recognition) OR (Detection) OR (Translation))))))

Any sensor-based or vision-based SSL recognition research was considered from 2022 and below for this study, and the papers that addressed literature surveys of any type were identified as potentially relevant. One of two researchers reviewed each journal and conference proceedings (Munasinghe and Yapa). One researcher was responsible for vision-based approaches, and the other for sensor-based methods.

2.3 Data collection

The data extracted from each study were:

- The source and full reference.
- Classification of the study (vision-based or sensor-based)
- The author(s).
- Summary of the study, including the main research questions and the answers.

3. RESULTS

This section summarizes the results of the study. We found eight articles via the search process. Five studies were based on vision-based, and three were on sensor-based SSL recognition. The summaries of the studies can be found in the discussion section.

4. DISCUSSION

In the discussion, we will summarize the results with their aim, methodologies, accuracy, limitations, and future works.

4.1 Sensor-based approaches

(Madushanka et al., 2016) This study aims to overcome the deaf and normal people gap by a system that recognizes sign language and translating. This study uses a wearable wristband and the muscle data provided by the band (surface Electromyography) that measures the muscle activity and motion data (accelerometer, gyroscope & orientation). The mapping was accomplished using numerous artificial neural networks. Results show 100% accuracy for person-dependent (personalized) study and 94.4% for person-independent (generalized) analysis. This research's limitations are the high armband cost, and some words were identified with lower accuracy. As

for future works, they suggested adding more test subjects and SSL signs to the framework. Provide real-time gesture capturing and recognition.

(Fernando & Wimalaratne, 2016) The goal of this study is the real-time translation of Sinhala sign language to natural language to close the communication gap between deaf and hearing people. Once the depth-sensing camera has acquired the sign-based movements, several feature extraction algorithms will be utilized to detect important properties in the gesture. The identified feature frame will be compared to a pre-trained gesture dictionary using classification algorithms. The detected word will be shown to the average user or used to communicate between two people in two separate geographical areas. Results show an overall recognition rate of 94.2% for a dictionary of 15 signs in Sinhala sign language.

As for limitations of using the Kinect sensor, The camera could not identify a few skeletal points once the distance was over 140 inches.

- The height will affect the accuracy as it is only trained for the test subject's heights.
- When gesture completion frames are relatively short, most movements are incorrectly detected.

As for future work, they have suggested adding finger movement and facial expression detection through the Kinect sensor.

(Rishan et al., 2022) SSL is primarily based on British Sign Language (BSL), but there are unique signals in the SSL vocabulary. They may convey their ideas through facial expressions and body movements.

Because of the importance of such indicators, interpreting SSL has become a research problem. Furthermore, sensor-based systems perform better in gesture identification. This study describes a sensor-based technique that combines Leap Motion technology with geometric template matching and Natural Language Processing (NLP) to recognize and interpret unique, multiple-meaning, and combination signals in SSL into Sinhala text. Results show average accuracy of 80% for static signs and 77% accuracy for dynamic sign recognition. As for the limitations of this research, The Leap Motion controller is solely intended for recording hand motion. Leap Motion controller cannot adequately capture the movements. Sometimes, the controller has difficulty registering the data if there is a yellow light in the scene.

As for future work, they have suggested combining a visual-based approach to detect facial expressions and including (Artificial Neural Networks) ANN with geometric template matching to improve the accuracy of dynamic sign recognition.

4.2 *Vision-based approaches*

(Dissanayake et al., 2020) 'U Talk' and 'Easy Talk' are a couple of studies that made their way near the production stage in 2020. The 'U Talk' approach was introduced as a Sri Lankan Sign Language translation attempt using Convolutional Neural Network (CNN) and Recurrent Neural Network (RNN). The model will accept a video stream as the input, and the stream will be divided into bit images. Those images will be the data source for the machine learning algorithm. U Talk can translate 27 static and dynamic signs in SSL. The main

drawback of this study was that it was not designed to solve in real-time, and the signs trained using this model were not enough to perform a complete sentence. The approach handled single words well but failed to translate signs with multiple meanings.

(Manoj Kumar et al., 2020) 'Easy Talk' stepped ahead from 'U Talk' with its two-stage detection algorithm based on a Region-based Convolutional Neural Network (R-CNN). The first stage will identify a subset of regions in an image, and the second will classify each object according to the areas it contains. Using R-CNN is more accurate and efficient than using the CNN approach. The model was trained using 26 classes that included 250 images each. Because of the wide variety of training data sets and the architecture's accuracy, Easy Talk could translate 247 static signs. But the study was lacking in translating dynamic signs and translating in real-time. Both 'EasyTalk' and 'UTalk' could decode signs performed using both hands. (Hettiarachchi & Meegama, 2020) The proposed system could translate 26 letter signs based on CNN image processing methodology. Since there are two types of signs in Sri Lankan sign language, Letter signs and Word signs, the research focused on letter signs because letter signs can perform more words and phrases than training the model to many data sets. The significant improvement of this attempt was that it could translate signs in real time such that the model would only take 1.75 seconds to recognize a static sign. As a drawback of the approach, there were background color, brightness, and light intensity constraints.

All images taken as inputs should have the same background color and light intensity

Table 1: Sri Lankan Sign Language Translation Summary

Ref & Year	Features	Technology/Classifier	Recognition rate	Category
Rishan et al., 2022	20 gestures and poses	Leap Trainer SDK/NLU	78%-80%	Sensor-based
Perera & Jayalal 2021	20 static poses	CNN-SIFT	70%	Vision-based
Hettiarachchi & Meegama 2020	26 static poses	CNN	91.23%	Vision-based
Perera et al., 2020	20 static signs	CNN	99.34%	Vision-based
Dissanayake et al., 2020	27 static and dynamic gestures	CNN + RNN	90%	Vision-based
Kumar et al., 2020	247 static poses	RCNN	97%	Vision-based
Fernando & Wimalaratne, 2016	15 static and dynamic gestures	Kinect + CNN	92.4%	Sensor-based
Madushanka et al., 2016	150 static and dynamic gestures	ANN	94%	Sensor-based

Though the study was on the front line of real-time sign language translation, it was only designed to translate single-handed static signs. (Perera, Kulasekara & Gunasekara, 2020) The research was carried out in 2020 based on a combination of Artificial Neural Networks (ANN) and Support Vector Machines (SVM). The model was developed to identify 20 static signs. The approach used 50000 color images as the training data set, and the system could translate only single-handed static signs like the previous study. The recognition rate was lower

than in the previous research, but the performance rate was the same, with 3.54 validation accuracy and 99.34% training accuracy. The data set approach must use images with the same specs; otherwise, the model could not recognize them.

(Perera & Jayalal, 2021) A combined approach was taken to translate static signs in Sri Lankan sign language using CNN and SIFT with the objective of a low-cost, simple translator to achieve higher accuracy levels by using a small data set since using sensors was complex and costly and affected the

accuracy. The proposed approach recognized 20 static signs and used low-quality images as inputs. After training the model, it showed an 86.5% accuracy when considering 20 static signs. The study has common constraints when using image processing, such as background lighting, color, etc. As future improvements, the study can be improved to recognize dynamic signs with the help of combining facial expression recognition in SSL.

5. CONCLUSION

This paper presents a literature survey of the most up-to-date research published on the Interpretation of Sinhala Sign Language. It highlights the strengths and weaknesses of the discipline and analyses research work in terms of accuracy, technology, features, drawbacks, and future improvements. Two of three sensor-based studies have achieved more than 92% accuracy, while four of five vision-based have been completed with more than 90% accuracy. Six studies have used CNN to train the machine learning model and achieved more than 90% of accuracy. Compared to the sensor-based approach, the vision-based approach is non-invasive as the user is not required to wear any devices. Also, this approach enables capturing more data, such as facial expressions and body movement, which can aid in recognizing signs. High processing power and limitations such as lighting conditions, image quality, background color removal, and object detection (pre-processing) are the drawbacks of the vision-based approach. Sensor-based does not require higher pre-processing, and sensory data can be included as raw signals without the drawbacks of vision-

based approaches. But because of the many different sensors, they can be uncomfortable to wear and can affect the user's ability to sign. These sensors can cost more, use more space, and be less portable. These can limit the number of sensors we can use, thus restricting the range of movement it can capture. In conclusion, both vision-based and sensor-based approaches have their advantages and disadvantages in detecting sign language. The choice of approach depends on the specific requirements of the application, such as accuracy, ease of use, cost, and user comfort. A combination of both approaches may also be used to overcome the limitations of each approach and achieve better recognition accuracy. We believe that for more accurate sign gesture detection and real-time translation, it's more suitable to use a sensor-based approach.

Moreover, we recommend that readers focus on following a sensor-based glove approach as it has proven to be cost-effective and efficient in interpreting sign languages in other countries.

REFERENCES

- Department of Census & Statistics. (2012). Census of Population and Housing. *Ministry of Policy Planning and Economic Affairs - Sri Lanka.*, Retrieved from <http://www.statistics.gov.lk/Resource/en/Population/CPH 2011/CPH 2012 5Per Rp t.pdf>
- Dissanayake, I. S. M., Wickramanayake, P. J., Mudunkotuwa, M. A. S., & Fernando, P. W. N. (2020). Utalk: Sri Lankan Sign Language Converter Mobile App using Image Processing and Machine Learning. *2020 2nd International Conference on Advancements in Computing (ICAC), 1*,

LITERATURE REVIEW ON SIGN LANGUAGE TRANSLATION APPROACHES ON SINHALA SIGN LANGUAGE – A SURVEY

- 31–36. doi: 10.1109/ICAC51239.2020.9357300
- Fernando, P., Wimalaratne, P. (2016). Sign Language Translation Approach to the Sinhalese Language. *Springer Science and Business Media LLC in Gstf Journal on Computing (joc)Vol5*, pp 1-9. doi:10.7603/s40601-016-0009-8.
- Hettiarachchi, S.D. & Meegama, R.G.N. (2020). Machine Learning Approach for Real-Time Translation of Sinhala Sign Language into Text. *International Conference on Advances in Computing and Technology (ICTACT-2020) Proceedings- University of Kelaniya, Sri Lanka*. 23-25. Retrieved from <https://fct.kln.ac.lk/media/pdf/proceedings/ICTACT-2020/A-8.pdf>
- Madushanka, A. L. P., Senevirathne, R. G. D. C., Wijesekara, L. M. H., Arunatilake, S. M. K. D., & Sandaruwan, K. D. (2016). Framework for Sinhala Sign Language recognition and translation using a wearable armband. *2016 Sixteenth International Conference on Advances in ICT for Emerging Regions (ICTer)*, 49–57. doi:10.1109/ICTER.2016.7829898
- Manoj Kumar, D., Bavanraj, K., Thavananthan, S., Bastiansz, G. M. A. S., Harshanath, S. M. B., & Alosious, J. (2020). EasyTalk: A Translator for Sri Lankan Sign Language using Machine Learning and Artificial Intelligence. *2020 2nd International Conference on Advancements in Computing (ICAC), 1*, 506–511. doi:10.1109/ICAC51239.2020.9357154.
- Perera, H.K.K., Kulasekara, D.M.R., & Gunasekara. A. (2020). Finger spelled Sign Language Translator for Deaf and Speech Impaired People in Sri Lanka using Convolutional Neural Network. *13th International Research Conference - General Sir John Kotelawala Defense University*, 87-95. Retrieved from <http://ir.kdu.ac.lk/bitstream/handle/345/2930/FOC%2087-95.pdf?sequence=1&isAllowed=y>
- Perera, L.L.D.K.; Jayalal, S.G.V.S. (2021), Sri Lankan Sign Language to Sinhala Text using Convolutional Neural Network Combined with Scale Invariant Feature Transform (SIFT). *International Conference On Advanced Research In Computing (ICARC – 2021) - Sabaragamuwa University of Sri Lanka*. Retrieved from <http://repo.lib.sab.ac.lk:8080/xmlui/handle/123456789/1739>
- Rishan, R. M., Jayalal, S., & Wijayasiriwardhane, T. K. (2022). Translation of Sri Lankan Sign Language to Sinhala Text: A Leap Motion Technology-based Approach. *2022 2nd International Conference on Advanced Research in Computing (ICARC)*, 218–223. doi:10.1109/ICARC54489.2022.9754050
- Stone, A. & Rego, M. (2007). An Introduction to Sri Lankan Sign Language. *Rohana Special School*.



Preventing Ergonomic Hazards in Sri Lankan Private Sector: Identifying Incorrect Computer Posture using Deep Convolutional Neural Network and Mini Survey

Panduawala PKPG¹, Kumaradasa PP²

Department of IT, Faculty of Computing, Sri Lanka Institute of Information Technology.^{1,2}

pkpgpanduawala@gmail.com¹

Department of Pharmacology, Faculty of Medicine, University of Colombo.

pamodee.panchalee.k@gmail.com²

ABSTRACT

This study presents a solution to the long-term sitting problems faced by office employees through a mobile application that analyzes their sitting position and alerts them in real-time if a problematic posture is detected. The experiments were conducted using a deep convolutional neural network based on Keras, which accurately categorizes different sitting positions. The accompanying smartphone app provides real-time feedback, encouraging users to adopt a healthier posture and reducing their risk of repetitive stress injuries (RSI). The app also provides summaries of posture and activity over a set period of time. The trials showed a 95% accuracy in posture categorization and a significant reduction in time spent in incorrect postures, demonstrating the effectiveness of the mobile application in improving posture and reducing ergonomic hazards.

KEYWORDS Convolutional Neural Network (CNN), Long-Short Term Memory (LSTM), Posture, Position

1 INTRODUCTION

On average, office employees spend 75% of their day in a seated position, with over half of that time in a sedentary posture (Ishac & Suzuki, 2018). Desk-based workers are found to sit for approximately 9.95 hours a day and even outside of work, most adults spend 8.07 hours a day seated (Mattmann et al., 2007).

A dysfunctional spine, as a result of poor posture while sitting, leads to redistribution of weight and stress throughout the body, causing compensatory strain on the joints and leading to long-term discomfort and the development of osteoarthritis (Klibanski et al., 2001). Figure 1 illustrates the discrepancy between a healthy and unhealthy spine, emphasizing the importance of maintaining proper posture while seated.

This investigation aimed to determine if incorrect posture among

employees could be classified. To achieve this, a system architecture was proposed that combines machine learning techniques and computer vision services. The prediction model for each degree of incorrect posture was constructed using machine learning techniques, while the computer vision service was utilized to identify the incorrect posture of the employees.

The results indicated that the use of a Convolutional Neural Network (CNN) had the highest average accuracy of 95%, demonstrating the feasibility of constructing a prediction model for various levels of incorrect posture using information obtained from recorded video

The current study aims to highlight the importance of accurately analyzing incorrect posture and developing a predictive model for incorrect posture in a desk-based office setting through the utilization of regression analysis.

The paper is structured as follows: Section II provides an overview of related literature, Section III outlines three algorithms, Section IV presents the findings and discussion, while Section V offers final thoughts and conclusions. Finally, Section VI lists the reference materials utilized in the study.

2 RELATED WORKS

A range of solutions have been explored to the posture recognition challenge. However, the available solutions either demonstrate limited efficacy or are cost-prohibitive for widespread adoption. Initially, posture recognition research relied on visual information obtained from cameras, as described in studies published by Samieizounous et al., and Estrada and Veal (Alexey, 2011), as it represented a straightforward method. Currently, a depth camera is utilized to track the human skeleton and determine sitting posture based on the relative positions of the shoulder, hip, and knee joints.

The exponential growth of this industry has led to the creation of numerous mobile applications aimed at monitoring sitting and standing posture (Juang & Chang, 2007). A solution that leverages accelerometer readings from multiple spine sites integrated into smartphones, in conjunction with a web camera, to recognize sitting position and determine the positioning and distances of upper body parts has been proposed in the previous study. Several garment-based approaches for this technique can cause discomfort for the user as the sensors must be in close contact with the body. To obtain accurate recordings,

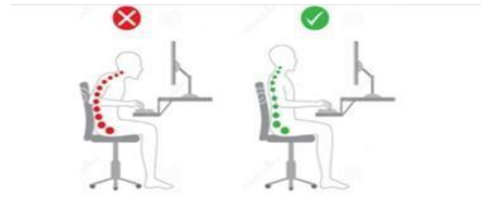


Figure 1: Bad Vs Good Posture

```
print("Number of entries in each category:")
print("training: ", x_train.shape)
print("testing: ", x_test.shape)
```

```
Number of entries in each category:
training: (24000, 2114)
testing: (6000, 2114)
```

Figure 2: Split dataset into training (80%) testing (20%)

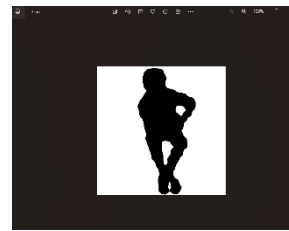


Figure 3: Image of the dataset

these solutions require a close-fitting garment and precise alignment between the body and sensors, which can lead to discomfort for the user. More recently, wearable sensors have been utilized for posture recognition, with studies employing acceleration sensors embedded in clothing to measure back-bending posture. (Samiei-Zonouz, Memarzadeh-Tehran, & Rahmani, 2014)

Both blind and known trials have demonstrated the efficacy of pressure sensing devices in accurately identifying and tracking posture (Estrada & Veal, 2017). A posture detection system based on pressure sensors was developed, emphasizing the need for an effective, low-cost, non-invasive solution. A recent study proposed a mobile application for posture monitoring that integrates CNN models with state-of-the-art deep learning techniques, as well as a mobile app to provide warnings and reports to users and healthcare providers.

3. METHODOLOGY

3.1 Dataset

The "DAISEE: Dataset for employees' incorrect posture in a desk-workbench environment" comprises of 9068 video clips collected "in the wild" from 112 participants using an HD webcam setup in figure 3 there is an example of the datasets. This dataset enables the tracking of natural variations in incorrect posture and was captured in diverse settings such as dorm rooms, a laboratory, and a library, under varying lighting conditions (light, dark, and neutral). The video collection pertains to several incorrect posture states.

3.2 Splitting the Dataset

A validation set was utilized to prevent overfitting of the network and to fine-tune the model's hyper parameters. The dataset consisted of 30000 preprocessed images with a size of 200 * 200 pixels. As shown in Figure 2, the dataset was randomized and divided into two parts: the training and testing sets. The training data values do not alter the model's weights but serve as a stopping point for the back-propagation algorithm, which is necessary for the equation to be treated as a figure and inserted into the text after the paper has undergone styling.

3.3 Build a CNN to take output.

In order to detect incorrect posture of employees in a desk-based environment, a CNN was designed with a accuracy of 95%. The model underwent ten epochs of training and was optimized using three different densities: 100, 50, and 10.

3.4 Build a LSTM to take the output

An LSTM model was developed to detect incorrect posture of employees in a desk-based scenario with an accuracy of 54.4%. The model underwent ten epochs of training to optimize its performance.

How many hours do you use the computer during a working day?
100 responses

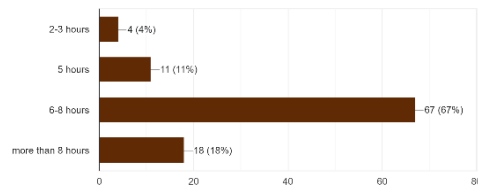


Figure 4: How many hours use the computer during the working days?

If not, do you like to be educated about it?
100 responses

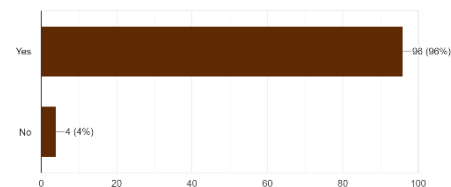


Figure 5: How many are knowing the proper when using the computer?

Do you know proper posture when using computer?
100 responses

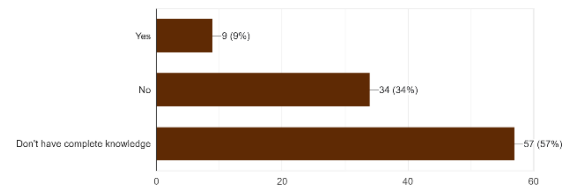


Figure 6: How many are like to have the knowledge about it?ss

4. RESULTS AND DISCUSSION

4.1 Mini Survey

The results of a mini survey with 100 participants were analyzed, with a gender distribution of 48% male and 52% female. The majority of respondents (96%) reported using a computer for more than five hours per day, as depicted in Figure 4. Additionally, 91% of participants stated that they lacked knowledge about optimal computer posture, as shown in Figure 5. The desireFor information about proper

posture was expressed by 96% of the survey participants, as illustrated in Figure 6.

Mini survey was used to recognize the knowledge, awareness and the amount of priority given regarding correct ergonomics while using the computer during working hours.

Analyzing the overall results of the mini survey indicated that there is a significant need to effectively and accurately identify incorrect posture patterns during computer use. The algorithm fulfills these criteria in identifying incorrect posture. Thus the output of the algorithm is useful for computer users and employers to minimize workplace health hazards.

4.2 Model Evaluation Outcome for CNN Classifier

The experiment utilized a validation split of 0.2, and the model was trained for ten epochs using a batch size of 50, which is the default value. The early stopping callback method was employed, and the density was set to 100, 50, and 10 for each validation loss within the model. The loss function of the model reached a saturation point of approximately 0.22 prior to completion of the 10 epochs, and the overall accuracy achieved a maximum of 95.4%.

4.3 Model Evaluation Outcome for LSTM Classifier

The use of three densities at the same time resulted in a 2% gain in accuracy for the LSTM model. Before completing 10 epochs, the loss function hit a plateau of 0.13, and the total accuracy was 54.4%. However, the accuracy and loss value acquired from the testing set cannot be used to determine the model's success. Figure 7

shows that epoch 10 had the best model accuracy.

The accuracy of the training set improved initially, however, it declined and stabilized over time. On the other hand, the accuracy of the testing set remained constant throughout the epochs. It should be noted that the final data point of the validation learning curve may not always correspond to the most accurate model. The investigation of the current study revealed that the model's accuracy was optimized at each epoch as depicted in Figure 8.

Figure 8 demonstrates the relationship between the loss function of the training and testing sets in a series of studies. The lack of progress in the validation loss function led to the adjustment of the patience parameter to 6 for each epoch. Due to the implementation of updated callbacks in the CNN model, the graph terminates at epoch 10 with the patience parameter set to 6.

In Figure 10, the loss function relationship between the training and testing sets in the LSTM model is presented. Similar to the CNN model, the validation loss function failed to show any progress, leading to the adjustment of the patience parameter to 1 for each epoch. The graph terminates at epoch 10 due to the updated callbacks in the LSTM model, with the patience parameter set to 1.



Figure 7: Accuracy graph: Training vs. Validation of CNN

PREVENTING ERGONOMIC HAZARDS IN SRI LANKAN PRIVATE SECTOR: IDENTIFYING INCORRECT COMPUTER POSTURE USING DEEP CONVOLUTIONAL NEURAL NETWORK AND MINI SURVEY

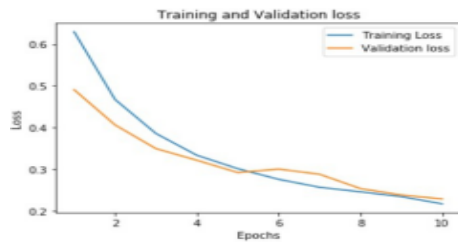


Figure 8: Accuracy graph: Training vs. Validation of LSTM

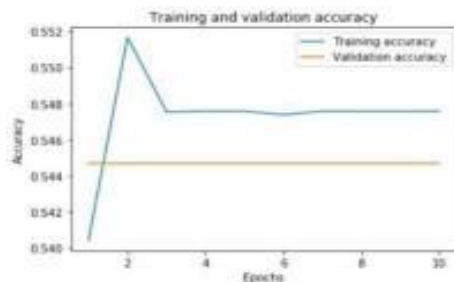


Figure 9: Loss graph: Training vs. Validation of CNN

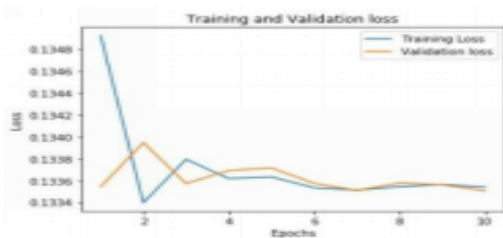


Figure 10: Loss graph: Training vs. Validation of LSTM

The deep learning Convolutional Neural Network (CNN) model outperformed the Long Short-Term Memory (LSTM) model, however it needed more training time and produced the most misclassified examples. The CNN model achieved a maximum accuracy rate of 95.4%.

5. CONCLUSION

A prediction accuracy of 95.46%, this study discovered that a Convolutional Neural Network (CNN) model is the best machine learning strategy for evaluating an employee's posture based on their sitting position. The study also looked at the link between posture state and the influence of sitting

position on posture quality and discovered that the deep CNN model provides a reliable and accurate platform for assessing various degrees of employee posture depending on sitting position.

REFERENCES

- Alexey. (2011, October). Sitting posture recognition with Kinect sensor. *CODE PROJECT*.
<https://www.codeproject.com/Articles/260741/Sitting-posture-recognition-with-Kinnect-sensor>
- Estrada, J., & Veal, L. (2017, November). Sitting posture recognition for computer users using smartphones and a web camera. In *TENCON 2017-2017 IEEE Region 10 Conference* (pp. 1520-1525). IEEE.
- Ishac, K., & Suzuki, K. (2018). A smart cushion system with vibrotactile feedback for active posture correction. In *Haptic Interaction: Science, Engineering and Design 2* (pp. 453-459). Springer Singapore.
- Juang, C. F., & Chang, C. M. (2007). Human body posture classification by a neural fuzzy network and home care system application. *IEEE Transactions on Systems, Man, and Cybernetics-Part A: Systems and Humans*, 37(6), 984-994.
- Klibanski, A., Adams-Campbell, L., Bassford, T., Blair, S. N., Boden, S. D., Dickersin, K., ... & Russell, W. E. (2001). Osteoporosis prevention, diagnosis, and therapy. *Journal of the American Medical Association*, 285(6), 785-795.
- Mattmann, C., Amft, O., Harms, H., Troster, G., & Clemens, F. (2007, October). Recognizing upper body postures using textile strain sensors. In *2007 11th IEEE international symposium on wearable computers* (pp. 29-36). IEEE.
- Samiei-Zonouz, R., Memarzadeh-Tehran, H., & Rahmani, R. (2014, June). Smartphone-centric human posture monitoring system.

In *2014 IEEE Canada International Humanitarian Technology Conference-(IHTC)* (pp. 1-4). IEEE.



Real-time Facial Expression Classification using ResNet-50

Supunthaka MGS¹, Arudchelvam T²

Department of Computing and Information Systems, Faculty of Applied Sciences, Wayamba University of Sri Lanka^{1,2}

sachinsupunthaka@ieee.org¹

arul@wyb.ac.lk²

ABSTRACT

Recognizing and understanding facial expressions are very important to understand the feeling of a person for continuing the discussion. It helps people in many ways such as a smooth relationship, avoiding conflicts, deciding whether to continue the conversation or not. Therefore, it would be better if there is a system that classifies facial expressions based on emotions. That will be very helpful for security, entertainment, and even for choosing the right feedback. This paper presents a method for real-time facial expression recognition based on the emotions of people using HAAR cascading classification for face identification and convolutional neural networks for expression classification. For classification, the ResNet-50 classifier with customized layers is employed. A system was designed using the model weights from the trained classifier. This system obtains the image of a face through a webcam and classifies the image based on the facial expression. Seven different human emotions, including anger, disgust, fear, happiness, sadness, surprise, and neutrality are successfully classified with an accuracy of 60%.

KEYWORDS: Convolutional Neural Networks, Facial expression Recognition, ResNet-50

1. INTRODUCTION

People can express their feelings instantly through their facial expressions. Studies on computer vision and artificial intelligence have found a substantial role in facial expression-based recognition techniques (Shan, Gong, & McOwan, 2009). While wearable sensors can be used for face recognition, It is more crucial and flexible to perform facial expression recognition with visual inputs without a physical link (Ko, 2018). The development of various intelligent systems over the past ten years has given the study of human-computer interactions a completely fresh outlook. Facial expressions allow them to communicate information relatively and instantly. A productive method for the use of facial expression recognition may be useful in various situations, including enhancing safety and auto customization

stages, facial recognition interviews, testing of video games, and other research conducted in psychology or marketing (Porusniuc et al, 2019).

Facial expression recognition aims to classify particular emotions by analyzing facial expressions (Hajarolasvadi & Demirel, 2020; Rajananda, Zhu, & Peters, 2020). Seven categories can be made from them: joyful, sad, afraid, furious, astonished, disgusted, and indifferent.

Researchers have followed different methods to develop FER systems. Ali, Hariharan, Yaacob, and Adom suggested the support vector machine (SVM) approach (Ali et al, 2015). The usage of the HAAR wavelet transform (HWT) approach was proposed by Evans (Lu & Evans, 2017). A brand-new approach combining stationary wavelet entropy

and the Jaya algorithm was presented by Phillips (Wang et al, 2018). The difficulty was that the original emotional information is likely to be lost, according to the analysis of the prior research. Additionally, these network models of generalization and robustness are poor, and the accuracy of recognizing facial expressions is low comparatively.

A better facial emotion recognition model was developed to address the issues as mentioned above. ResNet-50 serves as our network infrastructure. CNNs are utilized to extract features, and Batch Normalization and activation function ReLU is used to enhance the model's capacity for convergence. The expression of a human face expression will be categorized by the algorithm into one of seven expressions. The developed Model is then used to classify human faces in real-time using a webcam with the help of the HAAR Cascade Algorithm.

2. METHODOLOGY

2.1 Dataset

The FER2013 dataset from the Kaggle FER challenge was utilized to construct the FER system (Goodfellow et al, 2013). The FER2013 dataset contained 48x48 black and white photos. Images from the FER2013 dataset came in various scales, angles, and lighting conditions (Talegaonkar et al, 2019).

In the dataset, the training images and test images were stored in 2 different files which were named "train.csv" and "test.csv". "Emotion" and "Pixels" were two columns in train.csv. The emotion that was present in the image was represented by a numeric code in the "emotion" column that ranges from 0 to

6, inclusive. For each image, a string enclosed in quotes was presented in the "pixels" column. The values in this string were separated by spaces and were arranged in row-major order. Based on the labels on the data in the train.csv, the following graph in Fig 1 will display how each label is distributed among the different images.

2.2 Process of Realtime Facial Expression Recognition

There were three steps in the FER process. The preprocessing stage entails getting the input image frame ready so that it may produce effective results. The face was picked out of real-time photos in the face detection stage. Then the output was Readjusted based on the CNN weights, divides the input image into one of seven categories.

2.2.1 Pre-Process Input Data

The illumination, size, and color of the image, received by the FER system as input, may vary. Some pre-processing procedures were performed on the image to improve algorithm performance and accuracy. Three preprocessing techniques were employed in this work. They were grayscale conversion, normalization, and image scaling.

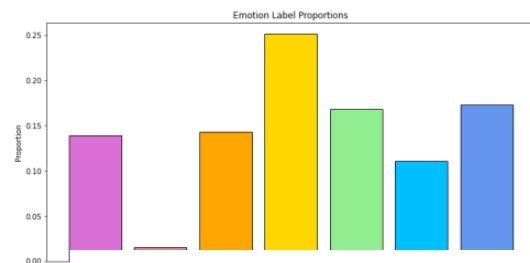


Figure 1: label distribution among training data

Table 1: Training parameters

Experient No	01				02			
Parameters	Optimizer	Initial Learning Rate	Max epochs	Batch size	Optimizer	Initial Learning Rate	Max epochs	Batch size
Value	Adam	1e-10	30	64	Adm	1e-10	60	64
Experient No	03 – Fine Tuned				04 – Fine Tuned			
Parameters	Optimizer	Initial Learning Rate	Max epochs	Batch size	Optimizer	Initial Learning Rate	Max epochs	Batch size
Value	Adam	1e-10	60	64	Adam	1e-10	100	64

- Normalization - Normalization is the process of removing lighting variations from an image to improve the face's appearance.
- Gray scaling - Gray scaling is done because colored images are challenging for processing algorithms.
- Resizing – The image is shrunk to eliminate any outside areas. As a result, less memory is needed, and computation speed is increased.

2.2.2 Face detection Algorithm

Identifying the face was the first stage in any FER system. The HAAR algorithm was applied to find the target (Talegaonkar et al, 2019). They practiced over a selection of both favorable and unfavorable facial images. HAAR cascades had shown to be a successful and very accurate method of object detection in photos. The HAAR characteristics, such as eyebrows, can be used to identify three dark areas on the face. The Modal was then trained to identify two dark areas on the face, and their location is

Determined using quick pixel calculation, which excludes unnecessary

background information. (Talegaonkar et al, 2019).

2.2.3 Trained Model

In this study, the ResNet-50 classifier is used as the input layer, and the output layer consists of 3 dense layers and the SoftMax layer.

The modal was trained and Fine-Tuned using GPU Instance on the Google Collab.

The output from the Resnet-50 model first went through a Batch Normalization process. It was used to normalize the production of the previous layers. The activations scale the input layer in normalization. This will help the learning become efficient and help to avoid overfitting. Then the layers are flattened the 3D vector into a 1D vector. This will serve as a connection between convolution and dense layers.

At the output level, the CNN is provided with four dense layers. The first three thick layers are used to scale the output layers, and the final dense layer

act as a SoftMax layer; it'll make the output sum up to one so that output can be interpreted as probabilities.

3. RESULTS AND DISCUSSIONS

3.1 Experimental Results

Based on the training data provided by the FER dataset, 17225 images were used as training dataset, 5742 images were used as validation dataset, and another 5742 images were used on the test dataset. The values of parameters used for training are presented below in Table 1.

Based on the results of the Confusion Matrix in Table 2 and 3, Experiments 1 and 2 provided the most successful results for happy and surprised facial expressions, but they also offered many faulty results.

data and validation data, some increase in the validation accuracy based on the image data augmentation used in training in Fig 2, and the model could benefit from additional epochs and fine Tuning. After fine-Tuning the model, it was observed that, based on Fig 3, the model performed better by providing a higher accuracy on the test data. Based on the results in Tables 4 and 5, we can observe that the model shows many accurate results after Fine tuning.

3.2 Real-time FER

Fig. 4 demonstrates the results of the FER. System. After the experiment, model weights were obtained from the trained CNN. This method was used to analyze each video frame separately, and real-time video was used for facial expression classification.

Table 2: Experiment 1 confusion matrix (accuracy 39%)

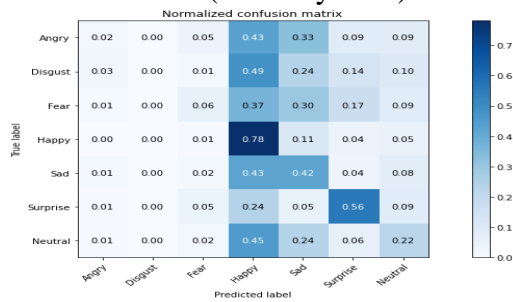


Table 3: Experiment 2 confusion matrix (accuracy 39%)

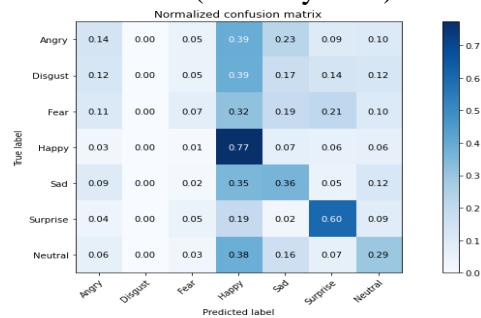


Table 4: Experiment 3 confusion matrix (accuracy 60%)

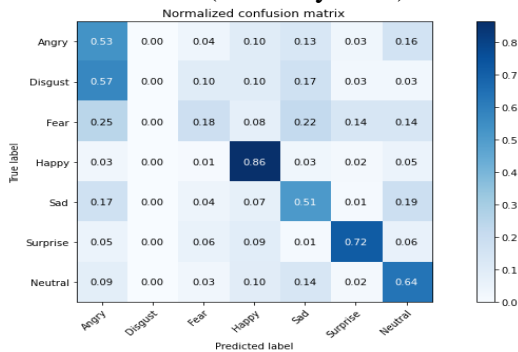
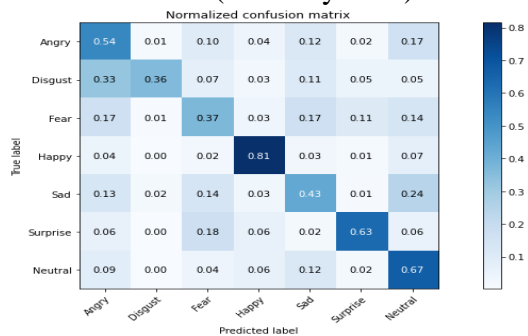


Table 5: Experiment 4 confusion matrix (accuracy 60%)



Based on the results on the graphs, there's slight overfitting on the training

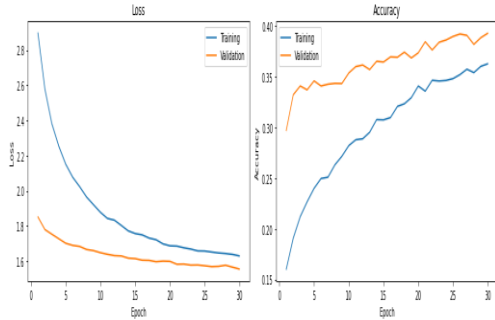


Figure 2: Loss and Accuracy Graph for the model at 30 epochs

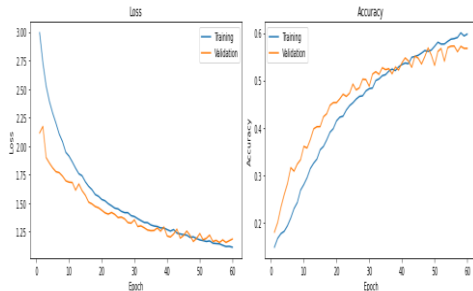


Figure 3: Loss and Accuracy Graph for Fined-tuned model at 60 epochs

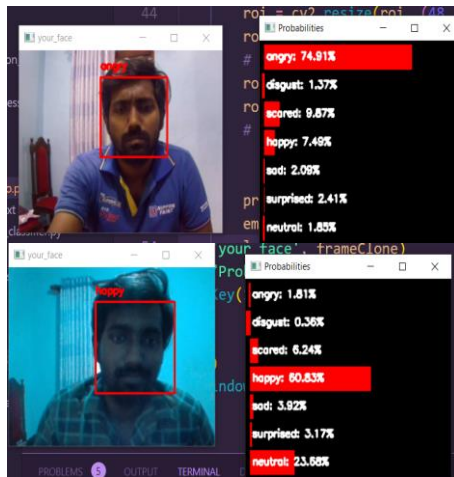


Figure 4: Results on Real time FER System

4. CONCLUSION

In this work, a method was presented for real-time facial expression recognition based on the emotions of the people using HAAR cascading classification for face identification and convolutional neural networks for expression classification. In the

experimental studies, 39% accuracy was first achieved with the developed model. In order to increase the overall accuracy, the CNN model was fine-tuned. It increased the accuracy up to 60%.

The faces on the images were found using the Viola-Jones algorithm and then the FER was done through the created CNN. This application was tested in real-time using a webcam and results were obtained in changing light and environmental conditions. The max error occurred between the fear and surprise classes because both share similar features. The error can be reduced by normalizing the dataset.

REFERENCES

Ali, H., Hariharan, M., Yaacob, S., & Adom, A. H. (2015). Facial emotion recognition based on higher-order spectra using support vector machines. *Journal Of Medical Imaging And Health Informatics*, 5(6), 1272-1277.

Goodfellow, I. J., Erhan, D., Carrier, P. L., Courville, A., Mirza, M., Hamner, B., ... & Bengio, Y. (2013). Challenges in representation learning: A report on three machine learning contests. In *Neural Information Processing: 20th International Conference, ICONIP 2013, Daegu, Korea, November 3-7, 2013. Proceedings, Part III* 20 (pp. 117-124). Springer berlin Heidelberg

Hajarolasvadi, N., & Demirel, H. (2020). Deep facial emotion recognition in video using eigenframes. *IET Image Processing*, 14(14), 3536-3546.

Ko, B. C. (2018). A brief review of facial emotion recognition based on visual information. *sensors*, 18(2), 401.

Lu, S., & Evans, F. (2017, March). Haar wavelet transform based facial emotion recognition. In *2017 7th International Conference on Education, Management, Computer and Society (EMCS 2017)* (pp. 342-346). Atlantis Press.

Porușniuc, G. C., Leon, F., Timofte, R., & Miron, C. (2019, November).

- Convolutional neural networks architectures for facial expression recognition. In *2019 E-Health and Bioengineering Conference (EHB)* (pp. 1-6). IEEE.
- Rajananda, S., Zhu, J., & Peters, M. A. (2020). Normal observers show no evidence for blindsight in facial emotion perception. *Neuroscience of consciousness*, 2020(1), niaa023.
- Shan, C., Gong, S., & McOwan, P. W. (2009). Facial expression recognition based on local binary patterns: A comprehensive study. *Image and vision Computing*, 27(6), 803-816.
- Talegaonkar, I., Joshi, K.R., Valunj, S., Kohok, R., & Kulkarni, A.H. (2019). Real Time Facial Expression Recognition using Deep Learning. *SSRN Electronic Journal*.
- Wang, S. H., Phillips, P., Dong, Z. C., & Zhang, Y. D. (2018). Intelligent facial emotion recognition based on stationary wavelet entropy and Jaya algorithm. *Neurocomputing*, 272, 668-676.



Sinhala Font Recognition Using Transfer Learning: Literature Review

Samarakoon JSMAN¹, Jayalal S²

Department of Industrial Management, Faculty of Science, University of Kelaniya, Sri Lanka^{1, 2}

samarako_im17065@stu.kln.ac.lk¹

shantha@kln.ac.lk²

ABSTRACT

In Sri Lanka, Sinhala is the primary language spoken by more than 75% of the population, and approximately 20% speak it as a second language. The Sinhala script is used for official and unofficial activities throughout the country, and many calligraphers have introduced various font styles. Recognizing and identifying different Sinhala font styles is critical in numerous use cases, including UX/UI design, Graphic design, page layout, handwriting recognition, document analysis, pattern recognition, and web development. However, distinguishing between font styles requires professional knowledge and almost inevitably leads to errors for those who cannot handle Sinhala fonts. The aim of this research review is to assess existing studies on font recognition systems and evaluate their effectiveness in order to propose an efficient and accurate Sinhala font recognition system that utilizes transfer learning to recognize and classify various Sinhala fonts with a high degree of accuracy. Transfer learning is a technique where a pre-trained model, trained on a large dataset, is fine-tuned for a specific task. The proposed font recognition system can be a useful tool for researchers and practitioners working in this area. The results of this research contribute to the advancement of the field of font recognition, enabling the development of more efficient and accurate font recognition systems for Sinhala and other languages. Ultimately, the successful development of a Sinhala font recognition system could facilitate more effective optical character recognition systems, document analysis, and other tasks requiring the recognition and classification of Sinhala fonts.

KEYWORDS: Sinhala Characters, Font Recognition, Deep Learning, Transfer Learning

1. INTRODUCTION

Font recognition has become an increasingly important task in the field of optical character recognition. It enables the improvement of optical text recognition rate and accuracy (Wang et al., 2018). The ability to identify and classify typefaces automatically in digital documents, images, and other multimedia content has many practical applications, particularly in the fields of graphic design, page layout, and handwriting identification. As such, font recognition is a rapidly growing area of research that has gained significant attention in recent years.

When it comes to Sinhala language, among other Asian languages (such as Arabic, Tamil, and Chinese), Sinhala characters are unique, mainly because they are round in shape and have mostly curves and dots. This uniqueness makes it difficult to create a model that can accurately detect and recognize Sinhala characters (Gunarathna, Chamikara & Ragel, 2021). Moreover, Sinhala characters have been made into numerous font styles., which present a significant challenge in recognising these fonts.

Users can recognise fonts by font similarity on a number of websites, including Identifont, MyFonts,

WhatTheFont, and Fontspring (Wang et al., 2015). Most of these websites are not capable of identifying Sinhala fonts, even though there are lots of applications and use cases in Sinhala font identification.

The aim of this research review paper is to provide a comprehensive analysis of the current state of research in font recognition to propose an efficient and accurate Sinhala font recognition system. Various approaches and techniques that have been proposed for Sinhala font recognition will be examined and their effectiveness and limitations will be assessed. The results of this research will contribute to the advancement of font recognition technology and provide a valuable insight for researchers and practitioners working in this area.

2. METHODOLOGY

The research methodology for Sinhala font recognition using transfer learning involves several steps. The first step is to develop a comprehensive search strategy that uses multiple databases and sources, such as Google Scholar, IEEE Xplore, Research Gate and Science Direct, to identify relevant studies. After the search strategy is executed, a set of relevant studies are selected based on the inclusion criteria of using transfer learning for Sinhala font recognition and the publication of relevant results. Once the relevant studies are identified, data is extracted from each study, such as the research design, methods, results, and conclusions. The quality of each study is then assessed using a predefined set of quality criteria, such as the use of a validated methodology and appropriate statistical analysis. The extracted data is then

synthesized and analyzed to identify patterns and trends in the existing literature. The final step is to draw conclusions based on the data synthesis, identify areas for future research, and make recommendations for future studies on Sinhala font recognition using transfer learning.

3. LITERATURE REVIEW

This research needs to answer two main research questions. Firstly, it is needed to identify the most prominent Sinhala fonts and determine the characters that need to be taken into account when creating the dataset. And need to design and develop a model that can effectively recognize Sinhala fonts based on the dataset.

Optical Character Recognition (OCR) is a software or system that allows computers to read characters that are either printed or handwritten. Typically, documents processed by an OCR system fall into one of three categories: mono-font, multi-font, or omni-font. Mono-font OCR considered only documents written in a certain font. Multi-font OCR systems considered only the subset of the fonts which are already available. While the Omni-font OCR technology can read characters from any fonts (Bharath & Rani, 2017).

(Li et al., 2022) introduces a model built on a convolutional neural network to identify different Chinese character font styles. 15 convolutional layers are present in this model. In order to effectively extract the classification features from the input image, the number of convolutional kernels was gradually increased for each layer. This research obtained 99.03% accuracy on

the 18-class NCFS (Nankai Chinese Font Style) dataset, which was created by them. According to the experimental findings, this outperformed the other six Convolution Neural Network (CNN) models, including ResNet, ShuffleNet, and GoogleNet, in terms of recognition accuracy.

(Bharath & Rani, 2017) Using support vector machines (SVM) and distance profile characteristics with respect to the left, right, and diagonal directions of a character image, a method for classifying font styles based on character images was proposed in this study. The primary objective of this study was to use font style recognition to lessen the complexity of generic OCR systems. Font styles employed for experimentation were Times new roman, Calibri, Cambria, Bodoni MT, Arial Narrow, Consolas, Arial, Arial black, Arial rounded MT bold, and Arial rounded MT bold. An input image is initially captured for processing before moving on to pre-processing and then being directed for feature extraction. Finally, an SVM classifier is used to classify the computed features. The technique they used leads to an average accuracy of 80%.

According to the (Chang, 2018) authors, the traditional OCR text recognition system's recognition rates are low, with many errors. And also, it cannot effectively identify the different text fonts. Therefore, the authors have proposed a CNN based recognition method that has a high recognition rate and high speed and is suitable for complex applications. Their dataset consisted of 200,000 Experimental data characters, of which 150,000 as training

data, and 50,000 as validation data. The method achieves a high recognition rate for the printed Chinese fonts.

(Wang et al., 2015) research builds up the first available large-scale Visual Font Recognition (VFR) dataset, named AdobeVFR, consisting of both labeled synthetic data and partially labeled real-world data with the aim of automatic font identification and similar font suggestion from an image. As the method of this VFR system for the Roman alphabet was based on the CNN. They named it as DeepFont. While depending on CNN's ability of learning, they had to deal with the mismatch between the training and testing data that was available. The inclusion of Stacked Convolutional Auto-Encoder (SCAE) based domain adaptation helps in the model's training to reach an accuracy of more than 80%.

Using the transfer learning method, (Hasan et al., 2022) represents a model for recognizing Bangla fonts from images. The authors trained five different transfer learning models to classify images into predefined font classes containing five different Bangla fonts. Train datasets contribute for 80% of all data collected. The remaining 20% is set aside for test data. 6500 raw images of five different fonts are used, with augmentation creating 26000 image data to train and 2600 images to validate the model. In the research, the authors have used a total number of 31200 of five classes to train the model. To assess accuracy, the confusion matrix of the various algorithms was compared. Three transfer learning models, VGG-16, VGG-19, and Xception, were used, and their performances were compared.

VGG-16 model has the highest accuracy of 96.23% among them.

(Vijayakumar & Vinothkanna, 2020) The proposed method is validated by classifying Times New Roman, Arial black, and Algerian font styles in English letters, as well as evaluating performance in terms of accuracy and confusion matrix parameters, and this font style classification algorithm is enforced with Capsule Network (CapsNet) algorithm for executing the font style classification task. The font classification algorithm based on CapsNet is intended to detect font style changes in a document or phrase. This leads to an intelligent proofing system for document verification. The dataset contains 702 font images, 468 of which are designated as training datasets and 234 as testing datasets. The images were preprocessed, the letters in the document or phrase are converted in to uppercase and tokenized. To determine the shape of a letter, the tokenized images are subjected to boundary estimation. The letter images were then transferred to various classifiers for comparison to the proposed CapsNet algorithm. The comparison performance result shows that the CapsNet-based algorithm outperforms the other 15 algorithms in terms of accuracy (96.15%), F1 score (97.8%), and geometric mean (94.58%).

(Mohammadian et al., 2022) this research proposed the first publicly available datasets in the field of Persian font recognition in this paper and used CNN to solve the Persian font recognition problem. The image shape in these two datasets is 224*224. The PTI SEG dataset's real images are in RGB color mode, while the mask images are in

grayscale colour mode. Persian font recognition based on CNN models in two parts. In part one, the authors used a CNN-based image segmentation model to remove the images' backgrounds. In part two, used another CNN model to predict the font typeface class on the images. The pipeline's final component is image classification, creation of a small CNN model with only 827K trainable parameters. The proposed pipeline achieved top-1 accuracy of 78.0% on their new datasets, 89.1% on the IDPLPFOD dataset, and 94.5% on the KAFD dataset.

(Chanda, Pal, & Franke, 2012) The study's goal is to devise a method for identifying ten different fonts for an Indian script (Bangla). The authors have followed two mechanisms to achieve the objectives as, line, word, and character segmentation and curvature-based feature extraction. Curvature-based features from segmented characters are extracted and fed into a SVM classifier. For each segmented character obtained from a document, the classifier determines the font type. The dataset is made up of 50 document images from each font type (500 document images in total). 100 of these 500 files were used for training (10 files from each font type). Extracted features from 85,695 segmented characters using those 100 training files. The remaining 400 images were used for testing purposes. When using a standard Gaussian Kernel SVM, the study achieved 94.00% accuracy at the document level. The study achieved 98.5% accuracy at the document level after employing an MKL SVM (Multi-Kernel Learning). (Chen et al., 2014) addresses the large-scale VFR problem,

which seeks to automatically identify the typeface, weight, and slope of text in an image or photo without knowledge of the content. This study makes use of a large-scale dataset with 2,420 font classes, which easily outnumbers the scale of most image categorization datasets in computer vision. The authors developed and tested two baseline algorithms: a representative font recognition algorithm on scanned documents and LLC, a widely used image recognition algorithm. The core algorithm is based on local feature embedding, local feature metric learning, and max-margin template selection, which lends itself naturally to NCM and thus such open-ended classification problems. The authors face challenges with the algorithm as in cases of decorated texts, very low-resolution, extremely noisy input, and very cluttered backgrounds. Considering all of these challenging factors in real-world VFR, this study's top 1 accuracy is 52.61%.

(Wang et al., 2018) proposed a novel method based on deep learning and transfer learning to address the more difficult task of accurately recognizing the font styles of texts in natural images. The study carried out in the three main steps. First, the authors created a fast and scalable system for generating vast amounts of natural images with text in various fonts and styles, which are then used to train the deep neural network for font recognition. Second, a transfer learning scheme was developed to address the domain mismatch between synthetic and real-world text images. Finally, constructed a benchmarking database of numerous labelled natural images with Chinese characters in 48 fonts. The dataset contains approximately

30,000 images from the dataset with labels whose backgrounds are overly cluttered. Their font classifiers were constructed by modifying two famous CNN models, AlexNet and VGG16.

4. CONCLUSION

The literature review on Sinhala font recognition using transfer learning provides insight into the potential of transfer learning for improving the accuracy of character recognition tasks, including Sinhala font recognition. Transfer learning leverages the knowledge learned from one task to improve performance on another task. It is particularly useful when there is limited labeled data available for the target task.

Several studies have shown that transfer learning can be effectively applied to font recognition by fine-tuning pre-trained deep neural networks on font datasets. These networks, such as VGG, ResNet, and Inception, have achieved high accuracy results in recognizing Sinhala fonts and characters. In comparison to traditional machine learning algorithms, these methods have demonstrated improved accuracy in font recognition. However, the literature also highlights some challenges in applying transfer learning to Sinhala font recognition. One of the major challenges is the similarity of Sinhala characters, which results in a large number of font variations for each character. This variability makes it difficult to accurately recognize Sinhala characters and fonts.

In conclusion, while there have been many studies on font recognition for various languages, there is currently no research available for the Sinhala

language. This presents an opportunity for further investigation and development in this area, and it is important to address this gap in the current context.

REFERENCES

- Bharath, V., & Rani, N. S. (2017, August). A font style classification system for English OCR. In *International Conference on Intelligent Computing and Control (I2C2)* (pp. 1-6). Coimbatore, India.
- Chanda, S., Pal, U., & Franke, K. (2012, November). Font identification - In context of an Indic script. In *Proceedings of the 21st International Conference on Pattern Recognition (ICPR2012)* (pp. 1-6). Tsukuba, Japan.
- Chang, Y. (2018, May). Chinese font recognition based on convolution neural network. In *2018 3rd International Conference on Automation, Mechanical Control and Computational Engineering (AMCCE 2018)* (pp. 562-566). Atlantis Press.
- Chen, G., Yang, J., Jin, H., Brandt, J., Shechtman, E., Agarwala, A., & Han, T. X. (2014, June). Large-scale visual font recognition. In *2014 IEEE Conference on Computer Vision and Pattern Recognition* (pp. 1-8). Columbus, OH, USA.
- Gunarathna, G. I., Chamikara, M. A. P., & Ragel, R. G. (2021, January). A fuzzy based model to identify printed Sinhala characters. In *2021 6th International Conference on Information Technology Research (ICITR)* (pp. 1-6). Moratuwa, Sri Lanka.
- Hasan, S., Rabbi, G., Islam, R., Bijoy, H. I., & Hakim, A. (2022). Bangla font recognition using transfer learning method. In *IEEE Conference on Artificial Intelligence* (pp. 1-6). Nepal.
- Li, X., Wang, J., Zhang, H., Huang, Y., & Huang, H. (2022). SwordNet: Chinese character font style recognition network. *IEEE Access*, 10, 1-7.
- Mohammadian, M., Maleki, N., Olsson, T., & Ahlgren, F. (2022, May). Persis: A Persian font recognition pipeline using convolutional neural networks. In *2022 12th International Conference on Computer and Knowledge Engineering (ICCCKE)* (pp. 1-6). Mashhad, Iran, Islamic Republic of.
- Vijayakumar, T., & Vinothkanna, R. M. (2020). Capsule network on font style classification. *Journal of Artificial Intelligence and Capsule Networks*, 2(2), 64-67.
- Wang, Y., Lian, Z., Tang, Y., & Xiao, J. (2018). Font recognition in natural images via transfer learning. In *MultiMedia Modeling* (pp. 229-240).
- Wang, Z., Yang, J., Halin, J., & Shechtman, E. (2015, October). DeepFont: Identify your font from an image. In *ACM Multimedia 2015* (pp. 1-8)



Software Development Trend Prediction: a survey

Rasingolla RWMLSB¹, Shantha Jayalal²

Department of Industrial Management, Faculty of Science, University of Kelaniya, Sri Lanka^{1,2}

rasingol_im17063@stu.kln.ac.lk¹

shantha@kln.ac.lk²

ABSTRACT

Software development is the discipline of designing, developing, and testing software products. The software industry has grown significantly more within the last two decades. This growth is due to several factors, including the increased reliance on technology in businesses and everyday life, the growth of the internet and mobile devices, and the increasing availability of affordable and user-friendly software. Trend prediction in software development refers to the process of forecasting the direction and magnitude of changes over time in the software development domain. Trend prediction can help businesses and organizations make informed decisions, gain competitive advantage, and better resource planning by identifying and understanding which technologies and tools will likely become more critical. Further, it helps software developers to stay up to date with the upcoming deviations in the domain. This study evaluates the most up-to-date research work published related to software development trend prediction. The authors surveyed the existing methodologies for software trend prediction, identified their challenges and inaccuracies, and identified possible improvements that can be made in the domain. The research studies were analyzed in terms of methodologies used, the type of data required, and the type of predictions provided. The findings of this study will be beneficial for many parties involved with the software development domain, including scholars who are researching related domains. This survey aims to observe existing software development trend prediction methodologies, identify their knowledge gaps, and brief existing knowledge for the reference of future research.

KEYWORDS: Software development, Information technology, Trend prediction,

1 INTRODUCTION

Information Technology (IT) is one of the fastest-growing industries in the world. The high growth rate of the IT industry can be seen clearly due to globalization. Some countries such as the United States, India, and China are ahead of the game. One major industry group within the IT sector is software and services. The software and services sector is made up of internet services as well as companies that provide software development services and IT services. There is mutual dependability between the industry and the people who are working in the industry. The people working in the IT industry depend on the

industry, and the future movements of the industry rely on the people contributing to the industry/domain. Therefore, industry movements or trends are significant for those who are working and contributing to the industry. Even experienced workers in the industry

May find it challenging to keep up with this rapid evolution. The fast growth of the software development industry has brought its own set of challenges. Software developers struggle to keep up with the rapid growth of the industry. Some companies lay off employees who are unable to keep up with the growth of the industry. Companies are seeking

candidates who are competent with upcoming technologies. These are some of the challenges faced by existing employees and those who are seeking to join the industry. They need to keep an eye on upcoming trends in the software development domain. Predicting upcoming trends is a feasible solution for the above-mentioned challenges that can be provided from an academic perspective. Hence, the authors are aiming at briefing the existing knowledge of software development trend prediction and identifying room for improvement in the existing domain knowledge through this survey.

2 METHODOLOGY

The methodology of the literature review consists of several steps. The following steps were followed for the literature review.

- Define research topic
- Locate information
- Evaluate and utilize information
- Synthesis

The first step was defining the topic with clear boundaries and identifying specific keywords related to the research topic. Then the possible sources were identified that might contain the information required. Some of them were Google Scholar, Research Gate, Z-Library, Science Direct, IEEE, and Scopus. Software development, trend prediction, and information technology trends are some major keywords used to search research studies. Then, the located information was evaluated based on its accuracy, authority (reputation of the source), objectivity (purpose of information), and coverage (does it

provide the required information?). Further, we tried to collect as much recent information as possible. Finally, the filtered information was organized and integrated into the literature content.

3 LITERATURE REVIEW

3.1 Trend prediction

Trend prediction is a technique used in different domains for forecasting purposes. It is also a common approach that can be seen in research. Trend prediction approaches can be categorized into two main categories known as qualitative and quantitative, according to the study 'a quantitative model for software engineering trends' was done in 2011. Qualitative approaches are based on expert opinions, and qualitative assessments and quantitative methods are based on factual numerical data and statistical analysis. Further, this research emphasizes that qualitative approaches can be subjective and prone to error. Therefore, a quantitative approach has been introduced by this research. Recent research projects tend to use quantitative approaches such as Machine Learning (ML). Further, this research includes two approaches to modeling the evolution of software engineering trends. The top-down approach takes a generic evolutionary model and specializes in software engineering, and the Bottom-up approach builds specific evolutionary models from empirical historical data. (ArfaRabai, Bai and Mili, 2011). Another research done in 2013 regarding time-series-based technology intelligence framework trend prediction indicates that the data used in expert-based and qualitative approaches are influenced by the subjective opinions of experts (Chen, Zhang, and Lu, 2013). There are different

types of time series forecasting methods and techniques available. Time series forecasting is a crucial area in machine learning. Various machine learning models are available such as regression, neural networks, support vector machines, random forests, and XGBoost, for this purpose. A recurrent neural network was among the most popular due to its high accuracy. Later, this method was replaced by the Long Short Term Memory (LSTM) due to the vanishing gradient problem. LSTM is able to model long-term dependencies better than traditional RNN models (Varuna & Mohan, 2019). Time series forecasting methods are common in trend prediction. Varuna and Mohan (2019) have done a software engineering trend prediction study using time series forecasting. Time series can be divided into two approaches, univariate time series, and multivariate time series, depending on the number of features. This research has used multivariate time series forecasting to incorporate multiple input parameters for prediction. The prediction uses Long Short Term Memory (LSTM) model, which can be used for multivariate time series forecasting (Varuna and Mohan, 2019).

3.2 *Trend prediction using text mining*

Text mining is a branch of Artificial Intelligence (AI) that uses Natural Language Processing (NLP) to make unstructured data into usable structured data. Text mining is extracting information or patterns previously unknown from unstructured textual data, such as natural language text. (Hassani et al., 2020). The goal of text mining, also known as text data mining and text analytics, is to examine textual

documents, such as emails, reviews, plain texts, web pages, reports, and official documents, to extract data, transform it into information, and make it useful for different types of decision-making (Bach et. al., 2019). Further trend predictions can be made based on the extracted data. Text mining has become crucial due to the expansion of the Internet and the vast volumes of text data it contains (Morris, 2021).

3.3 *Related research findings*

In 2019, a trend prediction of GitHub was conducted using a time series analysis. Trend prediction has been categorized into three main tasks in this research. Repository trend prediction, programming language trend prediction, and domain trend prediction. GitHub events such as create, fork, pull request, push, and issue were used for trend prediction. The basic principle of using events is that a repository's popularity is proportionate to its number of events. GitHub data from 2015 to 2018 was used for this analysis. A vital aspect of this research is using five events with multivariate time series analysis, unlike the traditional system, which takes only one event. A drawback of this research is that it does not consider interconnections among programming languages, domains, and repositories. Further, this research has not addressed other factors that could impact the trends apart from the features available on GitHub (Varuna & Mohan, 2019).

Identifying current trends in programming languages is essential as an initial step for future language trend prediction. The research (Orlowska et al., 2021) was carried out on the usage-based statistical analysis of programming

languages. This research discovers current trends in programming languages and their evolution. A highlight of this research is using two data sources, GitHub and StackOverflow, for analysis. This study has used a linguist library to detect languages in codebases. The main two findings of this research are current programming language trends and interoperability of languages. Language interoperability is a new feature addressed by this research. But the research findings were limited to current trends.

In 2020, research (Dayananda & Jayalal, 2020) was carried out regarding software development trend prediction using stack overflow text mining. The StackOverflow question dataset was used for data analysis. The main findings of this research are programming language trends and a classification and prediction model for trend prediction. Multiple machine learning algorithms have been tested for stack overflow post-classification. After classifying posts, trends were predicted using time series techniques. The main prediction in this research is the programming language trend prediction for 2019. Ten programming languages were considered. The data analysis was done using a part of the stack overflow dataset. The prediction has conducted with exponential smoothing using Microsoft Excel. (Dayananda & Jayalal, 2020).

3.4 Knowledge gaps in the domain

Software development trends can be identified with different criteria. Varuna and Mohan, (2019) have used GitHub to predict programming language trends, domain trends, and repository trends. Many previous research projects have

considered language trend prediction a criterion under software development trends (Dayananda, Jayalal, 2020) & (Orlowska et al., 2021). But many other predictions can be made in this domain, such as frameworks, development tools, models/methodologies, etc. (Dayananda & Jayalal, 2020) Software development libraries and frameworks often influence programming language trends. There are different types of frameworks available for different purposes. Some of them are web, frontend, mobile, backend, and data science frameworks. Frameworks are becoming popular and widely used in software development. The usage of frameworks is increasing due to factors such as extensibility, flexibility, portability, reliability, and scalability (Schmidt, Gokhale & Natarajan, 2004).

Further, using frameworks to speed up and simplify programming operations is becoming more popular (Ochs & Waidner, 2014). Therefore, frameworks can be considered important in software development trend prediction. However, none of the previous research considered frameworks as predictive elements.

The research (Dayananda & Jayalal, 2020) has used a questions dataset of stack overflow that contains only the questions asked by the users. The question tags dataset in stack overflow also can be used for trend prediction (Orlowska et al., 2021) But there are other types of datasets available in the stack overflow data collection such as Answers, Badges, comments, users' detail that can be used for further analysis (Dayananda & Jayalal, 2020). Using only the questions dataset reflects the number of times that a specific language has been used or mentioned.

But there might be other factors that could influence the programming language trends. The research (Chen et al., 2005) indicates several factors, such as institutional support, industrial support, government support, organizational support, grassroots support, and technology support, that could influence the programming language trends. The grassroots support or the support given by the ordinary programming community is an important factor among them (Chen et al., 2005). Integrating these types of different aspects might improve prediction accuracy as well. Above are some gaps and possible improvement areas in which this study can be navigated. The authors expect future researchers to get an overall understanding of the domain knowledge through this survey and expand the domain knowledge into untouched territories.

4 CONCLUSION

The significance of predicting software development trends and the different methodologies available for that were discussed in the study. The dynamic behavior of the domain makes it difficult to predict upcoming trends, even with the latest technologies. The challenges of making predictions and the inaccuracies of existing methodologies were identified in order to discuss possible improvements that can be made in the current domain knowledge.

REFERENCES

- ArfaRabai, L. ben, Bai, Y. Z., & Mili, A. (2011). A quantitative model for software engineering trends. *Information Sciences*, 181(22).
- Bach, M. P., Krstić, Ž., Seljan, S., & Turulja, L. (2019). Text mining for big data analysis in financial sector: A literature review. *Sustainability*, 11(5), 1-27.
- Chen, H., Zhang, G., & Lu, J. (2013, October). A time-series-based technology intelligence framework by trend prediction functionality. In *2013 IEEE International Conference on Systems, Man, and Cybernetics* (pp. 3477-3482). IEEE.
- Chen, Y., Dios, R., Mili, A., Wu, L., & Wang, K. (2005). An empirical study of programming language trends. *IEEE software*, 22(3), 72-79.
- Dayananda, W. D. M. S., & Jayalal, S. (2020). *An approach for predicting future trends in software development domain using text mining on Stack overflow*.
- Hassani, H., Beneki, C., Unger, S., Mazinani, M. T., & Yeganegi, M. R. (2020). Text mining in big data analytics. *Big Data and Cognitive Computing*, 4(1).
- Morris, T. (2021). Using Text Mining And Machine Learning Classifiers To Analyze Stack Overflow.
- Ochs, C., & Waidner, E. M. (2014). *EmErgingTrEnds in softWareEdEvElopmEnT&implicaTions for iTsEcuriTy: anExploraTivEsTudy*. Retrieved from <https://www.sit.fraunhofer.de.html>
- Orlowska, A., Chrysoulas, C., Jaroucheh, Z., & Liu, X. (2021, March). Programming Languages: A Usage-based Statistical Analysis and Visualization. In *Proceedings of the 4th International Conference on Information Science and Systems* (pp. 143-148).
- Schmidt, D. C., Gokhale, A., & Natarajan, B. (2004). Frameworks: Why they are important and how to apply them effectively. *ACM Queue magazine*, 2(5).
- Varuna, T. V., & Mohan, A. (2019, July). Trend Prediction of GitHub using Time Series Analysis. In *2019 10th International Conference on Computing, Communication and Networking Technologies (ICCCNT)* (pp. 1-7). IEEE



Stress Detection of Employees using Image Processing and Machine Learning

Jayasekara MHCO¹, Arudchelvam T²

Department of Computing and Information Systems, Faculty of Applied Sciences, Wayamba University of Sri Lanka^{1,2}

chithmijayasekara@gmail.com¹

arul@wyb.ac.lk²

ABSTRACT

Stress is a common experience for many people. In fact, millions of employees who have been working in front of a computer for a longer duration say they feel stress during working hours. Stress contributes to nervousness, poor sleep, high blood pressure, muscle tension, and excess worry. Therefore, if there is a system to detect stress, it is very helpful to people. Specially, if we could detect whether an employee is stressed, it would be easy for the company as well. The main goal of this paper is to detect stress in employees with the help of image processing and machine learning techniques. Facial expressions are very important for detecting emotions in the face. There are eight universal facial expressions, which include: neutral, sadness, happiness, contempt, disgust, anger, fear, and surprise. Based on the emotions captured from video images, the stress level will be calculated. The emotion recognition techniques and classifier techniques will be used to classify stress based on emotions. The model is built using a combination of image processing techniques and convolutional neural networks (CNN) to detect stress. The stress level will be calculated with the help of eyebrow and lip contractions. This paper will be a great help to manage stress and working hours effectively and is also beneficial for employers to get the best out of employees throughout the working hours.

KEYWORDS: Emotion Recognition, CNN Classifier, Stress Detection, Deep Learning

1. INTRODUCTION

Nowadays, computers have become a way of life; much time is spent on them, so we are more affected by the ups and downs that they cause. Monitoring the emotional status of a person who is working in front of a computer for a longer duration is crucial for the safety and health of that person. Employees who are working in an organization, especially in software houses or IT sectors, must work on computers the whole day, sitting in a particular cabin. This emerging situation has become a challenge to human health and life quality because of the nature of work, targets, achievements, night shifts, and overwork. Hence, the detection of stress

before it becomes a heinous problem is significant.

In this research, we enhance a stress detection system based on the facial expressions for the seven basic emotions (angry, happy, sad, fear, surprise, disgust, and neutral). A human face can convey countless emotions without saying a single word, and it is a form of non-verbal communication. The proposed system includes capabilities that overcome the limitations of existing systems. The images used are captured in real-time mode and processed with the help of a machine learning algorithm.

2. RELATED WORKS

To understand the existing processes, a deep review of equivalent research has been done as a guideline for developing this project and minimizing the problems faced.

(Raichur, Lonakadi & Mural, 2017) developed a monitoring system for detecting emotional stress in a person working continuously in front of a computer. The proposed system integrates image processing and deep learning to detect stress. In this work, real-time, non-intrusive videos are captured, that detect the emotional status of a person by analyzing their facial expression

(Patil et al., 2020) also introduced a stress detection system to predict stress in the employees by monitoring captured images of authenticated users, which makes the system secure. The image capturing is done automatically when the authenticated user is logged in based on some time interval, and then the traditional survey forms will be given to the employees. The captured images are used to detect the stress of the user based on some standard conversion and image processing mechanisms.

As proposed by (Priya, Garg & Tigga, 2020), machine learning algorithms are used to predict anxiety, depression, and stress in modern life. In this paper, five machine learning algorithms were applied to determine five different severity levels of anxiety, depression, and stress. Subsequently, five different classification techniques were applied: Decision Tree (DT), Random Forest Tree (RFT), Naive Bayes, Support Vector Machine (SVM), and K-Nearest

Neighbor (KNN). Giannakakis G. et al. (2017) developed a framework for the detection and analysis of stressful and anxious emotional states through video-recorded facial cues. (Tanev et al., 2014) worked on a Naive Bayes classifier to detect mental stress in humans using linear and non-linear heart rate using ECG.

3. METHODOLOGY

35887 images of faces were acquired from Kaggle and classified into seven classes. The emotion field from the dataset consists of seven emotions: happy, neutral, angry, sad, fear, surprise, and disgust, with labels 0 to 6.

3.1 Image preprocessing

Image preprocessing is the most specific step for face recognition. OpenCV is a library that is mainly focused on image processing. There are multiple factors that are used to improve the performance of CNN.

3.2 Data augmentation

Expanding the training data by using transformations like horizontal flips, zooms, shifts, and rotations. The ImageDataGenerator class in Karas is used to augment images. This helps create more data to train and validate our model and prevent overfitting.

3.3 Data balancing

After the preprocessing steps, images are labeled into seven different classes: angry, happy, sad, fear, surprise, disgust, and neutral. The chosen dataset cannot be balanced; its distribution to all known classes may discriminate against them. Therefore, it has to be balanced. There are some strategies for data balancing. They are oversampling,

undersampling, and boosting. Here, oversampling is used to increase the sampling rate.

3.4 Proposed method

The proposed solution includes a proper way to detect stress in employees using eyebrow and lip movements. The model was created with the help of machine learning algorithms. After the preprocessing step, a proper algorithm was selected for the model's development. Machine learning algorithms come in many versions. There are mainly three types of machine learning models: supervised learning, unsupervised learning, and reinforcement learning. Classification algorithms and regression algorithms fall under the umbrella of supervised learning. Deep learning is a subset of machine learning. The Convolutional Neural Networks (CNN) architecture in sequential mode is used for image stress detection because it allows for layer-by-layer model construction.

First, start with initializing the model by specifying it as a sequential model. This model architecture contains two 2D convolution layers with a number of filters, a kernel size, and a "relu" (Rectified Linear Unit) activation function. Adding relu ensures that all the negative values are not passed on to the next layer. Filters means the number of convolution filters the convolution 2D layer should create, kernel sizes means the size of the kernel matrix of our convolution, and additionally, we pass input shape: the dimension of the input image. The first layer is followed by batch normalization, maxpooling, and dropout layers, respectively.

There are three types of pooling methods available in Keras: max pooling, min pooling, and avg pooling. We used the Max Pooling layer. So that it easily detects the object and does not focus on the background. Figure 4 indicates the CNN model text diagram. To overcome overfitting, we used a drop-out layer. On passing a dropout of 0.25, 25% of nodes are dropped out randomly from the network.

In between the Conv2D layer and dense layer there is a flatten layer. It usually acts as a bridge between the Conv2D layer and dense layer and provides the output to the dense layer. Dense layers are the ones that are used for the output layer. The activation used is "SoftMax", which gives a probability for each class and makes the output sum up to one. After the creation of the Softmax layer, the model is prepared. Next, we compiled our model. Fig. 1 explains the CNN model using a simple text diagram.

- Conv -> Conv -> BN -> MP -> DO
- Conv -> Conv -> BN -> MP -> DO
- Conv -> Conv -> BN -> MP -> DO
- Conv -> Conv -> BN -> MP -> DO
- Flatten
- Dense -> DO
- Dense -> DO
- Dense -> DO
- Dense
- Output Layer

Figure 5: CNN model text diagram

RESULTS AND DISCUSSIONS

About 80% of the data is used to train the model, 10% of the data is used for validation, and 10% of the data is used to test the model. There are 35887

images used for this research as the dataset. Fig. 2 indicates the distribution of emotions, which are the main focus of the study.

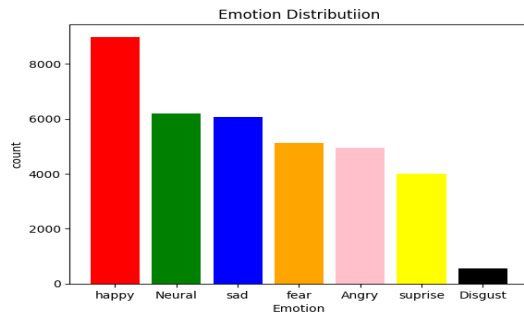


Figure 2: Emotion distribution

To obtain this system, there are a few stages to go through. The first step is to take already existing CNN algorithms and test them in order to obtain the test results. Here, we trained and tested the dataset with several CNN architectures, such as LeNet, AlexNet, VGGNet, ResNet, and Xception. These models were checked with the same hyperparameters, like batch size and steps per epoch, as all the others. Architecture of CNN was studied first before creating a model. Then it was used to compare them with each other to select the best model with the highest accuracy. When the batch size increases, it will increase the accuracy as well. According to the training results, steps per epoch have little effect on final results.

In the next step, a neural network is made using a CNN algorithm. Although the CNN can show great success rates, it is still hard to generate them. Therefore, due to this being a problem, the accuracy obtained was about 80%. This research discusses the most suitable machine learning model for real-time stress detection using emotion recognition. In

this model, accuracy is the fraction of the predictions the model got right. Figure 3 and 4 indicate the accuracy and loss graphs for training and validation, respectively.

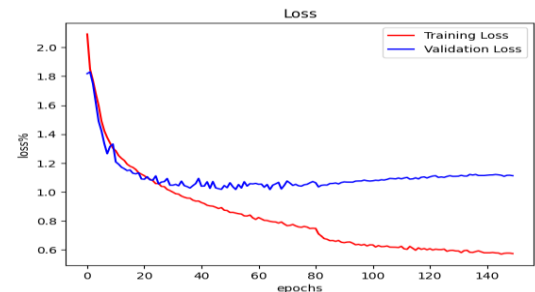


Figure 3: Loss Vs. Validation loss graph

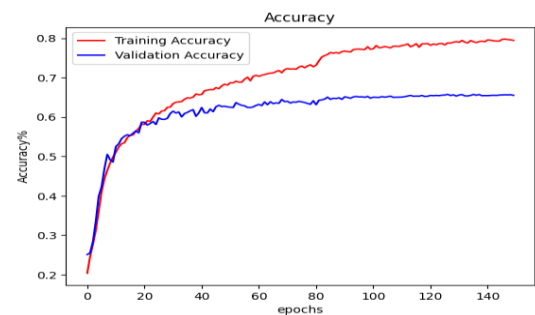


Figure 4: Accuracy Vs. Validation accuracy graph

After finishing the implementation of the model, the effectiveness of the model was recognized. There are different evaluation matrices. A confusion matrix is a classification evaluation matrix that is used to measure the performance of classification problems where output can be from two or more classes. The confusion matrix was identified with the help of the `confusion_matrix()` function of sklearn. Fig. 5 indicates the confusion matrix which plotted using Scikit-Learn and Matplotlib: It tabulates the correct predictions vs. incorrect predictions for seven categories.

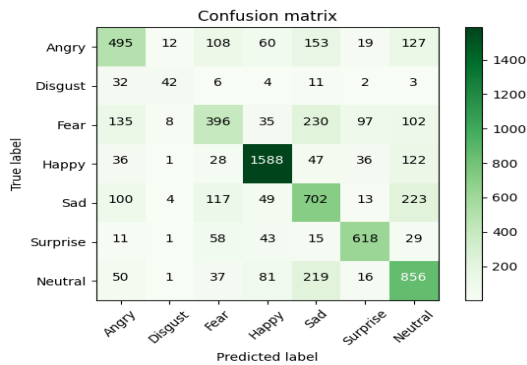


Figure 5 Confusion matrix of the model for the seven classes

4. CONCLUSION

The main goal of this study is to accurately measure the employees stress level and conclude whether the employees are stressed or not. This research has experimented with using deep learning techniques within the CNN model for identifying facial emotions in order to detect stress. This research has improved the background needed to understand image processing concepts, neural networks, convolutional neural networks, and emotion recognition via a webcam.

A system is developed to detect the stress of employees using image processing techniques and machine learning and the model is successfully tested as well.

REFERENCES

- Giannakakis, G., Pedititis, M., Manousos, D., Kazantzaki, E., Chiarugi, F., Simos, P. G., ... & Tsiknakis, M. (2017). Stress and anxiety detection using facial cues from videos. *Biomedical Signal Processing and Control*, 31, 89-101.
- Patil, A., Mangalekar, R., Kupawdekar, N., Chavan, V., Patil, S., & Yadav, A. (2020). Stress detection in IT professionals by image processing and machine learning. *International Journal of Research in Engineering, Science and Management*, 3(1).

Priya, A., Garg, S., & Tigga, N. P. (2020). Predicting anxiety, depression and stress in modern life using machine learning algorithms. *Procedia Computer Science*, 167, 1258-1267.

Raichur, N., Lonakadi, N., & Mural, P. (2017). Detection of stress using image processing and machine learning techniques. *International journal of engineering and technology*, 9(3), 1-8.

Tanev, G., Saadi, D. B., Hoppe, K., & Sorensen, H. B. (2014, August). Classification of acute stress using linear and non-linear heart rate variability analysis derived from sternal ECG. In *2014 36th Annual International Conference of the IEEE Engineering in Medicine and Biology Society* (pp. 3386-3389). IEEE.



Success Factors for the Effective Usage of an ERP System in the Post-Implementation Period; Case of Sri Lankan Firms: A Systematic Review of Literature

De Silva HSM¹, Withanaarachchi AS²

Department of Industrial Management, Faculty of Science, University of Kelaniya.^{1,2}

desilvah_im17014@stu.kln.ac.lk¹

amilaw@kln.ac.lk²

ABSTRACT

Even though ERP delivers superior advantages to an organization through various process improvements, it cannot easily be implemented as intended due to various reasons. A vast area of knowledge and studies are available on resistance to change during ERP total solution implementation and on factors to overcome such resistance. This research aims to investigate the confrontation by users, on new process-improving implementations such as sub-processes in modules of an ERP, on the changes done by the ERP vendors such as new functionalities, features and version upgrades on the effective usage of the ERP System. Hence, this literature review investigates the success factors for the effective usage of an ERP system during its post-implementation period as it plays a major role in further maximising the benefits of the system in organizations.

KEYWORDS: Enterprise Resource Planning System implementation, Success Factors, Effective Usage of an ERP System, Post - Implementation period, Resistance to Change

1 INTRODUCTION

In today's businesses, higher value creation compared to competitors is one of the main key factors to being a winner in the market. To create value, accurate decision-making at the right time is critical in every business event and process such as production, cost monitoring, selling and distribution, and pricing. These decisions must be made on solid integrated information across the organization where Enterprise Resource Planning (ERP) Systems play a crucial role in the integration of all processes in the business with standardized solutions increasing the efficiency of the business events. Estimated figures state that 41% of companies fall short to achieve above 50% of the expected usage from the total ERP solution due to resistance in an organization (Carlton, 2019). Therefore, investigating the success factors for the

effective usage of an ERP System during the post-ERP implementation period is essential to attain a valuable return from the ERP. Hence, the researcher intends to brief on ERP systems and critically review different theories and literature available on the effective usage of an ERP system during the post-implementation period.

2 METHODOLOGY

This study focused on finding the most recent scholarly work related to the success factors for the effective usage of an ERP system during the post-ERP implementation period. A systematic literature review was undertaken to address the research topic, identify the emerging pathways and prospects, and existing studies, and make comments or suggestions. To guarantee accuracy and generalizability, a structured selection approach was employed and defined

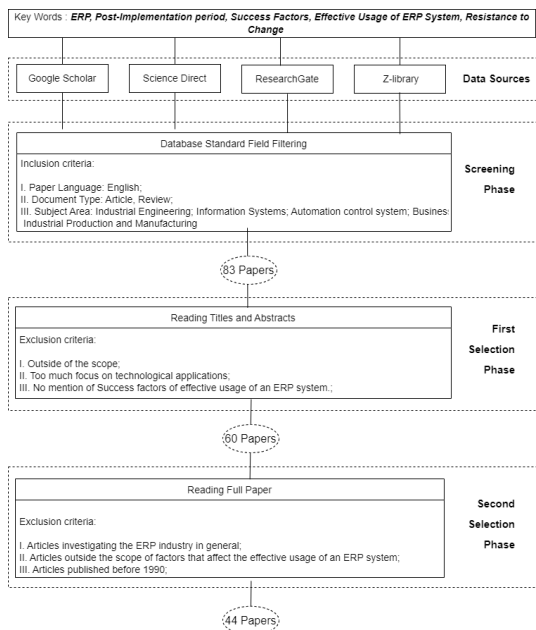
criteria were adopted to include similar studies and eliminate unrelated cases.

Most relevant empirical studies that examine the success factors for the effective usage of an ERP system during the post-ERP implementation period are included in this systematic literature review. This study used Google Scholar, Science Direct, ResearchGate, and Z-library in its database search method. "ERP implementation," "Effective Usage of an ERP system," "Success Factors of ERP implementation," "Post ERP implementation," and other pertinent terms like "Change Management," "Resistance to Change," "Systematic Literature Review," are the keywords for all databases. The flow diagram of the methodology could be summarized in Fig 1.

3 LITERATURE REVIEW

3.1 Success Factors for the Effective Usage of an ERP System

It has been a difficult procedure for



many firms throughout the world to comprehend the success factors in implementing Enterprise Resource Planning (ERP) systems. To increase

productivity and keep up with the competition, a firm can connect all of its core business processes using an ERP system. However, the anticipated advantages of increased productivity and competitive advantage would not materialize without the proper implementation of the system (Al-Salti & Eldabi, 2008).

The fact that 49% of ERP organizations claim that even after initial ERP implementation, their ERP process implementation is a never-ending show (Deloitte Consulting, 1999). After completing their initial implementation, organizations must plan and prepare for a more rewarding path with the ERP that involves practically every component of the integrated system.

3.2 Active Top Management Support

Top management participation is a component that directly affects the results and success of ERP implementation (Al-Mudimigh, Zairi & Al-Mashari, 2001). For an organization to adapt to change and maintain its long-term success, it needs a strategic vision (Kotter, 1996). Organizations cannot undergo radical changes without the genuine engagement and support of the top management, which is ranked as the top facilitator of transformation (Lanning, 2001). The literature emphasizes that good leadership is necessary for organizational cultural shifts and the use of information technology (Senge, 1990). Additionally, research indicates that leaders' attitudes and behaviours have a crucial role in how well employees understand IT change and, as a result, accept it (Armstrong & Sambamurthy, 1999). Therefore, top management motivation, enthusiasm,

progressive feedback, proper attention, support and adequate communication can be considered as one of the success factors for the effective usage of an ERP system.

3.3 *Less Complexity of the ERP used*

Although businesses all over the world use ERP solutions, significant challenges that these businesses encounter while implementing new processes are growing. Because of the complexity of the ERP, there is a lack of knowledge and awareness on how to handle these difficulties during implementations, which results in significant project failures and cost overruns (Momoh, Roy & Shehab, 2010). Since they are composed of numerous interrelated sub-modules with dynamic changes, ERP deployment projects have the characteristics of a complex system, making implementations challenging to manage (Mishra, Pundir & Ganapathy, 2018). Deviations from the predetermined scope can increase costs, reworks, and delays, all of which ultimately result in project failure (Besner & Hobbs, 2012). Enterprise systems have become more complicated as a result of complex business processes, expanding client needs, and stringent software requirements (Badzakova-Trajkov et al., 2009). User assistance during a transaction or business process data entry is one of the main methods for reducing ERP complexity. This is done by suggesting ideas like auto-completion, the next steps, highlighting mandatory fields, or displaying help, warning, or mistake prevention instructions (Lambeck & Groh, 2013). Although the aforementioned approach is quite

effective at decreasing ERP interface complexity, it can only help to reduce the amount of time users spend learning how to transfer their domain and process expertise to the ERP system.

3.4 *Better IT Infrastructure in the Business*

The organization's technological infrastructure plays a 38.4% influence in deciding the overall ERP implementation's effectiveness (Egdair et al., 2015). A solid IT infrastructure provides sustenance and maintenance for the existing ERP in the enterprise. Maintaining an organization's advancement in technological competency is quite expensive and requires significant financial expenditure. An organization must have appropriately designed server technology and open database connection to install an ERP and access and exchange information across all organizational applications (Walker, 2005). Proper IT infrastructure is known to be a crucial component from the beginning of the ERP implementation and for the rest of the solution's life cycle, even though it is expensive for a company (Egdair et al., 2015).

3.5 *Pre-Identification of Hidden Costs of ERP Changes*

Yusuf, Gunasekaran & Abthorpe (2004) conclude that an ERP system has issues of uncertainty in the acquisition and hidden costs in ERP implementation (Al-Mudimigh, Zairi & Al-Mashari, 2001). Tarn, Yen & Beaumont (2002) conclude that financial considerations are important for both big and small firms when implementing an ERP system. Furthermore, they emphasize how hidden costs may be underestimated by businesses installing ERP solutions.

According to the literature, the most underestimated hidden cost is training. Also, integration and implementation are frequently disregarded. The cost to train a full workforce on a new system is enormous. High consulting cost becomes unavoidable as a consequence of many organizations not budgeting consulting costs effectively.

3.6 *Effective Usage of ERP System*

Despite the qualities and significant benefits offered by ERP systems, their usage is not always efficient. The majority of businesses are unable to properly justify their expenditures on ERP software because the majority of its advantages are still untapped. Marnewick & Labuschagne (2005) conclude that 25% of the ERP installs cost more than expected and roughly 20% cannot be finished.

4 RESULTS AND DISCUSSION

When there is greater top management involvement, there will be less resistance to the implementation of change management strategies from an organization's point of view. Al-Mudimigh, Zairi & Al-Mashari (2001) demonstrate that top management involvement is an essential component of change management strategies that directly impact on successful implementation of the ERP system.

There is a lack of knowledge and understanding on handling the challenges faced with the complexity of the ERP during any changes within the organization's business processes or the changes in the ERP system. This leads to ineffective usage of the ERP system (Momoh, Roy & Shehab, 2010).

ERP implementation is a dynamic process of mutual adaptation between IT and the surrounding environment. Given the slim possibility of achieving a perfect match between technology and organisation, misalignment can occur which can be rectified through technological measures, organisational measures or a combination of both (Ho, Wu & Tai, 2004).

Yusuf, Gunasekaran & Abthorpe (2004) manifest that an ERP system has problems of uncertainty in the acquisition and hidden costs in implementation. Tarn, Yen & Beaumont (2002) assert that cost is a critical part of ERP implementation for both large and small businesses alike. They further emphasize that companies that install ERP solutions may underestimate the hidden cost.

5 CONCLUSION

Senior Managers and ERP coordinators of each department need to focus on creating a solid vision and communicating with users until they become comfortable with the change. More attention should be paid to matters that may arise which can prevent a successful change such as individual issues that must be addressed with progressive feedback. It can be recommended to the management to identify major areas where the user feels discomfort working with the ERP and respond with adequate measures to rectify such complexities. Managers in the department need to assess the misfit of the organizational process with the process in the ERP and employ consultants to reduce such gaps. Since Strategic managers have less involvement with the ERP, allowing operational managers to have greater

SUCCESS FACTORS FOR THE EFFECTIVE USAGE OF AN ERP SYSTEM IN THE POST-IMPLEMENTATION PERIOD; CASE OF SRI LANKAN FIRMS: A SYSTEMATIC REVIEW OF LITERATURE

control over decisions with ERP issues and giving access to information can execute quick decisions at the right time. Moreover, it is concluded that pre-identification of the hidden costs and investing in better IT infrastructure will also lead to the effective usage of the ERP system after its initial implementation.

As the limitation of this study, a deeper understanding could be gained through quantitative research on what success factors affect the effective usage of the ERP system when there are system and process improvements.

REFERENCES

- Al-Mudimigh, A., Zairi, M., & Al-Mashari, M. (2001). ERP software implementation: an integrative framework. *European Journal of Information Systems*, 10(4), 216-226.
- Al-Salti, Z., & Eldabi, T. (2008). Critical success factors in ERP implementation: A review Healthcare Hybrid Simulation View Project Obesity View Project. *Proceedings of the European and Mediterranean Conference on Information Systems, Dubai*
- Armstrong, Curtis P. and Sambamurthy, V., (1999), Information Technology Assimilation in Firms: The Influence of Senior Leadership and IT Infrastructures, *Information Systems Research*, 10, issue 4, p. 304-327.
- Badzakova-Trajkov, G., Barnett, K. J., Waldie, K. E., & Kirk, I. J. (2009). An ERP investigation of the Stroop task: The role of the cingulate in attentional allocation and conflict resolution. *Brain Research*, 1253, 139-148.
- Besner, C. and Hobbs, B. (2012), An Empirical Identification of Project Management Toolsets and a Comparison Among Project Types. *Project Management Journal*, 43: 24-46.
- Carlton, R. (2019). *Ten ERP failure statistics that highlight the importance of getting it right first time round*. Retrieved from <https://www.erpfocus.com/ten-erp-failure-statistics.html>
- Deloitte Consulting. (1999). ERP's Second Wave: Maximizing the Value of ERP-Enabled Processes. *Deloitte Consulting, Atlanta, GA*.
- Egdair, I. M., Rajemi, M. F., & Nadarajan, S. (2015). Technology factors, ERP system and organization performance in developing countries. *International Journal of Supply Chain Management*, 4(4), 82-89.
- Ho, C. F., Wu, W. H., & Tai, Y. M. (2004). Strategies for the adaptation of ERP systems. *Industrial Management and Data Systems*, 104(3), 234-251.
- Kotter, J. (1996), *Leading Change*. Boston: *Harvard Business Review Press*.
- Lambeck, C., & Rainer Groh. Mastering ERP Interface Complexity: A Scalable User Interface Concept for ERP Systems. *In Proceedings of the 15th International Conference on Enterprise Information Systems*, 170-178., 2013.
- Lanning, H. (2001). Planning and Implementing Change in Organizations - A Construct for Managing Change Projects, *Helsinki University of Technology*
- Marnewick, C., & Labuschagne, L. (2005). A conceptual model for enterprise resource planning (ERP). *Information Management and Computer Security*, 13(2), 144-155.
- Mishra, R., Pundir, A.K. and Ganapathy, L. (2018), "Empirical assessment of factors influencing potential of manufacturing flexibility in organization", *Business Process Management Journal*, Vol. 24 No. 1, pp. 158-182.
- Momoh, A., Roy, R. and Shehab, E. (2010), "Challenges in enterprise resource planning implementation: state-of-the-art", *Business Process Management Journal*, Vol. 16 No. 4, pp. 537-565.
- Senge, P. M. (1990). *The Fifth Discipline: The Art and Practice of the Learning Organization*, Random House Business
- Tarn, J. M., Yen, D. C., & Beaumont, M. (2002). Exploring the rationales for ERP and SCM integration. *Industrial Management and Data Systems*.
- Walker, S. M. (2005). *Secrets of a Civil War submarine: solving the mysteries of the H.L. Hunley*. *Carolrhoda Books*.
- Yusuf, Y., Gunasekaran, A., & Abthorpe, M. S. (2004). Enterprise information systems

project implementation: A case study of ERP
in Rolls-Royce. *International Journal of
Production Economics*, 87(3), 251–266.



The Role of Enterprises Resources Planning Systems in Future Smart Factories - A Systematic Literature Review

Silva AMH¹, De Silva HSM², Sandamali PDD³, Wickramaarachchi R⁴, Withanaarachchi AS⁵

Department of Industrial Management, Faculty of Science, University of Kelaniya^{1, 2, 3, 4, 5}

*silvaamh_im17074@stu.kln.ac.lk*¹

*desilyah_im17014@stu.kln.ac.lk*²

*dinushikasandamali2016@gmail.com*³

*ruwan@kln.ac.lk*⁴

*amilaw@kln.ac.lk*⁵

ABSTRACT

The industrial sector is undergoing significant change and innovation. Smart factories are powered by various technologies, including cloud computing, the Industrial Internet of Things (IIoT), artificial intelligence, machine learning, and more. But how does ERP software fit into all of this? After all, it is utilized by a wide range of other commercial industries. This research intends to study its role in the smart factory. Furthermore, ERP systems seamlessly interact with the numerous technologies that allow for smart production on the factory floor. A single centralized ERP system can improve many innovative and developing technologies. ERP acts as an anchor from which the other technologies for smart factories might flow. The objectives of ERP and the smart factory are very similar: greater automation, improved business function integration, and sharper business intelligence. A systematic literature review was conducted to address the research problem. Through this research, how ERP systems can support the implementation of smart factories and the advantages and the disadvantages were identified as the outcome of the study.

KEYWORDS: ERP and Smart Factory, Factory of the Future, Systematic Literature Review, IOT, Smart ERP

1. INTRODUCTION

ERP aims to replace the standard method of getting components to the assembly line and generating identical things with sustainable intelligent production procedures. Customized product configurations for distinct customer needs are possible with the aid of ERP. By controlling expenses and revenues and effectively utilizing the information to leverage profitability, ERP allows businesses to track their profitability. Complete visibility into the industrial facilities engaged in supply chains is made possible by using ERP. Additionally, it aids in the early detection of production faults throughout the whole supply chain, allowing for quick

adjustments to schedules and shop floor operations whenever unanticipated concerns pop up. Simulating recall incidents also results in cheaper costs and better corrective actions. Greater collaboration and efficiency will be made possible by realizing the significant opportunities that the intelligent manufacturing age presents. On the basis of open communication, adaptability, decision-making, and real-time cost, resource, and availability optimization procedures, new kinds of value creation will emerge.

Customer service greatly benefits from Industry 4.0's integrated software solutions. More and more businesses are seeing the value of an ERP system as a

long-term investment that boosts efficiency by enhancing production and communication. Since ERP systems have been widely employed to control the operations and processes of manufacturers, now the question is what role does an ERP system play to tap into Smart Factories to better manage its operations and enhance productivity?

2. METHODOLOGY

This study focused on finding the most recent scholarly work related to ERP systems and its role in the smart factories to enhance the capabilities of ERP systems. A systematic literature was conducted to address the research problem and identify the emerging paths and opportunities, existing studies as well as making comments or suggestions. A thorough literature review was conducted in order to analyze the impact of ERP on Smart factories and to compile the most recent findings in the focus areas of ERP and Industry 4.0.

A structured selection method was used, and defined criteria were chosen to include related studies and eliminate unrelated cases in order to ensure the accuracy and generalizability. This Systematic Literature Review contains all empirical research that examines ERP systems that are integrated with smart factories. Research papers that analyzed ERP systems in the context of the Industry 4.0 were also chosen for this study. The database search process of this study includes Google Scholar, Science Direct, ResearchGate and Z-library. The keywords for all databases are "ERP systems," "Industry 4.0," "smart factory," "ERP and Smart Factory," as well as other terms that are relevant, such as "Factory of the Future,"

"Systematic Literature Review," "IOT," or "Smart ERP".

The following Fig. 1 shows how the authors screened out the most relevant articles with all the criteria adopted.

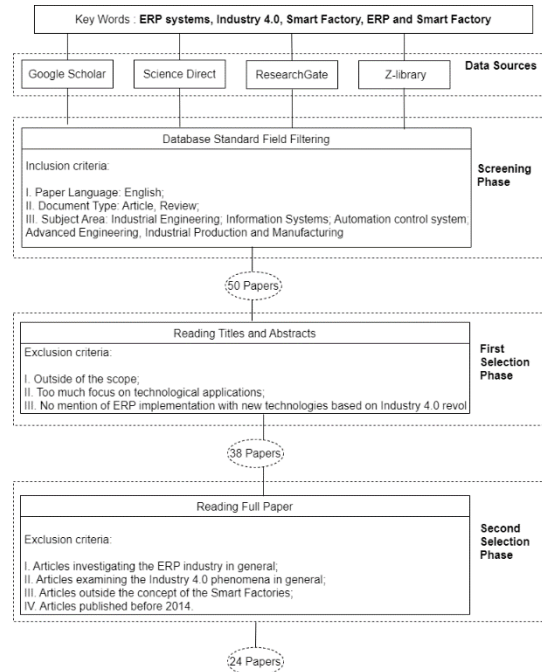


Figure 7 - Selection Procedure of Articles

3. LITERATURE REVIEW

3.1 Enterprise Resource Planning Systems

Inventory management & control software was developed in 1960 with the combination of business processes and information technology targeting to maintain a suitable level of inventory in warehouses (ERP information, 2022). Manufacturing and operations were combined with inventory control later in the 1970s to produce schedules for purchasing inventory and running operations. This system was called Material Requirements Planning (MRP). Enterprise resource planning system, a comprehensive solution that integrated product planning, inventory control, product distribution, production,

accounting, and marketing, was created in 1990. (ERP information, 2022). This provided a bird's-eye view of business events and included cross-functional operations. ERP companies currently provide cloud-based solutions with additional customizations to a variety of clients in a variety of industries.

3.2 *ERP & Smart Factory*

When Irwin Welber delivered the keynote address at the 1986 international symposium on robot manipulators, the phrase "Smart Factory" was first used. The performance of autonomous and automatic operations based on optimal production plans, and the manufacture of sophisticated and smart manufacturing services and goods are some common features of smart factories. These include networked components from which user data can be obtained (Yoon et al., 2019).

Business resource planning systems (ERP) are regarded as the foundation of Industry 4.0 (Haddara & Elragal, 2015), and in smart factories, they are expected to be integrated with two other significant software applications, namely Product Lifecycle Management (PLM) and Production Management System (MES) with digital technologies (Ayvarnam & Mayurappriyan, 2017). Suppose an ERP system has a predictive maintenance system. In that case, it may effectively monitor the entire production chain, spot any urgent problems in the workshop, and help to balance the workload or prevent downtime. SAP has created a thorough framework for predictive maintenance that can incorporate various diagnostic and prognostic models of equipment wear (Haddara & Elragal, 2015). Also, Manufacturers of ERP systems such as

Siemens (PLM), Oracle, IBM (Asset Management), and INFOR (BAAN) have previously developed components of intelligent manufacturing support solutions.

The current data in existing ERP systems is its greatest strength since it can be used for preventative maintenance and can give the manufacturer vital information about the longevity and dependability of their goods (Rojko, 2017). The integration framework, which has been built to facilitate communication between ERP and other objects, indicates whether the ERP system is ready for a smart factory (Haddara & Elragal, 2015). For instance, integrating an ERP into a smart factory helps synchronize communications, enables more accurate and efficient data analysis and enables monitoring of the duration of each production cycle and the coordination of necessary operations to spot inefficiencies and potential problems (Prakash et al., 2022). The benefits of deploying ERP systems in Smart Factories include the potential to introduce novel business models, save money, be flexible, agile, and scalable, and improve business productivity and efficiency (Prakash et al., 2022).

The modular structure of ERP with centralized work and the limited capacity to dynamically adapt the production plan (Lee, 2021), issues with monitoring the circumstances of live production and data exchange at the enterprise level, and the fact that although most ERP systems have production planning modules, most factories still do not rely on ERP in this process. The disadvantages of adopting ERP systems in implementing smart factories include vendor lock-in,

interoperability, network balancing and latency, organizational issues, and conservative thinking (Prakash et al., 2022).

4. RESULTS AND DISCUSSION

As for smart factories, adopting ERP systems implies advantages and disadvantages that need to be carefully analyzed. Hence, the authors identified the pros and cons related to the study by reviewing the literature.

4.1 Advantages of applying ERP systems in Smart Factories

Enhanced Business Productivity and Efficiency

In the context of Industry 4.0, the ability to automate services, processes, and procedures increases productivity and is therefore highly desirable. ERP enables automation and greater output, which boosts overall effectiveness (Dai et al., 2019). ERP has improved business operations, user perception, and efficiency (Willner & Gowtham, 2020). In this aspect, standardization is essential to fostering collaboration among many sites and streamlining corporate processes.

Provide flexibility and speed

There's a great amount of existing data within the ERP system (Rojko, 2017). As a result, companies are able to respond swiftly to shifting market demands. Therefore, it should come as no surprise that ERP and smart factories give organizations a meaningful competitive edge.

Facilitate the decision-making process

Improved real-time data flow, capital flow, and information flow for better decision-making. Smart factories are made to integrate machines and deliver real-time data that can be

analyzed to yield conclusive knowledge for simpler decision-making.

4.1 Disadvantages of applying ERP systems in Smart Factories

Security and Privacy

Data security is essential since ERP may reveal sensitive information, such as financial or industrial data in edge and cloud environments. When a corporation chooses ERP, it also consents to share sensitive and important business data with outside service providers. It might also include information from other businesses. Due to the complexity of the ERP system, the security settings may be difficult, which may cause security problems.

Internal organizational conflicts –

ERP has an impact on organizational aspects such as staff skill sets, infrastructure, strategy, and scalability. The transition from traditional ERP to Industry 4.0-related ERP requires additional investments and a reorganization of resources and processes. Therefore, the necessary considerable adjustments in how organizations carry out their standard business operations and processes discourage managers frequently.

High maintenance cost

Great investment of additional resources for adaptations will lead to high maintenance cost of machinery (Kirikova, 2019). In addition, since ERP requires hard adding of new elements and functionalities will also lead to intermediary costs. Furthermore, additional hiring and training costs will make the decision to embrace the benefits of ERP in a smart factory environment debatable.

5. CONCLUSION

Realizing the advantages of ERP systems in the Industry 4.0 environment to build the future smart factory is crucial for promoting the adoption of ERP systems with new technologies. According to this study, using ERP systems that incorporate Industry 4.0 technology offers a company a number of advantages over using conventional ERP systems. In future work, the study will investigate the role of ERP systems from the smart factory to the 'smart supply chain' concept. Future studies will also take into account any problems with integrating ERP systems with other technologies that emerged with the 4th Industrial revolution.

REFERENCES

- Ayvarnam, N., & Mayurappriyan, P. (2017). Dynamic Scheduling of Machines Towards the Vision of Industry 4.0 Studio—A Case Study. *Proceedings of 2nd International Conference on Intelligent Computing and Applications*, pp.103-111. doi:10.1007/978-981-10-1645-5_9
- Dai, W., Nishi, H., Vyatkin, V., Huang, V., & Shi, Y. (2019). Industrial Edge Computing: Enabling Embedded Intelligence. *IEEE Industrial Electronics Magazine*, 13, 48–56. doi:10.1109/MIE.2019.2943283.
- ERP Information. *A Brief History of ERP – since 1960 and the future of ERP*. Retrieved from ERP Information: <https://www.erp-information.com/history-of-erp.html>, 2022
- Haddara, M., & Elragal, A. (2015). The Readiness of ERP Systems for the Factory of the Future. *Procedia Computer Science*, 64, 721–728. doi:10.1016/j.procs.2015.08.598
- Kirikova, M. (2019). Challenges in enterprise and information systems modeling in the contexts of socio cyber physical systems. *Lecture Notes in Business Information Processing*, 366 LNBIP, 60–69. doi:10.1007/978-3-030-35646-0_5
- Lee, R. (2021). The effects of smart factory operational strategies and system management on the innovative performance of small-and medium-sized manufacturing firms. *Sustainability* 13(6), 3087. doi:10.3390/su13063087.
- Prakash, V., Savaglio, C., Garg, L., Bawa, S., & Spezzano, G. (2022). Cloud- and Edge-based ERP systems for Industrial Internet of Things and Smart Factory. *Procedia Computer Science*, 200, 537–545. doi:10.1016/j.procs.2022.01.251
- Rojko, A. (2017). Industry 4.0 concept: Background and overview. *International Journal of Interactive Mobile Technologies (iJIM)*, 11(5), pp.77–90. doi:10.3991/ijim.v11i5.7072
- Willner, A., & Gowtham, V. (2020). Toward a Reference Architecture Model for Industrial Edge Computing. *IEEE Communications Standards Magazine*, 4, 42–48. doi:10.1109/MCOMSTD.001.2000007
- Yoon, S. C., Um, J., Suh, S. H., Stroud, I., & Yoon, J. S. (2019). Smart Factory Information Service Bus (SIBUS) for manufacturing application: requirement, architecture and implementation. *Journal of Intelligent Manufacturing*, 30(1), 363–382. doi: 10.1007/s10845-016-1251-9



A Time Series Analysis of Coconut Prices at the Colombo Coconut Auction

Aberathna UMLI¹, Francisco GS²

Department of Mathematical Sciences, Faculty of Applied Sciences, Wayamba University of Sri Lanka
umisuri.com2016@gmail.com¹

Department of Mathematical Sciences, Faculty of Applied Sciences, Wayamba University of Sri Lanka
gfrancisco@wyb.ac.lk²

ABSTRACT

Sri Lanka is the fourth largest coconut products exporter in the world. Sri Lankan coconut is sold through the Colombo coconut auction. This study was conducted in order to analyze and model the monthly coconut auction prices based on time series analysis. Symmetric Garch Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model was used to investigate and model the volatility on the coconut prices. Stationary was checked by using Augmented Dickey-Fuller test (ADF) and the conditional mean model ARIMA(0,1,1) was fitted to differenced series. After checking residuals of the ARIMA(0,1,1) model, Conditional Heteroscedasticity in residuals of fitted ARIMA(0,1,1) model was detected using Autoregressive Conditional Heteroskedasticity (ARCH) Lagrange Multiplier (LM) test. Under this effect, conditional variance model GARCH(1,1) was built to forecast the coconut prices. Finally, the ARIMA(0,1,1)-GARCH(1,1) was identified as the best time series model for the analysis of coconut prices. The accuracy of the model is calculated as 86.43%.

KEYWORDS: ARIMA, Coconut price , GARCH

1 INTRODUCTION

Sri Lanka is a major exporter of coconut products, being the fourth largest in the world. The coconut industry is an essential component of Sri Lankan rural livelihoods and nutrition, and provides livelihoods around 700,000 people and indirect employment to another 135,000. The main coconut-growing regions in Sri Lanka are known as the “coconut triangle”, covering the districts of Colombo, Kurunegala and Puttalam. The annual coconut production in the country ranges between 2800 to 3000 million nuts.

1.1 Significance of the Study

Forecasting the coconut price can regulate the production and supply activities of coconut and provide a better idea to guide the members in the business system of coconut industry. It will be very helpful to utilize the resources

optimum level, reduce the cost of production and improve efficiency and productivity of the coconut production.

1.2 Objective of the Study

The objective of the study is to analyze the behavior of the monthly coconut prices in the Colombo coconut auction to construct a more appropriate time series model for monthly coconut prices and evaluate the forecasting performance of the model.

2 LITERATURE REVIEW

In past studies, few researchers have analyzed the coconut industry and importance of the modeling coconut prices. They have proposed different modeling methods for forecasting coconut prices and they are underlined below in detail.

Abeygunawardana et al. (1996) became visible to be the introductory and only group of researchers who forecasted

one year ahead of retail and wholesale prices of coconut with a VAR model, a stochastic process model that captures the linear interdependencies among multiple time series.

Rangoda et al. (2006) attempted to find an appropriate model to forecast coconut and allied products in Sri Lanka. Stationary data series were fitted to six standard time series models, viz; General decomposition method, Winter's method, Moving average method, Double exponential smoothing method, Single exponential smoothing method and ARIMA method. The results revealed that the ARIMA and exponential methods are better than other models to predict prices of coconut and coconut products.

Sahoo et al. (2022) examined prices of coconut in APMC Sakhigopal market. ARIMA method was used for modeling and forecasting the prices of coconut. The results designated that ARIMA (1,1,1) model was the most appropriate and efficient model for forecasting the coconut prices.

Kumarasinghe et al. (2017) focused on modeling and analyzing the annual national coconut production. According to the residual analysis and Akaike Information Criterion, ARIMA (2,1,0) model was selected as the best fitting model for annual national production of coconut in Sri Lanka.

3 METHODOLOGY

This study was undertaken by using monthly coconut prices at Colombo coconut auction. The secondary data of monthly coconut auction prices from 2010 to 2020 were collected from the Coconut Development Authority. The analysis was done by using R software.

Box-Jenkins method was used to develop the mean model. First, stationary of the series was checked by using Augmented Dickey Fuller test (ADF). The findings of ADF test prove that the t-statistics of the series is greater than the critical value at the 5% significance level, outlining that the series is not stationary. Different methods should be done to create a trend or seasonally adjusted time series of monthly time series data. The ACF and PACF were used to identify mean model. For stationary data set, Seasonal Decomposition of Time Series (STL) is applied to check the seasonal and Trend component. Significant ACF and PACF lags suggest MA terms (q) and AR terms (p), respectively.

After checking significance of the parameters, goodness fit of the model should be checked. In order to check randomness and normality of residuals, serial Correlation LM test and Jarque-Bera test can be used.

3.1 GARCH Model

Bollerslev and Taylor (1986) generalized Engle's model to make it more realistic, called GARCH (Generalized Autoregressive Conditional Heteroscedasticity) model. GARCH model describes the conditional variance as a function of past conditional variances and past squared error terms. GARCH (p, q) is the usual notation for this model, where p is the order of the GARCH terms and q is the order of ARCH terms.

The GARCH (p, q) model is defined by,

$$y_t = \mu_t + \varepsilon_t$$

$$\varepsilon_t = z_t \sigma_t$$

$$\sigma_t^2 = w + \sum_{j=1}^p \beta_j \sigma_{t-j}^2 + \sum_{i=1}^q \alpha_i \varepsilon_{t-i}^2$$

$$z_t \sim (0,1), \quad \varepsilon_t \sim N(0, \sigma_t^2)$$

Where, γ_t is return, $w > 0$, $\alpha_i \geq 0$, $i = 1, \dots, q$, $\beta_j \geq 0$, $j = 1, \dots, p$;

$\sum_{j=1}^p \beta_j \sigma_{t-j}^2 + \sum_{i=1}^q \alpha_i \varepsilon_{t-i}^2 \quad i < 1$ for ensuring $\{\sigma_t^2\}$ as weak stationary.

In most of the financial time series data analysis, GARCH models with lower order ($p, q = 1, 2$) are enough to capture the conditional heteroscedasticity. GARCH (1, 1) is the most commonly used model, known as Vanilla GARCH model in financial time series analysis. The most important one is GARCH model cannot capture the asymmetric performance.

4 RESULTS AND DISCUSSION

Table 1: Descriptive Statistics of Monthly Coconut Auction Prices 2010-2020

Mean (Rs.)	SD (Rs.)	Min. (Rs.)	Max. (Rs.)
33728.4	10779.39	18739	67970

Table 1 illustrates the mean coconut price at Colombo auction over the time period is Rs. 33728.4 per 1000 nuts. The maximum and minimum prices are Rs. 67970 and Rs. 18739 per 1000 nuts respectively.

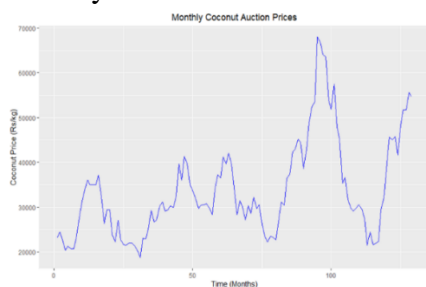


Figure 1: Time series plot

According to the time series plot, seasonal pattern or trend pattern cannot be recognized.

Table 2: Augmented Dickey-Fuller test

	Original	Differenced
P-value	0.5355	0.01

Although there is no clear trend pattern or seasonal pattern in Figure 1, ADF test confirms that coconut price series is not stationary (P value > 0.05). After the first order differencing, ADF test reveals that differenced data are stationary (P value < 0.05).

Table 3: Seasonal and Trend decomposition using Loess test

	Seasonal	Trend
Values	0.0000	0.0099

The seasonal component is 0.0000, indicating that there is no seasonality present in the data. The trend component is non-zero, indicating that there is a trend in the data.

Significant ACF and PACF suggest $q = 0$ and $p = 1$ respectively.

Based on the AIC value, ARIMA (0,1,1) is the most suited model among MA(1), ARMA(0,1) and ARIMA(0,1,1) to forecast the price where all the parameters are significant at their respective significance levels.

Table 4: Residuals Diagnostic Tests on ARIMA(0,1,1) Model

Test	P value	Conclusion
Serial correlation LM test	0.91433 > 0.05	Residuals are random
Jarque-Bera test	0.9774 > 0.05	Residuals are normal
ARCH LM test	0.04186 < 0.05	Residuals have volatility

According to ARCH LM test result, conditional heteroscedastic behavior is present and volatility clusters exist there among residuals. The GARCH model must be fitted to remove this impact. Hence, ARIMA (0,1,1) GARCH (1,1) was selected as the best conditional variance model which has the minimum value for all three information criterion

Table 5: Sign Bias Test

	P-value
Sign Bias	0.883139
Negative Sign Bias	0.099872
Positive Sign Bias	0.478203

By using Table 5, asymmetric effect on the model was checked. According to the Table, P-value of sign bias test is greater than 0.05. Therefore, null hypothesis is not rejected at 5% significance level and it is concluded that there is no asymmetric effect in residuals.

Here, four GARCH models were fitted as GARCH(1,1), GARCH(1,2), GARCH(2,1) and GARCH(2,2).

Table 6: Parameter estimation of ARIMA(0,1,1)-GARCH(1,1)

	Estimate	Pr(> t)
mal		0.120047
0.010567		
omega		1.227095
0.007301		
alpha 1	0.48021	0.00001
beta 1	0.734190	0.00000
gamma 1		0.000091
0.000000		

According to Table 6, coefficients of all terms of mean equation and all parameters of variance equation have probabilities less than 0.05. Therefore all parameters are significant at 5% level of significant in the ARIMA(0,1,1)-GARCH(1,1) model. By comparing results, ARIMA(0,1,1)-GARCH(1,1) was selected as the most preferable model.

Normality Q-Q plot and density plot of the fitted ARIMA(0,1,1)-GARCH(1,1) are shown in Figure 3.

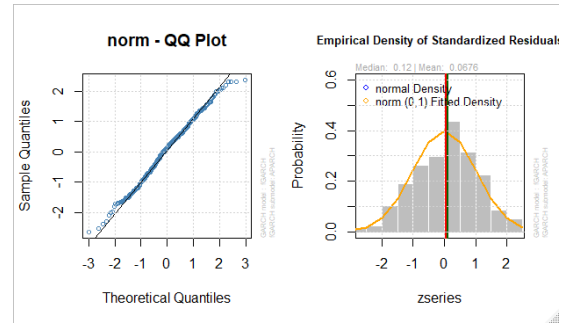


Figure 2: Normal Q-Q Plot and Density Plot of Residuals

According to the Figure 2, normal Q-Q plot illustrates that residuals are well fitted with the straight line. And also density plot visualizes distribution of the residuals very close to bell shape, which means residuals are normally distributed. Therefore, normality of the residuals is confirmed by both normal Q-Q plot and density plot.

After checking the adequacy of the model, it is proved that the ARIMA(0,1,1)-GARCH(1,1) model is the best for modeling coconut auction prices.

Table 7: Forecasting Performance

Time period	9 months of 2019
MAPE(%)	13.57

It can be concluded that the accuracy of the ARIMA(0, 1, 1)-GARCH(1,1) model is approximately equal to 86.43% and indicates a good fit for forecasting coconut prices because the error is minimal.

5 CONCLUSION

This study mainly concentrated on analyzing and modeling the monthly coconut auction prices at Colombo coconut auction. As a whole, it showed that there was a slight upward trend over the entire time span. Among them, there was a huge upward trend pattern from 2017 to 2018. And also, there was a

downward trend pattern observed after 2018. Such fluctuation happened due to a production drop. These fluctuations can be accounted for building the univariate model.

Due to the volatility in the monthly coconut auction prices, a symmetric GARCH model which denoted as ARIMA(0,1,1)-GARCH(1,1) fitted for forecasting coconut auction prices. It is capable to captivate the volatility, the time varying conditional variance, and errors.

ARIMA(0,1,1)-GARCH(1,1) was selected as the best fitted model for forecasting Colombo coconut auction prices. The mean absolute percentage error of ARIMA(0,1,1)-GARCH(1,1) based on predictions of 9 months of 2020 is 13.57%. On the other hand, the mean absolute percentage error based on prediction of 12 months of 2019 is 8.31%. The results show that ARIMA(0,1,1)-GARCH(1,1) is a good fitted model and can be used for modeling and forecasting of monthly coconut auction prices at Colombo coconut auction.

REFERENCES

- Abeygunawardana, P., Idirisinghe, I. M. S. K., and Ariyawardana, A. (1996). Forecasting of coconut prices: A vector autoregression approach. *Sri Lankan Journal of Agricultural Sciences*, 33, 159-181.
- Bollerslev, T., (1986). Generalized Autoregressive Conditional Heteroskedasticity, *Journal of Econometrics*, 31, 307-327
- Kumarasinghe, H. P. A. S. S., Senevirathne, B. G. P. S. V., and Wijeratne, A. W. (2017). Model Fitting and Forecasting of Annual National Coconut Production in Sri Lanka.
- Rangoda, B. D. P., Abeywickrama, L. M., and Fernando, M. T. N. (2006). An

Analysis of different forecasting models for prices of coconut products in Sri Lanka.

- Sahoo, U. K., Chavan, R. V., and Bharati, S. V. (2022). Predictive analysis of coconut prices in Odisha: An ARIMA approach.



An Artificial Neural Network Approach for Predicting Tidal Elevation in Sri Lanka

Perera JARM¹, Appuhamy PADAN², Ekanayake EMP²

Department of Mathematical Sciences, Faculty of Applied Sciences, Wayamba University of Sri Lanka. ^{1,2}

malsharashini96@gmail.com ¹

asankanidarshani@wyb.ac.lk ², *piyalekanayake@wyb.ac.lk* ²

ABSTRACT

Information on tidal heights is useful for ensuring safe and effective port development, coastal building, the fishing industry, and human activities. The conventional harmonic method could not predict tidal heights accurately without a significant volume of measurements. The objective of this study was to apply the Artificial Neural Network technique with a back-propagation procedure to forecast the tidal heights using limited measurable data. Hourly tidal heights at Colombo and Trincomalee coastal areas spanning from September 2020 to January 2021 were used for this study. The network was trained, validated, and tested for eight different periods with one hidden layer to identify the minimum data required for accurate tidal predictions. Mean Squared Error (MSE) and the Coefficient of Determination (R^2) were used to measure the accuracy of predictions. The tidal type of Colombo coastal area was found to be mixed semidiurnal whereas it was semidiurnal in Trincomalee area. Out of 69, five tidal constituents were significant and the same for both locations. The optimal neural network structures for predicting hourly tidal heights in Trincomalee and Colombo were achieved from 15 days of hourly data with eight neurons and two months of data with five neurons, respectively. These structures were found to produce the minimum MSE values and the highest R^2 values, resulting in the most accurate predictions for both locations, thus leading to the conclusion that the Artificial Neural Network model with a short period of data could provide an accurate tidal forecasts for both locations.

KEYWORDS: Artificial Neural Network, Back propagation, MSE, Tide

1 INTRODUCTION

Ocean tides can generally be described as stemming from gravitational interactions among the Sun, Moon, and Earth, which cause a body of water to rise and fall regularly. There are hundreds of periodic motions of the Earth, Sun, and the Moon and each of these motions are called a constituent or a Harmonic constituent which affects the generation of ocean tides. Predicted tidal heights are always important for people who look to the sea for their livelihood and for those involved in ocean construction. The waves can be expected well in advance with a high degree of accuracy, which depends on each

location. In the past, tidal predictions were mainly based on harmonic analysis that required large volumes of tidal measurements at a particular location to predict tidal heights accurately (Leffler & Jay, 2009; Yang et al., 2020). However, the collection of data over a long period is challenging and expensive. Moreover, instrumental breakdowns and errors are frequent in observation centers established in developing countries like Sri Lanka, which delays data collection process and creates many missing data reducing the accuracy of predictions. To overcome such issues, economically sound methods must be used to accurately predict the tidal elevation with

minimal usage of data. Therefore this study aims to investigate spatial and temporal properties of tidal elevations and to model tidal elevations using the backpropagation neural network method while forecasting tidal heights at both eastern and western coastal areas of Sri Lanka.

2 LITERATURE REVIEW

In relation to the highly-predictable characteristics of tides, particular attention was paid to tidal forecasting by comparing traditional harmonic techniques with machine learning methods (Lee & Jeng, 2002). Meena & Agrawal (2015) constructed an Artificial Neural Network (ANN) model to predict tidal levels with different learning algorithms using limited measured data as an alternative to conventional harmonic analysis which requires a large amount of data. They showed that ANN is a good technique for short-term prediction of tidal heights with site-specific models.

Moreover, the Feed Forward Back Propagation (FFBP) and Non-linear Auto Regressive with exogenous input (NARX) network were used by Salim et al. (2015) to predict year-long hourly tidal levels at Mangalore, Karnataka, based on short-term hourly tides as input and they showed that NARX network outperformed FFBP network in terms of data requirement, the accuracy of predictions, and computational time. Yang et al. (2020) developed a Long Short-Term Memory (LSTM) Recurrent Neural Network (RNN) model for tidal prediction and compared its performance with six other forecasting models, including an ANN. Their study used data over 21 years from 17 harbors, according

to which the LSTM and ANN models had almost similar accuracies in predicting tidal levels. The LSTM recurrent neural network is preferred for learning long-term dependencies, such as long-term trends in data (Yang et al., 2020) and performs well when longer time series data are available to deal with (Yu et al., 2019).

As there is ample room to study the prediction of tidal elevations in the coastal areas surrounding Sri Lanka and to circumvent the need for long-term tidal records, the artificial neural network with backpropagation procedure was used in this study with short-term tidal records instead of LSTM, which perform well with sequential data for a longer period of time, to predict tidal heights at the Eastern and Western coastal areas of Sri Lanka.

3 METHODOLOGY

The objective of this study was to apply ANN techniques to model and predict tidal heights in the eastern and western coastal areas in Sri Lanka using limited data. First, the descriptive statistics of tidal heights were obtained to compare the tidal elevations at both sites. Then, the tidal type at each location was determined by using form numbers introduced by Dietrich (1963) which used the amplitude of the four constituents for a place namely M2 (Principal lunar semi-diurnal), S2 (Principal solar semi-diurnal), K1 (Lunar diurnal) and O1 (Lunar diurnal). The ocean package in R software was used to identify the tidal constituents at each site, and the tidal members significant at a 1% level for each location were considered for tidal predictions. The Tidal elevation is a combination of harmonic

constituents, considered a periodic function for a particular location, and it is expressed as a sum of sine and cosine terms of all its harmonic constituents. $\cos(w_j t_i)$ and $\sin(w_j t_i)$, where w_j is the frequency of the j th branch and t_i is the time of the i th tidal measurement, of significant constituents identified for each location were considered as input neurons of the network. Then the neural networks were trained, validated, and tested for eight different periods in order to identify the minimum length of hourly tidal heights required to attain the optimal network structure at each location.

The eight-time periods comprised 7-, 10-, 15- days and 1-, 2-, 3-, 4- and 5-months and each data set was divided into 70%, 15%, and 15% for training, validating and testing, respectively. Moreover, the neural networks were trained with zero and one hidden layer with neurons varying from 1 to 10. The transfer functions considered for hidden and output neurons were sigmoid and linear, respectively. Further, low learning rate (η) and high momentum factor (α) were selected to improve the performance of the network.

Finally, the network structure with the minimum mean squared error and the highest coefficient of determination produced by testing data was selected as the optimal network structure for each location.

4 DATA COLLECTION & ANALYSIS

The hourly tidal heights (in meters) spanning from September 2020 to January 2021 at two different locations in Sri Lanka, Colombo and Trincomalee, were used for this study. The data were

collected from the National Aquatic Resources Research and Development Agency (NARA) in Sri Lanka. The Artificial Neural Network technique was applied to model and predict the tidal elevation at each location. At the same time, Back-propagation procedure with Stochastic Gradient Descent algorithm was used to find the optimal network structure for each site.

5 RESULTS AND DISCUSSION

It was revealed that the mean tidal height in Trincomalee (4.94m) was significantly higher than that in Colombo (1.07m) during the study period. The maximum (minimum) tidal elevations at Trincomalee and Colombo were found to be 5.53m (4.47m) and 1.65m (0.54m), respectively. Moreover, out of 69 constituents obtained for each location, M2 (Principal lunar semi-diurnal), S2 (Principal solar semi-diurnal), N2 (Larger lunar elliptic semi-diurnal), K1 (Lunar diurnal) and O1 (Lunar diurnal) were identified as significant at both locations at 1% level. M2 constituent possessed the highest amplitude, and S2 was identified as the most frequent constituent at both sites. According to the form numbers, it was seen that the tidal type around Colombo was mixed semi-diurnal, whereas it was semi-diurnal at Trincomalee. This indicates that the tidal type around the Colombo area is different from the general tidal type in equatorial countries like Indonesia, which is semi-diurnal. It was observed that the maximum length of hourly tidal data required to identify the significant constituents at each location was two months. The neural network structures with one hidden layer performed better than that with zero layers for both

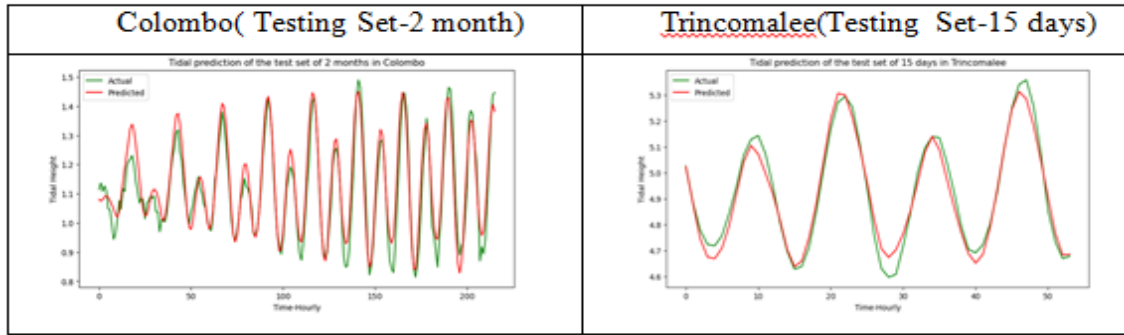


Figure 1: Plots of the actual vs predicted tidal heights at Colombo and Trincomalee

locations. The optimal neural network structure for Colombo coastal area was attained with five neurons in the hidden layer based on two months of hourly tidal data when $\eta=0.01$ and $\alpha=0.8$ with 1000 iterations. The prediction accuracies obtained from this structure was very high compared to other network structures developed for different time periods, yielding an MSE of 0.00257 and R2 of 0.901 (Table 1). In contrast, the highest tidal prediction accuracy for Trincomalee coastal area was obtained with the back propagation neural network with eight neurons in the hidden layer using 15 days of hourly tidal measurements, which yielded an MSE of 0.00118 and R2 of 0.963.

Table 1: The optimal structures of the ANN for each location when $\eta=0.01$, $\alpha=0.8$ and number of iterations =1000

Coastal Area	Colombo	Trincomalee
Required Time period	2 months	15 days
Number of inputs	10	10
Number of hidden layers	1	1
Number of hidden neurons	5	8
MSE	0.002573	0.001182

R² 0.90165 0.96398

The results summarized in Table 1 confirmed that both network structures could provide accurate tidal predictions with limited measurements of tidal data. Moreover, the optimal neural network structure for Trincomalee coastal area outperformed that for Colombo in terms of data requirement and the accuracy of predictions.

Figure 1 illustrates the prediction accuracy of the optimal networks for both sites. It can be seen that both actual and predicted tidal heights for both locations are impressively closer to each other except at a few time points.

6 CONCLUSION

Accurate information on tidal heights in the future is becoming vital as it affects the livelihood of fishermen, offshore constructions, flooding of low lands etc. It was concluded from the study that the tidal elevation at Trincomalee coastal area was significantly higher than that at Colombo coastal area. The tidal type at Trincomalee is semi-diurnal, which is the expected type for an equatorial country, whereas it is mixed-semi diurnal in Colombo. The significant tidal constituents identified at each location are similar and comprise the constituents

O1, K1, N2, M2, and S2, which can be derived with just 2 months of hourly data obtained from both locations. It was identified that 15 days and two months of hourly data are sufficient to get accurate tidal predictions at Trincomalee and Colombo, respectively. Colombo requires little more data than Trincomalee due to the presence of mixed semi-diurnal tidal type, which is not the standard type for tropical countries. Moreover, it could be concluded that the traditional Back propagation Neural Network model with a short period of data could provide accurate tidal forecast for both locations. However, according to the literature, achieving such a high level of accuracy is not possible with conventional models like harmonic analysis for a similar time period. This information helps when planning future coastal engineering projects and many other activities, including the generation of tidal power.

REFERENCES

- Dietrich, G. (1963). *General Oceanography*. Interscience Publishers, New York.
- Lee, T. L., and Jeng, D. S. (2002). Application of artificial neural networks in tide-forecasting. *Ocean Engineering*, 29(9), 1003–1022.
- Lee, T.L., Tsai, C. P., and Shieh, R. J. (2006). Applied the Back-Propagation Neural Network to Predict Long-term Tidal Level. *Asian Journal of Information Technology*, 5(4), 396–401.
- Leffler, K. E., and Jay, D. A. (2009). "Enhancing tidal harmonic analysis: Robust (hybrid L1/L2) solutions". *Continental Shelf Research*, 29(1), 78-88.
- Meena, B. L., and Agrawal, J. D. (2015). Tidal level forecasting using ANN. *Procedia Engineering*, 116(1), 607–614.
- Salim, A. M., Dwarakish, G. S., Liju, K. V., Thomas, J., Devi, G., and Rajeesh, R. (2015). Weekly prediction of tides using neural networks. *Procedia Engineering*, 116(1), 678–682.
- Yang, C. H., Wu, C. H., and Hsieh, C. M. (2020). Long Short-Term Memory Recurrent Neural Network for Tidal Level Forecasting. *IEEE Access*, 8, 159389–159401.
- Yu, Y., Si, X., Hu C., and Zhang, J.(2019). A review of recurrent neural networks: LSTM cells and network architectures. *Neural Computation*, 31(7), pp.1235-1270.



Analysis of Daily Energy Consumption and Daily Peak Demand in Sri Lanka

Abeyrathne AHMMM¹, Francisco GS²

Department of Mathematical Sciences, Wayamba University of Sri Lanka. ^{1, 2}

maheeshamayangi@gmail.com ¹

gfrancisco@wyb.ac.lk ²

ABSTRACT

This study aimed to model and forecast energy consumption and peak demand in Sri Lanka using a symmetric Generalized Auto Regressive Conditional Heteroscedasticity Model (GARCH). A mixed-methods approach was employed, including a boxplot to identify natural disaster-related outliers in the data set and an Augmented Dickey-Fuller (ADF) test to assess the stationary behavior of time series data. The Bayesian Information Criteria (BIC) was employed to select and compare models, while the Lagrange multiplier (LM) test was used to determine the presence of volatility clusters in the residuals. Based on the lowest BIC values, ARMA (2,2) and ARMA(3,3) were chosen as conditional mean models of daily energy consumption and daily peak demand, respectively. The Ljung-Box test was applied to detect the autoregressive conditional heteroscedasticity (ARCH) in the residuals of the conditional mean model. A GARCH (1,1) model was built to forecast the daily energy consumption and daily peak demand, with the accuracy of the model measured using Mean Absolute Percentage Error (MAPE). The MAPE in the ARMA (2,2) – GARCH (1,1) model was 5.3222, and the MAPE in the ARMA (3,3) – GARCH (1,1) model was 4.5806. The symmetric GARCH models ARMA (2,2)–GARCH (1,1) and ARMA (3,3)–GARCH (1,1) were selected as the best time series models for forecasting the daily energy consumption and daily peak demand in Sri Lanka, respectively. These models are capable of capturing the volatility and the time-varying conditional variance on the daily energy consumption and daily peak demand in Sri Lanka.

KEYWORDS: ARMA, Energy Consumption, GARCH, Peak Demand

1 INTRODUCTION

1.1 Background of the study

Electricity is the world's most important primary energy source. It directly affects the economy of any country. Although Sri Lanka is rich in various renewable energy sources such as biofuels, hydropower, solar energy, and wind, it is still a developing country in South Asia. Ceylon Electricity Board is Sri Lanka's largest electricity company. It has almost complete market control over key power production, transmission,

distribution, and retail activities. In 2014, the business made about LKR 204.7 billion, and there were roughly 5.42 million consumer accounts overall. For the generation of electricity, several sources such as thermal power, hydropower, and other non-conventional renewable energies (biomass, solar, wind, tidal, biofuel, and ocean wave) are used. Hydropower is primarily used to generate electricity. Both advantages and disadvantages are associated with these sources in terms of aspects such as initial cost, maintenance cost, space, etc. The

aim of this study is to analyze daily electricity peak demand and daily energy consumption over the past two years. The findings help to design an efficient power development plan with the new power generating sources, which assures the availability of power to cater to the required demand in the future.

1.2 Significance of the Study

Energy forecasting is a vital technique that helps to predict the needs of future energy and maintain a balance between energy supply and demand. It is crucial to model daily energy consumption and peak demand accurately as electricity demand increases. This helps reduce carbon emissions, optimize energy production and distribution, and lower energy costs. Accurate forecasting also plays a crucial role in policy decisions and power demand forecasting, as it provides a foundation for making informed decisions in power system planning and operation. Therefore, energy forecasting is a critical process that helps ensure sustainable energy use and efficient energy management.

1.3 Objectives of the Study

The objective of this study is to analyze the behavior of daily electricity energy consumption and peak demand in Sri Lanka to construct a suitable univariate time series model.

2 LITERATURE REVIEW

Many studies have been carried out in the past to analyze the daily electricity consumption and peak demand in Sri Lanka. One of such studies is Ananthasingam & Atputharajah (2015), which has been used to examine the forecast daily night peak electric power

demand in Sri Lanka using the Box-Jenkins ARIMA model methodology. 334 data points from January 2013 to November 2013 were used for modeling and analysis. The final, successful model, ARIMA (3,1,3) (1,1,1)⁷, was evaluated for effectiveness. The MAPE for a month ahead forecast was 4.195%, and the MAPE for a week ahead forecast was 1.855%.

According to Yasmeeen & Sharif (2014), monthly electricity consumption in Pakistan was examined using linear and nonlinear modeling techniques. They have identified the best model as ARIMA (3,1,2).

Garcia et al. (2005) created a prediction model based on the GARCH approach based on Box Jenkins methodology for forecasting day-ahead electricity prices in Spain and California electrical markets.

Kim et al. (2019) analyzed the daily peak load demand for a Seoul institution building between January 1 and December 31, 2017. The best predictive model, according to them, is the ARIMA-GARCH model for predicting daily peak load demand.

Niel & Pierre (2015) developed the GARCH, GJR-GARCH, and EGARCH models for forecasting daily volatility indices on the Johannesburg Stock Exchange from 2007 to 2009. They suggested that the GJR-GARCH model is the best prediction model for forecasting the daily stock exchange.

Cristina (2008) developed a univariate asymmetric GARCH model to model the volatility of the Romanian and American stock markets over the period January 2001–February 2008 with daily observations.

Franses & Van (1996) have developed a GARCH model and two non-linear models to predict weekly stock market volatility. A comparison of the QGARCH model and the linear GARCH model using five weekly stock market indexes demonstrates that the QGARCH model can perform much better.

3 METHODOLOGY

Data for this study was collected from the daily economic indicators of the Central Bank of Sri Lanka from the years 2020 to 2021. The study was conducted as a univariate time series analysis to fit a model to the collected data.

The box-Jenkin method is used to analyze time series data for forecasting. This method allows the model to identify trends using Auto regression (AR), Moving averages (MA) and seasonal differencing, which is known as Autoregressive Moving Average (ARMA) or Autoregressive Integrated Moving Average (ARIMA). The Box-Jenkins method consists of three steps: model identification, parameter estimation, and diagnostic checking.

3.1 Model Identification

In order to identify a good model, the stationarity of the series must be checked. An ADF test can be used to check the stationarity of the series. In the case of non-stationarity, the Box-Jenkins method recommends the differencing approach in order to achieve stationarity. Once stationarity and seasonality have been addressed, the order of the autoregressive (p) and moving average (q) terms should be identified. For this purpose, ACF and PACF are used to identify a reasonable model.

3.2 Parameter Estimation

Parameter estimation involves approximating numerical solutions of nonlinear equations. The preferred technique is Maximum Likelihood estimation. All the estimated parameters should be significantly different from zero.

3.3 Diagnostics Checking

A well-fitting model yields residuals with four properties. Residuals have no autocorrelation; residuals have a zero mean; residuals have a constant variance; and residuals should be normally distributed. Serial correlation LM test and Jarquebera test can be used to determine the properties of residuals. The ARCH LM test is carried out to detect conditional heteroscedasticity in residuals. The selection of the model is done using the Akaike Information Criterion (AIC) value. For the purpose of forecasting, the MAPE is used as a measure of prediction accuracy.

4 RESULTS AND DISCUSSION

4.1 Descriptive and Advanced Analysis

Before creating the univariate time series models, the outliers of the daily total energy consumption and daily peak demand were estimated. An outlier is an observation that is located far from the other observations.

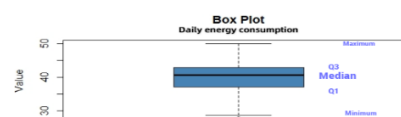


Figure 1: Box plot of energy consumption

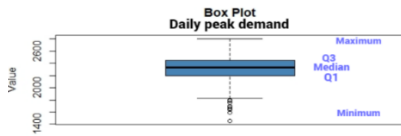


Figure 2: Box plot of peak demand

Figure 1 and Figure 2 indicate the outliers of daily total energy consumption and daily peak demand. The outliers were replaced in the data set using variable transformation.

Table 1: Descriptive statistics

	Mean	SD	Max	Min	Median
Energy	39.9	4.109	50.0	27.7	40.6
Peak	2309	197.0	2807	1483	2336

According to Table 1, the mean daily total energy consumption and peak demand over the period 2020 to 2021 are 39.98 and 23.09 respectively.

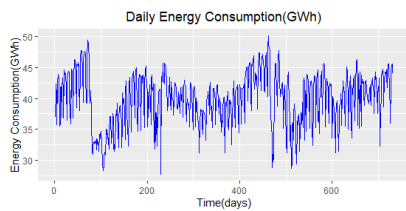


Figure 1: Time series plots of energy consumption

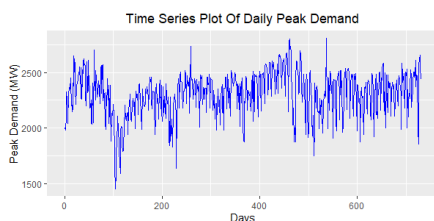


Figure 2: Time series plots of peak demand

Table 2: ADF Test of Difference Series Augmented Dickey-Fuller Test

	Energy consumption	Peak demand
P value	0.01	0.01

According to the ADF test, daily total energy consumption and daily peak demand are not stationary. After the first

order log transformation, the ADF test reveals that the transformed data are stationary for both cases.

Based on residual diagnostic tests and the minimum BIC values (-1763.257, -1969.148) ARMA (2,2) and ARMA (3,3) were selected as mean models for daily total energy consumption and daily peak demand, respectively.

Table 3: Serial Correlation LM test Breusch-Godfrey test for serial correlation

	Energy Consumption	Peak Demand
P value	0.9089	0.8551

Based on P-values, it is concluded that the models ARMA (2,2) and ARMA(3,3) have no serial correlations.

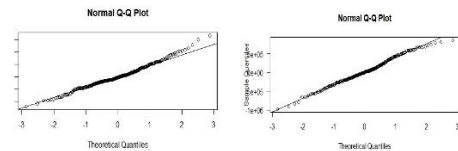


Figure 3: Normal Q-Q plot of Residuals

Normality of residuals was checked using Jarque-Bera test.

Table 3: Jarque-Bera test Jarque - Bera Normality Test

	Energy Consumption	Peak Demand
P value	0.6874	0.6875

The test results confirmed that residuals are normally distributed.

Table 4: ARCH LM test ARCH LM test

	Energy Consumption	Peak Demand
P value	1.734e-12	0.00589

Based on p-values, the ARCH LM test indicates that conditional heteroscedastic behavior is present and residuals have volatility clusters. The

variance is not constant in the residuals, and the GARCH model must be fitted to vanish that impact. Hence, ARMA (2,2)-GARCH (1,1) and ARMA (3,3)-GARCH (1,1), which have the minimum BIC value, were fitted for the variance equations. Before model estimation, using the sign bias test, it is important to check whether the obtained ARMA (2,2)-GARCH (1,1) and ARMA (3,3)-GARCH (1,1) models are symmetric or asymmetric. Thereafter, symmetric effects on these models were checked using the sign bias test.

Table 5: Sign Bias Test

Model	Prob.
ARMA(2,2)-GARCH(1,1)	0.0127
ARMA(3,3)-GARCH(1,1)	0.000633

According to Table 6, the coefficient of sign bias test is significant. Then, there is a difference between the impact of a negative and positive shock to the ARMA(2,2)-GARCH(1,1) and ARMA(3,3)-GARCH(1,1) models as an symmetric models.

The mean absolute percentage error in the ARMA(2,2) GARCH(1,1) model was 5.3222 and that of ARMA(3,3) GARCH(1,1) model was 4.5806.

5 CONCLUSION

Electricity is the most important primary source on earth. It directly affects the economies of all countries. This study's major objective was to predict and assess Sri Lanka's daily energy consumption and daily peak demand. It demonstrated that the two years between 2020 and 2021 had both an upward and downward trend.

The mean absolute percentage error in the ARMA(2,2)-GARCH (1,1) and ARMA(3,3)-GARCH(1,1) based on predictions of the 20 days in 2022 are

5.3222 percent and 4.5806 percent, respectively. It has the ability to capture errors, conditional variation that varies over time, and volatility. Precautionary measures, such as the creation of an effective power development plan, are crucial to reducing difficulties. The study suggests that other distributions outside the normal distribution be assumed.

The findings of the study could help policymakers and energy companies in Sri Lanka make better decisions regarding energy production and distribution, leading to more efficient and sustainable energy systems. Furthermore, the use of GARCH models in the study to forecast energy consumption and peak demand in Sri Lanka is a novel approach, and the findings contribute to the body of knowledge in the field of energy forecasting.

REFERENCES

- Ananthasingam, A., and Atputharajah, A. (2015). Forecast daily night peak electric power demand in Sri Lankan power system. In *2015 IEEE 10th International Conference on Industrial and Information Systems (ICIIS)* (pp. 238-243).
- Franses, P. H., and Van Dijk, D. (1996). Forecasting stock market volatility using (non-linear) Garch models. *Journal of forecasting*, 15(3), 229-235.
- Garcia et al. (2005). A GARCH forecasting model to predict day-ahead electricity prices. *IEEE transactions on power systems*, 20(2), 867-874.
- Kim et al., (2019). Short term electricity load forecasting for institutional buildings. *Energy Reports*, 5, 1270–1280.
- Yasmeen, F., and Sharif, M. (2014). Forecasting electricity consumption for Pakistan. *International Journal of Emerging Technology and Advanced Engineering*, 4(4), 496-503.



Analysis of the Electricity Demand in the Matara Area

Widanagamage HE¹, Sampath MIGS²

Department of Mathematical sciences, Faculty of Applied Sciences, Wayamba University of Sri Lanka^{1,2}

hashanierangika96@gmail.com¹

migsuranga@wyb.ac.lk²

ABSTRACT

In this research, the weekly electricity data from 2017 to 2021 was utilized to do a time series analysis on the weekly electricity demand of the houses connected to the Matara primary substation. ARIMA model was used for forecasting the weekly electricity demand using the Box-Jenkins approach of Time Series Analysis. Descriptive and Advanced Analysis were used for this. Descriptive analysis was done, and it was found that the average demand of weekly electricity demand is 1202.5 MWh. Advanced analysis was used to find the best ARIMA model. Several Autoregressive Integrated Moving Average (ARIMA) models were fitted and the best fitted model was ARIMA (0,1,2). The mean absolute percentage error in the ARIMA (0,1,2) based on forecast values from the first 10 weeks of 2022 was 4.89 percent. The accuracy of the ARIMA (0,1,2) model was estimated to be 95.11 percent.

KEYWORDS: ARIMA, Box-Jenkin Method, Electricity Demand

1 INTRODUCTION

Electricity is an essential daily requirement for human life. The present is characterized by rapidly rising electricity demand and the emergence of a power crisis. The power problem is influenced by increased human electrical use, natural calamities, and political and societal forces. Due to the inability to create enough power to fulfill demand, the people of Sri Lanka are currently experiencing a variety of socioeconomic issues. Urban areas have the largest electricity usage. The demand for electricity in urban areas is currently high due to many socioeconomic and political causes such as economic development, rapid urbanization, and the growing needs of the urban population. The usage of renewable energy for electricity generation is a crucial answer to the current power issue. Wind, solar, biomass, and geothermal energy are examples of renewable energy sources. All energy sources that are new or

permanent in a short period of time are included in this category. Hydropower is a renewable energy source that is only partially renewable. Such power interruptions can be reduced if renewable energy is used. This research aims to forecast future electricity demand in the Matara area.

2 LITERATURE REVIEW

Yunsun et al. (2019) have done a short-term electricity load forecasting for institutional buildings. The campus's 23 buildings are where the dataset was gathered. There are four types of models used: ANN models, multiple seasonal exponential smoothing, and ARIMA-GARCH models. They compared the performances of models based on ARIMA, exponential smoothing techniques, and artificial intelligence in this study.

Zhongfu et al. (2009) forecasted day-ahead electricity price using wavelet transform combined with ARIMA and

GARCH models. They have shown that ARIMA and GARCH model was more accurate for the forecasting.

Using ARIMA, GARCH, and Winters Triple Exponential Smoothing models, Patcharakorn and Pasapitch (2021) created and compared predicting time series data on the use of home power. Two models, ARIMA and ARIMA-GARCH, were used to replicate the SPI-9 drought index, and the findings revealed that ARIMA-GARCH performed better than ARIMA.

Fadhilah et al.(2013) used hybrid ARIMA-GARCH models for time series analysis of rainfall data. Thus, the combined ARIMA-GARCH model more accurately reflects the dynamics of the daily rainfall series in the study locations. On the other hand, the seasonal ARIMA model proved to be a good fit for the locations treated's monthly average rainfall data.

Yeziz et al. (2013) used hybrid ARIMA-GARCH modeling to predict the price of gold. In this study, gold prices are predicted using Box-Jenkins, specifically the autoregressive integrated moving average (ARIMA) models.

Using hybrid ARIMA-GARCH modeling, Chaido (2018) has predicted the price of oil. Box-Jenkins methodology through ARIMA models is one technique for predicting oil prices. These models are capable of accurate predicting for brief periods of time, but they are unable to deal with the volatility and nonlinearity that are inherent in data series. In order to forecast the volatility in the return of oil prices, they tested a hybrid ARIMA-GARCH model in this work.

3 METHODOLOGY

In this study ARIMA model is implement using Box-Jenkins methodology.

The weekly electricity consumption from January year 2017 to year 2021 was collected from Matara Electricity board. Box-Jenkins methodology involves 4 steps as follows:

1. Model identification
2. Parameter estimation
3. Checking model adequacy
4. Forecasting

4 RESULTS AND DISCUSSION

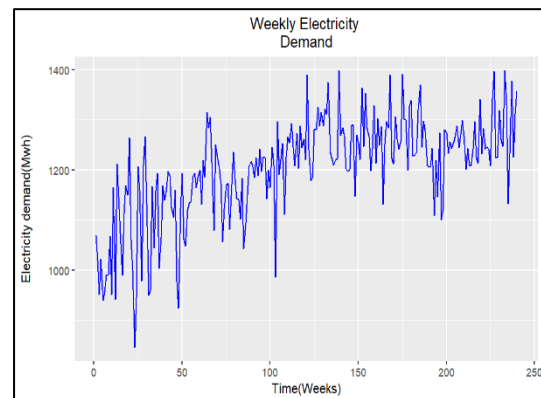


Figure 1: Time series plot of the weekly electricity demand 2017-2021

The time series plot of the weekly electricity demand at the sub division of the Matara Chief Electrical Engineering Center is shown in Figure 1. A trend pattern is shown in the time series plot from 2017 to 2020.

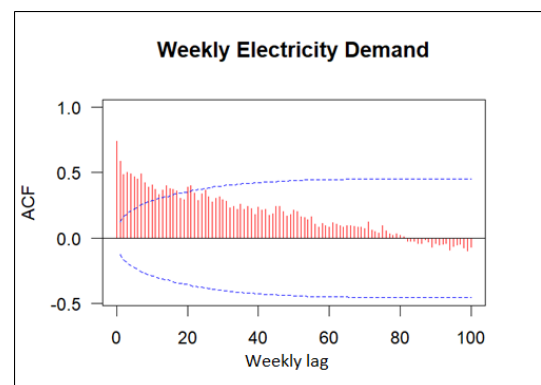


Figure 2: Autocorrelation function of weekly electricity demand

According to the figure 2 , ACF of weekly electricity demand, The increasing upward trend in these data was validated , and it is now clear that the trend pattern's presence indicates that these data are non-stationary.

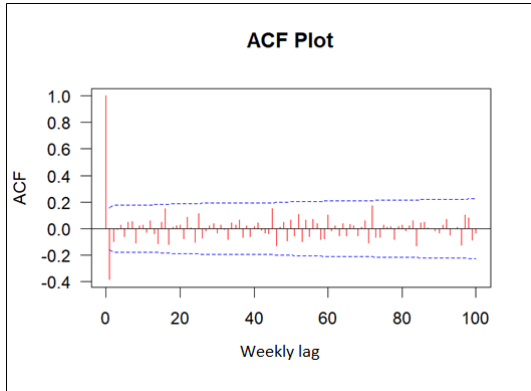


Figure 3: Autocorrelation function of differenced series

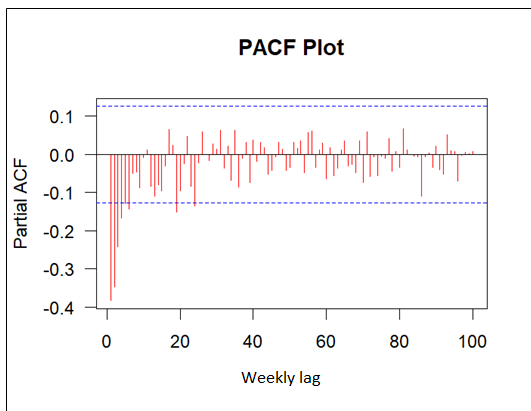


Figure 4: Partial Autocorrelation function of differenced series

Figure 3 indicated that the first non-seasonal lag of the ACF plot is significant. and Figure 4 indicated that the PACF plot is quickly dies down. It is clear that there were no seasonal patterns in those seasonal lags of ACF. Therefore, Tentative model is ARIMA(0,1,1).

The best ARIMA model of original series can be found using the auto.arima function of R softwae. The results obtained here are shown in the Table 1 below.

Table 1: BIC values of ARIMA models for the differenced series

Models	BIC Values
ARIMA(2,1,2)	2732.179
ARIMA(0,1,0)	2836.106
ARIMA(1,1,0)	2800.756
ARIMA(0,1,1)	2730.901
ARIMA(1,1,1)	2727.271
ARIMA(2,1,0)	2834.147
ARIMA(2,1,1)	2731.59
ARIMA(1,1,2)	2727.822
ARIMA(0,1,3)	2728.409
ARIMA(1,1,3)	2729.69
ARIMA(0,1,2)	2726.167

According to Table 1, considering the minimum Bayesian Information Criteria (BIC) values of the ARIMA models, ARIMA (0,1,2) model is selected as the most preferable model.

The summary of the parameter estimation of ARIMA (0,1,2) model is illustrated in Table 2.

Table 2: Parameter estimation for ARIMA (0,1,2) Model

	Estimate	Z value	P value
Ma1	-0.750593	-11.1	0.2×10^{-15}
Ma2	-0.159893	-2.35	0.0334
Intercept	1.091026	2.44	0.0144

Since p value is less than 0.05, there is enough evidence to conclude that the ma1, ma2 and intercept terms are significant at 5% level of significance. Hence, ARIMA(0,1,2) model is fitted for the given data under the usual assumption of the residuals.

Several diagnostic tests should be performed to confirm the model's goodness-of-fit. Model diagnostic checking is included main four assumptions.

1. The residuals have zero mean.
2. The residuals are uncorrelated.
3. The residuals are normally distributed.
4. The residuals have constant variance.

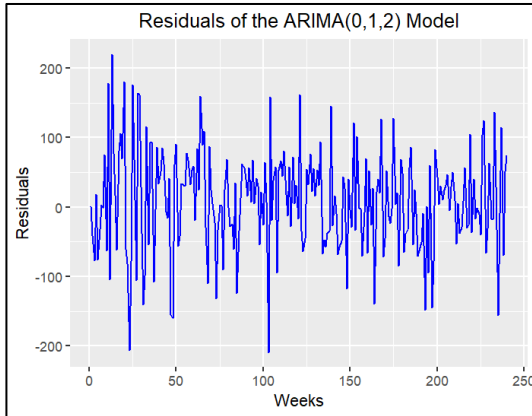


Figure 5: Residuals of the ARIMA (0,1,2) Model

The Figure 5 above indicates that the mean of residuals is zero.

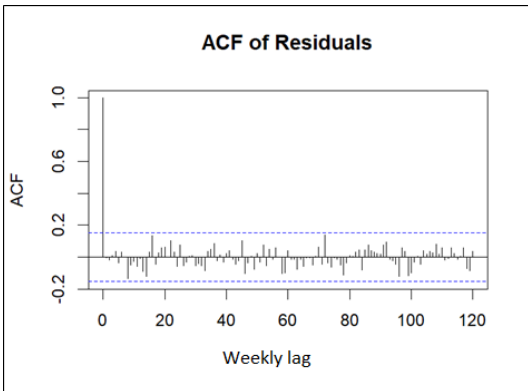


Figure 6: Autocorrelation function of residuals

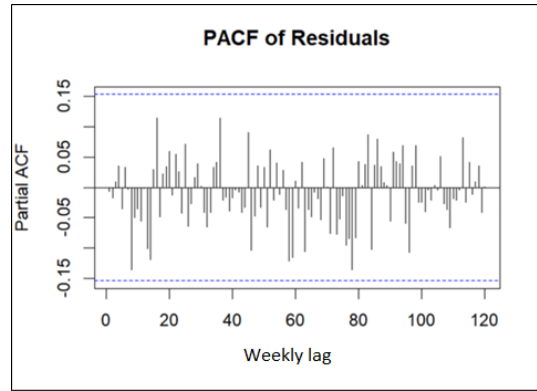


Figure 7: Partial autocorrelation function of residuals

ACF and PACF in Figures 6 and 7 demonstrate a realization of a discrete white noise process, which shows that we have successfully established a satisfactory fit with the ARIMA (0,1,2) model. We can see from these plots that the residuals appear to be uncorrelated.

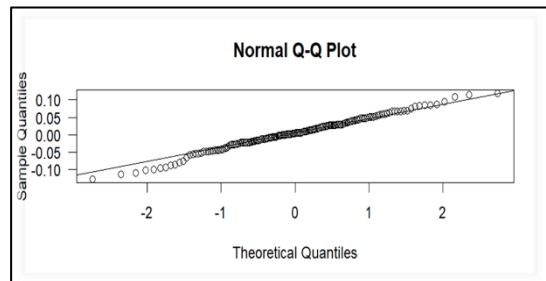


Figure 8: Normal Q-Q plot of residuals

According to Figure 8, The normal Q-Q plot shows that the straight line provides a good fit for the residuals. The residuals are found to be normally distributed.

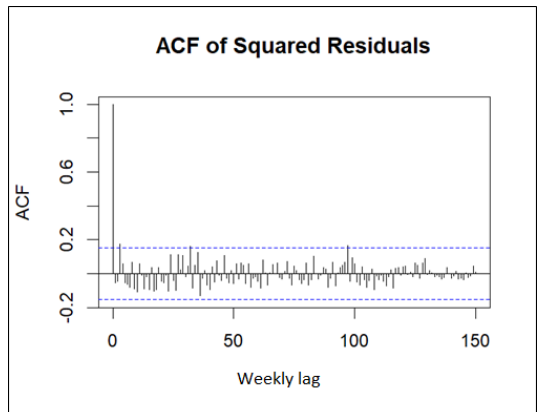


Figure 9: Autocorrelation function of squared residuals

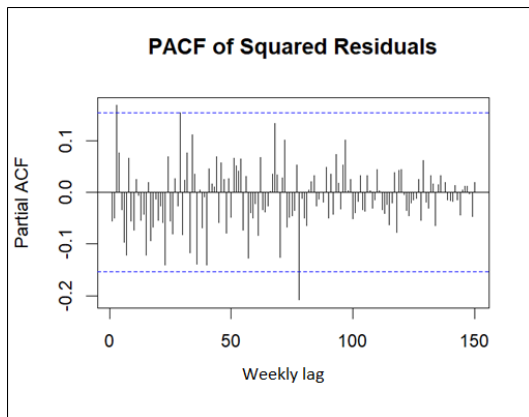


Figure 10: Partial Autocorrelation function of squared residuals

The ACF and PACF both show some significant spikes, as shown in Figures 9 and 10. Here, it cannot be confirmed that there is a conditional heteroscedastic behavior. Further evidence for it can be provided by the ARCH test.

The p value of ARCH test is 0.08793 and greater than 0.05. Then there is not enough evidence to reject the null hypothesis at 5% level of significance. Hence, it can be concluded that residuals of fitted ARIMA(0,1,2) model have not ARCH effects.

After checking the ARCH LM test, it is proved that the ARIMA (0,1,2) model is the best for modeling electricity demand.

The mean absolute percentage error in the ARIMA (0,1,2) based on forecast values from first 10 weeks of 2022 is 4.89 percent. If MAPE < 10%, The model is supposed to be excellent. It can be concluded that the accuracy of the ARIMA (0,1,2) model is approximately equal to 95.11 percent. Clearly, it is a low error percentage, which means that the ARIMA (0,1,2) model gives more accurate forecasting performance.

5 CONCLUSION

In this study, the ARIMA model is employed to forecast the demand for power in the Matara Chief Electrical Engineering Center's subdivision.

Original series are fitted with the ARIMA (0,1,2) model.

This fitted model does not exhibit conditional heteroscedasticity in the residuals of the fitted ARIMA(0,1,2) model.

It has been demonstrated that there is no ARCH impact in the fitted model.

Based on projected results from the first 10 weeks of 2022, The mean absolute percentage error in the ARIMA(0,1,2) based on forecast values from first 10 weeks of 2022 is 4.89 percent.

It can be concluded that the accuracy of the ARIMA(0,1,2) model is approximately equal to 95.11 percent. Clearly, it is a low error percentage, which means that the ARIMA (0,1,2) model gives more accurate forecasting performance.

REFERENCES

- Chaido Dritsaki. (2018). The Performance of Hybrid ARIMA-GARCH Modeling and Forecasting Oil Price. *International Journal of Energy Economics and Policy*, 8(3), 14–21.
- Dilaver, Z., & Hunt, L. C. (2011). Industrial electricity demand for Turkey: A structural time series analysis. *Energy Economics*, 33(3), 426–436.
- Hamzacebi, C., & Es, H. A. (2014). Forecasting the annual electricity consumption of Turkey using an optimized grey model. *Energy*, 70, 165–171.
- Kim, Y., Son, H. G., & Kim, S. (2019). Short term electricity load forecasting for institutional buildings. *Energy Reports*, 5, 1270–1280.

- Mirjat, N. H., Uqaili, M. A., Harijan, K., Walasai, G. D., Mondal, M. A. H., & Sahin, H. (2018). Long-term electricity demand forecast and supply side scenarios for Pakistan (2015–2050): A LEAP model application for policy analysis. *Energy*, *165*, 512–526.
- Sim, S. E., Tay, K. G., Huong, A., & Tiong, W. K. (2019). Forecasting Electricity Consumption Using SARIMA Method in IBM SPSS Software. *Universal Journal of Electrical and Electronic Engineering*, *6*(5B), 103–114.
- Sokannit, P. (2021). Forecasting Household Electricity Consumption Using Time Series Models. *International Journal of Machine Learning and Computing*, *11*(6), 380–386.
- Tan, Z., Zhang, J., Wang, J., & Xu, J. (2010). Day-ahead electricity price forecasting using wavelet transform combined with ARIMA and GARCH models. *Applied Energy*, *87*(11), 3606–3610.
- Yaziz, S.R., Azizan, N.A., Zakaria, R., and Ahmad, M.H. (2013). The performance of hybrid ARIMA-GARCH modeling in forecasting gold price. *Piantadosi, J., Anderssen, R.S. and Boland J. (Eds) MODSIM2013, 20th International Congress on Modelling and Simulation*.
- Yusof, F., Kane, I. L., & Yusop, Z. (2013). Hybrid of ARIMA-GARCH Modeling in Rainfall Time Series. *Jurnal Teknologi*, *63*(2).



Application of Lean Manufacturing for Improving the Efficiency in Apparel Binding – A Case Study

Perera AGMB¹, Panahatipola PMOP²

*Department of Mathematical Sciences, Faculty of Applied Sciences, Wayamba University of Sri Lanka.^{1,2}
madushabuddhini02@gmail.com¹
pmoshadhi@gmail.com²*

ABSTRACT

Lean is a philosophy of manufacturing process improvement to identify waste and reduce wastage while adding values to products and services. The purpose of this study is to implement lean in the binding section of the cutting department through eliminating wastage. Sewing, winding, and cutting are the main processes that require analysis in the binding section. In order to improve the efficiency, analyzing the layout, process flow and batch size is done exquisitely. 20 samples were taken from each employer in both shifts A and B in the binding section by analyzing the cycle time of each operation. Activity analysis (time study) for each three operations is used to generate the equation and to identify value-adding and non-value adding variables of collected sample data. Transportation, inventory, motion, waiting, overproduction, over processing and defects were identified as main wastages of this manufacturing process. To reduce the wasting time between two consecutive operations, accurate models were created. For sewing quick change over time (QCO), sewing time and dispose time were identified as independent variables and for winding it is QCO, winding and dispose and for cutting the binding it is QCO, cutting and dispose. The model was constructed using the average of these independent variables. This paper proposes a systematic solution to predict day plans with higher efficiency in order to reduce wasting time by using the standard minute value (SMV) calculating method.

KEYWORDS: Binding, Improving efficiency, Lean manufacturing, Lean implementation

1 INTRODUCTION

Toyota production has recently adapted the lean manufacturing concept for the use in Western Industries and its primary goal is to optimize mathematical linear programming in the service industry in order to lower the cost through waste identification and reduction. Kaizen, Kanban, just in time, line balancing, layout redesigning, cellular layout and the source quality are the main key techniques that are not limited to such tools. Nowadays many industries including consumer product manufacturing, electronics and automobiles have reached to use applications in lean manufacturing. Application of lean manufacturing is

considered recent to textile industries compared to extensive implementation in other fields. Stranded Minute Value (SMV) is a comprehensive lean approach which helps to enhance the performance of an operation by spotting and tackling its criticalities. Producing quality products with more efficiency and less time is the implemented lean manufacturing concept in the textile industry. Identification of non-value adding steps, value adding steps and streamline a process helps to improve the former and eliminate the latter by reducing the waste. The main goal of the study is to propose a programmatic application to improve the efficiency in the Binding section of the textile

company by reducing the 7 wastes in lean manufacturing. The study includes,

- a) Balancing flow throughout the process.
- b) Reducing inventory and waste in the production process.
- c) Producing a capacity that helps achieve the target.

2 LITERATURE REVIEW

Bonaccorsi, et al., (2011) have presented a comprehensive lean approach based on value stream management to enhance the performance of a service in the service industry. It is motivated by the growing need to extend lean concepts to the industry and to support technical staff by lack of operating capable tools.

Shakil & Parvez (2018) have investigated an application of lean manufacturing in a sewing line to improve the overall equipment effectiveness. In that study they analyzed the layout, process flow and batch size and then proposed a new layout reorganizing the process flow that eliminated backflows and reduced the transportation time.

Kim (2013) has studied a lean practice case for improving service operations of a donuts company. He analyzed the data using lean thinking tools and provided a pragmatic view of lean application that can be adapted into real world situations. Both value identification and service quality improvement were applied and finally it clarifies lean by showing how the process can be supported to add incremental value.

Rother (1999) and Abdulmaleka (2007) have observed that lean production means identification of all types of waste in the value stream of the

supply chain and implementing necessary tools to minimize lead time.

MacDufile (1997) has defined waste as anything that interferes with the smooth flow of production. Overproduction, over processing, excess inventory, unnecessary movement, waiting time, defects, unused employee creativity and conveyance were highlighted as key wastes.

3 METHODOLOGY

In order to collect the sample data from sewing, winding and cutting the winding, the work study(activity analysis) method was used and to measure the cycle time a stopwatch was used. Firstly, the noisy variables (non-value adding) and value adding variables were identified from the collected data.

Table 1: Variables selected for the program creation.

Sewing SMV	Binding SMV		Cutting SMV
	Winding Straight	Winding Cross	
QCO Sewing OL	QCO Roll Length	QCO Roll Length	QCO Piece Width
No. of panels	Dispose	Dispose	No of Pieces
Dispose			Dispose

As illustrated in table 1, the dependent variables for the study was taken as Sewing SMV, Straight Winding SMV, Cross Winding SMV and Cutting SMV and independent variables were QCO, Dispose, Sewing ol, Number of panels, Roll width, Piece width and Number of pieces.

QCO- the time gap between two consecutive operations.

Dispose- the time period that goes to end up the operation.

Standard Minute values per meter were calculated for each four operations

by taking the average of samples separately. Next, linear models were generated using independent and dependent variables to predict future outcomes.

A program then was developed to automatically calculate the standard minute values for the fore processes in the binding section. Finally, the performance of the program was evaluated using accuracy measures of predicted data.

4 DATA COLLECTION AND ANALYSIS

Primary data for the study were collected by doing the activity analysis of sewing, winding and cutting the winding in the binding section separately. 20 samples were taken from each employer in both shifts A and B in the binding section in the cutting department. Then a production study was done for the same process in order to categorize the collected data into value adding and non-value steps. Using the variables, an accurate model was built for SMV calculation.

Sewing SMV=Sewing QCO + (Sewing OL * No of panels) +Dispose

(1)

Cross Winding SMV=QCO + (Winding 1st roll + Winding 2nd roll) * length + Dispose

(2)

Straight Winding=QCO + Winding*length + Dispose

(3)

Cutting SMV=QCO + Cutting + Dispose

(4)

Using these equations, the VBA program was created to calculate SMV. According to fig. 2, Line number and Docket number are the initial information

which can be introduced as independent variables that do not affect the calculation results. For sewing SMV, the total length given is enough for the calculation. For straight winding and cross winding SMV, choosing the winding type and total length is necessary. For cutting SMV, piece width and number of pieces are the inputs. Data can be uploaded to the excel at the same time by using the “load to excel command” and exit command can be used to close the program.

5 RESULTS AND DISCUSSION

The study found sewing, straight winding, cross winding and cutting the winding as the main processes in binding. Sewing and winding vary according to the length of the fabric. Cutting depends on the piece width and number of pieces. So, to identify a similarity, separate models were created for the four operations and accuracy was measured. Also, the descriptive analysis helped to understand the distribution of variables.

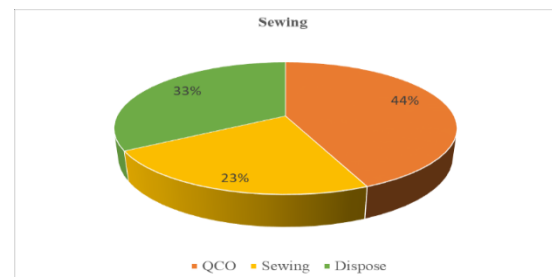


Figure 1: Distribution of total time

The fig. 1, distribution of total time for sewing indicated that the QCO and Dispose percentages are higher than the value adding process time. So the non-value adding time must decrease in order to improve the efficiency in productivity.



Figure 2: SMV Calculation program design

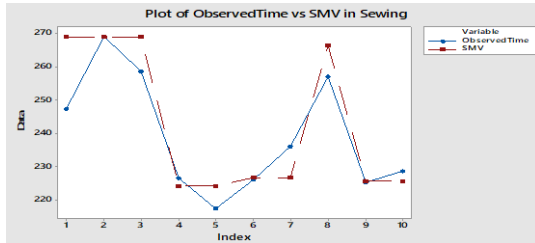


Figure 3: Comparison of observed and calculated SMV in Sewing

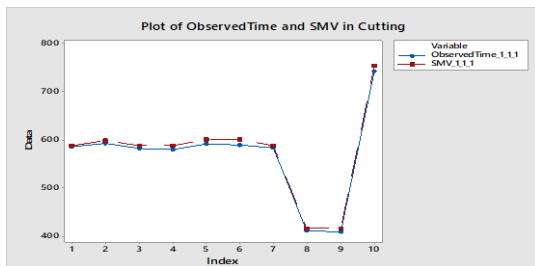


Figure 4: Comparison of observed and calculated SMV in Cutting

Accuracy of the program was measured by comparing the actual observed values with calculated SMV values. The fig. 3 and fig. 4 depicts that the both values are approximately equal.

Table 2: Accuracy of the program.

Operation	MAPE (%)	Accuracy (%)
Sewing	2.62671	97.4
Straight winding	2.28897	97.7
Cross winding	5.50215	94.5
cutting	1.26228	98.7

The table 2 verifies that the created program has more than 94% accuracy. It is because the mean absolute percentage error (MAPE) values of sewing, straight

winding, cross winding and cutting are less than 6%.

6 CONCLUSION

Lean manufacturing principles have been used in different industries for several years, but in the sewing industry the usage is low. But the results of this project give some evidence of the applicability of lean manufacturing concept in garment industry. Also, lean can be introduced as an appropriate strategy to consider a high investment process in machining, technology or human training.

In this study the lean concept was successfully instituted into the garment industry in order to improve the productivity in binding section. For improving the productivity, the existing processes and layout was studied. To keep track of overall efficiency, improvement monitoring and measuring is very important. In that case standard minute value (SMV) calculation is the standard method to monitor and measure the effectiveness.

According to this study, waiting time has been identified as the main factor that reduces the productivity. For that a program was proposed to minimize the transportation and waiting time by automatically calculating the SMV of binding operations sewing, winding and cutting. It helps to sum up the capacity of a certain day and keep to a daily target.

REFERENCES

- Andrea B., Gionata C. and Francesco Z., Service Value Stream Management (SVSM): Developing Lean Thinking in the Service Industry. *Journal of Service Science and Management*, 2011, 4, 428-439, doi:10.4236/jssm.2011.44048 Published Online December 2011, <http://www.SciRP.org/journal/jssm>.

APPLICATION OF LEAN MANUFACTURING FOR IMPROVING THE EFFICIENCY IN APPAREL
BINDING

Joseph C.C. and Ronald A.C., Value Stream Management for Lean Office—A Case Study, Department of Industrial and Manufacturing Engineering and Technology, Bradley University, Peoria, USA; 2, College of Engineering, Iowa State University, Ames, US, American Journal of Industrial and Business Management, 2012, 2, 17-29 Published Online April 2012, <http://www.SciRP.org/journal/ajibm>

Parvez M. and Shakil S.I., Application of Lean Manufacturing in a Sewing Line for Improving Overall Equipment Effectiveness (OEE), Department of Industrial Engineering and Management, Khulna University of Engineering & Technology, Khulna, Bangladesh, American Journal of Industrial and Business Management, 2018, 8, 1951-1971, ISSN Online: 2164-5175,

Song-Kyoo Kim, Lean Practice Case for Improving Service Operations of Donuts Company, Washington SyCip Graduate School of Business, Asian Institute of Management, Makati, Philippines, *Journal of Service Science and Management*, 2013, 6, 232-239 <http://dx.doi.org/10.4236/jssm.2013.63026>, Published Online August 2013



Driver Drowsiness Detection

Rajakaruna DSJ¹, Dahanayaka SD², Wickramasinghe WAAD³

Department of Mathematical Sciences, Faculty of Applied Sciences, Wayamba University of Sri Lanka. ^{1, 2, 3}

sudarshirajakaruna@gmail.com ¹

shalikadahanayaka@wyb.ac.lk ²

ayasha91wickramasinghe@gmail.com ³

ABSTRACT

Today, road accidents have become the main cause of injury and death. It is very important to take extra care while driving. Therefore, driver drowsiness detection is an important application of image processing. In recent years, much research using numerous methods has been reported in the literature in this field. The goal of this research was to develop an intelligent system to detect sleepiness in drivers. In this research, unlike traditional sleep detection methods based only on eye blinking patterns, facial expressions were used. If a person's eye blinking is fast, there is a problem. The method based on image processing is quicker and more reliable compared to other methods. Image processing is widely used for object recognition. It can be used to recognize human facial expressions and emotions. For that, the facial features should be observed first. Often, the characteristics of facial expressions and the style of showing emotions to the outside world are different from person to person, so it is very difficult to build an accurate system for recognizing emotions. To overcome this problem, this research considered the detection of yawning and head nodding rather than only detecting eye closure. This proposed method performed with a high average accuracy of 82.14%.

KEYWORDS: Drowsiness detection, Image processing, Blinking patterns, Facial expression, Object recognition

1 INTRODUCTION

Driving is a common activity in most people's lives. Thousands of road accidents occur across the globe every day. According to the statistics, in Sri Lanka, nearly six people die and 50 get injured daily.

Some of the most common reasons for road accidents are speeding: folks ignoring the speed limit on highways, drunk drivers: drunk drivers lose control, cannot focus, and cannot function properly. Night driving: driving at night doubles the risk of an accident and drowsiness while driving. Among those reasons, human errors play a major role in vehicle accidents. Often, drivers get tired after spending a few hours at the wheel, which can lead to an accident.

Various studies have suggested that about 20% of all road accidents are associated with fatigue, up to 50% on some roads. This condition requires a solution to detect drowsiness while driving and actions to awaken drivers. The first sign of sleepiness is the inability to keep the eyes open. Next, when someone is sleepy, they tend to shake their head back and forth. Yawning is also a sign of sleepiness. These common signs can be used to detect sleepiness in a person.

2 RESEARCH OBJECTIVE

Numerous methods have been developed to detect sleepy drivers, based on the various techniques to reduce those road accidents. Most of these developed systems have only used the eye blinking

pattern of the driver to detect the driver's sleepiness. If the eye blinking is high, then it will give the driver the wrong warning. The main objective of this research was to develop an intelligent system to detect sleepiness in drivers using MATLAB through image processing to avoid the problems associated with accidents involving drivers who experience fatigue.

3 LITERATURE REVIEW

Rajahrajasingh (2016) proposed a driver detection system based on eye blinking rate using image processing. MATLAB was used in the research. The algorithm used to detect sleepiness in drivers has an average accuracy of 73.74%, and it has a higher accuracy of 89.34% with people not wearing glasses. The detection was carried out in three main steps. It began with face detection and facial feature detection using the famous Viola Jones algorithm, followed by eye tracking. By using the correlation coefficient for template matching, the eyes were tracked. Whether the driver is awake or asleep was identified by matching the extracted eye image with the externally fed template (open eyes and closed eyes).

Santoshi et al. (2020) have developed an automated system for detecting the sleepiness of the driver. The haar features in the haar cascade algorithm were used to detect faces and eyes. In this research, an architecture with six modules was used to detect drowsy drivers. The six modules were face detection, eye detection; face tracking, eye tracking, drowsiness detection, and distraction detection.

Satish et al. (2020) developed a system to detect drowsy drivers using

OpenCV libraries. For facial and eye detection, OpenCV and Histogram The driver's face was detected using HOG (Histogram of Oriented Gradient) and SVM algorithms.

4 METHODOLOGY

This research basically justifies the use of a driver sleepiness detection system to warn drivers to avoid road accidents caused by human error due to fatigue. This research was based mainly on the image processing method. The main steps of the proposed method are given below:

1. Face detection using the Viola Jones algorithm
2. Crop out the eyes from the detected face using the concept of facial symmetry.
3. Crop out the mouth from the detected face using the concept of facial symmetry.
4. Head-lowering detection using skin segmentation
5. Developing an alarm system with alert messages

The following flowchart will describe the proposed method in more detail.

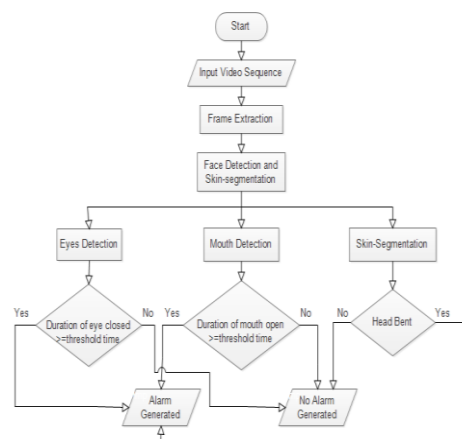


Figure 1: Flow chart for the proposed method

3.1 Video Acquisition

In this research, the first step was reading the videos. Video acquisition was achieved by making use of a camera, and pre-recorded videos were used as input. Then, those videos were converted into a series of frames. The captured frames were represented in RGB space by 8-bit pixels (256 colors).

3.2 Initialization of the Program

MATLAB software was used to perform image processing in this research. MATLAB was chosen because it is easier to understand, to debug, and to use for prototyping.

3.3 Image Processing

Face detection: As the first step in the proposed methodology, face detection was performed for frames extracted from the videos.

Eyes detection: After detecting the face, the eye features were cropped out of the detected face in order to determine whether the eyes were open or closed. Histograms were used to contrast the images. The histograms depicted the difference between the three color space images properly.

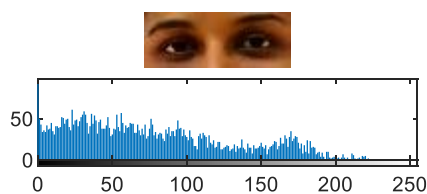


Figure 2: Cropped eyes (RGB color space) and histogram

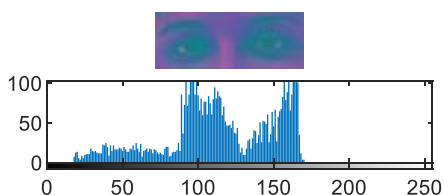


Figure 3: YCbCr color space image and histogram

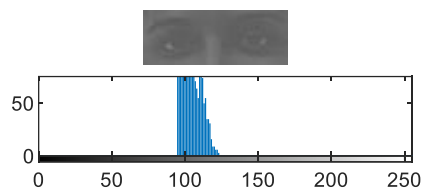


Figure 4: Grayscale image and histogram

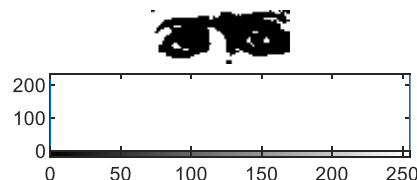


Figure 5: Binary image and histogram

Mouth detection: To detect yawning, the mouth features were cropped out of the detected face.

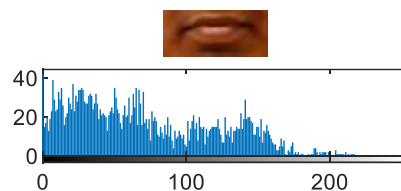


Figure 6: Cropped mouth (RGB color space) and histogram

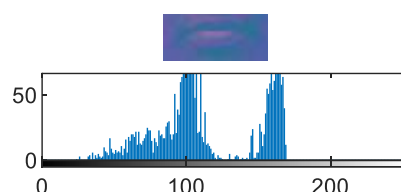


Figure 7: YCbCr color space image and histogram

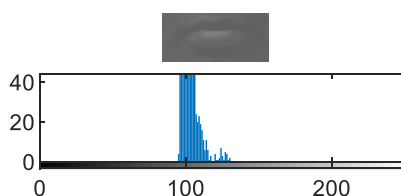


Figure 8: Grayscale image and histogram

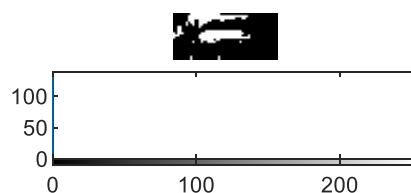


Figure 9: Binary image and histogram

Skin segmentation: The next step in this research was detecting head lowering using skin segmentation. First, the face was detected from the extracted frames using the Viola Jones algorithm. Then the RGB image was converted to YCbCr color spaces as before. Then, in the image, skin-colored image regions were looked at.

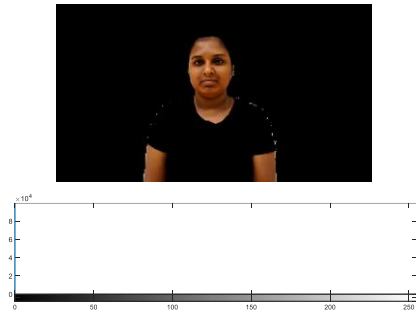


Figure 10: After skin segmentation image and histogram

Decision making: When the driver's eyes were closed, the number of black pixels in the binary image was significantly reduced compared to the ideal frame. If the eyes were open, no action was taken. But if the eyes were closed for at least 2 seconds continuously, that is some number of successive frames containing closed eyes, and then it was concluded that the driver is feeling sleepy. If the closed conditions of the eyes were not continuous, then it was considered a blink.

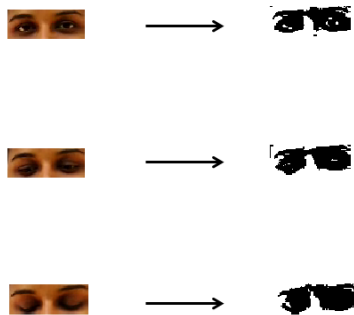


Figure 11: Closed eyes detection (original cropped eyes and after binarization)

When the driver yawns, the number of black pixels in the binary image increases significantly compared to the ideal image. If the mouth was open for at least 2 seconds continuously, which is some number of successive frames containing an opened mouth, then it was concluded that the driver was feeling sleepy.

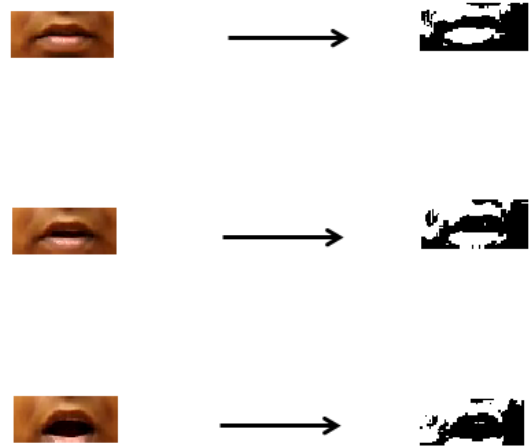


Figure 12: Yawning detection (original cropped mouth and after binarization)

The next step in this research was detecting head lowering using skin segmentation. In the image, look for skin-colored image regions. Then the percentage of the skin was computed. Whether the head was lowered or not was determined by the percentage of skin. When the driver's head was lowered, the number of pixels in the image decreased significantly compared to the ideal image.

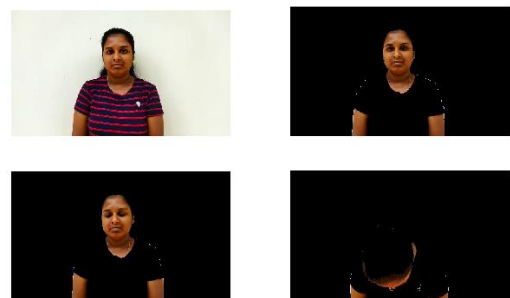


Figure 13: Head lowering detection with skin segmentation

5 RESULTS AND DISCUSSION

5.1 Results

Table 1: Test results

Scenario	Number of tests	False identity	Accuracy
Eye Closure	7	2	71.43%
Yawning	3	0	100%
Head lowering	4	1	75%
Average Accuracy			82.14%

The above table states that the average accuracy of this method is 82.14% and there was a high accuracy of this proposed method.

5.2 Discussion

In this research work, a method based on image processing was proposed to detect drowsy drivers as the solution to the research problem. The three approaches used were eye closure, yawning, and head lowering. Drowsiness detection improved further through these different stages. MATLAB was used as the programming platform in this research. To test this proposed method, ten pre-recorded videos were used. The Viola-Jones algorithm and Haar-like features were used to detect faces in the extracted frames. Histogram analysis displayed the relative frequency of different gray levels in images. The number of frames for a certain period of time (2 seconds) was considered to determine that the driver was drowsy. To make decisions, the percentage of black pixels in the binary images was calculated, and the increasing and decreasing of that percentage was considered. After drowsiness is identified, an alert with a warning

message will be displayed on the screen, and an alarm will be sounded.

6 CONCLUSION

Through this method, it was possible to prevent the carelessness of the driver and most vehicle accidents and extend the capability and applicability of existing vision-based techniques for driver drowsiness detection. And also, it hasn't been tested in the real world and uses only pre-recorded videos. Both false and positive results were generated with an average accuracy of 82.14%. This proposed method will not work for those who sleep with their eyes open. And also, we can improve the warning system of this proposed method by creating a third-party warning system, such as issuing a warning message to the driver's caretaker.

REFERENCES

- Chaudhari, M. N., Deshmukh, M., Ramrakhiani, G., and Parvatikar, R. (2018, August). Face detection using viola jones algorithm and neural networks. In *2018 Fourth International Conference on Computing Communication Control and Automation (ICCCUBEA)* (pp. 1-6). IEEE.
- Gunawardane, D. A., and Dharmaratne, S. D. (2014). Level of fatigue and daytime sleepiness among heavy vehicle drivers in Sri Lanka. *South East Asia Journal of Public Health*, 4(1), 9-16.
- Rajahrajasingh, H., and Campus, I. C. B. T. (2016). Driver Drowsiness Detection Using Matlab. *International Journal of Engineering*, 1(8), 1-6.
- Satish, K., Lalitesh, A., Bhargavi, K., Prem, M. S., and Anjali, T. (2020, July). Driver drowsiness detection. In *2020 International Conference on Communication and Signal Processing (ICCSP)* (pp. 0380-0384). IEEE.
- Santoshi, M. G. (2020). Automated Driver Drowsiness Detection for Non 2 Wheelers (Doctoral dissertation, Andhra University).



Forecasting Daily Bean Sales at ABC Supermarket Using Time Series Analysis

Rajakaruna DSJ¹, Dahanayaka SD² and Lakshmi MPDS³

Department of Mathematical Sciences, Faculty of Applied Sciences, Wayamba University of Sri Lanka. ^{1, 2, 3}

sudarshirajakaruna@gmail.com ¹

shalikadahanayaka@wyb.ac.lk ²

mpdslakshmi@gmail.com ³

ABSTRACT

In 2020, a study was conducted by the Food and Agriculture Organization of the United Nations (FAO) and the International Water Management Institute (IWMI), focusing on three major waste disposal centers in the Western Province of Sri Lanka. It revealed that about 724 tons of the total waste is generated by food waste within a day. In this research, the wastage data of ABC supermarket from 2021.08.31 to 2022.08.31 were studied and according to the data the most wastage has been done from vegetables. It was approximately 38% of the total wastage. In a further study, it was found that beans are the most wasted vegetable at the supermarket. So, the main objective of this study was to reduce vegetable wastage at the supermarket by forecasting daily beans sales. Here, the forecasted daily bean sales will be taken as the daily demand of the supermarket. The data set was collected from the ABC supermarket and provided the daily sales (in kilograms) of beans at the supermarket from 1st December 2021 to 30th November 2022. Box Jenkins Method in time series analysis was used to analyse the data. A model for the time series was ARIMA(5,1,1) which was found by using the auto.arima function in RStudio. After the parameter estimation for this model, ARIMA(0,1,1) was found to be the best model for the time series. Finally, a symmetric GARCH model was found as ARIMA(0,1,1)-GARCH(1,1) to predict the data. The accuracy of the model was measured by using MAPE, and it was 82.4756%.

KEYWORDS: Food waste, Forecasting, Demand, Time series analysis

1 INTRODUCTION

Food wastage is a major concern in many developing countries. Food wastage is approximately one-third of the global food production, and it ranges between 50% and 76% of the total municipal solid waste, with an average of 56% (FAO and IWMI 2021a) in local authority areas in Sri Lanka. Some of the main causes of food wastage in supermarkets are occurred due to lack of coordination in the food supply chain, marketing standards (rejection due to product or package defects), and errors in forecasting and ordering systems (overstocking and perishability of

products, short life, and sensitivity of products).

According to the below pie chart in Fig. 1 the most wastage has been done from vegetables and from vegetables the most wasted vegetable was beans.

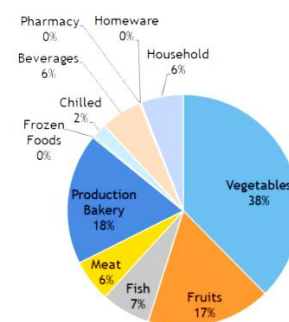


Figure 1: Pie chart of the wastage of supermarket ABC from 2021.08.31 to 2022.08.31

1.1 Research Objective

The main objective of this study was to reduce beans wastage in the supermarket by forecasting daily beans sales. Here, the daily bean sales can be approximately considered as the daily demand of the supermarket. This will help to reduce beans wastage and provide customers fresh vegetables at all times.

2 LITERATURE REVIEW

Warnakulasooriya et al. (2020) has proposed a method that can forecast the future price and demand of retail vegetables. Several techniques were used for data analysis. Four machine learning and learning algorithms were prioritized. They were ARIMA, SARIMA, LSTM, and XGBOOST models.

Arunraj et al. (2014) has proposed a methodology to develop an appropriate SARIMAX model to forecast the daily sales of perishable foods in a retail store when there are variations due to holidays and price reductions. For this study, the daily data of bananas (in kilograms) was collected from a retail store in the region of Lower Bavaria, Germany, from December 2009 to August 2014 to develop a model and forecast the daily sale of bananas in a retail store in Germany.

Wickramaratne & Chandrasekara (2020) have fitted models for forecasting monthly Colombo open market average retail prices of big onions in Sri Lanka. A differencing technique was applied to convert the non-stationary series into stationary. Several models were fitted using both univariate and multivariate time series analysis techniques. The ARIMA (1, 0, 1) (1, 1, 1) [12] model was identified as the best model. The RMSE and MAPE values of this model were

12.0215 and 9.1384 respectively. The RMSE and MAPE of fitted ARDL (1, 0, 3) is 15.5622 and 11.2504 respectively. According to the measures of the forecasting error, it implies that the SARIMA model provides more accurate predictions than the ARDL model.

3 METHODOLOGY

This study was based on time series analysis with linear modeling techniques. The analysis was done using R software. The Box-Jenkins methodology was used to construct a time series model.

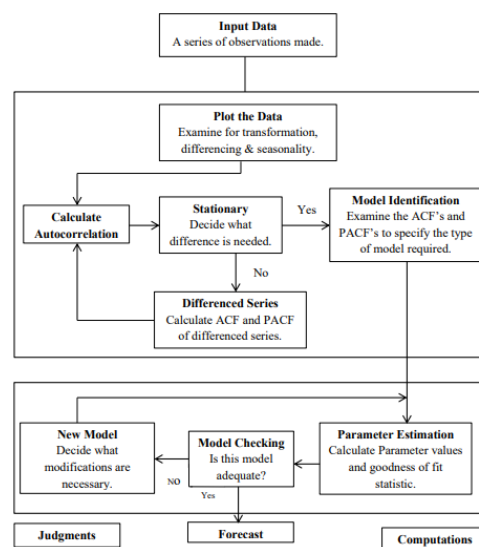


Figure 2: Box-Jenkins Methodology Process.

4 DATA COLLECTION AND ANALYSIS

For this research, the data set was collected from the ABC supermarket. This data set provided the daily sales (in kilograms) of beans at the supermarket from 1st December 2021 to 30th November 2022.

Under model identification, a descriptive analysis was used to summarize and describe the characteristics of a data set, a time series plot was used to understand the distribution of the data points, and a

boxplot was used to identify the outliers. The autocorrelation function (ACF) of the time series was checked to clearly identify the components of the time series, and the Augmented Dickey-Fuller (ADF) test was used to identify the stationary of the series.

A seasonal differencing technique was applied to convert the non-stationary series into stationary. A model was chosen using the auto.arima function and parameter estimation was done for ARIMA model, which is based on less informational criteria. After fitting the model, the assumptions of autocorrelation, heteroscedasticity, and normality were checked. The Breusch–Godfrey test was used to test autocorrelation in the residuals. And also, the modified Box-Pierce statistic (Ljung Box statistic) was used for collectively testing the magnitudes of the residual autocorrelations for insignificance. Using autoregressive conditional heteroscedasticity (ARCH) was used to test the heteroscedasticity and Jarque Bera was used to check the normality of the residuals. Then, univariate GARCH models were used, and Information Criteria was used to compare different possible models and determine which one is the best fit for the data. The sign bias test was used to check whether past positive and negative shocks different affect heteroscedasticity.

Then, using the best fitted model forecasted the daily sales of bean. Finally, the accuracy of the fitted model was measured using the mean absolute percentage error (MAPE).

5 RESULTS AND DISCUSSION

5.1 Descriptive Analysis

According to the below descriptive analysis data, the mean of the daily bean sales was 15.791896 kg, and the standard deviation was 6.726098.

Table 1: Descriptive analysis of daily bean sales

Mean	SD	Media n	Mini mum	Maxi mum
15.791896	6.726098	15.410000	0.000000	38.590000

5.1 Time Series Analysis

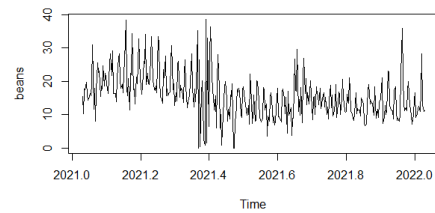


Figure 3: Time series plot of daily bean sales

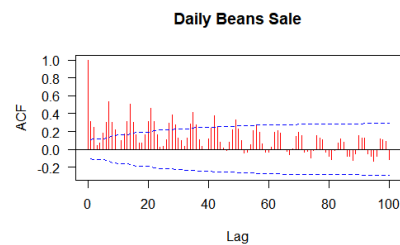


Figure 4: ACF plot of daily bean sales

Looking at the Fig. 3 time series plot, it could not be clearly identified whether it had an upward or downward trend or whether it had seasonal or non-seasonal variation. Therefore, the autocorrelation function of the time series was checked to clearly identify the components of the time series.

The above Fig. 4 ACF plot showed that there is a seasonal variation. Therefore, it was clear that the series was not stationary. So, the ADF test was used to identify the stationary of the series further as shown in Table 2. Therefore,

seasonal differencing was required to make the series stationary.

Table 2: ADF Test

	Original Series	Differenced Series
STATISTIC:	-0.6504	-10.144
Dickey-Fuller		
P VALUE	0.409	0.01

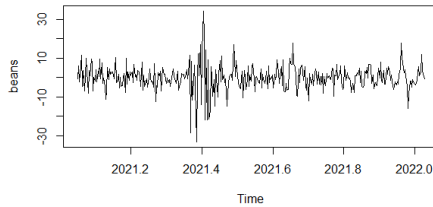


Figure 5: Time series plot of the differenced series

Table 3: AIC and BIC values of suggested models

Model	AIC value	BIC value
ARIMA(5,1,1)	2358.197	2385.322
ARIMA(5,1,0)	2408.968	2432.218
ARIMA(0,1,1)	2355.368	2363.118

After the log difference, the ADF test was performed for the differenced series, and according to the test results in the Table 2, the differenced series was stationary.

Using the auto.arima function ARIMA(5,1,1) was chosen as the model, and the best model was chosen based on less informational criteria as shown in the Table 3. The ARIMA(0,1,1) model was chosen as the most desirable model after taking the minimal Bayesian Information Criteria (BIC) and Akaike Information Criteria (AIC) values of the suspected models into account.

Then, parameter estimation was done for the ARIMA(0,1,1) model. There was not any insignificant terms of ARIMA(0,1,1) model to be eliminated. So, ARIMA(0,1,1) model was fitted for the given data.

Table 4: Parameter estimation for ARIMA(0,1,1) model

Model	Estimate	Std. Error	Z Value	P value
ma1	-0.9999	0.0080187	-124.71	< 2.2e-16 ***

After fitting the model, the assumptions of autocorrelation, heteroscedasticity, and normality were checked using the Breusch–Godfrey test, the modified Box–Pierce statistic (Ljung Box statistic), the ARCH test, and the Jarque Bera.

According to the ARCH test results p-value was < 2.2e-16. Therefore, there was enough evidence to reject the null hypothesis at the 5% level of significance. Because, the p-value of the ARCH test was less than 0.05. This indicated that different series have conditional heteroscedastic behavior and volatility clusters exist among residuals. To eliminate this impact, the GARCH model was necessary to be fitted. The GARCH(1,1) clearly displayed the minimum value for each of the three informational criteria. The optimal conditional variance model for daily bean sales was the ARIMA(0,1,1)-GARCH(1,1) model.

Table 5: GARCH(p,q) model related to ARIMA(0,1,1)

GARCH(p,q)	AIC	BIC	HQIC
GARCH(1,1)	6.294017	6.340377	6.312516
GARCH(1,2)	6.321896	6.376206	6.343498
GARCH(2,1)	6.333126	6.387436	6.354728
GARCH(2,2)	6.327498	6.392670	6.353420

Table 6: The forecasted values for the fitted model

Point	Forecast Value
1	21.45345
2	24.62998
3	27.32442
4	27.41902
5	26.56706
6	25.15510
7	24.34498
8	24.66827
9	25.62204
10	26.44322
11	26.80478
12	26.64080
13	26.21608
14	25.90525
15	25.90723
16	26.16210
17	26.47763
18	26.68083
19	26.71386
20	26.63398

Finally, ARIMA(0,1,1)-GARCH(1,1) model was used to forecast the daily bean sales.

The mean absolute percentage error in the ARIMA(0,1,1)-GARCH(1,1) was 17.5244%. So, it was concluded that the accuracy of the model was 82.4756% and indicated a good fit for forecasting the daily bean sales.

6 CONCLUSION

According to the data analysis, it was shown that there is a seasonal variation. After parameter estimation for ARIMA(5,1,1) model, ARIMA(0,1,1) model was found to be the best model for the time series. Finally, a symmetric GARCH model was found as ARIMA(0,1,1)-GARCH(1,1) to predict the data. Also, the mean absolute percentage error of the model was 17.5244%, and the accuracy of the model was 82.4756%. So, this result showed

that ARIMA(0,1,1)-GARCH(1,1) is a good fit model that can be used for modeling and forecasting the daily bean sales at the ABC supermarket. The equation of the final model is ARIMA(0,1,1)-GARCH(1,1).

REFERENCES

- Arunraj, N., Ahrens, D., Fernandes, M., and Müller, M. (2014). Time series sales forecasting to reduce food waste in retail industry. *Rotterdam*.
- Box George, E. P., Jenkins Gwilym, M., Reinsel Gregory, C., and Ljung Greta, M. (1976). Time series analysis: forecasting and control. *San Francisco: Holden Bay*.
- Li, W. K., Ling, S., and McAleer, M. (2002). Recent theoretical results for time series models with GARCH errors. *Journal of Economic Surveys*, 16(3), 245-269.
- Warnakulasooriya, H., Senarathna, J., Peiris, P., Fernando, S., and Kasthurirathna, D. (2020, November). Supermarket Retail-Based Demand and Price Prediction of Vegetables. In *2020 20th International Conference on Advances in ICT for Emerging Regions (ICTer)* (pp. 308-309). IEEE.
- Wickramarathne, R. H. M., and Chandrasekara, N. V. (2020). An Analysis of Colombo Open Market Average Retail Prices of Big Onion in Sri Lanka Using Time Series Forecasting Techniques.



Forecasting Daily Knitting Production of ABC Garment Manufacturing Company in Sri Lanka

Madhurangi RTD¹, Aponsu GMLM²

Department of Mathematical Sciences, Faculty of Applied Sciences, Wayamba University of Sri Lanka. ^{1,2}

dranawaka26@gmail.com ¹

lakshana@wyb.ac.lk ²

ABSTRACT

ABC garment manufacturing company in Sri Lanka is renowned for its production of high-quality products which are supplied for their customers. Throughout the years, the company has expanded the items produced, production area and the quality of products. The company has several departments out of which, Knitting department plays a main role. Most of the times, the company fails to complete their orders on time. Because of this, the company has to bear an additional cost for extra employees, machines, yarns, time, etc. If the future daily knitting production is known, then it will be possible to complete the orders on time by taking suitable actions. Therefore, this study was carried out to identify a forecasting model to forecast the daily knitting production of ABC garment manufacturing company by using Box-Jenkins approach of time series analysis. Secondary data of daily knitting production of the company from 6th January 2022 to 31st of July 2022 were used in the study. By comparing the fitted adequate Autoregressive Integrated Moving Average (ARIMA) models, the most suitable model to predict the daily knitting production was identified as ARIMA(1,1,1) with an accuracy of 88.1% and a Mean Absolute Percentage Error (MAPE) of 11.9.

KEYWORDS: ARIMA, Box-Jenkins, Knitting, MAPE

1 INTRODUCTION

The apparel industry, which has a significant impact on the national economy, is one of Sri Lanka's largest manufacturers and exporters. ABC garment manufacturing company is a reputable commercial entity in Sri Lanka with 54 production facilities spread throughout 17 countries, including Sri Lanka. It generates 28 million dollars in income and employs more than 99,000 people. As the company's demand rises, their supply chain is expanded with the help of design firms. The company is well known for new sustainability and ethical manufacturing concepts, it is committed to excellence on a worldwide scale, and is advancing newer

technologies like wearables, Fem Tech, and innovation hubs.

ABC Garment Manufacturing Company produces high-quality garment products. But regularly, they are unable to complete their orders on time, which results in a considerable loss for the company. Once order is delayed, an additional cost are incurred for human resources, machines, yarns, time, delivering the finished goods, etc. Currently, there is no proper model to forecast the daily knitting production of the company. If the future daily knitting production is known, then it will be possible to complete the orders on time. Therefore, the main purpose of this study is to identify a forecasting model to forecast the daily knitting production of the ABC garment manufacturing

company by using time series analysis and, thereby, support the company to plan and finish the orders in time, which will result in the reduction of extra cost.

2 LITERATURE REVIEW

Frank et al. (2003) conducted a study on Forecasting women's apparel sales using mathematical modeling. Statistical time series methods like moving average (MA), autoregression (AR), or combinations of them were used for forecasting sales. Since these models predict future sales only on the basis of previous sales, they fail in an environment where the sales are more influenced by exogenous variables such as size, price, color, climatic data, effect of media, price changes or campaigns. Although, a linear regression model can take these variables into account, its approximation function is restricted to be linear. In this paper, two approaches have been investigated for forecasting women's apparel sales, namely, statistical time series modeling, and modeling using ANNs. The performance of the models was tested by comparing one of the goodness-of-fit statistics, R^2 , and also by comparing actual sales with the forecasted sales of different types of garments. On an average, an R^2 of 0.75 and 0.90 was found for single seasonal exponential smoothing and Winters' three parameter model, respectively. The model based on ANN gave a higher R^2 averaging 0.92. Although, R^2 for ANN model was higher than that of statistical models, correlations between actual and forecasted were lower than those found with Winters' three parameter model.

Grilo (2022) conducted a study on Predicting Demand in Fashion Retailing: A Data Analytics Approach. The

objective of this study was to develop a predictive model for demand forecasting. The results showed that the deep neural network model and the random forest model had the best predictive accuracy, with the deep neural network model achieving an R^2 of 0.770 and the random forest model achieving an R^2 of 0.786.

Rahman (2008) conducted a study on Stochastic demand forecast and inventory management of a seasonal product: a supply chain system. The focus here was to determine an appropriate demand forecast for the peak-demand period. In the first set of forecasting models, a standard gamma and an inverse gamma prior distribution were used to forecast the demand. The parameters of the prior model were estimated and updated based on current observation using Bayesian techniques. The forecasts were derived for both complete and incomplete datasets. The second set of forecasts were derived by the ARIMA method using Box-Jenkins approach. A Bayesian ARIMA was proposed to forecast demand from an incomplete dataset. A partial dataset of a seasonal product, collected from the US Census Bureau, was used in the models. Missing values in the dataset often arise in various situations. In the second set of forecasting models, the seasonal demand was estimated based on SARIMA model. A SARIMA (0,1,1)(1,1,0)₁₂ model was found to be the best time series model for the data series. A sampling-based ARIMA (BS-ARIMA) model was used to forecast demand from the incomplete data. The data series used in BS-ARIMA model was incomplete since the data points at stage-2 (July to December) in 2004 were assumed to be unobserved. Finally, a multiplicative exponential

smoothing (M-ES) model was used to forecast the seasonal demand. This forecast is considered the base reference for comparing the demand forecasts made previously. Test results of the ARIMA (F-ARIMA and BS-ARIMA) and M-ES models showed that both approaches are significantly accurate. The errors were less than 13% for all models. Checking the tracking signals of the models, it was found that the M-ES model has negative trends, which indicates that the forecast made by the M-ES model has larger differences with respect to actual demand. Therefore, ARIMA models were appropriate for seasonal forecasts and the Bayesian ARIMA model was the most advantageous among all forecasting models.

Star (2015) conducted a study on the evaluation of time series forecasting methods for sales of printed bed sheets in Bahir Dar Textile Share Company. The study employed necessary monthly data spanning from January 2013 to December 2014 on the sales of printed bed sheets from the company's sales and marketing department. Time series forecasting techniques such as naïve method, simple moving average method, weighted moving average method, and exponential smoothing method were selected to forecast the sales demand of the printed bed sheets and POM-QM software was applied to compare the forecasting techniques based on accuracy measures using Mean Forecast Error (MFE), mean Absolute Deviation (MAD), mean Square Error (MSE) and mean absolute percentage error (MAPE). A comparison with the other time series forecasting methods has shown that Weighted Moving Average Method

(weight 1 = 0.5, weight 2 = 0.3 and weight 3 = 0.2) is the best technique for an accurate sales forecast of the printed bed sheet.

Lima et al. (2015) conducted a study on Sales demand forecasting in a textile factory using an artificial neural network. This study presented sales demand forecasting based on Elman Neural Networks (ENN). The forecasting is applied to the textile industry where a specialist group is responsible for the sales forecasting. It is clear from the results that the ENN ($MSE = 2.5567e^9$) can forecast the sales series with a lower error than the specialist group ($MSE = 3.2659e^9$). Also, they have proposed the use of Hybrid computational intelligence methods in the future to improve forecasting performance.

3 METHODOLOGY

The Box-Jenkins approach to Time Series Analysis was used to forecast the daily knitting production of ABC garment manufacturing company by using the secondary data of daily knitting production over the last six months from 6th of January 2022 to 31st of July 2022. As the original series was not stationary, it was differenced and by looking at the Auto-Correlation Function (ACF) and Partial Auto-Correlation Function (PACF), several tentative models were identified. Then various diagnostic tests were used to validate the goodness of fit of the model. Fitted adequate models were evaluated by using several model diagnostic tests, such as Modified Box-Pierce (Ljung-Box) Chi-Square statistic, correlation matrix, Residual ACF and PACF plots and, normal probability plot of residuals. Finally, the best model was selected by comparing the MAPE and

MSE values of the models, and the model with the minimum of both was selected as the best model.

4 RESULTS AND DISCUSSION

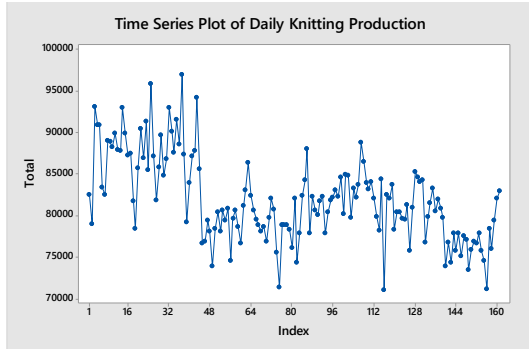


Figure 1: Time series plot of daily knitting production

Figure 1 shows a time series plot of daily knitting production from 6th of January to 31st of July, 2022. According to Figure 1, the daily knitting production suddenly dropped after 12th of March and remained at an approximately constant level after that. Also, it is clear that there is a downward trend in the daily knitting production.

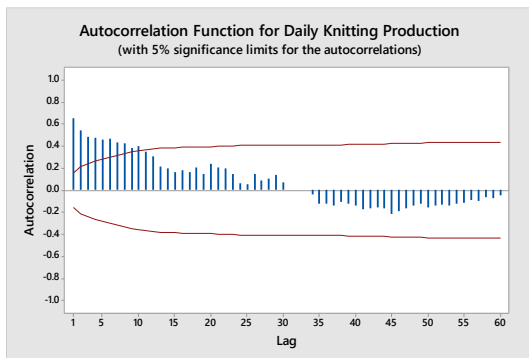


Figure 2: ACF of daily knitting production

According to Figure 2, the ACF of daily knitting production dies down slowly, indicating the existence of trend variation in the original time series. Therefore, the original dataset is not stationary. The Trend difference was carried out to make the series stationary.

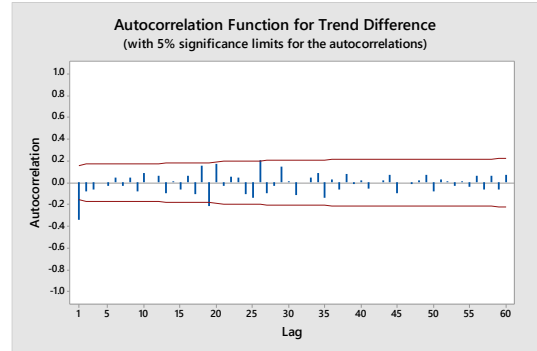


Figure 3: ACF of trend differences

Figure 3 shows the ACF of trend - differenced series, and the ACF cuts off at lag 1 in the non-seasonal area, and there are no significant spikes in the seasonal area.

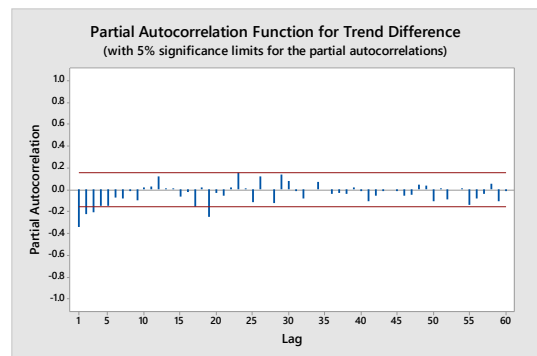


Figure 4: PACF of trend differences

Figure 4 shows the PACF of the differenced series and it cuts off at lag 3 in the non-seasonal area. Based on the ACF and PACF, ARIMA(0,1,2), ARIMA(1,1,3), ARIMA (1,1,1), ARIMA(2,1,1), ARIMA(2,1,0), ARIMA (3,1,1) and ARIMA(3,1,0) were identified as tentative models.

Final estimates of parameters for the ARIMA (1,1,1) model are given in Table 1.

H_0 : Coefficients of parameters are zero.

H_1 : Coefficients of parameters are not zero.

Table 1: Final estimates of parameters-
ARIMA(1,1,1)

Type	Coef	SE Coef	T	P
AR 1	0.3050	0.0980	3.11	0.002
MA 1	0.8695	0.0505	17.21	0.000
Constant	-37.92	38.27	-0.99	0.323

Since only the p-value of the constant term is greater than 0.05, the constant term was removed from the model, and the final estimated parameter was checked again for the ARIMA(1,1,1) model.

Table 2: Final Estimates of Parameters-
ARIMA(1,1,1)

Type	Coef	SE Coef	T	P
AR 1	0.2863	0.1021	2.81	0.006
MA 1	0.8473	0.0561	15.12	0.000

Since all P-values are less than 0.05, H_0 is rejected, and the parameters are significant at the 5% significance level.

Then the randomness of the residuals of the ARIMA (1,1,1) model was checked, and the results are shown in Table 3.

$$H_0 : \rho_1 = \rho_2 = \rho_3 = \dots = \rho_k = 0$$

$$H_1 : \text{at least one } \rho_k \neq 0$$

Table 3: Modified Box-Pierce (Ljung-Box) Chi-Square statistic -
ARIMA(1,1,1)

Lag	12	24	36	48
Chi-Square	2.8	24.4	44.4	53.4
DF	10	22	34	46
P-Value	0.987	0.325	0.108	0.210

The results in Table 3 show that all the , P values are greater than 0.05 and

therefore H_0 is significant at the 5% level of significance. Therefore, it can be considered that the residuals are random.

Then the parameter redundancy of ARIMA(1,1,1) model was checked, and the results are shown in Table 4.

Table 4: Correlation matrix of the estimated parameters - ARIMA(1,1,1)

1	
2	0.661

According to Table 4, all P-values < |0.9| indicating that no parameter redundancy exists in this model. The residual plots of this model are shown in Figure 5.

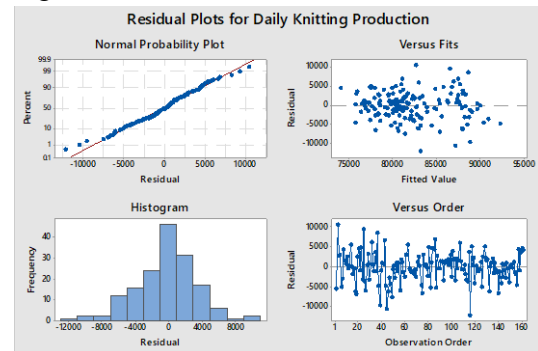


Figure 5: Residuals Plots
ARIMA(1,1,1)

According to Figure 5, the normal probability plot of residuals follows an approximate straight line, indicating that the residuals are normally distributed. The Versus fits and versus order plots of residuals show symmetrical scattering, which indicates that there is equal error variance and no correlation between error terms. Also, the histogram of residuals follows an approximate bell curve. Therefore, ARIMA(1,1,1) can be considered an adequate model to forecast daily knitting production.

Having calculated parameter estimates, the Box-Pierce (Ljung-Box) Chi-Square statistic, the correlation

matrix, and residual analysis, it was found that ARIMA(0,1,2), ARIMA(1,1,3), ARIMA(1,1,1), ARIMA(2,1,1), ARIMA(2,1,0), ARIMA(3,1,1) and ARIMA(3,1,0) models are also adequate to forecast the daily knitting production. The adequate models along with their MSE, MAPE, and accuracy values are shown in Table 5.

Table 5: Accuracy measures of the adequate models

Adequate model	MSE	MAPE	Accuracy
ARIMA(0,1,2)	7.9768	12.06	87.94
ARIMA(1,1,3)	7.8070	11.91	88.09
ARIMA(1,1,1)	7.8014	11.90	88.10
ARIMA(2,1,1)	8.5926	12.02	87.98
ARIMA(2,1,0)	8.7203	12.16	87.84
ARIMA(3,1,1)	8.3821	11.94	88.06
ARIMA(3,1,0)	8.5037	12.05	87.95

Based on the results of Table 5, it is clear that the ARIMA(1,1,1) model has the lowest MSE, MAPE values and highest accuracy. Therefore, ARIMA(1,1,1) model was identified as the most suitable model to forecast the daily knitting production of the company.

5 CONCLUSION

The main objective of this study was to identify a forecasting model to forecast the daily knitting production of ABC garment manufacturing company, by using the Box-Jenkins approach of time series analysis. After the parameter estimation and diagnostic checking, a few adequate models were identified. After comparing the MAPE, MSE, and accuracy values of the adequate models, the best-fitted model to forecast the daily

knitting production was identified as ARIMA(1,1,1) with an accuracy of 88.10% and MAPE of 11.90.

REFERENCES

Abrham, S. (2015). Evaluation of time series forecasting methods for Sales of printed bed sheet in Bahir Dar Textile Share Company. *International Journal of Recent Engineering Research and Development*, 2(4), 115-120.

Frank, C. and Garg, A. (2003). Forecasting women’s apparel sales using mathematical modeling. *International Journal of Clothing Science and Technology*, 15(2), 107-125.

Grilo, T. M. (2022). *Predicting demand in fashion retailing: a data analytics approach* (203172604) [Master’s Dissertations, University of Porto]. <https://hdl.handle.net/10216/140647>

Lima, F. and Junior, J. C. (2015). Sales demand forecasting in a textile factory using artificial neural network. *PMOS 26th Annual Conference at Washington DC*.

Rahman, M. A. (2008). *Stochastic demand forecast and inventory management of a seasonal product in a supply chain system* (2716) [LSU Doctoral Dissertations, Louisiana State University]. https://digitalcommons.lsu.edu/gradschool_dissertations/2716



Forecasting Monthly Treated Water Production of Akuressa Area

Madhurangi RTD¹, Aponsu GMLM²

Department of Mathematical Sciences, Faculty of Applied Sciences, Wayamba University of Sri Lanka.^{1,2}

*dranawaka26@gmail.com*¹

*lakshana@wyb.ac.lk*²

ABSTRACT

Water is the most important requirement for life and due to the complexity of people's lives, many people are accustomed to purchasing water supplies from National Water Supply & Drainage Board (NWSDB), Sri Lanka. NWSDB aims to meet the demand qualitatively and quantitatively. Appropriate operations and maintenance strategies can be used to maintain the quality of the water. However, it is somewhat difficult to supply the increasing demand as water supply utilities are expanded by large-scale investments. Therefore, forecasting the water demand is essential to supply without any disturbance and to invest in expanding the existing resources under a proper structure. This study is focused on forecasting the monthly treated water production level of Akuressa area in Matara District by using the Box-Jenkins approach of Time Series Analysis. The secondary data of monthly treated water production of the last ten years from January 2012 to December 2021, were obtained from NWSDB of Akuressa branch and analyzed with the use of Minitab software. Several Autoregressive Integrated Moving Average (ARIMA) models were fitted and ARIMA(2,1,3) was found to be the best model to forecast the monthly treated water production level of Akuressa area with an accuracy of 95.67% and a Mean Absolute Percentage Error (MAPE) of 4.33.

KEYWORDS: Akuressa, ARIMA, MAPE, NWSDB

1 INTRODUCTION

Water is extremely important for every living being in the world. About 71% of the earth's surface is covered with water and the oceans hold about 96.5% of the earth's water according to the U.S. Geological Survey, 2016. Humans usually get water from surface water resources such as rivers, lakes, and wells. This volume is approximately 93,113 km³.

Sri Lanka is not a water-scarce country. But especially in groundwater, the quantity, quality, and availability have begun to deteriorate due to the increasing human activities. 40% of the Sri Lankan population have organized water supply facilities obtained from NWSDB and 59.4% is depending on

other sources such as wells, tube wells, streams, rivers, etc.

Akuressa is a developing city in Matara district where the purchase of water supply from NWSDB has increased during the last few years. People tend to use an organized water supply system to make day-to-day life easy. To supply this increasing demand, water supply utilities should be expanded by large-scale investments. If it is possible to forecast the water requirement, then the necessary actions can be taken to cater to the demand and to expand the existing facilities. Therefore, the monthly treated water production of NWSDB of Akuressa branch will be forecasted in this study.

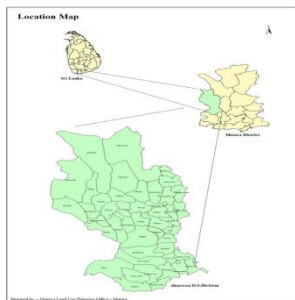


Figure 1: Research area of Akuressa in Matara District

2 LITERATURE REVIEW

Ito et al. (2021) determine the physical and non-physical factors associated with water consumption. This study quantitatively examines the association between multiple water sources and individual water consumption. In addition, they investigated the relationship between individual water consumption and physical (water source, supply time) and non-physical (wealth status, education for household head, house ownership, participation in local community, water treatment) factors before and after the 2015 Gorkha earthquake. The region of new hydrological insights for this study confirms the use of additional water sources is associated with greater individual water consumption.

Manzungu & Machiridza (2005) conducted a study on the analysis of water consumption and prospects for implementing water demand management at the household level in the City of Harare, Zimbabwe. Traditional approaches to solving the problem such as developing new water sources do not hold much promise because of a lack of finance. The study found that implementation of water demand management at the household level was hindered by poor physical infrastructure, lack of information dissemination and

training at the household level, and lack of institutional capacity of the department responsible for water supply.

Gómez-Llanos et al. (2020) analyze consumer awareness of sustainable water consumption by the water footprint concept. The study was focused on evaluating the perception of sustainable water consumption (SWC), considering the direct and indirect water consumption through the Water Footprint (WF) indicator and the information about the nexus between urban services and water uses. Based on the norm activation model (NAM) proposed by Schwartz, this research evaluated the perception of the water footprint of different aspects of water consumption. The methodology used in this analysis is Structural Equation Modeling (SEM). The sample is composed of consumers in the Extremadura region, Spain. The model tested at a confidence level higher than 99.9% with a moderated explanatory capacity ($R^2 = 55.7\%$).

Sadr et al. (2016) study the analysis of domestic water consumption in Jaipur, India. They tried to explore the relationship between water consumption and water use behavior and attitudes, and devices applied in households in urban areas in India. A questionnaire containing over 60 questions was developed to collect information on households' characteristics (e.g. family size, household type, and the number of children), indoor and outdoor water use activities, and their respective frequencies and durations. The survey results were analyzed using cluster analysis and one-way analysis of variance (ANOVA). The results showed that the per capita consumption varies considerably with household type and

size. The average water consumption was 183 and 215 liters/person/day for standalone households and apartments, respectively. Water used in bathing and WC's represent the highest proportion of water consumption in both stand-alone houses and apartments. Over 40% of the households reported no use of showers. The per capita water consumption is inversely related to family size, especially in stand-alone houses.

Pirouz et al. (2018) identify the role of power consumption and type of air conditioner in direct and indirect water consumption in Italy. The analysis of cooling systems showed that, evaporative air conditioners will consume a high rate of water directly and that for a house with an area of 140 m² is about 40 m³ /month, which is about 10% of the total annual water use in typical households in an arid climate. The high power usage in compression air conditioners will also consume high water withdrawal indirectly and up to 102 m³ /month in the once-through cooling system. The results of the research showed that the evaporated water in evaporative air conditioners is from the municipal network and since it is being evaporated, the impact is much higher than the urban water consumption that can be collected by wastewater systems.

3 METHODOLOGY

The Box-Jenkins approach of Time Series Analysis was used to forecast the monthly treated water production of Akuressa area by using the secondary data of monthly treated water production of the last ten years from January 2012 to December 2021, obtained from NWSDB of Akuressa Branch. As the original series was not stationary, it was different

and by looking at the Auto-Correlation Function (ACF) and Partial Auto-Correlation Function (PACF), tentative models were identified. Then various diagnostic tests were used to validate the goodness of fit of the model. Fitted adequate models were evaluated by using several model diagnostic tests such as Modified Box-Pierce (Ljung-Box) Chi-Square statistic, correlation matrix, Residual ACF and PACF plots, and residual plots. Finally, the best model was selected by comparing the MAPE and MSE values of the models, and the model with the minimum of them was selected as the best model.

4 RESULTS AND DISCUSSION

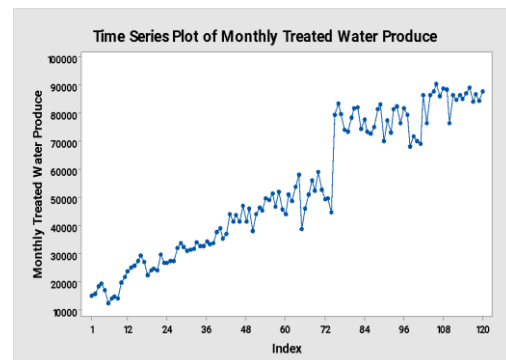


Figure 2: Time series plot of monthly treated water production

Figure 2 shows the time series plot of monthly treated water production from January 2012 to December 2021. According to Figure 2, the treated water production in Akuressa has suddenly increased in March 2018 as the NWSDB started a project in 2018 to increase their water production and they launched it to the people. Also, there is an upward trend in the monthly treated water production.

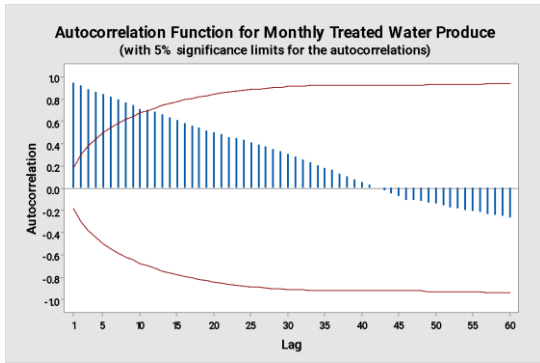


Figure 3: ACF of monthly treated water production

According to Figure 3, ACF of monthly treated water production dies down slowly indicating the existence of trend variation in the original time series. Therefore, the original dataset is not stationary and trend difference was carried out to make the series stationary.

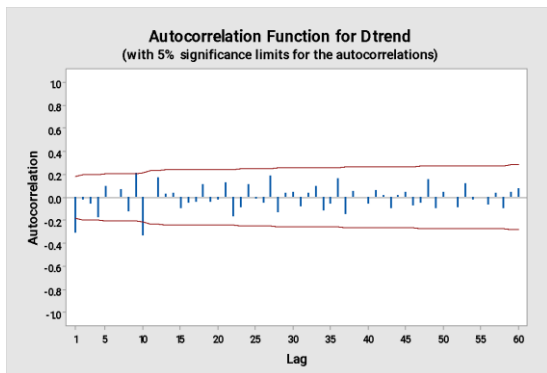


Figure 4: ACF of trend differences

Figure 4 shows the ACF of trend differenced series and ACF cuts off at lag 1 in the non-seasonal area and there are no significant spikes in the seasonal area.

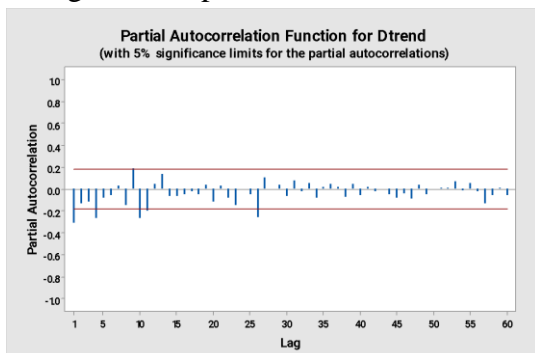


Figure 5: PACF of trend differences

Figure 5 shows the PACF of differenced series and PACF cuts off at lag 1 in the non-seasonal area. Based on the ACF and PACF, ARIMA(0,1,2), ARIMA(0,1,1), ARIMA(1,1,1), ARIMA(3,1,3) and ARIMA(2,1,3) were identified as tentative models.

Final estimates of parameters of ARIMA (2,1,3) model is given in Table 1.

H_0 : Coefficients of parameters are zero.
 H_1 : Coefficients of parameters are not zero.

Table 1: Final estimates of parameters-ARIMA(2,1,3)

Type	Coef	SE Coef	T	P
AR 1	0.9893	0.0673	14.69	0.000
AR 2	-0.9443	0.0534	-17.69	0.000
MA 1	1.3895	0.0557	24.94	0.000
MA 2	-1.3414	0.0656	-20.45	0.000
MA 3	0.4490	0.0819	5.48	0.000

Since all P-values are less than 0.05 according to Table 1, H_0 is rejected and the parameters are significant at a 5% significance level.

Then the randomness of residuals of ARIMA (2,1,3) model was checked and the results are shown in Table 2.

H_0 : Residuals are Random

H_1 : Residuals are not Random

Table 2: Modified Box-Pierce (Ljung-Box) Chi-Square statistic-ARIMA(2,1,3)

Lag	12	24	36	48
Chi-Square	19.8	29.2	45.2	57.2
DF	7	19	31	43
P-Value	0.006	0.062	0.048	0.072

The results in Table 2 demonstrate that the P value of lag 12 is less than 0.05 and H0 is rejected at a 5% level of significance confirming that the residuals are not random. Therefore ACF and PACF of residuals were observed.

Figure 6: ACF of Residuals

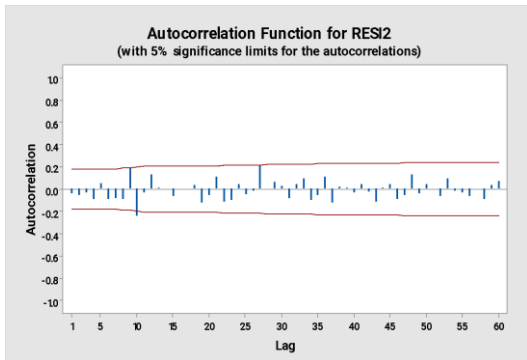
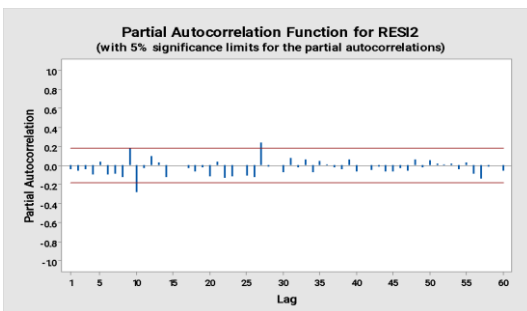


Figure 7: PACF of Residuals



ACF of residuals of ARIMA(2,1,3) model is shown in Figure 6 and PACF of residuals is shown in Figure 7. There are no significant spikes at the non-seasonal area in both plots except one at lag 9. But it is unlikely to have any noticeable impact on the forecasts. Therefore it can be considered that the residuals are random.

Then the parameter redundancy of ARIMA(2,1,3) model was checked and the results are shown in Table 3.

Table 3: Correlation matrix of the estimated parameters-ARIMA(2,1,3)

	1	2	3	4
2	-0.533			
3	0.012	0.245		
4	0.605	-0.004	-0.367	
5	-0.771	0.606	0.456	-0.670

According to Table 3, all P-values < |0.9| indicate that parameter redundancy is not existing in this model. The residual plots of this model are shown in Figure 8.

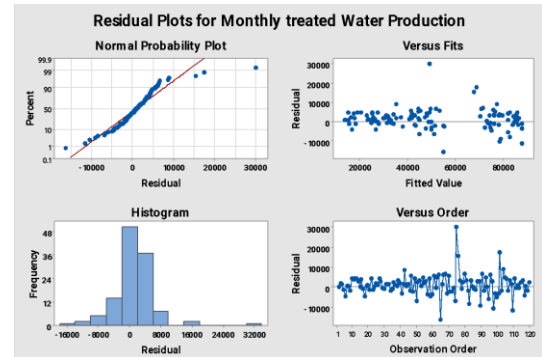


Figure 8: Residuals Plots ARIMA(2,1,3)

According to Figure 8, the normal probability plot of residuals follows an approximately straight line indicating that the residuals are normally distributed. Versus fits and versus order plots of residuals show symmetrical scattering, which indicates that there is equal error variance and there is no correlation between error terms. Also, the histogram of residuals follows an approximate bell curve. Therefore, ARIMA(2,1,3) can be considered an adequate model to forecast monthly treated water production.

Having calculated parameter estimates, Box-Pierce (Ljung-Box) Chi-Square statistic, correlation matrix, and residual analysis, it was found that ARIMA(0,1,2), ARIMA(0,1,1), ARIMA(1,1,1) and ARIMA(3,1,3) models are also adequate to forecast the monthly treated water production. The adequate models along with their MSE, MAPE, and accuracy values are shown in Table 4.

Table 4: Accuracy measures of the adequate models

Adequate model	MSE	MAPE	Accuracy
ARIMA(0,1,2)	21.7510	4.5527	95.4473
ARIMA(0,1,1)	22.2702	4.6071	95.3929
ARIMA(1,1,1)	20.9601	4.4692	95.5308
ARIMA(2,1,3)	19.6962	4.3301	95.6699
ARIMA(3,1,3)	20.8143	4.4525	95.5475

Based on the results of Table 4, ARIMA(2,1,3) model has the lowest MSE, MAPE values, and highest accuracy. Therefore most suitable model to forecast monthly treated water production in Akuressa area is ARIMA(2,1,3).

5 CONCLUSION

The main objective of this study was to identify a forecasting model to forecast monthly treated water production in Akuressa area by using the Box-Jenkins approach of time series analysis. After the parameter estimation and diagnostic checking, few adequate models were identified. After comparing the MAPE, MSE, and accuracy values of the adequate models, the best-fitted model to forecast monthly treated water production of Akuressa area was identified as ARIMA (2,1,3) with an

accuracy of 95.67% and the MAPE of the model is 4.33. It is suggested to use nonlinear modeling techniques in future studies to grasp the nonlinear patterns of the data.

6 REFERENCES

Gómez-Llanos, E., Durán-Barroso, P., & Robina-Ramírez, R. (2020). Analysis of consumer awareness of sustainable water consumption by the water footprint concept. *Science of the Total Environment*, 721, 137743. <https://doi.org/10.1016/j.scitotenv.2020.137743>

Ito, Y., Kobayashi, Y., Yokomichi, H., Malla, S. S., Kiem, A. S., & Nishida, K. (2021). Physical and non-physical factors associated with water consumption at the household level in a region using multiple water sources. *Journal of Hydrology: Regional Studies*, 37, 100928. <https://doi.org/10.1016/j.ejrh.2021.100928>

Manzungu, E., & Machiridza, R. (2005). An analysis of water consumption and prospects for implementing water demand management at household level in the City of Harare, Zimbabwe. *Physics and Chemistry of the Earth, Parts A/B/C*, 30(11-16), 925-934. <https://doi.org/10.1016/j.pce.2005.08.039>

Pirouz, B., & Maiolo, M. (2018). The role of power consumption and type of air conditioner in direct and indirect water consumption. *Journal of Sustainable Development of Energy, Water and Environment Systems*, 6(4), 665-673.

Sadr, S. M., Memon, F., Jain, A., Gulati, S., Duncan, A. P., Hussein, W. E., ... & Butler, D. (2016). An analysis of domestic water consumption in Jaipur, India. *British Journal of Environment and Climate Change*, 6(2), 97-115. <https://doi.org/10.9734/bjecc/2016/23727>



Identification of Main Risk Factors for Heart Disease and Comparison of Predictive Models for the Assessment of Heart Disease Status

Munasinghe BSNG¹, Perera KKKR²

Department of Mathematics, Faculty of Science, University of Kelaniya. ^{1,2}

gayanimunasingha1995@gmail.com ¹

kkkrperera@kln.ac.lk ²

ABSTRACT

Heart disease is a broad phrase that covers a variety of heart issues. Patients may have few indications or symptoms of heart disease in its early stages. This study aims to determine the risk factors for heart disease and compare predictive models that will most accurately identify the major causes of heart disease. The UCI website was used to collect the secondary data. There were 1025 participants and 13 factors with heart disease status. The full dataset was examined for any potential missing values as a part of the data pre-processing. Then the previously categorized data was changed by being converted into numeric values. Chi-Square and K-Wallis tests were performed to identify factors that influence heart disease status when the dataset was first acquired from the website. To identify heart disease without using FBS (fasting blood sugar), 12 critical factors were found to be significant. To build the models after factor identification, Logistic Regression, Support Vector Machine, Naive Bayes, and Random Forest were used with the K-fold cross-validation method. Among the constructed models, Random Forest and Naive Bayes showed the highest accuracy and the cross-validation scores were 96.11 and 94.17, respectively. Logistic regression and support vector machines have cross-validation scores of 85.44 and 83.30, respectively. According to the results, the Naive Bayes and Random Forest methods appear to be the most effective for predicting the presence of heart disease among the models tested in this study. Among these, Random Forest shows higher accuracy than other models.

KEYWORDS: Heart disease, Logistic regression, Naïve bayes, Random forest, Support Vector Machine (SVM)

1 INTRODUCTION

The Centers for Disease Control and Prevention (CDC) reported that cardiovascular disease is one of the leading causes of death worldwide. Heart disease comes in a wide variety of forms, each with its own set of symptoms and approach to therapy (Deal, 2009). Modifying one's way of life and taking medication can have profound effects on one's health for some people. Surgery is sometimes the only option for those who want their ticker to start beating normally again (Kay, 2003). Heart attacks, angina pectoris, strokes, myocardial infarctions, and irregular heart rhythms are all symptoms of cardiovascular disease,

characterized by the narrowing or obstruction of blood vessels. Carelessness is common, and as a result, many people smoke heavily and ignore their weight, all of which contribute to the rising incidence of cardiovascular disease. Diseases of the heart are common in human populations, and heart attacks fall into the following categories: heart failure, atrial flutter, and so on (Bell, 1996).

The most common sign of a heart attack is an irregular heartbeat, but patients also experience chest discomfort, perspiration, nausea, vomiting, weakness, disorientation, anxiety, and shortness of breath. As a result, the patient will need

chest surgery to improve blood flow to the heart's muscles. Some forms of heart disease generally impact on cardiovascular health, while others target specific organs or systems (Moodie, 2016).

Among the many potentially fatal illnesses, heart disease is the focus of extensive scientific study. Diagnosing the cardiac disease is difficult, but with computerized prediction, doctors can better assess a patient's health and determine the best course of therapy (Mensah, 2009). Patients with heart disease are typically diagnosed after doctors see telltale symptoms and conduct a thorough physical exam. Cigarette smoking, high blood cholesterol levels, a personal or family history of cardiovascular disease, being overweight, having high blood pressure, and not getting enough exercise all contribute to an increased risk of cardiovascular disease (Mensah, 2009).

The model's potential for enhancing the precision with which heart failure can be predicted in any given individual was governed by a beneficial method (Harshit, et al., 2020). KNN and Logistic Regression, as presented by Harshit Jindal, Sarthak Agrawal, Rishabh Khera, Rachna Jain, and Preeti Nagrath, have proven to be a powerful tools for predicting the presence of heart disease in an individual. However, the worth of that certainty was relatively low.

The study's main objective is to identify the risk factors for heart disease and choose a predictive model to identify the main factors of heart disease with the highest accuracy. The worldwide number of people diagnosed with heart disease is growing up now. The rising prevalence of heart disease can be attributed to a

wide range of causes. The underlying causes of heart disease could be studied with the help of statistical models such as logistic regression, support vector machine, naïve bayes and random forest that could be used for early diagnosis in cardiac patients.

2 METHODOLOGY

In this research, the first step was to collect the data. The secondary data was collected from the UCI website. It is a live data set from 1987 to today. There are 14 variables with 1025 records in the data set, and Table 1 shows the description of the variables.

Table 1: Description of variables

Attributes	Description
age	age in years
sex	Value 1 = male Value 0 = female
cp	Chest pain type (4 values) Value 1: typical angina Value 2: atypical angina Value 3: non-anginal pain Value 4: asytreetopsc
trestbps	Resting blood pressure (in mm Hg on admission to the hospital)
cholesterol	Serum choleFBSral in mg/dl
fbs	Fasting blood sugar > 120 mg/dl)
restecg	resting electrocardiographic resNormal Value 0: normal Value 1: having ST-T wave abnormality (and inversions and/or ST elevation or

IDENTIFICATION OF MAIN RISK FACTORS FOR HEART DISEASE AND COMPARISON OF PREDICTIVE MODELS FOR THE ASSESSMENT OF HEART DISEASE STATUS

	depression of > 0.05 mV)
	Value 2: showing probable or definite left ventricular hypertrophy by Esthaliiteria
thalach	Exercise-induced
exang	Exercise induced angina
	Value 1: yes
	Value 0: no
Old peak	ST depression induced by exercise relative to rest
slope	the slope of the peak exercise ST segment
	Value 1: upsloping
	Value 2: flat
	Value 3: downsloping
ca	number of major vessels (0-3) colored bfluoroscoppyp
thal	Value 0: normal
	Value 1: fixed defect
	Value 2: reversibilele defect
target	Dependent variable
	Status of heart disease

correlation between two categorical variables (Bahassine, Madani, & Kissi, 2016). The Kruskal-Wallis Test was utilized to determine the correlation between a flat and a continuous variable (Bhattacharyya, 2006).

Then the cross-validation method was used. Cross-validation is a machine learning evaluation approach used to determine how effectively the machine learning algorithm can foresee the result of unknown data. It is an easy-to-understand strategy that works well with a small data sample and provides a less biased judgment, resulting in its popularity. In this study, we used the K-fold Cross Validation method. It aids in preventing overfitting. The best performance accuracy is achieved when a model is trained using all of the data in a single brief run. Therefore, the generalized model was developed using k-fold cross validation. The dataset is divided into a K number of folds during cross-validation, which assesses the model's performance when faced with new data. K is the number of groups into which the data sample is divided. In this study, we used the value of k as 5 (Kucheryavskiy et al., 2020).

Model development was then carried out. Under this, four typesstic algorithms were employed; Logistic Regression, Support Vector Machine, Naïve Bayes, and Random Forest.

2.1 Logistic Regression

Suppose the dataset has one binary dependent variable and multiple nominal, ordinal, interval, or ratio-level independent variables (Menard, 2010). The Logistic regression technique can be used to define and explain the relationship between the independent and

The Next step was preprocessing of data. As a part of the data pre-processing, the complete dataset was checked for any potential missing values. The dataset was modified by transforming the previously classified information into numeric values. Finding the connections between the variables was a significant focus of the exploratory investigation. The variable of interest (or dependence) was a category in this dataset. The independent variables, also called the "factor variables," are in both categorical and continuous elements. The Chi-square test was performed when looking for a

dependent variables (Kleinbaum, & Klein, 2010). Independent observations, no multicollinearity between independent variables, linearity between independent variables, and lack of enormously influential outliers are all prerequisites for logistic regression model (Kleinbaum, 1994). The equation of the logistic regression model with p explanatory variables is as follows:

$$\log\left(\frac{\hat{p}}{1-\hat{p}}\right) = \beta_0 + \beta_1x_1 + \beta_2x_2 + \dots + \beta_px_p$$

By taking $X=[\text{age, sex,cp, trestbps, cholesterol, fbs, restecg, thalach, exang, old peak, slope, ca, thal}]$ and $X=[x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9, x_{10}, x_{11}, x_{12}, x_{13}]$, logistic regression equation for the model used in this study can be explained as

$$\begin{aligned} \log\left(\frac{\hat{p}}{1-\hat{p}}\right) = & \beta_0 + \beta_1x_1 + \beta_2x_2 + \beta_3x_3 \\ & + \beta_4x_4 + \beta_5x_5 + \beta_6x_6 \\ & + \beta_7x_7 + \beta_8x_8 + \beta_9x_9 \\ & + \beta_{10}x_{10} + \beta_{11}x_{11} \\ & + \beta_{12}x_{12} + \beta_{13}x_{13} \end{aligned}$$

2.2 Support Vector Machine

Linear and nonlinear data can be classified using support vector machines (SVMs) (Joachims, 2002). The support vector machine algorithm aims for a hyperplane in N-dimensional space (where N is the number of features) that accurately categorizes the data points. In SVM, a kernel is utilized to locate a hyperplane in the higher-dimensional space with no additional computing expense (Kecman, 2001)

2.3 Naive Bayes

Among the many machine learning models available for classification work, the Naive Bayes classifier is among the most popular and widely utilized (Seref, B., & Bostanci, E. 2019). The Bayes

theorem provides the backbone for the classifier (Shanahan, J. G. 2000)

Bayes Theorem:

$$P(C_k|X) = P(C_k) * P(X|C_k)$$

$X=[\text{age, sex,cp, trestbps, cholesterol, fbs, restecg, thalach, exang, old peak, slope, ca, thal}]$

$X=[x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9, x_{10}, x_{11}, x_{12}, x_{13}]$

$C_1 - \text{Heart disease status} = \text{'Yes'}$

$$\begin{aligned} P(C_1|x_1 \cap x_2 \dots \cap x_{13}) \\ = \frac{P(x_1 \cap x_2 \dots \cap x_{13}|C_1) * P(C_1)}{p(x_1) * p(x_2) \dots * p(x_{13})} \end{aligned}$$

$C_0 - \text{Heart disease status} = \text{'No'}$

$$\begin{aligned} P(C_0|x_1 \cap x_2 \dots \cap x_{13}) \\ = \frac{P(x_1 \cap x_2 \cap x_3 \dots \cap x_{13}|C_0) * P(C_0)}{p(x_1) * p(x_2) \dots * p(x_{13})} \end{aligned}$$

2.4 Random Forest

The algorithm known as the random forest is used in supervised learning. It creates a "forest" from a collection of decision trees, typically bagged for training. The bagging approach is based on the premise that using many learning models together to improve performance (Hastie et al., 2017). To make a more precise forecast, Random Forest produces several decision trees that are combined. The idea behind the Random Forest model is that the sum of its parts is greater than the sum of its parts (in this case, the individual decision trees). (Henderson & Bialeschki). The quality of the fitted models was evaluated using a confusion matrix. Confusion matrices are among the most insightful and practical ways to evaluate a model's precision and assessment (Privitera, 2015). It solves the classification issue, resulting in a binary or multinomial.

3 RESULTS AND DISCUSSION

The dataset contains fourteen variables. The Pie chart for the dependent variable shows in Figure 1.

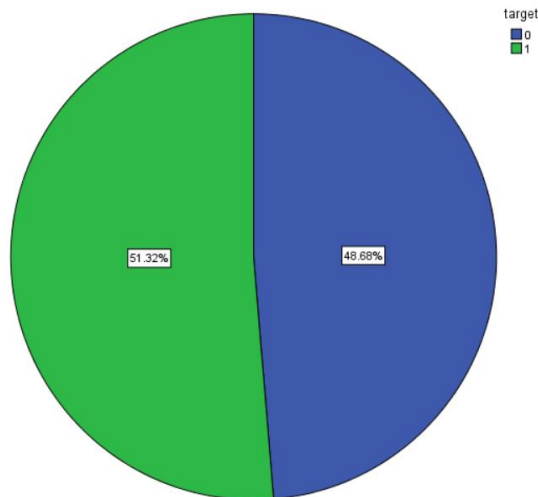


Figure 1: Dependent variable - Status of heart disease

Figure 1 shows that 51.32 % of the total data set were heart patients and 48.68 % were a healthy person.

This study focuses on determining whether the participants were heart-healthy or not. Using the use of the Chi-square test and Kruskal-Wallis test during the feature selection phase, all variables except the variable FBS were significant at a 5% level. The techniques of Logistic Regression, Support Vector Machine, Naïve Bayes, and Random Forest were used in both phases to identify better models to recognize individuals with hearts. The model's performance in Table 2 was assessed using an unseen test data set. The results of the performance evaluation using each statistical mining algorithm are shown in Table 2:

Table 2: Model Performance for Phase

Algorithms	Cross-validation	Standard deviation
------------	------------------	--------------------

	score	
Logistic Regression	85.44	0.0303
Support Vector Machine	83.50	0.0396
Naïve Bayes	94.17	0.0376
Random Forest	96.11	0.0329

Random Forest and Naïve Bayes exhibit higher cross-validation score of 96.11 and 94.17, respectively while the support vector machine and logistic regression shows 83.50 and 85.44 accuracy respectively. Results indicate that the naïve bayes and random forest outperform the SVM and Bayesian in recognizing the individuals suffering from heart disease.

4 CONCLUSION

This study focuses on identifying proper models which describe the heart diseases of individuals. When participants were divided into healthy and heart disease patients, 12 characteristics were revealed to be influencing factors in diagnosing heart disease without fbs. The Random Forest and Naïve Bayes model performs well in identifying heart patients. These validation scores are 96.11 and 94.17, respectively. The Logistic Regression model has an accuracy of 85.44, while the Support Vector Machine has an accuracy of 83.50. As a result, we may utilize the Random Forest and the Naïve

Bayes models to identify cardiac disease. However most accurate model came from the random forest algorithm. This identified model can be utilized to create a decision support tool for medical practitioners to aid with clinical decisions.

5 LIMITATIONS

This study only looked at 13 characteristics that affect heart disease. However there may be other criteria that can be utilized to identify the ailment.

6 FUTURE WORK

An online dataset was used to simulate here. However it is possible to conduct this research obtained from patients in Sri Lanka. Furthermore, the study's scope can be increased by discovering additional elements that contribute to disease diagnosis.

REFERENCES

- Bahassine, S., Madani, A., and Kissi, M. (2016). An improved Chi-square feature selection for Arabic text classification using decision tree. *2016 11th International Conference on Intelligent Systems: Theories and Applications (SITA)*.
- Bell, D. S. H. (1996). Diabetes mellitus and coronary artery disease. *Coronary Artery Disease*, 7(10), 715–722. <https://doi.org/10.1097/00019501-199610000-00004>
- Berk, R. A. (2008). *Statistical learning from a regression perspective*. Springer Verlag.
- Bhattacharyya, H. (2006). Kruskal-Wallis test. *Encyclopedia of Statistical Sciences*. <https://doi.org/10.1002/0471667196.ess1369.pub2>
- Boyle, B. H. (2011). *Support Vector Machines Data Analysis, machine learning and applications*. Nova Science Publishers.
- Carver, R. H., & Nash, J. G. (2012). *Doing Data Analysis with Spss version 18.0*. Brooks/Cole Cengage Learning.
- Deal, B. J. (2009). Arrhythmias in congenital heart disease. *Adult Congenital Heart Disease*, 221–236. <https://doi.org/10.1002/9781444311846.ch15>
- Ferilli, S. (2011). *Automatic Digital Document Processing and management: Problems, algorithms and Techniques*. Springer.
- Goel, R. (2021). Heart disease prediction using various algorithms of machine learning. *SSRN Electronic Journal*. <https://doi.org/10.2139/ssrn.3884968>
- Hastie, T., Tibshirani, R., and Friedman, J. H. (2017). *The elements of Statistical Learning: Data Mining, Inference, and prediction*. Springer.
- Henderson, K. A., and Bialeschki, M. D. (2010). *Evaluating leisure services: Making enlightened decisions*. Venture Pub.
- Joachims, T. (2002). *Learning to classify text using support vector machines*. Kluwer Academic Publishers.
- Kay, R. H. (2003). Contemporary diagnosis and management of valvular heart disease. *Heart Disease*, 5(4), 303. <https://doi.org/10.1097/01.hdx.0000080721.09294.fb>
- Kecman, V. (2001). *Learning and soft computing: Support Vector Machines, neural networks, and Fuzzy Logic Models*. MIT Press.
- Kleinbaum, D. G. (1994). Introduction to logistic regression. *Logistic Regression*, 1–38 https://doi.org/10.1007/978-1-4757-4108-7_1
- Kleinbaum, D. G., and Klein, M. (2010). Ordinal logistic regression. *Statistics for Biology and Health*, 463–488. https://doi.org/10.1007/978-1-4419-1742-3_13
- Kucheryavskiy, S., Zhilin, S., Rodionova, O. Y., and Pomerantsev, A. L. (2020). Procrustes cross-validation — a bridge between cross-validation and independent validation set. <https://doi.org/10.26434/chemrxiv.12327803>
- Menard, S. W. (2010). *Logistic regression: From introductory to advanced concepts and applications*. Sage.
- Mensah, G. A. (2009). The burden of valvular heart disease. *Valvular Heart Disease: A Companion to Braunwald's Heart Disease*, 1–18.

IDENTIFICATION OF MAIN RISK FACTORS FOR HEART DISEASE AND COMPARISON OF
PREDICTIVE MODELS FOR THE ASSESSMENT OF HEART DISEASE STATUS

- Moodie, D. (2016). The journal congenital heart Disease-2016. *Congenital Heart Disease*, 11(1), 5–6.
<https://doi.org/10.1111/chd.12342>
- Privitera, G. J. (2015). *Statistics for the behavioral sciences*. SAGE.
- Seref, B., and Bostanci, E. (2019). Performance comparison of naïve Bayes and complement naïve Bayes algorithms. *2019 6th International Conference on Electrical and Electronics Engineering (ICEEE)*<https://doi.org/10.1109/iceee2019.2019.00033>
- Shanahan, J. G. (2000). *Soft computing for knowledge discovery: Introducing Cartesian granule features*. Kluwer Academic.
- Stout, K. (2009). Valvular heart disease in pregnancy. *Valvular Heart Disease: A Companion to Braunwald's Heart Disease*, 424–436. <https://doi.org/10.1016/b978-1-4160-5892-2.00025-8>
- Xiao Fang. (2013). Inference-based naïve Bayes: Turning naïve bayes cost-sensitive. *IEEE Transactions on Knowledge and Data Engineering*, 25(10), 2302–2313. <https://doi.org/10.1109/tkde.2012.196>



Impact of Customer Relationship on Customer Satisfaction in Marketing: A Case Study

Perera AGMB¹, Panahatipola PMOP²

Department of Mathematical Sciences, Faculty of Applied Sciences, Wayamba University of Sri Lanka.^{1,2}
madushabuddhini02@gmail.com¹
pmoshadhi@gmail.com²

ABSTRACT

Customer satisfaction has been viewed as a vital theoretical and practical issue for many marketers in the present era. Satisfaction refers to the pleasant or unpleasant feeling caused by imagination function and expectations. It mainly depends on company products or services that meet with customer expectations. Measuring customer feedback, staying proactive and reacting in real time are the most critical indicators of purchase intentions and customer loyalty. They can be applied to enhance business operations in the marketing sector and to produce benefits for performance outcomes. The main goal of this study is to investigate the impact of customer relationship (Product Quality, Service Quality and Customer Behavior) on customer satisfaction and to advise marketing firms on how to build customer value. Designing a Likert type questionnaire, which is a unidimensional scale that used to collect respondents' opinions and attitudes, primary data for the study were collected. Altogether, 211 observations were taken from each of the 4 manufacturing industries of a selected company by using the convenience sampling method. The independent variables gender, age, income and educational qualification have no significant association with customer satisfaction. Correlation and binary logistic is used to measure the relationship and contribution among independent variables with dependent variable. In conclusion, service quality is found to be more significantly associated with customer satisfaction in marketing.

KEYWORDS: Customer satisfaction, Customer behavior, Service quality, Product quality

1 INTRODUCTION

In today's highly competitive marketing environment, customer perspective can be introduced as the most important factor in deciding the success of a business. Most companies are unable to survive longer with a transactional attitude towards customers. So, they need to focus their marketing lenses for customer satisfaction and maintenance. Nowadays, customer satisfaction has been viewed as a vital theoretical and practical issue for many marketers because of this reason.

Mainly, satisfaction refers to pleasant or unpleasant feelings caused by imagination, function and expectations. It

mainly depends on company products or services that meet customer expectations. So, measuring customer feedback, staying proactive and reacting in real-time are the most important indicators of purchase intentions and customer loyalty. They can be used to deliver benefits for performance outcomes and to improve the business within the marketing field.

The main goal of this study is to build a long-term relationship with key constituents. Satisfied customers are the precious assets of companies to gain customer loyalty and retention. Building a customer-centric business is the main purpose in business satisfaction. It mainly helps the marketing companies to predict business outcomes, personalize

customer engagement, improve business strategy through better market intelligence and pattern recognition, gain competitive advantage, improve Product/Service Quality control and to increase Process, Labor and Value chain efficiencies.

2 LITERATURE REVIEW

Dastane & Fazlin (2017) investigated the key factors affecting customer retention for the fast food industry. Product quality, service quality, facility, emotional factor and price were examined in the study. It concludes by showing that emotional factor and facility plays an important role in customer satisfaction in the Malaysian fast-food industry.

Alkilani (2017) referred to the impact of experiential marketing and customer satisfaction on customer commitment in social networks. The objective of that study was to evaluate an inner-relationship among experiential marketing and concluded that sense and feel experiences are positively related to customer satisfaction and commitment.

Sivesan & Velnampy (2012) examined the relationship between customer relationship marketing and customer satisfaction in mobile service providing companies in Sri Lanka. Trust, commitment, equity and empathy were measured and correlation contribution among variables was analyzed in the study and showed that priority should be given to reduce customer dissatisfaction.

Berry & Parasuraman (1991) examined customer relationship marketing as a best contemporary strategy in gaining business goals. It measured trust, mutuality, commitment, marketing attraction and a long-term

companionship as the essential factors for the companies to satisfy the customer wants and needs in marketing.

3 METHODOLOGY

The data for the study were collected using a questionnaire and designed by covering three sections: product quality (A), service quality (B) and customer behaviour (C). The identified factors are mentioned in fig. 1.

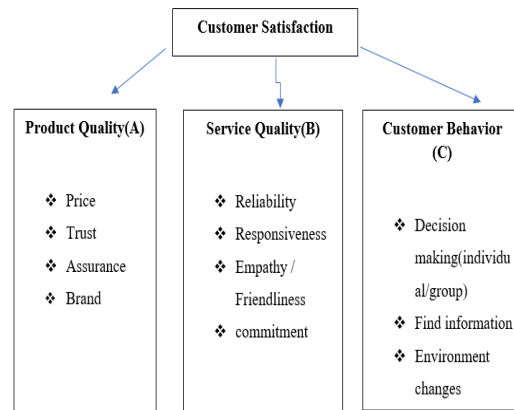


Figure 1: Questionnaire designed for three factors

Descriptive statistics analysis was carried out using graphical representations such as bar chart, pie chart to better grasp the issue. Correlation analysis was used to find the relations and Binary Logistic Regression model was used to find the relationship between independent variables and dependent variables. SPSS software was used for the Descriptive Statistics and R software was used to build the model and test it.

4 DATA COLLECTION AND ANALYSIS

The study is based on the primary data that were collected by designing a questionnaire using the convenience sampling method. Altogether 211 observations were taken from each of the four manufacturing sections of the

company including 50 employees from each section.

For the binary logistic analysis, the variables were encoded as “0” for not satisfied values and “1” for satisfied values. The independent variables age, educational qualification, income and gender were mainly used for the descriptive analysis.

Table 1: Descriptive Statistics

	Mean	Std. Deviation
Overall_Satisfaction	3.73	.702
Product_Quality	4.16	.770
Service_Quality	4.37	.714
Customer_Behaviour	4.19	.707
Age	2.84	1.105
Maximum_Education_Qualification	3.40	.818
Income	2.38	1.441

Table 1 summarized the mean and standard deviation values of the collected sample data of the study.

5 RESULTS AND DISCUSSION

The graphical representation of dependent variables and independent variables helped gaspe the preference of customers in marketing. The statistical methods like reliability test, validity test, normality test, goodness of fitting, significance of the model and accuracy were used to illustrate the meticulous results of the study.

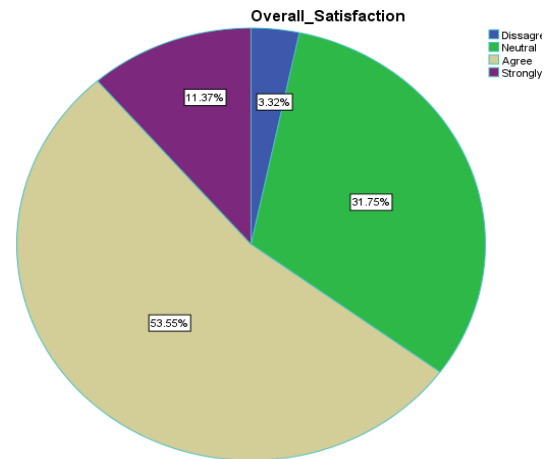


Figure 2: Distribution of Overall Satisfaction

According to fig. 2 most of the employees agreed that they were satisfied with the current marketing system, but only 11.37% of customers were fully satisfied. Most of the customers were not satisfied with the current marketing system.

To check the Reliability Statistics of the study, the value of Cronbach’s Alpha was used. The null and alternative hypothesis was taken as,

H₀: Study was reliable ($\alpha > 0.6$)

H₁: Study was not reliable.

Cronbach's Alpha for this study was 0.700 and since it was higher than 0.6. It concludes that the internal consistency was good and the study was reliable and will give creditable results.

In order to verify the validity of the collected sample data of the study, ANOVA test was used. Then the significance of the model was evaluated with the hypothesis,

H₀: Model is not significant

H₁: Model is significant (sig value < 0.05)

Table 2: ANOVA Test

	F	Sig
Significance of the model	47.040	.000

According to table 2, the F value of the collected data is 47.040 and sig. the value is 0.00. Sig. value is less than 0.05. So, the model is significant at 95% level of confidence.

Table 3: Variables in the Equation

Variable	B	Sig.	Exp(B)	95% C.I. for EXP(B)	
				Lower	Upper
Service Quality	.794	.000	2.21	1.84	2.65

H₀: The variable is not significant

H₁: The variable is significant (sig.-value<0.05)

Since the sig. value (0.000) <0.05, H₀ can be rejected and can conclude that the variable service quality is significant with 95% CI of 1.841 to 2.656.

Calculated B in table 3 is the predicted change in Log Odds for one unit change in predictor and exp(B) is the change in the probability outcome. According to the odd ratio (2.211) is greater to the probability of falling (1) the event is likely to occur.

To check the goodness of fit statistic, Hosmo and Lemeshow test was used. It gives the chi-square value with significance.

Table 4: Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	3.892	1	.059

H₀: The model adequately fits the data

H₁: The model does not adequately fit the data (P-value<0.05)

The table 4 gives the sig. value as 0.059 and since sig. value (0.059) >0.05 in Hosmer and Lemeshow Test, we can conclude that the model adequately fits the data. Hence, there is no difference between the observed and predicted model.

Table 5: Model summary

Step	-2 Log likelihood	Nagelkerke R Square
1	61.740 ^a	.887

With categorical outcomes, it has a theoretical maximum value of less than 1.0. For this reason, Nagelkerke proposes a modification that allows the index to take values in the full zero-to-one range. Results were as shown in table 5. Finally, it can be said that 88.7% change in criterion variable can be accounted to the predictor variables in this model.

Table 6: Percentage Accuracy

Actual value	Predicted Value	
	FALSE	TRUE
0	0	4
1	0	112
Overall percentage		96.55172

According to the above table 6 the model correctly classified 96.6% (112+0)/ (112+4+0+0) of cases (percentage accuracy) overall.

6 CONCLUSION

The study demonstrates the use of binary logistic regression statistical technique to model customer satisfaction in marketing. This statistical tool is used to determine a reason-result relationship of independent variable(s) with dependent variable that is dichotomous/binary.

Clearly, the binary regression model is a technique to the field of educational research and model assumption and it can be verified by fitting information, goodness of fit information, parameter estimation, contingency in predictions and the accuracy.

The independent variables that have no significance associated with customer satisfaction are gender, age, income and educational qualifications. Customer satisfaction is strongly associated with independent variables product quality, service quality and customer behaviour. This study clearly expressed that the service quality has the most significant impact on customer satisfaction in marketing. However, proportion of impact customer behaviour and product quality were low level in the study. It is because of the inability of marketing companies to build trust among customers. Most marketing companies spend their time on maintaining the company and infrastructure facilities but fail to make fruitful efforts in satisfying customer needs of a certain product.

In conclusion, marketing companies have to give priority to their products and customer needs in order to reduce customer dissatisfaction.

REFERENCES

- Admassie A., and Abebawa D., *Journal of Development Effectiveness* (2009) 1(4): 430–449.
- Bender, R., and Benner A. (2000), “Calculating Ordinal Regression Models in SAS and S-Plus”, *Biometrical Journal* 42, 6, pp677-699.
- Chau-Kuang C., and Hughes J. (2004), “Using Ordinal Regression Model to Analyze Student Satisfaction Questionnaires”. *Journal of IR Applications*, 1(1).
- Chirani, E., Mirrashed, S.A. and Taleghani, M. (2011). “Conceptuality approach to relationship marketing and customer loyalty to banks”, *Journal of Basic and Applied scientific research*, 11, 2022-2025.
- Emmanue B., and Priscilla O., “A Review of Corporate Social Responsibility and Its Relationship with Customer Satisfaction and Corporate Image”, Centre for West African Studies, University of Electronic Science and Technology of China, Chengdu, China.
- Nuri H. Salem Badi, “Asymptomatic Distribution of Goodness-of-Fit Tests in Logistic Regression Model”, Mathematics Department, Faculty of Art and science-Alabyar University of Benghazi, Benghazi, Libya,
<https://www.scirp.org/journal/paperinformation.aspx?paperid=76814>.
- Omkar Dastane, and Intan Fazlin. “ Re-investigating Key Factors of Customer Satisfaction Affecting Customer Retention for Fast Food Industry”, *International Journal of Management, Accounting and Economics* Vol. 4, No. 4, April, 2017 ISSN 2383-212.
- Sivesan S. and Velnampy T. *Global Journal of Management and Business Research* Volume 12 Issue 18 Version 1.0 Year 2012, *Type: Double Blind Peer Reviewed International Research Journal*, Publisher: Global Journals Inc. (USA)Online ISSN: 2249-4588.



Lung Cancer Diagnosis Using the Lloyd K-means Algorithm

Gayathri YKKMK¹, Napagoda NADN²

Department of Mathematical Sciences, Faculty of Applied Sciences, Wayamba University of Sri Lanka. ^{1,2}

minushigayathri@gmail.com¹

namaleen@wyb.ac.lk²

ABSTRACT

Ensuring patient safety in their decision-making is one of the major concerns in healthcare. Data mining in health care is a new application for identifying helpful information and discovering patterns associated with various diseases. The most prevalent type of cancer, with a global prevalence, is lung cancer. Although there is a very high chance of curing lung cancer in its early stages, this study is implemented to help the detection of the disease at an early stage. The main aim of this study is to use K-means with the Lloyd technique to find trends in a lung cancer database and comprehend how clustering affects the data on lung cancer. The majority of studies used algorithms to evaluate the lung cancer dataset to identify clusters of small cell or non-small cell lung cancer in different stages. Lung cancer data are applied using the methods suggested by the extremely well-known partition-based algorithm, the K-means approach with the Lloyd algorithm. The complexity of organizing the data can be reduced by repeatedly running the K-means method. Lloyd's algorithm is the typical batch, hill-climbing method for lowering the K-means optimization criterion. The suggested approach has demonstrated its efficacy in categorization, and the system's accuracy is 75.8%.

KEYWORDS: Data mining, K-means, Lloyd algorithm, Lung cancer

1 INTRODUCTION

Data Mining (DM) is the process of identifying anomalies, patterns, and correlations in a large collection of data to predict outcomes. An effective DM method could be used as a clinical diagnosis for effective decision-making. Alberg et al., (2016) discussed that the vast majority (85%) of lung cancer cases are caused by long-term tobacco use, and 10-15% of case scenarios occur in people who had never smoked. Coughing (including coughing up blood), fat loss, difficulty breathing, and chest pains are the most common symptoms of lung cancer.

A data mining technique called clustering is used to separate dissimilar data into various clusters and to group comparable data into one cluster. The most significant unsupervised DM

technique is clustering, which, like all other problems of this type, involves identifying a structure in a set of unlabeled data. The process of grouping items into groups whose members share some characteristics is known as clustering. One of the most straightforward partition-based cluster analysis techniques is K-means clustering. The procedure starts by defining the number of clusters (K) and the distribution of initial center values, which may be chosen randomly or from the first K items.

In our study, the Lloyd K-means cluster algorithm has been used to recognize lung cancer patterns. There are two types of attributes in the lung cancer dataset: demographic attributes (gender, age, patient Id) and diagnosis attributes (air pollution, alcohol use, dust allergy,

smoking). Our study aimed to (1) apply the K-means clustering methods with Lloyd algorithm in lung cancer data. (2) find the accuracy (performance) by using the correctly classified cluster and an original class of instance in the database.

The paper is organized in the following way: section 2 highlights the related works, section 3 gives an overview of Lloyd K-means clustering, and describes the proposed methodology. Section 4 introduced data collection and analysis. Section 5 deals with the results and section 6 discuss our research's conclusion and future work.

2 RELATED WORKS

Due to the severity of this condition, numerous studies on lung cancer diagnosis have been conducted over the years and are still being conducted.

Anas et al., (2017) classify skin cancer using K-means clustering. The researchers combine the color and texture data, producing better results than only the color or gray level information. Six distinct color-texture feature extractors have been employed to separate the features from the segmented images. The results from the proposed method are computed using five different classification rates to undertake a better of the suggested system. Azevedo et al., (2020) propose cluster analysis for breast cancer pattern identification. Finding trends in breast cancer requires the use of the K-means technique, which performs a three-dimensional clustering analysis. The findings manifest that the health professionals can better understand the traits of different tumor kinds by mining abstract tumor properties. Ayoob (2018) proposes a K-means methodology for breast cancer diagnosis. The suggested

method has demonstrated its usefulness in categorization, and the system's accuracy is 96.4861%. Dubey et al., (2018) recommend a comparative study on breast cancer data by using K-means and Fuzzy C-Means (FCM) algorithms. The computational results showed that, when used with various iterations, fuzziness levels, and termination criteria, the FCM approach was found to be more prominent and reliable than the K-means algorithm. Additionally, the results of the experiment show that the FCM clustering method outperforms the traditional K-means clustering strategy when used with real data. Yadav et al., (2013) recommend the Foggy K-means clustering algorithm for lung cancer. The results demonstrate that the foggy K-means clustering algorithm performs better on real data than the basic K-means clustering algorithm and offers a more effective solution to the situation at hand. Dubey et al., (2016) analyze the K-means clustering approach on the Breast Cancer Wisconsin (BCW) data. The overall accuracy of this method's positive predictions was 92%. When using the same centroid and the highest variance, better results were found. The results indicate that the BCW data may be classified using K-means.

3 METHODOLOGY

Numerous scholars in the realm of clustering applications have devised various clustering methods. However, in recent years so many researchers have implemented K-means algorithms for lung cancer data and breast cancer data. These methods have a substantial impact on the clustering findings' quality. This study offers insight into the classification of a global database used for lung cancer

research using Lloyd K-means technology. Also, the K-means technique is slower than Lloyd's K-means clustering, which is more effective with very big data sets. Therefore, the technique is used to illustrate how well it can identify data related to lung cancer. The study was conducted to produce far better results by using its simplicity. Moreover, the effectiveness of the Lloyd K-means algorithm is examined in this study.

3.1 K means Algorithms

The K-means algorithm is a partition-based clustering technique. One of the basic unsupervised learning strategies to solve the well-known clustering problem is the K-means approach.

3.2 Lloyd K means Algorithm

Lloyd is a well-known K-means application. Lloyd's algorithm is understanding and simple. At first, Lloyd randomly selects K data points to serve as centroids. The centroids are then recalculated as the mean over all the allocated data points, and all data points are then assigned to the nearest centroid. Lloyd repeats these final two steps until nothing in their assignment changes.

Algorithm: Lloyd

1: Indicate how many clusters (K) are produced (by the analyst).

2: Randomly choose k centers at random from the dataset to serve like the initial cluster centroid.

3: Repeat

4: for each center **do**

5: modified every point to its nearest cluster centroid

6: Recalculate the centroid using the mean of all the points.

7: end for

8: until convergence

3.3 Analysis steps applying for lung cancer data

- a. Preprocessed the lung data.
- b. Apply Lloyd K-mean algorithm.
 - Identified the number of clusters:

Since the dataset has three classes (i.e. cluster for high cases, cluster for medium cases, and cluster for low cases), the dataset was analyzed by using three clusters.
 - Found the random centers of the cluster:

This was accomplished by choosing three instances at random and making sure that each of their classes is distinct to act as a magnet for cases that are related.
 - The class of the cluster:

The cluster's class was represented by the initial centers' class.
 - Re-initialized centroids:

The method declared the end of the cycle after all cases in the database have been classified into clusters, and then updated every center by averaging(using mean value) the points that belong to that cluster.

- Finished Lloyd K-mean steps:
The suggested technique terminated when all instances remain permanently in clusters; in other words, instances were not moved from one cluster to another.

c. Calculated the accuracy.
After an instance has been assigned to a specific cluster, the database class of the instance and the cluster's class are compared. If they are identical, a counter is raised by one to indicate that the system was successful in classifying this instance. The algorithm then divides the number of cases that were correctly categorized by the total number of cases (1000).

$$Accuracy = \frac{\text{Number of correctly classified class}}{\text{Total instance}} \times 100\% \quad (1)$$

4 DATA COLLECTION AND ANALYSIS

The Lung cancer dataset contained details on 1000 patients, including their demographic and diagnostic attributes. The datasets can be found at <https://www.kaggle.com/datasets>.

Table 1: Dataset details

Types of Attributes	Attribute Name
Demographic Attributes	age, gender
Diagnosics Attributes	air pollution exposure, alcohol use, dust allergy, occupational hazards, genetic risk, chronic lung disease, balanced diet, obesity, smoking, passive smoker, chest pain, coughing of blood, fatigue, weight loss, shortness of breath, wheezing, swallowing difficulty, clubbing of fingernails, and snoring

In the preprocessing step of the lung cancer dataset, the value of class Lable attributes had changed into 1 or 2, or 3 (low 1, medium 2, and high 3). Missing values and duplicates were not in the database. Also, to make variables comparable, the data scaled (normalized). That means the dataset should be scaled so that each variable has a mean of 0 and a standard deviation of 1.

5 RESULTS AND DISCUSSION

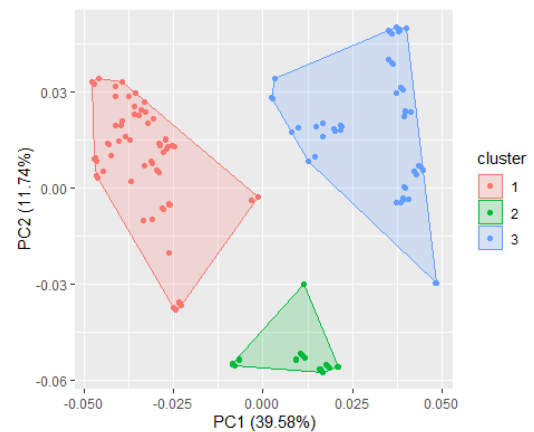


Figure 1: Plot of data points into 3 clusters.

Fig.1 visualizes the data in a scatter plot by coloring each data point according to its cluster assignment. Although this visualization introduced where true delineations occur between clusters. However, the 3 clusters were made which are of 445, 180, and 375 sizes respectively. Within the cluster, the sum of squares is 44.3 %. Table 2 introduces some important details about the performance of the proposed system:

Table 2: Performance measures for the proposed algorithm

Performance	Number of Instances		
	Low	Medium	High
Number of correctly classified instances	288	145	325

Number of wrongly classified instances	15	187	40
Total	303	332	365

$$\begin{aligned} \text{Accuracy} &= \frac{758}{1000} \times 100\% \\ &= 75.8\% \end{aligned}$$

6 CONCLUSION

Our study used the Lloyd algorithm to conduct K-mean clustering on lung cancer data. The Lloyd K-means clustering algorithm's most notable feature in data mining is how well it clusters large data sets. The fact that homogenous, unstructured, semi-structured, or a combination of all data types is involved leads to the widespread use of the Lloyd K-means clustering algorithm in data mining applications. The technique has successfully classified the database, and despite its simplicity, it has obtained a respectable performance. Results showed that the Lloyd K-means algorithm was successful (accurate) in classifying the data by up to 75.8%, though. It is a considerably good average.

In future studies, it may be feasible to boost the performance of the approach with optimization techniques that improve the performance of the system. The initial thought is to utilize a genetic algorithm to conduct one of the following operations.

-Reduce the number of features and obtain nominations for the best and most significant.

-Determining the initial cluster centers by contrasting the findings of the Elbow method, Silhouette method, and Gap statistic approach.

-Calculate the results' accuracy using the Support Vector Machine(SVM) classification method.

REFERENCES

- Alberg, A. J., Brock, M. V., and Samet, J. M. (2016). Chapter 52: Epidemiology of lung cancer. *Murray & Nadel's Textbook of Respiratory Medicine (6th ed.)*. Saunders Elsevier.
- Anas, M., Gupta, K., and Ahmad, S. (2017). Skin cancer classification using K-means clustering. *International Journal of Technical Research and Applications*, 5(1), 62-65.
- Ayoob, N. K. (2018). Breast Cancer Diagnosis Using K-means Methodology. *Journal of University of Babylon for Pure and Applied Sciences*, 26(1), 9-16.
- Azevedo, B. F., Alves, F., Rocha, A. M. A., and Pereira, A. I. (2022, January). Cluster analysis for breast cancer patterns identification. In *Optimization, Learning Algorithms and Applications: First International Conference, OL2A 2021, Bragança, Portugal, July 19–21, 2021, Revised Selected Paper* (pp. 507-514). Cham: Springer International Publishing.
- Dubey, A. K., Gupta, U., and Jain, S. (2016). Analysis of k-means clustering approach on the breast cancer Wisconsin dataset. *International journal of computer assisted radiology and surgery*, 11, 2033-2047.
- Dubey, A. K., Gupta, U., and Jain, S. (2018). Comparative study of K-means and fuzzy C-means algorithms on the breast cancer data. *International Journal on Advanced Science, Engineering and Information Technology*, 8(1), 18-29.
- Yadav, A.K., Tomar, D., and Agarwal, S. (2013). Clustering of lung cancer data using Foggy K-means. *2013 International Conference on Recent Trends in Information Technology (ICRTIT)*, 13-18.



Mathematical Modelling of Tumorigenesis

Jayarathna RAVM¹, De Silva TMM², Karunarathna SPDSSK³

Department of Mathematics, Faculty of Science, University of Kelaniya.^{1,2}

jayarath_ps16088@stu.kln.ac.lk¹

Department of Mathematical Sciences, Faculty of Applied Sciences, Wayamba University of Sri Lanka.³

karunarathna@wyb.ac.lk³

ABSTRACT

Cancer is a well-known killer of humans worldwide, and which has a variety of treatments that are sporadically effective. On a biological level, the term "cancer" refers to a wide range of illnesses with a similar origin: unchecked cell proliferation brought on by a malfunction in the homeostatic signaling that controls cell division. Mathematical biology offers a promising approach to predicting the dynamics of this faulty cell growth, with goal of furnishing insight into potential treatments. As such, model the dynamics and interactions of healthy and cancer cells under treatments which is viewed as a competition for body resources were modeled in this work. We analyze the competitive Lotka-Volterra equations in the context of cancer modeling was analyzed and present a treatment model for tumor growth which is adapted from the Lotka-Volterra model. There exist four qualitatively different scenarios for the competing populations, and we discuss stability conditions for each. It was observed that if the treatment targets the healthy cells beyond a certain threshold, eradication will not occur. Moreover, criteria on the existence and global asymptotic stability of unique positive solution of the system have been obtained. It has been demonstrated that when the treatment is applied, the cancer cells neither grow unrestricted nor tend to zero.

KEYWORDS: Lotka-Volterra Competition model, Threshold, Lyapunov stability

1 INTRODUCTION

Cancer is one of the malignant illnesses in the world. Cancer causes an increase in the death rate in both developed and developing countries. In Sri Lanka, it is estimated at least eighty percent of all cancers diagnosed over the last three decades (Jayarajah, 2001-2010). In 2020, there were about 19.3 million new cases and almost 10.0 million cancer deaths occurred in the world based on the GLOBOCAN estimates.

Smoking, obesity, physical inactivity, urbanization, the development of electrolysis and changes in reproductive patterns increase the risk of cancer (Siegel, 2014).

By detecting and treating cancer at an early stage, the chances of the disease being cured are higher. There are many types of cancer treatment, such as chemotherapy, radiation therapy, surgery, immunotherapy, targeted therapy and hormone therapy. The treatment depends on the type of cancer. It can destroy the cancer cells or control the growth of cancer cells. Chemotherapy is a drug treatment that uses powerful chemicals to kill rapidly growing cells in the body. Radiation therapy is a type of cancer treatment that uses high energy beams to destroy cancer cells and shrink tumors (Vincent T, 2004). Immunotherapy refers to the treatment of disease by inducing, enhancing, or suppressing an immune

response. It uses cytokines usually together with adoptive cellular transfer to boost the immune system (Anderson, 2008).

A mathematical model can be used to understand the collective behavior of a population of cancer cells. Analysis of ordinary differential equations, partial differential equations, and stochastic processes are necessary to undertake a different type of cancer modeling. Barmann et al. review three common models of cancer growth (Barmann, 2019). These are the Exponential model, Power Law model, and Gompertz-Laird equations. The exponential model is used to study cellular growth. This model is generally not valid for modeling long-term growth (Laird, 1965). The power-law model is a generalization of the exponential model. And also, Gompertz-Laird equations are used in population modeling, especially in modeling cancer growth (Tjorve, 2017). Also, the stability of cancer cells and healthy cells can be examined during treatment. The Competitive Lotka Volterra equations are used to model the dynamics of competing populations at both the micro and macroscopic level (Wangersky, 1978). In this study, the competitive Lotka-Volterra equations in cancer modeling was considered.

The model is built upon the classical Lotka-Volterra competition system of two species by incorporating treatment into one species. By constructing a Luapunov function, global behaviour of the model is discussed.

2 THE LOTKA-VOLTERRA COMPETITION MODEL

It was strated by exploring a specific, simple model that describes the

competition for space among two species or clones of cancer cells.

This analysis was generalized by considering its axiomatic models of competition among two species of cells. Let $x = x(t)$ and $y = y(t)$ represent the volume of healthy cells and volume of cancer cells at time t respectively. The competitive Lotka-Volterra model is (Allen, 2007)

$$\frac{dx}{dt} = r_1x \left(1 - \frac{x}{K_1}\right) - b_1xy$$

$$\frac{dy}{dt} = r_2y \left(1 - \frac{y}{K_2}\right) - b_2xy$$

where r_1, r_2 are growth rates, K_1, K_2 are carrying capacities, and b_1, b_2 are coefficients of competition. Here all the constants are assumed to be positive.

3 THE TREATMENT MODEL

3.1 The Competition Model with Treatment

The following model is proposed to investigating the effect of incorporating a treatment term into the competition.

$$\frac{dx}{dt} = r_1x \left(1 - \frac{x}{K_1}\right) - b_1x - c_1x \tag{1}$$

$$\frac{dy}{dt} = r_2y \left(1 - \frac{y}{K_2}\right) - b_2xy - c_2y$$

where c_1x, c_2y are treatment terms. The treatment negatively affects for both cells. It means, cancer treatment may have many side effects and can be different for each person and for different medicines and treatments. So, in this case, the terms of treatment are used in a negative way. First it was verified that solutions of our model are nonnegative and are bounded so that our model is biologically sound.

3.2 Boundedness of the Solution

Proposition 3.1: Solutions of (1) remain nonnegative and are bounded for $t \geq 0$.

Proof: Let x and y be arbitrary solutions. Since $dx/dt=0$ and $dy/dt = 0$ for $(x, y) = (0,0)$ solutions of (1) remain nonnegative on the interval of existence (Thieme, 2018).

Let $S = b_2x + b_1y$ then $S' = b_2x' + b_1y'$. Then

$$\mu S + S' \leq b_2 \frac{(r_1+\mu)^2}{4r_1} K_1 + b_1 \frac{(r_2+\mu)^2}{4r_2} K_2.$$
 Let $K = b_2 \frac{(r_1+\mu)^2}{4r_1} K_1 + b_1 \frac{(r_2+\mu)^2}{4r_2} K_2.$

Hence

$$\limsup_{t \rightarrow \infty} S(t) \leq \frac{K}{\mu}$$

Therefore, solution of (1) exist for all $t > 0$ and remain nonnegative and there exist $\tilde{K} > 0$ such that $\limsup_{t \rightarrow \infty} x(t) \leq \tilde{K}$. Here, we only analyze the healthy cells. The cancer cells can be analyzed similarly.

3.3 Non-dimensionalized Form

To reduce the number of parameters, we obtain the following non-dimensionalized form:

$$\begin{aligned} \frac{dM}{d\tau} &= M(1 - M - \beta_1 N) - \delta_1 M \\ \frac{dN}{d\tau} &= \rho N(1 - N - \beta_2 M) - \rho \delta_2 N \end{aligned} \quad (2)$$

Where,

$$\begin{aligned} M &= \frac{x}{K_1}, N = \frac{y}{K_2}, \tau = \frac{r_2}{r_1}, \beta_1 = \frac{b_1 K_2}{r_1}, \\ \beta_2 &= \frac{b_2 K_1}{r_2}, \delta_1 = c_1/r_1 \text{ and } \delta_2 = c_2/r_2. \end{aligned}$$

It follows from proposition (3.1) that solutions of (2) remain nonnegative and are bounded for $t \geq 0$.

4 EXISTENCE OF EQUILIBRIA

System (2) has three boundary steady states $E_0 = (0, 0), E_1 = (1 - \delta_1, 0), E_2 = (0, 1 - \delta_2)$ and one interior steady state $E_3 = (1 - \beta_1 - \delta_1 + \beta_1 \delta_2 / 1 - \beta_1 \beta_2,$

$$1 - \beta_2 - \delta_2 + \beta_2 \delta_1 / 1 - \beta_1 \beta_2) \equiv (M^*, N^*).$$

The stability of extinction equilibrium, boundary equilibria and coexistence equilibria by the nature of eigenvalues of the Jacobian matrix were studied next.

$$J = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}$$

where

$$\begin{aligned} a_{11} &= 1 - 2M - \beta_1 N - \delta_1, a_{12} = -\beta_1 M, \\ a_{21} &= \rho \beta_2 N, a_{22} = \rho - 2\rho N - \rho \beta_2 M - \delta_2 \rho. \end{aligned}$$

Theorem 4.1: System (2) has three boundary steady states $E_0 = (0, 0), E_1 = (1 - \delta_1, 0)$ and $E_2 = (0, 1 - \delta_2)$ where E_0 is an attractor if and only if $\delta_1 > 1$ and $\delta_2 > 1, E_1$ is stable if and only if $\delta_1 < 1$ and $\delta_2 > (1 - \beta_2 + \beta_2 \delta_1)$ and E_2 is stable if and only if $\delta_1 > (1 - \beta_1 + \beta_1 \delta_2)$ and $\delta_2 < 1$.

Lemma 4.1: System (2) has at least one interior steady state if $1/\beta_1 > 1 - \delta_2 / 1 - \delta_1 > \beta_2$ is satisfied.

By using Lyapunov function, we obtain the sufficient conditions under which the positive equilibrium is globally asymptotically stable.

Theorem 4.2: The coexistence equilibria is globally asymptotically stable, if the following inequalities are satisfied:

$$1 - \beta_1 \beta_2 > 0, \text{ and } \frac{1}{\beta_1} > \frac{1 - \delta_2}{1 - \delta_1} > \beta_2.$$

Proof: By considering the following Lyapunov function

$$\begin{aligned} V(M, N) &= \left(M - M^* - M^* \ln \left(\frac{M}{M^*} \right) \right) + \\ &\left(N - N^* - N^* \ln \left(\frac{N}{N^*} \right) \right). \end{aligned}$$

Next, we calculate the derivative of V along solutions:

$$\begin{aligned} \frac{dV}{d\tau} = & \left(1 - \frac{M^*}{M}\right) (M - M^2 - \beta_1 MN \\ & - \delta_1 M) \\ & + \left(1 - \frac{N^*}{N}\right) (N - N^2 \\ & - \beta_2 MN - \delta_2 N) \end{aligned}$$

After a direct computation we have,

$$\frac{dV}{d\tau} < -(M - M^*)^2 - \rho(N - N^*)^2.$$

E_3 exists if and only if $\beta_1\beta_2 < 1$. We obtain $dV/d\tau < 0$ strictly for all $(M, N) > 0$ except the equilibrium E_3 , where $dV/d\tau = 0$.

Therefore, $V(M, N)$ satisfies Lyapunov's stability theorem, then coexistence equilibria is globally asymptotically stable. Hence, the system (2) is permanent that is, the healthy cells and cancer cells are coexistence. Figure 1 represents coexistence of fixed point when $\beta_1\beta_2 \leq 1$.

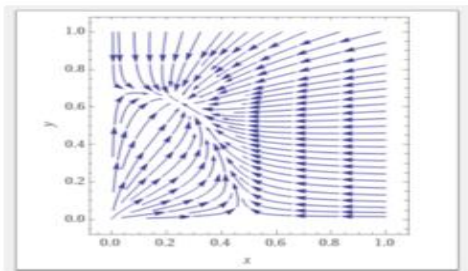


Figure 1: $\rho = 0.5$, $\beta_1 = 0.4$, $\beta_2 = 0.3$, $\delta_1 = 0.5$, $\delta_2 = 0.3$

5 CONCLUSION

A slight variation of the competitive Lotka-Volterra equations that was modified with treatment terms was used to describe the dynamics between healthy cells and cancer cells for the cancer treatment. We observed four qualitatively different scenarios which are extinction of both species, competitive exclusion and coexistence of both species were observed. It was shown that if the treatment targets the healthy cells beyond

a certain threshold, eradication will not occur. Also, the larger the value of ρ , the greater the treatment effect on the cancerous cells must be to eradicate them. Using the Lyapunov stability theorem, it was determined that the necessary criteria for globally stability of the unique positive equilibrium point. It was found that when the treatment is applied, the cancer cells neither grow unrestricted nor tend to zero.

REFERENCES

- Albano, G., Giorno, V., (2006). A stochastic model in tumor growth. *Journal of Theoretical Biology*, 242(2):329–336.
- Allen, L. (2007). An Introduction to Mathematical biology, *Pearson Education, Inc.*
- Anderson, J. Y. (2008). Qualitative behavior of systems of tumor-cd4+–cytokine interactions with treatments. *Mathematical Methods in the Applied Sciences*, 38(17):4330–4344.
- Horst R Thieme. Mathematics in population biology. Princeton University Press, 2018.
- Jayarajah, U., Prabashini, S., Fernando, E., Senevirathna, S. (2018). Incidence and histological patterns of thyroid cancer in sri lanka 2001-2010: an analysis of national cancer registry data. *BMC cancer*, 18(1):1–7.
- Kwang, K. S., Kim, S., Jung I.H. (2016). Dynamics of tumor virotherapy: A deterministic and stochastic model approach. *Stochastic Analysis and Applications*, 34(3):483–495.
- Laird, A. K. (1965). Dynamics of tumour growth: comparison of growth rates and extrapolation of growth curve to one cell. *British Journal of Cancer*, 19(2):278.
- Reya, T., Morrison, S., Clarke, M., Weissman, I. (2001). Stem cells, cancer, and cancer stem cells. *nature*, 414(6859):105–111.
- Siegel, R., Miller, K.D., Hanah, B.S., Ahmedin, J. (2014). Cancer statistics. *CA: a cancer journal for clinicians*, 64(1):9–29.

- Tjorve, K. M., Tjorve, E., (2017). The use of gompertz models in growth analyses, and new gompertz-model approachh: An addition to the unified-richards family. *PloS one*, 12(6):e0178691.
- Tomlinson, B., Bodmer, W. (1995). Failure of programmed cell death and differentiation as causes of tumors: some simple mathematical models. *Proceedings of the National Academy of Sciences*, 92(24):11130–11134.
- Vincent T, D. J., Edward, C., (2004). A history of cancer chemotherapy. *Cancer Research*, 68(21):8678–8686.
- Vladimir A Kuznetsov, Makalkin, I. A., Taylor, M., Perelson, A. (1994). Nonlinear dynamics of immunogenic tumors: parameter estimation and global bifurcation analysis. *Bulletin of mathematical biology*, 56(2):295–321.
- Wangersky, P. J. (1978). Lotka-volterra population models. *Annual Review of Ecology and Systematics*, 9(1):189–218.
- Wodarz, D., Komarova, N. (2014). *Dynamics of cancer: mathematical foundations of oncology*. World Scientific.



Predicting the Final Score of Twenty-Twenty International Cricket Match after the Power Play

Kumari DASR¹, Arivalzahan S²

Department of Mathematics and Statistics, Faculty of Science, University of Jaffna.^{1,2}
deguruarachchi@gmail.com¹
arivu@univ.jfn.ac.lk²

ABSTRACT

Predicting the final score of twenty-twenty international cricket match (for both the first and second innings) after the power play is the objective of this study. Separate statistical models have been developed to predict the final scores of the first and second innings. Though there are twelve T-20 international cricket teams (known as the full members of the ICC), in this study, we considered only the Sri Lankan cricket team. For the second innings, currently the Duckworth-Lewis-Stern (DLS) method is being used to predict the final score. Our proposed model for the second innings incorporates DLS target (DLST) as one of the predictor variables. In addition to DLST, we considered some more predictor variables such as the average strike rate of the remaining batsmen after the power play (ASRB), venue, toss results, and the average economy rate of the opponent team bowlers (AEROB). DLST, AEROB, and toss results are found to be significantly influencing the second innings final score for the current Sri Lankan team. Stepwise regression has been used for the model selection. The coefficient of determination is 0.8146. RMSE of the proposed model is smaller than the RMSE of the DLS method in a test sample of five recent matches. Since DLST is not available for the first innings, instead of DLST, the power play score, and the number of wickets lost in the power play are being considered as predictor variables. Moreover, ASRB, venue, toss results, AEROB, and average final score of the first innings in the last five matches (AFS) are also being considered as predictor variables in the model for the first innings. The predictors AEROB and ASRB are found to be significantly influencing the first innings final score for the current Sri Lankan team. The coefficient of determination for the first innings model is 0.8585. This model is also being validated with a test sample of six recent matches.

KEYWORDS: T20 cricket, DLS method, Statistical models, Stepwise regression, Coefficient of determination.

1 INTRODUCTION

Cricket is one of the most popular sports in the world because, it has more than one billion fans worldwide, with the potential for significant growth. The stochastic property of the cricket match results made billions of people around the world big fans of cricket and wait for the results eagerly. Among all formats of cricket, the popularity of T-20 Internationals (T20I) is the highest. Setting the target score in T20I cricket game has been considered as a challenging problem.

2 LITERATURE REVIEWS

Duckworth & Lewis (1998) introduced the Duckworth Lewis (D/L) method to predict the final score for second innings batting. The D/L method is indeed a mathematical formula to calculate the target score for the second batting when the match is interrupted by weather or any other issues in a one day international (ODI) cricket matches.

Later Stern (2016) updated the method and currently the method is being called as Duckworth-Lewis-Stern (DLS)

method. Brooker & Hogan (2011) have developed a stochastic model to predict the final score only in the first innings. They have used nature of the pitch, size of the ground and weather circumstances as the explanatory variables. Moreover, Monte-Carlo method and Bayes' approach are also being employed in their method. This method can be considered as an alternative to the DLS method. Perera & Swartz (2013) have examined the suitability of the Duckworth-Lewis method as an approach to resetting goals in an interrupted Twenty20 cricket match. Anuthrika et al.(2019) have used the markov chain model to rank the cricket teams.

So far, not much work has been done on predicting the final score of the cricket matches after the power play. The present study was undertaken with the general objectives of predicting the final score of the T-20 international cricket matches after the power play. We are using DLST after the power play as an explanatory variable, and hence the model will predict the final score after the power play. Since there are two innings in a cricket match, we have to predict the final score for both first and second batting after the power play. We have decided to develop separate statistical models to predict the final score for the two innings. Currently, the DLS method is being used to decide the final score for cricket matches.

Therefore we have decided to improve the existing DLS method by incorporating DLS target (DLST) as one of the explanatory variable in the statistical model for the second innings. DLS target (DLST) after the power play has been calculated, using the runs

scored and wickets lost during the power play. In addition to the DLST, some other explanatory variables are also being used in the proposed model for the second innings.

3 METHODOLOGY

DLS method is the existing method for the prediction in the second innings. We have decided to improve the existing DLS method for the second innings by incorporating DLS target (DLST) as one of the explanatory variable in the statistical model for the second innings. The DLS method considers the wickets in hand (number of not out batsmen) and the number of overs remaining as the assets of the batting team. Thus, number of wickets lost and the number of overs remaining are the explanatory variables for the DLS method. In this study, we plan to incorporate some more explanatory variables (in addition to the DLST) and develop a statistical model to predict the final score or target score for second batting. Let the explanatory variables be; X1-DLST, X2-average strike rate of the remaining batsmen after the power play (ASRB), X3-average economy rate of the opponent team bowlers (AEROB), X4-venue, and X5-toss results.

The categorical explanatory variable venue has two levels; home or away and the variable toss results is being classified as winning or losing the toss. Based on the nature of these explanatory variables separate statistical models need to be developed for each cricket team. Though there are twelve T-20 International cricket teams, (known to be as the full members of ICC) only the Sri Lankan cricket team has been considered in this study. Thus, for the Sri

Lankan cricket team separate statistical models will be developed to predict the final score of the first and second battings.

The results of the thirty eight matches (38 matches in which Sri Lankan team has batted in the second innings) during the period 2015-2021 have been used as the training sample to develop the statistical model for the second batting. Five recent matches(05 recent matches in which Sri Lankan team has batted in the second innings) in the year 2022 have been kept as the test sample to validate the model. Stepwise regression technique has been used to develop the model.

Usually the final score of the first innings of any cricket match is predicted using CRR (current run rate) method. That means the average runs scored in an over is multiplied by the total number of overs to get the final score. In this study we are planning to develop a statistical model to predict the final score of the first innings as well. As DLST can not be considered as an explanatory variable for the first innings model, we have to use X6-number of wickets lost during the power play and X1-runs scored during the power play as the explanatory variables. In addition to these two explanatory variables, we have also considered, X2-(ASRB), X3-(AEROB), X4-venue, X5-toss results and X7-average final score of the first innings in the last five matches (AFS) as the additional explanatory variables.

Forty one matches (41 matches in which Sri Lankan team has batted in the first innings) during the period 2015-2021 have been used as the training sample to develop the statistical model for the first batting. Six recent matches

(06 recent matches in which Sri Lankan team has batted in the first innings) in the year 2022 have been kept as the test sample to validate the model. Stepwise regression technique has been used to develop the model.

The data for this study has been extracted from the website <https://www.espnricinfo.com/>.

4 RESULTS AND DISCUSSION

As per the second batting, the final statistical model from the training sample has been obtained using the stepwise regression method. The final model with a p-value of 3.731×10^{-13} is given below,

$$Y = -12.77 + 0.32 * X_1 + 14.39 * X_3 - 13.29 * X_4$$

Among the five explanatory variables only the three variables DLST(X_1), AEROB(X_3) and the Toss results(X_4) are found to be significant.

As per the final model, if the AEROB is increased by one run, the average final score of the Sri Lankan team increases by the 14.39 runs, while all the other variables are kept constant.

Similarly, the interpretation of the DLST coefficient suggests that, if the DLST prediction is increased by one run, the mean final score increases by 0.32 runs, while all the variables are held constant.

Moreover, the Adjusted R-square value of the final model is 0.8146. Thus, 81.46% of the total variation of final score in second innings has been explained by the suggested final model.

Currently, DLS method is the existing method for the prediction in the second innings. We have decided to compare the performance of the existing

DLS method with our suggested final model. Thus, we have developed a

significant among the seven explanatory variables.

Table 1: Comparison of Suggested model and SLR (DLST) model in the test sample

	Second Batting	Adjusted R²	RMSE
Our Suggested model	$Y \sim X_1 + X_3 + X_4$	0.8146	19.86
SLR (DLST) model	$Y \sim X_1$	0.3658	20.21

simple linear regression (SLR) model with DLST as the only predictor variable using the training sample. The R-square

of the SLR model is 0.3658. Thus, DLST as the predictor variable explained only 36.58% total variation of the final score of the Sri Lankan team in their second innings. Note that the suggested model explained the 81.46% of the total variation of the final score of the Sri Lankan team in their second innings. Thus, the suggested model performs better than DLS method.

The test sample of the five matches of the year 2022 has been used to validate the suggested final model and SLR model with DLST as the only predictor variable.

The Table: 1 shows the Root Mean Square Error (RMSE) values of the models in the test sample. As the RMSE of the suggested model is smaller than the RMSE of the SLR (DLST) model in the test sample, we can say that the suggested model performs better than the DLS method.

As per the first batting, the final statistical model has been developed using the stepwise regression method from the training sample. The final model with a p-value of 2.2×10^{-16} is given below,

$$Y = 4.53 + 0.30 * X_2 + 14.59 * X_3$$

Only the two variables ASRB(X_2) and AEROB(X_3) are determined to be

If the AEROB is increased by one run, the average final score of the Sri Lankan team increases by 14.59 runs, while the ASRB kept constant. Note that, for the second innings also AEROB is significant and the estimated value of the coefficient is 14.39.

Similarly, the interpretation of the ASRB coefficient suggests that, if the ASRB is increased by one run, the mean final score would increase by 0.30 runs while the AEROB variable remain constant.

Moreover, the Adjusted R-square value of the final model for the first innings is 0.8585. Thus, 85.85% of the total variation of final score in first innings has been explained by the suggested model. Six recent matches in the year 2022 have been kept as test sample and the test sample for model validation. The RMSE value for the suggested model is 11.76 in the test sample

The Fig: 1 show that the Q-Q plots of residuals for two suggested models and the plots supports the normality assumption of the error terms.

The response variable is a counting data and hence the appropriate model would be a Poisson regression model. However, as the average final runs (λ) is large enough, the count data approximately follows normal distribution. Hence, multiple linear regression has been employed in this study. The Q-Q plots also support that

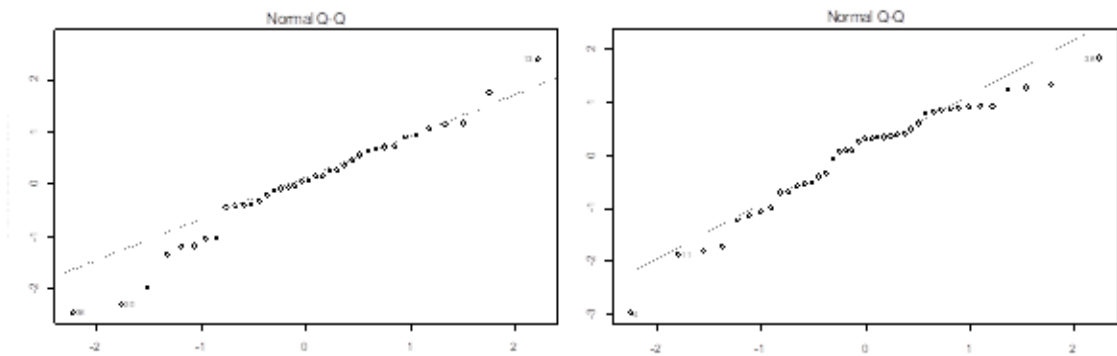


Figure 1: Q-Q plots for both suggested model

the error term follows the normal distribution, and hence the response variable is also following the normal distribution.

5 CONCLUSION

The average economy rate of the opponent team bowlers (AEROB) is significantly influencing the final score of the current Sri Lankan cricket team in both first and second innings. Moreover, for both innings, if AEROB increases by one run on average the final score increases by around 14 runs, given the other variables remains unchanged. Moreover, we have compared the performance of the existing DLS method with our suggested final model for predicting the final score in the second innings, using the test sample of recent five matches of the year 2022. As the RMSE of the suggested model is smaller than the RMSE of the SLR (DLST) model in the test sample and the R-square of the suggested model is larger than the R-square of the SLR (DLST) model, we can say that the suggested model performs better than the DLS method for the Sri Lankan cricket team. Developing statistical models for the other international cricket teams is one of our plans for the future.

REFERENCES

- Anuthrika,T., Arivalzahan, S.,Tharshan,R. (2019). A Markov model for ranking cricket teams playing one day international matches: *Vingnanam Journal of science*, 14(1), 1-6.
- Brooker,S., Hogan,S. (2011). A Method for Inferring Batting Conditions in ODI Cricket from Historical Data. White Paper, University of Canterbury, No. 44.
- Duckworth,F.C., and Lewis,A.J. (1998). A fair method for resetting targets in one-day cricket matches: Palgrave Macmillan Journals. *The Journal of the Operational Research Society*, 49,207-215.
- Perera,H., and Swartz,T.B. (2013). Resource estimation in Twenty20 Cricket. *IMA Journal of Management Mathematics*, 24(3), 337-347.
- Stern, S.E., (2016). The Duckworth-Lewis-Stern method: Extending the Duckworth-Lewis methodology to deal with modern scoring rates: *Journal of the operational Research Society*, 67(12), 1469-1480.



Quality Control in Dyeing of Textiles: A Case Study

Bhagya MDPK¹, Panahatipola PMOP²

Department of Mathematical Science, Wayamba University of Sri Lanka.^{1,2}

kalanibhagya96@gmail.com¹

oshadi@wyb.ac.lk²

ABSTRACT

The textile industry is one of the key manufacturing industries in Sri Lanka which contribute the export revenue and it specializes in producing and delivering a complete range of exceptional quality Knitting, Dyeing, Finishing, Printing, Brushing, Sueding and Preshrunk fabric. Quality control in the textile industry is a critical component that aids in maintaining consistency and quality and makes sure that all of the items adhere to a particular set of standards and specifications. This research intended to analyze the quality improvement of a leading manufacturer and exporter of textiles in Sri Lanka to reduce the defect level of the goods. This study mainly focuses on the defects occurring in the dyeing department. Results suggested that color shading and uneven dye make up the majority of the defects. The analysis has been done using histogram, Pareto charts, C charts and fishbone diagrams. By using Control Chart C (C-Chart) in quality control activity, it can be known that many product qualities are in out of control limits. This condition indicated that the processes are uncontrollably and there are deviations, which suggests further improvements of quality in the Dyeing Department of the company. Based on Histogram and Pareto Chart, the dominant defects consist of Color shading 43.28%, uneven dye 15.66%, Bruise place 15.25%, Crease mark 13.30% and Stain 12.5%. From the analysis using Fishbone Chart, it indicated that the causative factors underlining the defects occurring in the dyeing department were material factor, method factor, personnel (man) factor, and machine factor.

KEY WORDS: Quality control, Textile, Dyeing, Control chart

1 INTRODUCTION

The increase of the defect level of a company causes a reduction in quality of the product. By analyzing past data, the defect level of the company has been increasing in the last few months through the process as illustrated in table 1. The department that handles dyeing has the majority of defect points. Therefore, in this study, the dyeing department's defects were taken into consideration. Following an inquiry, it was discovered that the dyeing department has several different types of defects including color shading, bruised place, crease marks, uneven dye, hole, joints, air mark, and watermark, among others.

Table 1: Defect quantity from May to August

Month	Defect quantity
May	7089
June	10196.65
July	17414.95
August	18139.27

The aims of the study were to find out the implementation of quality control of products by using Quality Control technique and to identify the type of dominant products defects and to identify the factors that resulted in product defects.

2 LITERATURE REVIEW

Dr. Mangala Gowri M. (2018) analyzed the quality inspection system of the Tirupur Garment Industry to study the importance and analyze the quality inspection system of selected garment industries providing suggestions to improve the quality system. The study has been carried out using secondary data which has been collected from final inspection reports of different buyers and different styles. Percentage analysis is used to describe the garment inspection parameters and factor analysis has been used to identify the underlying factors of parameters which determine the quality of the garment. Results suggested that the quality parameters, appearance of the garment and workmanship were very poor in all the companies irrespective of styles of the garments. The study has been concluded that for attaining good quality and to avoid the rejected level of products the company should concentrate more on the quality parameters.

Kassu Jilcha (2019) carried out a study with the purpose of investigating quality control and supply chain management practice in the case company (Wossi Garment Factory) and applied the statistical quality control tools to solve the process and product quality problems in shirt manufacturing and increase the competitiveness of the company. The case study has been done using both qualitative and quantitative approaches. The data were collected using the check sheet. The case study team has shown the methodology and the sequence of the application of the statistical quality control tools and basically systematic application following with check sheet, process flow

diagram, fishbone, Pareto Chart, histogram, control limits and process capability enhancement which bring significant quality improvement in the case company.

3 METHODOLOGY

Primarily, this study is based on the statistical tools contained in Statistical Quality Control (SQC) and Statistical Process Control (SPC).

Figure 1 illustrates the major steps followed to assess the quality in the Dyeing Department.

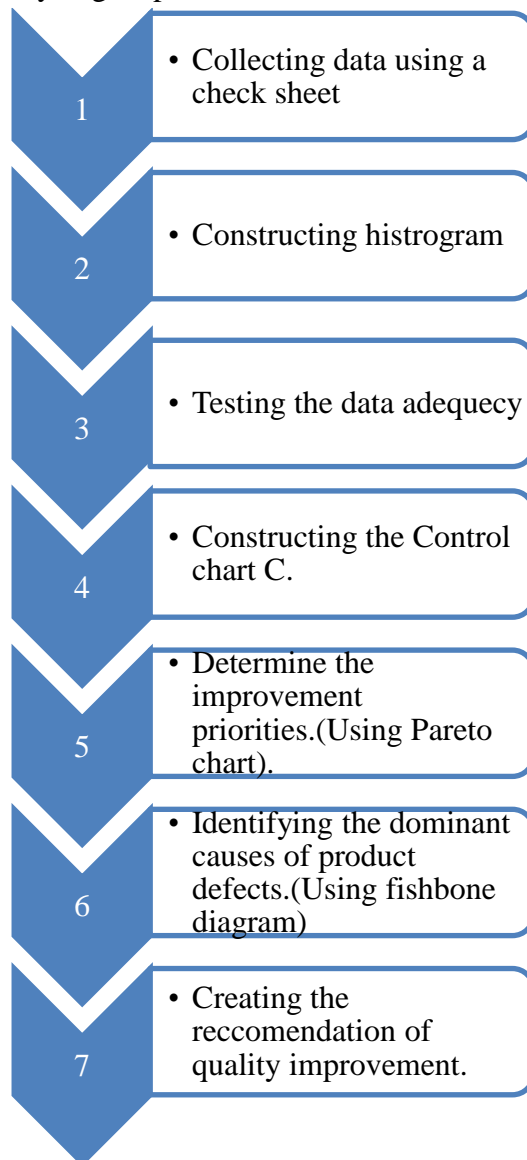


Figure 1: major steps followed to assess the quality in the Dyeing section.

4 DATA COLLECTION AND ANALYZING

Daily defects data collected from the daily reports shared within the employees and the defect quantities from May to August were considered in this study. Primary analysis suggested that color shading, Bruised place, crease mark, stain and uneven dye produce a large amount of defects and therefore those defect types were taken for further analysis.

5 RESULTS AND DISCUSSION

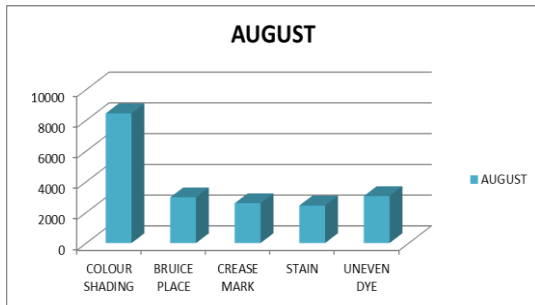


Figure 2: Histogram of product defects period August 2022

From histogram in the Figure 2, it can be seen that out of five types of defects, the majority of defects are caused by Color shading with the number of defect about 8442.54 defect points followed by Uneven dye that causes 3055.28 defect points, Bruise place that causes 2975.34, Crease mark that causes 2593.77 and Stain that causes 2437.92 defect points.

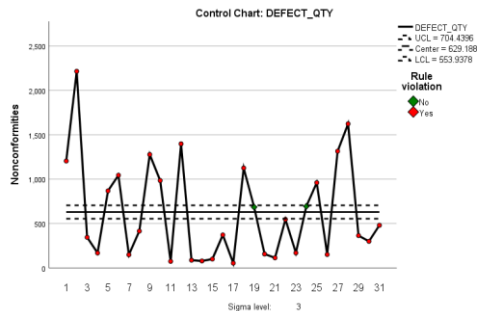


Figure 3: C chart of fabric product defect points

The analysis of the control chart C (C-chart) shows that there are many data that are out of control limits and there are many extreme spread of the data i.e.93.54% of the product defect data in August 2022. On the dates of 3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18, 20,21,22,23,25,26,27,28,29,30 and 31, the number of defect level passes through the lower control limit. It suggests that the defect level is good enough because in production, the lower the defect level, the better the production result. Meanwhile, there is also much data passing through the upper control limit (36% of product defect data) i.e. 11 days in August 2022. Therefore, it can be concluded that the quality control requires further improvement.

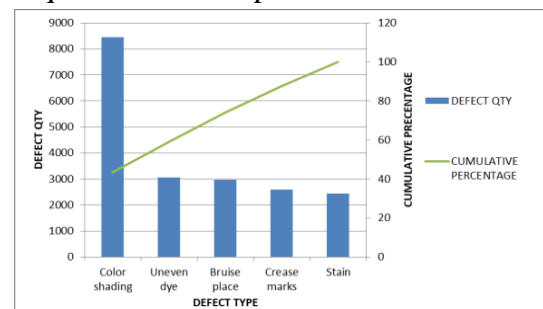


Figure 4: Pareto chart of product defect

The Pareto chart in figure 4 shows the most dominant type of product defects in production during August 2022. After identifying the number of defect points in each type, it is sorted by the number of product defects, from the largest to smallest and the cumulative percentage. The cumulative percentage is useful to state how many differences in the frequency of occurrence among several dominant problems.

After knowing the dominant types of product defects, the company needs to take corrective measures to prevent similar defects or to reduce the number of dominant defects. The most important

thing to do and explore is finding the causes of the product defects. As a tool to facilitate finding the causes of the defects, it can be used in Cause and Effect Diagram or Fishbone Chart. By

using Fishbone Chart, the causes of each defect type could be identified. Figure 5 and Figure 6 below are the Fishbone Chart for Color shading and Uneven dye.

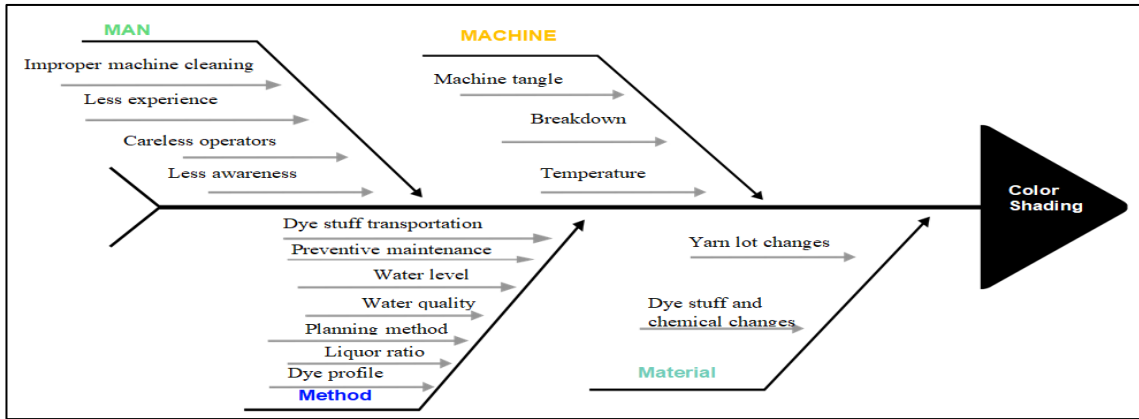


Figure 5: Fishbone chart of color shading

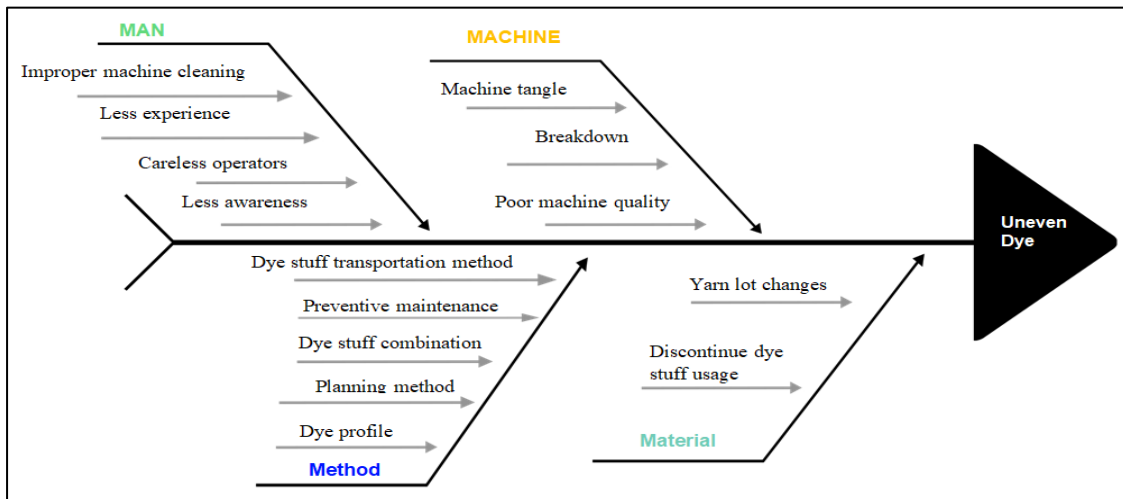


Figure 6: Fishbone chart of uneven dye

6 CONCLUSION

By using Control Chart C (C-Chart) in quality control activity, it can be known that many product qualities are out of control limits. As seen on C-Chart, there are many data passes through the upper control limit (36%) on the date of 1, 2, 5, 6, 9, 10, 12, 18, 25, 27 and 28. This condition indicates that the processes are uncontrollably and there are still deviations, it means that quality

control in the Dyeing Department of the company requires further improvement.

According to production data obtained from the Dyeing Department of the Company, it can be seen that the number of fabric production in August 2022 is about 287342.83 yards while the number of defects is about 19504.85 yards. Based on Histogram and Pareto Chart, the dominant defects consist of Color shading 43.28%, Uneven dye

15.66%, Bruise place 15.25%, Crease mark 13.30% and Stain 12.5%.

From the analysis using Fishbone Chart, it can be seen the causative factors are material factor, method factor, personnel (man) factor, machine factor, and environment factor. There are three dominant factors that trigger product defects i.e. method factor, personnel factor, and machine factor.

REFERENCES

- Beckwith, O. P. (1944). The Quality Control Chart Technique in Applied Textile Research. *Textile Research*, 14(10), 319-325.
- Das, A. (2013). *Testing and statistical quality control in textile manufacturing*. In Process Control in Textile Manufacturing (pp. 41-78). Woodhead Publishing.
- Ertuğrul, İ., & Aytaç, E. (2009). *Journal of Intelligent Manufacturing*, 20(2), 139-149.
- Sitanggang, J. M., Sinulingga, S., & FAchruddin, K. A. (2019). Analysis Of The Effect Of Product Quality On Customer Satisfaction And Customer Loyalty Of Indihome ATPT Telkom Regional 1 Sumatera, Medan, North Sumatra, Indonesia. *American International Journal of Business Management (AIJBM)*, 2(3), 26-37.
- Pambreni, Y., Karnowahadi, K., & Prasetya, B. (2016). A case study at pt sari warna asli ii boyolali. *JOBS Journal of Business Studies*, 2(2)



Some Properties of Fuzzy Compact Topological Space and Strong Fuzzy Metric Space

Kajan N¹, Kannan K²

Department of Physical Science, Faculty of Applied Science, University of Vavuniya¹

Kajankajan914@gmail.com¹

Department of Mathematics and Statistics, Faculty of Science, University of Jaffna²

p_kkannan@yahoo.com²

ABSTRACT

The notion of fuzzy metric space has many advantages in the analysis due to George and Veeramani since many notations and results from classical metric space, and topological space theory can be extended and generalized to the setting of fuzzy metric space. In our work, some concepts of fuzzy metric space, triangular norm condition, membership function, fuzzy set, fuzzy topology, fuzzy continuous function, fuzzy compact and strong fuzzy metric space proved the following results were used. It proved that a fuzzy space X is fuzzy compact if and only if any collection of closed fuzzy subsets of X has finite intersection property, the continuous image of a fuzzy compact space is compact. Next, it proved (X, T_1) and (Y, T_2) be fuzzy topological space with (X, T_1) is compact, and let $f: (X, T_1) \rightarrow (Y, T_2)$ be a fuzzy continuous surjection. The (Y, T_2) is compact. Furthermore, illustrated some examples of strong fuzzy metric space in I^X .

KEYWORDS: Fuzzy set, Fuzzy topology, t –norm, Fuzzy metric space, Strong fuzzy metric space

1 INTRODUCTION

The fuzzy set theory and its applications have been established as one of the most active areas of research in mathematics and engineering. This theory was introduced by Zadeh in 1965 and since then, a large number of research papers have been published using the notion of fuzzy sets, fuzzy numbers and fuzzification of several classical theories has also been introduced. Many authors have introduced the concept of fuzzy metric spaces in different ways and also, studied the relation with fuzzy topology. Fuzzy metric spaces are usually introduced by means of the points in the crisp set X with fuzzy distance mapping or by using the fuzzy points in I^X with a fuzzy distance between fuzzy points. I^X is

called set of all fuzzy sets on X . For instance, George and Veeramani (1994) introduced a fuzzy metric space by considering points in the crisp set and a fuzzy distance between them. Strong fuzzy compactness and ultra-fuzzy compactness of topological spaces are also extended to these notions. Introduce a new notion of proof that theorem of fuzzy compactness in fuzzy topological spaces. The definition of fuzzy set, fuzzy topological space, and fuzzy compactness are recalled.

In this paper, a fuzzy metric space by considering fuzzy points in the family of all fuzzy sets with crisp set X is introduced. Some results related to fuzzy compact topological space and strong fuzzy metric space in I^X are investigated.

2 MATERIALS AND METHODS

2.1 Definition (Zadeh L.A.,1965)

Let X be a non empty set and let I be the unit interval ($I = [0, 1]$). A fuzzy set μ_A is a function from X into the unit interval I . That is $\mu_A: X \rightarrow [0, 1]$. A fuzzy set A in X can be represented by the set of pairs $A = \{(x, \mu_A(x)); x \in X\}$ is said to be a fuzzy set in X with membership function μ_A . The family of all fuzzy sets on X is denoted by I^X . It is obvious that

$0 \leq \mu_A(x) \leq 1$ and hence every fuzzy set is bounded. It is said that a fuzzy set A is empty if $\mu_A(x) = 0$ for all $x \in X$, the whole fuzzy set has the membership function $\mu_A(x) = 1$ for all $x \in X$.

2.2 Definition (Deng Z., 1982)

A fuzzy point λ_x^α in X is a fuzzy set with membership function defined as

$$\lambda_x^\alpha(y) = \begin{cases} \alpha, & y = x \\ 0, & \text{otherwise} \end{cases}$$

, where $0 < \alpha < 1$. The fuzzy point λ_x^α is said to have support x and the value α .

2.3 Definition (Deng Z., 1982)

The complementary of a fuzzy point λ_x^α in I^X with support x and value α is a fuzzy point denoted by $(\lambda_x^\alpha)^c$ with the same support x and value $1 - \alpha$, so

$$(\lambda_x^\alpha)^c = \begin{cases} 1 - \alpha, & y = x \\ 0, & \text{otherwise} \end{cases}$$

2.4 Definition (Chang Z.L., 1968)

Let $A = \{(x, \mu_A(x)); x \in X\}$ and $B = \{(x, \mu_B(x)); x \in X\}$ be two fuzzy set in X .

Then their union $A \cup B$, intersection $A \cap B$ and complement A^c are also fuzzy sets with membership functions defined as follows:

- $\mu_{A \cup B}(x) = \max \{ \mu_A(x), \mu_B(x) \}, \forall x \in X$

- $\mu_{A \cap B}(x) = \min \{ \mu_A(x), \mu_B(x) \}, \forall x \in X$

- $\mu_{A^c}(x) = 1 - \mu_A(x), \forall x \in X$

2.5 Definition (Chakraborty, M.K. et al., 1992)

A fuzzy topology on a set X is a collection T of fuzzy set in X satisfying:

- $0, 1 \in T$
- If $A_i \in T$ for all $i = 1, 2, 3, \dots, n$ then $\bigcap_{i=1}^n A_i \in T$
- If $A_i \in T$; for some $i \in I$ then $\bigcup_{i \in I} A_i \in T$.

Here $\bigcap_{i=1}^n A_i$ and $\bigcup_{i \in I} A_i$ are defined by

$$\bigcap_{i=1}^n A_i = \inf \{ A_i ; i \in I \}$$

$$\bigcup_{i \in I} A_i = \sup \{ A_i ; i \in I \}$$

If T is a fuzzy topology on X , then the pair (X, T) is called fuzzy topological space. Members of T are called fuzzy open sets. Fuzzy sets of the form $1 - A$; where A is fuzzy open set are called fuzzy closed set.

2.6 Definition (Chang Z.L., 1968)

Let X and Y be two nonempty sets $f : X \rightarrow Y$ be a function. For a fuzzy set $B \in Y$, the inverse image of B under f is fuzzy set $f^{-1}(B) \in X$ with membership function denoted by the rule $f^{-1}(B)(x) = B(f(x))$, for $x \in X$. For a fuzzy set A in, the image of A under f is the fuzzy set $f(A)$ in Y , with membership function $f(A)(y); y \in Y$ defined by

$$f(A)(y) = \begin{cases} \sup A(x)_{x \in f^{-1}(y)} ; f^{-1}(y) \neq \emptyset \\ 0 ; f^{-1}(y) = \emptyset \end{cases}$$

2.7 Definition (Chang Z.L., 1968)

Let (X, T_1) and (X, T_2) be two fuzzy topological spaces and let $f: (X, T_1) \rightarrow (X, T_2)$ be a mapping. Then f is said to be fuzzy continuous if $f^{-1}(B) \in T_1$ for each $B \in T_2$.

2.8 Definition (Am hammed Omar, K.M. et al., 2019)

A family U of fuzzy set is a cover of fuzzy set A if and only if $A \subseteq \cup_{i \in I} \{B_i : B_i \in U, \forall i \in I\}$. It is called fuzzy open cover if each member of B_i is fuzzy open set.

2.9 Definition (Vick J.W., 2012)

Let (X, T) be a fuzzy topological space and let $A \in I^X$, then A is said to be a fuzzy compact set if for every fuzzy open cover of A has finite subcover of A .

If $A = X$ then X is called a fuzzy compact space that is $A_i \in T$ for each $i \in I$ and $\cup_{i \in I} A_i = 1$ then there exist $i = 1, 2, \dots, n \in I$ such that $\cup_{i=1}^n A_i = 1$.

2.10 Remark

A fuzzy topological space (X, T) is fuzzy compact if and only if for every collection $\{M_\alpha : \alpha \in I\}$ of fuzzy closed set of X having finite intersection property $\cap_{\alpha \in I} M_\alpha \neq 0$.

In fuzzy space the intersection of a fuzzy compact set with a fuzzy closed set is fuzzy compact.

A fuzzy closed subset of a fuzzy compact space is fuzzy compact.

2.11 Definition (George, A. et al., 1994)

A binary operation $*$: $[0, 1] \times [0, 1] \rightarrow [0, 1]$ is a continuous t – norm if it is satisfying following conditions:

1. $*$ is associative and commutative,
2. $*$ is continuous,
3. $a * 1 = a, \forall a \in [0, 1]$,

4. $a * b \leq c * d$, where $a \leq c, b \leq d$, for each $a, b, c, d \in [0, 1]$

Some typical examples for t –norm are the following;

1. $a * b = ab$ (product)
2. $a * b = \min \{ a, b \}$ (minimum)
3. $a * b = \max\{a + b - 1, 0\}$ (Lukasiewicz)
4. $a * b = \frac{ab}{a+b-1}$ (Hamacher)

2.12 Definition (George, A. et al., 1994)

Let X be an arbitrary set. A fuzzy subset M of $X \times X \times [0, \infty)$ is called fuzzy metric space on X if it is satisfying the following conditions for all $x, y, z \in X$ and $t \in \mathbb{R}$

1. If $t \leq 0$ then $M(x, y, t) = 0$;
2. For all $t > 0, M(x, y, t) = 1 \Leftrightarrow x = y$
3. For all $t > 0, M(x, y, t) = M(y, x, t)$.
4. For all $s, t \in \mathbb{R}, x, y \in X, M(x, y, t + s) \geq M(x, z, t) * M(z, y, s)$
5. $M(x, y, *)$ is a continuous function of \mathbb{R} and $\lim_{t \rightarrow \infty} M(x, y, t) = 1$

The triple $(X, M, *)$ is called a fuzzy metric space.

2.13 Definition (George, A. et al., 2022)

Let $(X, M, *)$ be a strong fuzzy metric space. M is said to be strong if it is satisfying the following additional axiom

$$M(x, y, t) \geq M(x, y, t) * M(y, z, t), \forall x, y, z \in X \text{ and } t > 0$$

2.14 Definition (George, A. et al., 1994)

A fuzzy subset M of $I^X \times I^X \times [0, \infty)$ is called fuzzy metric space in I^X if the following condition are satisfied for all $\lambda_x^\alpha, \mu_y^\beta \in I^X$ and $t, s \in [0, \infty)$,

1. $M(\lambda_x^\alpha, \mu_y^\beta, 0) = 0$
2. For all $t > 0$, $M(\lambda_x^\alpha, \mu_y^\beta, t) = 1$
if and only if $x = y, \alpha \leq \beta$,
3. For all $t > 0$, $M(\lambda_x^\alpha, \mu_y^\beta, t) =$
 $M((\mu_y^\beta)^c, (\lambda_x^\alpha)^c, t)$
4. For all $s, t \in [0, \infty)$,
 $\lambda_x^\alpha, \mu_y^\beta, \eta_z^\gamma \in I^X$,
 $M(\lambda_x^\alpha, \mu_y^\beta, t + s) \geq$
 $M(\lambda_x^\alpha, \eta_z^\gamma, t) * M(\eta_z^\gamma, \mu_y^\beta, s)$
5. $M(\lambda_x^\alpha, \mu_y^\beta, *)$ is continuous
function of $[0, \infty)$ and
 $\lim_{t \rightarrow \infty} M(\lambda_x^\alpha, \mu_y^\beta, t) = 1$

Then the triple $(X, M, *)$ is called fuzzy metric space in I^X .

2.15 Definition (George, A. et al., 1994)

Let $(X, M, *)$ be a fuzzy metric space. M is said to be strong fuzzy metric space in I^X satisfying following additional axiom:

For all $t \in [0, \infty)$, $\lambda_x^\alpha, \mu_y^\beta, \eta_z^\gamma \in I^X$,

$$M(\lambda_x^\alpha, \mu_y^\beta, t) \geq M(\lambda_x^\alpha, \eta_z^\gamma, t) * M(\eta_z^\gamma, \mu_y^\beta, t).$$

3 RESULTS AND DISCUSSION

3.1 Proposition

A fuzzy space X is fuzzy compact if and only if any collection of closed fuzzy subsets of X has finite intersection property.

Proof: Suppose that X has fuzzy compact set. Let $\{M_\alpha : \alpha \in I\}$ be collection of closed fuzzy sets in X such that $\bigcap_{\alpha \in I} M_\alpha = 0$, then $X = 1 - \bigcap_{\alpha \in I} M_\alpha = \bigcup_{\alpha \in I} (1 - M_\alpha)$, $\{(1 - M_\alpha)\}$ is a collection of open fuzzy set of X . Since X is fuzzy compact space. Therefore $X = \bigcup_{i=1}^n (1 - M_{\alpha_i}) =$

$1 - \bigcap_{i=1}^n M_{\alpha_i} = 1$, therefore $\bigcap_{i=1}^n M_{\alpha_i} = 0$

Conversely suppose that $\{N_\alpha : \alpha \in J\}$ is a fuzzy open cover of X , then $\{(X - N_\alpha) : \alpha \in J\}$ is a collection of closed fuzzy sets. But X has finite intersection property $\bigcap_{i=1}^n (X - N_{\alpha_i}) = 0$ thus, $X = \bigcup_{i=1}^n N_{\alpha_i}$, therefore X is fuzzy compact.

3.2 proposition

The Continuous image of a fuzzy compact space is compact.

Proof: Let $f: X \rightarrow Y$ is a continuous map and X is a fuzzy compact space. Suppose that $\{M_\alpha : \alpha \in I\}$ is a fuzzy open set of $f(X)$. $f(X) = \bigcup_{\alpha \in I} M_\alpha$, then

$X = f^{-1}(\bigcup_{\alpha \in I} M_\alpha)$ then $\{f^{-1}(M_\alpha), \alpha \in I\}$ is fuzzy open cover of X . Then we have $X = \bigcup_{i=1}^n f^{-1}(M_{\alpha_i})$ then

$f(X) = \bigcup_{i=1}^n (M_{\alpha_i})$, therefore $f(X)$ is Compact.

3.3 proposition

Let (X, T_1) and (Y, T_2) be fuzzy topological space with (X, T_1) is compact, and let $f: (X, T_1) \rightarrow (Y, T_2)$ be a fuzzy continuous surjection. Then (Y, T_2) is compact.

Proof: Let $M_i \in T_2$ for each $i \in I$, and assume that $\bigcup_{i \in I} M_i = 1$, for each $x \in X$,

$$\bigcup_{i \in I} f^{-1}(M_i)(x) = \bigcup_{i \in I} M_i(f(x)) = 1$$

So the open fuzzy sets $f^{-1}(M_i)$ open cover of X , then we have

$\bigcup_{i=1}^n f^{-1}(M_{ij}) = 1$, if M is any fuzzy set in Y , then the fact that f is surjective, for any $y \in Y$, $f(f^{-1}(M))(y) = \sup\{f^{-1}(M)(z): z \in f^{-1}(y)\} = \sup\{M(f(z)): f(z) = y\} = M(y)$ which implies that $f(f^{-1}(M))(y) =$

$M(y)$. Thus $1=f(1) = f(\cup_{i=1}^n f^{-1}(M_{ij})) = \cup_{i=1}^n f(f^{-1}(M_{ij})) = \cup_{i=1}^n (M_{ij})$
Therefore (Y, T_2) is compact.

3.4 Example

Let $X = \mathbb{R}$ and $\lambda_{x_1}^{\alpha_1}$ and $\mu_{x_2}^{\alpha_2}$ any two fuzzy points in I^X , where $x_1, x_2 \in \mathbb{R}$

and $\alpha_1, \alpha_2 \in (0,1]$ and $t \in [0, \infty)$, then

$$M(\lambda_{x_1}^{\alpha_1}, \mu_{x_2}^{\alpha_2}, t) = \begin{cases} \frac{t}{t + (\alpha_1 - \alpha_2) + |x_1 - x_2|}, & \text{if } \alpha_1 \geq \alpha_2 \\ \frac{t}{t + |x_1 - x_2|}, & \text{if } \alpha_2 \geq \alpha_1 \end{cases}$$

it is a strong fuzzy metric space.

(1) Clearly $M(\lambda_{x_1}^{\alpha_1}, \mu_{x_2}^{\alpha_2}, 0) = 0$

(2) Suppose that $(\lambda_{x_1}^{\alpha_1}, \mu_{x_2}^{\alpha_2}, t) = 1$, if $\alpha_1 \geq \alpha_2$ then $\frac{t}{t + (\alpha_1 - \alpha_2) + |x_1 - x_2|} = 1$ which implies that $x_1 = x_2, \alpha_1 = \alpha_2$

if $\alpha_2 \geq \alpha_1$ then $\frac{t}{t + |x_1 - x_2|} = 0$ then $x_1 = x_2$.

conversely suppose that $\alpha_1 \geq \alpha_2$ and $\alpha_2 \geq \alpha_1$ and $x_1 = x_2$ it has $M(\lambda_{x_1}^{\alpha_1}, \mu_{x_2}^{\alpha_2}, t) = 1$

(3) if $\alpha_1 \geq \alpha_2$ then $M(\lambda_{x_1}^{\alpha_1}, \mu_{x_2}^{\alpha_2}, t) = \frac{t}{t + (\alpha_1 - \alpha_2) + |x_1 - x_2|}$ and $1 - \alpha_2 \geq 1 - \alpha_1$, then $M((\mu_{x_2}^{\alpha_2})^c, (\lambda_{x_1}^{\alpha_1})^c, t) = \frac{t}{t + (1 - \alpha_2 - (1 - \alpha_1)) + |x_2 - x_1|} = \frac{t}{t + (\alpha_1 - \alpha_2) + |x_1 - x_2|} = M(\lambda_{x_1}^{\alpha_1}, \mu_{x_2}^{\alpha_2}, t)$

If $\alpha_2 \geq \alpha_1$ then $M(\lambda_{x_1}^{\alpha_1}, \mu_{x_2}^{\alpha_2}, t) = \frac{t}{t + |x_1 - x_2|}$ and $1 - \alpha_1 \geq 1 - \alpha_2$, then $M((\mu_{x_2}^{\alpha_2})^c, (\lambda_{x_1}^{\alpha_1})^c, t) = M(\lambda_{x_1}^{\alpha_1}, \mu_{x_2}^{\alpha_2}, t)$

(4) Let $\eta_{x_3}^{\alpha_3}$ be another fixed point, it has the following cases:

Case 1: If $\alpha_1 \geq \alpha_2 \geq \alpha_3$, then it has

$$M(\lambda_{x_1}^{\alpha_1}, \mu_{x_2}^{\alpha_2}, t + s) = \frac{t+s}{t + (\alpha_1 - \alpha_2) + |x_1 - x_2|}, M(\lambda_{x_1}^{\alpha_1}, \eta_{x_3}^{\alpha_3}, t) = \frac{t}{t + (\alpha_1 - \alpha_3) + |x_1 - x_3|} \text{ and } M(\eta_{x_3}^{\alpha_3}, \mu_{x_2}^{\alpha_2}, s) = \frac{s}{s + |x_3 - x_2|}.$$

Now consider $M(\lambda_{x_1}^{\alpha_1}, \mu_{x_2}^{\alpha_2}, t + s) -$

$$M(\lambda_{x_1}^{\alpha_1}, \eta_{x_3}^{\alpha_3}, t) * M(\eta_{x_3}^{\alpha_3}, \mu_{x_2}^{\alpha_2}, s) = \frac{t+s}{(t+s) + (\alpha_1 - \alpha_2) + |x_1 - x_2|} - \frac{t}{t + (\alpha_1 - \alpha_3) + |x_1 - x_3|} \times \frac{s}{s + |x_3 - x_2|} = \frac{(t+s)(t + (\alpha_1 - \alpha_3) + |x_1 - x_3|)(s + |x_3 - x_2|) - ts((t+s) + (\alpha_1 - \alpha_2) + |x_1 - x_2|)}{((t+s) + (\alpha_1 - \alpha_2) + |x_1 - x_2|)(t + (\alpha_1 - \alpha_3) + |x_1 - x_3|)(s + |x_3 - x_2|)}$$

≥ 0 .

Which implies that $M(\lambda_{x_1}^{\alpha_1}, \mu_{x_2}^{\alpha_2}, t + s) \geq M(\lambda_{x_1}^{\alpha_1}, \eta_{x_3}^{\alpha_3}, t) * M(\eta_{x_3}^{\alpha_3}, \mu_{x_2}^{\alpha_2}, s)$.

Case 2: $\alpha_2 \geq \alpha_1 \geq \alpha_3$, then it has

$$M(\lambda_{x_1}^{\alpha_1}, \mu_{x_2}^{\alpha_2}, t + s) = \frac{t+s}{t+s + |x_1 - x_2|}, M(\lambda_{x_1}^{\alpha_1}, \eta_{x_3}^{\alpha_3}, t) = \frac{t}{t + (\alpha_1 - \alpha_3) + |x_1 - x_3|}, \text{ and } M(\eta_{x_3}^{\alpha_3}, \mu_{x_2}^{\alpha_2}, s) = \frac{s}{s + |x_3 - x_2|},$$

Now consider

$$M(\lambda_{x_1}^{\alpha_1}, \mu_{x_2}^{\alpha_2}, t + s) - M(\lambda_{x_1}^{\alpha_1}, \eta_{x_3}^{\alpha_3}, t) * M(\eta_{x_3}^{\alpha_3}, \mu_{x_2}^{\alpha_2}, s) = \frac{t+s}{(t+s) + |x_1 - x_2|} - \frac{t}{t + (\alpha_1 - \alpha_3) + |x_1 - x_3|} \times \frac{s}{s + |x_3 - x_2|} = \frac{(t+s)(t + (\alpha_1 - \alpha_3) + |x_1 - x_3|)(s + |x_3 - x_2|) - ts((t+s) + |x_1 - x_2|)}{((t+s) + |x_1 - x_2|)(t + (\alpha_1 - \alpha_3) + |x_1 - x_3|)(s + |x_3 - x_2|)}$$

≥ 0

Which implies that $M(\lambda_{x_1}^{\alpha_1}, \mu_{x_2}^{\alpha_2}, t + s) \geq M(\lambda_{x_1}^{\alpha_1}, \eta_{x_3}^{\alpha_3}, t) * M(\eta_{x_3}^{\alpha_3}, \mu_{x_2}^{\alpha_2}, s)$

Case 3: If $\alpha_2 \geq \alpha_3 \geq \alpha_1$, then it has

$$M(\lambda_{x_1}^{\alpha_1}, \mu_{x_2}^{\alpha_2}, t+s) = \frac{t+s}{t+s+|x_1-x_2|}, M(\lambda_{x_1}^{\alpha_1}, \eta_{x_3}^{\alpha_3}, t) = \frac{t}{t+|x_1-x_3|}$$

and $M(\eta_{x_3}^{\alpha_3}, \mu_{x_2}^{\alpha_2}, s) = \frac{s}{s+|x_3-x_2|}$.

Now consider

$$M(\lambda_{x_1}^{\alpha_1}, \mu_{x_2}^{\alpha_2}, t+s) - M(\lambda_{x_1}^{\alpha_1}, \eta_{x_3}^{\alpha_3}, t) * M(\eta_{x_3}^{\alpha_3}, \mu_{x_2}^{\alpha_2}, s) = \frac{t+s}{(t+s)+|x_1-x_2|} - \frac{t}{t+|x_1-x_3|} \times \frac{s}{s+|x_3-x_2|}$$

$$= \frac{(t+s)(t+|x_1-x_3|)(s+|x_3-x_2|) - ts((t+s)+|x_1-x_2|)}{((t+s)+|x_1-x_2|)(t+|x_1-x_3|)(s+|x_3-x_2|)} \geq 0.$$

Which implies that $M(\lambda_{x_1}^{\alpha_1}, \mu_{x_2}^{\alpha_2}, t+s) \geq M(\lambda_{x_1}^{\alpha_1}, \eta_{x_3}^{\alpha_3}, t) * M(\eta_{x_3}^{\alpha_3}, \mu_{x_2}^{\alpha_2}, s)$.

The other cases are similar.

(5) $M(\lambda_{x_1}^{\alpha_1}, \mu_{x_2}^{\alpha_2}, t)$ is continuous function and both cases $\lim_{t \rightarrow \infty} M(\lambda_{x_1}^{\alpha_1}, \mu_{x_2}^{\alpha_2}, t) = 1$

(6) Case 1: If $\alpha_1 \geq \alpha_2 \geq \alpha_3$, then it has

$$M(\lambda_{x_1}^{\alpha_1}, \mu_{x_2}^{\alpha_2}, t) = \frac{t}{t+(\alpha_1-\alpha_2)+|x_1-x_2|}, M(\lambda_{x_1}^{\alpha_1}, \eta_{x_3}^{\alpha_3}, t) = \frac{t}{t+(\alpha_1-\alpha_3)+|x_1-x_3|}$$

and $M(\eta_{x_3}^{\alpha_3}, \mu_{x_2}^{\alpha_2}, t) = \frac{t}{t+|x_3-x_2|}$.

Now consider

$$M(\lambda_{x_1}^{\alpha_1}, \mu_{x_2}^{\alpha_2}, t) - M(\lambda_{x_1}^{\alpha_1}, \eta_{x_3}^{\alpha_3}, t) * M(\eta_{x_3}^{\alpha_3}, \mu_{x_2}^{\alpha_2}, t) = \frac{t}{t+(\alpha_1-\alpha_2)+|x_1-x_2|} - \frac{t}{t+(\alpha_1-\alpha_3)+|x_1-x_3|} \times \frac{t}{t+|x_3-x_2|}$$

$$= \frac{t(t+(\alpha_1-\alpha_3)+|x_1-x_3|)(t+|x_3-x_2|) - t^2(t+(\alpha_1-\alpha_2)+|x_1-x_2|)}{(t+(\alpha_1-\alpha_2)+|x_1-x_2|)(t+(\alpha_1-\alpha_3)+|x_1-x_3|)(t+|x_3-x_2|)} \geq 0.$$

Case 2: $\alpha_2 \geq \alpha_1 \geq \alpha_3$, then it has

$$M(\lambda_{x_1}^{\alpha_1}, \mu_{x_2}^{\alpha_2}, t) = \frac{t}{t+|x_1-x_2|}, M(\lambda_{x_1}^{\alpha_1}, \eta_{x_3}^{\alpha_3}, t) = \frac{t}{t+(\alpha_1-\alpha_3)+|x_1-x_3|}$$

and $M(\eta_{x_3}^{\alpha_3}, \mu_{x_2}^{\alpha_2}, t) = \frac{t}{t+|x_3-x_2|}$. Now consider

$$M(\lambda_{x_1}^{\alpha_1}, \mu_{x_2}^{\alpha_2}, t) - M(\lambda_{x_1}^{\alpha_1}, \eta_{x_3}^{\alpha_3}, t) * M(\eta_{x_3}^{\alpha_3}, \mu_{x_2}^{\alpha_2}, t) = \frac{t}{t+|x_1-x_2|} - \frac{t}{t+(\alpha_1-\alpha_3)+|x_1-x_3|} \times \frac{t}{t+|x_3-x_2|}$$

$$= \frac{t(t+(\alpha_1-\alpha_3)+|x_1-x_3|)(t+|x_3-x_2|) - t^2(t+|x_1-x_2|)}{(t+|x_1-x_2|)(t+(\alpha_1-\alpha_3)+|x_1-x_3|)(t+|x_3-x_2|)} \geq 0.$$

≥ 0 .

Case 3: $\alpha_3 \geq \alpha_2 \geq \alpha_1$, then it has

$$M(\lambda_{x_1}^{\alpha_1}, \mu_{x_2}^{\alpha_2}, t) = \frac{t}{t+|x_1-x_2|}, M(\lambda_{x_1}^{\alpha_1}, \eta_{x_3}^{\alpha_3}, t) = \frac{t}{t+|x_1-x_3|}$$

and $M(\eta_{x_3}^{\alpha_3}, \mu_{x_2}^{\alpha_2}, t) = \frac{t}{t+|x_3-x_2|}$.

Now consider

$$M(\lambda_{x_1}^{\alpha_1}, \mu_{x_2}^{\alpha_2}, t) - M(\lambda_{x_1}^{\alpha_1}, \eta_{x_3}^{\alpha_3}, t) * M(\eta_{x_3}^{\alpha_3}, \mu_{x_2}^{\alpha_2}, t) = \frac{t}{t+|x_1-x_2|} - \frac{t}{t+(\alpha_1-\alpha_3)+|x_1-x_3|} \times \frac{t}{t+|x_3-x_2|}$$

$$= \frac{t(t+|x_1-x_3|)(t+|x_3-x_2|) - t^2(t+|x_1-x_2|)}{(t+|x_1-x_2|)(t+(\alpha_1-\alpha_3)+|x_1-x_3|)(t+|x_3-x_2|)} \geq 0.$$

Which implies that $M(\lambda_{x_1}^{\alpha_1}, \mu_{x_2}^{\alpha_2}, t) - M(\lambda_{x_1}^{\alpha_1}, \eta_{x_3}^{\alpha_3}, t) * M(\eta_{x_3}^{\alpha_3}, \mu_{x_2}^{\alpha_2}, t)$

The other cases are similar.

Therefore $(X, M, *)$ is a strong fuzzy metric space in I^X .

3.5 Example

Let $X = \mathbb{R}$ and $\lambda_{x_1}^{\alpha_1}$ and $\mu_{x_2}^{\alpha_2}$ any two fuzzy points in I^X , where $x_1, x_2 \in \mathbb{R}$

and $\alpha_1, \alpha_2 \in (0, 1]$ and $t \in [0, \infty)$, then

$$M(\lambda_{x_1}^{\alpha_1}, \mu_{x_2}^{\alpha_2}, t) = \frac{t}{t+|x_1-x_2|+\max\{0, \alpha_1-\alpha_2\}}$$

is a strong fuzzy metric space in I^X .

It can be proved that; this example is as similar to the above part.

4 CONCLUSION

It has proved some properties of fuzzy compact topological space and illustrate some examples of strong fuzzy metric space.

REFERENCES

- Chakraborty, M. K., and Ahsanullah, T. M. G. (1992). Fuzzy topology on fuzzy sets and tolerance topology. *Fuzzy sets and systems*, 45(1), 103-108.
- Chang, C. L. (1968). Fuzzy topological spaces. *Journal of mathematical Analysis and Applications*, 24(1), 182-190.
- Deng, Z. (1982). Fuzzy pseudo-metric spaces. *Journal of Mathematical Analysis and Applications*, 86(1), 74-95.
- George, A., and Veeramani, P. (1994). On some results in fuzzy metric spaces. *Fuzzy sets and systems*, 64(3), 395-399.
- Gregori, V., Miñana, J. J., Morillas, S., and Sapena, A. (2022). On Principal Fuzzy Metric Space. *Mathematics*, 10(16),2860
- Khadija Mohammed Am hammed Omar, Almbrok Hussin Alsonosi Omar. (2019). Some Properties of Fuzzy Compact topological Space. *Journal of Pure & Applied Sciences*, 18(4).
- Vick, J. W. (2012). Fuzzy Regular Compact Space.
- Zadeh, L. A. (1965). Fuzzy sets. *Information and control*, 8(3), 338-353.



The Best Approach to Estimate the Extreme Quantiles of the Distribution of Fire Claims: A Case Study

Thewarapperuma TDAG¹, Appuhamy PADAN²

Department of Mathematical Sciences, Faculty of Applied Sciences, Wayamba University of Sri Lanka^{1, 2}

thewarapperumaaparna@gmail.com¹

asankanidarshani@wyb.ac.lk²

ABSTRACT

This study aimed to identify the best approach for estimating extreme quantiles of the distribution of fire claims to help control the risk of extreme claims. The daily fire claims of the year 2021 obtained from a pioneering insurance company in Sri Lanka were used for the study. The study considered two approaches to estimate the extreme quantiles: the best-fit probability distribution for the entire fire claims and the extreme claims obtained from the Peak-Over-Threshold (POT) approach of the Extreme Value Theory (EVT). Moreover, four-parameter estimation methods were considered under the POT approach to select the best when limited data is available in the tail area. The study revealed that the distribution of fire claims was heavy-tailed. The best-fitted probability distributions for the entire fire claims and for the extreme claims were the Generalized Pareto distribution with the shape and scale of 0.8696 & 35243 and 0.6334 & 3.781e+05, respectively. The comparison of the accuracy of estimates of extreme quantiles showed that the estimates derived under POT were more accurate than that obtained from the best-fitted distribution for entire claim data. The information helps to revise existing policies for better risk management due to extreme claims in the future. Although there are attempts in the literature to model extreme claims using EVT, this study compares accuracies of tail estimates of the distribution of fire claims obtained from the above methods, which has not been done locally.

KEYWORDS: Extreme data, Fire claims, Insurance, Risk

1 INTRODUCTION

Risk is an inherent part of life due to unforeseen tragedies embedded in every moment of the day. This leads people to buy insurance as a form of financial security to overcome or minimize the risk involved in such tragedies. Non-life insurance provides protection to policyholders against losses or damages resulting from specific risks, including natural disasters, construction failures, fire disasters, motor accidents and other similar events. Size and the frequency of claims are essential for both the insured and insurer. Extreme-size claims rare in frequency but does occur, especially in non-life insurance. Beirlant et al., (2004) noted that the distribution of non-life

insurance claims is typically heavy-tailed due to the presence of extreme claims that lie in the tail area of the claim distribution. Insurers face significant challenges when unexpected extreme claims occur, which can potentially lead to the bankruptcy of the company. The tail of the claim distribution has become a paramount concern among actuaries and researchers than the body as it derives many critical estimates which determine insurance premiums, reserves, positioning high-excess loss layers in reinsurance and designing of policies to minimize financial risk due to such extreme claims in the future. However, estimating tail properties accurately can be challenging due to a lack of

information on the tail area. Therefore, this study aims to estimate extreme quantiles using the two approaches viz. the best fit probability distributions for entire fire claims and for the extreme claims obtained from Extreme Value Theory (EVT) approach and identify the best approach based on the accuracy of tail estimates.

2 LITERATURE REVIEW

A thorough understanding of the claims distribution allows insurers to make better decisions, which can ultimately lead to a more sustainable and profitable business. However, modeling real insurance data is challenging mainly due to the nature of the data, which consists of several features to be accounted for (Kazemi et al., 2017). Also, obtaining an accurate tail estimates is problematic due to the lack of information in this area. In the literature, several methods have been proposed to estimate the tail properties. In the early decades, the bulk and the tail (entire) data were modeled together using Gamma, Weibull, Exponential and Log-normal distributions. These models seem to be appropriate for small and moderate claim sizes. However, Lee (2012) mentioned that these distributions overestimate or underestimate the tail probabilities. Kazemi et al., (2017) mentioned that claim sizes in non-life insurance policies are very skewed, exhibit high kurtosis and extreme tails. They suggested skew distributions are reasonable models for describing claims and estimating tail properties in property-liability insurance. On the other hand, several studies have shown that Extreme Value Theory (EVT) is a better approach to deal with the challenges in modeling

data with extremes (McNeil, 1997). The Peak-Over-Threshold approach of the EVT was widely used in practice to deal with extreme data modeling (Wang et al., 2020). This approach provides a model for exceedances over a high threshold. Pickands (1975) has shown that the excess values over a sufficiently high threshold can be approximated by the Generalized Pareto distribution (GPD). The selection of a sufficiently high threshold is critical and challenging. The threshold must be sufficiently high to ensure the reliability of the GPD approximation. However, the high threshold reduces the sample size for modelling and increases the variance of the parameter estimation. This lead to conclude that the choice of threshold should strike a balance between bias and variance (Scarrott & MacDonald, 2012). Researchers are also cautious when estimating the parameters of the GPD due to the limited data available in the tail area. This is because parameter estimation methods are largely dependent on the sample size available. The smaller the sample size, the greater the uncertainty in the estimated parameters, making it difficult to model the tail behavior of the distribution accurately. Incorrect choice of the parameter estimation method would seriously affect the inference drawn (Kang & Song, 2017). Maximum Likelihood Estimation (MLE), Method of moment (MOM), Probability Weighted Moment Biased (PWMB), Probability Weighted Moment Unbiased (PWMU) are some of the parameter estimation methods used to estimate the shape and the scale parameters of GPD under the POT approach (De Zea Bermudez & Kotz, 2010). Though the studies on tail

properties of non-life insurance claims are important for insurance companies for controlling insurance risk, only limited attempts can be seen, particularly in Sri Lanka, which assists premium determination, setting of reserves etc. Therefore, this study compares accuracies of tail estimates, specifically, extreme quantile estimates, obtained from the POT approach and the best probability distribution fitted for entire fire claims to identify the best approach to estimate tail properties.

3 METHODOLOGY

The aim of this study is to compare the accuracies of the tail estimates obtained from both the best probability distribution fitted to the entire claims data and the EVT to find the best approach to estimate the tail properties. First, the best probability distribution for the entire fire claims received during the period of study was identified. For this purpose, 10 skewed distributions were initially fitted to the claim data. The MLE method was used to estimate the parameters as it is suitable when a large sample of data is available for modelling. Then the goodness of fit of the probability distributions was tested using Anderson-Darling, Kolmogorov-Smirnov and Chi-square at a 5% level of significance. The null hypothesis tested under each goodness of fit test was as follows.

H_0 : The fire claims follow the specified distribution

Next, the probability distribution with the minimum test statistics value for each of the three goodness of fit tests was selected independently. The simulated data generated from each of the three selected distributions were then used to

calculate the Mean Square Errors (MSEs) of the fitted distributions. Finally, the probability distribution with minimum MSE was selected as the best probability distribution for the entire fire claims. Second, the study considered the EVT's POT approach to model the claim distribution's tail. According to the Pickands (1975) the excess values over a sufficiently high threshold approximated by a GPD. Using the rule of thumb method proposed by DuMouchel (1983), the study considered the 90th percentile as the sufficiently high threshold for the POT approach which separates extreme claims from bulk. Then, the shape and the scale parameters of the GPD were estimated using four different parameter estimation methods viz, MLE, MOM, PWMB and PWMU as these methods perform differently with the sample size available for modelling. The bootstrap goodness of fit test was used to check the goodness of fit of these four GPDs.

Finally, the extreme quantiles, 0.92, 0.94, 0.96, 0.97, 0.98, and 0.99, were estimated using the best-fit probability distribution for entire insurance claims and from the four GPDs obtained from the POT approach of the EVT. The accuracies of the extreme quantile estimates were compared using the MSE. The approach which yielded the minimum MSE was selected as the best approach to estimate tail properties of the fire claims distribution.

4 DATA COLLECTION AND ANALYSIS

The total daily fire insurance claims received by a pioneering insurance company in Sri Lanka from January 2021 to December 2021 were used for this study. Initially, the descriptive statistics

were examined to get an idea about how claims were distributed over the period of study. Three goodness of fit tests were used to fit the probability distribution for entire data as those more or less sensitive to different parts of the distribution.

5 RESULTS AND DISCUSSION

It was revealed that the maximum and the minimum claim sizes received by the insurance company during the period of study were Rs. 9,913,194.00 and Rs. 3,000.00, respectively. Moreover, 50% of the claims received were above Rs.44,348.00. In addition to that, the claim distribution was leptokurtic ($kurtosis > 3$) and positively skewed with skewness of 2.445. These properties indicate that the entire fire claims distribution was heavy-tailed. The best probability distribution fitted under the Kolmogorov Smirnov and Anderson Darling goodness of fit test was Generalized Pareto, whereas for Chi-square, it was Generalized extreme value distribution. The Generalized Pareto distribution yielded the minimum MSE, which was 0.8997 compared to 1.1073 of the Generalized extreme value distribution. Therefore, the Generalized Pareto distribution (shape=0.86961, scale=35243) was selected as the best-fitted distribution for the entire fire claims received during the period of study. The 90th percentile was considered the optimal threshold under the POT approach, amounted to Rs.374,418.40, while the number of claims above this amount was 67. Only 67 out of 668 claims were identified as extreme claims and considered for tail modelling when the threshold was set to Rs.374,418.40. The bootstrap goodness of fit tests confirmed that all four GPDs fitted with

four different parameter estimation methods follow the GPD with a positive shape parameter. Below Table 1 summarizes the probability distributions selected under each approach together with the parameter estimation method and the corresponding MSEs of extreme quantile estimation.

Table 1: Summary of the probability distributions fitted under each approach and the corresponding MSEs of estimates of extreme quantiles

Modeling Approach	Probability distribution with parameter estimation method	MSE of extreme quantile estimation
The best fit probability distribution for entire claims	MLE GPD(shape, 0.8691 scale,3524)	1.0616
	MLE GPD(shape, 0.3739 scale, 1.031e+05)	1.2587
Peak-Over-Threshold (POT) under Extreme value Theory (EVT)	MOM GPD(shape, 0.3614 scale, 6.587e+05)	0.4342
	PWMB GPD(shape, 0.6334 scale, 3.781e+05)	0.3072
	PWMU GPD(shape, 0.6455 scale, 3.656e+05)	0.3778

According to the results presented in Table 1, GPDs fitted under the POT approach exhibit lower MSE values

when compared to the MSE obtained from the best-fitted probability distribution for the entire claim data. The exception to this is the GPD fitted using the MLE, which had the highest MSE in estimating extreme quantiles. On the other hand, the GPD fitted under the POT approach with PWMB method exhibits the lowest MSE in estimating the extreme quantiles. That is the best-fitted probability distribution for the tail of the claim data was the Generalized Pareto Distribution with a shape of 0.6334 and a scale of $3.781e+05$. This suggests that the PWMB approach is the most appropriate method for estimating the GPD parameters when there is limited data for the tail. Additionally, the POT approach with PWMB method was identified as the best approach among the two considered in estimating the extreme quantiles of the fire claim distribution.

6 CONCLUSION

Many individuals choose to purchase insurance to mitigate the financial risks associated with unexpected events in day to day life. Sometimes the extreme claims from policyholders may negatively affect the insurance company's sustainability and profit. A better understanding of the size of claims from policyholders is essential for profitable business decisions. It was found that fire claims received during the period of study were heavy-tailed. The best-fitted probability distribution for the entire fire claims was GPD ($k=0.86961$, $\sigma=35243$). Moreover, PWMB was the best parameter estimation method when limited data in the tail area. It was concluded that out of the two approaches considered, the GPD fitted for extreme claims under the POT-PWMB approach

was the best to estimate the extreme quantiles of the distribution of fire claims. The information helps the actuaries and the relevant parties to revise existing strategies and policies to maintain a profitable business in the future.

REFERENCES

- Beirlant, J., Joossens, E. and Segers, J. (2004). Generalized Pareto fit to the society of actuaries' large claims database. *North American Actuarial Journal*, 8(2), 108-111.
- De Zea Bermudez, P. and Kotz, S. (2010). Parameter estimation of the generalized Pareto distribution – Part II. *Journal of Statistical Planning and Inference*, 140(6), 1374-1388.
- DuMouchel, W.H. (1983). Estimating the stable index α in order to measure tail thickness: A critique, *Ann. Statist.*, 11, 1019–1031.
- Kang, S. and Song, J.(2017). Parameter and quantile estimation for the Generalized Pareto distribution in peak over threshold framework. *Journal of the Korean Statistical Society*,46,487-501.
- Kazemi, R., Jalilian, A., and Kohansal, A. (2017).Fitting Skew Distributions to Iranian Auto Insurance Claim Data. *Applications and Applied Mathematics: An International Journal*, 12(2), 790-802.
- Lee, W.C. (2012). Fitting the generalized Pareto distribution to commercial fire loss severity: evidence from Taiwan. *The Journal of Risk*, 14(3), 63-80.
- McNeil, A. J. (1997). Estimating the tails of loss severity distributions using extreme value theory. *ASTIN Bulletin*, 27(1), 117–137.
- Pickands, J. (1975). Statistical inference using extreme order statistics. *The Annals of Statistics*, 3, 119–131.
- Scarrott, C., and MacDonald, A. (2012). A review of extreme value threshold estimation and uncertainty quantification. *Revstat-Statistical Journal*,10(1),33-60.
- Wang, Y., Haff, I. H. and Huseby, H. (2020). Modelling extreme claims via composite models and threshold selection methods. *Insurance: Mathematics and Economics*, 91, 257-268.



Time Series Analysis of the Weekly Sales of Roti Flour for the Year 2022

Gunawardena H L¹, Widanagamage HE², Sampath MIGS³

Department of Mathematical Sciences, Faculty of Applied Sciences, Wayamba University of Sri Lanka. ^{1, 2, 3}

hansiegunawardena@gmail.com¹

hashanierangika96@gmail.com²

migsuranga@wyb.ac.lk³

ABSTRACT

Flour is a necessary ingredient for everyone in Sri Lanka. It is the main ingredient in many baked goods, including bread and pastries, as well as in battering and frying meat, seafood, and vegetables. The number of carbs and calories in flour as well as other nutritional information about flour vary depending on the type of flour used. One of the most widely used types is, all-purpose flour. The effectiveness of forecasting is particularly beneficial for the processes like planning, delivering, operation, and management. Furthermore, the analysis of Roti flour for the three years is important to predict future sales for the stability of the company. The secondary data of weekly Roti flour sales over the period 2019 to 2021 were collected from ABC (Pvt) Ltd. The analysis is done by using RStudio software. This study proposes a model to fit the sales of Roti flour for the year 2022 in ABC (Pvt)Ltd and to forecast future values for the sales of Roti flour. First plotted times series plot and then, the stationarity is checked by using the ADF test and the conditional mean model AR (1) model is fitted to differenced series. The best-fitted model was ARIMA (0,1,1). After checking the residuals of the model, conditional heteroscedasticity in residuals of the fitted model is detected using the ARCH LM test. The accuracy of the model is measured using MAPE. The result shows that the best-fitted model was ARIMA (0,1,1). MAPE value was 14.97192 and it has 85% accuracy.

KEYWORDS: Roti Flour, Sales Prediction

1 INTRODUCTION

In order to produce forecasts and guide strategic decision-making, time series forecasting involves analyzing time series data using statistics and modeling. The likelihood of forecasts can vary a lot, especially when dealing with frequent variables time series data, and other outside influences. It is not always possible to make an exact prediction. Scientific methods for predicting the future include time series modeling and ARIMA forecasting. The most popular and frequently employed data modeling technique for predicting time series is ARIMA modeling.

The statistics data set provides information on ABC (Pvt) Ltd's weekly sales of Roti Flour for the three years between 2019 and 2021. The demand for the weekly sales of Roti Flour for 2021 can be foecasted by creating a statistical model utilizing the relevant data set.

It is possible to generate a number of assumptions by creating an ARIMA model for the weekly sales rates and identifying the different parts of the data sets. It is essential to check for assumptions in every step of the statistical analysis process when modeling statistical data, and to test those assumptions statistically using the hypothesis testing approach.

Conclusions should be generated and the Roti Sales for 2021 should be predicted after evaluating each and every function and graph developed by the analysis using the relevant dataset.

The purpose of the model is to analyze the behavior of weekly sales of Roti flour over the past three years (2019,2020 and 2021) at ABC (Pvt) Ltd and predict the future values for sales of Roti flour and buildup the best-fitted model.

2 LITERATURE REVIEW

Over the past three decades, the autoregressive integrated moving average (ARIMA) has become one of the most widely used linear models for time series forecasting. Time series is a widely used model for forecasting using past data.

Nirmala, et al., (2021) conducted research on Sales Forecasting by using the Exponential Smoothing Method and Trend Method to Optimize Product Sales in PT. Zamrud Bumi Indonesia During the Covid-19 Pandemic. The purpose of this study is to analyze the sales pattern of Power Bumi products during the covid-19 pandemic and compare the forecasting method that can produce the smallest error value in forecasting sales of Power Bumi products PT. Zamrud Bumi Indonesia. This study uses 2 methods, namely exponential smoothing, and the least square trend model. To calculate the error rate using MAD, MSE, and MAPE.

Mahendra & Susanto (2019) have researched about Procurement of management information system cv. radja sale. The forecasting method used in this study is Single Exponential Smoothing with Mean Square Error, the method of controlling raw material

inventory in the warehouse using Safety Stock. The goal is to assist the Procurement Manager in planning the procurement of raw materials to suppliers, as well as avoiding excess and lack of raw material stocks in the warehouse.

Paduloh & Ustari (2022) researched Analysis and Comparing Forecasting Result Using Time Series Method to Predict Sales Demand on Covid -19 Pandemic Era. This study aims to minimize forecasting errors by analyzing which demand forecasting model is the most suitable model for demand conditions based on historical data on demand for masterbatch products. The method used in this study is a time series model, which consists of the season naive method, holt exponential smoothing, exponential triple smoothing, and autoregressive integrated moving average (ARIMA).

Santos & Rebelo (2015) researched about Performance of state space and ARIMA models for consumer retail sales forecasting. This work compares the forecasting performance of state space models and ARIMA models. The forecasting performance is demonstrated through a case study of retail sales of five different categories of women's footwear: Boots, Booties, Flats, Sandals, and Shoes. The results show that when an automatic algorithm the overall out-of-sample forecasting performance of state space and ARIMA models evaluated via RMSE, MAE, and MAPE is quite similar on both one-step and multi-step forecasts.

Zhang (2003) has researched Time series forecasting using a hybrid ARIMA and neural network model. Over the past three decades, the autoregressive

integrated moving average (ARIMA) has become one of the most widely used linear models for time series forecasting. In this paper, a hybrid methodology that includes both ARIMA and ANN (Artificial Neural Network) models is developed to capitalize on the distinct advantages of ARIMA and ANN models in linear and nonlinear modeling.

3 METHODOLOGY

The Box-Jenkins approach of Time Series Analysis was used to forecast the weekly sales of Roti flour for 2022 at ABC (Pvt) Ltd. To choose an acceptable model for forecasting, the weekly sales of roti flour for the past 3 years (2019, 2020, and 2021) were applied. As the original series was not stationary, it was differenced and by looking at the Auto-Correlation Function (ACF) and Partial Auto-Correlation Function (PACF), tentative models were identified. Then various diagnostic tests were used to validate the goodness of fit of the model. The stationarity is checked by using the ADF test. Auto ARIMA function is used to identify the best model and after checking residuals of the ARIMA model, conditional heteroscedasticity in residuals of the fitted model is detected using the ARCH LM test. The accuracy of the model is measured using MAPE.

4 RESULTS AND DISCUSSION

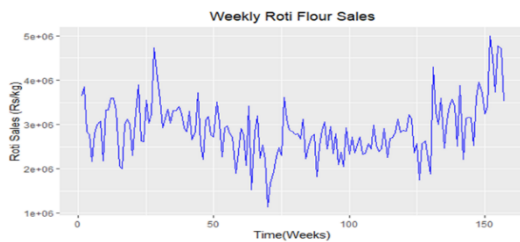


Figure 1: Time Series Plot of Weekly Roti Flour sales

Since the time series plot fluctuated without a fixed frequency and duration caused, we can say that the pattern has some cyclical variation. Also, it is difficult to determine whether figure 1 has a seasonal or trend pattern. The ACF and PACF plots have to be analyzed to check the pattern.

A histogram is a statistical information presentation that uses rectangles to illustrate the frequency of data items in equal-sized numerical intervals. Figure 2 shows the histogram of weekly Roti sales.

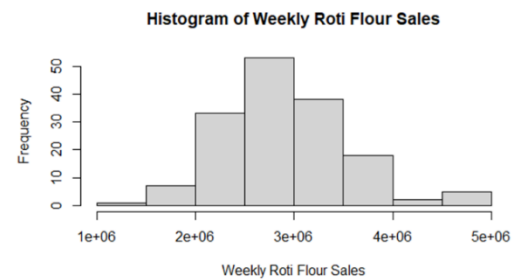


Figure 2: Histogram Plot of Weekly Roti Flour Sales

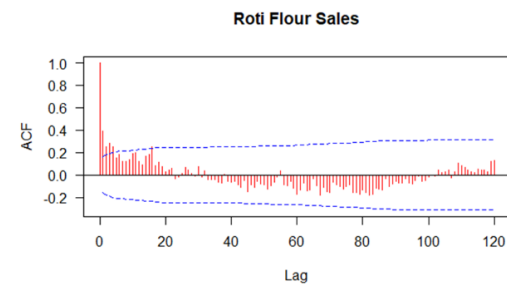


Figure 3: Autocorrelation Function for Weekly Flour Sales

Figure 3 shows ACF does not die down quickly. It can be concluded that the data set has a trend variation. Thus, the data set is not stationary. Therefore, 1st order differencing should be done.



Table 1: ADF test results for original series and different series

	Original Series	Differenced series
Statistic:		
Dickey-Fuller	0.5085	-5.1218
P Value	0.7764	0.01

Table 1 shows the p-value of the Augmented Dickey-Fuller test (ADF) conducted for the original series is 0.7764, as shown in Table 1. It is higher than 0.05. At the 5% level of significance, it is concluded that there is sufficient evidence to support the null hypothesis.

The Augmented Dickey-Fuller (ADF) test's (0.01) final p-value for the differenced series is less than 0.05. At a 5% level of significance, it is concluded that there is sufficient evidence to reject the null hypothesis. As a result, it suggests that the differenced series is stationary.

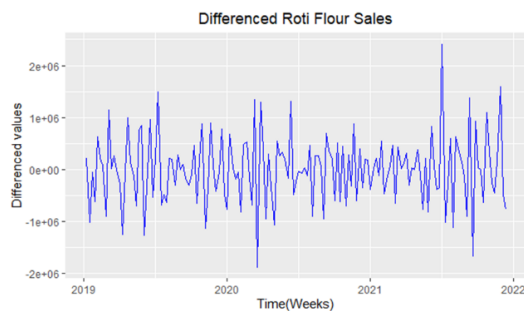


Figure 4: The Plot for the Differenced Series

The Figure 4 shows that the graph has a constant mean. The differenced series' mean is almost zero, as seen in Figure 4. It is obvious that there are times when volatility significantly rises. Figures 5 and 6 below illustrate the autocorrelation function (ACF) and partial autocorrelation function (PACF) of the differenced series.

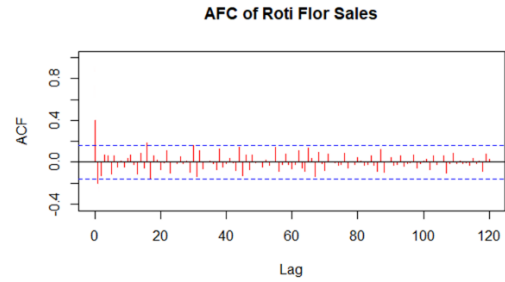


Figure 5: Autocorrelation Function for Trend Differences

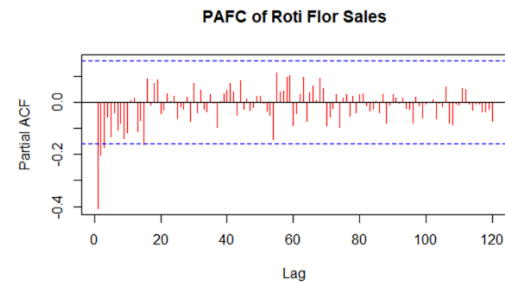


Figure 6: Partial Autocorrelation Function for Trend Differences

Table 2: BIC Values of ARIMA Models for the Original Series

Model	BIC value
ARIMA (2,1,2) With Drift	4468.201
ARIMA (0,1,0) With Drift	4515.465
ARIMA (1,1,0) With Drift	4493.374
ARIMA (0,1,1) With Drift	4460.807
ARIMA (0,1,0)	4510.434
ARIMA (1,1,1) With Drift	4468.288
ARIMA (0,1,2) With Drift	4464.072

Model	BIC value
ARIMA (1,1,2) With Drift	4471.39
ARIMA (0,1,1)	4455.887
ARIMA (1,1,1)	4463.342
ARIMA (0,1,2)	4459.143
ARIMA (1,1,0)	4488.345
ARIMA (1,1,2)	4466.451

According to Table 2, considering the minimum Bayesian Information Criteria (BIC) values of the ARIMA models, ARIMA (0,1,1) model is selected as the best model.

Table 3: Z coefficients of the ARIMA (0,1,1) model

	Estimate	Std. Error	z value	Pr(> z)
MA ₁	-0.774	0.060297	-12.84	< 2.2e-16***

The coefficient of MA1 is significant from zero since the p value < 0.05. Reject H_0 . So, we can clearly show that the best-fitted model is ARIMA (0,1,1).

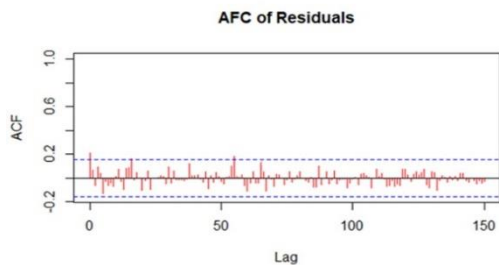


Figure 7: Auto Correlation Function of Residual

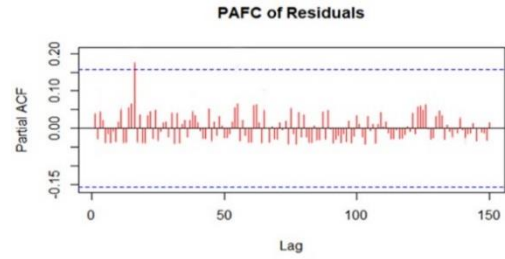


Figure 8: Partial Auto Correlation Function of Residual

ACF and PACF in Figures 7 and 8 demonstrate a realization of a discrete white noise process, which shows that we have successfully established a satisfactory fit with the ARIMA (0,1,1) model. We can see from these plots that the residuals appear to be uncorrelated. Consequently, the residuals are random. The serial correlation LM test can also be used to confirm this.

Table 4: Serial correlation LM test results

LM test =	df = 50	p-value =
37.257		0.9089

The serial correlation LM test's p-value is higher than 0.05. Therefore, at a 5% level of significance, Hence, it can be said that residuals are random. The results of the ACF and PACF of the residuals of the fitted ARIMA (0,1,1) model have been validated by this test.

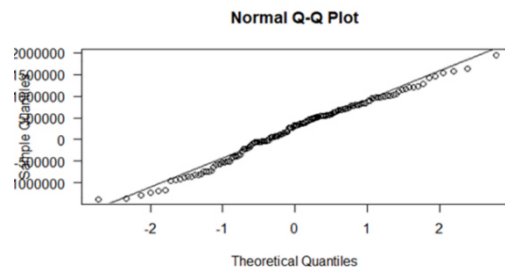


Figure 9: Normality Plot of Residuals

According to Figure 9, The normal Q-Q plot shows that the straight line provides a good fit for the residuals. The residuals are found to be normally

distributed. The Jarque-Bera test can also be used to verify the residuals' normality.

Table 5: Jarque-Bera test results

X-squared = 7.213	df= 2	p-value = 0.6795
-------------------	-------	------------------

At the 5% level of significance, the null hypothesis cannot be rejected because the Jarque-Bera test's p-value is higher than 0.05. As a result, it is concluded that residuals have a normal distribution.

Table 6: ARCH LM Test Result

Chi-squared = 10.83	Df = 12	p-value= 0.5436
---------------------	---------	-----------------

The p-value of the ARCH test is 0.5436 and greater than 0.05. Then there is not enough evidence to reject the null hypothesis at a 5% level of significance. Hence, it can be concluded that residuals of the fitted ARIMA (0,1,1) model have no ARCH effects.

After checking the ARCH LM test, it is proved that the ARIMA (0,1,1) model is the best for modeling weekly Roti sales.

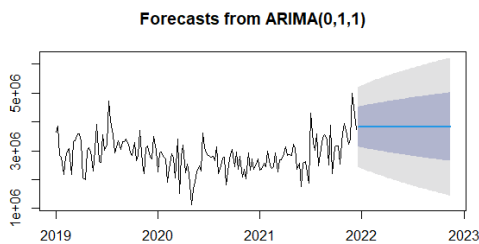


Figure 10: Time Series plot of Forecast

In Figure 10, the last 48 points produced the same plot, as the autArima function does not detect the seasonality. The below figure shows the time series plot after detecting the seasonality.

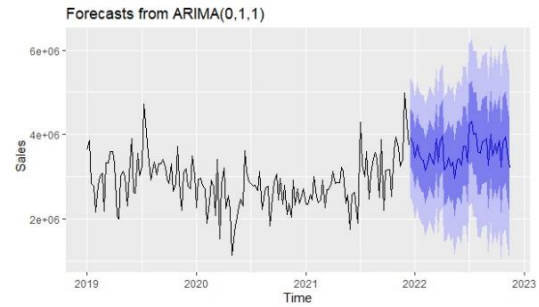


Figure 11: Time Series plot of Forecast with the seasonality

Now the most important task is evaluating the forecasting performance of the ARIMA (0,1,1). For this study, predictions were made for the first 48 weeks of 2022.

Table 8: MAPE value of Forecasting Performances

Time period	MAPE value	MAPR (%)
Training set	14.97192	85.028

5 CONCLUSION

The objective of this research is to analyze the behavior of weekly sales of Roti flour over the past three years (2019,2020 and 2021) at ABC (Pvt) Ltd. The primary goal of this project is to forecast future values for sales of Roti flour and to build the best-fitted model for the year 2022. The methodology applied for forecasting the Roti flour for the year 2022 was time series and analysis was done by using R studio. During the modeling process, the best-fitted model was ARIMA (0,1,1). The model accuracy is 85.028% and the MAPE value is 14.97192. Therefore, ARIMA (0,1,1) is the best-fitted model that can be used for modeling and forecasting the weekly sales of Roti flour at ABC (Pvt)Ltd.

Since, MAPE < 20%, can conclude that the forecasting performance of the ARIMA (0,1,1) model is good.

5.1 Future implementation

The Roti flour sales data of ABC company in 2022 are going to be collected as a future implementation for this research. The real data in 2022 and predicted data are going to be compared using the cross-validate technique.

REFERENCES

- Darwas, R., Rahimullaili, R., and Abdi, N. (2021). Good Sales Forecasting Information System Using a Single Exponential Smoothing Method. *Jurnal Teknologi Informasi Dan Pendidikan*, 14(1), 77–82. <https://doi.org/10.24036/tip.v14i1.453>
- Fattah, J., Ezzine, L., Aman, Z., El Moussami, H., and Lachhab, A. (2018). Forecasting of demand using ARIMA model. *International Journal of Engineering Business Management*, 10, 184797901880867. <https://doi.org/10.1177/1847979018808673>
- Paduloh, P., and Ustari, A. (2022). Analysis and comparing forecasting results using time series method to predict sales demand on COVID-19 pandemic era. *Journal of Engineering and Management in Industrial System*, 10(1), 37–49. <https://doi.org/10.21776/ub.jemis.2022.010.01.4>
- Panoff, L. (2021, November 10). 5 of the healthiest flours for every purpose. Retrieved January 14, 2023, from <https://www.healthline.com/nutrition/healthiest-flour>
- Ramos, P., Santos, N., and Rebelo, R. (2015). Performance of state space and Arima models for consumer retail sales forecasting. *Robotics and Computer-Integrated Manufacturing*, 34, 151–163. <https://doi.org/10.1016/j.rcim.2014.12.015>
- Shin, Y. (2017). Time series analysis as an impact analysis method. *Time Series Analysis in the Social Sciences*. <https://doi.org/10.1525/cialifornia/9780520293168.003.0007>
- Wineka Nirmala, V., Harjadi, D., and Awaluddin, R. (2021). Sales forecasting by using exponential smoothing method and trend method to optimize product sales in pt. Zamrud Bumi Indonesia during the COVID-19 pandemic. *International Journal of Engineering, Science and Information Technology*, 1(4), 59–64. <https://doi.org/10.52088/ijesty.v1i4.169>
- Zhang, G. (2003). Time series forecasting using a hybrid ARIMA and neural network model. *Neurocomputing*, 50, 159–175. [https://doi.org/10.1016/s0925-2312\(01\)00702-0](https://doi.org/10.1016/s0925-2312(01)00702-0)



A Literature Review on critical success factors in implementing big data in ERP systems in Manufacturing Industry

Nimmi Jayamali MA¹, Roshenka Dabarera², Abhilashani GK³ Amila Withanachchi⁴, Ruwan Wickramarachchi⁵

Department of Industrial Management, Faculty of Science, University of Kelaniya, Sri Lanka

*jayamali_im17034@stu.kln.ac.lk*¹

*dabarera_im17011@stu.kln.ac.lk*²

*abhilash_im17002@stu.kln.ac.lk*³

*amilaw@kln.ac.lk*⁴

*ruwan@kln.ac.lk*⁵

ABSTRACT

Entity Resource Planning (ERP) systems have become a popular tool for organisations in the competitive business environment. ERP has evolved and integrated with other technologies to enhance efficiency and achieve organisational benefits. Big Data has emerged as a valuable tool for supporting digital transformation and providing faster insights. However, the successful implementation of Big Data projects requires alignment with organisational, technological, and analytical features. ERP implementation is a critical stage in the digital transformation journey of any organisation, allowing them to consolidate their operations into a single solution. ERP failures have resulted in significant financial meltdowns, income loss, and reputation harm. Such failures often result from needing to factor in various project management components. The literature has identified critical success factors for adopting extensive data-integrated ERP systems in the manufacturing industry and the benefits of such adoption. This review is based on 36 papers from bibliographic databases and science search engines from 2012 to 2022. The paper aims to provide a deeper understanding of the existing critical success factors for Big Data implementation in ERP systems in the manufacturing industry.

KEYWORDS: ERP, Big data, Critical success factors (CSFs), Manufacturing Industry

1. INTRODUCTION

Big data analytics and ERP systems can provide businesses valuable insights for informed decision-making. Integrating big data with ERP improves ERP capabilities, expedites decision-making, and helps interpret discarded data. Real-time data on supply chains and inventory can assist in forecasting demand and improve supply chain efficiency. Only 12% of business data is currently analysed, with the rest ignored, which is a missed opportunity for businesses to gain insight and improve efficiency and financial prospects. Integrating big data and ERP systems will uncover advantages such as improved demand prediction and consumer behaviour analysis. This paper presents a systematic literature review on the role of big data in ERP systems,

specifically in the manufacturing industry, and the critical success factors affecting implementation.

2. METHODOLOGY

This study's methodology is based on the five steps suggested by (Khan et al., 2003). The research is based on a systematic review. The authors explained the procedures for conducting a systematic literature review, including selecting, examining, and evaluating the quality of the reviewed materials. The five steps are as follows, 1) Before beginning the literature evaluation, this phase should clearly define the study issue and associated words. There are two components, or two research questions, to this study. First, to identify critical success factors in adopting extensive data-integrated ERP systems in the manufacturing industry. Second, to

identify the benefits of adopting extensive data-integrated ERP systems in the manufacturing industry. 2) The resources of the pertinent literature should be identified in this research step. In this study, the keywords "Big data integration with ERP," "Manufacturing Industry," and "critical success factors (CSFs)" are the ones that are concentrated on in e-resources and documents. More precisely, the sources were journals like the European Journal of Operational Research, Science Direct, IEEE Xplore, Journal of Enterprise Information Management, and Association for Information Systems that deal with ERP research in IT, computing, and business management. 3) In this step, the discovered papers or publications would be subjected to several quality measures to filter the found publications. These requirements are: The research question must be directly addressed in the paper, The publication's methodology must be transparent, The study must be based on reliable sources and journals, and the papers must have been published in 2012 or later. 4) The evidence that has been found that relates to the research questions will be gathered and summarised in this stage to get them ready for the data analysis or findings interpretations in the fifth step. 5) The findings from the earlier rounds of the study will be analysed in this final step to conclude the crucial success criteria in implementing big data in ERP systems in the manufacturing industry.

3. LITERATURE REVIEW

3.1. ERP in the Manufacturing industry

The manufacturing sector is businesses that engage in the mechanical, physical, or chemical transformation of raw materials, substances, or parts into finished goods (Gupta et al., 2019). Business competitions among manufacturing industries are extreme, especially in producing competitive goods. The crucial point for many companies is building their competitive advantage by increasing their target

markets and implementing changes to develop the business (Tarigan, Suprpto & Basana, 2019).

Now, industries are moving into intelligent manufacturing because innovative manufacturing is essential to national economies since it creates jobs, fosters innovation, and increases sustainability. A wide range of software is used to achieve those objectives, and the ERP system is one among them (Cui, Kara & Chan, 2020). ERP in the manufacturing sector is an extension of MRP II. It uses relational databases, a richer graphical user interface, a fourth generation of languages, open system portability, and a more integrated design. This was introduced in the 1970s to address the issue of companies' inability to keep extensive inventories and has evolved from the inventory control software of the 1960s (Singh, Singh & Singh, 2013). ERP systems were used first by large manufacturing organisations on-premises to manage the raw material in process, finished goods and information communication. ERP system acceptance rate was slow in the beginning due to ERP implementation being a time-consuming and high investment process for any organisation; however, it is adopted by nearly all businesses nowadays and changing the business legacy due to its exceptional benefit (Kenge & Khan, 2020).

Quality management which gives a competitive advantage, especially to the manufacturing industry, can be maintained and improved using ERP systems. The primary objective of manufacturing firms using ERP systems is to increase productivity and quality (Singh et al., 2013). Enterprise resource planning (ERP) systems provide firms with extensive facilities and capabilities to share and transfer data and processes of organisations inside and outside the enterprise into a single system and database (Fundamentals of Risk Management, n.d.). Sharing data between a firm's departments or firms across the supply chain helps in many aspects and

aims to achieve better firm performance. ERP is a business management software system category that aims to integrate all functional units, typically a suite of integrated applications, cooperatively. It facilitates organisations to collect, record, manage and interpret data from these business activities. The fact is that ERP has so far been widely implemented by different organisations of different sizes in many sectors and in many countries to seek competitive advantages in the market. (Gupta et al., 2019).

ERP system in manufacturing integrates six core functions: CRM, SCM, Business Intelligence, HRM, Inventory Management and Accounting Management. In the organisation, none of the existing approaches for ERP systems has directly emphasised "veracity", "validity", and "value". As ERP systems focus on integrating and processing internal data, these data are usually structured, filtered and stored based on the need and data policy of business organisations. Therefore, the data's trust, correctness and worth should be very high (Dinh, Karmakar & Kamruzzaman, 2020). This feature can be seen in manufacturing sector organisations, mainly since they mostly deal with internally generated, production-related data. For successful ERP adoption, a company has to do business processes known as Business Process Re-engineering. The changes are conducted by adjusting all procedures in the companies so that they can fit into applying ERP modules. Proper adjustments will increase the employment performance of manufacturing companies. (Tarigan et al., 2019).

3.2. Benefits of integrating big data with ERP

Big Data analytics is being considered by businesses to gain insights into customer behaviour and preferences, leading to better products or services through a better understanding of clients. Predictive analytics on stored data's 3Vs (volume, variety, and velocity) is done using new data science approaches.

(Dutta & Bose, 2015). Businesses recognise the importance of extracting insights from big data due to its growth, leading to technology and data research investments. Big data has many benefits, including cost savings and increased accuracy. However, businesses and researchers face challenges gathering valuable and relevant data (Dinh et al., 2020). ERP software can improve business efficiency by analysing more data faster and providing deeper insight into operational inefficiencies. It allows for real-time monitoring of processes and can connect data points across the firm to optimise resource allocation. Big data provides a clearer perspective, but security measures such as encryption must be in place to protect sensitive data. (How Big Data Is Transforming Enterprise Resource Planning? - Technical - Various (Tech Insights, Reviews, Alternatives & Guides, n.d.). Maintaining product quality and compliance requires complete insight across the supply chain. Quality can be enforced via big data by establishing a closed-loop process. ERP will collect large amounts of data from equipment to diagnose faults and eliminate downtime. Its quality assurance module tracks and tracks parts and products across the supply chain to reduce risk. You may apply methods to improve product design, streamline workflows, and reduce costs when you have access to information such as product lifecycles and cost of quality reports. Big data assists manufacturers in maintaining the high quality that their customers expect. (Understanding Big Data and ERP, n.d.). Big data can benefit businesses in five ways: 1) making information public and accessible, 2) providing more precise performance data, 3) enabling more precise customer segmentation, 4) improving decision-making through advanced analytics, and 5) creating new goods and services through data-driven innovation (Fanning & Grant, 2013). With more and broader data points, such as machine and sensor data, big data helps ERP to have a contextual

perspective. Big data allows organisations to address all information sets while reducing their reliance on sampling. The majority of the value of big data comes from the insights it yields after analysis—finding patterns, deriving meaning, making choices, and eventually reacting intelligently. Social media, call centre interactions, web behaviour, warranty and service histories, purchase details, and demographics are just a few examples of the significant data sources that ERP systems may employ. Reduced customer churn, high customer lifetime value, and increased positive sentiment through earned reputation are indicators of the success of big data analytics (Babu et al., n.d.).

3.3. CSFs in ERP adoption with Big Data

Big data analytics can transform business processes and affect business value and performance. Hence, increasing its usefulness for managers. Consequently, managers can pay more attention to corporate initiatives and more advanced information usage (Romero & Abad, 2022). The critical success factors in ERP adoption with big data analytics are as follows.

1) Best Practices: ERP systems have incorporated the concept of best practices with the help of vendors such as SAP and Oracle. Combining Big data with ERP helps firms develop comprehensive and effective best practices due to data collection, analysis, and storage advancements. Integrating big data and ERP will result in faster and better implementation quality for the organisation.

2) Data Privacy: Combining ERP and big data presents challenges in terms of data privacy. Regulators worldwide are implementing rules to protect individual and data privacy. Combining data from ERP and big data can expose data to the outside, presenting unique privacy limitations that require careful analysis before deployment. Companies like Facebook have committed to regular privacy audits to avoid issues (Cadersaib,

Sta & Rahimbux, 2018)(Al-Sai, Abdullah & Husin, 2020).

3) Data Quality: The data in the ERP system adhere to the organisation's quality restrictions and internal quality measurements and processes. However, there may be biases and discrepancies when this data is combined with those from outside sources. Data for big data comes from numerous sources with varying degrees of data quality. This is a problem when combined with ERP data. This data needs to be harmonised, and when we do so, we must define confidence levels for aggregates and raw data(Elragal, 2014)(Al-Sai et al., 2020).

4) IT facilities and Infrastructure: Big data has impacted traditional ERP systems with n-tier design, causing a shift to cloud computing and adding BI to improve decision-making. This increased reliance on big data has put new demands on IT infrastructure design and deployment, requiring ERP suppliers to prepare for third-party app integration. (Elragal, 2014) (Félix, Tavares & Cavalcante, 2018).

5) Communication: Technology-based significant data initiatives should communicate effectively for system promotion, enhancement, and dispute resolution. Communicating makes it possible for IT and business departments to operate together. Aiming for improvements based on understanding user demands, communication facilitates the dissemination of results from advanced analytical approaches, favours the adoption of projects and technology, and aids in conflict resolution. (Félix et al., 2018).

4. CONCLUSION

The literature assessment recognised top management support, data governance, change management, and proper employee training as essential success elements. However, there needs to be more knowledgeable in the literature regarding the issues that small and medium-sized firms (SMEs) encounter

when incorporating big data in ERP systems. Future research should identify the problems that SMEs encounter and establish strategies for overcoming them to ensure the successful application of big data in ERP systems in the manufacturing industry.

REFERENCES

- Al-Sai, Z. A., Abdullah, R., & Husin, M. H. (2020). Critical Success Factors for Big Data: A Systematic Literature Review. In *IEEE Access* (Vol. 8, pp. 118940–118956). Institute of Electrical and Electronics Engineers Inc. <https://doi.org/10.1109/ACCESS.2020.3005461>
- Babu, M. S. P., Li, W., Tsui, E., & Institute of Electrical and Electronics Engineers. (n.d.). *Proceedings of 2014 IEEE 5th International Conference on Software Engineering and Service Science: ICSESS 2014: June 27- 29, 2014, China Hall of Science and Technology, Beijing, China.*
- Cadersaib, B. Z., Sta, H. B., & Rahimbux, B. A. G. (2018, October). Making an Interoperability approach between ERP and Big Data context. In *2018 Sixth International Conference on Enterprise Systems (ES)* (pp. 146-153). IEEE. <https://doi.org/10.1109/ES.2018.00030>
- Cui, Y., Kara, S., & Chan, K. C. (2020). Manufacturing big data ecosystem: A systematic literature review. In *Robotics and Computer-Integrated Manufacturing* (Vol. 62). Elsevier Ltd. <https://doi.org/10.1016/j.rcim.2019.101861>
- Dinh, L. T. N., Karmakar, G., & Kamruzzaman, J. (2020). A survey on context awareness in big data analytics for business applications. *Knowledge and Information Systems*, 62(9), 3387–3415. <https://doi.org/10.1007/s10115-020-01462-3>
- Dutta, D., & Bose, I. (2015). Managing a big data project: The case of Ramco cements limited. *International Journal of Production Economics*, 165, 293–306. <https://doi.org/10.1016/j.ijpe.2014.12.032>
- Elragal, A. (2014). ERP and Big Data: The Inept Couple. *Procedia Technology*, 16, 242–249. <https://doi.org/10.1016/j.protcy.2014.10.089>
- Fanning, K., & Grant, R. (2013). Big Data: Implications for Financial Managers. *Journal of Corporate Accounting and Finance*, 24(5), 23–30. <https://doi.org/10.1002/jcaf.21872>
- Félix, B. M., Tavares, E., & Cavalcante, N. W. F. (2018). Fatores críticos de sucesso para adoção de Big Data no varejo virtual: Estudo de caso do Magazine Luiza. *Revista Brasileira de Gestao de Negocios*, 20(1), 112–126. <https://doi.org/10.7819/rbgn.v20i1.3627>
- Fundamentals of Risk Management.* (n.d.).
- Gupta, S., Qian, X., Bhushan, B., & Luo, Z. (2019). Role of cloud ERP and big data on firm performance: a dynamic capability view theory perspective. *Management Decision*, 57(8), 1857–1882. <https://doi.org/10.1108/MD-06-2018-0633>
- How Big Data Is Transforming Enterprise Resource Planning? - Technicali - Various Tech Insights, Reviews, Alternatives & Guides.* (n.d.). Retrieved December 6, 2022, from <https://technicali.com/how-big-data-is-transforming-enterprise-resource-planning/>
- Tarigan, Z. J. H., Suprpto, W., & Basana, S. R. (2019, February). The effect of procedure change, TQM and ERP implementation to company performance on manufacturing industries. In *IOP Conference Series: Materials Science and Engineering* (Vol. 473, No. 1, p. 012052). IOP Publishing.
- Kenge, R., & Khan, Z. (2020). A Research Study on the ERP System Implementation and Current Trends in ERP. *Shanlax International Journal of Management*, 8(2), 34–39. <https://doi.org/10.34293/management.v8i2.3395>
- Khan, K. S., Kunz, R., Kleijnen, J., & Antes, G. (2003). Five steps to conducting a systematic review. In *J R Soc Med* (Vol. 96). <http://www.ncbi.nlm.nih.gov/entrez/query/>
- Romero, J. A., & Abad, C. (2022). Cloud-based big data analytics integration with ERP platforms. *Management Decision*. <https://doi.org/10.1108/MD-07-2021-0872>
- Singh, C. D., Singh, R., & Singh, M. (2013). Critical Appraisal For Implementation Of Erp In Manufacturing Industry. In *Int. J.*

Mgmt Res. & Bus. Strat. Retrieved from
<http://www.ijmrbs.com/currentissue.php>

Understanding Big Data and ERP. (n.d.).
Retrieved December 6, 2022, from
<https://blog.datixinc.com/blog/big-data-erp>



A Study on How Perceived Economic Crisis Affect on Consumer Attitudes Towards Shopping and Brand Switching for Dairy Products in Sri Lanka

Ranaweera EC¹, Wattegama EJ²

^{1,2} *Department of Industrial Management, Faculty of Applied Sciences, Wayamba University of Sri Lanka*

fas172127@kul.wyb.ac.lk¹

erandiw@wyb.ac.lk²

ABSTRACT

At present, the consumption behavior, attitudes toward shopping, and brand switching of Sri Lankan consumers for food and beverages have changed significantly due to the prevailing economic crisis in the country. This study aimed at comparing the effect of the perceived economic crisis on consumer attitudes toward shopping and brand switching for dairy products before and during the economic crisis. Primary data were collected from consumers who are employees and are above 18 years of age. Consumers' self-reported attitudes toward statements related to attitudes toward shopping and brand switching were extracted through a survey-based questionnaire and compared those responses using paired sample t-test to reveal if there was a statistically significant difference in consumers' attitudes before and during the economic crisis. The results revealed that consumers' attitudes toward shopping and brand switching were influenced by the prevailing economic crisis in Sri Lanka. The results also showed that when the economy recovers, Sri Lankan consumers stick to some of the decisions that they have made during the economic crisis and take steps to make new changes to their consumption behavior during the economic recovery.

KEYWORDS: Brand switching, Consumer attitudes toward shopping, Economic crisis

1 INTRODUCTION

Sri Lanka has been experiencing an economic crisis since early 2022 due to increasing inflation, weak governance, financial mismanagement, effects of COVID 19 pandemic, high foreign debt, ill-timed taxes, and political instabilities in major export markets, such as, the war between Russia and Ukraine (Majumdar, 2022). Moreover, all the essential goods that are available in the market are imported from other countries. According to the imports, exports, and inflation rate MoM in June 2022) it has shown a low import rate, high export rate, and high inflation rate (Reports of Central Bank of Sri Lanka, n.d.; Sri Lanka Inflation Rate MoM, 2022). When considering the dairy products, Sri Lankan consumers believe that those products as an integral in fulfilling their basic food

requirement (Vidanapathirana, 2019) within a given brand preference. However, at present the economic crisis that is prevailing in the country has caused for many consumers to reduce the demand for dairy products due to high prices in exported products, shortage in supplying of products domestically, and reluctant to shift from loyal brands to new brands. The reviewed literature has shown that there is a gap for studies that have focused on studying the effects of economic crises on changing the consumption and buying behavior of consumers of dairy products. As a result, the present study aimed to compare the effect of the economic crisis on consumer attitudes toward shopping and brand switching for dairy products before and during the economic crisis.

2 LITERATURE REVIEW

An economic crisis is “a situation of a marked deterioration in the main economic variables that remains for a prolonged period” (SAGE Encyclopedia of Economics and Society, 2016). The consumer attitudes are a summation of a consumer’s (1) beliefs about, (2) sentiments, (3) and behavioral intentions toward some object within the context of marketing, usually a brand or retail outlet. These components are viewed together since they are highly interdependent and together represent forces that influence how the consumer will react to the object (Perner, 2018). Before buying any product, consumers generally need to decide whether to buy this product or not. A five-stage decision-making process is presented to consumers; problem recognition, information search, evaluation of alternatives, purchase decision, and post-purchase evaluation (Stávková et al., 2008). When it is considering the dairy industry, dairy products are highly nutritious. According to the findings of Parimala and Suruthi (2022), the following ranking could be given when measuring the satisfaction level for dairy products; (1) good quality, (2) purchasing price, (3) good taste, (4) getting more flavors, (5) brands, and (6) gifts and offers while purchasing. If the cost of the product is increasing, it leads consumers to changes in quantity and brand or the type of product being purchased (Thompson, 2012).

According to Theodoridou et al. (2019), when it was investigating how people behave when it comes to purchasing food during the current economic crisis, they have found that in addition to socioeconomic factors, attitude, and perception must play a role in consumer behavior during an economic crisis. Voinea and Filip (2011) have

analyzed that 65% of American consumers use coupons and discount card promotions more often and prefer to acquire items at lower prices at the expense of comfort shopping with a focus on savings. Moreover, it was revealed that the majority of consumers who participated in the survey changed their consumption behavior by adopting a logical standby or a replacement, distinguishing their purchases, or giving up different brands.

3 METHODOLOGY

The population of present study was considered as the employees who are above 18 years of old. Accordingly, the recommended sample size was calculated as 385 using Krejcie and Morgan table. To achieve the objective of the study, the independent variable was selected as the perceived economic crisis and the dependent variables were selected as the consumer attitudes toward shopping and brand switching. Primary data were collected by conducting an online survey using a standard questionnaire. The questionnaire has introduced two sets of scenarios which explained the conditions before and during economic crises. Table 1 shows the details of selected variables and the results of the reliability test (Cronbach’s alpha). According to the results of the reliability test (as shown in Table 1), all the Cronbach’s alpha values obtained for each variable were greater than 0.7. Hence it was concluded that the questionnaire could be used to collect the data for the final analysis. The collected data were analyzed using IBM Statistical Software Package for Social Sciences (SPSS) and it was followed the paired sample t-test to compare consumers’ attitudes toward shopping and brand switching before and during economic crises.

Table 1: Details of Variables and Results of Reliability Test

	Variable	Type of Variable	Indicators	α Value	Source
Before Economic Crisis Situation	Perceived Economic Crisis	Independent	Q1. Perception on Inflation rate	0.743	(Einarsdottir, 2016)
			Q2. Perception on GDP growth rate		
			Q3. Perception on Purchasing power		
	Consumer Attitudes toward Shopping	Dependent	Q1. Looking for the lowest price.	0.754	
			Q2. Usage of coupon and discount card promotion		
			Q3. Quality and quantity		
			Q4. Starting to think more about what money is spent on		
	Consumer Attitudes toward Brand Switching	Dependent	Q1. Brand loyalty	0.707	
			Q2. Fun to try different brands		
Q3. Private label products					
During Economic Crisis Situation	Perceived Economic Crisis	Independent	Q1. Perception on Inflation rate	0.835	
			Q2. Perception on GDP growth rate		
			Q3. Perception on Purchasing power		
	Consumer Attitudes toward Shopping	Dependent	Q1. Looking for the lowest price.	0.702	
			Q2. Usage of coupon and discount card promotion		
			Q3. Quality and quantity		
			Q4. Starting to think more about what money is spent on		
	Consumer Attitudes toward Brand Switching	Dependent	Q1. Brand loyalty	0.738	
			Q2. Fun to try different brands		
Q3. Private label products					

Following hypothesis was established to achieve the objective of the study;

Hypothesis:

There is an impact of the economic crisis (before and during) in Sri Lanka on consumer attitudes toward shopping and brand switching for dairy products.

4 DATA COLLECTION AND ANALYSIS

After excluding illogical and incomplete questionnaires, only 302 responses were considered for the analysis. The results of the paired sample t-test (Table 2) showed that there was a statistically significant difference in the inflation rate, GDP growth rate, and purchasing power between before and during economic crises. The result of the same test for consumer attitudes towards shopping

(Table 2) showed that there was not any statistically significant difference in looking for the lowest price and starting to think more about what money is spent between before and during the economic crises. And also the results showed that there was a statistically significant difference in usage of coupon and discount card promotions, quality, and quantity between before and during the economic crises. Then, result of the paired sample t-test for consumer attitudes towards brand switching (Table 2) showed that there was not any statistically significant difference in brand loyalty and private label products. And the results showed that there was a statistically significant difference in fun to try different brands between before and during economic crises.

Table 2: Results of Paired Sample t-test

	Mean	Std. Deviation	Paired Differences					t	Sig. (2-tailed)
			Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference			
						Lower	Upper		
P EC Q1	3.030	1.068	-1.122	1.340	0.077	-1.274	-0.971	-14.57	0.000
D EC Q1	4.152	0.904							
P EC Q2	3.337	0.763	-0.710	1.154	0.06632	-0.840	-0.579	-10.7	0.000
D EC Q2	4.046	0.927							
P_EC_Q3	3.165	1.026	-0.792	1.487	0.08543	-0.960	-0.624	-9.271	0.000
D EC Q3	3.957	1.194							
P_Shopping_Q1	3.343	0.647	-0.082	0.765	0.04397	-0.169	0.004	-1.876	0.062
D Shopping Q1	3.426	0.587							
P_Shopping_Q2	2.865	0.618	-0.264	0.782	0.04495	-0.352	-0.176	-5.874	0.000
D Shopping Q2	3.129	0.671							
P Shopping Q3	3.399	0.678	0.251	0.933	0.0536	0.1453	0.356	4.679	0.000
D_Shopping_Q3	3.149	0.715							
P Shopping Q4	3.422	0.635	-0.009	0.908	0.05216	-0.113	0.093	-0.19	0.850
D_Shopping_Q4	3.432	0.647							
P BS Q1	2.868	0.648	-0.056	0.942	0.05412	-0.163	0.050	-1.037	0.301
D_BS_Q1	2.924	0.684							
P BS Q2	2.756	0.546	-0.158	1.027	0.05899	-0.274	-0.042	-2.686	0.008
D BS Q2	2.914	0.831							
P_BS_Q3	3.208	0.474	0.046	0.833	0.04783	-0.048	0.140	0.966	0.335
D BS Q3	3.162	0.683							

Df = 302

Where; P Pre Economic Crisis Situation EC Economic Crisis
D – During Economic Crisis Situation BS – Brand Switching

5 DISCUSSION

The results of the present study have shown that there was no significant difference in looking for the lowest price before and during the economic crises because Sri Lankan consumers always look for the lowest price when they purchase any product irrespective of whether there is an economic crisis or not as Sri Lanka is still a developing country. Although the consumers did not have much attitude towards using promotions before the crisis, during the

economic crisis, they had much more positive attitude towards using coupons or discount card promotions whenever it is possible. Previous studies have found that during the economic crisis, consumers have started to focus more on the quality, durability, and value of the product or service than they did before the economic crisis (for example, Sharma & Sonwalkar, 2013). The economic crisis in year 2022 of Sri Lanka has influenced the consumers' attitudes toward quality and quantity. Sri Lankan consumers had a significantly more positive attitude

toward the statement that “quality is more important than quantity” during the economic crisis. Moreover, the findings have revealed that there was no significant difference in starting to think more about what money is spent on before and during the economic crises because Sri Lanka has already thought about what and how money is spent even prior to the economic crisis. Moreover it was also shown that there was no significant difference in brand loyalty before and during economic crises because Sri Lankan consumers had a poor attitude towards brand loyalty for dairy products even before the economic crisis. Also, it was shown that there was a significant difference in fun to try different brands before and during economic crises. As Sri Lankan consumers think it is just fun to try different brands during the economic crisis. Most Sri Lankan consumers had thought that known brands were better than private-label products because Sri Lankan consumers do not have enough money to try private-label products during the economic crisis.

6 CONCLUSION

Based on the findings of the study, it is suggested that the economic environment has impacted on Sri Lankan consumers’ attitudes toward shopping and brand switching. Due to the economic crisis, the environment in Sri Lanka took drastic changes with low economic growth, increase in inflation rates, and decrease in purchasing power. During the economic crisis, the consumers did not become much more price conscious, because consumers became price conscious even before the economic crisis. But compared to pre economic crisis, the consumers started utilizing coupons and discount cards more to save money during the economic crisis. The economic downturn also has influenced the consumers’ attitudes toward quality and

quantity in the sense that following the crisis as Sri Lankan consumers think that quality is more than quantity during the economic crisis. Sri Lankan consumers had the same attitude during and prior to the economic crisis regarding what they spent money on. The negative sign of indicators of the economic crisis has influenced the consumers’ attitudes towards brand switching of Sri Lankan consumers but in a small way. Because Sri Lanka is still a developing country, hence Sri Lankans have less brand loyalty even prior to the economic crisis. As a result, there is not much more difference in brand loyalty between before and during economic crises.

REFERENCES

- Central Bank of Sri Lanka. (2023). Sri Lanka Inflation Rate MoM [Dataset]. In *The Consumer Price Index in Sri Lanka increased 2.90 percent in March of 2023 over the previous month*. Trading Economics. <https://tradingeconomics.com/sri-lanka/inflation-rate-mom>
- Central Bank of Sri Lanka. (n.d.). Annual Reports. In *Central Bank of Sri Lanka*. <https://www.cbsl.gov.lk/en/publications/economic-and-financial-reports/annual-reports>
- Einarsdóttir, H. (2016). *The impact of economic crisis on buying behavior and consumer attitudes* (Doctoral dissertation).
- Majumdar, R. (2022, March 28). What’s behind Sri Lanka’s economic crisis? *www.dw.com*. <https://www.dw.com/en/whats-behind-sri-lankas-economic-crisis/a-61281707>
- Parimala, M. & Suruthi, S. (2022). A Study on Customer Attitude towards Dairy Products in Madurai North. *ARIV - International Journal of Business*.
- Perner, L. (2018). *Consumer Behavior*. SAGE Encyclopedia of Economics and Society. (2016). Thousand Oaks: *SAGE Publications Inc.*
- Sharma, V., & Sonwalkar, J. (2013). Does Consumer Buying Behavior Change During Economic Crisis? *International Journal of Economics & Business Administration (IJEBA)*, 1(2), 33–48. Retrieved from <https://EconPapers.repec.org/RePEc:ers:ijeba:a:v:i:y:2013:i:2:p:33-48>

- Stavkova, J., Stejskal, L., & Toufarova, Z. (2008). Factors influencing consumer behaviour. *ZEMEDELSKA EKONOMIKA-PRAHA*
- Theodoridou, G., Tsakiridou, E., Kalogeras, N. & Mattas, K. (2019). The Impact of Economic Crisis on Greek Consumer Behaviour towards Food Consumption. *International Journal on Food System Dynamics*.
- Thompson, B. (2012). Impact of Financial and Economic Crisis on Nutrition–Policy & Programme.
- Vidanapathirana, R. (2019, April 5). Recent trends in milk production and consumption. *www.dailynews.lk*.
<https://www.dailynews.lk/2019/04/05/features/182279/recent-trends-milk-production-and-consumption>
- Voinea, L., & Filip, A. (2011). Analyzing the main changes in new consumer buying behavior during economic crisis. *International Journal of Economic Practices and Theories*



An Analysis of Turnover Intention of Frontend and Backend Web Developers in Sri Lanka

Fernando WHLN¹, Wattedgama EJ²

^{1,2} Department of Industrial Management, Faculty of Applied Sciences, Wayamba University of Sri Lanka
lachinnanu123@gmail.com¹
erandiw@wyb.ac.lk²

ABSTRACT

Due to the prevailing high employee turnover rate of frontend and backend web developers in the Sri Lankan IT Industry, IT firms are witnessing high HRM and administration issues. The objective of this study is to identify the significant factors that have an impact on the turnover intention of those employees as such identification is important for IT firms to make their strategies. Independent variables have been identified as job satisfaction, alternative job opportunity, recognition, organizational support, job stress, and organizational commitment to make the nexus with the turnover intention. Primary data were collected through an online survey using a standard questionnaire from randomly selected frontend and backend web developers. Pearson correlation test and multiple logistic regression analysis were performed to derive the results using R software. Using 203 no. of responses, it was found that job stress, alternative job opportunity, and organizational commitments are significant factors that have impacted the turnover intention among frontend and backend web developers. As managerial implications, it is recommended that IT firms consider these significant factors when they make HRM strategies to reduce the turnover rates of frontend and backend web developers in Sri Lanka.

KEYWORDS: Frontend and Backend Web Developers, Turnover Intention, IT Industry

1 INTRODUCTION

The IT industry in Sri Lanka has been accelerating rapidly for several years. As the revenue contribution from this industry, it is estimated to generate 1.8 billion USD by the end of 2022 (ICT Industry Information, n.d.). In the last decade, the overall strength of the workforce has been accelerated by 50.7% and is projected to leap further. IT firms try to attract the most knowledgeable and skillful employees as their workforce. However, the turnover of more experienced employees affects much more in the sense of productivity and cost. The firms have to bear the extra cost of recruitment and it takes considerable time. Frontend and backend web developers are the key backbone roles of any IT firm who are functioning

in web development, mobile application development, the domain of artificial intelligence, etc. Accordingly, the research problem of this study is identified as “What are the significant factors that are affecting the turnover intentions of frontend and backend web developers in Sri Lanka?”.

2 LITERATURE REVIEW

2.1 Turnover Intention

Employee turnover can be defined as the rate at which employees leave the organization. Unpreventable turnover occurs due to illnesses, family matters, or retirement. Desirable turnover happens when the employees do not have the core competencies to follow up with the responsibilities or their work (She et al., 2013).

2.2 *Development of Relationship among variables*

According to Ying & Linzhu (2010), there is a relationship between organizational commitment and the turnover intentions of IT operators in Wuhan, China. Five indicators have been selected to measure organizational commitment; affective commitment, normative commitment, ideal commitment, economic commitment, and opportunity commitment. The results of this study have found that there were negative relationships between every dimension of organizational commitment and turnover intentions. Another research study that focused on identifying the relationship between occupational job stressors and job satisfaction level and turnover intentions among Chinese knowledge workers found that knowledge workers who have high-stress levels in workload, co-workers, and physical conditions, were having low attitudes towards the job and having high turnover intentions (Yuhui, 2011). The direct effect of personal organizational fit on turnover intention was not significant and only person-manager fit had a significant effect. The company policies, managers, and co-workers make a significant impact on employee job satisfaction, and only a person-manager is negatively correlated with turnover intentions (Chunjiang, Honglan & Ye, 2011). The results of this study revealed that there is the greatest turnover risk among employees who have a passion for entrepreneurship in both founding and inventing. The low intrapreneurship in the organization has also significantly affected turnover intentions (Bulmash, & Winokur, 2020). In another study which

has focused on key factors that are affecting job satisfaction and its effects on employee retention in Gulf cooperation countries, employee recognition was found as a key factor that is resulting in turnover intentions of the employees. Friendly-based environments, best remuneration packages, etc. will increase retention capabilities and reduce turnover intentions (Santhanam, Jayaraman, & Badrinath, 2012). According to Li, Yuchuan, & Feng-jiang (2011), it has relied on organizational support which directly affects the job satisfaction levels of the employees and the results of this study have supported that high satisfaction with work support leads the employees to be more satisfied with organizational resources and therefore their retentions levels are more likely to increase and turnover intentions are more likely too low.

3 METHODOLOGY

Since the study expects to identify the significant factors that impact employee turnover intention using available literature, the research design was explanatory and used quantitative and qualitative variables. To achieve the study objective, the following model has been established along with the hypotheses.

Hypothesis: There is a significant effect of job satisfaction, alternative job opportunity, recognition, perceived organizational support, job stress, and organizational commitment on the turnover intention of frontend and backend web developers in Sri Lanka.

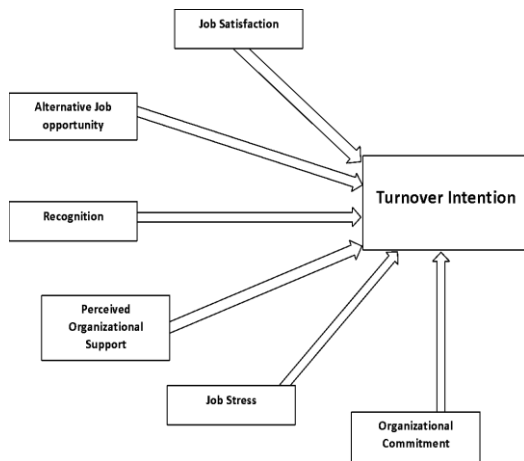


Figure 1: Research Model

The sample size was determined as 383 frontend and backend web developers who are currently working in IT firms in Sri Lanka based on the Krejcie and Morgan formula with a population of 113,000 employees and a confidence interval of 95%. An online survey-based questionnaire was used to collect the data. The respondent was selected randomly. Cronbach's alpha test was carried out using data that were collected from a pilot test to check the reliability of the questionnaire. The correlation analysis was performed to identify the relationships among the variables while multiple logistic regression analysis was used to investigate the impact because this is a binary classification problem. R software was used for the analysis.

4 DATA COLLECTION AND ANALYSIS

Table 1 shows the results of the reliability analysis and all the values were greater than 0.8. Hence the reliability of the data was secured and the questionnaire could be used for the final survey.

Table 1: Cronbach's Alpha Values

Variable	α Value
Job Satisfaction	0.875
Alternative Job Opportunity	0.876

Job Recognition	0.923
Organization Support	0.886
Job Stress	0.780
Organizational Commitment	0.856

After excluding illogical and incompleting questionnaires, only 203 responses were considered for the analysis.

5 RESULTS AND DISCUSSION

Based on the results of the descriptive statistics, the majority of the respondents were males who belonged to the age category of 20-30 years and were unmarried. 69% of respondents were degree holders. Most of the respondents were following their careers as full-stack developers. 80.80% of respondents were full-time employees and 151 respondents were not willing to relocate from their working place. The mode of work of most of the respondents worked from home.

5.1 Correlation Analysis

Table 2: Correlation Analysis

Variable	Correlation with turnover	P - value
Job Satisfaction	0.4857	0.000
Alternative Job Opportunity	0.5661	0.000
Recognition	-0.5061	0.000
Organizational Support	0.5155	0.000
Job Stress	0.6606	0.000
Organizational Commitment	-0.6091	0.000

The results of the correlation analysis as shown in Table 2, that job satisfaction, job recognition, organizational support, and organizational commitment were having a moderately negative relationship with the turnover intentions of frontend and backend developers. However, the variables of alternative job opportunities and job stress were having a positive

moderate relationship with the turnover intentions of those employees.

5.2 Regression Analysis

According to the results as shown in Table 3, p-values of alternative job opportunity, job stress, and organizational commitment were less than 0.05, which rejected the null hypothesis and statistically proved that there were significant relationships between those variables and turnover intention. Among those variables, job stress was found as a critical factor and it was significant especially for the web developers due to the high workload. The organizational commitment toward employee well-being was highly concerned for the web developers

because they believed that continuous development is essential for the web developers to move on with new technologies. However, p-values of job satisfaction, recognition, and organizational support were greater than 0.05, which concluded that those variables were not having any significant relationship with turnover intentions. Since the IT field is highly demanded, there are so many opportunities and those web developers can easily find out satisfactory jobs in the market.

Table 3: Results of Multiple Logistic Regression

Logit Regression Results						
Dep. Variable:	Turnover Intention	No. Observations:	203			
Model:	Logit	Df Residuals:	197			
Method:	MLE	Df Model:	5			
Date:	Thu, 29 Dec 2022	Pseudo R-squ.:	0.6329			
Time:	06:16:52	Log-Likelihood:	-40.320			
converged:	True	LL-Null:	-109.85			
Covariance Type:	nonrobust	LLR p-value:	2.843e-28			
	coef	std err	z	P> z	[0.025	0.975]
Job Satisfaction	-0.0461	0.708	-0.065	0.948	-1.434	1.342
Alternative Job Opportunity	1.4283	0.551	2.594	0.009	0.349	2.507
Recognition	-0.4688	0.838	-0.559	0.576	-2.111	1.174
Organizational Support	-1.1078	0.752	-1.473	0.141	-2.582	0.366
Job Stress	1.6205	0.508	3.187	0.001	0.624	2.617
Organizational Commitment	-1.4410	0.671	-2.148	0.032	-2.756	-0.126

6 CONCLUSION

This study aimed at identifying the significant factors that are affecting the turnover intention of frontend and backend web developers in the IT industry in Sri Lanka. The results revealed that alternative job opportunities, job stress, and organizational commitment were the

significant factors that are affecting the turnover intention among the employees. Hence, IT firms should have to consider these factors to make employee retention strategies for the job position of frontend and backend web developers as they are skilled employees and the return on investments for training and development of those employees has to be maximized to earn profits from this industry.

As a limitation, the number of respondents was found as fairly small to generalize the study findings. Moreover, there were huge biases in the age category of the respondents since most of the respondents were from the age group of 20-30. For future work, it is recommended to do a depth study on this topic by collecting data from employees who have changed the workplace more recently. Also, only two major roles; frontend and backend developers have been focused on here but future studies can be extended in such a way as to analyze the turnover intentions of all the major job roles in the IT industry in Sri Lanka

REFERENCES

- Bulmash, B., & Winokur, M. (2020). Entrepreneurial passion and turnover intentions: The role of intrapreneurship opportunities and risk tolerance. *2020 IEEE International Conference on Industrial Technology (ICIT)*, 1205–1209. doi:10.1109/ICIT45562.2020.9067259
- Chunjiang, Y., Honglan, W., & Ye, L. (2011). The effects of person-organization fit on job satisfaction and turnover intention The case of service industries. *2011 International Conference on Business Management and Electronic Information*, 2, 320–323. doi:10.1109/ICBMEI.2011.5917911
- ICT Industry Information- Service Providers in Sri Lanka - EDB. (n.d.). *ICT Industry Information - Service Providers in Sri Lanka - EDB*. Retrieved February 8, 2023, from <https://www.srilankabusiness.com/ict-services/about>.
- Santhanam, G., Jayaraman, R., & Badrinath, V. (2012). Influence of perceived job satisfaction and its impacts on employee retention in Gulf Cooperation Countries. *Conference Proceeding: 2012 - International Conference on Management Issues in Emerging Economies, ICMIEE 2012*, pp. 69-73. Retrieved from https://www.researchgate.net/publication/261394538_Influence_of_perceived_job_satisfaction_and_its_impacts_on_employee_retention_in_Gulf_Cooperation_Countries.
- She, C.K., Thoong, L.S., See, S.N.& Qing, T.H. (2013). A Study on factors that impact turnover intent of employees among SME firms in ICT industry. *UTAR Institutional Repository - University Tunku Abdul Rahman*. Retrieved from <http://eprints.utar.edu.my/id/eprint/1023>.
- Ying, X., & Linzhu, W. (2010). Empirical Research on the Relationship between Organizational Commitment and Turnover Intention of Wuhan Telecom Best Tone Center. *International Conference on Management and Service Science, 2010*, pp. 1-5. doi:10.1109/ICMSS.2010.55786202010
- Yuhui, L. (2011). Occupational stressors, turnover intention and the mediating influence of job satisfaction: Evidence from China. *IEEE International Conference on Quality and Reliability, 2011*, pp. 341-344, doi: 10.1109/ICQR.2011.6031738.
- Z. Li, L. Yu-chuan, & L. Feng-jiang. (2011). Work support and turnover intention: The mediating roles of work-to-family conflict and facilitation. *2011 International Conference on Management Science & Engineering 18th Annual Conference Proceedings*. pp. 726-732, doi: 10.1109/ICMSE.2011.6070042.



Antecedents of Intention for e-HRM Adoption – A Case Study of the Sri Lankan Apparel Sector

Edirisinghe EADDD¹, Deegahawature MMDR²

Department of Industrial Management, Faculty of Applied Sciences, Wayamba University of Sri Lanka
dilesha98dde@gmail.com¹
dharsana@wyb.ac.lk²

ABSTRACT

Many organizations are moving toward e-HRM adoption because organizations that have implemented e-HRM have utilized human resources effectively and enjoyed a complete edge. To promote the adoption of e-HRM, this study attempts to identify the antecedents of e-HRM adoption in the apparel industry in Sri Lanka. The study hypothesized that system usefulness, organizational resources, and social influence are positively related to the intention for e-HRM adoption. Data were collected from 120 HR employees in 60 apparel sector firms in Sri Lanka using previously tested measures. The data were analyzed by descriptive statistics and multiple regression analysis. The results reveal that the independent variables significantly predict the intention for e-HRM adoption. Thus, the independent factors of system usefulness, organizational resources, and social influence positively affect the choice for e-HRM adoption in the apparel sector in Sri Lanka. The apparel sector can use the findings of this study to promote the e-HRM with the aim of achieving its benefits and opportunities.

KEYWORDS: e-HRM, System Usefulness, Organizational Resources, Social Influence

1 INTRODUCTION

Many organizations are adopting e-HRM because they recognize the opportunities of integrating information technology and human resources management. Organizations must comprehend how technological, organizational and social factors affect their goals to achieve the desired goals of adopting e-HRM. The intention to adopt e-HRM is positively or negatively influenced by these antecedents. The Technology, Organization, and People (TOP) framework proposed by Bondarouk, Parry, and Furtmueller (2017) primarily summarizes e-HRM adoption antecedents. Social factors, which are an antecedent of e-HRM adoption, have been neglected by many researchers in predicting e-HRM adoption. However, according to

Venkatesh et al., (2003), social factors also play a significant part in adopting e-HRM. However, there is a scant of scientific inquiries that focus on the TOP framework along with the social factors. Aiming at this research gap, the study plans to investigate the effect of social factors along with the technology, and organizational factors as the antecedents of e-HRM adoption. Accordingly, the objective of this study is to examine the factors influencing the intention for adopting e-HRM in the apparel industry in Sri Lanka.

2 REVIEW OF LITERATURE

2.1 e-HRM adoption

Strohmeier (2007) has defined e-HRM as the ‘planning, implementation and application of information technology for both networking and supporting at least two individual or

collective actors in their shared performing of HR activities'. The definition of e-HRM adoption by Bondarouk, Parry, and Furtmueller (2017) was 'the strategy and transfer process between an old (or non-existent) and a targeted e-HRM system and its acceptance by the users'. Organizations are more focused on adopting e-HRM due to the rapid changes and development of information technology to more profits (Waheed et al., 2020).

2.2 Antecedents of e-HRM adoption

The TOP framework, developed by Bondarouk et al., (2017), categorizes e-HRM adoption into three categories: technology, organization, and people. This framework is used to summarize the antecedents of e-HRM adoption. According to Venkatesh et al., (2003), social factors like social pressure can have an impact on a person's desire to use information technology and also have an effect on the adoption of e-HRM.

System usefulness has been identified by Bondarouk et al., (2017) as a technological factor affecting the adoption of e-HRM. According to Zhou et al., (2021), perceived usefulness can be coded as system usefulness. The definition of perceived usefulness given by Davis (1989) was 'the extent to which a person believes that using a particular system would enhance his or her job performance'.

One of the organizational factors influencing the adoption of e-HRM was organizational resources (Bondarouk et al., 2017). The adoption of e-HRM is encouraged by organizations with sufficient IT infrastructure, training, and

technical support (Bhattacharjee & Hikmet, 2008).

Three root constructs, including subjective norm, social factor and image have been identified to measure social impact by Venkatesh et al., (2003), who concluded that social influence also influences the adoption of e-HRM.

3 METHODOLOGY

3.1 Research Design

This descriptive study aims to examine the relationship between the adoption of e-HRM and its antecedents through a case study of several firms in the Sri Lankan apparel industry. This study discussed the variables affecting the intention to adopt e-HRM in the Sri Lankan apparel sector. Here, system usefulness, organizational resources, and social influence are used as independent variables, and intention to adopt e-HRM is used as the dependent variable. System usefulness was measured in perceived usefulness, and the scale was adapted from Venkatesh et al., (2003). Organizational resources were estimated in Information Technology infrastructure, training, and technical support, and scales were adapted from Bhattacharjee & Hikmet (2008) and Snell & Dean (1992). Social influence was measured in the subjective norm, social factor, and image, and scales were adapted from Venkatesh et al., (2003). Intention for e-HRM adoption was measured by using a scale adapted from Venkatesh et al., (2003). One hundred twenty responses from a total of 60 apparel sector firms were considered. Two HR employees were surveyed in each factory to ensure that the data was unbiased. Data were analyzed by

descriptive analysis and multiple regression.

3.2 Hypothesis

The research model is presented in Figure 01. The study postulates the following hypotheses.

H1: System usefulness positively affects the intention for e-HRM adoption.

H2: Organizational resources positively affect the intention for e-HRM adoption.

H3: Social influence positively affects the intention for e-HRM adoption.

4 DATA COLLECTION AND ANALYSIS

Previously tested standard measures found in the literature were used to gather primary data through a questionnaire. The responses were collected over a five-point Likert scale. Five workers in each garment factory's HR department were asked to respond to the questionnaire. There were only 130 responses collected, though. As a result, the analysis included 120 responses from 60 garment factories, including two responses from the HR departments of each factory. SPSS software was used to analyze the data that had been collected. Multiple regression techniques were used to test the hypotheses.

5 RESULTS AND DISCUSSION

5.1 Validity and Reliability

Table 01: Reliability Statistics for all variables separately

Variable	Cronbach's Alpha	Sig
Intention for e-HRM adoption	.574	.001
System Usefulness	.795	.000
Organizational	.754	.000

Resources		
Social Influence	.621	.000

The reliability statistics show that Cronbach's Alpha values for e-HRM adoption, system usefulness, organizational resources, and social influence were found to be 0.574, 0.765, 0.754, and 0.621, respectively. Therefore, the research instrument was reliable and would produce accurate results, and internal consistency was assured.

5.2 Correlation Analysis

According to Table 02, the correlations between the system usefulness, organizational resources, social influence, and intention for e-HRM adoption were statistical significance at the 0.01 level with a Pearson correlation coefficient of +0.331, +0.389, and +0.290, respectively. According to the findings, intention for e-HRM adoption was moderately positively correlated to system usefulness, organizational resources, and social influence.

Table 02: Correlations between independent variables and dependent variable

		1	2	3	4
1 e-HRM adoption	Pearson Correlation	1			
2 System Usefulness	Pearson Correlation	.331**	1		
3 Organizational Resources	Pearson Correlation	.389**	.396**	1	
4 Social Influence	Pearson Correlation	.290**	.282**	.264**	1

** Correlation is significant at 0.01 level (2-tailed)

N=120

5.3 Multi-Regression Analysis

Pearson correlation coefficients from the inter-correlation matrix were found to be less than 0.9. Also, the tolerance values were greater than 0.2, and VIF values were less than 5. As a result, the

tolerance and VIF values are within the expected range, alleviating the concern of multicollinearity. Thus, multiple regression analysis was carried out to test the hypotheses.

Table 03: Model Summary

R	R Square	F	Sig	Durbin-Watson
.462	.213	10.487	.000	2.191

Table 03 summarizes the model statistics, with a significance R square value $P < 0.05$. The summary indicates that system usefulness, organizational resources, and social influence predicted 21.3% of the variants in intention for e-HRM adoption. The Durbin-Watson statistic was 2.191 and ranged between +1 and +3, indicating that the observations were independent.

Table 04: Coefficients of regression model

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.564	.429		3.642	.000
	System_usefulness	.157	.082	.175	1.909	.059
	organizational_resources	.340	.113	.275	3.021	.003
	Social_influence	.122	.063	.168	1.923	.057

a. Dependent Variable: eHRM_adoption

The unstandardized coefficients for system usefulness, organizational resources, and social influence were 0.157, 0.340, and 0.122 respectively, and they are statistically significant.

Accordingly, the three independent variables of System Usefulness, Organizational Resources, and Social Influence positively affect the intention for e-HRM adoption, supporting the postulated effects in the hypotheses. Thus, H1, H2, and H3 were accepted.

6 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

This study aimed to identify the predictors of intention to adopt e-HRM in the Sri Lankan apparel industry. As a result of developing an integrated research model, system usefulness, organizational resources, and social influence were proven and demonstrated as antecedents of e-HRM adoption in the Sri Lankan apparel industry. All three variables influence the intention to adopt e-HRM. The findings of the study support and confirm the theory in predicting the intention to adopt e-HRM. In addition to the technology and organizational factors identified by Bondarouk et al., (2017) as antecedents of e-HRM adoption, the social factor identified by Venkatesh et al., (2003) also influences e-HRM adoption. As a result, system usefulness, organizational resources, and social influence factors influence the intention to adopt e-HRM in Sri Lankan apparel sector firms.

6.2 Recommendations

Researching the antecedents of e-HRM adoption has shown that the social factor also affects e-HRM adoption. Hence, in addition to improving IT infrastructure, conducting training sessions, etc., the senior management and supervisors are supposed to excel in social factors to effectively adopt e-HRM.

6.3 Limitations and Further Study

This study was limited to 60 garment factories in eight districts. Thus, future researchers can extend the study across different district garment factories.. Due to time constraints, the sample size was

limited to 120 respondents. These limitations may be addressed by future researchers.

REFERENCES

- Bhattacharjee, A., & Hikmet, N. (2008). Reconceptualizing organizational support and its effect on information technology usage: Evidence from the health care sector. *Journal of Computer Information Systems, 48*(4), 69–76.
- Bondarouk, T., Parry, E., & Furtmueller, E. (2017). Electronic HRM: Four decades of research on adoption and consequences. *The International Journal of Human Resource Management, 28*(1), 98–131.
- Davis, F. D. (1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Quarterly, 13*(3), 319-339.
- Snell, S. A. & Dean, J. A. Jr. (1992). Integrated manufacturing and human resource management: a human capital perspective. *Academy of Management Journal, 35*(3), 467-504.
- Strohmeier, S. (2007). Research in E-HRM: review and implications. *Human Resource Management Review, 17*(1), 19–37.
- Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly, 2*(3), 425–478.
- Waheed, A., Xiaoming, M., Waheed, S., Ahmad, N., & Tiantian, S. (2020). E-HRM implementation, adoption and its predictors: a case of small and medium enterprises of Pakistan. *International Journal of Information Technology and Management, 19*(2-3), 162-180.
- Zhou, Y., Cheng, Y., Zou, Y., & Liu, G. (2021). e-HRM: A meta-analysis of the antecedents, consequences, and cross-national moderators. *Human Resource Management Review, 32*(4), 100862.



Benefits and Challenges of Blockchain Integrated ERPs: A Systematic Review of Literature

H.Y. Kodithuwakku¹, H.M. Isira², B. Rathnayake³, R. Wickramarachchi⁴, A. Withanaarachchi⁵

^{1,2,3,4,5}*Department of Industrial Management, Faculty of Science, University of Kelaniya, Sri Lanka*

*kodithuw_im17041@stu.kln.ac.lk*¹

*lakshanh_im17043@stu.kln.ac.lk*²

*rathnaya_im17064@stu.kln.ac.lk*³

*ruwan@kln.ac.lk*⁴

*amilaw@kln.ac.lk*⁵

ABSTRACT

An Enterprise Resource Planning (ERP) system is a complex, highly integrated software package for a business organization that provides extensive benefits and facilities to the whole enterprise. Blockchain technology has been applied in many fields to improve information systems management and data security. The integration of blockchain technology and ERP systems has gained significant attention in recent years. While ERP systems provide extensive benefits to organizations, they face various challenges. This paper presents a Systematic Literature Review conducted using Kitchenham's methodological guidelines to explore the benefits and challenges of blockchain-integrated ERP systems. The review involved a comprehensive search of relevant literature, including 20 studies that met the predefined criteria. The findings of the review indicate that the integration of blockchain technology with ERP systems can enhance security and data integrity, improve transparency, streamline operations, decentralized control, facilitate information sharing, and improve economic transactions. However, the integration process poses several challenges, including resistance to change, issues related to organizational culture, scalability concerns, lack of standardization and interoperability, restrictions on payload size, data validation latency, lack of global legal and regulatory frameworks, and high implementation costs. The results of this review provide valuable insights for organizations considering integrating blockchain technology and ERP systems. This review helps organizations make informed decisions about whether and how to proceed with blockchain integration by identifying the potential benefits and challenges associated with this integration.

KEYWORDS: Blockchain integrated ERP, ERP systems, Blockchain, Enterprise systems integration

1 INTRODUCTION

ERPs, now the most effective solutions for sharing information, primarily concentrate on internal procedures and relational, centralized databases. ERP vendors have realized in recent years that Blockchain will seriously disrupt their existing systems (Parikh, 2018).

In addition to upgrading ERPs to a new and high level of integration among all stakeholders, such as manufacturers, suppliers, customers, governments, etc.,

Banerjee predicted that the introduction of Blockchain would also do so. According to him, the immutability of blockchain technology guarantees stakeholders that transaction records are not altered at any point, which enables the extension of audit trails through the process (Banerjee, 2018). Modern ERP systems are designed to foster close cooperation between various organizational units.

2 METHODOLOGY

The systematic literature review was conducted using Kitchenham's

methodological guidelines to discover the knowledge available in the related fields (Kitchenham et al., 2010).

2.1 *Search Strings and Digital Libraries*

A single searching method was used to select papers on blockchain-integrated ERP systems. The selection was made in September 2022 and covered studies published until that time. A predefined set of keywords and inclusion/exclusion criteria were used to reduce selection bias and ensure paper quality and relevance. Benefits and advantages were treated as equivalent terms: drawbacks, challenges, and disadvantages.

The authors selected twenty articles based on the title and content in the abstract.

2.2 *Exclusion Criteria and Selection*

Following are the exclusion criteria defined to select the candidate papers:

CR1: Exclude all papers not already published in a peer-reviewed conference, journal, report, or workshop.

CR2: Include only the publications written in English.

CR3: Include the publications published at any time through the years.

CR4: Exclude all the papers that did not address the benefits or challenges of Blockchain-integrated ERP.

2.3 *Data Extraction*

In this study, the authors performed data extraction and article quality assessment. The frequency analysis was conducted for each identified benefit and challenge to determine the most common ones. The literature review presents the results of the analysis as percentages, allowing for a quantitative analysis of the

most commonly identified benefits and challenges associated with the integration of blockchain technology and ERP systems.

3 LITERATURE REVIEW

3.1 *Benefits of Blockchain-integrated ERP*

In this section, we classify the various benefits of integrating ERP systems with blockchain-enabled applications.

Security and Data Integrity (Frequency- 50%)

ERPs can benefit from enhanced security by integrating blockchain, which complicates access permission for members and third parties. Data is stored on all network servers, but none can control or modify information without agreement from connected computers, ensuring data integrity and cryptographic security (Hader et al., 2021; Kostyuk et al., 2020; Hrishev, 2020). Blockchain and smart contracts can provide an additional layer of access control by verifying and authenticating identities, particularly for sensitive information (Haddara, 2021).

Transparency (Frequency- 30%)

Blockchain technology delivers end-to-end transparency and visibility in SC networks through innovative traceability mechanisms for products and processes (Banerjee, 2018). Once verified, the information in each block is copied to all nodes, resulting in network transparency (Hader et al., 2021).

Automation and streamlining of operations. (Frequency- 55%)

When combined with ERP systems, blockchain technology, and smart contracts can automate and streamline

logistics processes as well as improve the overall organizational efficiency of massive SC networks. Smart contract automation may also assist in managing supply-side logistics operations (purchasing cycle) effectively and efficiently while shortening lead times for acquiring raw materials. (Tönnissen & Teuteberg, 2018).

Decentralization (Frequency- 35%)

Blockchain can unite an extensive supply chain network thanks to its decentralized system. As this technology relies on a network, any entity does not control it, but the access is shared among all the users to verify the validity of transmitted data (Banerjee, 2018; Hader et al., 2021).

Information Sharing (Frequency- 60%)

Blockchain integration with ERP systems streamlines and enhances supply chain operations by sharing transparent and decentralized information (Banerjee, 2018). A blockchain network can serve as a middleware, connecting multiple ERP systems and enhancing information-sharing capabilities (Tönnissen & Teuteberg, 2018).

Improved economic transactions. (Frequency- 30%)

Integrating ERP and blockchain facilitates efficient and reliable data exchange across various businesses, which is especially helpful when accounting for financial and other commercial activities (Kaid & Eljazzar, 2018). Blockchain's permanent documentation of transactions may also ensure the verifiability and traceability of ERP records involving accounting or

financial records (Faccia & Petratos, 2021).

3.2 *Challenges of Blockchain-integrated ERP*

Various ERP - blockchain integration challenges are discussed in this section.

Resistance-to-change (Frequency- 65%)

Findings indicate resistance to adopting Blockchain technology despite the advantages. Recent studies from the shipping sector indicate that implementing new ERP systems was met with employee resentment, and prospective integration with blockchain technology would result in a similar situation (Papathanasiou et al., 2020).

Organizational Culture (Frequency- 50%)

Many organizations struggle to manage the technological uncertainty around blockchain because they lack organizational capabilities and a corporate culture ready to embrace new technologies. Any ERP-blockchain integration would require technical staff and employees to undergo time-intensive training (Papathanasiou et al., 2020).

Scalability (Frequency- 40%)

Blockchain platforms encounter this scalability limitation when rapidly managing large volumes of transaction data. Given the massive volume of transactions in contemporary supply chain networks, scalability may be a serious barrier to integrating ERP and blockchain. (Casino et al., 2019)

Lack of standardization and interoperability (Frequency- 35%)

Integrating ERP systems with blockchain faces significant challenges due to the diverse ERP solutions and blockchain architectures available in the market (Tönnissen & Teuteberg, 2018). Moreover, interoperability issues among various blockchain networks are crucial to Web3, as blockchains must interact seamlessly with ERP and other blockchain systems (Zheng et al., 2021).

Payload size restriction (Frequency-25%)

Every blockchain network has a payload size limit, whether open or private. There will be transactions that become invalid owing to size because the payload is finite. Due to payload limitations, this raises concerns about network and infrastructure issues. (Banerjee, 2018).

Data validation latency (Frequency-35%)

Data blocks in open network blockchains are validated and queued by miners for each transaction, but latency must be minimized for practical use in supply chain operations with timely decision-making (Banerjee, 2018; Haddara, 2021).

Lack of global legal and Regulatory Frameworks (Frequency- 20%)

The lack of a global legislative framework is one of the main challenges to advancing and accepting blockchain technology worldwide (Banerjee, 2018).

Costs (Frequency- 60%)

Integrating blockchain with ERP systems requires significant financial investments, including onboarding and maintenance costs as well as data storage costs on the blockchain, which is stored

on the cloud. Decision-makers must consider the financial cost and potential risks associated with ERP blockchain integration (Balasubramanyam, 2020; Papathanasiou et al., 2020).

4 CONCLUSION

Based on the findings, it is recommended that organizations consider integrating blockchain technology with their ERP systems to improve their digital transformation efforts. While several challenges are associated with this integration, the benefits make it a worthwhile investment for organizations. To ensure successful integration, organizations should carefully evaluate the potential benefits and challenges, as well as develop strategies to address any issues that may arise during the implementation process. This may involve providing training and support to employees to help them adapt to the new technology, as well as establishing standardized protocols for data validation and interoperability. It is also recommended that organizations consider working with experienced consultants or third-party providers to ensure successful implementation and long-term success.

Overall, by carefully considering the benefits and challenges and developing a comprehensive implementation strategy, organizations can position themselves for success in an increasingly digital and competitive business environment.

REFERENCES

- Balasubramanyam, K. (2020, February). Adaptation of Block Chain Technology in manufacturing sector. In *2020 International Conference on Mainstreaming Block Chain Implementation (ICOMBI)* (pp. 1-13). IEEE.
- Banerjee, A. (2018). Blockchain technology: supply chain insights from ERP. In *Advances*

BENEFITS AND CHALLENGES OF BLOCKCHAIN INTEGRATED ERPS: A SYSTEMATIC
LITERATURE REVIEW

- in computers* (Vol. 111, pp. 69-98). Elsevier.
- Casino, F., Dasaklis, T. K., & Patsakis, C. (2019). A systematic literature review of blockchain-based applications: Current status, classification and open issues. *Telematics and informatics*, 36, 55-81.
- Faccia, A., & Petratos, P. (2021). Blockchain, enterprise resource planning (ERP) and accounting information systems (AIS): Research on e-procurement and system integration. *Applied Sciences*, 11(15), 6792.
- Haddara, M., Norveel, J., & Langseth, M. (2021). Enterprise systems and blockchain technology: The dormant potentials. *Procedia Computer Science*, 181, 562-571.
- Hader, M., El Mhamedi, A., & Abouabdellah, A. (2021, January). Blockchain Integrated ERP for a Better Supply Chain Management. In 2021 *The 8th International Conference on Industrial Engineering and Applications (Europe)* (pp. 193-197).
- Hrischev, R. (2020, June). ERP systems and data security. In *IOP Conference Series: Materials Science and Engineering* (Vol. 878, No. 1, p. 012009). IOP Publishing.
- Kaid, D., & Eljazzar, M. M. (2018, December). Applying blockchain to automate installments payment between supply chain parties. In *2018 14th International Computer Engineering Conference (ICENCO)* (pp. 231-235). IEEE.
- Kitchenham, B. A., Brereton, P., Turner, M., Niazi, M. K., Linkman, S., Pretorius, R., & Budgen, D. (2010). Refining the systematic literature review process—two participant-observer case studies. *Empirical Software Engineering*, 15, 618-653.
- Kostyuk, P., Kudryashov, S., Madhwal, Y., Maslov, I., Tkachenko, V., & Yanovich, Y. (2020, April). Blockchain-based solution to prevent plastic pipes fraud. In *2020 Seventh International Conference on Software Defined Systems (SDS)* (pp. 208-213). IEEE.
- Papathanasiou, A., Cole, R., & Murray, P. (2020). The (non-) application of blockchain technology in the Greek shipping industry. *European Management Journal*, 38(6), 927-938.
- Parikh, T. (2018). The ERP of the future: blockchain of things. *Int. J. Sci. Res. Sci. Eng. Technol*, 4(1), 1341-1348.



Competitive Priorities of the Post COVID-19 Pandemic in the Sri Lankan Manufacturing Sector

Fernando WISN¹, Balasooriya BMAM², Dilanthi MGS.³

Department of Industrial Management, Faculty of Applied Sciences, Wayamba University of Sri Lanka

*Sasininf1996@gmail.com*¹

*amandabalasooriya0629@gmail.com*²

*shanikadilanthi@gmail.com*³

ABSTRACT

Globalization and rapid technological changes have increased manufacturers' interest in competitive priorities. These priorities are useful in the decision-making process and have changed drastically over the years. However, a study to evaluate the competitive priorities of the manufacturing sector for the COVID-19 pandemic could not be found yet in the accessible Sri Lankan research context. Therefore, the aim of this study was to identify the common competitive priorities in the Sri Lankan manufacturing sector for the post pandemic situation. The exploratory factor analysis was used to identify the competitive priorities. Stratified random sampling technique was used to select the sample for the study. Based on 72 survey data from 36 manufacturing companies in the Western province, delivery time was the most strongly emphasized competitive priority in the pandemic situation. It was significant to identify the key priorities of the manufacturing sector in an unexpected external event, and it was beneficial to small-scale manufacturing firms to develop their processes to adapt to such uncontrollable external events. The results of this research would help small and medium-sized enterprises reshape their competitive priorities to survive in the market.

KEYWORDS: Competitive Priorities, COVID-19, Pandemic Situation, Manufacturing Sector

1 INTRODUCTION

Due to globalization and rapid technological developments, manufacturers' interest in competitive priorities has increased (Takala et al., 2003). These useful decision-making competitive priorities have shifted dramatically over time (Takala, 2002). Manufacturing is one of the numerous industries affected by the COVID-19 epidemic, as it provides for some of humanity's most fundamental requirements. Traditional viewers think that a product's price determines the competition (Russel & Millar, 2014). In practice, though, there may be additional considerations, including cost, quality, flexibility, time, and innovation.

Therefore, choosing the best priority is crucial for an organization. According to the IIP 2021, the manufacturing sector's



Figure 1: Index of Industrial Production by Industry Divisions

overall IIP dropped in 2020 (Figure 1).

Additionally, from 2020 to 2021, the global IIP grew marginally by 2.83 per cent. This demonstrates how the

manufacturing industry has altered its operations to deal with the pandemic's effects. Therefore, the objective of this study was to identify the competitive priorities among the Sri Lankan manufacturing sector for the post pandemic situation.

2 LITERATURE REVIEW

A company's ability to compete might be influenced by its manufacturing function (Skinner, 1969). The phrase "competitive priorities" was initially introduced by Hayes and Wheelwright in 1984. They defined it as a company's strategic preferences or the dimensions along which it chooses to compete in the targeted market.

Identifying the competitive priorities of manufacturing firms has been considered a key element in manufacturing strategy research (Russell & Millar, 2014). Cost is defined as low-cost production and delivery (Dangayach & Deshmukh, 2003). The extent to which the manufacturing company is able to provide products of a quality that would meet customers' expectations is one approach to define quality (Koufteros, Vonderembse, & Doll, 2002). According to Spring and Boaden (1997), delivery dependability is defined as meeting delivery schedules and delivery speed as reacting quickly to customer orders. The ability to respond to changes in production, product mix, design, material fluctuations, and sequence changes is referred to as flexibility (Dangayach and Deshmukh, 2003). Innovation refers to the ability to implement new technologies and the ability to create new markets (Zhao, Yan Yeung, & Zhou, 2002).

3 METHODOLOGY

3.1 *Sample of the Study*

According to the Department of Census and Statistics (2019), there were 17847 manufacturing enterprises in Sri Lanka. Due to this large finite population, some industries were chosen based on having more than 2000 enterprises in each of the 24 manufacturing industries. The manufacture of food products, textiles, and apparels were the industries chosen. Additionally, it accounts for 54.6 per cent of the entire manufacturing sector in terms of proportion. The sample size for this study was 36 manufacturing enterprises chosen under stratified random sampling technique. When viewed as a ratio of the number of establishments, it represents 18 food manufacturing firms, 8 textile firms, and 10 apparel firms. Finally, 72 data points were obtained by 1-3 replies from each firm.

The study used primary data to examine five elements that have an impact on a manufacturing firm's competitive priorities. Data was gathered using a survey-based questionnaire with Likert scale questions pertinent to analyzing each element. To gain more accurate data, the production manager, plant manager, and general manager of each company were contacted over the phone and through emails.

3.2 *Variables and Measurements*

This study used composite measures to assess the importance of five competitive criteria, including cost, quality, delivery time, flexibility, and innovation, in line with many empirical studies. For cost, quality, delivery time, and flexibility, six measures were

identified per each, and four measures were introduced for the innovation factor. Altogether, 28 measures were identified to measure these five factors. It should be noted that different figures for priorities and related measurements were used in the literature (Zhao et al., 2002). Except for the main five factors, demographic factors were collected for the ease of firm categorization purposes. In this study, participants were asked to rate how important they felt each of the five competitive priorities was in a post-pandemic situation.

3.3 *Data Analysis*

R software was utilized for the data analysis process. Additionally, Bartlett's test was used to check for factorability, and Cronbach's alpha was calculated for each competitive priority to evaluate reliability. The chosen variables were then validated using factor analysis. Additionally, computed the mean score for each element and ordered them accordingly to identify the degree of focus given to the competitive priorities.

3.4 *Reliability Assessment*

A common metric used to assess the reliability of composite variables is the internal consistency of the items that make up a construct, which is determined using Cronbach's alpha. In a post-pandemic scenario, the relative Cronbach's alpha values for cost, quality, delivery time, flexibility, and innovation are 0.87, 0.93, 0.84, 0.86, and 0.72. Since all the numbers are higher than 0.7 (Nunnally, & Bernstein, 1978), which denotes acceptable.

3.5 *Kaiser-Meyer-Olkin and Bartlett's Test*

To obtain a sufficient sample size, the KMO measure of sampling adequacy value should be greater or equal to 0.7. A correlation matrix's identity matrix claim was put to the test using Bartlett's Test of Sphericity. The null hypothesis is rejected when the Bartlett's Test of Sphericity is less than 0.05, as determined by the 5 percent significance level (Napitupulu, Kadar, & Jati, 2017).

The KMO measures the Sampling Adequacy for the post-pandemic situation was 0.735, and the result of Bartlett's Test of Sphericity was 0.00. It showed that the sample data was sufficient and that the variables were interrelated.

4 RESULTS & DISCUSSION

4.1 *Demographic Data*

In this study, 36 manufacturing companies in the Western Province were surveyed, including all three districts. The demographic information of each firm for the study is shown in Table 1.

4.2 *Post-pandemic Situation*

This part considered the statistics from the post-pandemic situation. This study's main objective was to identify the most prevalent competitive priority.

4.3 *Factor Analysis*

A factor analysis was performed using the information gathered in a post-pandemic situation. As shown in Table 2, each item loaded more strongly on its respective factor than it was on other constructs. The five components together could account for 73.46 per cent of the total variation. For simplicity, only

loadings greater than 0.4 are shown in Table 2.

Table 1: Demographic Data of firms

Descriptive (Sample Size = 72)	Frequency	Percentage
District		
Colombo	36	50.00
Gampaha	32	44.44
Kalutara	4	5.56
Age of Firm (Years)		
<10	6	8.33
10 - <25	16	22.22
25 - <50	38	52.78
>50	12	16.67
Number of employees		
<50	2	2.78
50 - <100	2	2.78
100 - <500	30	41.67
500 - <1000	18	25.00
>=1000	20	27.78
Industry Sector		
Food Manufacturing Industry	36	50.00
Apparel Manufacturing Industry	20	27.78
Textile Industry	16	22.22

(Source: Author compile)

4.4 Emphasis on Competitive Priorities

Delivery time was the most important competitive priority for most enterprises in the post-pandemic environment. Among the five priorities, it had the highest mean (4.8125) and as shown in Table 3.

Table 3: Ranks of Competitive Priorities
(Source: Author compile)

	Mean	Std. deviation	Rank
Delivery Time	4.8125	1.12397	1
Innovation	4.68403	1.01503	2
Quality	4.65525	1.2963	3
Flexibility	4.63426	1.37689	4
Cost	4.3588	1.37416	5

5 CONCLUSION

The major goal of this study was to examine the manufacturing sector's competitive priorities in Sri Lanka considering the COVID-19 epidemic. Sri Lanka has seen numerous changes since the COVID-19 pandemic. Lockdown conditions were a major factor in the failure of most manufacturing companies. The most adaptable companies have altered their operations to deal with the pandemic's effects. The primary goal of this study was to identify the most prevalent competitive priority for the post-pandemic environment. Delivery time was the competitive objective that was stressed the most among the five priorities based on the results since it had the highest mean value.

The nearly equal mean values of innovation, quality, and flexibility showed that manufacturers in the post-pandemic period concentrated on the three priorities in the same way. The least important priority is cost, which also has a mean value above four. This indicates that the pandemic scenario has changed the priorities of manufacturers. The conclusion was drawn that Sri Lankan manufacturers prioritize several

COMPETITIVE PRIORITIES OF THE POST COVID 19 PANDEMIC IN THE SRI LANKAN
MANUFACTURING SECTOR

Table 2: Factor Analysis (Source: Author compile)

Measures	Factors				
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Cost Importance					
C1 - Reduce material cost			.835		
C2 - Reduce overhead cost			.828		
C3 - Reduce inventory cost			.788		
C4 - Increase capacity utilization			.716		
C5 - Reduce production costs			.789		
C6 - Increase labor productivity			.581		
Quality Importance					
Q1 - Improving product quality				.714	
Q2 - Improve product durability				.780	
Q3 - Meeting customer needs				.839	
Q4 - Provide high-performance products				.547	
Q5 - Improving product reliability				.828	
Q6 - Improve design quality				.717	
Delivery Time Importance					
D1 - Improving on time delivery					.870
D2 - Provide fast deliveries					.545
D3 - Meet delivery promises					.574
D4 - Reduce production lead time					.555
D5 - Improving pre-sales service					.789
D6 - Improving after-sales service					.742
Flexibility Importance					
F1 - Make rapid design changes		.792			
F2 - Adjust capacity quickly		.573			
F3 - Make rapid volume changes		.599			
F4 - Offer a large number of product features		.663			
F5 - Offer a large degree of product variety		.641			
F6 - Adjust product mix		.637			
Innovation Importance					
I1 - Timely introduction of new products to the market	.766				
I2 - Reducing new product development time	.535				
I3 - Adopting new manufacturing technology timely	.783				
I4 - Increasing new product development	.774				

goals simultaneously and that there is no evidence of trade-offs in the Sri Lankan

setting. These findings suggested that the pandemic situation has altered competitive priorities.

Small-scale manufacturing companies should build their methods for adjusting to such unpredictable external

occurrences by changing their major priorities in the manufacturing sector in response to unanticipated external events. Small and medium-sized businesses would be able to alter their competitive priorities because of the research findings to survive in the market.

REFERENCES

- Dangayach, G. S., & Deshmukh, S. G. (2003). *Evidence of manufacturing strategies in Indian industry: a survey*. International Journal of Production Economics, 83(3), 279-298.
- Koufteros, X. A., Vonderembse, M. A., & Doll, W. J. (2002). *Examining the competitive capabilities of manufacturing firms*. Structural equation modeling, 9(2), 256-282.
- Napitupulu, D., Kadar, J. A., & Jati, R. K. (2017). *Validity testing of technology acceptance model based on factor analysis approach*. Indonesian Journal of Electrical Engineering and Computer Science, 5(3), 697-704.
- Nunnally, J. C., & Bernstein, I. H. (1978). *Psychometric theory mcgraw-hill new york*. The role of university in the development of entrepreneurial vocations: a Spanish study, 387-405.
- Russell, S. N., & Millar, H. H. (2014). *Competitive priorities of manufacturing firms in the Caribbean*. IOSR Journal of Business and Management, 16(10), 72-82.
- Skinner, W. (1969). *Manufacturing-missing link in corporate strategy*.
- Spring, M., & Boaden, R. (1997). *“One more time: how do you win orders?”: a critical reappraisal of the Hill manufacturing strategy framework*. International Journal of Operations & Production Management.
- Takala, J. (2002), *“Analyzing and synthesizing multi-focused manufacturing strategies by analytical hierarchy process”*, Journal of Manufacturing Technology and Management, Vol. 4 No. 5, pp. 345-50.
- Takala, J., Hirvela, J., Galczynska, A., Lehtonen, M., Rinta-Rahko, S., & Virta, K. (2003). *Competitive priorities of manufacturing strategies: case study at Wartsila*. Department of Industrial Management, University of Vaasa, Finland.
- Zhao, X., Yan Yeung, J. H., & Zhou, Q. (2002). *Competitive priorities of enterprises in mainland China*. Total Quality Management, 13(3), 285-300.
- Department of Census and Statistics. (2019). *Annual Survey of Industries*. Retrieved from Department of Census and Statistics: http://www.statistics.gov.lk/Resource/en/Industry/Annual_Surveys/2019.pdf
- Department of Census and Statistics. (2021). *Index of Industrial Production 4th Quarter 2021*. Retrieved from Department of Census and Statistics: http://www.statistics.gov.lk/WebReleases/IP_Bulleting_2021Q3



Effect of Social Media e-WOM On Customer Influence to the Financial Services - a Case Study

De Livera AC¹, Wattegama EJ²

^{1,2}*Department of Industrial Management, Faculty of Applied Sciences, Wayamba University of Sri Lanka*
achinilivera1@gmail.com¹
erandiw@wyb.ac.lk²

ABSTRACT

Financial institutions in Sri Lanka use various types of marketing tools to attract and retain their potential and existing customers. The objective of present study is to analyze the effect of e-WOM on influencing the customers towards the services that are offered by those institutions. Based on the reviewed literature, five variables; trustworthiness of e-WOM sender, timeliness/volume of e-WOM message, and homophily, involvement and prior knowledge of e-WOM receiver were selected as independent variables for assessing the effect of those on influencing the customer. An online survey was carried out and 239 no. of responses were considered for the analysis. Multiple regression analysis was carried out to identify the significant variables that are making the effect. The results revealed that trustworthiness, timeliness/ volume and prior knowledge have significantly affected on the customer influence. As managerial implications it is suggested the marketers of financial institutions to consider those significant factors to develop an effective model to influence their customers towards the services that are offered by them.

KEYWORDS: Customer influence, e-WOM, Financial services

1 INTRODUCTION

There are a large number of financial services providing institutions in Sri Lanka and they offer a wide variety of services including vehicle leasing, fixed deposits, mortgage loans, savings, money exchange, gold loans, power drafts, educational loans and personal loans. In order to attract potential customers, they use various types of digital marketing tools; social media communication, direct marketing, and word of mouth (WOM) and those are common to every institution and use those as major marketing tools.

At present the online or electronic word of mouth (e-WOM) is one of major attractions to the customers when they are making their decisions (financial and/ or non-financial). According to Lu and Bai (2021), high Internet penetration has increased the quantity of e-WOM. Social

media e-WOM is a trending online marketing tool that is used by most of the financial institutions. Most of the institutions currently use various types of social media platforms to address their potential audience. Hence, the studies on social media e-WOM and its influence on the financial decisions of the customer are crucial. According to Sheng (2019), the initiation of the Internet became a major influence on communication and information exchange in social media. Hence, the present study addresses the effects of e-WOM in social media and sees how that changes the traditional marketing concept towards the customer influence. The e-WOM has a significant impact on attracting customers and shaping their decisions (Lu & Bai, 2021). Therefore, studying the success factors of e-WOM is important for the financial institutions to draw the managerial implications. Although there are studies

that are related to social media e-WOM and banking sector in global or Sri Lankan context, still there is a gap in studying how social media e-WOM influences on the customers of financial institutions. Moreover, when it is handling e-WOM campaigns, the factors that have been considered by the financial institutions should be identified for gaining success in the financial business. As a result, the outcomes of present study are beneficial for financial institutions in Sri Lanka when they make marketing related decisions.

2 LITERATURE REVIEW

According to the Central Bank of Sri Lanka, by the end of year 2022, there were 37 no. of licensed financial institutions in Sri Lanka and they use different types of marketing strategies to attract and retain their potential and existing customers in the competitive business industry. The widespread use of the Internet results in a greater impact on the relationship between the firm and their customers. With the use of websites, forums, and social networks, the customers become self-sufficient in fulfilling their information needs. Therefore, the e-WOM permits the firms to determine what the firm's customers think as well as what they exactly need. Further, most firms create profiles on social networks such as Facebook, Twitter, and MySpace to directly communicate with their existing and potential customers (Mendez et al., 2015). According to Donthu et al. (2021), e-WOM was defined as "online sharing campaigns which include experienced customer opinions and recommendations". At present e-WOM

has become an important platform for not only the individuals but also for the marketers to share their thoughts and attract the attention of people. Most people have started to use e-WOM as a reference for their product or service selection. According to Standinga et al. (2016), e-WOM is impacted by strong visual and artistic effects. Castellano and Dutot (2017) have stated that the recommendations from peers have a strong influence on customer's purchase decisions. Hence, e-WOM becomes a major component of the communication strategies and the reputation of a firm. Moreover, according to Sheng (2019), the customers participate in sharing their experiences with firms and other members of the community by using reviews, recommendations, and ratings. According to Castellano and Dutot (2017), positive reviews regarding a firm generate a positive influence and this review takes the form of comments, ratings, or recommendations to the peer. Hence, the bond between sender of the review and receiver of the review is crucial. According to Cheung and Thadani (2012), communication includes four main parties namely; the sender, the receiver, the message, and the response. According to Wattedegama and Qing (2014), the perspective of the e-WOM message; valance, credibility, response volume, argument quality, usefulness, and consistency of e-WOM are identified as elements of the social communication process. Further, social tie, homophily, trust, normative and informational interpersonal influence act as major factors affecting the customer's perception in the social media e-WOM on the e-WOM sender's side. Also, the involvement, focused search, homophily,

skepticism, and prior knowledge of the customer moderate the relationship between the e-WOM and the effect on the customer (Chu & Kim, 2011, Doh & Wang, 2009; Wattegama & Qing, 2014).

Trustworthiness of the information source is an important factor to consider in social media e-WOM communication. According to Hong and Cha (2013), trust in an online merchant completely mediates the effect of performance risk but partially mediates the psychological risk. e-WOM communicator's trustworthiness is measured under the reliability of the source and the relationship with the information source.

Homophily refers to the perceived source similarity which describes the degree to which individuals are similar in terms of certain attributes (Wattegama & Qing, 2014). Homophily increases the e-WOM trust and influence and it is measured under the degree to which the e-WOM sender's economic and social status matches the receiver of information and to the extent to which the sender accepts the similarity.

Sheng (2018) has found that the response/volume and the speed of e-WOM communication are the important factors that affect customer interaction. This is measured by the quantity and frequency of the firm's interaction with the customer and the social media presence. The timeliness of e-WOM is measured by the speed and the average time between the responses.

Sheng (2019) has also stated that the engaged customers of a firm become WOM advertisers for a business. Further, the customer involvement impacts a deeper level of customer-firm

relationships as well as long-term business performance. Product or service popularity depends on the number of users in the online brand community and this popularity attracts the customer's attention and recognition.

Prior knowledge of the customer regarding the same industry, brand, or firm is affected by the customer's perception of the firm.

Accordingly, following hypothesis has been established to achieve the study objective;

Hypothesis: trustworthiness and homophily of the e-WOM sender (financial institution), timeliness/volume of the e-WOM message, and involvement and prior knowledge of the e-WOM receiver (customer) significantly effect on influencing the customer towards the services that are communicated by Sri Lankan financial institutions via the social media platforms.

3 METHODOLOGY

The analysis of the study was based on primary data collected through an online survey using a structured questionnaire. Table 01 shows the details of the variables.

Table 01. Details of the Variables

Type of Variable	Description	Source
Independent	Trustworthiness	Chu & Kim (2011)
	Homophily	Chu & Kim (2011)
	Volume/ Timeliness	Sheng (2019)
	Customer's prior knowledge	Doh & Hwang (2009)
	Customer's involvement	Doh & Hwang (2009)

Dependent Variable: Customer Influence

The population was the customers who are social media users and currently using or are expected to use the services that are offered by the financial institutions in Sri Lanka. The sample was selected using a convenient sampling method and the size was determined based on Krejcie and Morgan Table. The data were analyzed using descriptive statistics and regression analysis. IBM SPSS statistical software was used for the analysis.

4 RESULTS

According to the results of descriptive statistical analysis that was carried out using 239 responses, 200 responses (83.7%) were belonged to the existing customers and the remaining 39 (16.3%) were the potential customers of financial institutions in Sri Lanka. 99.6% of the sample have the Internet experience greater than five years and 62.3% have a social media usage of greater than five years. Also most of them were using social media platforms like WhatsApp, YouTube, and Facebook. Table 02 shows the results of the reliability analysis.

Table 02. Results of Reliability Analysis

Variable	Cronbach's α
Trustworthiness	0.565
Homophily	0.628
Timeliness/ Volume	0.682
Customer Involvement	0.737
Prior Knowledge	0.882
Customer Influence	0.927

Although there was a poor internal consistency for the variable of trustworthiness, the other variables were laid in an acceptable region. As shown in Table 3, 65.5% of the variance in the dependent variable was predicted from the independent variables. Further, the

Durbin-Watson statistic was 1.348 which indicated the independence of the observation that has been met.

Table 3. Model Summary

R ²	Std. Error of the Estimate	Durbin-Watson
0.655	0.44702	1.348

According to results that were shown in Table 4, only trustworthiness, timeliness/ volume, and prior knowledge were found as significant at the 5% significant level.

Table 4. Results of Regression Analysis

Model	Unstandardized Coefficients	Sig.
(Constant)	0.967	0.000
Trustworthiness	-0.106	0.025
Homophily	0.013	0.752
Timeliness/ Volume	0.467	0.000
Involvement	-0.046	0.509
Prior Knowledge	0.332	0.000

5 DISCUSSION AND CONCLUSION

Results of the study revealed that trustworthiness of the e-WOM sender, timeliness/volume of the e-WOM message and customer involvement and his/her prior knowledge have made significant effects on influencing the customers about the services that are offered by financial institutions in Sri Lanka via social media. Hence, by considering these factors the marketers can develop an effective marketing model to enhance their customer influence towards the financial services that are offered by them. Moreover, they can easily advance their marketing campaigns via social media such as WhatsApp, Facebook and YouTube as those platforms were highly used by majority of the customers including existing and potential to get information

about the services that are offered by the financial institutions in Sri Lanka. As a limitation of the study, the population size was not certain or definable because the study has considered the existing and potential customers of the financial institutions in Sri Lanka. Hence the study was carried out using a small representation of existing and potential customers of financial institutions in Sri Lanka. The future researchers can overcome it by conducting the studies as cases for a specifically selected financial institution in Sri Lanka.

REFERENCES

- Castellano, S. & Dutot, V. (2017). Investigating the Influence of E-Word-of-Mouth on E-Reputation. *International Studies of Management & Organization*, pp. 42-60.
- Cheung, C. & Thadani, D. (2012). The impact of electronic word-of-mouth communication: A literature analysis and integrative model. *Decision Support Systems*, 10(3), pp. 163-176.
- Chu, S. & Kim, Y. (2011). Determinants of consumer engagement in electronic word-of-mouth (eWOM) in social networking sites. *International journal of advertising*, 30(1), pp. 47-55.
- Doh, S. & Hwang, J. (2009). How consumers evaluate eWOM (Electronic word of mouth) messages. *12(2)*, pp. 193-198.
- Donthu, N., Kumar, S., Pandey, N., Pandey, N. & Mishra, A. (2021). Mapping the electronic word of mouth (eWOM) research; A systematic review and bibliometric analysis. *Journal of Business Research*, 135, pp. 758-773.
- Lu, J. & Bai, H. (2021). Information usefulness and attitude formation a double dependent variable model (DDV) to examine the impacts of online reviews on consumers. *Journal of Organizational and end user computing*, 33(6).
- Mendez, J., Leiva, F., & Fernandez, J. (2015). The influence of e-word-of-mouth on travel decision-making. *consumer profiles*, 18(11), pp. 1001-1021.
- Sheng, J. (2019). Being Active in Online Communications: Firm Responsiveness and Customer Engagement Behaviour. *Journal of Interactive Marketing*, pp. 40-51.
- Standinga, C., Holzwebe, M. & Mattssonb, J. (2016). Exploring emotional expressions in e-word-of-mouth from online communities. *Information Processing and Management*, 52(2016), pp. 721-732.
- Wattegama, W.G.E.J. & Qing, P. (2014). Effect of eWOM on Buying Intention for a Crisis Product: A Theoretical Reflection. *Wayamba Journal of Management*, 5(2), pp. 37-46.



Factors Affecting Brain Drain of Sri Lankan IT Professionals

Samarakoon WSMSS¹, Deegahawature MMDR.²

^{1,2}Department of Industrial Management, Wayamba University of Sri Lanka

sakunikasewwandi96@gmail.com¹

dharsana@wyb.ac.lk²

ABSTRACT

Currently, Sri Lankan government is promoting migrant labor due to the economic crisis in Sri Lanka. This has caused a brain drain and a shortage of highly skilled labor within the country. On the other hand, there are relatively higher migration opportunities for IT professionals, as the IT industry is growing fast. Hence, it is essential to identify the factors promoting the brain drain among IT professionals to implement strategies to minimize it. Therefore, this study attempts to identify the pull factors that cause the brain drain of Sri Lankan IT professionals. Based on the past literature, the study considers six pull factors affecting the intention to migrate. An online survey using a structured questionnaire collected responses from 357 IT professionals over a 5-point Likert scale. The binary logistic regression results identify multiple pull factors namely; higher salary packages, greater job availability, greater career development opportunities, better living condition abroad, exposure and experience, and opportunity for permanent residency. Also, the majority of IT professionals prefer to migrate to a developed country. The study recommends the Sri Lankan government and policymakers implement appropriate strategies to minimize the migration of IT professionals considering the outcome of this study.

KEYWORDS: Brain drain, Intention to migrate, IT professionals, Pull factors, Sri Lankan IT industry

1. INTRODUCTION

1.1 Study Background

Information Technology and Business Process Management (IT-BPM) have become the fastest-growing industrial sector among all other industries, as the IT-BPM sector services have a significant impact on economic stability (Kumari, 2017). IT-BPM industry can boost multi-sector growth to accelerate a country's competitiveness and innovative capabilities (SLASSCOM, 2021). Further, as stated by the Sri Lanka Association of Software and Services Companies (SLASSCOM), the Sri Lankan IT-BPM industry aims to attract young future talents into a knowledge-based workforce by providing job opportunities. However,

retaining future skills and the existing workforce becomes a challenge to the IT-BPM industry in Sri Lanka (Kumari, 2017, as cited in SLASSCOM, 2016).

Brain drain is a common phenomenon in developing countries with the rapid increase in skilled and professional emigration in developing countries (Bashir et al., 2014). Additionally, it appears to be a major issue in the IT-BPM sector in the global south that depends on the knowledge of workers (Wanniarachchi, Jayakody & Jayawardana, 2022). According to SLASSCOM (2016), Sri Lanka was ranked 20 out of 103 countries based on the emigration rates, according to data from the year 2000. Therefore, the country has taken several initiatives to

minimize brain drain and retain a skilled workforce in the IT-BPM sector (SLASSCOM, 2016).

1.2 Research Problem

There is a significant increase in the migration of Sri Lankan employees. This may lead to the flow of innovative ideas, professional labor forces, and skills to foreign countries. Hence, it is necessary to identify the causes and take appropriate steps to minimize the brain drain among Sri Lankan Information Technology (IT) professionals.

The study aims to identify the pull factors affecting brain drain among Sri Lankan IT Professionals. Brain drain has become a global concern due to the lack of knowledgeable workers, and has intensified due to the easy mobility of the workforce. The higher unemployment and low wages in Southern Asian countries have promoted migration for working in Middle East countries (McAuliffe & Triandafyllidou, 2021). Also, it has been noted that there is a shortage of IT professionals in Sri Lanka due to the brain drain (Kumari, 2017). Therefore, it is essential to investigate the pull factors affecting the brain drain of IT professionals in Sri Lanka. The study's outcome would help the IT industry and the government to take appropriate steps to minimize brain drain among IT professionals. Accordingly, the study would facilitate the retention of those professionals thereby strengthening the industry.

2. LITERATURE REVIEW

2.1 Introduction to brain drain

The “brain drain” refers to the international transfer of a high-level human capital from developing nations to

developed nations to setup permanent residences in the developed countries (Truscott, 1971; Valavanidis, 2017; Ekanayake & Amirthalingam, 2022, pp. 450-468). Over the past decade, large amounts of people across the world have migrated to different countries. Therefore, this area has attracted a wide range of attention in the recent past (Wanniarachchi et al., 2022). According to World Bank statistics (as cited in Kumari, 2017), Sri Lanka has the highest skilled emigration rate in the South Asian region. Currently, Sri Lanka is in a significant economic crisis. Aneez (2023) has argued that 311,269 people migrated in 2022 indicating the highest amount of migrated people in history. Also, migration in Sri Lanka was 300,413 in Sri Lanka in 2014.

2.2 Theoretical framework and Hypothesis development

Many factors influence the brain drain of Sri Lankan IT professionals, and those factors depend on other factors such as host countries and the working industry of the employer, etc. (Kumari, 2017). The following sections discuss the effect of various pull factors on the intention to migrate.

Higher salary packages

Abbas & Gururo (2018) investigated a significant influence of salary package as a cause of brain drain of business and IT graduates. The study by Fernando (2019) revealed that the ability to earn a suitable and larger salary in the host country than in the home country is a major cause for skilled migrants in the case of South–North migration. Therefore, this study postulates the following hypothesis.

H1: High salary packages positively affect the brain drain of IT professionals

Greater job availability

According to the study of Iqbal et al. (2020), creating and providing more job opportunities in the home country helps to minimize the brain drain. Abbas & Guriro (2018) and Kumari (2017) have concluded that better employment opportunities attract immigrants to developed countries. Therefore, Pakistan suffers from severe brain drain. On this ground, the study develops the following hypothesis.

H2: The greater job availability positively affects the brain drain of IT professionals

Greater career development opportunities

Providing the facilities for good education opportunities and career development opportunities are major factors that will increase migration intention in developing countries (Kumari, 2017). Hence, the below hypothesis is proposed.

H3: The more excellent career development opportunity positively affects the brain drain of IT professionals

Better living conditions abroad

Aytaç & Aydın (2019) have identified that living conditions and quality of life propel the intention to migrate among individuals. Additionally, most individuals migrate to developed countries to give a better life to their family members. Hence, the following hypothesis is proposed.

H4: Better living conditions in host countries positively affect the brain drain of IT professionals

Exposure and experience

According to Kumari (2017), people value exposure, and what they gain through experience while working in

developed countries thus, they attempt to migrate. Accordingly, the following hypothesis is proposed.

H5: The exposure and experience positively affect the brain drain of IT professionals

Opportunities for permanent residency

Kumari (2017) concluded that people inspired by better working environments, quality of life, and living conditions in the migration destinations increase their motivation and dedication to become permanent residents. Therefore, the following hypothesis is postulated

H6: The opportunities for permanent residency positively affect the brain drain of IT professionals

3. RESEARCH METHODOLOGY

This research adopted a quantitative approach to identify the factors that influenced the brain drain of Sri Lankan IT Professionals. Primary data were collected from IT professionals working in private-sector IT companies in the Western province of Sri Lanka through a self-administrated survey questionnaire distributed online. The sample size was 381, which was determined based on the Morgan table. The responses were analyzed by binary logistic regression using the statistical software SPSS (version 26). There were six pull factors identified as independent variables, namely; higher salary packages (P1), greater job availability (P2), greater career development opportunities (P3), better living conditions abroad (P4), exposure and experience (P5), and opportunities for permanent residency (P6) based on the literature support.

Also, intention to migrate (IM) is recognized as the dependent variable that has binary outcomes '1' for when the IT professional has the intention to migrate and '0' for when the IT professional has no intention to migrate.

The conceptual framework represented in Figure 1 outlines six pull factors that impact the migration of Sri Lankan IT professionals.

Also, descriptive analysis, the goodness of fitness, model summary, correlation analysis, and hypothesis testing were performed. Further, binary logistic regression analysis was used to test the hypotheses.

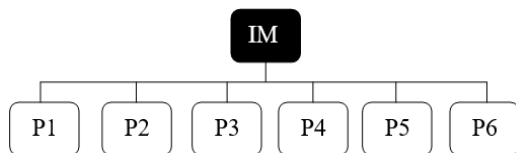


Figure 1: Conceptual Framework

4. DATA COLLECTION AND ANALYSIS

4.1 Descriptive Analysis

Most respondents were between the ages of 25 to 30 years, contributing 66.4% of the sample. While the majority of Sri Lankan IT professionals (73.4%) intend to migrate, 24.6% intend to migrate to Australia, 18.8% to Singapore, 16.5% to Canada, and 10.4% to other countries. Other countries include Germany, Finland, countries in the European region, UAE (United Arab Emirates), and Norway.

Table 1: Results of Descriptive Analysis

Demographic Variable	Frequency	Percent
Age		
Below 25	48	13.4
25 to 30	237	66.4
31 to 35	67	18.8
Above 40	5	1.4
Gender		
Female	90	25.2
Male	267	74.8
Intention to migrate		
No	95	26.6
Yes	262	73.4
Occupation		
Software Engineering	105	29.4
Network Engineering	23	6.4
Business Analysis	51	14.3
Software Quality Assurance	36	10.1
Cyber Security	33	9.2
Software Project Management	25	7
Database Development	47	13.2
Other Support Functions	37	10.4
Country like to migrate		
Australia	88	24.6
Canada	59	16.5
New Zealand	41	11.5
Singapore	67	18.8
United Kingdom	29	8.1
USA	36	10.1
Other	37	10.4

4.2 The goodness of fit statistics

The 1 model's goodness of fit was tested using the Omnibus Test and Hosmer and Lemeshow Test. Omnibus Test results showed that the model was fitted significantly ($\chi^2=223.595$, $df=6$, $0.000<0.01$). This outcome shows that the model fit has significantly improved compared to the null mode. Also, Hosmer and Lemeshow's test statistics were insignificant ($df=7$, $0.466>0.05$). Therefore, the model of the study has fitted the data adequately. Overall, these two fit measures showed that the estimated model is significant.

Further, Cox & Snell's R² value was 0.465, indicating that the model explains 46.5% of the variation in the dependent variable. Nagelkerke's R² value was 0.678, and that represented a strong relationship of 67.8% between predictors and prediction.

5. RESULTS

5.1 Correlation analysis

Most of the correlation coefficients were equal to or greater than 0.5. Also, all factors were identified as positively correlated to migrate.

Table 2: Correlation Analysis

	IM	P1	P2	P3	P4	P5	P6
IM	1	.577**	.609**	.596**	.584**	.469**	.527**
P1	.577**	1	.670**	.714**	.658**	.699**	.436**
P2	.609**	.670**	1	.816**	.548**	.576**	.523**
P3	.596**	.714**	.816**	1	.652**	.673**	.585**
P4	.584**	.658**	.548**	.652**	1	.715**	.688**
P5	.469**	.699**	.576**	.673**	.715**	1	.587**
P6	.527**	.436**	.523**	.585**	.688**	.587**	1

** Correlation is significant at the 0.01 level (2-tailed).

Notes : N = 357, ** $p < 0.01$, * $p < 0.05$

5.2 Hypotheses testing

Table 3 includes the results of the binary logistic regression analysis. Accordingly, the higher salary packages, greater job availability, greater career development opportunities, better living conditions abroad, exposure and experience, and opportunity for permanent residency significantly impact the intention to migrate among Sri Lankan IT professionals.

Table 3: Evaluation of hypotheses

Relationship	S.E.	Sig	Decision
H1:P1->IM	.220	.000**	Accepted
H2:P2->IM	.231	.046*	Accepted
H3:P3->IM	.330	.021*	Accepted
H4:P4->IM	.273	.001**	Accepted
H5:P5->IM	.294	.000**	Accepted
H6:P6->IM	.209	.000**	Accepted

Notes: N = 357, ** $p < 0.01$, * $p < 0.05$

6. CONCLUSION

According to the findings, among IT professionals in Sri Lanka had a higher brain drain. Past literature identified certain pull factors that affect the brain drain of IT professionals. The findings of the present study confirm those findings. This study concluded that the factors such as higher salary packages, greater

job availability, greater career development opportunities, better living conditions abroad, exposure and experience, and opportunity for permanent residency determined the intention to migrate among IT professionals in the Western province of Sri Lanka.

Sri Lanka needs more skilled labor. Therefore, it is essential to consider migration policies to reduce the brain drain within the country. Policymakers may consider the findings of this study and take appropriate strategies to minimize brain drain.

As this study considered only six pull factors, future studies may focus on further pull-push factors influencing the intention to migrate. Also, future researchers may extend this study to other industries as the present study has focused on the IT industry.

REFERENCES

- Abbas, A., & Guriro, S. (2018). Brain drain of business and it graduates in Pakistan. *Journal of Business Administration and Management Sciences (JOBAMS)*, 2(2), 316-326.
- Aneez, S. (2023, January 2). Crisis-hit Sri Lanka sees record labour migration as rupee collapse, high inflation weigh. *EconomyNext*. Retrieved from <https://economynext.com/crisis-hit-sri-lanka-sees-record-labour-migration-as-rupee-collapse-high-inflation-weigh-108055/>
- Aytaç, S., & Aydın, G. Ç. (2019). Analysis of the effects of pull and push factors on brain drain: An example of Turkey. *Journal of Social Economics Research*, 6(2), 74-84.
- Bashir, M. F., Xu, C., Zaman, K., & Akhmat, G. (2014). Key factors determining the rationale for brain drain: An irony never recovered. *International Journal of Economics and Empirical Research (IJEER)*, 2(8), 308-320.

- Ekanayake, A., & Amirthalingam, K. (2022). Impact of migration of Sri Lankan professionals to Qatar on skill acquisition and brain drain. *Migration and Development, 11*(3), 450-468.
- Iqbal, K., Peng, H., Hafeez, M., Wang, Y., & Li, C. (2020). The current wave and determinants of brain-drain migration from China. *Human Systems Management, 39*(3), 455-468.
- Kumari, M. A. D. L. (2017). *Factors affecting the Sri Lankan IT professionals' migration* (Doctoral dissertation).
- McAuliffe, M., & Triandafyllidou, A. (2021). *World Migration Report, 2022*. International Organization for Migration (IOM), Geneva.
- Fernando, P. J. S. (2019). *The Relationship between Brain Circulation and Industry Growth: A Case Study of the Knowledge Services Industry in Sri Lanka* (Doctoral dissertation, NAGOYA UNIVERSITY).
- SLASSCOM (2016). Strategy Document 2016. Sri Lanka Association of Software and Service Companies. Retrieved from <http://www.slasscom.lk>
- SLASSCOM (2021). Sri Lanka Association of Software and Service Companies. Retrieved from Sri Lanka Business Process Management Industry study: <https://slasscom.lk/wp-content/uploads/2021/07/SRL-BPM-Industry-study-30-Jun.pdf>
- Truscott, M. H. (1971). *The Brain Drain of Scientists, Engineers, and Physicians from the Developing Countries to the United States*. Louisiana State University and Agricultural & Mechanical College.
- Valavanidis, A. (2017). Migration of Skilled and University Educated Scientists and Engineers. The “brain drain” Phenomenon and Inverse “brain drain”. Retrieved from https://www.researchgate.net/publication/320947791_Migration_of_Skilled_and_University_Educated_Scientists_and_Engineers_The_brain_drain_Phenomenon_and_Inverse_brain_drain.
- Wanniarachchi, H. E., Kumara Jayakody, J. A. S., & Jayawardana, A. K. L. (2022). An organizational perspective on brain drain: What can organizations do to stop it? *The International Journal of Human Resource Management, 33*(8), 1489-1525.



Factors Affecting Consumer Post Purchase Cognitive Dissonance in Online Shopping: A Case Study of Southern Province in Sri Lanka

Madushani GW¹, Jothirathne PAAU²

Department of Industrial Management, Faculty of Applied Sciences, Wayamba University of Sri Lanka
wasanagalhenage@gmail.com¹
anoja@wyb.ac.lk²

ABSTRACT

This study explores the factors that contribute to post-purchase cognitive dissonance among online consumers residing in the southern province of Sri Lanka. The significance of this study lies in its potential to identify gaps in customer expectations and the delivery of online shopping services, the post-purchase customer experience. The research framework includes an examination of product quality issues, pricing, impulse buying, and the return process experience of consumers. A sample of 400 randomly selected online shoppers provided the basis for data collection. Data collection was done through online platforms using a questionnaire. The study findings indicate a positive correlation between product quality issues and post-purchase regret among consumers. Conversely, the research shows that pricing, impulse buying, and return process experiences did not significantly affect post-purchase regret. The results suggest that consumers prioritize product quality over other factors in their purchasing decisions.

KEYWORDS: Cognitive Dissonance, Online Shopping, Post Purchase, Product Quality Issues

1 INTRODUCTION

In the recent era of technological advancements, everything is continuously digitizing. Retail shopping has converted to online shopping and this has become a trend. The digital economy boomed during COVID-19 pandemic. People turned to online shopping more than ever before as they embraced social distancing and the travel restrictions taken by the government. The business organization tends to serve its products through online platforms with this trend. No matter whether online or offline stores, customers are the most powerful asset to a company. It is important to maintain customer satisfaction, especially in the global pandemic situation. Customers adapted to online shopping even though the pandemic is reaching an endpoint. Hence business organizations continued to use

online platforms to promote their products and to compete with the developing call for online purchases. Consumers are more susceptible to post-purchase regret is the negative side effect of this technological advancement.

This study aims to find factors that affect post-purchase regret of consumers in the Southern province of Sri Lanka.

The importance of this study is to find the gaps in customer expectations and what they were delivered through the online selling platforms. This study highlights the most significantly affected variables for customer post-purchase regret. This will provide some useful insights about customer behaviors in online shopping.

Customer recognition is a must for making a satisfied customer. According to Lazim et al. (2020) to face the

competition and to increase sales, sellers should meet customer expectations, increase positive word of mouth, and brand loyalty increases if the performance of the brand is more than the expected performance.

Through dissatisfaction, a lot of customers are lost and the marketer suffers losses, hence the marketer needs to monitor whether the customer is satisfied. This is difficult in online marketing since the absence of physical contacts. To avoid this, a marketer has to be on the lookout for causes of dissatisfaction.

2 LITERATURE REVIEW

Based on the literature review conducted, cognitive dissonance in the context of selling is driven by anxiety related to purchasing decisions. Mensah et al. (2021) classify cognitive dissonance into emotional dissonance, which relates to psychological post-purchase discomforts such as regret and disappointment, and product dissonance, which is primarily related to the purchased product.

The study by Amoah, Abubakar and Sikayena (2017) aimed to investigate the factors contributing to post-purchase regret and the level of regret among consumers. Their findings indicate that only price is significantly related to post-purchase regret. Mensah et al. (2021) found that choice overload has a direct significant effect on the poor choice quality and a strong positive association with post-purchase dissonance using social media tools.

Lazim et al. (2020) stated that consumers who make impulsive online purchases tend to experience post-

purchase dissonance, caused by anxiety over the possibility of unexpected consequences, and they may doubt whether they made the right choice. Sarwar, Awang, and Habib (2019) found that customers are less likely to regret their purchases when they can return the items, highlighting the importance of a favorable return policy.

Therefore, based on the literature review, it can be concluded that post-purchase regret arises due to various factors such as product quality issues, product price, impulse buying, and the return process experience. These findings have implications for sellers and marketers to focus on customer satisfaction by offering high-quality products, competitive pricing, easy return processes, and avoiding choice overload. By addressing these factors, sellers can minimize post-purchase dissonance and build trust with their customers, leading to increase customer loyalty and repeat business.

Table 01: Identified Factors

Factor	Literature
Quality Issues	(Mensah et al., 2021).
Price	Amoah, Abubakar and Sikayena (2017).
Impulse Buying	Lazim et al. (2020)
Return process Experience	Sarwar, Awang, and Habib (2019)

Based on the literature following hypotheses were derived;

H1: Product Quality does not influence post-purchase regret in online shopping

H2: Price does not influence post-purchase regret in online shopping

H3: Impulse buying does not influence post-purchase regret in online shopping

H4: Return Process experience does not influence the post-purchase regret in online shopping

3 METHODOLOGY

The study focused on online shopping consumers within the Southern Province of Sri Lanka. Sample size was 384 (Krejcie & Morgan, 1970). To gather data, a semi-structured questionnaire was developed using a five-point Likert scale ranging from “strongly disagree” to “strongly agree” to measure the indicators of interest. Primary data were collected through an online questionnaire. 450 questionnaires were distributed via emails and whatsapp. Out of 450 questionnaires distributed, 430 complete responses were received. However, due to incompleteness, 30 responses were discarded, resulting in a total of 400 completed responses being utilized for data analysis.

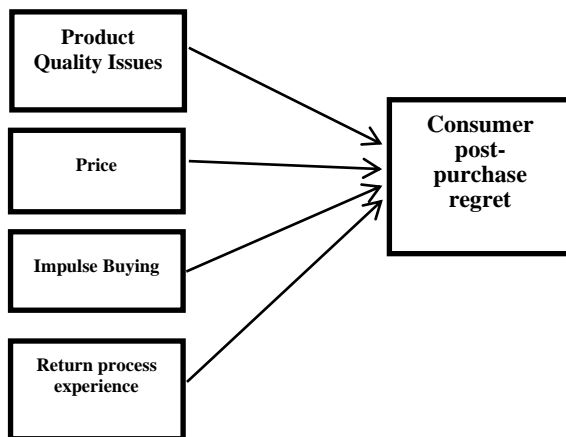


Figure 01: Research Model

4 RESULTS

According to the KMO coefficients and the respective significant values for both composite variables, the study sample seems statistically adequate to perform an Exploratory Factor Analysis (EFA) to assess the construct validity.

Moreover, Extraction Sums of Squared Loadings (ESSL) Cumulative percentage for both composite variables and the dimensions of the independent variable are greater than 50% and the Factor Loading values of individual items in the scales used were adequate. Hence, it could be concluded that the multi-item scales are valid, and the data set seems statistically free from bias.

According to the reliability and validity analysis, no item was deleted, thus all the items included in the standard scales were retained.

Table 02: Reliability Statistics

Variable	No. of Items	Cronbach alpha
Post-purchase Regret	03	0.800
Product Quality Issues	04	0.712
Price	04	0.687
Impulse Buying	05	0.832
Return process experience	03	0.767

Table 03: Validity Statistics

Variable	No. of Items	Highest FL	Lowest FL	ESSL Cum%
Post-purchase Regret	03	0.862	0.835	71.567
Product Quality Issues	04	0.858	0.312	55.055
Price	04	0.880	0.314	54.779
Impulse Buying	05	0.822	0.725	60.002
Return process experience	03	0.869	0.781	68.364

Using SPSS, boxplots were generated to test for outliers and no outliers were found in the primary data set. Hence, keep all the responses and proceed with further statistical analysis. Linearity between the dependent variables and independent variables was determined using scatterplots.

According to Scatterplot, there is a linear relationship between post-purchase regret and product quality issues, while price, impulse buying, and return process experience, there is no clear linear relationship between post-purchase regret. However this needs to test statistically.

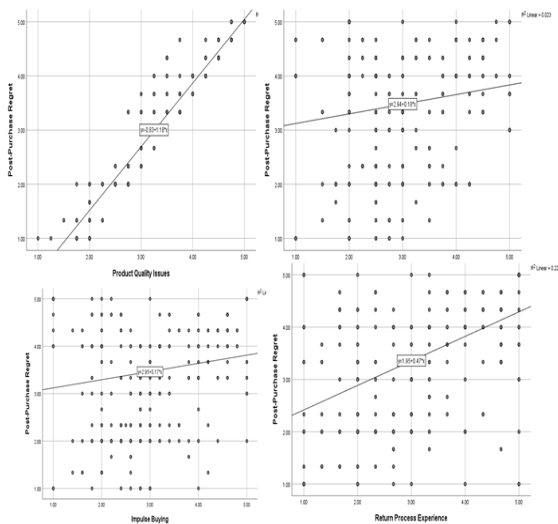


Figure 02: Scatter Plots

Table 04: Correlation statistics

	Post purchase Regret	Sig. (2-tailed)
Quality Issues	.963**	.000
Price	.151**	.002
Impulse Buying	.161**	.001
Return Process Experience	.475**	.000

Pearson Correlation Coefficient was used to assess the strength of association among the said four constructs. Further, a Significant (2-tailed) test was applied to test the significance of the correlation

coefficient since the hypotheses were non-directional. A strong positive correlation was shown between consumer post-purchase regret and product quality issues (r=0.963) which is statistically significant. .

For the other variables r values were statistically insignificant hence price, impulse buying, and return process experience were not significantly correlated with the consumer post purchase regret.

Table 05: Regression statistics for product quality issues

R	0.963
R Square	0.927
Adjusted R Square	0.927
Standard Error	0.27280
Observations (N)	400
F	5084.075
Sig.	0.000
Regression	Linear
Method	Enter

Thus, according to the regression results, H1 is accepted statistically claiming that there is a significant impact of product quality issues on consumer post-purchase regret. Accordingly, a regression equation could be reported in which both the intercept [C] and the marginal contribution [m] are statistically significant to be included in the equation.

Table 06: Coefficients

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	.834	.062		13.527	.000
Product Quality Issues	1.176	.016	.963	71.303	.000

$$Y = mX + C$$

Consumer post-purchase regret = 1.176 (Product Quality Issues) - 0.834
Equation 01

5 DISCUSSION

This study aimed to investigate the impact of product quality issues, price, impulse buying, and return process experience as independent variables on consumer post-purchase regret, which serves as the dependent variable. The findings of the study suggest that product quality is a critical determinant of consumer post-purchase regret. Specifically, the results of the correlation analysis reveal a significant and strong positive relationship between product quality issues and consumer post-purchase regret, indicating that higher product quality issues are associated with increased regret. These findings are consistent with previous research conducted by Selvaraj and Shrikrishnan (2018) and Mensah et al. (2021).

Furthermore, the study's results indicate that the majority of respondents (approximately 43%) earn between Rs. 50,000-75,000 per month and prefer online purchasing to other methods. Additionally, approximately 10% of respondents earn more than Rs. 100,000, while 6% of respondents earn less than Rs. 25,000. These demographic findings are relevant to understanding consumer behavior and preferences in the studied population.

Overall, the study's findings contribute to the existing literature on consumer behavior by shedding light on the importance of product quality in relation to post-purchase regret and providing insights into consumer demographics and online purchasing preferences.

6 CONCLUSION

The primary objective of this study was to investigate the factors affecting consumer post-purchase regret. The findings suggest that product quality issues have a significant correlation with consumer post-purchase regret, indicating that poor product quality leads to higher regret, while good quality products result in consumer satisfaction. However, factors such as price, impulse buying, and return process experiences did not show any significant correlation with consumer post-purchase regret. Additionally, the study highlights that product quality is a more critical concern for consumers than other factors.

Despite the valuable insights provided by this study, it is important to acknowledge some limitations. The study examined only four variables, leaving out potential other reasons contributing to post-purchase regret.

The use of a convenience sample in the sample selection method raises questions about the representativeness of the sample, as certain groups or demographics may have been excluded from the study. Furthermore, the study focused on a specific population in a particular geographic area, which may restrict the generalizability of the findings to other regions or populations with different cultural and social backgrounds. To address these limitations, future studies should employ more representative sample selection methods and consider examining the impact of external factors on consumer behavior.

REFERENCES

- Amoah, Abubakar and Sikayena. (2017). Investigating into factors accounting for cognitive dissonance (Post purchase regrets). *International Journal of Multidisciplinary Research and Development*. 4, 2349-4182.
- Krejcie, R. V., & Morgan, D. W. (1970). Determining sample size for research activities. *Educational and Psychological Measurement*, 30(3), 607–610.
- Lazim, N. A. M., Sulaiman, Z., Zakuan, N., Mas'od, A., Chin, T. A., & Awang, S. R. (2020). Measuring Post-purchase Regret and Impulse Buying in Online Shopping Experience from Cognitive Dissonance Theory Perspective. *2020 6th International Conference on Information Management (ICIM)*, 7–13.
doi:10.1109/ICIM49319.2020.244662
- Mensah, K., Boateng Dankwah, J., Mensah, G., & Masope-Crabbe, J. A. (2021). Choice, Purchase Decision and Post-Purchase Dissonance: The Social Media Perspective. *Information Management and Business Review*, 13(3(I), 1-13.
doi:10.22610/imbr.v13i3(I).3209
- Sarwar, M. A., Awang, Z., & Habib, M. D. (2019). Consumer Purchase Regret: A Systematic Review. *International Journal of Academic Research in Business and Social Sciences*, 9(9), 403–425. doi:10.6007/IJARBS/v9-i9/6307
- Selvaraj, D.S., Shrikrishnan J. (2018). Factors affecting post purchase regret in online shopping. *International Journal of Pure and Applied Mathematics* (ISSN: 1314-3395), Vol. 118, No. 22, 915-920.



Factors influencing successful ERP usage in the Manufacturing industry in Sri Lanka: A systematic literature review

Nimmi Jayamali MA¹, Amila Withanachchi²

Department of Industrial Management, Faculty of Science, University of Kelaniya, Sri Lanka

*jayamali_im17034@stu.kln.ac.lk*¹

Department of Industrial Management, Faculty of Science, University of Kelaniya, Sri Lanka

*amilaw@kln.ac.lk*²

ABSTRACT

This paper explores the critical success factors of Enterprise Resource Planning (ERP) usage in the manufacturing industry, focusing on the Sri Lankan context. Despite the widespread adoption of ERP systems to improve productivity and efficiency, high failure rates still need to be solved. This study identifies critical success factors, and they are in each of the stages of the ERP usage process. A research gap in the implication of moderating variables, the economic depression and availability and accessibility to third-party ERP solution providers/vendors on critical success factors of ERP usage are identified in this paper. This study will focus on the Sri Lankan context since significant studies cannot be identified on the Sri Lankan context ERP usage and the implication of the above-mentioned moderating variables.

KEYWORDS: ERP (Enterprise Resource Planning), CSF (Critical Success Factors)

1 INTRODUCTION

ERP is a software solution that helps organizations manage resources efficiently by integrating information processing. Its critical attributes include automating and integrating business processes, sharing enterprise data, and accessing real-time information (Singh, Singh & Singh, 2013). While ERP can significantly improve productivity and profits, many companies fail to achieve this due to incorrect selection or implementation failures. Although ERP is widely adopted in developed countries, there is still low adoption in developing countries such as Sri Lanka, where its success is even more critical due to limited resources (Senadheera et al., 2018)

Manufacturing firms use ERP systems to increase productivity and quality (Perera & Costa, 2008; Singh et al., 2013). ERP helps maintain and

improve quality management for a competitive advantage in the industry (Singh et al., 2013). Companies often reengineer their processes to reduce customization costs to fit with the ERP system (Beheshti et al., 2014). However, ERP implementation requires significant investment, especially for companies in developing countries like Sri Lanka (Senadheera et al., 2018).

2 METHODOLOGY

This study uses a systematic literature review to analyze the critical success factors of using ERP systems in manufacturing. The methodology follows five steps: framing the question, identifying relevant literature, assessing quality, summarizing evidence, and understanding findings (Khan et al., 2003). The literature was gathered from academic websites such as Google Scholar, Research Gate, and Scopus, and 50 papers were selected using keywords

and publication year sorting, with 30 chosen for analysis based on quality and relevance.

3 FINDINGS AND DISCUSSION

3.1 *ERP in the Manufacturing industry*

The manufacturing industry is characterized by its competitive nature, as businesses convert raw materials into finished products. In this context, the adoption of Intelligent Manufacturing is gaining traction to promote sustainability, job creation, and innovation. The Enterprise Resource Planning (ERP) system is a widely used tool for achieving these objectives, as it integrates all functional units into a single system and facilitates data management. Although ERP implementation was initially a high investment and time-consuming process, its significant benefits have led to widespread adoption in manufacturing.

The primary objective of manufacturing firms utilizing ERP systems is to enhance productivity and quality. The ERP systems provide firms with improved operational performance and increased competitiveness by enabling the sharing and transfer of data and processes. Consequently, ERP implementation has become a popular strategy for seeking competitive advantages in many countries and sectors (Gupta et al., 2019; Cui et al., 2020; Kenge & Khan, 2020; Singh et al., 2013).

3.2 *Risks associated with ERP usage*

More than two-thirds of ERP system projects fail despite their stated benefits. In order to prepare their staff for new problems and teach them how to use technology effectively, organizations need to understand system adoption from the user's point of view. Even if the ERP

system is appropriately implemented, the ERP journey does not finish at the system's "go-live" point. The significant issues frequently start during the system's post-implementation or exploitation stage (Lan et al., 2009). According to previous studies, it is evident that when using, maintaining, and improving the ERP systems in the post-implementation period, user organizations frequently run into a wide variety of challenges. These hazards are not only centered on technological issues but also across various operational, managerial, and strategic thinking domains. Various risks in the ERP exploitation may have adverse effects on the ERP viability and substantial declines in corporate productivity (Pan, Nunes & Peng, 2011).

An organization's usage of an ERP system is critical since it consumes more resources and time and needs a substantial monetary investment (Singh et al., 2013). Most manufacturing firms are not getting the desired outcomes from the ERP system usage, and they need the support of consultancy firms to overcome the issues. Companies hesitate to use consultancy support since consultancy firms in Sri Lanka are costly (Perera & Costa, 2008).

3.3 *Critical success factors of ERP usage*

Top management support and data management are the critical success factors cited (Singh et al., 2013). Fully utilizing the ERP benefits requires a strong alignment and reconciliation mechanism between technical and organizational imperatives. A clear understanding of strategic goals, excellent project management, organizational change management, a great

implementation team, data accuracy, extensive education and training, focused performance measures, and multi-site issues are some other CSFs in research findings (Singh et al., 2013). Especially in developing countries, low IT maturity, small firm size, lack of process management, and insufficient BPR adversely affect the ERP system's success (Huang & Palvia, 1992). The organizational structure changed with the ERP system deployment, and management needed to adjust the employee activities and corporate culture according to the change (Beheshti et al., 2014).

Computer self-efficacy, Organizational support, categorized into technology support, management support, technical support, user training and technological compatibility, are identified as critical success factors in using ERP systems (Rajan & Baral, 2015). Technical assistance is the term for individuals who assist customers who use computer hardware and software products, faxes, automatic telephone voice response systems, remote control software, and other facilities with machine-readable support knowledge bases. Lack of training has been cited as a significant reason for the failure of ERP systems. Employee tension and anxiety related to using the ERP system will be reduced through training and education, improving their comprehension of the system's advantages for their duties. The complexity of ERP systems restricts how much information users can learn before using them. Complexity increases mental strain and workload. Users' attitudes toward utilizing the ERP system may be negatively impacted by the system's complexity (Rajan & Baral, 2015).

Studies have identified four dimensions of technological compatibility: compatibility with existing work practices, compatibility with preferred work style, prior experience, and compatibility with existing values (Rajan & Baral, 2015).

The main risks identified during the ERP usage stage are operational, analytical, organization-wide, and technical. They have highlighted the most frequently recognized CSF within these primary categories, including top management support, vendor and consultant assistance, user resistance, education, and change management (Pan et al., 2011). The long-term ERP exploitation in their firm might be significantly impacted by highly qualified and experienced IT experts. Additionally, losing qualified IT professionals can frequently result in losing priceless ERP knowledge and skills.

A clear purpose and plan, senior management backing, sufficient education and training, a robust implementation team, business process re-engineering, and data accuracy are essential variables in the successful usage of the ERP systems. A country's economic condition also has been identified as critical for successful ERP implementation in a few studies, but more analysis needs to be done. Some factors have been placed in many studies, and some factors still need to be identified in many studies. However, a deeper analysis is more critical since it is visible that only identifying factors that affect failure and success is done in many types of research but not deeper analysis on those factors.

3.4 ERP vendors

Due to the significant investment required and associated risks, selecting a vendor and its technology that aligns with a firm's goals is vital (Vaidyanathan & Fox, 2017). Many factors are considered when selecting a vendor by organizations. Mainly, those factors can be categorized as technological and change management. Factors in the technological section are customization ability, ease of implementation, maintenance programs, the flexibility of software implementation, integration with other systems etc. The software maintenance program is of great importance by providing add-ons and patches as necessary (Vaidyanathan & Fox, 2017). Vendor issues such as knowledge of business, after-services, consulting capabilities, technical strength, and software upgrade policies can be identified as CSFs that need to be considered in ERP usage (Ngai, Law & Wat, 2008). Some general factors considered are the vendor's market share, reputation, number of consultants, number of installations performed, support infrastructure, and demonstration of previous implementations are critical factors that show the vendor's commitment to the product (Vaidyanathan & Fox, 2017). More than the cost, considering the vendor's capabilities is more critical in selecting the best-suited vendor (Kaur & Mahanti, 2008). Product quality, just-in-time delivery, service levels and technical support are essential. Selecting an ERP system that matches all the company's functionalities is hard. Therefore, it is crucial to choose a flexible vendor

responsive to changing customer needs (Kaur & Mahanti, 2008).

Since studies show that vendor is a crucial factor that decides the success or failure of an ERP system, it is essential to study deeper on that. Studies have not analyzed the effect of the availability and accessibility of the ERP vendor on the identified critical success factors for ERP success.

3.5 Economic depression

An economic depression is a state of unstable finances brought on by adverse economic activity. It makes difficult for the firms to increase sales, cut expenses, lay off employees, or invest in new products like ERP systems. According to Huang and Palvia (1992), increased political and economic stability is beneficial for the advancement of ERP. Depending on the status of the economy or the culture of the nation where the company is located, several important success variables for the deployment of ERP have different weights (Dezdar & Ainin, 2012).

A company's goals are of critical importance in periods of crisis where both firms and customers become more cost-conscious, and efficient utilization of resources may become a survival issue (Antoniadis et al., 2015). Thus, top management's attention, time and effort are more towards the cost reduction and survival of the company. SMEs, particularly during times of crisis, redirect resources from "cost" operations like training and integrating new software and its capabilities, giving up the possibility to develop core competencies and potentially advantageous competitive advantages. (Antoniadis et al., 2015). According to some estimates, allocating

10% to 15% of the overall ERP implementation budget for training will increase an organization's chances of success by 80% (Singh et al., 2013). Reserving a considerable budget for training and getting a high commitment from top management during a crisis is challenging. Change management includes re-engineering key business processes and developing new business processes, which consume lots of resources and time and are crucial factors in economic depression (Singh et al., 2013). A country's IT/IS development can be broadly predicted by its economic standing. IT/IS development is fueled by rapid economic growth as businesses strive to gain a competitive edge. Therefore, a robust economic foundation offers a solid basis for IT/IS development as well as for the deployment of ERP (Huang & Palvia, 1992). Since a country facing an economic depression have an economic downturn, it hinders IT infrastructure development while hindering successful ERP usage. Most of the ERP systems used by manufacturing companies in Sri Lanka are international ERP systems. Factors such as government policy encouraging foreign investment affect successful ERP system usage (Huang & Palvia, 1992).

4 CONCLUSION

Successful ERP usage depends on several factors: top management support, user training and education, change management, and IT infrastructure. Top management support is crucial as large-scale projects require approval and resources from top management. User training and education are essential to ensure proper usage of the ERP system. Change management is necessary to

effectively balance forces in favor of change and achieve the full benefits of ERP. IT infrastructure is an essential prerequisite for ERP usage, and companies with high IT maturity have more chances of success. Poor IT infrastructure can lead to the slow processing capability of the ERP system. (Ngai et al., 2008; Nah et al., 2001; Senadheera et al., 2018; Singh et al., 2013; Somers & Nelson, 2001; Jayawickrama & Yapa, 2013; Wong et al., 2005).

Previous studies have yet to address the effect of the economic situation of a country on the critical success factors of successful ERP usage. More studies can be found on the effect of third-party ERP solution providers on successful ERP usage. Thus it is vital to address the identified research gap.

REFERENCES

- Beheshti, H., K. Blaylock, B., A. Henderson, D., & G. Lollar, J. (2014). Selection and critical success factors in successful ERP implementation. *Competitiveness Review, 24*(4), 357-375. <https://doi.org/10.1108/CR-10-2013-0082>
- Huang, Z., & Palvia, P. (1992). ERP implementation issues in advanced and developing countries. *Business Process Management Journal, 7*(3), 276–284.
- Jayawickrama, U., & Yapa, S. (2013). Factors affecting ERP implementations: client and consultant perspectives. *Journal of Enterprise Resource Planning Studies, 2013*(online), 1-13.
- Kaur, P., & Mahanti, N. C. (2008). A fuzzy anp-Based approach for selecting erp vendors. *International Journal of Soft Computing, 3*(1), 24– 32.
- Khan, K. S., Kunz, R., Kleijnen, J., & Antes, G. (2003). Five steps to conducting a systematic review. *Journal of the royal society of medicine, 96*(3), 118-121.
- Lan, Hua., Yang, Y., Guo jia zi ran ke xue ji jin wei yuan hui (China), Haerbin gong ye da xue., & IEEE Technology Management

- Council. (2009). The Process of ERP Usage in Manufacturing Firms in China: An Empirical Investigation. IEEE.
- Nah, F. F. H., Lau, J. L. S., & Kuang, J. (2001). Critical factors for successful implementation of enterprise systems. *Business process management journal*, 7(3), 285-296.
<http://www.emerald-library.com/ft>
- Ngai, E. W. T., Law, C. C. H., & Wat, F. K. T. (2008). Examining the critical success factors in the adoption of enterprise resource planning. *Computers in Industry*, 59(6), 548–564.
<https://doi.org/10.1016/j.compind.2007.12.001>
- Pan, K., Nunes, M. B., & Peng, G. C. (2011). Risks affecting ERP postimplementation: Insights from a large Chinese manufacturing group. *Journal of Manufacturing Technology Management*, 22(1), 107–130.
<https://doi.org/10.1108/17410381111099833>
- Perera, H. S. C., & Costa, W. K. R. (2008). Analytic Hierarchy Process for Selection of Erp Software for Manufacturing Companies. *The Journal of Business Perspective*, 12(4).
<https://doi.org/10.1177/097226290801200401>
- Rajan, C. A., & Baral, R. (2015). Adoption of ERP system: An empirical study of factors influencing the usage of ERP and its impact on end user. *IIMB Management Review*, 27(2), 105–117.
<https://doi.org/10.1016/j.iimb.2015.04008>
- Senadheera, P. M., Wadugedara, P. M., H Chandrasekara, W. P., K I S Yasiharan, C. A., Suwadika Sivaroshan M Dissanayake, M. P., D Lakshani, A. W., A N Helali, K. G., & J Hennakgedara, P. G. (2018). An Analysis of the Challenges and Barriers of Implementing Erp in Listed Companies of Colombo Stock Market.
- Singh, C. D., Singh, R., & Singh, M. (2013). Critical appraisal for implementation of erp in manufacturing Industry. *International Journal of Management Research and Business Strategy*, 2(1).
- Somers, T. M., & Nelson, K. (2001, January). The impact of critical success factors across the stages of enterprise resource planning implementations. In *Proceedings of the 34th annual Hawaii international conference on system sciences* (pp. 10-pp). IEEE.
- Vaidyanathan, G., & Fox, M. (2017). ENTERPRISE RESOURCE PLANNING VENDOR SELECTION: A CASE STUDY. *Issues in Information Systems*, 18(2).
https://doi.org/10.48009/2_iis_2017_39-47
- Wong, A., Scarbrough, H., Chau, P., & Davison, R. (2005). Critical failure factors in ERP implementation.



Human Resource Allocation in Software Projects: a Case Study

Mendis BSL¹, Jothirathne PAAU²

Department of Industrial management, Faculty of Applied Science, Wayamba University of Sri Lanka
slakindumendis@gmail.com¹
anoja@wyb.ac.lk²

ABSTRACT

The Project Management department of the organization has a severe issue with meeting project deadlines. A preliminary internal study had deduced that this may be due to improper human resource allocation in their Software Projects. Hence, this study intends to affirm whether there is an issue in project staffing and if so, propose a suitable model to follow when allocating human resources to software projects. The study methodology presented the top-tier decision-making employees of the organization with a sample scenario of a task with a skill requirement and a set of software engineers with different skill availabilities asking them to rank the available human resources that would be best fit for the task. Results indicated the allocation is done considering the prominent skill required for the software project neglecting any other supplementary skills needed. Hence, allocated Human Resources are compelled to learn the skills that they currently do not possess but are required by the task. The Best Fitted Resource allocation methodology was introduced to the company. With this method, the training-time factor was taken into account when allocating human resources to software projects. Many projects are undertaken simultaneously by software development firms. Hence this study can be extended to assigning human resources to multiple projects simultaneously.

KEYWORDS: Best-Fitted Resource Allocation Methodology, Human Resource Allocation, Skill Availability, Skill Requirement, Training Time

1 INTRODUCTION

The software development industry has seen steady growth, leading to high competition among organizations. Speed of delivery is a key competitive factor, but many organizations struggle to meet deadlines despite having proper plans in place. Staffing issues, including the failure to allocate tasks to the right people, are major factors contributing to these difficulties. If the ideal resources are not allocated to a project, it can have a crucial impact, especially if the allocated HR lacks the required skillset. In such cases, HR must gain the necessary competency through training (Plekhanova, 1999).

1.1 Objectives of the study

The organization faces the problem of having project backlogs. This project backlog could be mainly due to improper allocation of HR to projects and is yet to be proven. Hence the objective of this study was to optimize HR allocation to software projects by identifying the possible cause and thereby reduce the project backlogs of the company. The secondary objective of the study was to identify a suitable model to allocate HR in software project tasks even though the most desirable skills are not available within the existing workforce.

2 LITERATURE REVIEW

2.1 Software Projects

Being deduced from the concepts of Projects, a Software Project is the complete procedure of software development starting from requirement gathering and ending at testing and maintenance, performed in a given period of time to achieve an intended software product. Hence, Project Management related concepts can be found true for Software Project Management (Martin & McClure, 1988). Setting up the right team is a critical factor for Software Development Processes (Chow & Cao, 2008) since the prominent cause for failures in software development projects is often found to be the incorrect allocation of human resources (Kang, et al., 2011). There are major limitations in research conducted on human resource allocation techniques for software projects (Kan, 1995). However, eliminating a vast number of limitations, Otero et al., (2009) proposed a method termed Best-Fitted Resource (BFR) methodology which took into account the complete set of capabilities of candidates, levels of skills required, and priorities of required skills for tasks.

3 METHODOLOGY

The research followed an Explanatory Research Design.

3.1 Research Model

The research employed a sample scenario (figure 01) for the respondents to answer.

In this sample scenario, it is assumed that C# programming language is the most important skill requirement for the task. Accordingly, Software Engineer (SE) 5 possesses the highest skill rating

A software engineer with the following requirements is needed,						
<ul style="list-style-type: none"> • Perfect knowledge regarding C# programming language is essential • Intermediate knowledge of the Windows 07 and 08 operating systems • Fair experience with GitHub is preferable 						
There are six software engineers available with particular skill levels as depicted below.						
Please rank from 1 to 6, the best fitted engineer for the above task out of the table below						
	C# programming language	Windows 07	Windows 08	GitHub	C++ programming language	Java programming language
SE 1	Low	Moderate	Moderate	High	Moderate	High
SE 2	Moderate	Low	Low	Null	Low	Low
SE 3	Moderate	Low	Moderate	Moderate	Low	Low
SE 4	Low	Null	Low	Null	Low	Low
SE 5	High	Low	Low	Null	Null	Null
SE 6	Low	High	Moderate	Null	High	Null

Figure 01: The Sample Scenario

in C# programming. If respondents assign SE5 top-rank to the task, then it provides strong evidence that the selection was based on the capability of the SE on a single and most prominent skill. However, if the entire set of skills available in the resources is considered technically SE1 is the best fit for the task.

3.2 Sample

The respondents for this study were Project Managers, Tech Leads, and Software Engineers working at the organization. The population size is 40, among them, 30 employees were selected randomly since the sample size 30 is adequate for any given study according to Kar & Ramalingam, (2013).

3.3 Data Collection & Analysis

Primary data was used in the study. The data were collected using an online survey-based questionnaire which was distributed among the targeted employees. The online survey recorded the respondents' perspectives regarding a team allocation relative to the common sample scenario.

4 DATA COLLECTION AND ANALYSIS

4.1 The current human resource allocation status

In the questionnaire, respondents were asked to rank SE allocation for the task in the Sample Scenario. The results of the survey are shown in table 1.

Table 1: Probability of selecting software engineers for the task from rank

	1 to 6					
	1st	2nd	3rd	4th	5th	6th
SE 1	0	0.1	0.3	0.5	0.23	0.17
SE 2	0	0	0.57	0.3	0.03	0
SE 3	0.4	0.6	0	0	0	0
SE 4	0	0	0	0.03	0.2	0.67
SE 5	0.6	0.3	0	0	0	0
SE 6	0	0	0.13	0.17	0.53	0.17

The first choice of 60% of the respondents is SE 5 and the others' first choice is SE 3. The fact, whether there was a significant difference in the preference when selecting between SE 5 and SE 3 was determined using a Sign Test. Letting P_{SE5} indicates the proportion of the population selecting SE 5 as the first choice, the following hypotheses were tested.

H₀: P_{SE5} ≠ 0.50

H₁: P_{SE5} = 0.50

Selecting SE 5 or SE 3 as the first choice would have a significant difference if H₀ is supported, implying consideration of only the C# skill availability for resource assessment. A supported H₁ suggests that the allocation of resources was based on the knowledge of resources in the entire available skillset required to complete the tasks.

E₊ = 15, σ₊ = 11.84146

The large sample statistic is given by

Z_{cal} = $\frac{i - E_+}{\sigma_+} = \frac{18 - 15}{11.84146} = 0.25335$

σ₊ = 11.84146

where i refers to the number of times that SE 5 was selected as the first choice. The hypothesis was tested at the 0.05 level of significance; therefore, the Z_{cal} test statistic was compared to 0.59095. Since |Z_{cal}| < 0.59095, it is concluded that the null hypothesis is accepted. The analysis of the data collected has provided significant evidence that SE 5 was the preferred selection for the first choice. Therefore, it is concluded that the assumption that decisions are based on the capability of candidates in one main skill is valid. These results are of importance because they provide evidence that in this organization the complete skill sets of resources are not being properly considered to determine the suitability of candidates with tasks. If it was the entire skill availability that was taken into account in figure 1 when allocating the resources, ideally it would be SE 1 who would be technically the best match.

4.2 Application of the Best-Fit Resource (BFR) Allocation methodology to select the best resource

Time spent on skill improvement is based on resource knowledge in related skills. Training time reduces productivity as it represents idle time not spent working on tasks, but instead getting ready to work. Brooks' Law, states that adding manpower to a late software project delays the project even more (Brooks, 1975). Training time is considered one of the causes of this delay. That is, reducing training time becomes even more critical in the later stages of projects. Therefore, the importance of correctly matching resources with tasks increases as projects

progress through their phases. The BFR methodology comprises four basic steps. Each step aims at developing a set of tabular information to set up a process that deduces the best-fit resource for a provided task. The tables are the deliverables of each step. The four steps are; Task Required Skills (TRS), Skill Relationships (SR), Resources' Skill Set (RSS), and Best-Fitted Resource (BFR).

4.3 The Task Required skills (TRS)

Determining the levels of skills needed for a task is the first step. Each level of skill is defined in terms of its anticipated use (q_{jt} ; Minor Use = 0.3, Considerable Use = 0.7, High Use = 1.0) and complexness (u_{jt} ; Easy = 0.3, Complex = 0.6, Very Hard = 1.0). Both q_{jt} and u_{jt} are expressed subjectively by decision-makers with discrete values varying from 0 to 1 for better clarity and flexibility. s_{jt} , which refers to the importance of each required skill for a task, is computed as the product of the anticipated use times the complexity. A Task Required Skills (TRS) table for the Sample Scenario (figure 1) is provided in table 2. Assume that the GitHub platform is used to develop a computer program that shares code with it. The direction that explains the GitHub platform work is simple. Hence, an index of 0.3 is designated for the complexity. Since the GitHub platform will be used only to push and pull code, the anticipated use is little. Thus, the s_{jt} index computed is $0.3 \times 0.3 = 0.09$, which implies that knowledge of the functionality is a preferred one and not essential.

Table 2: TRS Table

	q_{jk}	u_{jk}	$s_{jt} = q_{jk} * u_{jk}$
C#	1 000	1 000	1 000

Windows 10	0.700	0.600	0.420
Windows 11	0.700	0.600	0.420
GitHub	0.300	0.300	0.090

4.3.1 The Skill Relationships (SR)

Table 3: SR table showing learning arc indexes

	C#	Win10	Win11	Git	C++	Java
C#	1	0	0	0	0.3	1.0
Win10	0	1.0	1.0	0	0	0
Win11	0	1.0	1.0	0	0	0
Git	0	0	0	1.0	0	0
C++	0.3	0	0	0	1.0	0.3
Java	1.0	0	0	0	0.3	1.0

Measuring how different skills can reduce the time needed to learn others is crucial in assessing resource capabilities. For example, the skill in C# programming language can lessen the time to become skilled in Java programming language since they both are object-oriented languages. A more comprehensive assessment of the abilities of resources is provided by the Skill Relationships (SR) table. This table depicts the association between known and unknown skills in terms of learning arcs (r_{jk} ; No relationship = 0, Weak relationship = 0.3, Intermediate relationship = 0.6, Strong relationship = 1.0). Decision makers subjectively describe learning arc associations with discrete values spanning from 0 to 1. Decision makers subjectively describe learning is associated with discrete values spanning from 0 to 1.

The higher the knowledge of the Java programming language, the lesser time it takes to learn C# programming language since the syntax of both programming languages is quite similar.

4.3.2 The Resource's Skill Set (RSS)

The next step is to tabulate available resources (n_{yj} ; No knowledge = 0, Minor knowledge = 0.3, Intermediate knowledge = 0.6, Extreme knowledge =

1.0) with discrete values ranging from 0 to 1. These values are defined by decision-makers subjectively. The resource’s Skill Set (RSS) for the Sample Scenario is shown in Table 4.

Table 4: RSS table depicting n_{yj} values

	Available skills					
	C#	Win10	Win11	Git	C++	Java
SE1	0.3	0.6	0.6	1.0	0.6	1.0
SE2	0.6	0.3	0.3	0	0.3	0.3
SE3	0.6	0.3	0.6	0.6	0.3	0.3
SE4	0.3	0	0.3	0	0.3	0.3
SE5	1.0	0.3	0.3	0	0	0
SE6	0.3	1.0	0.6	0	1.0	0

4.3.1 The Best Fitted Resource (BFR)

The fourth and final phase of the procedure is to set up a BFR table to define the appropriateness of available resources with the skills needed for a task. The most matching resource will presumably bear the shortest amount of training time. Given a required skill k , there exist two factors considered for each given resource y . The foremost factor is the level of understanding of resource y in the needed skill, denoted by n_{yk} . The second factor is the level of understanding of resource y in all other probable skills and their association to the expected skill, obtained by multiplying $n_{yp} * r_{pk}$, where $p \in P$. The ability of a resource in a needed skill, which indicates the anticipated training time, is expressed as,

$$B_{yk} = \text{Max}_{p \in P} [n_{yp} * r_{pk}] \quad (\text{Otero et al., 2009})$$

Table 5, shows the capabilities of the available resources in each of the required skills from figure 1, taking into account the relationships between skills. For example, the calculation of the knowledge of SE 1 in C# programming language is as follows. Since the level of knowledge of SE 1 in C# is 0.3 (low),

and $r_{jj} = 1$, the capability of this resource in C# programming language based on his/her knowledge of C# programming language is 0.2. Now, since knowledge of Windows 10, Windows 11, or the GitHub platform has no relationship with C# programming language knowledge, then $r_{pj} = 0$, which means that knowledge in any of these three skills does not contribute to the resource’s capability in C# programming language. The relationship between C++ and C# programming language is low, therefore $r_{pj} = 0.3$. Since the level of knowledge of the resource in C++ is Intermediate, then $n_{yp} = 0.6$. Therefore, the capability of SE 1 in C# programming language due to the software engineer’s knowledge of C++ is $0.3 * 0.6 = 0.18$. The relationship between Java and C# programming language is high, therefore $r_{pj} = 1$. Since the level of knowledge of the resource in Java is high, then $n_{yp} = 1$. Therefore, the capability of SE 1 in C# programming language due to his/her knowledge of Java is 1.0. Even though the resource’s experience with C# is low, his/her expert knowledge in Java programming language will decrease the training time in C# programming language.

Table 5: Abilities of resources in the needed skills for the task

	C#	Win10	Win11	Git	C++	Java
SE1						
C#	0.3	0	0	0	0.18	1
Win10	0	0.6	0.6	0	0	0
Win11	0	0.6	0.6	0	0	0
Git	0	0	0	1	0	0
SE2						
C#	0.6	0	0	0	0.09	0.3
Win10	0	0.3	0.3	0	0	0
Win11	0	0.3	0.3	0	0	0
Git	0	0	0	0	0	0
SE3						
C#	0.6	0	0	0	0.09	0.3
Win10	0	0.3	0.6	0	0	0

Win11	0	0.3	0.6	0	0	0
Git	0	0	0	0.6	0	0
<hr/>						
SE4						
C#	0.3	0	0	0	0.09	0.3
Win10	0	0.3	0.6	0	0	0
Win11	0	0.3	0.6	0	0	0
Git	0	0	0	0	0	0
<hr/>						
SE5						
C#	1	0	0	0	0	0
Win10	0	0.3	0.3	0	0	0
Win11	0	0.3	0.3	0	0	0
Git	0	0	0	0	0	0
<hr/>						
SE6						
C#	0.3	0	0	0	0.3	0
Win10	0	1	0.6	0	0	0
Win11	0	1	0.6	0	0	0
Git	0	0	0	0	0	0

The suitability of a resource y with a given task t possessing a skillset $P(t)$ is determined by the total of the products of the significance of the skill j for the task t times the capability of the resource y in the skill j as,

$$f_{yt} = \sum_{j \in P(t)} S_{jt} * c_{yj}, \quad \forall y \text{ (Otero et al., 2009)}$$

Table 6: The calculated results

SE 1	$f_{yt} = 1.594$
SE 2	$f_{yt} = 0.852$
SE 3	$f_{yt} = 1.158$
SE 4	$f_{yt} = 0.804$
SE 5	$f_{yt} = 1.252$
SE 6	$f_{yt} = 1.14$

Table 6 illustrates the outcomes from the Sample Scenario. Established on the BFR method, SE 1, is the best fitted followed by SE 5 because the f_{yt} weight for SE 1 is highest at 1.597 followed by that of SE 5 at 1.252. The implications are that the BFR methodology is an ideal model for the target organization to follow during Human Resource allocation to their software projects.

5 DISCUSSION

The organization has an issue with allocating HR to Software Projects. the root cause for this is when HR is

allocated to the projects a predominant skill requirement of the available tasks and the predominant skill availabilities of the relevant resources are considered while the other available skills are neglected. This leads to taking time for training other skill requirements of the task. According to technical know-how, the ideal resource to allocate for the task in the Sample Scenario is SE 1. The BFR methodology provides a successful model to apply when allocating human resources to software projects. This deduction has been made by the model considering all the skill requirements of the task and all the skill availabilities of the resources. The BFR model (Otero et al., 2009) has deduced that SE 1 is the ideal resource to take up the task from the sample scenario.

6 CONCLUSION

One limitation of the study was the questionnaire includes a single scenario of a hypothetical project. If there were multiple scenarios of many projects, responses may change. The study considered a sample scenario with a small number of skill requirements and skill availabilities, future studies could incorporate more skill requirements and availabilities to deduce whether the ideal usage of the BFR methodology is still valid. Further, this study facilitated only a single task. The study could expand to allocating human resources in multiple tasks simultaneously.

REFERENCES

- Brooks, F. P. (1975). *The mythical man-month*. Reading, MA: Addison-Wesley.
- Chow, Tsun & Cao, Dac-Buu. (2008). A Survey Study of Critical Success Factors in Agile Software Projects. *Journal of Systems and Software*. 81. 961-971. 10.1016/j.jss.2007.08.020.

- Kan, S. H. (1995). Metrics and models in software quality engineering. Addison-Wesley.
- Kang D., Jung J., and Bae D.H., "Constraint based Human Resource Allocation in Software Projects," *Software Practice Experience*, vol. 41, pp.551–577, 2011
- Kar, Sitanshu & Ramalingam, A.. (2013). Is 30 the magic number? issues in sample size estimation. *Natl. J. Commun. Med.* 4. 175-179.
- Martin, J. and McClure, C. (1988) Structured Techniques: The Basis for CASE (Revised Edition), Englewood Cliffs, New Jersey, Prentice Hall.
- Otero, Luis & Centeno, Grisselle & Ruiz-Torres, Alex & Otero, Carlos. (2009). A systematic approach for resource allocation in software projects. *Computers & Industrial Engineering.* 56. 1333-1339. 10.1016/j.cie.2008.08.002.
- Plekhanova, V. (1999). Capability and compatibility measurement in software process improvement. *In Proceedings of the 2nd European software measurement conference – FEESMA'99*, Amsterdam, The Netherlands (pp. 179– 188)..



Identifying the Customer Segmentation for Buying Mercedes Benz Vehicles: A Phase from Sri Lanka

Ranaweera EC¹, Dharmawansa AD²

*Industrial Management Department, Faculty of Applied Sciences, Wayamba University of Sri Lanka
fas172127@kul.wyb.ac.lk¹*

*Industrial Management Department, Faculty of Applied Sciences, Wayamba University of Sri Lanka
asankad@wyb.ac.lk²*

ABSTRACT

Mercedes Benz vehicles are considered as a luxury brand and its parent company is headquartered in Germany. Mercedes Benz vehicles are characterized by the three most pronounced traits: tangible self-assurance, optimum ride comfort, and high driving safety. Due to the COVID-19 pandemic situation and the prevailing economic crisis in Sri Lanka, customers' purchasing power for Mercedes Benz vehicles has decreased. So, the organization needs to market the product. The research study aims to identify customer segmentation for buying Mercedes-Benz vehicles. The results of this research will provide recommendations for the organization to identify the targeted Mercedes-Benz customers to market the product. The research is mainly relied on secondary data including 306 data records and data collected from DIMO 800 – Mercedes Benz Centre in Colombo-14. Data were analyzed using factor analysis and IBM Statistical Package for Social Sciences (SPSS) was used to conduct the analysis. Based on the results of factor analysis, the researchers identified the customer segmentation for buying Mercedes-Benz vehicles. Personally identifiable information, lifestyle, child census, and age are considered as the customer segments for buying Mercedes Benz vehicles. The descriptive analysis was used to identify the targeted Mercedes-Benz customers. Most of the Mercedes Benz customers are in the range of 45-64 ages. Most of the Mercedes Benz customers have less than three children. The majority of Mercedes Benz customers have an income of more than 750,000 rupees per month and most of the customers are in the Western province. Among them, most of the Mercedes Benz customers are in the Colombo district. The majority of Mercedes Benz customers are married people.

KEYWORDS: buying behavior, customer segmentation, marketing, Mercedes Benz vehicles, targeted customers

1 INTRODUCTION

Sri Lanka is a developing country, and the Sri Lankan automobile industry mainly consists of the motor vehicle retail sector and after-sales service sector. Sri Lanka still does not have a developed automobile manufacturing process. As a result of that, it is based on importing motor vehicles from foreign countries and assembling motor vehicles in Sri Lanka (RATHNAYAKA, et al.).

Due to COVID-19 pandemic and the economic crisis in Sri Lanka, DIMO 800-Mercedes Benz Centre could not market

their products because they could not import brand new Mercedes Benz vehicles as a result of strict restrictions on imports. So, DIMO is considering of importing vehicle parts and assembling Mercedes Benz vehicles in Sri Lanka.

The main objective of this research is to identify the customers' segmentation for buying Mercedes Benz vehicles and to identify the targeted Mercedes Benz Customers. The organization can use suggested improvements and sales promotion strategies to increase the sales of

Mercedes-Benz vehicles. It will help the organization to increase its profit also.

2 LITERATURE

Customer segmentation for buying motor vehicles is a combination of economical, technological, cultural, demographical, and natural factors as well as the own characteristics which are reflected by customers' attitudes, motivations, perceptions, personality, knowledge, and lifestyle (Shende, 2014).

The study of demographic data is essential for organizations, businesses, and governments to analyze data for making decisions (Indeed Editorial Team, 2020).

The research study investigated that Mercedes Benz customers who are between 18 and 35 years old have a significantly higher threshold than older customers. However, other luxury brand manufacturers do not have this effect (Paulssen & Birk, Satisfaction and repurchase behavior in a business-to-business setting: Investigating the moderating effect of manufacturer, company, and demographic characteristics, 2007).

Most current luxury Mercedes Benz owners typically have previously owned a car; thus, the buyer may have formed an attitude toward it. Here, attitudes are considered as evaluating judgement based on prior or present experience such as products and services provided (warranty and after-sales services), previous satisfaction from dealers, driving experience, and socio-economic status of customers.

When considering Mercedes-Benz vehicles, they have many features with a large variety of models named A, B, C, E, G, S, V, and X classes and GLE,

GLA, GLC, CLA, CLS, GLB, and AMG types of models (Mercedez Benz Sri Lanka, n.d.).

MB vehicles have dominated the luxury market globally. Because MB vehicles have been a part of owners' life. That means it provides the owner the practicability both from functional and perceptual points of view (Boraiah, 2004).

According to (Kumar et al., 2016), the Indian mass luxury car market may still be in first gear, however luxury vehicles are set to increase in 2015. The market leader Mercedes Benz had a 41% increase in sales from January through June 2015 compared to the same period the previous year. Audi, BMW, and Mercedes Benz have been considered as three top brands and collectively control almost 90% of the Indian luxury automobile market.

3 METHODOLOGY

According to the research onion, this research could be considered a combination of positivism and pragmatism under the philosophy category. And the research "Identifying customer segmentation for buying Mercedes Benz vehicles" could be approached using a deductive approach according to the research onion. The researchers have done the research for the DIMO 800 Mercedes Benz Centre, which is the training location of the first author. Therefore, the research is considered a case study. This research used a mono-method to collect data. But the research used a mixed method for the data analysis. That means using factor analysis as well as descriptive analysis for analyzing data.

According to the research study, there are eight variables. The research is supposed to take data related to variables such as “age”, “gender”, “marital status”, “Number of children”, “monthly income”, “district”, “hobby” and “interests”. This research is supposed to take secondary data from the industrial training location and collected data for the research study from DIMO 800, Mercedes Benz Center which is in Colombo-14. This research collected company data from October 2019 to October 2022. And this research removed outliers and blanked columns from the data set and get the final data set with a 306-sample size.

The data analysis part has been done by using IBM Statistical Package for Social Sciences (SPSS). And the researcher used factor analysis to identify the customer segmentation for buying Mercedes Benz vehicles. And this research is supposed to identify targeted customers for buying Mercedes Benz vehicles using descriptive analysis.

4 DATA COLLECTION & ANALYSIS

An Exploratory Factor Analysis (EFA) was performed using principal component analysis and varimax rotation. The minimum factor loading criteria was set to 0.50. The communality of the scale, which indicates the amount

of variance in each dimension, was also assessed to ensure acceptable levels of explanation. The results show that all communalities were over 0.50.

An important step involved weighing the overall significance of the correlation matrix through Bartlett’s Test of Sphericity, which provides a measure of the statistical probability that the correlation matrix has significant correlations among some of its components. The results were significant, $\chi^2(n = 306) = 51.550$ ($p < 0.001$), which indicates its suitability for factor analysis. The Kaiser Meyer–Olkin measure of sampling adequacy (MSA), which indicates the appropriateness of the data for factor analysis, was 0.505. Previous research studies have suggested that KMO greater than 0.5 can be used for factor analysis (Li, Huang, & Feng, 2020). In this regard, data with MSA values above 0.50 are considered appropriate for factor analysis. Finally, the factor solution derived from this analysis yielded five factors for the scale, which accounted for 57.911 percent of the variation in the data.

The results of this analysis confirmed the four-dimensional structure theoretically defined in the research. It is shown in table 1.

Table 1: Results of the Factor Analysis

Item	Factors			
	1	2	3	4
Personal Identifiable Information				
Gender	0.751			
Marital Status	0.819			
Lifestyle				
Monthly Income		0.537		

Hobby		0.642		
Interests		0.602		
Child Census				
Number of Children			-0.6	
District			0.776	
Age				0.703

Finally, a descriptive analysis was done using Microsoft Excel to identify target Mercedes Benz customers. The descriptive analysis results show that the target customers for Mercedes Benz vehicles. Most of the Mercedes Benz customers are in the range of 45-64 years. The results show that most of the Mercedes Benz customers are married. And most of the Mercedes Benz customers have less than three children. Most Mercedes Benz customers have an income of more than 750,000 rupees per month, and most of the customers are in the Colombo district.

5 DISCUSSION

The most fundamental part of an organization is its customers (Mansoor & Jalal, 2011), and understanding their buying patterns is the most important factor in the success of business organizations (Sharma & Sonwalkar, 2013). Customer behavior is dynamic since it is affected by various factors (Kotler & Armstrong, 2012) and has been observed to take changes over the years. For companies to succeed, it is vital for them to identify and understand these changes in customer behavioral patterns and adapt accordingly.

The findings categorized the eight independent variables into four variables. The researcher used factor analysis to categorize those large numbers of variables into smaller numbers of variables. The results of the factor

analysis show personal identifiable information, lifestyle, child census and age are the segments that affect for buying Mercedes Benz vehicles.

The descriptive analysis results show that the target customers for Mercedes Benz vehicles. Most of the Mercedes Benz customers are between 45-64 ages. And most of the Mercedes Benz customers have less than three children. And also, the majority of Mercedes Benz customers are married people and they live a good life with their babies. Most Mercedes Benz customers have an income of more than 750,000 rupees per month and most of the customers are in the Colombo district.

6 CONCLUSION

Understanding customers' buying segmentation is one of the key factors in the success of the organization (Sharma & Sonwalkar, 2013). Because customers are the major identities helps to gain profit for the organization.

Factor analysis was used and use of the analysis results, the research study concludes that there is a connection between gender - marital status, monthly income – hobby – interests, number of children district, and age.

The descriptive analysis results conclude that the targeted Mercedes Benz customers should be aged between 45-64, have less than three children, have above 750,000 monthly incomes, and live in the Colombo district.

REFERENCES

- (n.d.). Retrieved from Mercedes Benz: <https://www.mercedes-benz.lk/en/desktop/passenger-cars/vehicle-type/new-cars/model-overview-standard.html#>
- Boraiah, S. (2004). *The Relationship Between Innovative Personality Traits And Perceived Attributes: A Case Study Of Mercedes Benz Car Consumers In Sukhumvit Area, Bangkok*. Bangkok, Thailand. Retrieved from <https://repository.au.edu/server/api/core/bitstreams/f726ce56-64cc-419a-a892-786f3cdf2b35/content>
- Indeed Editorial Team. (2020). *Career Guide*. Retrieved from Indeed: <https://www.indeed.com/career-advice/career-development/demographics-definition#:~:text=Demographics%20are%20the%20characteristics%20of,and%20governments%20to%20make%20decisions.>
- Kotler, P., & Armstrong, G. (2012). *Principles of Marketing (14th ed.)*. Boston: Pearson Prentice Hall.
- Kumar, A., Das, N., Khumar, A. P., Bakshid, S. A., & Vishnu, V. (2016). A Study on the Market Perception and Consumer Behavior of High End Cars (Mercedes-Benz, Audi and BMW). *International Education & Research Journal*, 2(3).
- Li, N., Huang, J., & Feng, Y. (2020). Construction and confirmatory factor analysis of the core cognitive ability index system of ship C2 system operators. *PLOS ONE*, 1-23. doi:10.1371/journal.pone.0237339
- Mansoor, D., & Jalal, A. (2011). The Global Business Crisis and Consumer Behavior: Kingdom of Bahrain as a Case Study. *International Journal of Business and Management*, 104-115. doi:10.5539/ijbm.v6n1p104
- Paulssen, M., & Birk, M.M. (2007). Satisfaction and repurchase behavior in a business-to-business setting: Investigating the moderating effect of manufacturer, company and demographic characteristics. *Industrial Marketing Management*, 36, 983-997. doi:10.1016/j.indmarman.2007.05.011
- Sharma, V., & Sonwalkar, J. (2013). Does Consumer Buying Behavior Change During Economic Crisis? *International Journal of Economics & Business Administration*, 33-48. Retrieved from http://www.ersj.eu/repec/ers/pijeba/13_2_p2.pdf
- Shende, V. (2014). Analysis of Research in Consumer Behavior of Automobile Passenger Car Customer. *International Journal of Scientific and Research Publications*, 4. Retrieved from <https://www.ijsrp.org/research-paper-0214/ijsrp-p2670.pdf>



Identifying the most effective layout design for the production floor: A Case study of Apparel industry

De Silva PKS¹, Dharmawansa AD²

Department of Industrial Management, Faculty of Applied Sciences, Wayamba University of Sri Lanka^{1,2}

fas172029@kul.wyb.ac.lk¹

Asankad@wyb.ac.lk²

ABSTRACT

Cutting, sewing and quality checking are the main processes in the Apparel manufacturing process. Among them, sewing is the most critical operation. Different apparel companies use different types of machine layouts in their production lines. This study aims to identify the most effective layout design for the production floor. In this selected company, there are mainly two layout types named “U type” and “|| type”. This study only focuses on the third section production lines which were converted into “U type” layouts. Four production lines were selected as the sample for the study. Generated standard hours, Work-in-progress level, AQL (Acceptable quality limit) and QCO (Quick change overtime) time used to measure effectiveness. Four months data were collected from four lines as two months data for each layout. Considering all the collected data, average values were calculated under each variable to compare two layouts. Performance rankings were given, comparing both average values. The final results conclude that the “U-type” layout is more effective than the “|| type” layout or the production floor.

KEYWORDS: Layout design, Production floor, Apparel industry

1 INTRODUCTION

The Apparel apparel industry has been contributing to Sri Lanka's economy since the 1980s. The apparel sector became the largest gross export earner since 1986, accounting for more than 52 per cent of total export earnings of the country in 2002. (Dheerasinghe, R., 2009). The Sri Lankan apparel industry has provided thousands of employments (Dheerasinghe, 2001) representing more than 1060 garment factories. Further, this sector employs about 15% of the workforce of Sri Lanka (BOI Sri Lanka). Sri Lanka has obtained a reputed market position by contributing international apparel market.

In the Apparel manufacturing, there are main processes like cutting, sewing and quality checking. Among them, sewing is the of the most critical

operation. Different apparel companies use different types of machine layouts in their production lines. That layout change happens due to many reasons, such as style changes, labor shortages and pandemic situations. Because of changing layouts from time to time, it may affect efficiency and quality. With Corona pandemic situation, the Selected apparel company's management had to change the production layout from “U type” to “|| type” to keep the social distance between team members. Now they have identified some issues on the production floor, like quality failures, efficiency drops, and high WIP levels. In both layouts, there are specific good characteristics compared to others.

Research question

- What is the most effective layout design for the production floor?

Research objective

- To identify most effective layout in the production floor that contributes most to the organizational performance.

It is vital for a garment factory to select a suitable layout design to maintain good production floor efficiency in order to succeed in different ways. Most of the garment factories now use production lines to produce/manufacture their garments. Now almost all garments tend to calculate daily production line efficiency to have a better idea about the flow of the production in the factory. Then management needs to figure out the effective layout for the production floor. Otherwise, shipment dates should be rescheduled frequently due to the low production line efficiency on the production floor.

2 LITERATURE REVIEW

2.1 *Layout design and sewing process*

Layout design often has a significant link with the performance of a manufacturing or service company. Layout design is a key factor in organizing operations in a way to utilize resources maximum and overall system throughput. Improper layout design creates bottlenecks, and lead time will be increased. Further, the existing bottleneck in the production floor results in long queues, long waiting times, high operating costs, low throughput and overall system inefficiency. It also led to the accumulation of work-in-process (WIP) and lot of quality issues.

2.2 *Quick change over*

Nowadays, fashion trends do not last more than two weeks. Fashion designs

are changing rapidly. Due to the increase of design varieties, orders come up in low quantities. Apparel companies face the necessity of having flexible production lines to produce a range of products in a short period. When switching from one style to another one, it should not take longer time. As long as the period of layout change increases, the firm's efficiency falls down with respect to the change over time. That is called the quick change over time. More specifically, Quick Changeover time is the time needed to change from the last piece of the previous product to the first good piece of the next. The aim is to reduce the loss of efficiency due to a layout change. There needs to be some time duration for operators to adopt the new style. (Kentli, Dal, & Alkaya, 2013)

Considering the existing literature about the apparel industry, there are particular number of studies that focus about layout of the production. Effective facility layout design reduces throughput time, and increases the quantity and efficiency of the plant.

A study conducted by Ratnayake & Dinosh (2018) is about the effectiveness of the lean manufacturing layout of a firm within the apparel industry. Quality, speed, flexibility, dependability and cost and employee contentment were used. Three types of layouts, named Lean layout, Zig Zag layout, and Straight line layout compared concerning above mentioned variables and ranked them. The study concluded that the lean layout is practical and can be rolled throughout the organization and in other SBUs as well.

The same conceptual framework is used in the study Annamalai, Kumar & Bagathsingh (2020) to analyze the lean

manufacturing system. Using variables as failure rate, work in progress, throughput time, change over time & Standard hours, researchers rank the three layouts named process layout, product layout and lean layout. After averaging those ranks lean layout got the lowest rank which is the best one.

According to the study Islam et al., (2014) to obtain the optimized layout there were existing layout, alternative layout and proposed layout. A T-shirt sewing line was considered, with the existing balancing efficiency was calculated as 46.2%. By changing the sequence of the machines, an alternative scenario is created without making any huge changes. Total cycle time and man required were reduced while efficiency increased to 48.5%. By combining the above two layouts, the proposed layout was designed and the efficiency was further improved to 50.9%. This study finally concludes that an optimized layout indicates high efficiency, a low level of man power manpower and low process time.

In another work, studied and developed the precedence diagram and determined the balance efficiency, balance loss and other performance measures associated with line balancing in designing product layouts for automobile assembling. (Ubani, 2012). Above mentioned studies conclude that line balancing (balancing percentage) and balancing loss are major tools used in measuring the effectiveness a layout.

Only a few studies focus on comparing different types of layouts on production floor. Some studies have been conducted considering different types of layouts such as product layout, process layout & fixed layout. So, the

researcher think of conducting this study focusing on two sewing layouts would be an excellent contribution to the existing literature.

In modern manufacturing garment industries, five performance objectives are quality, speed, dependability, flexibility and cost (Sudharshan & Rao, 2013). So, the researcher selected those key elements as the variables of this study except the dependability considering data availability and easy access to data. An r indicator of dependability is On-time-

delivery and there is no variation in data since almost all orders are delivered on time. This conceptual frame work obtained from the studies (Ratnayake et al., 2018) and (Annamalai, et al., 2020) with some modifications. That framework includes clear indicators and dimensions to measure as follows

3 METHODOLOGY

3.1 research design

This study was mainly quantitative research in descriptive format that uses relatively less complex and common statistical tools such as descriptive statistics. Study uses secondary data from various types of reports.

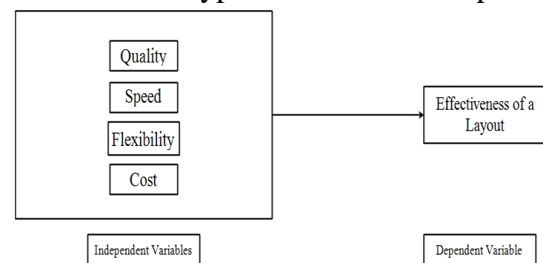


Figure 2.1 - Conceptual framework

3.2 Sample selection

The production floor has four sections named 01, 02, 03 and 04. The

population is all U-type layouts on the production floor. But this study only focuses on the section 03 production lines, which were converted into “U type” layouts. More specifically, lines 41, 42, 43 and 44 are considered the sample with the use of convenience sampling method.

3.3 Conceptual frame work

This conceptual frame work obtained from the studies (Ratnayake et al., 2018) and (Annamalai et al., 2020) with some modifications. That framework includes clear indicators and dimensions to measure as follows.

4 DATA COLLECTION AND ANALYSIS

4.1 Data collection

Study used the company reports (monthly reports) to collect the relevant data. To collect data on generated

standard hours and WIP, several monthly Efficiency reports & weekly WIP Audit reports were collected from the IE department. Data on Accepted quality level was gathered from the quality department while referring the monthly AQL reports. QCO data were obtained from the technical department. Since all the data received from the Excel format it was easy to sort and filter necessary data using MS Excel. Data collected from July to October (4 months) for each production line. Line no 41,42,43 and 44 were selected and data categorized as before converting to “U type” and after converting to “U type”. Since the layout converting programme was started in September, data from July and August months categorized under “|| type” layout and data from next two months categorized under “U type” layouts.

Table 4.1 – Variables Operationalization

Variable	Indication	Dimensions	Basis
Quality	AQL pass percentage (Number of pieces quality passed against the manufactured pieces)	Percentage (The higher the better)	AQL report
Speed	WIP control (Control the number of pieces resting on machine table without adding value)	Percentage (The higher the better)	WIP Audit report
Flexibility	Quick change over time (Time taken from the last piece of the previous style to the first good piece of the new style)	Minutes (The lower the better)	QCO report
Cost	Standard hours generated (Percentage of achieved hours to planned hours)	Percentage (The higher the better)	Efficiency report

IDENTIFYING THE MOST EFFECTIVE LAYOUT DESIGN FOR THE PRODUCTION FLOOR: A
CASE STUDY OF APPAREL INDUSTRY

Table 4.2 - Data Analyzation

	" " Layout		"U" Layout	
	July	August	September	October
AQL (pass percentage)	98.34%	96.01%	96.44%	98.37%
	97.17%		97.41%	
Generated standard hours (Achieved hours/Planned hours) *100%	90%	95%	80%	96%
	92%		88%	
QCO time (in minutes)	161.25		130.75	
WIP control (percentage of controlling WIP)	67%	44%	65%	59%
	55%		62%	

After collecting the data from several monthly reports, data were filtered to obtain the data required for the study. Considering all the data, average values were calculated under each variable to compare two layouts. For the entire analysis process, MS Excel was used. Then, the average value for each layout type is calculated as in the table 4.1. The nextstep was to give a performance ranking

comparing average values for both layouts.

5 RESULT AND DISCUSSION

By considering the values in table 4.1, performance rankings were given. Rank 1 was given for the higher percentage, except for the QCO time. Because in QCO time, it should be a lower value to contribute to the overall performance.

According to table 4.2, the highest contributing layout design to organization performance is the "U-type"

layout. Because it obtained the lowest ranking average of 1.25 as shown in Table 4.2.

Table 4.3 - Performance Ranking

Indicators	" " Layout	"U" Layout
AQL	2	1
Generated standard hours	1	2
QCO time	2	1
WIP control	2	1
Average	1.75	1.25

It can be concluded that the "U-type" layout is the most effective layout design for the organization.

In this study, different layouts were considered for a common sewing process. Under different criteria, ranks were given. The researcher's idea was to show how an optimized layout contributes to organizational performance. This study has focused on comparing two layout types: "||" Layout

and "U" Layout. The Main main positive factor that the "U-type" layout has is more opportunities for team members to balance within the layout. So, multi-skilled members can perform multiple operations to reduce the work-in-progress level within the layout. In addition, for some styles, machine layout has additional machines to balance particular operations. Because the "U-type" layout provides short distance for all members when balancing for other operations. But, in the "||" layout, team members on one side of the layout cannot balance operations in other side. Furthermore, company reduces machine renting costs by using minimum machines in "U layout". The following recommendations are suggested to the management and all the staff members.

6 CONCLUSION

WIP Level - The WIP levels of the "||" layout are comparatively higher than the "U" layout. According to the lean principles, work in progress indicates waste and masks other issues in production. Reduced WIP levels lead to identify problems quickly and solving timely. Some reasons, like unwanted motions, absenteeism, and poor line balancing can cause high WIP. In order to eliminate unwanted motions, time study and motion study can be done for every team member in the production line. Multi-skilled team members are a good option to control the work-in-progress level in "U" layouts because in there are many operations for multi-skill members to balance within short movements. But, in the "||" layout, there are limited number of operations for a member to balance within the layout.

Quick change over time - Quick changeover time has a direct impact on loss of standard hours produced. This is called the bucket loss in the apparel industry. As mentioned in the study "U" layout has a lower changeover time on average than the previous layout. So, it was a good move to change the layout design. These positive results can further be developed by preparing needed external machines and training team members earlier to the changeover. Also, the researcher would like to suggest doing an activity analysis to mechanics responsible for machine setting process and improving them more to increase standard hours.

Improving quality - The researcher observed minor deviations in quality levels in both layouts. There was no proper standard way to keep cut pieces, not following five pieces flow, and the cleanliness of the machines in the production floor should be improved. This study suggests demarcating the machine table to place cut pieces and demarcating floor areas to keep 5S practices.

Achieved standard hours - This study surprisingly revealed that standard hours achievement is low in "U-Type" though QCO time is also at low level. Some reasons might be poor line balancing, skill gap, and bottlenecks. Researchers recommends monitoring production lines' hourly target, closely monitoring each operation, and solving bottlenecks. Team leaders and group leaders should identify bottlenecks and need to do time studies, method studies in order to improve the throughput time of the layout.

Finally, it can be concluded that the "U" Layout is effective and can be rolled

throughout the plant and in other
Business units as well.

REFERENCES

- Annamalai, S., Kumar, H. V., & Bagathsingh, N. (2020). Analysis of lean manufacturing layout in a textile industry. *Materials Today: Proceedings*, 33, 3486-3490. doi:10.1016/j.matpr.2020.05.409
- Islam, M. M., Mohiuddin, H. M., Mehidi, S. H., & Sakib, N. (2014). An optimal layout design in an apparel industry by appropriate line balancing: A case study. *Global Journal of Researches in Engineering: G Industrial Engineering*, 14(5), pp 34-44. Retrieved from https://globaljournals.org/GJRE_Volume14/4-An-Optimal-Layout.pdf
- Kentli, A. , Dal, V. & Alkaya, A. F. (2013). Minimizing Machine Changeover Time In Product Line In An Apparel Industry . *Textile and Apparel* , 23 (2) , 159-167 . Retrieved from <https://dergipark.org.tr/en/pub/tekstilvekonfeksiyon/issue/23820/253783>
- Ratnayake, R. M. D. K., & Dinosh, V. (2018). Effectiveness of lean manufacturing layout of a firm within the apparel industry of Sri Lanka: a case study. *University of Moratuwa, Sri Lanka*. Retrieved from <http://dl.lib.mrt.ac.lk/handle/123/13016>
- Ubani, E. C. (2012). Application of assembly line balancing heuristics to designing product layout in motor manufacturing operations. *Interdisciplinary Journal Of Contemporary Research In Business*, 4(6), pp 1297-1307. Retrieved from <https://journal-archives24.webs.com/1297-1307.pdf>



Impact of e-WOMs on Cosmetic Products Purchase Intention of Young and Middle-Aged Women: Evidence From Sri Lanka

Yasora KGC¹, Dilanthi MGS²

Department Of Industrial Management, Faculty of Applied Sciences, Wayamba University of Sri Lanka)

yasoragamage95@gmail.com¹

shanikadilanthi@gmail.com²

ABSTRACT

This study explores the impact of e-WOMs on social networking sites (SNSs) on cosmetic product purchase intention and identifies successful SNSs that use e-WOMs to increase purchase intention. With the rise of web 2.0 technology and the introduction of social media platforms, traditional communication has been transformed. Marketers have recognized SNSs as a powerful tool for advertising due to the vast number of users on social media sites, which currently stands at 3.6 billion according to Statista. e-WOM communication has become prevalent on SNSs, and it has been found to play a significant role in online shopping, with customers using reviews and comments to make informed purchasing decisions. The study was conducted among young and middle-aged women in Sri Lanka, with a sample size of 384 using purposive sampling as a technique. A well-structured questionnaire was used to collect data on variables identified from the literature review. The study used mediation regression analysis to examine the relationship between variables, and all hypotheses were supported by the findings. The study concludes that e-WOMs on SNSs can be used as a strategic tool to increase purchasing insights in consumers' minds, and past shopping experience, tie strength, and altruism can be used as tools to increase e-WOMs on SNSs. Instagram, WhatsApp, Facebook, and YouTube were identified as successful SNSs to run e-WOM marketing campaigns. The findings of this study provide insights into how marketers can use e-WOMs on SNSs to improve purchase intention and highlight the importance of understanding the factors that influence e-WOMs.

KEYWORDS: e-WOM, Social Networking Sites, Past Shopping Experience, Tie Strength, Altruism

1 INTRODUCTION

In today's world, social media plays a vital role in transforming people's lifestyles. According to Statista, Facebook, YouTube, WhatsApp, Instagram, WeChat, and TikTok are the most famous social networking sites in the world as of January 2022. Therefore, marketers are looking at SNS as an advertising tool with great potential (eMarketer, 2009). Electronically generated word of mouth (e-WOM) is widely available on SNSs and plays a vital role in online shopping and based on the reviews and comments, customers

can make correct purchasing decisions (Duan, & Whinston, 2008).

Companies related to the cosmetic industry in Sri Lanka try to increase their sales and attract new customers. Thus, an understanding of the impact of e-WOMs as a marketing tool on purchasing intention of cosmetic products is worthy of exploration and has yet to be closely studied in the context of Sri Lanka.

The objectives of this study were to explore the impact of e-WOMs on SNSs on cosmetic product purchasing intention and to identify successful SNSs and methods for improving and using e-

WOM tactics productively as a marketing tool.

The result of this study would be beneficial for cosmetic product companies, digital marketing firms and digital marketers, online shopping platform administrators, and web designers to plan their marketing campaigns and attract a new customer base. Moreover, future researchers can use the results of this study for future discussions.

2 LITERATURE REVIEW

The past online shopping experience is a strong positive predictor of online shoppers' purchase intention (PI) for digital and non-digital product categories (Dai, 2007) and affects perceived benefits and perceived ease of use while these perceptions affect online PI (Abd Aziz & Abd Wahid, 2018; Sharma & Chopra, 2019). Consumers who had memorable shopping experiences such as special promotions or exceptional services tend to influence the e-WOMs on SNSs more than other factors (Yoon, 2012). Moreover, the relationship between past shopping experience (PSE) and PI is mediated by e-WOMs on SNSs (Farzin & Fattahi, 2018).

Zhu, Chang & Luo, (2016) carried out research to understand the influence of C2C communication on purchase decisions in online communities based on the information adoption model and elucidated that there is a positive relationship between tie strength (TS) and purchase decision-making. These results were further proved by Albayrak & Ceylan (2021). Yoon (2012) scrutinized the relationship between the strength of one's ties in a social network

and e-WOMs and revealed that the TS can be positively affected by the e-WOMs on SNSs. However, findings of Farzin & Fattahi (2018) elucidated that there is no relationship between TS and e-WOMs on SNSs.

Farzin & Fattahi (2018), revealed that altruism (ALT) has a positive impact on PI and e-WOMs on SNSs. Also, e-WOMs mediated the relationship between ALT and PI. Panda et al., 2020 indicated that ALT has a positive influence on the green PI. These results were further proved by Albayrak & Ceylan, (2021).

Bataineh (2015) defined that e-WOM communication in terms of quality, quantity, and credibility can be influenced consumers' PI. Lin, Lu & Wu, (2012) defined that e-WOM communication in terms of quality, quantity, and sender expertise can influence consumer PI. e-WOM communication has a strong positive impact on PI and brand image influences PI (Jalilvand & Samiei, 2012).

Consumers intend to buy products they tend to search for relevant information about goods and services that they are about to use and gather and synthesize and make comparisons about products and make judgments accordingly (Wang, & Wei, 2012) and e-WOM is one of the most effective factors influencing brand image and PI (Jalilvand & Samiei, 2012).

3 METHODOLOGY

For achieving the research objectives, primary data were collected quantitatively through a self-administered online survey questionnaire. Purposive sampling was

used as a non - probabilistic sampling technique. According to the new age classification of the World Health Organization under the United Nations in 2015 age range for young age women is 20-44, and for middle-aged women is 45-59. The population was selected based on the Department of Census and Statistics reports, 2012, and Krejcie & Mogan table was used as the criteria in selecting the sample size. Accordingly, the sample size based on the total population is 384. SPSS software was used for the analysis of data. Descriptive analysis was used to create an overall picture of the population. Since this research consists of independent variables, a dependent variable, and a mediating variable, bi-variant analysis method was used to identify the e-WOMs impact on PI. To uncover patterns and trends in the data set, statistical techniques such as regression analysis and Pearson's correlation coefficients were used.

Since the study consists of three independent variables and one mediating variable which influences the dependent variable, mediation regression analysis was used. Finally, analyzed data were

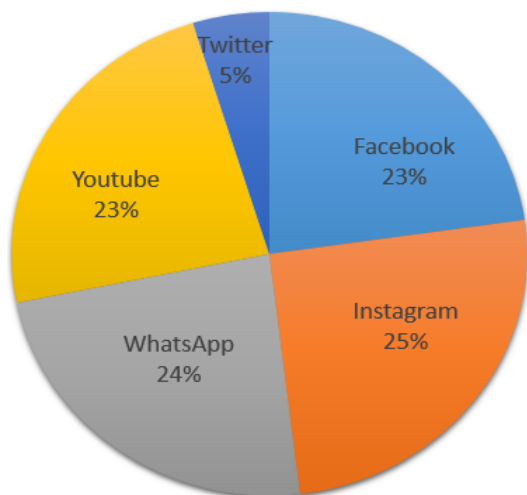


Figure 1: Social Networking Sites Preferences

presented through tables and figures.

4 DATA COLLECTION AND ANALYSIS

According to descriptive analysis results, 310 respondents belonged to the 20-44 age categories which were 80.7% and 19.3% respectively. 307 out of 384 respondents visited social networking sites frequently and which was 79.9%. The monthly income level of the most of respondents lay between 25000 and 50000 and which was 43.8%.

23% of respondents used both Facebook and YouTube. Instagram had a high usage rate of 25%. Twitter was used by less number of participants and was recorded in the 5% percentage. WhatsApp had the second large usage rate of 25% (figure 1).

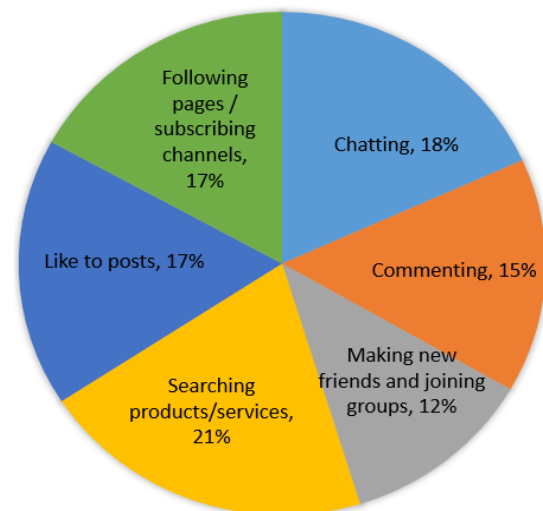


Figure 2: Activities Engaged in SNSs

Table 1: Description of Respondent

Characteristics		Frequency	Percentage (%)	Cumulative Percentage (%)
Age	20 - 44	310	80.7	80.7
	45 - 59	74	19.3	100.0
Social Media Usage	Very rare	2	.5	.5
	4 or 5 days per week	20	5.2	5.7
	Once a day	55	14.3	20.1
	Frequently	307	79.9	100.0
Monthly Income	Under 25000	90	23.4	23.4
	25000 50000	168	43.8	67.2
	51000 100000	80	20.8	88.0
	Above 100000	46	12.0	100.0

Table 2: Mediation Analysis

	Model	B	Sig	R ²
Model 1	PSE → PI	.633	.000	.395
	PSE → e-WOM	.608	.000	.500
	PSE → e-WOM → PI	.911 .078	.000 .041	.698
Model 2	TS → PI	.659	.000	.381
	TS → e-WOM	.618	.000	.459
	TS → e-WOM → PI	.899 .104	.000 .011	.700
Model 3	ALT → PI	.681	.000	.473
	ALT → e-WOM	.612	.000	.524
	ALT → e-WOM → PI	.826 .175	.000 .000	.710
	e-WOM → PI	.976	.000	.695

21% of the respondents used social networking sites for searching products and services like posts, following pages and subscribing channels, chatting, commenting and making new friends,

and joining groups having 17%, 17%, 18%, 15%, and 12% percentages respectively (figure 2).

As depicted in table 2, as the first, second, and third steps of regression

mediation analysis relationship between PSE, e-WOMs, and PI, the relationship between TS, e-WOMs, and PI, and the relationship between ALT, e-WOMs, and PI were scrutinized and identified that the total effect and direct effect were significant. Sobel test (Table 3) indicated that the indirect effect between PSE and PI, TS and PI, and ALT and PI with the presence of e-WOM was significant respectively. Thus, all the hypotheses were accepted and e-WOMs on SNSs had a partial mediation on the relationships between PSE and PI, TS and purchase intention, and ALT and PI.

5 RESULTS AND DISCUSSION

Results obtained from mediation analysis proved that all the hypotheses can be accepted. Results are tailed with Dai, B. (2007) and Aziz et al., (2018). (Yoon, 2012; Farzin & Fattahi, 2018). Albayrak & Ceylan (2021) etc. Since e-WOMs on SNS partially mediated all relationships between independent variables and PI, e-WOMS on SNSs had a significant impact on PI. Thus, the impact of e-WOM on PI was identified. According to the results of descriptive analysis, Instagram, WhatsApp, Facebook, and YouTube are successful social networking sites for developing e-WOM marketing campaigns. The findings of this research implied that PSEs, TS, and ALT positively influence the consumer PI towards cosmetic products and e-WOMs on social networking partially mediate the relationship between independent variables and PI. Thus, PSE, TS, and ALT can be used as strategic tools for improving the e-WOMs on SNSs. Finally, the author suggests, Facebook and Instagram fan pages share reviews of

cosmetic products, give loyalty schemes, and use beauty vloggers. Furthermore, promotional campaigns can be used as e-WOM marketing tools to attract new customers.

Table 3: Sobel Test

Indirect Effect	<i>p</i> -value
PSE→PI	.000
TS→PI	.000
ALT→PI	.000

6 CONCLUSION

In conclusion, the study found that all variables, including PSE, TS, and ALT, had a positive impact on cosmetic product purchasing intention through the mediating variable of e-WOMs on SNSs and the results revealed that e-WOMs on SNS partially mediate the relationship between PSE, TS, ALT, and PI.

The study also identified successful social networking sites for e-WOM marketing campaigns, including Instagram, WhatsApp, Facebook, and YouTube.

The findings of this research implied that past shopping experiences, tie strength, and altruism positively influence the consumer purchase intention towards cosmetic products and can be used as strategic tools for improving the e-WOMs on SNSs.

The study recommends giving favorable shopping experiences, using a target group of customers to attract new customers, promotional campaigns by giving loyalty rewards, and using people with altruistic intentions such as beauty vloggers, volunteers, social media influencers, and celebrities to increase the number of e-WOM presence in the social networking sites and thereby increase sales of cosmetic products.

Future studies can address a similar issue in another context by examining the relationship between e-WOMs on SNSs, brand image, brand loyalty, brand awareness, and PI and drawing a valid conclusion. The mediating effect of e-WOMs on perceived risk-taking and PI can be scrutinized in future research directions. In addition, cross-country analysis also can be conducted to compare the perceptions of consumers in terms of e-WOM information for different countries.

REFERENCES

- Abd Aziz, N. N., & Abd Wahid, N. (2018). Factors influencing online purchase intention among university students. *International journal of academic research in business and social sciences*, 8(7), 702-717.
- Albayrak, M., & Ceylan, C. (2021). Effect of eWom on purchase intention: metaanalysis. *Data Technologies and Applications*.
- Bataineh, A. Q. (2015). The impact of perceived e-WOM on purchase intention: The mediating role of corporate image. *International Journal of marketing studies*, 7(1), 126. behavior: an exploratory study of household end users. *Journal of Organizational and End User Computing (JOEUC)*, 18(1), 1-22. doi: 10.4018/joeuc.2006010101
- Dai, B. (2007). The impact of online shopping experience on risk perceptions and online purchase intentions: *the moderating role of product category and gender* (Doctoral dissertation).
- Duan, W., Gu, B., & Whinston, A. B. (2008). The dynamics of online word-of-mouth and product sales—An empirical investigation of the movie industry. *Journal of retailing*, 84(2), 233-242.
- eMarketer (2009, September 28). What's in a retail E-mail? eMarketer. Retrieved from <http://www.emarketer.com/Article/Whats-Retail-E-Mail/1007294>
- Farzin, M., & Fattahi, M. (2018). eWOM through social networking sites and impact on purchase intention and brand image in Iran. *Journal of Advances in Management Research*, 15(2), 161-183.
- Jalilvand, M.R., & Samiei, N. (2012). The effect of electronic word of mouth on brand image and purchase intention: An empirical study in the automobile industry in Iran. *marketing intelligence & planning*, 30(4), 460-476.
- Lin, T. M., Lu, K. Y., & Wu, J. J. (2012). The effects of visual information in eWOM communication. *Journal of research in interactive marketing*, 6(1), 7-26.
- Panda, T. K., Kumar, A., Jakhar, S., Luthra, S., Garza-Reyes, J. A., Kazancoglu, I., & Nayak, S. S. (2020). Social and environmental sustainability model on consumers' altruism, green purchase intention, green brand loyalty and evangelism. *Journal of Cleaner production*, 243, 118575.
- Sharma, S. K., & Chopra, P. (2019). Predicting factors influencing online purchase behavior among Indian youth. *International Journal of Recent Technology and Engineering*, 8, 765-769.
- Sobel, M. E. (1982). Asymptotic confidence intervals for indirect effects ed.). New York: McGraw-Hill. in structural equations models. In S. Leinhardt (Ed.), *Sociological Woodworth*, R. S. (1928). *Dynamic psychology*. In C. Murchison (Ed.), *methodology 1982* (pp. 290-312). San Francisco: Jossey-Bass.
- Statista. (2020a). Forecast the number of mobile users worldwide from 2020 to 2024. Retrieved from <https://www.statista.com/statistics/218984/number-of-global-mobile-users-since2010/>
- Statista. (2020b). Number of social network users worldwide from 2017 to 2025 (in

billions). Retrieved from <http://www.statista.com/statistics/278414/number-of-worldwide-social-networkusers>

- Wang, X., Yu, C., & Wei, Y. (2012). Social media peer communication and impacts on purchase intentions: A consumer socialization framework. *Journal of interactive marketing*, 26(4), 198-208.
- Yoon, S. J. (2012). A social network approach to the influences of shopping experiences on e-wom. *Journal of Electronic Commerce Research*, 13(3), 213.
- Zhu, D. H., Chang, Y. P., & Luo, J. J. (2016). Understanding the influence of C2C communication on purchase decision in online communities from a perspective of information adoption model. *Telematics and Informatics*, 33(1), 8-16.



Impact of factors of inventory management on inventory performance measures in the Sri Lankan wholesale industry: A Systematic Literature Review

Shanilka LPH¹, Chathumi Ayanthi Kavirathna²

Department of Industrial Management, Faculty of Science, University of Kelaniya, Sri Lanka
shanilka_im17071@stu.kln.ac.lk¹

Department of Industrial Management, Faculty of Science, University of Kelaniya, Sri Lanka
chathumi@kln.ac.lk²

ABSTRACT

Inventory management is a crucial component of trade since it enables companies to reduce expenses, enhance cash flow, and increase profitability. Inventory makes up a majority of current assets in the wholesale sector. The wholesalers face various challenges and hardships in the current dynamic economic conditions. This research focuses on the topic of inventory management factors and performance metrics of inventory management. To identify factors and performance measures of inventory management in the Sri Lankan wholesale industry, this study conducted a systematic review of the literature and consulted experts in the industry. In the literature that has been published over the past years, a systematic literature review on the relationship between inventory management factors and how it has affected the inventory performance measures based on various indicators in Sri Lanka's wholesale industry has not yet been taken into consideration. The findings of the research help to identify the factors and performance measures of inventory management and evaluate the impact of these inventory management factors on the performance measures of inventory management. It assists wholesale businesses in achieving excellence and a competitive edge in the Sri Lankan wholesale market. As well, finding answers to the ongoing business issues in the wholesale sector will be aided by this.

KEYWORDS: Factors of inventory management, performance measures, wholesale industry

1. INTRODUCTION

Inventory management involves overseeing the materials used and stored within a company to ensure that the right amount of supplies is available at the right place and time while minimizing excess stock and minimizing costs (Pushpakumara, 2018). Inventory management is critical in the wholesale market because inventories are the working capital component of assets. The wholesale inventory can be divided based on the type of goods: fast-moving consumer goods (FMCG), durable consumer goods (DCG), raw materials (RM), and equipment wholesale (EP) (Chen, Frank, & Wu, 2007). The factors

of inventory management can be advantageous or disadvantageous to an organization.

Inventory performance measures are indicators that assist you in keeping track of and making decisions regarding your stock in inventory management. They enable the identification of the areas in the wholesale industry that are not operating as expected and the discovery of solutions to the difficulties that are currently being experienced.

The wholesale and retail industry contributes about 11.0% of Sri Lanka's overall GDP, which increased by 3.0% in 2019. The total number of business establishments under wholesale and

retails is 23,519 and the total output from trade activities is Rs Mn 3,059,613. Inventory accounts for 20% to 30% of retail, and wholesale companies' overall investments. High costs associated with inventory management, stock-out, and over-stock situations, back-order situations, obsolete stock situations and inventory discrepancies are common issues faced by wholesalers in Sri Lanka. Solutions can be implemented to these problems, by identifying significant factors and performance measures of inventory management, and evaluating the impact of these factors on the performance measures of inventory management.

2. METHODOLOGY

A review of the literature is conducted by referring to 32 research papers to understand significant factors and performance measures of inventory management in the wholesale sector. This used databases including Emerald Insight, Semantic Scholar, Science Direct, and Google Scholar to gather pertinent data. The search criteria consisted of keywords such as "Factors of Inventory Management," "Performance Measures of Inventory" and "Wholesale Industry". To incorporate additional factors and performance measures, interviews with professionals in the Sri Lankan wholesale industry were conducted.

3. FINDINGS AND DISCUSSION

3.1 *Inventory Management Factors*

To evaluate the variables influencing the inventory management procedures in Kenya Seed Company, (Okwaro et al., 2017) conducted a study. The outcomes suggest the effectiveness of inventory management at Kenya Seed company was

positively and significantly correlated with staff training, technological level, stock evaluation, and procurement rules. (Chan et al., 2017) highlighted planning, documentation/ store records, knowledge of employee/ staff skills, and financing as elements that have a major impact on inventory management in manufacturing small to medium firms. The studies (Ngatuni, 2018), (Bhandari, 2017), (Islam, Pulungan, & Rochim, 2019) emphasize competence or the skills of the staff as a significant factor in inventory management.

A study by (Godana & Ngugi, 2014) identified information technology, distribution routes, staff competency, and material handling equipment as the main factors of inventory management. The studies of (Musiyu, 2017), (Islam et al., 2019), (Godana & Ngugi, 2014) highlighted material handling equipment as a factor of inventory management. The studies of (Godana & Ngugi, 2014), (Ujene & Otali, 2020) also manifested the inventory management principles and techniques used are important factors to be considered for the concept of inventory management.

According to (Bhandari, 2017), (Islam et al., 2019), (Ondari & Muturi, 2016) the forecasting procedure had been a well-recognized factor in inventory management. Funds might be a barrier to efficient inventory control (Dobler, & Burt, 1996), if they aren't enough to cover all of the organization's material needs over the budgetary period. The studies of (Pushpakumara, 2018), (Ngatuni, 2018), (Elema & Karanja, 2014) mentioned the importance of the security system of the inventory in a warehouse for the process of inventory management.

IMPACT OF FACTORS OF INVENTORY MANAGEMENT ON INVENTORY PERFORMANCE MEASURES IN THE SRI LANKAN WHOLESALE INDUSTRY: A SYSTEMATIC LITERATURE REVIEW

	No	Performance Measures	[Al-Rushood et. al., 2020]	[Chae, 2009]	[Rodrigo et. al., 2020]	[Gunasekaran et. al., 2001]	[Wahid and Rahman, 2022]	[Ghosh and Kumar, 2003]	[Van Heck et. al., 2010]	[Rachad et. al., 2017]	[Liang and Zhu, 2018]	[Chen et. al., 2007]	[Aranyan et. al., 2007]	[Chan and Qi, 2003]	[Ogbo et al, 2014]	[Patnaik et. al., 2021]	[Plambeck, 2012]	[Bouchery et. al., 2012]	[Saadany and Bonney, 2011]	Percentage of Selected Factors	Industry Opinion (Acceptance)		
Operational Performance	1	Inventory Days on Hand	☑	☑	☑	☑	☐	☐	☑	☑	☑	☑	☑	☐	☑	☐	☐	☐	☐	☐	59%	☑	
	2	Inventory Turnover	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	40%	☑	
	3	Inventory to Sales Ratio	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	35%	☑
	4	Inventory Holding Cost per unit	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	35%	☑
	5	Product Damage Cost per line-per unit	☑	☐	☑	☐	☐	☐	☐	☐	☑	☑	☐	☐	☐	☑	☐	☐	☐	☐	☐	30%	☑
	6	Ordering Costs per line	☑	☐	☑	☑	☑	☑	☑	☑	☑	☐	☑	☑	☑	☐	☐	☐	☐	☐	☐	41%	☑
Customer Satisfaction	7	Backorder Rate	☐	☐	☐	☐	☑	☑	☐	☑	☐	☐	☑	☐	☐	☑	☐	☐	☐	☐	30%	☑	
	8	Order Fill Rate	☑	☑	☐	☐	☐	☐	☑	☑	☐	☐	☑	☑	☑	☐	☐	☐	☐	☐	41%	☑	
	9	Rate of Return	☐	☐	☐	☐	☑	☑	☐	☑	☐	☐	☑	☐	☐	☑	☐	☐	☐	☐	30%	☑	
	10	Range of Products Available	☐	☐	☐	☑	☐	☐	☑	☐	☐	☐	☑	☐	☐	☑	☐	☐	☐	☐	24%	☑	
Environmental Performance	11	Electricity Consumption per unit	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☑	☑	☐	☐	18%	☑	
	12	Solid Waste Generation -(per Square Me	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☑	☑	☑	18%	☑	
	13	Carbon Footprint	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☑	☑	☑	☑	24%	☑	
	14	Equipment Fuel Consumption per unit	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☑	☑	☑	☑	18%	☑	

Figure 1: ARABIC 2 Summary of Inventory Performance Measures

Effective inventory management has been justified by five factors: planning for inventory management (PL), record keeping (RK), procurement (PR), personnel characteristics (SC), and storage system (SS) by (Hamid K and Dhar S.S, 2021). The studies (Musiyu, 2017), (Hamid & Dhar , 2021) have stated the storage system as a significant factor in inventory management.

3.2 Performance Measures of Inventory Management

A study conducted by (Gunasekaran, Patel, & Tirtiroglu, 2001) created a framework for evaluating the performance at the strategic, tactical, and operational levels of China's supply chain. Performance measurement criteria were listed as total supply chain cycle time, rate of return on investment, range of products, and order lead time. Under the tactical level, the accuracy of forecasting techniques, product development cycle time, purchase order cycle time, and planned process cycle time were focused. Cost per operation hour, capacity utilization, supplier rejection rate, and

efficiency of purchase order cycle time were considered as performance measures at the operational level.

The study of (Al-Rushood , Rahbar, & Dweiri 2020) identified the metrics and key performance indicators (KPIs) that ought to be benchmarked against the industry's standards. On-time delivery, cycle time, average days inventory level, inventory carrying cost, inventory turnover, and

order fill rate are some of the industry metrics that are utilized in this model.

(Chae, 2009) developed a set of key KPIs; performance measures of rate of obsolete inventory, total inventory days of supply, supplier fill rate and order fill rate for supply chain management practitioners. According to (Salahudeen , & Abraham, 2018) the important operational performance measures of manufacturing firms are, carrying, costs of inventory, inventory forecasting, inventory valuation, inventory visibility, future inventory price forecasting, available physical space for inventory,

replenishment lead time, returns and defective goods and demand forecasting.

The accuracy of the forecast is mentioned as a performance measure in the study of (Chan & Qi, 2003). Studies of (Rodrigo & Pathirawasam, 2020), (Chen, Frank, & Wu, 2007) pointed out space utilization as a performance measure to assess inventory management. (Ghosh & Kumar, 2003), (Lin, 2018) have mentioned labor productivity as a main performance measure.

Lead time, carrying costs of inventory, asset management, physical space available for inventory, returns and defective goods, replenishment, and reorder level were used to analyze the performance of the inventory management system by (Kapileshwar et al., 2007). (Pattnaik, Nayak, Abbate, & Centobelli, 2021), (Plambeck, 2012), (Saadany, Jaber, & Bonney, 2011) have focused on environmental performance measures. Electricity consumption, solid waste generation, carbon footprint and equipment fuel consumption are the measures mentioned in the above literature.

4. CONCLUSION

Based on the research papers reviewed, factors of inventory management consist of organization, operation, technology and economic categories. The performance measures identified as operational, customer satisfaction, and environmental categories.

REFERENCES

Al-Rushood, M., Rahbar, D. F., & Dweiri, D. F. T. (2020, August). Benchmarking Key Performance Indicators and Metrics on Inventory Turnaround Practices in Middle East Petroleum Projects. In *Proceedings of*

- the 5th NA International Conference on Industrial Engineering and Operations Management, Detroit, Michigan, USA.*
- Bhandari, H. B. (2017). Factors Affecting the Efficiency of Inventory Management of Janapriya Multiple Campus, Pokhara. *Janapriya Journal of Interdisciplinary Studies*, 6, 78-87.
- Chae, B. K. (2009). Developing key performance indicators for supply chain: an industry perspective. *Supply Chain Management: An International Journal*.
- Chan, F. T., & Qi, H. J. (2003). An innovative performance measurement method for supply chain management. *Supply chain management: An international Journal*.
- Chan, S. W., Tasmin, R., Aziati, A. N., Rasi, R. Z., Ismail, F. B., & Yaw, L. P. (2017, August). Factors influencing the effectiveness of inventory management in manufacturing SMEs. In *IOP Conference Series: Materials Science and Engineering* (Vol. 226, No. 1, p. 012024). IOP Publishing.
- Chen H, Frank M.Z and Wu O.Q, (2007), Supply chain management six sigma: a management innovation methodology at the Samsung Group”, *Supply Chain Management: An International Journal*, Vol. 12 No. 2, pp. 88-95.
- Dobler D.W and Burt D.N, (1996), *Modern Production and Operations Management*, (8th ed). New York: John Wiley and Sons.
- Elema B. G and Karanja N, (2014), Determinants of Effective Inventory Management at Kenol Kobil Limited. *European Journal of Business Management*, 1(11), 1-17.
- Ghosh, A. K., & Kumar, P. (2003). *Production Management*. New Delhi: Anmol Publication Pvt. Ltd.
- Holander, T.(2000). *Accounting Information Technique and Business Solutions*.
- Godana, B. E. & Ngugi, K . (2014). Determinants of Effective Inventory Management At Kenol Kobil Limited. *European Journal of Business Management*, 1 (11), 341- 361.

IMPACT OF FACTORS OF INVENTORY MANAGEMENT ON INVENTORY PERFORMANCE MEASURES IN THE SRI LANKAN WHOLESALE INDUSTRY: A SYSTEMATIC LITERATURE REVIEW

- Gunasekaran, A., Patel, C., & Tirtiroglu, E. (2001). Performance measures and metrics in a supply chain environment. *International journal of operations & production Management*, 21(1/2), 71-87.
- Hamid, M. K., & Dhar, S. S. Factors Influencing Effective Inventory Management In The Textile Industries Of Bangladesh. *The Chittagong University Journal Of Business Administration*, 299.
- Heck G.V, van den Berg, J., Davarynejad, M., van Duin, R., & Roskott, B. (2010). Improving Inventory Management Performance Using a Process-Oriented Measurement Framework. In CCIS (Vol. 109).
- Islam, S. S., Pulungan, A. H., & Rochim, A. (2019, December). Inventory management efficiency analysis: A case study of an SME company. In *Journal of Physics: Conference Series* (Vol. 1402, No. 2, p. 022040). IOP Publishing.
- Kapileshwar N, Sindhu, S., Nirmalkumar, K., Krishnamoorthy, V., & Prof, A. (2007). Performance Analysis of Inventory Management System in Construction Industries in India. *International Journal of Innovative Research in Science, Engineering and Technology* (An ISO, 3297).
- Lin, Y., Liang, B., & Zhu, X. (2018). The effect of inventory performance on product quality: The mediating effect of financial performance. *International Journal of Quality & Reliability Management*.
- Okwaro, F., Iravo, M., & Berut, Z. (2017). Factors Affecting Inventory Management Efficiency in Kenya Seed Company, Kitale Branch, Kenya. *International Journal of Recent Research in Commerce Economics and Management*, 4(1), 19-39.
- Ondari L.M and Muturi W, (2016), Factors Affecting the Efficiency of Inventory Management In Organizations In Kenya A Case of Firms In Kisii Town, *International Journal of Economics, Commerce and Management*.
- Pattnaik, S., Nayak, M. M., Abbate, S., & Centobelli, P. (2021). Recent trends in sustainable inventory models: A literature review. *Sustainability*, 13(21), 11756.
- Plambeck, E. L. (2012). Reducing greenhouse gas emissions through operations and supply chain management. *Energy Economics*, 34, S64-S74.
- Pushpakumara, W. M. P. G. R. (2018). Factors affect to effective inventory management system in government sector organizations in Sri Lanka: with special reference to government sector organizations situated in Dambulla secretary division. *International Journal of Scientific Research and Innovative Technology*.
- Rodrigo, W. L. M. P. U., Rathnayake, R. M. S. S., & Pathirawasam, C. (2020). Effect of Inventory Management on Financial Performance of Listed Manufacturing Companies in Sri Lanka. *IAR Journal of Business Management*.
- El Saadany, A. M. A., Jaber, M. Y., & Bonney, M. (2011). Environmental Performance Measures For Supply Chains. *Management Research Review*.
- Ujene, A. O., & Otali, M. Efficiency Of Inventory Management Techniques And Performance Of Construction Industry Firms In South-South, Nigeria. *Journal of Contemporary Research in the Built Environment*, 128.



Impact of Social Media Influencer Marketing on Making Purchase Decisions of Ready-to-Eat Foods - a Case Study

Dewage NS¹, Wattedgama EJ²

Department of Industrial Management, Faculty of Applied Sciences, Wayamba University of Sri Lanka
nuwangidewage@gmail.com¹
erandiw@wyb.ac.lk²

ABSTRACT

Social media influencer marketing is one of the digital marketing tools. These influencers promote various food types through their content and ready-to-eat food is one of them. The objective of the present study was to investigate the impact of social media influencer marketing on consumer purchase decisions for ready-to-eat foods during a pandemic. It was expected that the results of the study would be an insight into how social media influencers can involve in purchase decisions for those foods by reaching the audience and connecting with them during a pandemic. An online survey was carried out to collect data from 384 participants who use social media and each has an income level that is sufficient to make a purchase decision on ready-to-eat foods. The collected data were analyzed using the SPSS software package. The findings of the study revealed that the reviews of the social media influencer have moderated the relationship between purchase intention and purchase decision.

KEYWORDS: Pandemic, Purchase decision, Ready-to-eat food, Social media influencer

1 INTRODUCTION

Social media influencer marketing is one of the tools of digital marketing. Social media influencers are personalities on various online platforms. The general concept of social media influencers is that they create contents for the products and services they endorse and promote. These influencers have some expertise in different fields, such as food, fashion, lifestyle, travel, and beauty care. The influencers promote various food types through their content and ready-to-eat food is one of them. Ready-to-eat is a pre-cooked food type that consumers can consume without prior preparation.

Many social, regional, and cultural differences will be affected and human lifestyle develops changes in many aspects, such as consumption habits and purchase habits during the pandemic. The problem that was identified is what

kind of impact was made by social media influencers on purchase decisions during the pandemic period. Hence, the problem was specified into what is the impact of social media influencer marketing on ready-to-eat food during a pandemic. The importance of this research is it gives an insight into how social media influencers can involve in purchase decisions concerning ready-to-eat food by reaching the audience and connecting with them. The objective of this research is to understand the mechanism of social media influencers' engagement with their followers regarding their purchase decisions.

2 LITERATURE REVIEW

Diederich (2018) indicates that influencer marketing can be defined as “a process in digital marketing where opinion leaders as known as influencers are identified and then integrated into a

brand's communication on social media platforms. Influencers have established a strong online identity by first sharing their interests and opinions in personal blogs and then quickly turning to social media with the emergence of social networking sites (Hudders, De Jansa & De Veirmana, 2020). Evers (2019) indicates that it is not simply the number of followers that matters for sponsors but rather an intimacy of engagement that can generate value which highlights that an influencer's engagement is more significant than several followers. Hudders et al. (2020) manifest that brands can opt for more affordable influencers compared with the exorbitant fees required to sign one or more renowned celebrity endorsers. A key conclusion that was drawn from this is that influencers are more cost-effective than celebrity endorsements. Dubbelink, Herrando & Constantinides (2021) demonstrates that digitalization and the pandemic have enhanced the importance of adapting corporate communication to digital channels. Throughout this literature review, some gaps have been identified in previous studies which were based on different countries and different timelines to increase consumer trust and brand. Accordingly, this research was carried out during the COVID-19 pandemic to fill out the research gaps and apply the findings to the Sri Lankan context.

3 METHODOLOGY

The type of this research is applied and descriptive. It was carried out in the Sri Lankan context targeting urban areas mostly. The COVID-19 pandemic period was considered the period of the study. The active users of social media who

have purchasing power in Sri Lanka at the time of the pandemic period were considered the research population. According to Morgan's table around 384 customers were selected as the sample size. The primary data were collected from randomly selected customers using a standard questionnaire and an online survey method was followed. Multiple regression analysis and moderator effect analysis were performed using SPSS software to analyze the data.

3.1 Research Model

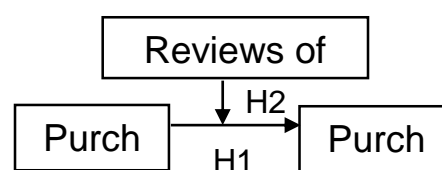


Figure 1: Research Model

According to Figure 1, the following are the hypotheses that have been established to achieve the objective of the study.

H₁: Purchase intention affects the purchase decision of ready-to-eat food during the pandemic.

H₂: Reviews of social media influencers moderate the relationship between purchase intention and purchase decision of ready-to-eat food during the pandemic.

4 RESULTS AND DISCUSSION

The results of regression analysis are shown in Table 1 and moderator effect analysis in Interact1 is shown in table 2. Interact1 variable is an Interaction variable developed by multiplying the purchase intention variable and reviews of social media influencers' variable.

Table 1: Results of Regression Analysis

Model		Coefficients ^a			t	Sig.
		Unstandardized Coefficients		Standardized Coefficients		
		Beta	Std. Error	Beta		
1	(Constant)	2.188	0.175		12.504	0.000
	Purchase intention	0.458	0.040	0.504	11.398	0.000

a. Dependent Variable: Purchase Decision

Table 2: Results of Moderator Effect Analysis Interact 1

Model		Coefficients ^a			t	Sig.
		Unstandardized Coefficients		Standardized Coefficients		
		Beta	Std. Error	Beta		
1	(Constant)	-.156	.643		-.242	.809
	Purchase intention	.958	.184	1.053	5.193	.000
	Reviews of social media influencers	.597	.151	.526	3.947	.000
	interact1	-.128	.041	-.886	-3.139	.002

Table 3: Moderator Effect Analysis Interact 2

Model		Coefficients			t	Sig.
		Unstandardized Coefficients		Standardized Coefficients		
		Beta	Std. Error	Beta		
1	(Constant)	4.181	0.024		174.382	0.000
	Zscore: Reviews of social media influencers	0.021	0.032	0.039	0.656	0.512
	Zscore: Purchase intention	0.210	0.028	0.389	7.487	0.000
	interact2	-0.036	0.011	-0.187	-3.139	0.002

a. Dependent Variable: Purchase Decision

The results of the Moderator affected analysis in Interact2 was shown in Table 3. Interact2 variable is an Interaction variable developed by

multiplying the z-score of the purchase intention variable and the z-score of the reviews of social media influencers' variable.

5 CONCLUSION

Based on the results as shown in Table 1, the consumers' purchase decision was influenced by their purchase intention (H1 was accepted). The reviews of social media influencers proved that it significantly moderated the relationship between purchase intention and purchase decision as shown in the results of Tables 2 and 3. Accordingly, it was shown that the reviews of social media influencers have moderated the relationship between purchase intention and purchase decision of ready-to-eat food during the COVID-19 pandemic (H2 was accepted). Based on the acceptance of H2, it could be concluded that the reviews of social media influencers' either positive or negative have affected converting the purchase intention into the purchase decision of the consumers of ready-to-eat foods during the COVID-19 pandemic in Sri Lanka. This means that the objective of the study has been achieved. Moreover, as the reviewed literature had highlighted the importance of congruence between a product and its' reviews as the key criterion for the success of the marketing function of a firm, the findings of the present study also have proven it.

REFERENCES

- COVID-19 pandemic. *Sustainability*, *13(18)*, 10310. doi:10.3390/su131810310
- Evers, C. W. (2019). The gendered emotional labor of male professional 'freesurfers' digital media work. *Sport in Society*, *22(10)*, 1691–1706. doi:10.1080/17430437.2018.1441009
- Hudders, L., De Jans, S., & De Veirman, M. (2021). The commercialization of social media stars: a literature review and conceptual framework on the strategic use of social media influencers. *International Journal of Advertising*, *40(3)*, 327–375. doi:10.1080/02650487.2020.1836925
- Diederich, B. (2018). Journal of Emerging Trends in Marketing and Management. *The Bucharest University of Economic Studies*, *1(1)*, 79–87. Retrieved from <https://ideas.repec.org/a/aes/jetimm/v1y2018i1p79-87.html>
- Dubbelink, S. I., Herrando, C., & Constantinides, E. (2021). Social media marketing as a branding strategy in extraordinary times: Lessons from the



Implications of Brand Equity on Purchase Intention of Personal Care Products: A Study on University Undergraduates

Senevirathne VVK¹, Jothirathne PAAU²

*Department of Industrial Management, Faculty of Applied Sciences, Wayamba University of Sri Lanka,
Kuliyapitiya*

vishuvksenevirathne@gmail.com¹

anoja@wyb.ac.lk²

ABSTRACT

Personal appearance and beauty care are exciting topics among the younger generation. The use of personal care products among university students is growing rapidly. Even after graduation, these groups will continue to use personal care products. This trend created steady growth in the personal care products industry. This study investigated how university students' purchase intentions for personal care products were affected by the brand equity dimensions: brand awareness, brand association, perceived quality, and brand loyalty. The sample comprised 186 university students from Sri Lankan private and public universities, which were gathered using the non-probability convenience sampling method. Multiple linear regressions were used to analyze the collected data. The results showed that brand awareness, brand association, perceived quality, and brand loyalty had a significant and positive impact on university students' purchase intentions toward personal care products. Hence, the marketers of personal care products need to pay more attention to developing a strong brand for their products.

KEYWORDS: Brand Awareness, Brand Association, Brand Loyalty, Perceived Quality, Purchase Intention

1 INTRODUCTION

The personal care products industry in Sri Lanka has expanded dramatically within the last decade as people have become more aware of their appearance, beauty, and selection of personal care products. In 2023, the personal care market would generate US\$1.27 billion in revenue. The market is anticipated to expand by 4.63% every year until 2027 (Statista, 2022). The younger generation is widely considered to be image-driven and to place more importance on materialistic values like money, recognition, and one's own self-image (Healy, 2012). Hence, this study focused on the factors that affect the purchase intention of university students for personal care products.

Although empirical data has shown a positive relationship between purchase intention and brand equity in several scenarios (Chang and Liu, 2009), in the Sri Lankan context, there are numerous studies speaking about these brand equity dimensions separately. But a smaller number of studies state the brand equity dimensions collectively. Thereby, this study intends to examine how customers' purchase intentions for personal care products are affected by Aaker's brand equity aspects, including brand awareness, brand association, perceived quality, and brand loyalty. The study limited the customer group to university students since that could be an easily focused market segment.

2 LITERATURE REVIEW

Purchase intention is defined as the attitude toward specific goods or services and is an element of customer behaviour (Soebagyo, 2014). Customers express their propensity, willingness, or intention to buy particular brands when they express their purchase intention (Mirabi et al., 2015). The relationship between these two elements is that the higher the purchase intention, the higher the customer's willingness to make a purchase (Schiffman and Kanuk, 2000).

Brand awareness refers to a consumer's capacity to recognize a particular brand (Keller, 2003). The brand is the most influential factor for the purchase intention towards beauty care products (Hakala et al., 2012; Malik et al., 2013).

As per Aaker (1991) and Keller (1993), anything associated with a brand preference is referred to as a brand association. The brand association serves as the basis for purchasing decisions and brand loyalty (Aaker, 1991), and the brand association has also been acknowledged as a key factor influencing purchase intention (O'Cass and Lim, 2002).

Perceived quality is the customer's intangible opinion of the overall value or excellence of a good or service (Ramaseshan and Tsao, 2007). Positive brand perception can influence consumers' purchasing decisions, help brands stand out from the competition, make brand extensions possible, and enable businesses to demand more (Aaker, 1991).

According to Aaker (1991), brand loyalty is the absence of a consumer's desire to switch to a different brand,

especially when the brand changes its price or product attributes. Customers may remain loyal to a brand since they are happy with it and want to maintain their relationship with it (Malik et al., 2013). Current studies have found that brand loyalty is positively correlated with customers' purchase intentions (Malik et al., 2013; and Khan et al., 2015).

The following hypotheses are drawn from the above discussion.

H₁: There is an impact of brand awareness on university students' purchase intentions of personal care products.

H₂: There is an impact of brand association on university students' purchase intentions for personal care products.

H₃: There is an impact of perceived quality on university students' purchase intentions for personal care products.

H₄: There is an impact of brand loyalty on university students' purchase intentions for personal care products.

3 METHODOLOGY

To study how the dimensions in Aaker's brand equity model affect the purchase intention of personal care products by young consumers, the study selected public and private university students in Sri Lanka. The study population is about 0.45 million (Sri Lanka University Statistics, 2020). 186 university students were enlisted as the sample. Further, non-probability convenience sampling was used in this investigation. Sekaran and Bougie (2013) have also used convenience sampling, especially because it will minimize the error with the sampling techniques. Primary data were collected using a structured questionnaire. A Five-point

Table 1: Reliability statistics

	Cronbach's Alpha	N of Items	Sig.
Purchase Intention	.763	4	.000
Brand Awareness	.711	3	.000
Brand Association	.747	3	.000
Perceived Quality	.782	3	.000
Brand Loyalty	.788	3	.000

Likert scale (1 strongly disagree to 5 strongly agree) was used to measure the indicators. Statistical tasks including reliability analysis, descriptive statistics, Pearson correlation analysis, and regression analysis were conducted to analyze the collected data.

4 RESULTS AND DISCUSSION

4.1 Reliability Analysis

According to Table 1, all the alpha values were greater than 0.7 with a significance of p-value < 0.005. The internal consistency was good, and the research tool was reliable. Therefore, the data set was used for further analysis.

4.2 Descriptive Analysis

Based on the results in Table 2, the majority of the respondents were females (76.9%). Besides, 75.8% of the people who participated in this survey had an income level of less than 25,000. 13.4% of the sample had an income level of 25,000 to 50,000.

4.3 Correlation Analysis

According to the correlation test in Table 3, both brand awareness and brand association have a moderately positive relationship with purchase intention, which is 0.563 and 0.576, respectively. But purchase intention and perceived quality have a weak positive association (0.383), while purchase intention and brand loyalty have a strong positive association (0.618).

4.4 Regression Analysis

The R-squared value of the identified model is 0.617, which is greater than 0.6. This indicates that 61.7% of the variation in purchasing intention is explained by the variables brand awareness, brand association, perceived quality, and brand loyalty.

Table 1: Results of sample demographics

Variable	Category	Frequency	Percentage
Gender	Female	143	76.9
	Male	43	23.1
Income Level	Less than 25,000	141	75.8
	25,000 - 50,000	25	13.4
	50,000 - 75,000	13	7.0
	75,000 - 100,000	2	1.1
	More than 100,000	5	2.7

Table 3: Correlation between dependent variable and independent variables

		Brand Awareness	Brand Association	Perceived Quality	Brand Loyalty
Purchase Intention	Pearson Correlation	.563**	.576**	.383**	.618**
	Sig. (2-tailed)	.000	.000	.000	.000

** . Correlation is significant at the 0.01 level (2-tailed).

Table 4: Results of partial least square

	Std. Beta	Std. Error	t	Sig.	R	R Square	Sig. F Change
(Constant)	-.562	.279	-2.012	.046	.785 ^a	.617	.000
Brand Awareness	.290	.055	5.259	.000			
Brand Association	.285	.058	4.922	.000			
Perceived Quality	.197	.050	3.917	.000			
Brand Loyalty	.427	.058	7.321	.000			

a. Predictors: (Constant), Brand Loyalty, Perceived Quality, Brand Awareness, Brand Association

Hence, these variables adequately represent the research model.

As per the results in Table 4, the t-values for H1, H2, H3, and H4 were all significantly higher than 0.05, indicating that all variables investigated in the research model were significant. The standardized beta results were 0.290 (brand association), 0.285 (brand awareness), 0.197 (perceived quality), and 0.427 (brand loyalty). Moreover, this research revealed that every variable studied has a favourable impact on purchase intention. Therefore, all the hypotheses H1, H2, H3, and H4 were accepted. The fitted model consists of the independent variables; brand awareness, brand association, perceived quality, and brand loyalty.

Thus, the identified regression model is;

$$\text{Purchase Intention} = -0.562 + 0.290 * (\text{Brand Awareness}) + 0.285 * (\text{Brand Association}) + 0.197 * (\text{Perceived Quality}) + 0.427 * (\text{Brand Loyalty})$$

The findings showed that the purchase intentions of consumers are positively influenced by brand awareness. A similar result between brand awareness and purchase intention has also been demonstrated in the studies conducted by Hakala et al. (2012) and Malik et al. (2013). Further, Keller (1993) indicated that brand awareness

will affect purchasing intention because it increases the likelihood that the brand will be taken into account.

Additionally, the findings demonstrated that brand association influences consumers' intentions to make purchases favourably. This particular conclusion is consistent with the study conducted by Perera and Dissanayake (2013).

The study found that perceived quality positively affects consumers' purchase intentions. This is supported by the study of Asshidin et al. (2016), which revealed that perceived quality significantly affects customers' purchase intentions. Positive brand perception may influence customer preferences, and purchasing behaviour. This enables businesses to charge premium prices, and facilitate brand distinctiveness and brand expansion.

This study found that brand loyalty is the most influential factor in purchase intention. Lavuri and Sreeramulu (2019) revealed that brand loyalty positively correlates with consumer purchase intention for personal care products.

5 CONCLUSION

The purpose of this study is to investigate the determinants that affect university students' purchase intentions for personal care products. According to

Aaker's brand equity model, only four factors were considered; brand awareness, brand association, perceived quality, and brand loyalty. It has been discovered that all four factors examined in this study had a positive impact on the purchasing intentions of university students. Among these four factors, brand loyalty was the most significant influencing factor. Brand association influences their relationship with the firm and, in turn, their desire to make a purchase. Brand awareness is crucially significant since, without it, no conversation or transaction would take place. Further, consumers' purchase intentions for personal care products were shown to be significantly influenced by perceived quality. To maintain a competitive edge over rivals, businesses must develop perceived quality traits. Hence, marketers must develop a strong brand to overcome competition and attract loyal customers.

6 LIMITATIONS AND FUTURE STUDIES

This study primarily focuses on the personal care sector; the findings cannot be applied to other sectors since customer trends and preferences vary with respect to the industry. Hence, the study can extend to other sectors; food, services, apparel, fast-moving commodities, etc. The backgrounds of the respondents are not diverse. The study focused on university students, including both undergraduate and postgraduates. They were aged between 18 and 30, while more female respondents had less income. This lack of variety in terms of age, gender, and income may have an impact on the results, since the respondents of different

ages, genders, and income levels may exhibit different purchasing behaviors depending on their needs, wants, preferences, and attention while making a purchase choice. Therefore, future research can be done with a diverse demographic community.

REFERENCES

- Aaker, D. A. (1991), *Managing Brand Equity. Capitalizing on the Value of Brand Name*, The Free Press, New York, NY.
- Asshidin, N. H. N., Abidin, N. and Borhan, H. B. (2016), "Perceived quality and emotional value that influence consumer's purchase intention towards American and local products", *Procedia Economics and Finance*, 35, 639-643.
- Chang, H.H. and Liu, Y.M. (2009), "The impact of brand equity on brand preference and purchase intentions in the service industries", *The Service Industries Journal*, Vol. 29 No. 12, p. 1687.
- Hakala, U., Svensson, J. and Vincze, Z. (2012), "Consumer-based brand equity and top-of-mind awareness: a cross-country analysis", *Journal of Product and Brand Management*, 21(6), 439-451.
- Healy, M. (2012), "Millennials might not be so special after all, study finds", 49 USATODAY.COM, available at: <http://usatoday30.usatoday.com/news/health/wellness/story/2012-03-15/Millennials51might-not-be-so-special-after-all-study-finds/5>
- Keller K. L. (2003). *Strategic Brand Management: Building, Measuring, and Managing Brand Equity*, Pearson, Upper Saddle River, NJ.

- Keller, K. L. (1993), "Conceptualizing, measuring, and managing customer-based brand equity", *Journal of Marketing*, 57(1), 1-22.
- Khan, N., Rahmani, S. H. R., Hoe, H. Y. and Chen, T. B. (2015), "Causal relationships among dimensions of consumer-based brand equity and purchase intention: fashion industry", *International Journal of Business and Management*, 10(1), 172-181.
- Lavuri, R., and Sreeramulu, D. (2019). Personal Care Products: A Study on Women Consumer Buying Behaviour. *International Journal of Research & Review*, 6(6).
- Malik, M. E., Ghafoor, M. M., Hafiz, K. I., Riaz, U., Hassan, N. U., Mustafa, M. and Shahbaz, S. (2013), "Importance of brand awareness and brand loyalty in assessing purchase intentions of consumer", *International Journal of Business and Social Science*, 4(5).
- Mirabi, V., Akbariyeh, H., and Tahmasebifard, H. (2015). A study of factors affecting on customers purchase intention. *Journal of Multidisciplinary Engineering Science and Technology (JMEST)*, 2(1).
- O'Cass, A. and Lim, K. (2002), "The influence of brand associations on brand preference and purchase intention", *Journal of International Consumer Marketing*, 14(2/3), 41-71.
- Perera, W. L. M. V. and Dissanayake, D. M. R. (2013), "The impact of brand awareness, brand association, and brand perceived quality on female consumers' purchase decisions of foreign makeup products (a study of youth segment)", *Conference Proceedings of 4th International Conference on Business and Information (ICBI)*, University of Kelaniya, Sri Lanka
- Ramaseshan B., Tsao H-Y, 2007, Moderating effects of the brand concept on the relationship between brand personality and brand equity, *Journal of Brand Management*, 14, 458-466.
- Schiffman, L.G. and Kanuk, L.L. (2000), *Consumer Behavior*, 7th ed., Prentice Hall, New York, NY, pp. 15-36.
- Sekaran, U., and Bougie, R. (2013). *Research Methods for Business: A Skill-Building Approach. Leadership & Organization Development Journal*, 34(7), 700-701.
- Soebagyo, T. (2014). Analisa Pengaruh Store Image Terhadap Purchase Intention di Toserba "Ramai" Ngawi. *Jurnal Strategi Pemasaran*, 2(1), 9.
- Sri Lanka University Statistics 2020 - AC. (n.d.). Retrieved from https://www.ugc.ac.lk/index.php?option=com_content&view=article&id=2301%3Asri-lanka-university-statistics-2020&catid=55%3Areports&Itemid=42&lang=en
- Statista. (2022). *Beauty & Personal Care - Sri Lanka: Market forecast*. Retrieved from <https://www.statista.com/outlook/cmo/beauty-personal-care/sri-lanka>



Minimizing Defects in Sri Lankan Footwear Industry: A Case Study

Madushani GW¹, Deegahawature MMDR²

Department of Industrial Management, Faculty of Applied Sciences, Wayamba University of Sri Lanka

wasanagalhenage@gmail.com¹

dharsana@wyb.ac.lk²

ABSTRACT

The Prevention of defects has a direct impact on controlling the cost of production and the quality of deliverables. Thus, introducing a defect prevention strategy into the process is an investment as it leads to a ‘satisfied customer’. In this thread, this study aims to identify the factors influencing defect production in the Sri Lankan footwear industry. Accordingly, the study attempts to identify defect types, root causes, and preventive actions to minimize reject percentages in the footwear industry. The data gathered through observation, discussions, and secondary sources of a leading footwear manufacturer in Sri Lanka on rejected pairs due to PU (Poly Urethane) Rotary machine from 01st September to November 30th, 2022 were used. The Pareto analysis revealed that insole wrinkles greatly contribute to defect production. The fishbone diagram was used to identify all possible causes contributing to defective products. Thereafter, upper deformity, incorrect mounting, material defects, and adhesive were identified as the causes for insole wrinkles by a focus group discussion with the top management and quality team. The “five-why-analysis” was conducted with the same team to identify the grass root level causes and it identified not enough plastic crates, employee negligence, unavailability of imported (I code) material, and unavailability of adhesive 1802 as the grass-root level causes. Finally, the study suggests an action plan with the responsible person to minimize the adverse effects of root causes. Accordingly, the footwear industry can minimize the defects related to insole wrinkles by implementing the proposed action plan.

KEYWORDS: Defects of the footwear industry, Quality, Pareto analysis, Five-why analysis, Root cause analysis

1 INTRODUCTION

Footwear manufacturing is one of the leading sectors in the rubber industry in Sri Lanka. It adopts new technology in its journey towards automation, higher capacity, and high-quality production. The footwear manufacturers use semi-automated PU rotary machines to manufacture the PU soles for the sandals. After installing this machine with the aim of increasing production volume and quality in 2021, it was noted that the reject rate increased beyond 3%, which was about 1% before installing the machine. Also, after taking several steps to minimize the defects and the learning

period, the defect percentage remains above 2.5%.

According to the previous research findings, there are various causes for the defect production in the footwear manufacturing industry, including needle thread breakage, bobbin or looped thread breakage, skipped stitches, seam pucker sewing defects, improper setting during toe lasting, improper setting during seat lasting, inappropriate sourcing, side lasting problems due to feather edge stitching, inappropriate chilling are lasting defects and improper polishing, inefficient spraying, long mark defects, bumps or hollows. Also, previous research has identified various causes for

defects in rubber manufacturers including turning the mould bead out and not using PCI I.L. Pleat, IN Side Pleat M.P.I, L.C.B, Bead Damage, Bead Pre Cure, Air Leak, Air Bag Pleat, AB. Bead Crack In Side Wrong Core, Lug Damage, SW Damage Wrong Plate, Bladder Mark, Wrong Ply, Bead Cracks, Hose Leak, Double Tire Over Weight. However, there are a scant number of studies that investigate the causes of defects due to the use of PU rotary machines.

Therefore, the aim of the research is to find the highest contributing factor for defect production in the Sri Lankan footwear industry and propose solutions to minimize defect production. The prevention of defects has a direct impact on controlling the cost of production and the quality of the deliverables. Thus, introducing a defect prevention strategy into the process is essential, and it is an investment as it leads to a 'satisfied customer'. The outcome of this study will help the footwear industry find defect types, root causes, and preventive actions to minimize the reject percentage. Also, it helps such firms control costs and thereby enjoy competitive advantages. Finally, it helps firms effectively and efficiently use limited resources.

2 LITERATURE REVIEW

Eleftheriadis & Myklebust (2016) stated that management in the manufacturing industry has often used different types of quality improvements to achieve "near zero" perfection in product and process development. The goal of Zero Defects Manufacturing (ZDM) is to eliminate defective parts, which leads to higher efficiency, eco-friendliness, and lower production costs

(Psarommatis & Kiritsis, 2018). According to Ferretti et al. (2013), minimizing rejects can be achieved through direct and indirect actions.

Mahajan and Mishra (2022) describe Six Sigma as a new and growing approach to quality assurance and management that focuses on continual improvement in quality. Sandeepsoni et al. (2015) explain that Quality Circle teams are created within industries to analyze processes and products for opportunities for improvement. As per Kumari and Agrawal (2019), the fundamental goal of QC is simply the identification and solution of problems any industry faces during the operation of production, and QC members will start execution on given problems after acquiring knowledge about techniques of ultimate problem-solving and analysis of quality. As per Teixeira, Lopes & Sousa (2012) quality is more or less static, aimed at satisfying their current customers. Eleftheriadis & Myklebust (2016) assert that Total Quality Management (TQM) is a critical management system that is essential to ensure internal requirements and non-conformances are met while satisfying customer requirements.

Mia et al. (2017) identify different types of manufacturing wastes, such as overproduction, defects, waiting, unnecessary processing, unnecessary inventory, unnecessary transportation between work sites, and unnecessary motion in the workplace. Pressure leak, marked pre-cure, low pressure, bladder leak, air bubble In SMSW, under cure, less under thread thickness, sponge, AB lung, bladder pleat, Liner thickness, foreign matter, center out, flash open,

airbag damage, chafer out two colors, I.L. damage plate damage, SW crack, thin bead less side, wall thickness, O-ring leak bladder damage, ABSW airbag leak, overcure and, SM. lug are some of the research findings of Dilrukshi (2015) which were conducted for a rubber product manufacturing company.

3 METHODOLOGY

For this study, primary data were obtained from observations and discussions, and secondary sources on PU slippers produced by a leading footwear manufacturer from 01st September to November 30th, 2022. After identifying the reasons for defects based on the data from secondary sources, a Pareto analysis was done to identify the most highly contributing reason for defect. Then a fishbone diagram was used to identify all the possible causes affecting the particular reason. Thereafter, the focus group discussion was used to identify the real causes of the defect. With the aim of identifying the grass-root level cause, the five-why-analysis was conducted with the participation of top management and the quality team. Finally, the focus group discussion with the same set of members was used to propose an action plan along

with the responsible person to solve the grass-root level causes.

4 RESULTS

The study, through observations and secondary data, figured out 23 reasons affecting defects in ABC Company. From the Pareto analysis (Figure 01) insole wrinkle is identified as the most contributing defect reason. Out of the total number of defective PU slippers produced 1216 (16.6%) are defective due to insole wrinkles. The fishbone diagram created with the aim of identifying all possible causes contributing to insole wrinkles is shown in Figure 02. The causes for the defect production identified through a focus group discussion revealed four causes upper deformation, incorrect mounting, material defects, and adhesive issues.

Thereafter, the five-why analysis conducted with the same team identified four grass root level causes, not enough plastic crates, employee negligence, unavailability of I-code material, and unavailability of adhesive 1802. Finally, the study develops an action plan with the responsible person to address the grass root level causes as presented in Table 2.

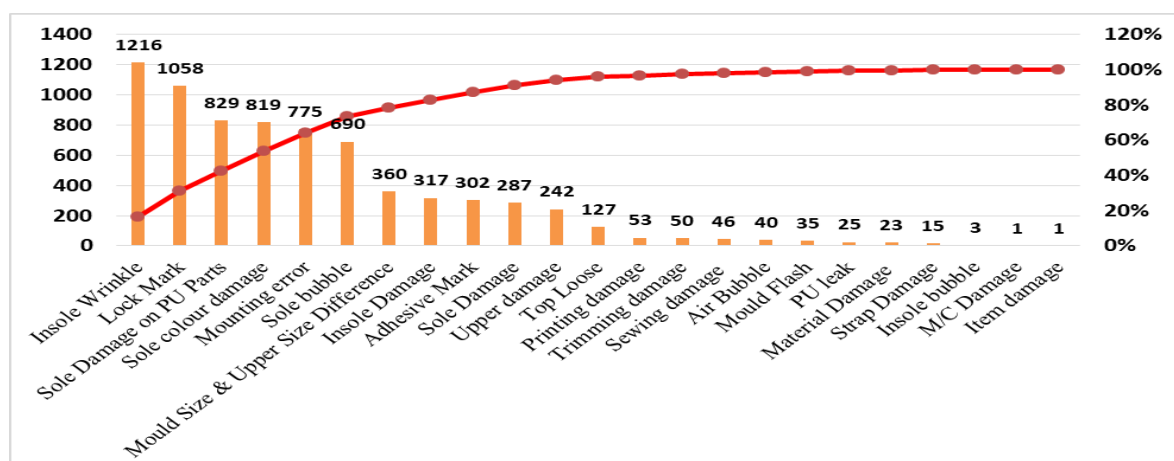


Figure 01: Pareto Analysis

Table 01: Five-Why-Analysis for Insole Wrinkles

Insole Wrinkles (1216)				
1 Why	2 Why	3 Why	4 Why	5 Why
Upper deform	Due to polybag packing	Not enough plastic crates.		
Incorrect mounting	Negligence/ Poor skill			
Material defects	Insole material stiffness	Used L code material is out of specifications	Unavailability of I code material	
Due to adhesive	Extra heating/ Not in the standard heating status	Poor bonding	Used alternative adhesive	Due to unavailability of 1802

Table 02: Action Plans for eliminating Insole Wrinkles

Root cause for defect production	Actions to be taken	Responsibility
Not enough plastic crates.	Store uppers in plastic bins to avoid folds and bends.	PCU leader
Negligence/ Poor skill	Do awareness for operators about the quality standards of the operation. Train new trainees before assigning to operation. Prepare standard work instructions and display them. Conduct a lean concept awareness session	Production Manager/ Quality Manager HR Manager/ Production Head Quality Manager/ Compliance In charge Production Manager
Unavailability of I code material	Need to procure appropriate insole material according to product specifications to avoid unnecessary elongation. Start a project with XYZ sub-plant to develop L code material similar to I code material.	Procurement FM/ COO
Due to unavailability of 1802	Ensure 1802 adhesive availability instead of 5030. Locally develop adhesive similar to 1802 specifications for a lower cost.	Procurement FM/ COO

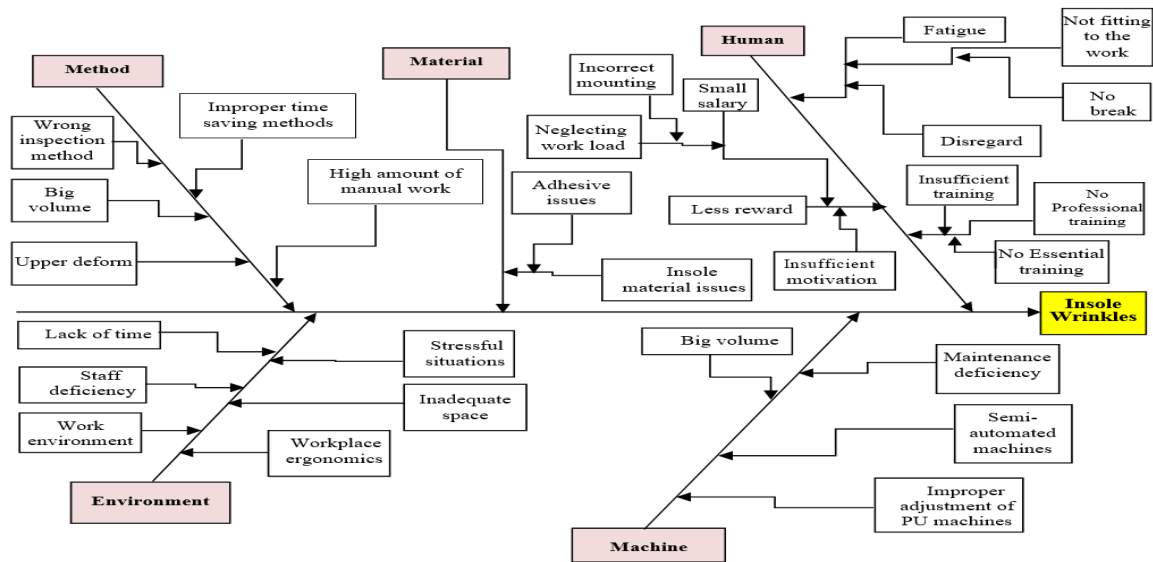


Figure 02: Fishbone Diagram for Insole Wrinkles

5 DISCUSSION & CONCLUSION

The footwear industry is highly competitive and requires continuous improvement in order to remain competitive while being effective and efficient. The results of this study provide valuable insights into the root causes of defects in the production process after installing the PU rotary machine. Insole wrinkles were identified as the most significant factor contributing to defects, and the proposed action plan aims to eliminate the causes leading to insole wrinkles. Respective responsible persons can implement this plan and work towards minimizing defects and improving efficiency and effectiveness.

The findings of this study can serve as a guideline for the footwear industry to improve the quality of their products and reduce waste. By adopting the proposed action plan, the industry can work towards achieving better quality control, reducing costs, and meeting the demands of consumers. Overall, this

study provides valuable insights into the defects produced in the footwear industry, and its proposed action plan can contribute to the industry's success.

The study provides valuable insights into the primary cause of defects in footwear production, specifically in relation to defects produced by the PU rotary machine. However, this study has certain limitations. For instance, it only focuses on one specific machine and defect type, and further research is needed to analyze all potential causes of defects in the industry. Additionally, extending the observation period may provide a more complete insight into the case. Future research could also consider other machines and defect types to provide a more comprehensive understanding of the challenges facing footwear production. By addressing these limitations, future research has the potential to provide useful insights into improving production processes and enhancing the quality of footwear products.

REFERENCES

- Dilrukshi, R. K. (2015). Statistical approach to minimize waste in tyre manufacturing process: a case study. Retrieved from <http://dl.lib.mrt.ac.lk/handle/123/11290>
- Eleftheriadis, R. J., & Myklebust, O. (2016). A guideline of quality steps towards zero defect manufacturing in industry. *Proceedings of the International Conference on Industrial Engineering and Operations Management IEOM Society*, 332-340. Retrieved from <http://ieomsociety.org/ieomdetroit/pdfs/164.pdf>
- Ferretti, S., Caputo, D., Penza, M., & D'Addona, D. M. (2013). Monitoring systems for zero defect manufacturing. *Procedia CIRP*, 12, 258-263.
- Kumari, A. S. H. A., & Agarwal, S. (2019). Role of quality circle in footwear industry. *International Journal of Research in Aeronautical and Mechanical Engineering IJRAME*, 7(5), 10-41. Retrieved from https://www.academia.edu/39287641/role_of_quality_circle_in_footwear_industry.
- Mahajan, M. T. S. R., & Mishra, N. (2022). Productivity Improvement in Manufacturing Industry Using Industrial Engineering Tools. *International Journal of Scientific Research & Engineering Trends*, 8(3), 1384-1389.
- Mia S., M. A., Alam, N., Rahman, & Uddin, M. (2017). Footwear Industry in Bangladesh: Reduction of Lead time by using Lean Tools. *Journal of Environmental Science, Computer Science and Engineering & Technology*, 6. doi:10.24214/jecet.C.6.3.25159
- Psarommatis, F., & Kiritsis, D. (2018). A scheduling tool for achieving zero defect manufacturing (ZDM): a conceptual framework. *Advances in Production Management Systems*, *Smart Manufacturing for Industry 4.0: IFIP WG 5.7 International Conference, APMS 2018, Seoul, Korea, Proceedings, Part II*, pp 271-278. doi:10.1007/978-3-319-99707-0_34
- Sandeepsoni, D., Kumar, R., Duhan, R., & Duhan, S. (2015). Quality circle: A methodology to identify scope of quality improvement through Kaizen approach. *International Journal of Modern Engineering Research (IJMER)*, 5(7), 43-51. Retrieved from http://www.ijmer.com/papers/Vol5_Issue7/Version-1/G5714351.pdf.
- Teixeira, H., Lopes, I., & Sousa, S. (2012). Diagnosis of Quality Problems in a Footwear SME. *Proceedings of the World Congress on Engineering, WCE, London, U.K*, 3, pp 1438–1443. Retrieved from https://www.iaeng.org/publication/wce2012/wce2012_pp1438-1443.pdf



Motivating Pro-environmental Behaviour through Green Human Resource Management Practices

Madhushika PN¹, Edirisuriya AW², Deegahawathura MMDR³

Department of Industrial Management, Faculty of Applied Science, Wayamba University of Sri Lanka

*nipoomadhushika0713@gmail.com*¹

*anuradhae@wyb.ac.lk*²

*dharsana@wyb.ac.lk*³

ABSTRACT

The attitudes, behaviors, and practices of the workforce (or employees or human beings) have a significant effect on the environment. Therefore, human resource experts strive to engage employees with more environmental-friendly practices. As a result, “Green Human Resource Management” is becoming a fad and helps achieve sustainable environmental goals. A limited number of studies have examined the impact of green human resource management (GHRM) practices such as green recruitment and selection, green training and development, green performance management and appraisal, green reward and compensation, and green empowerment on employee pro-environmental behaviors (PEBs). Such studies are scant in different countries including Sri Lanka and industries. Hence, to bridge this research gap, the present study examines the influence of GHRM practices on Pro-environmental Behaviors (PEBs) in the apparel industry of Sri Lanka. The objective of the study was to identify the GHRM practices that affect employee PEB in the apparel industry. The study adopted a descriptive research design and used 75 responses. Data collected from a structured questionnaire was analyzed by descriptive statistics and multiple regression. Present research findings reveal that GHRM practices influence employees' PEBs. Therefore, GHRM practices can be used to promote pro-environmental behaviors. The organization's long-term strategy for sustainable growth can be promoted through green HRM practices. Applying HRM techniques that are focused on the environment may be beneficial for firms that encourage environmental behaviors at the individual level.

KEYWORDS: Apparel industry, Green Human Resource Management Practices (GHRM Practices), Pro-environmental Behaviors (PEBs), Sri Lanka

1 INTRODUCTION

The term "Green Human Resource Management" (GHRM) refers to a set of procedures for preserving the environment and protecting it. The viability of organizational activities for environmental sustainability depends on employee pro-environmental behavior. Additionally, positive employee attitudes and behaviors significantly contribute to lowering businesses' environmental impact. Making sure that environmental sustainability is properly included in human resource policies is one of the current problems that professionals

working in human resources confront. Researchers in this discipline have begun to look into how GHRM affects positive employee attitudes and behaviors (Dumont, Shen & Deng, 2017). Only a small number of research, particularly in the Sri Lankan context, have looked into and described how GHRM practices affect pro-environmental behaviors (PEBs). Prior studies of the PEB have been conducted with constrained objectives. The PEB has been studied in the past through experiments with constrained objectives. Additionally, only a few industries have been the

subject of prior research on GHRM (Saeed et al., 2018), (Ansari, Farrukh & Raza, 2021). The apparel industry is very important for Sri Lanka and at the same time, PEBs are inquiring apparel sector. This study investigates the impact of GHRM practices on PEBs in the apparel sector within the Sri Lankan context.

2 REVIEW OF LITERATURE

2.1 *Green Human Resources Management (GHRM)*

The integration of corporate environmental management into human resource management is termed Green HRM (Renwick, Redman & Maguire, 2008). According to Tang et al., (2018), Green HRM refers to HRM practices that aim to promote environmentally friendly resource use, which will strengthen the impacts of environmental performance in general and increase employee awareness and commitment to environmental management issues.

Renwick, Redman & Maguire, (2013), has presented the categorization of GHRM practices. First, GHRM concerns with the development of green abilities in employees through green recruitment, selection, and training processes. Second, GHRM deals with the motivation of employees by rewarding their green performance. Third, GHRM relates to stimulating employees' involvement by empowering them and generating an environmentally friendly organizational culture.

2.2 *Pro-Environmental Behavior (PEB)*

Turning off lights when leaving the office, printing two sides of a paper, forgoing the use of disposable cups, assisting businesses with the implementation of greening strategies,

commuting by bicycle, reducing waste, and coming up with new initiatives to protect the environment from degradation have all been identified in the literature as pro-environmental practices. According to them, Employee's pro-environmental behavior has been defined as the "willingness to engage in pro-environmental activities" (Scherbaum, Popovich & Finlinson, 2008). According to Djellal & Gallouj, (2016) Employee involvement in environmental issues and pro-environmental behavior is considered as an effective strategy to become an environmentally responsible organization and enhance environmental performance.

3 METHODOLOGY

In this instance, a theory about the effect of GHRM practices on encouraging PEBs was developed using the deductive method. Green human resource management and employees pro-environmental behaviors: Examining the underlying mechanism (Saeed et al., 2018) and "Green human resource management and employees pro-environmental behaviors" (Ansari et al., 2021) were the subjects of previously published journal papers based on which the research framework was derived. Saeed et al., 2018 concluded a positive relationship between GHRM Practices and PEB.

3.1 *Hypothesis*

H1: Green recruitment and selection (GRS) is positively related to employee PEB.

H2: Green training and development (GTD) is positively related to employee PEB.

H3: Green performance management and appraisal (GPMA) is positively related to employee PEB.

H4: Green reward and compensation (GRC) is positively related to employee PEB.

H5: Green empowerment (GE) is positively related to employee PEB.

The quantitative research method and survey method were used to test the conceptual framework by answering the research questions. The survey was conducted focusing on a representative sample of the apparel industry in Sri Lanka to verify and test the identified relationships in the conceptual framework. The questions were distributed using Google Forms through the online platform.

The questionnaire developed based on standard measures was adopted to collect primary data, and a five-point Likert scale was used to gather responses. The data were analyzed through multiple regression analysis and descriptive statistics.

3.2 Sample

Executive or higher-level personnel of the Sri Lankan garment industry were the population. It was determined to gather data from 100 respondents based on the recommendations made by an accurate sample size calculator (Kibuacha, 2021). After distributing the questionnaire only 75 valid responses were obtained.

4 DATA ANALYSIS

The reliability of the measures was evaluated by Cronbach's Alpha. For each variable, Cronbach's Alpha results were above the threshold level of 0.5 with 95 percent confidence level. Each variable's internal consistency was at an acceptable

level. It demonstrates that the research is internally consistent and that the research methodology was trustworthy, producing reliable results. Then normality of the data was tested. According to the results generated using SPSS, the skewness of variables was found to range between -1 and +1, indicating that the data are approximately normally distributed. The kurtosis values of those variables are slightly far from 3, and negative indicating the data are flattened.

The Pearson correlation coefficient analysis reveals statistically significant relationships between variables ($p < 0.05$). While GRS and GPMA have a weak positive relationship with PEB, GTD, and GE have a strong relationship. However, GRC reported a moderate positive relationship with PEB.

Table 1: Correlation Analysis for Independent Variables

Correlations	PEB	
		Pearson Correlation
GRS		.248*
GPMA		.368**
GTD		.609**
GRC		.590**
GE		.627**

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Multiple regression was performed to test the hypothesis and a multicollinearity diagnostic test was done to check whether the independent variables were highly correlated among themselves. The VIF value and Tolerance value reveal no concern about multicollinearity as test VIF values are less than 5 and tolerance values are higher than 0.2.

Table 2: Multiple Regression analysis to check the effect of variables

Independent Variables	B	β	Sig.F
GRS	.264	.248	.040
GPMA	.464	.368	.002
GTD	.800	.609	.000
GRC	.664	.590	.000
GE	.598	.627	.000

The results of multiple regression indicate that GHRM Practices have a positive relationship with PEB.

As per R square statistics, 46.6% ($p < 0.05$) of the variants in the PEB were predicted from GHRM Practices, and the Durbin-Watson statistic, 1.376 indicate that the overall regression model is fit for the data.

All hypotheses were satisfied according to the above analysis.

5 RESULTS AND DISCUSSION

The results presented in tables 1 and 2 show that GRS has a significant positive impact on PEB ($\beta = .248, P < 0.05$). This confirms the first hypothesis (H1). The GPMA Practices also have a significant positive impact on PEB ($\beta = .368, P < 0.05$) and it confirms postulated relationship of the second hypothesis (H2). GTD has a significant positive impact on PEB ($\beta = .609, P < 0.05$), and that confirms the third hypothesis (H3). The GRC has a significant positive impact on PEB ($\beta = .590, P < 0.05$). It confirms the fourth hypothesis (H4). Finally, DE has a significant positive impact on PEB ($\beta = .627, P < 0.05$), and that supports the postulated relationship in the fifth hypothesis (H5).

The model statistics indicate that the R square value is 0.466 thus, 46.6% of the variance in the PEB can be predicted

from GHRM practices. The lower R-squared value may be due to the possibility of other factors influencing the PEB. On the other hand errors in observations and tools may be the reasons for lower R² value.

The current research developed a conceptual framework linking GHRM practices (green recruitment and selection, green training and development, green performance management and appraisal, green reward and compensation, and green empowerment) positively to PEBs. The findings of the study provide evidence in favor of the suggested hypothesis. This finding was in line with the findings of Saeed et al., (2018) and Ansari et al., (2021) providing evidence for the effect of GHRM practices on employees' PEB. Ansari et al., (2021) studied GHRM practices and PEB in the fertilizer and chemical manufacturing industry in Pakistan, and Saeed et al., (2018) studied PEB through GHRM practices in the industries of coal generating, power, food, chemical, and pharmaceutical. Despite receiving fewer responses than expected, the results of the current study reveal the same results.

Based on the study, it can be recommended that the management can include environmental concerns in their recruitment process and also employee participation and involvement in green suggestions. Furthermore, The firms can employ a wide range of GHRM practices like green training, green rewards, etc. to motivate employees' concerns regarding their environment. The executives can motivate employees to pay more attention to their personal concerns about PEB.

6. CONCLUSIONS

As a result of the key contributor to the economy, the apparel industry in Sri Lanka is now becoming a significant polluter of the environment (Dheerasinghe, 2009). Therefore, implementing GHRM Practices might be seen as a better way to reduce environmental pollution and move toward a sustainable future. This study investigated the impact of green HRM practices on employees' pro-environmental behavior. The study considered the GHRM practices such as green hiring and selection, green training and development, green performance management and appraisal, green rewards and remuneration, and green empowerment. The results confirmed that all the variables positively affect the PEBs.

Employers can inspire staff to care more about environmental preservation and to act in ways that benefit all stakeholders by implementing GHRM practices. The reasons offered by the attitude theory (Bagozzi, 1992) provide justifications for the findings of this study. This theory emphasizes the significance of positive affective responses from employees in mediating positive assessments of management practices (GHRM) and positive behaviors from employees (PEBs).

The management should include environmental concerns in the job description and job design. In addition to that the recruitment messages can have environmental criteria. Candidates may be given questions on the environment during interviews to evaluate their commitment, knowledge, and level of concern regarding the environment.

Organizations can improve performance management systems by incorporating corporate environmental management objectives and targets with the performance evaluation system. Providing environmental training to every employee to increase their concern and commitment towards protecting the environment.

The present study is limited only to the apparel industry, and this research only investigates the influence of GHRM practices in the Sri Lankan context. Future studies would provide fruitful results if the findings were expanded to other developing and rising economies and industries. Further prospective research can look into mediators and moderators to further explain the effect of green HRM practices on pro-environmental behaviors.

REFERENCES

- Ansari, N. Y., Farrukh, M., & Raza, A. (2021). Green human resource management and employees pro-environmental behaviours: Examining the underlying mechanism. *Corporate Social Responsibility and Environmental Management*, 28(1), 229-238.
- Bagozzi, R. P. (1992). The self-regulation of attitudes, intentions, and behavior. *Social psychology quarterly*, 178-204.
- Dheerasinghe, R. (2009). Garment industry in Sri Lanka challenges, prospects and strategies. *Staff studies*, 33(1), 33-72.
- Djellal, F., & Gallouj, F. (2016). Service innovation for sustainability: paths for greening through service innovation. *Service innovation: Novel ways of creating value in actor systems*, 187-215.
- Dumont, J., Shen, J., & Deng, X. (2017). Effects of green HRM practices on

- employee workplace green behavior: The role of psychological green climate and employee green values. *Human resource management*, 56(4), 613-627.
- Kibuacha, F. (2021, April 7). *How to Determine Sample Size for a Research Study*. GeoPoll. Retrieved from <https://www.geopoll.com/blog/sample-size-research/>
- Renwick, D., Redman, T., & Maguire, S. (2008). Green HRM: A review, process model, and research agenda. *University of Sheffield Management School Discussion Paper*, 1(1), 1-46.
- Renwick, D. W., Redman, T., & Maguire, S. (2013). Green human resource management: A review and research agenda. *International journal of management reviews*, 15(1), 1-14.
- Saeed, B. B., Afsar, B., Hafeez, S., Khan, I., Tahir, M., & Afridi, M. A. (2018). Promoting employee's proenvironmental behavior through green human resource management. *Responsibility and Environmental Management*, 26(2), 424-438.
- Scherbaum, C. A., Popovich, P. M., & Finlinson, S. (2008). Exploring individual-level factors related to employee energy-conservation behaviors at work 1. *Journal of Applied Social Psychology*, 38(3), 818-835.
- Tang, G., Chen, Y., Jiang, Y., Paillé, P., & Jia, J. (2018). Green human resource management practices: scale development and validity. *Asia pacific journal of human resources*, 56(1), 31-55.



The Influence of Job Stress, Work Environment, Salary and Benefits on Employee Job Satisfaction: Evidence from Tyre Industry Company

Amarasinghe GPP¹, Pallegedara A²

Department of Industrial Management, Wayamba University of Sri Lanka

*prabodi.gamage321@gmail.com*¹

*asankap@wyb.ac.lk*²

ABSTRACT

The employees with job stress found themselves in a pressured work environment. The previous studies argued that inappropriate pressure by management leads employees to job stress. This research aimed to examine the impact of job stress, salary and benefits on employee job satisfaction while investigating the company's work environment. The data were collected through a survey questionnaire and used the deductive approach to build the hypotheses. Data were collected from 118 responses at the company's Department of Sales and Marketing. The collected data through a questionnaire were analyzed using Smart-Partial Least Square (SmartPLS – 4.0). The findings proved a positive and significant impact of pay and benefits on employee job satisfaction and the work environment. The work environment mediated the relationship between salary and benefits with employee job satisfaction. Furthermore, the work environment positively and significantly affects job stress and employee job satisfaction. However, the study revealed no significant impact of job stress on employee job satisfaction. This study assists the top executives in arranging the work environment and raising the level of job satisfaction among employees working in the organization.

KEYWORDS: Employee Job Satisfaction, Job Stress, Salary and Benefits, Work Environment

1 INTRODUCTION

Job life has become the most important part of a person's life. Due to the competitive nature of the job environment, employees nearly from every sector are under pressure which ultimately causes stress (Kakada & Deshpande, 2021). The motivation for the study was the job stress of the employees in the company, especially targeting employees in the Department of Sales and Marketing due to the reduction of sales. The researcher hopes that the finding of this study will assist the top executive bodies of the organization in reducing job stress and raise the level of employee job satisfaction among employees. The researcher identified that the main reason for the job stress of

employees in the company was increasing tyre prices in Sri Lanka. According to the Export Development Board, Sri Lanka is the world's largest solid tyre manufacturer which supports nearly 25% of the global demand. The Sri Lankan tyre market was valued 0.25 billion in 2019. However, due to the high cost of production and import barriers, solid tyre production will show less growth in the next five years (Sri Lanka Export Development Board, 2021). Sales employees in the tyre industry are often given targets to achieve. However, if they could not achieve this target, inappropriate pressure comes from top management towards the sales and marketing team, if they cannot achieve this target. This has caused

higher job stress because of job insecurity and loss of bonuses (Inamdar, 2019). Another major problem was the low salary and benefits. The tyre industry does not offer competitive salaries and benefits compared with other industries which eventually cause the financial stress and makes it challenging to make ends meet (Madhani, 2009). As employees said, their salary and benefits are not enough to compare with other companies. Therefore, the objectives of this study were “To study the influence of work environment on employee job satisfaction in the company” and “To study the impact of job stress, salary and benefits on the employee job satisfaction of the company.”

2 LITERATURE REVIEW

The researcher has examined the key variables of job stress, employee job satisfaction, salary and benefits and work environment.

2.1 Job Stress

A study done on determinants of job stress in South Carolina in 2013 revealed that there were two dimensions of job stress: time stress and anxiety stress. The data were collected through 367 managers employed by a major restaurant chain. (Salas, Fiore & Letsky, 2013).

A study was conducted on job stress on employee job satisfaction among University staff in Malaysia in 2009. As per the study, the researcher defined job stress as “a situation in which some characteristics of the work situation are thought to cause poor psychological or physical health, or to cause risk factors making poor health more likely” (Ahsan et al., 2009).

2.2 Employee Job Satisfaction

A review conducted on employee job satisfaction in China in 2012 revealed many definitions of employee job satisfaction based on several authors. However, this research is based on the definition of “Employee job satisfaction is a kind of pleasant or positive affection state, which grows in evaluating an individual’s work experience” (Zhu, 2012).

Moreover, research has been conducted on the determinants of employee job satisfaction in Ethiopia in 2018 which revealed key dimensions for measuring job satisfaction: performance appraisal, promotion opportunities, vocational training, and intrinsic rewards (Addis, Dvivedi & Beshah, 2018).

2.3 Salary and Benefits

A study carried out on salary and benefits in 2008 revealed that the most widely discussed employer-sponsored benefits are health insurance, training and development, discounts on the firms’ products, subsidized or free beverages and meals, free child care, and retirement plan (Oyer, 2008).

Further, a study was carried out on compensation and employee job satisfaction in 2016 found that benefits and salary are highly affected by employee job satisfaction. However, the research found that salaries among females are less than men. But, gender was not a predictor of employee job satisfaction (Spencer et al., 2016).

2.4 Work Environment

As per Miao's (2016) review of the working environment and job satisfaction of employees revealed a positive correlation between the working environment of the organizations and job

satisfaction. This research was based on secondary data concerning conceptual and previous studies related to the significance of the working environment in service sector companies” (Miao, 2016).

Research has been done on assessing the work environment on creativity in the UK in 1996. This study has shown a perceived work environment based on challenging work, organizational encouragement, work group support, freedom, supervisory encouragement and workload pressure (Amabile et al., 1996).

3 RESEARCH METHODOLOGY

The data was collected through a survey questionnaire. Therefore, the research strategy was a survey, and the research technique was the questionnaire. The population of the research study was employees working in the CEAT Kelani International Tyres (Pvt) Ltd. As per the investigation, approximately 1000 employees are working. The sample size has been determined according to the online sample size calculator where Z is the confidence interval (95%), N is the population size which is 1000, P is the ratio of population characteristics available in the sample (50%), S the sample error (5%), and n is the sample size. Based on that, approximately 118 responses were collected. The sampling technique was nonrandom as 118 responses were collected only from the sales and marketing department. The reason for that is inappropriate pressure from top management towards the sales and marketing team because of lack of sales.

The hypotheses were built based on the existing literature of Butt et al.

(2020). Therefore, this research follows the deductive research approach. The hypotheses are as follows;

H1: Salary and Benefits have a positive and significant impact on the work environment

H2: Work environment has a positive and significant impact on job stress

H3: Job stress has a negative and significant impact on employee job satisfaction

H4: Salary and Benefits have a positive and significant impact on employee job satisfaction

H5: Work environment has a positive and significant impact on employee job satisfaction

4 DATA COLLECTION AND ANALYSIS

The data was collected through a survey questionnaire. The population of the research study was 1000 employees working in the CEAT Kelani International Tyres (Pvt) Ltd. Therefore, the sample size was taken as 118 survey responses.

4.1 Details of Design and Development of Data Collection Tools

All the variables were reserved using 5-point Likert scale ratings of 1 = strongly disagree, 5 = strongly agree adopted by standard questionnaires. The indicators of job stress are anxiety stress and time stress, which were extracted from Salas et al. (2013). The indicators of salary and benefits are basic payment, variable payment, health insurance, training and development, and discounts on the firm’s product which were extracted from Oyer, (2008). The work environment indicators are supervisory engagement, challenging work, freedom,

sufficient resources and workgroup support, which were extracted from Amabile et al., (1996). The indicators of employee job satisfaction are performance appraisal, promotion opportunity, vocational training and intrinsic rewards extracted from Addis et al., (2018).

5 RESULTS AND DISCUSSION

5.1 Measurement Model Evaluation

As per the rule of thumb, the coefficient value for Cronbach's Alpha must exceed 0.60 for all items (Hair, Ringle & Sarstedt, 2011). The Cronbach's Alpha coefficient for all the constructs (salary and benefits = 0.946, employee job satisfaction = 0.839, job stress = 0.895 and work environment = 0.815) was more than 0.60 and indicated high reliability. The composite reliability of the construct should exceed 0.70 (Hair et al., 2011). Composite reliability of all four constructs (salary and benefits = 0.953, employee job satisfaction = 0.882, job stress = 0.916 and work environment = 0.871) indicates high reliability.

To find the convergent validity of the constructs, outer loadings of the indicators and Average Variance Extracted (AVE) were used. The rule of thumb is that the standardized outer loadings should be 0.708 or higher (Hair et al., 2011). However, an item of time stress (an indicator of job stress) shows a factor loading of 0.617, and an item of performance appraisal (an indicator of employee job satisfaction) shows a factor loading of 0.152 which should be removed. AVE should be greater than 0.50, and AVE values of all four constructs (salary and benefits = 0.673, employee job satisfaction = 0.542, job

stress = 0.578 and work environment = 0.576) explain more than half of the variance of its indicators (Hair et al., 2011).

To find the discriminant validity, two methods were used which are Cross-loadings and Fornell-Larcker criterion. The indicator's outer loading on the associated construct should be greater than the other constructs in the cross-loading method. According to, the Fornell-Larcker criterion, the square root of each construct's AVE should be greater than other constructs. Therefore, both approaches ensured the satisfaction of discriminant validity. Hence, the study results are satisfactory (Hair et al., 2011). (See Figure 1).

5.2 Structural Model Evaluation

The structural path coefficients were measured using the t-value and p-value. The critical value for two-tailed t-tests was 2.57 at a 0.01 significance level. The corresponding p-value must be smaller than 0.01 to indicate a (Hair et al., 2011).

Based on the testing, hypothesis H3 was not accepted, and H2, H1, H4, and H5 hypotheses were acceptable (See Table 1).

6 CONCLUSION

According to the findings, the H3 hypothesis was not accepted, and H2, H1, H4, and H5 hypotheses were acceptable. That means salary and benefits, work environment has positive impact on job stress as well as salary and benefits, work environment have a positive impact on employee job satisfaction. According to the mediation analysis, the relationship between salary and benefits on employee job satisfaction is partially

THE INFLUENCE OF JOB STRESS, WORK ENVIRONMENT, SALARY AND BENEFITS ON
EMPLOYEE JOB SATISFACTION: EVIDENCE FROM TYRE INDUSTRY COMPANY

Table 1: Hypotheses testing using Path Coefficient

Hypotheses	Relationship	Path Coefficient	Mean	SD	t value	P value	Decision
H1	S&B -> WE	0.417	0.430	0.043	9.640	0.000	Supported
H2	WE-> JS	0.474	0.491	0.063	7.529	0.000	Supported
H3	JS -> EJSat	0.158	0.158	0.117	1.354	0.176	Not supported
H4	S&B -> EJSat	0.420	0.424	0.076	5.544	0.000	Supported
H5	WE -> EJSat	0.307	0.310	0.104	2.944	0.003	Supported

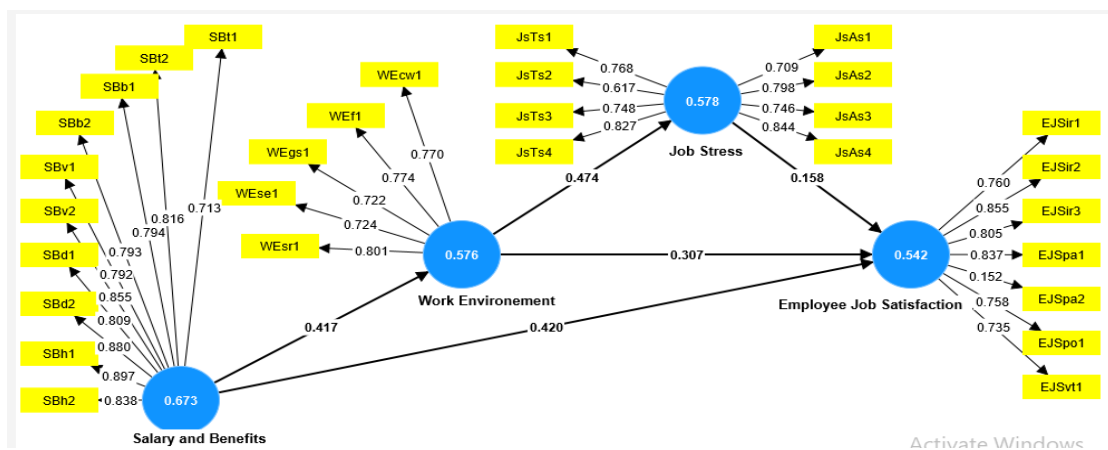


Figure 1: Outer loadings of the indicators

mediated by the work environment. And, there is no mediation between salary and benefit and employee job satisfaction when there are two mediator variables of job stress and the work environment.

6.1 Recommendation

This study is an original attempt that studies the impact of job stress, work environment and salary and benefits on employee job satisfaction in the company. Therefore, the results of this study support future researchers and provide organizations' executives with an idea about how to mitigate the level of job stress to increase employees' job benefits and job satisfaction. Moreover, to use this conceptual

satisfaction while improving the work environment.

6.2 Limitations and Future works

The researcher has assumed only the work environment, job stress as well as salary and benefits as a predictor of employee job satisfaction. However, there can be many indicators of measuring the variations of these constructs. Also the duration of the study was relatively limited to conducting the entire research, especially collecting the data. In future work, researcher suggests investigating other indicators of job stress, work environment, salary and framework for companies in different industries.

REFERENCES

- Addis, S., Dvivedi, A., & Beshah, B. (2018). Determinants of job satisfaction in Ethiopia: evidence from the leather industry. *African Journal of Economic and Management Studies*, 9(4), 410–429.
- Ahsan, N., Abdullah, Z., Fie, D. Y. G., & Alam, S. S. (2009). A study of job stress on job satisfaction among university staff in Malaysia: Empirical study. *European Journal of Social Sciences*, 8(1), 121–131.
- Amabile, T. M., Conti, R., Coon, H., Lazenby, J., & Herron, M. (1996). Assessing the work environment for creativity. *Academy of Management Journal*, 39(5), 1154–1184.
- Butt, R. S., Wen, D. X., Hussain, R. Y., & Pervaiz, S. (2020). Effect of Job Stress, Benefits and Salary on Employee Job Satisfaction Based on Mediating and Moderating Role of Work Environment and Leadership: Evidence from Telecom Sector. *International Journal of Engineering and Management Research*, 10(03), 121–130.
- Hair, J. F., Ringle, C. M., & Sarstedt, M. (2011). PLS-SEM: *Indeed a silver bullet*. *Journal of Marketing theory and Practice*, 19(2), 139–152.
- Inamdar, S. (2019). A study on camouflaged stress among teaching staff: An international review. *MERC Global's International Journal of Management*, 7(1), 85–90.
- Kakada, P., & Deshpande, Y. M. (2021). Working conditions and effective supervision: Does it matter for engineering faculty job satisfaction. *International Journal of Electrical Engineering and Education*, 58(2), 101–112.
- Madhani, P. M. (2009). Sales Employees Compensation: An Optimal Balance Between Fixed and Variable Pay. *Compensation & Benefits Review*, 41(4), 44–51.
- Miao, M. (2016). *Review Of Research Journal*. 5(5).
- Oyer, P. (2008). Salary or benefits? *Research in Labor Economics*, 28, 429–467.
- Salas, E., Fiore, S. M., & Letsky, M. P. (2013). Theories of team cognition: Cross-disciplinary perspectives. *Theories of Team Cognition: Cross-Disciplinary Perspectives*, 177, 1–638.
- Spencer, E. S., Deal, A. M., Pruthi, N. R., Gonzalez, C. M., Kirby, E. W., Langston, J., McKenna, P. H., McKibben, M. J., Nielsen, M. E., Raynor, M. C., Wallen, E. M., Woods, M. E., Pruthi, R. S., & Smith, A. B. (2016). *Gender Differences in Compensation, Job Satisfaction and Other Practice Patterns in Urology*. *Journal of Urology*, 195(2), 450–455.
- Zhu, Y. (2012). A review of job satisfaction. *Asian Social Science*, 9(1), 293–29



The Perceived Usefulness of (Enterprise Resource Planning) ERP System for a Productive Management System: The Case of a Glove Manufacturing Company in Sri Lanka

Mithrasena PGPR¹

*Department of Industrial Management, Faculty of Applied Sciences, Wayamba University of Sri Lanka ¹
pieumith@gmail.com ¹*

ABSTRACT

In this new business setting, Enterprise Resource Planning (ERP) platforms are advantageous since they save operational costs, shorten cycle times, and raise customer satisfaction. This study uses a questionnaire to investigate the key factors that influence a company's decision to adopt an ERP system, as well as the implementation issues that may arise. Numerous advantages of ERP systems, specifically for management processes, are supported by empirical research, but there are also drawbacks. The findings serve as the foundation for further investigation into the possibilities of ERP systems for improved business integration for manufacturing companies in Sri Lanka. The initial promise of Enterprise Resource Planning (ERP) system was the simplicity with which all organizational operations could be integrated. This study conducted an empirical analysis to see the indicators for ERP implementation, and perceived usefulness as a result of numerous reported ERP failures. According to the findings, both in terms of nominal values and in comparison, to comparable systems, the Perceived usefulness of an Enterprise Resource Planning (ERP) system depends on the factors perceived ease of use, learnability, system capability, user guidance and end-user satisfaction.

KEYWORDS: Enterprise Resource Planning (ERP), Perceived usefulness, Manufacturing Company, Management

1 INTRODUCTION

The goal of this study is to quantify the variables affecting how users perceive the value and usefulness of ERP systems across various departments in a leading glove manufacturing company in Sri Lanka. Based on previous literature, the research model is created. A questionnaire was created to gather data by adopting questions from earlier and more established literature. The manufacturing company for this study, ABC Company, was the main emphasis. The data collection instrument was distributed to nearly 90 employees who use the ERP system, and data is gathered from them. According to previous statistical studies, the ERP system's major success variables determining

usefulness are perceived ease of use, system capability, user guidance, learnability, and end-user satisfaction. By putting a fresh research model on usefulness to the test, the current study added to the theory.

2 REVIEW OF LITERATURE

According to scholars, ERP systems are extensive software packages that aim to integrate every aspect of a business process and function to give a comprehensive picture of the enterprise from a single information and IT architecture. One database, one application, and a uniform user interface are the foundation of an ERP system's basic architecture (Al-Mashari, Al-Mudimigh, & Zairi, 2003). Previous ERP initiatives have been found to have failed

(Gupta, 2000). This shows that there is still a need for success-oriented solutions as the causes of failure are still not well understood. The usability of interfaces can be considered as one of the variables that influence usefulness, according to several researchers who have claimed that usefulness is one of the important factors leading to the success of ERP systems (Al-Khaldi & Wallace, 1999; Szajna & Scamell, 1993). The management should be aware of the elements that influence the usefulness of the ERP system to get the most value out of a costly implementation. An ERP success model with six key aspects was first presented by (DeLone & McLean, 1992): system quality, information quality, use, user satisfaction, individual impact, and organizational effect. Perceived usefulness was investigated by (Larcker & Lessig, 1980) as a proxy for ERP success. It would be ideal, but challenging in practice, to gauge ERP impact directly from costs and benefits, productivity gains, competitive advantage, and impact on decision-making. Usefulness has gained significant recognition as a substitute tool due to the difficulties in applying such data (Seddon, 1994). According to (Gallagher, 1974), perceptions of usefulness may vary among users at various organizational levels. Formal Education Level: Users with higher levels of formal education tend to use computers more frequently and to be happier users. However, this study further examines those factors affecting the usefulness of the ERP systems in the Sri Lankan manufacturing sector focusing on the ABC glove manufacturing company attempting to make a successful ERP system for users. In conclusion, the study

determines the usefulness of ERP systems as an effective management function of a manufacturing company in Sri Lanka.

3 METHODOLOGY

The study's empirical survey was carried out at a Sri Lankan factory that makes safety gloves. Since its deployment, the ERP system at the facility has served as the primary IS, and employees are required to utilize it.

3.1 Research Design

This design was chosen to meet the objectives of the study to determine whether there is a relation of variables: Perceived usefulness, Learnability, Perceived ease of use, System capability, and User guidance.

3.2 Research Model

This study examines, in the ERP context, the factors affecting the perceived usefulness as five independent variables, user characteristics: Perceived ease of use, Learnability, System capability, User guidance and End-user satisfaction. The Proposed conceptual work model is depicted in Figure 3.1.

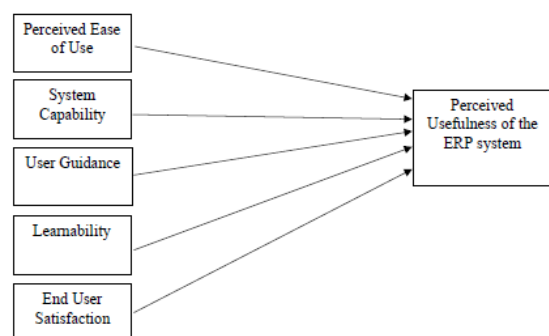


Figure 3. 1: Research Model

3.3 Data Collection and Analysis

The reliability of the created questionnaire is assessed using a Likert scale and closed-ended questions with multiple-choice options. There were two

THE PERCEIVED USEFULNESS OF (ENTERPRISE RESOURCE PLANNING) ERP SYSTEM FOR A PRODUCTIVE MANAGEMENT SYSTEM: THE CASE OF A GLOVE MANUFACTURING COMPANY IN SRI LANKA

sections to the questionnaire. A total of

four criteria were measured, including system capability, user guidance, learnability, and perceived ease of use. The descriptive statistics for the key variables within each experimental condition will be computed before testing the hypotheses. Cronbach's Alpha is used to show the data collection's scale reliability. Multiple regression Analysis was used to determine the factors affecting the usefulness of the ERP system. For each

independent variable, the significance level, t-statistic, and coefficient of the analysis will be presented along with the findings.

4 RESULTS AND DISCUSSION

4.1 Reliability Analysis

It was able to determine that the questionnaire developed had measured the variables accurately because the instrumental Cronbach's alpha is greater than its minimum of 0.700 which is presented in table 4.1.

Table 4.1: Reliability Statistics

Total valid cases (N)						98
Model	R	R ²	Adjusted R ²	Std. Error of the Estimate		
1	.630 ^a	.596	.563	0.605		
	Unstandardized B	Coefficients St. Error	Standardized Coefficients Beta	t	Sig.	
End user Satisfaction	0.108	0.050	0.178	2.14	0.035	
System Capability	0.608	0.110	0.520	5.55	0.000	
Perceived Ease of use	0.080	0.132	0.055	0.60	0.027	
User Guidance	0.121	0.141	0.089	0.85	0.016	
Learnability	0.220	0.133	0.176	1.65	0.000	
% of N						100%
Cronbach's Alpha Reliability statistics						0.813

4.2 Descriptive statistics

Descriptive statistics describing the sample means and standard deviations of the variables are depicted in table 4.2.

4.3 Multiple Regression Analysis

To determine which factors significantly contributed to predicting end-user satisfaction with ERP systems, a multiple regression analysis was used.

Regression analysis made use of the principal components identified by principal component analysis. The component scores for each end-user were computed when these components were made public. Table 4.3 presents the findings of the analysis, including the coefficient, t-statistic, and degree of significance for each independent variable.

Table 4.2: Descriptive Statistics

Model		Sum of Squares	Degrees of Freedom	Mean Square	F	Sig.
1	Regression	22.117	5	4.423	12.07	.000 ^b
	Residual	33.690	92	.366		
	Total	55.807	97			
a. Dependent Variable: Perceived usefulness						
b. Predictors: (Constant), Learnability, End-user satisfaction, Perceived Ease of use, Capability, User Guidance						

Table 4.3.1: Model Summary

N=98	Min	Max	Mean	Standard Deviation
End-user Satisfaction	1	5	2.20	1.251
System Capability	1.6	4.4	2.947	0.6483
Perceived Ease of use	1.2	3.8	2.186	0.519
User Guidance	1.6	4.6	3.465	0.554
Learnability	2.0	4.8	3.053	0.607
Perceived usefulness	1.5	5	3.204	0.758

4.3.1 Model Summary

From Table 4.3.1, the value is 0.630. R-square shows the total variation for the dependent variable that could be explained by the independent variables. A value greater than 0.5 shows that the model is effective enough to determine the relationship.

4.3.2 ANOVA results

ANOVA results generated along with the regression analysis are shown in Table 4.3.2. ANOVA results indicate the statistical significance of the regression model. Since $p < 0.05$, it is apparent that the regression model predicts the

THE PERCEIVED USEFULNESS OF (ENTERPRISE RESOURCE PLANNING) ERP SYSTEM FOR A
PRODUCTIVE MANAGEMENT SYSTEM: THE CASE OF A GLOVE MANUFACTURING
COMPANY IN SRI LANKA

dependent variable (i.e. Perceived Usefulness) significantly accepted.

Table 4.5: Hypothesis Testing

Hypothesis	Significance	Hypothesis Test
H1: There is a significant relationship between Perceived ease of use and Perceived usefulness.	0.027	Accepted
H2: There is a significant relationship between System Capability and Perceived usefulness.	0.000	Accepted
H3: There is a significant relationship between User guidance and Perceived usefulness.	0.016	Accepted
H4: There is a significant relationship between Learnability and Perceived usefulness.	0.000	Accepted
H5: There is a significant relationship between End-user satisfaction and Perceived Usefulness.	0.035	Accepted

4.4 Hypothesis testing

This research examined the influence of user characteristics: Perceived ease of use, Learnability, System capability, User guidance and End-user satisfaction on the perceived usefulness of enterprise resource planning (ERP) systems. For testing the hypothesis multiple regression analysis information was used and its results are shown in table 4.5 as follows.

According to the analyses, the variables Perceived ease of use, Learnability, System capability, User guidance and End-user satisfaction show a significant relationship with the dependent variable perceived usefulness and all such relationships are significant. When testing the significance for the Independent variables, Perceived ease of use, Learnability, System capability, User guidance and End-user satisfaction on perceived usefulness. According to the results, all the hypotheses were accepted from the regression results.

5 CONCLUSION

To evaluate the perceived usefulness of an ERP system, the research proposed

five hypotheses (H1, H2, H3, H4, and H5), and every one of them was accepted. According to multiple regression coefficients analysis, Perceived ease of use, Learnability, System capability, User guidance and End user satisfaction have a positive and significant effect on perceived usefulness of the ERP system. Therefore, it appears that the end users are more concerned with the functionality of the ERP system and its features that make it easier to use.

5.1 Further study

Proper addressing of the additional areas in further studies such as system flexibility, Compatibility and minimal memory load can be expected to lead to more effective use of the ERP systems at ABC Company which would in turn lead to positive performance implications for the other companies. To improve the generalization of their findings, future researchers might concentrate on conducting a comprehensive study inside the Sri Lankan context. The majority of the constructs employed in this research were system specific. However, there may be other factors, such as human behaviour, the environment, culture, etc.,

that could impact how useful ERP systems ultimately are. Future researchers can therefore concentrate on including similar constructs in their studies.

Szajna, B., & Scamell, R. W. (1993). The effects of information system expectations on their performance and perceptions. *MIS Quarterly*, 17, 493–516. doi:10.2307/249589

REFERENCES

- Al-Khaldi, M. A., & Wallace, R. S. O. (1999). The influence of attitudes on personal computer utilization among knowledge workers: the case of Saudi Arabia. *Information & Management*, 31, 185–204. Retrieved from <http://directory.umm.ac.id/Data%20Elmu/jurnal/I/Information%20and%20Management/1834.pdf>
- Al-Mashari, M., Al-Mudimigh, A., & Zairi, M. (2003). Enterprise Resource Planning: a taxonomy of critical factors. *European Journal of Operational Research*, 146, 352–364. doi:10.1016/S0377-2217(02)00554-4
- Delone, W., & McLean, E. (1992). Information Systems Success: The Quest for the Dependent Variable. *Information Systems Research*, 3, 60–95. doi:10.1287/isre.3.1.60
- Gallagher, C. A. (1974). Perceptions of the Value of a Management Information System. *The Academy of Management Journal*, 17(1), 46–55. doi:10.2307/254770
- Gupta, A. (2000). Enterprise resource planning: the emerging organizational value systems. *Industrial Management & Data Systems*, 100(3), pp. 114–18. doi:10.1108/02635570010286131
- Larcker, D. and V. Lessig. (1980) Perceived Usefulness of Information: A Psychometric Evaluation. *Decision Sciences*, 11:1, pp. 121–134.
- Seddon, P.B. (1994). A Respecification and Extension of the DeLone and McLean Model of IS Success. *Information systems Research*, 8:3, pp. 240–253. Retrieved from <http://eli.johogo.com/Class/p22.pdf>



THE Simulation on the Personal Detail Collecting for License Issuing Performance of the Department of Motor Traffic – Kurunegala: A Case Study

Jayarathna HADN¹, Hearth HMRL², Hewapathirana SS³, Madushani GW⁴, Mithrasena PGPR⁵, Dunusinghe HV⁶, Dilanthi MGS⁷

Department of Industrial Management, Wayamba University of Sri Lanka

devinilmi93@gmail.com¹

shanika@wyb.ac.lk²

ABSTRACT

The Sri Lankan Government Authorities offer a wide range of services to the public. In addition to many other Authorities, the Department of Motor Traffic issues the official document, the Driving License, which allows anyone over the age of 18 to drive different kinds of motor vehicles on roads. Several issues with license applications have resulted in clients having to wait for their applications to be processed. From the available literature, it is very rare to find studies that were carried out in the Sri Lankan context to examine the performance of queuing system of the Motor Traffic Department. Hence, this study focuses on analyzing the queuing system of the Motor Traffic Department Kurunegala Branch. 265 data were collected using direct observation and then analyzed and modeled using Rockwell Arena software version 14.5. Improvements to the current procedure were analyzed and each of the setups was simulated to obtain the performance measurements. Accordingly, the study recommended adding another counter might help in increasing the efficiency of the whole process.

KEYWORDS: Driver's License, Multi Server Queuing Theory, Arena Simulation

1 INTRODUCTION

The country's total vehicle population has more than doubled in the last eight years according to the Department of Motor Traffic statistics. A driving license is an administrative right of movement that allows one to drive one or more vehicles, such as cars, motorcycles, mopeds, trucks, or buses, on public roads in a specific geographical area, typically a country (Bitjoka, Bilong, & Edoa, 2020). In most countries, possessing a driving license that was created, altered, or completed illegally is considered a criminal offense. The Department of Motor Traffic in Sri Lanka is in charge of issuing driving licenses and police officers randomly check driving licenses and take action

against drivers who have fake driving licenses (Samarasinghe et al., 2017).

The main functions of the department of Motor Traffics include new registration of motor vehicles, registration of transferring of vehicles and issuance of driving licenses and also technical service in respect of motor vehicles, activities on road safety, and regulating of gas emissions.

Personal Detail Collecting counters are the bottleneck of the driving license issuing process. To get service, customers have to wait a long time and it is required to identify the behavior of such systems and provide solutions to minimize the problems. Simulation is the frequently used modeling technique to solve queuing-related problems (Rahman & Sabuj, 2015). An accurate simulation

model provides the spatial benefit of process flow improvement. However, it is extremely rare to find studies conducted in the Sri Lankan context to examine the performance of the Motor Traffic Department's queuing system in the available literature. The objective of the present study has been addressed to fill this literature gap. In this study, the Arena simulation application is used to analyze data and suggest the best possible options to reduce waiting time in queues.

2 LITERATURE REVIEW

Transportation is a necessity in today's world. Private vehicle use has increased rapidly in recent decades, with cars and motorcycles accounting for approximately 80% of these vehicles (Steg, 2003). The demand for driver's licenses has increased in tandem with the increase in the number of cars and roads being built. Yandug & Santos (2020) found that with the numerous land transportation offices, few issue new driver's licenses and thus must serve many applicants who expend a great deal of time and effort to complete the application process, which normally takes more than four hours.

Several issues with license applications are linked to the customer's waiting experience. These experiences are for new applications as well as extensions of existing license applications. Customers complained about the lengthy procedure, long waiting for lines, and the difficulty of moving from one counter to another to apply for a license. The length of waiting time has resulted from the emergence of long waiting lines to review the applicant's driver's license. The issue is

exacerbated by the applicant having to go through a complicated channel, as well as the imbalance between the number of applicants and the number of available employees (Vitasari, Sari, & Sinnadurai, 2017). Meanwhile, poor waiting time management can be very costly and harmful to the organization (Ayodeji & Rjoub, 2021).

3 METHODOLOGY

3.1 Data Collection

Inter-arrival times and service times necessary for the investigation were gathered on two days 7th and 11th of February 2022 by direct observation. People who visited to complete the documentation part of their personal detail collecting at Kurunegala Motor Traffic Department were the population of the study. The sample of primary data appended 265 arrivals to the system.

3.2 Data Analysis

The data were used in the calculation of the inter arrivals times and delay type. For that, the data was taken into the Input Analyzer of Rockwell Arena version 14.5 to find the most fitted statistical distributions.

3.3 Model Development

The model can be identified as an (M/M/3) :(FIFO/ ∞ / ∞). The assumptions to model the existing and proposed models were; customers randomly arrive for the counters, customers were served in First in First served method (FIFO) and the service is continuous, a customer only takes the service once on that day, customer arrival is independent, and one customer joins to the queue without any accompaniment.

4 RESULTS AND DISCUSSION

Inter-arrival times and service times were fed to the input analyzer and distribution patterns were identified as follows (Table 1).

Table 1: Probability Distributions

Data	Probability Distribution
Inter arrival Time	EXPO (2)
Service Time :	
Counter 1	NORM (1.41, 1.21)
Counter 2	NORM (1.73, 1.32)
Counter 3	NORM (1.32,1.15)

The existing system was developed using Rockwell Arena version 14.5 (Figure 1). There were three counters for customers to hand over their personal details. Each of those counters has been occupied by one officer. Thus, resources were distributed as one per counter.

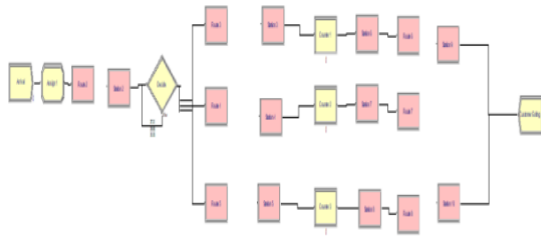


Figure 1: Arena Model for the Existing System

The animated Arena Model for the existing system is as follows (Figure 2)

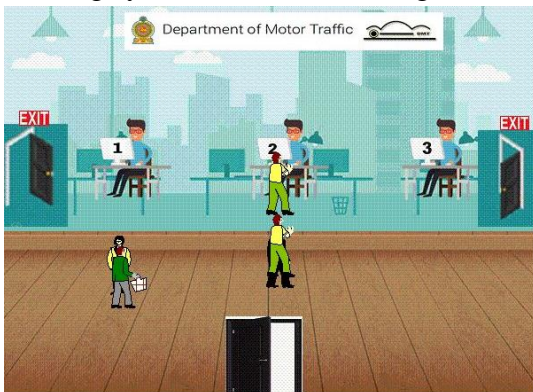


Figure 2: Animated Arena Model for the Existing System

4.1 Proposed Models

4.1.1 Proposed Model 1 Changing the Building Layout

This system can reduce waiting lines and process time by having a less complicated layout in the building. For that, it requires a complete change in the building and it is costly. It might not be a feasible solution.

4.1.2 Proposed Model 2 Adding an Additional Resource person to the counter

A single counter follows a simultaneous process. Adding an additional resource person to a counter would make the process fast.

4.1.3 Proposed Model 3 – Adding an Additional Counter

As the waiting time is high at every counter, adding another counter might help in increasing the efficiency of the whole process.

4.1.4 Comparison of the Existing and Proposed Models

After adding a new counter, it was completely visible that the waiting time has reduced according to Table 2. Even though proposed system 1 and proposed system 2 were suggested, those two systems weren't feasible. Since both approaches are not feasible to implement with financial and operational views, the selected system 3 can be implemented with any of those options.

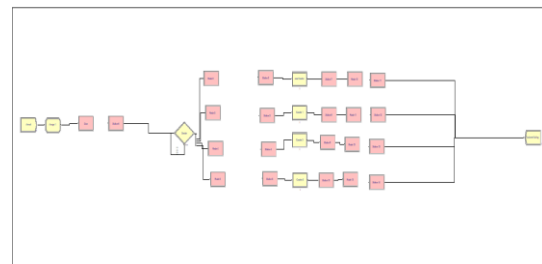


Figure 3: Proposed Model for the System

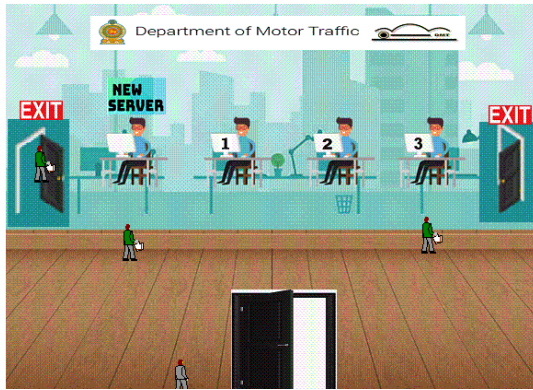


Figure 4: Proposed Animated Model for the System

5 CONCLUSION & RECOMMENDATION

The study assessed the existing queuing system for the Department of Motor Traffics in Kurunegala and identified that the customers had to wait for a long time in front of the counters to get the service done. Data gathered from the Department of Motor Traffics in Kurunegala was simulated by using the Arena Simulation application to identify the existing situation of the place. According to the results, the system has an infective way of serving the queue. There were three counters to serve the customers and as they were only served once per day, some customers must come in another day to submit the corrected files if their file was identified as incomplete file. Moreover, they must wait in the same queue the other day with the people who are there to check their files for the first time and that is a huge waste of time. Therefore, it is good to allocate one another counter to serve the customers who have corrected their personal files. It will reduce the length of the queue. The study recommended adding another counter as the optimal solution for the Department of Motor Traffics in Kurunegala as it is the most

cost-effective and short-term solution that can reduce the waiting line and increase the efficiency of the service.

REFERENCES

- Ayodeji, Y., & Rjoub, H. (2021). Investigation into waiting time, self-service technology, and customer loyalty: The mediating role of waiting time in satisfaction. *Human Factors and Ergonomics in Manufacturing & Service Industries*, 31(1), 27-41. doi:10.1002/hfm.20867
- Bitjoka, G. B., Bilong, P., & Edoa, M. M. N. (2020). Implementation of the blockchain in the optimization of the security of transport documents (driver's license and vehicle registration cards). *American Journal of Computer Science and Technology*, 3(3), 57-67. doi: 10.11648/j.ajcst.20200303.13
- Rahman, C., & Sabuj, S. U. (2015). Process flow improvement proposal of a batch manufacturing system using arena simulation modeling. *Review of General Management*, 21(1), 63-77. Retrieved from http://www.managementgeneral.ro/pdf/1_2015_6.pdf
- Samarasinghe, P., Lakmal, L. K. P., Weilkala, A. V., Wickramarachchi, W. A. N. P. C., & Niroshana, E. R. S. (2017, December). Sri lanka driving license forgery detection. *2017 Fourth International Conference on Image Information Processing (ICIIP)*, 1-6. doi:10.1109/ICIIP.2017.8313795
- Steg, L. (2003). Can Public Transport Compete With The Private Car? *IATSS Research*, 27(2), 27-35. doi:10.1016/S0386-1112(14)60141-2
- Vitasari, P., Sari, S. A., & Sinnadurai, S. K. (2017). Consumer Behavior in The Waiting Process for License Services. *Ijem (International Journal of Engineering and Management)*, 1(1), 9-14. Retrieved from

<https://ejournal.itn.ac.id/index.php/ijem/article/view/86/86>

Yandug, J. S. G., & Santos, C. A. S. (2020). Simulation Driven Appointment System Model for a License Processing Office in the Philippines. *Proceedings of the International Conference on Industrial Engineering and Operations Management*, pp 2010-2019. Retrieved from <http://www.ieomsociety.org/ieom2020/papers/489.pdf>



Work-Activity (WA) Study to Perform Manual Work by People with Physical Disabilities

Abeykoon KMW¹, Punchihewa HKG², Nanayakkara LDJF³

Division of Textile and Clothing Technology, Institute of Technology, University of Moratuwa
kokilaw@itum.mrt.ac.lk¹

Department of Mechanical Engineering, Faculty of Engineering, University of Moratuwa
himan@uom.lk²

Faculty of Engineering and Faculty of Business, University of Moratuwa
Julian.nanayakkara@gmail.com³

ABSTRACT

People with Physical Disabilities (PPDs) are willing to work if they are provided with suitable jobs that they can perform with their residual physical capabilities. Through an interview procedure, PPDs may not be able to explain typical manual Work-Activities (WAs) that can be performed in industries so the employers find difficult understanding the physical capabilities of PPDs thus reducing the employment opportunities for PPDs. This research focuses to identify manual WAs available in the industry in standard terms of use at work that can be performed by PPDs. It is evident that performance-related standard data have been extensively used for skilled workers or people without disabilities, however these have not yet been modified to accommodate PPDs. The research aimed to identify typical manual WAs in the industry that are physically capable to perform WAs to help employ PPDs. The objectives were to identify typical manual WAs in the industry that PPDs need to be performed, then categorize the WAs and finally refine and review the categorization. Industrial Engineers (n=3) participated in the study and one acted as the moderator. Data available in Method Time Measurement (MTM) which is a representative of Pre-determined Time Studies (PMTS) were studied. In future work, this categorization will be used to map with residual physical capabilities of PPDs and create a framework to help employ PPDs.

KEYWORDS: Work-Activity, people with physical disabilities, employment, industry.

1. INTRODUCTION

Employers expect employees to add value to their organizations, and employers will recruit People with Physical Disabilities (PPDs), only if their ability to perform specific work tasks is certain (de Guimarães, 2015; Guimarães et al., 2015; Abeykoon et al., 2019). Researchers suggest future engineers accommodate persons with the most common disability conditions in specified work (Armstrong & Kochhar, 1982). To perform manual work in the industry by PPDs, different typical manual work-activities (WAs) are used. It is revealed that PPDs require more time to perform simple assembly and

disassembly tasks than people with no disabilities (Subramanian & Mital, 2009). The reason they have identified is the restricted or controlled movements of the body regions such as arms, hands, and fingers of PPDs that inhibit the ability to freely move, manipulate objects and interact with the physical world (Laabidi et al., 2014; Hanková & Vávrová, 2016).

Therefore, it is essential to identify the typical manual WAs prevalent in the industry to enhance the employability of PPDs and thereby empower them to lead independent life. Literature on work-study elaborates on the principles of work and work norms for the normal

population. In this respect, a few repetitive basic motions have been identified that are necessary to perform manual WAs (Barnes, 1968). They are analyzed as psychomotor performance at work and identify them in terms of elemental motions (e.g. reach, grasp, move and position) or elements that constitute the Pre-determined Motion Time Systems (PMTS) (Salvendy & Knight, 1982). However, references on applications of these basic motions concerning for PPDs are limited in the literature.

Time measurements can be made utilizing either direct or indirect methods. Direct time measurement systems, for example, time studies, are used to determine the processing times in the industry. Instead, a standard data array in PMTS makes it possible to determine the processing times with greater consistency than the direct measurement systems (Currie & Faraday, 1978; Brisley & Eady, 1982; Juul-Kristensen et al, 1997). For example, manual WAs are described in some of the PMTS representatives in the literature. MTM (Mundel, 1978; Subramanian & Mital, 2009), Work Factor (Mundel, 1978; Currie & Faraday, 1978), and Method Time Analysis (MTA) (Mundel, 1978; Currie & Faraday, 1978) are three available such methods. Thus, PMTS represents an interesting proposition to determine the typical WAs carried out in the industry.

PPDs may be able to perform at least a portion of the manual WAs explained in PMTS as normal people with their limited functional capabilities. If such manual WAs can be identified, it could enable the PPDs to be employed to perform specific tasks.

1.1 Aim and objectives

The aim of the study was to identify typical manual WAs in the industry that are physically capable to perform WAs to help employ PPDs. The objectives were,

1. to identify typical manual work-activities in the industry in that PPDs need to be performed.
2. to categorize the work-activities.
3. to refine and review the categorization.

2. METHODOLOGY

A sample of participants who were experts in industrial engineering was recruited using a stratified sampling technique (Sekaran, 2007; Saunders et al., 2009). Later, the other participants of the study were selected using a snowballing approach for sampling (Saunders et al., 2009; Etiken et al, 2016). Informed consent was obtained from all participants to take part in the study. To collect demographic data from experts, a structured format was used.

Study design

Demographic information of the participants, i.e. designation and the speciality, types and locations of the workplaces, qualifications, types and countries of training, professional memberships, experience in the position in years and the previous posts held were recorded. If the participants of the study were willing to receive a copy of the final document, their name, contact telephone number and e-mail address were requested.

2.1 Initial draft document

Currently practiced and easily accessible PMTS representatives in industries were studied and manual WAs were extracted from the work unit

analysis reported in the literature. In MTM 1 and MTM 2 representatives, WAs to perform ‘movement’ in possible different work planes using the upper extremity were selected. Since hand activities were not readily recognized in MTM 1 and MTM 2 representatives, further literature was surveyed, and depending on the complexity of the hand activities, ‘get’ activities were extracted. These were termed manual WAs. WAs that can be performed using lower extremities were also selected similarly.

Initial document

The ‘initial draft document’ that consisted of the WAs selected from the PMTS representatives was presented to the moderator of the study and was asked to review before being presented to the rest of the experts. The resulting document was named the ‘initial document’.

2.2 Working document

The PMTS representatives in the ‘initial document’ were analyzed and added, and deleted and the information was amended by all expert participants one after another based on different criteria such as useful WAs (mostly) and complexity for both in upper and lower extremities. This was considered the ‘working document’. Every time the working document was refined by an expert, it was reviewed by the moderator, and this process went on for several rounds as indicated in Figure 1.

When there were no new suggestions (i.e when the point of saturation was reached), the moderator terminated the process and the document was finalized. This was named the ‘final document’.

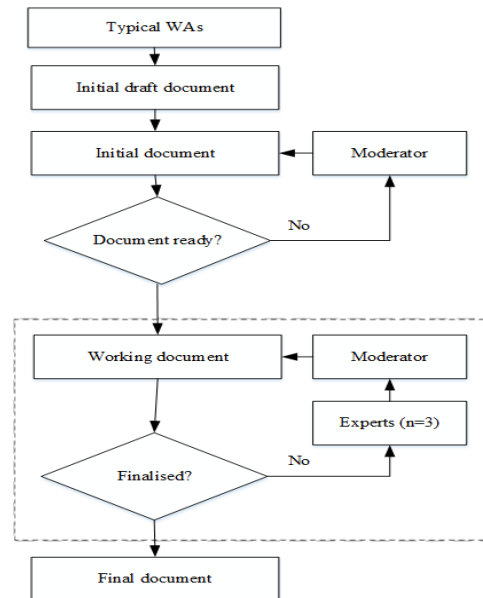


Figure 1: Study protocol for expert review survey

3. RESULTS

Three experts participated in the study. One of them acted as the moderator. Out of the three experts, two had doctoral-level qualifications while the other had a master-level research degree. Two of the participants had foreign qualifications and speciality in the fields of industrial engineering, while the other participant had work experience in an industrial engineering division in a manufacturing organization. All the participants had more than twelve years of experience in the areas of mechanical and industrial engineering.

Altogether, 50 iterations of review and refine cycles took place in the study and all the participants spent about 90-120 minutes for each session conducted for document reviews.

3.1 Descriptions of WAs

- Reach: Hand position in maximum & minimum work area
- Move: Transport an object to maximum & minimum work
- Turn: Turn the hand either empty or loaded

Apply pressure: Re-grasp or squeeze
Position: Align, orient, & engage an object with another object
Release: Relinquish control of an object
Disengage: Break the contact between one object & another
Crank: Move an object in a circular path with the hand.
Re-grasp: Change the grasp of an object
Crank (for stirring): Move an object in a circular path with the fingers.

The 'reach' and 'move' WAs are in both horizontal and vertical planes.

The 'grasp' activity was further subdivided into four classes based on the complexity of work and precision requirement of hand motion as 'no grip', 'power grip', 'power & precision grip' and 'precision grip' (Pheasant, 1986).

3.2 Descriptions of 'grip' WAs

No grip: Hand forms percussive or sustained
Power grip: Keep the object in contact & clamp it
Power & precision grip: Provide power grip & precise manipulation
Precision grip: Obtain precise control in gripping

Typical manual WAs of lower extremity explained in MTM 1 is 'step' and in MTM 2 is 'foot motion'. 'Step walking' and 'step (climbing)' were added and it was decided to use 'Pedalling' for clarity of use.

4. DISCUSSION

This study was used to identify a set of manual Work-Activities (WAs) prevalent in the industry to help select people with physical disabilities (PPDs) to carry out such activities with their residual capabilities. This section mainly discusses the justification for the use of literature to find WAs, its generalisability and the methodological limitations that

would affect the generalizability of the findings.

The reason why the MTM system became the most widespread is probably since it was made publicly available with no economical or judicial claims on behalf of the inventor (Laring et al., 2002). These factors were considered by the experts when choosing and accepting the PMTS representatives.

MTM is identified as the most common PMTS in the world and exhibits an internationally valid performance standard for manual tasks, thus establishing a worldwide uniform standard of planning and performance for a global business (Kuhlang, Edtmayr & Sihm, 2011).

Hands are identified as important instruments of daily life, and their work varies from very fine motor skills, such as writing to very gross motor tasks such as digging (Heus, Daanen & Havenith, 1995). Thus, literature was studied to select suitable hand activities since the classifications were not readily available in the literature. Several classifications of grasping activities/motions are explained as, 'no grasping motion required', 'grasping involving the closing of the hand or fingers with one motion', and 'complex grasping motion'. However, the action requires the muscles of the hand or arm to take up the weight of an object (Armstrong & Kochhar, 1982).

Currently, the MTM system and its modern versions are in extensive use in many different industries for calculating production times for line balancing, line pace setting, and in the calculation of business tenders (Laring et al., 2002). As an example, the General Sewing Data (GSD) System is widely used in the apparel sector which has been directly

derived from using the MTM family (Soltani, Abbas and Awang, 2012). This also justifies the use of MTM to identify the typical WAs prevalent in the industry.

PMTS is a technique used to design not only the motions but also the timing for a job.

References

- Abeykoon, K., Nanayakkara, J., & Punchihewa, H. (2019). Work-Activities and compatible ranges of movement to assess the capability of people with physical disabilities to enhance employability. *2019 Moratuwa Engineering Research Conference (MERCCon), IEEE*, pp. 441-446. doi:10.1109/MERCCon.2019.8818938
- Armstrong and Kochhar Dev S., (1982). *Work performance and handicapped persons. Industrial Engineering Handbook*, G. Salvendy, Wiley International Publication, 1 18.
- Barnes R. M., (1968). *Motion and Time Study Design and Measurement of Work*. (6th ed.). Wiley, New York.
- Brisley C. L. and Eady K. (1982). *Predetermined Motion Time systems, Handbook of Industrial Engineering*, G. Salvendy, Ed. 4.5.1 to 4.5.31.
- Currie R. M. and Faraday J. E. (1978). *Work Study*, (4th ed.). Pitman, London.
- de Guimarães B. M. (2015). Ergonomics and workplace adaptation to people with disabilities. *Work (Reading, Mass.)*, 50(4), pp 607–609. doi:10.3233/WOR-152013
- Etikan, I., Alkassim, R. and Abubakar, S. (2016). Comparison of Snowball Sampling and Sequential Sampling Technique. *Biometrics and Biostatistics International Journal*, 3, 6-7. doi:10.15406/bbij.2016.03.00055
- Guimarães B., Bezerra L., Barkokébas, M. and Junior B. B. (2015). Workplace adaptation of people with disabilities in the construction industry', *Procedia Manufacturing*, 3, 1832 1837. Retrieved from https://www.researchgate.net/publication/n/283264557_Workplace_adaptation_of_people_with_disabilities_in_the_construction_industry
- Hanková, M., & Vávrová, S. (2016). Emotional and Social Needs of Integrated Disabled Students in Secondary School Environment. *Procedia - Social and Behavioral Sciences*, 217, 229 238. doi:10.1016/j.sbspro.2016.02.073
- Heus, R., Daanen, H. A. M., & Havenith, G. (1995). Physiological criteria for functioning of hands in the cold: A review. *Applied Ergonomics*, 26(1), 5–13. doi:10.1016/0003-6870(94)00004-I
- Juul-Kristensen, B., Fallentin, N., & Ekdahl, C. (1997). Criteria for classification of posture in repetitive work by observation methods: A review. *International Journal of Industrial Ergonomics*, 19(5), 397–411. doi:10.1016/S0169-8141(96)00013-3
- Kuhlang, P., Edtmayr, T., & Sihn, W. (2011). Methodical approach to increase productivity and reduce lead time in assembly and production-logistic processes. *CIRP Journal of Manufacturing Science and Technology*, 4(1), 24–32. doi:10.1016/j.cirpj.2011.02.001
- Laabidi M., Mohamed J., Ayed L.J.B., Brahim H.B. and Jemma A.B. (2014). Learning technologies for people with disabilities. *Journal of King Saud University - Computer and Information Sciences*, 26(1), 29–45. doi:10.1016/j.jksuci.2013.10.005
- Laring, J., Forsman, M., Kadefors, R., & Örtengren, R. (2002). MTM-based ergonomic workload analysis. *International Journal of Industrial Ergonomics*, 30(3), 135–148. doi:10.1016/S0169-8141(02)00091-4

- Pheasant S. (1986). *Bodyspace, Anthropometry, Ergonomics & Design. British Library Cataloguing.* (2nd ed.). Taylor & Francis, Philadelphia, London.
- Salvendy G. and Knight J. (1982). *Psychomotor Work Capabilities. Handbook of Industrial Engineering, G. Salvendy.* Wiley Interscience Publication, John Wiley & Sons, Inc, New York.
- Saunders M., Lewis P., and Thornhill (2009). *A Research Methods For Business Students*, (5th ed.). Pearson.
- Sekaran U. (2007). *Research Methods for Business.* (4th ed.). Pashupati Printers Limited.
- Soltani S. H. K., Abbas M. Y. and Awang M. B. (2012), 'Disabled Children in Public Playgrounds: A Pilot Study', *Social and Behavioral Science*, 36, 670–676. doi:10.1016/j.sbspro.2012.03.073
- Subramanian A. and Mital A. (2009) Finger disabilities and higher level tasks - developing and validating MTM multipliers, *International Journal of Industrial Engineering*, 16, 4, 344–352. Retrieved from <https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=de0725fa759e236261380d4e027d9a4380bb6ba7>



Analysis of One Day Passport Issuing Service Performance of the Department of Immigration and Emigration Sri Lanka Using the Arena Simulation Model: A Case Study

Jayarathna HADN¹, Yasora KGC², De Silva PKS³, Deshika KT⁴, Wijesiriwardana D⁵, Dilanthi MGS⁶

Department of Industrial Management, Faculty of Applied Sciences,

Wayamba University of Sri Lanka^{1,2,3,4,5,6}

devinilmi93@gmail.com¹

ABSTRACT

Queuing is a common issue that Sri Lankans particularly encounter when seeking services from the Sri Lankan government sector. The Department of Immigration and Emigration Sri Lanka (DIESL) is one of the government sectors experiencing this issue, mainly when people apply for or renew a passport. Furthermore, causing the economic crisis, Sri Lankans seek passports for a better life, and the demand for passports has increased dramatically in recent times, resulting in customers having to wait in a long queue before getting services. Long queues appear because alternatives are not available for the customers to go to the private sector to get the same service. Making a passport includes a series of functions such as document submission, document processing, identity processing, payment process, and collecting process. The aim was to observe the average time customers wait for the service and suggest alternatives. Primary data were collected from 6 issuing counters using the observation technique, and 120 pieces of data were collected from each counter. SPSS version 21 is used to remove outliers from the data set. The simulation was performed for multiple queuing systems with six servers using Rockwell Arena version 14.5. The study revealed that the percentage of customers served by the existing system was 80.52% and suggested better alternatives. They were adding another issuing counter to the system and managing the waiting area to properly reach to counter and exit from the system to increase the customer served percentage. Adding a counter resulted in 92.36 %, and managing the waiting area resulted in 92.50% of customers served. Furthermore, the study recommended managing the waiting area to properly reach to counter and exit from the system by assessing financial feasibility.

KEYWORDS: Arena, Simulation, Passport Issuing, Waiting Time, FIFO

1 INTRODUCTION

A valid passport is required for any Sri Lankan traveling overseas. This is because using a passport allows people to prove their identity when traveling abroad. A person who travels without a valid passport is considered an illegal entrant. The passports are issued by the DIESL in Sri Lanka. The main issue that the DIESL is currently facing is that it has become a very hectic department with an enormous rush of clients due to the increase in clients. As a result, clients

who come to the department for assistance face serious difficulties. Since only a government-owned building has the authority to provide one-day or regular passports and the one-day passport service is faster than the basic passport issuing service, a big queue can be expected in the DIESL of Sri Lanka. Also, the one-day passport issuing service consists of 12 counters even though only six counters are occupied most of the time due to a lack of staff members. Due to high demand and less availability of service facilities, people

have to wait for hours and sometimes spend the whole day just waiting to get the service. Even though many scholars studied queueing systems in different contexts, limited research was done about passport issuing queueing systems. Hence the objective of this research is to analyze the existing structure and performance of the department and give viable solutions to increase the performance of the DIESL.

2 LITERATURE REVIEW

A queue can be defined as a line of people or vehicles waiting for their turn to be served. Long queues can give the customers a wrong idea about the quality of the service. Queues occur because of an imbalance between those served and their services (Hasugian, 2020). The queues occurs in hospitals ,banks on railway counters, industrial and manufacturing processes, call centers,restaurants, and many other services. Long waiting times and queues might cause dissatisfaction among customers because they have to wait for a long time (Lim, Azriani & Nor, 2016). Moreover, customers may get annoyed due to long waiting times (Hasugian, 2020). (Lim et al., 2016) elucidated that the high waiting times and long queues not only affected customers but also wasted the customers' time., Therefore, waiting time is a major issue in the immigration department since the customers need to line on the street for hours to get their passports. Simulations are one of the best techniques for reducing waiting time in any type of system, whether a production system, a servicing system, or even in our everyday lives. According to Akhavian and Behzadan (2014), this

simulation model assists an organization in achieving a high level of service efficiency.

3 METHODOLOGY

The study was conducted for the DIESL, and the time constraints are limited to the observations of the system for two consecutive days. It was done during the one-day passport issuing hours from 12.00 pm to 3.00 pm. This period was the peak hours of the day. The passport issuing service operated six service counters.

3.1 Data Collection

Data on times of arrival and the served times were taken through 120 observations from each counter. The inter-arrival time of the passport applicant to the queue, service starting time, and ending time were recorded to obtain inter-arrivals. Times of the observed data was recorded in seconds.

3.2 Data Analysis

The observed data were used to calculate the inter-arrival times and the service rate of the servers. The difference between two consecutive intervals was taken as the inter-arrival time. SPSS software version 21 and Microsoft Excel were used to analyze the data and remove the outliers. Then the inter-arrivals obtained from the calculations were fed into the Arena Input Analyzer to identify the probability distributions specified in each case. Arena simulation software was used for the model, animation, and generating results regarding the simulation.

3.3 Model Development

The existing system had multiple servers with unlimited capacity. Since

the customer names are announced by the staff members in particular counters, there is no chance to skip the queue. The assumptions were that no applicant leaves the queue without being served, queue capacity is unlimited, customers are served based on FIFO (First In, First Out), and the service time of a customer is random.

4 RESULTS AND DISCUSSION

The input Analyzer gave the following results as summarized in Table 1.

Table 1: Data Distributions

Data	Distribution
Arrival: Counter 1	$49.5 + 19 * \text{BETA} (1.45, 1.11)$
Arrival: Counter 2	$56.5 + \text{WEIB} (10.5, 2.17)$
Arrival: Counter 3	$2 + 133 * \text{BETA} (1.39, 2.56)$
Arrival: Counter 4	$3 + 140 * \text{BETA} (1.31, 2.41)$
Arrival: Counter 5	$20.5 + \text{LOGN} (15.5, 16.7)$
Arrival: Counter 6	$23.5 + \text{WEIB} (19.1, 1.86)$
Service Time: Counter 1	$\text{NORM} (64.6, 4.68)$
Service Time: Counter 2	$62.5 + \text{ERLA} (2.14, 2)$
Service Time: Counter 3	$\text{TRIA} (37.5, 48.6, 66.5)$
Service Time: Counter 4	$36.5 + 36 * \text{BETA} (1.41, 1.64)$
Service Time: Counter 5	$24.5 + \text{WEIB} (16.3, 2.15)$
Service Time: Counter 6	$25.5 + \text{GAMM} (8.13, 1.96)$

The developed model used basic process panels such as Create, Dispose, Process, and Advanced transfer such as station and route with the aim of animating the model. The developed

Arena model for the existing system is depicted in Figure 1, and the animated Arena model for the existing system is shown in Figure 2.

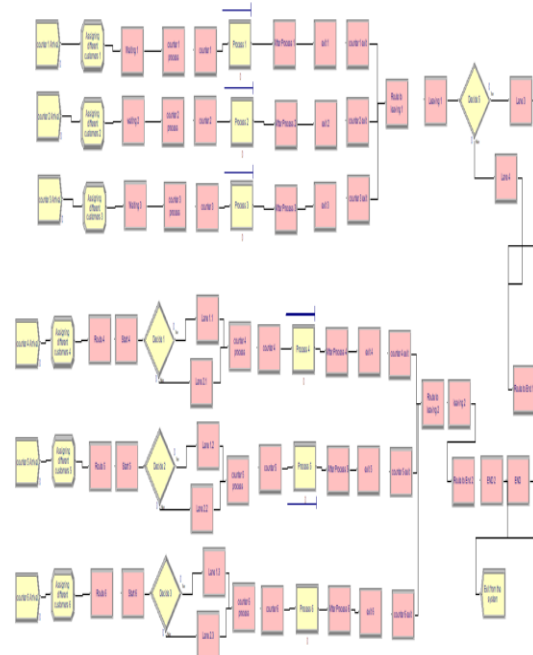


Figure 1: Existing Model Development in Arena



Figure 2: Animated Arena model for the existing system

4.1 Proposed Model

Thus the existing model occurs considerably high waiting times and long queues. This study is aimed to propose new models to overcome the current problems. This study recommended adding a new counter, adding an extra route, making online appointments through the website, and establishing a one-day passport issuing service in

regional offices as the solutions for the proposed system. A feasibility analysis was carried out to identify the optimal solutions, and the results were elucidated. Adding a new counter and adding an extra route are the best solutions that can be implemented as immediate changes to the current system.

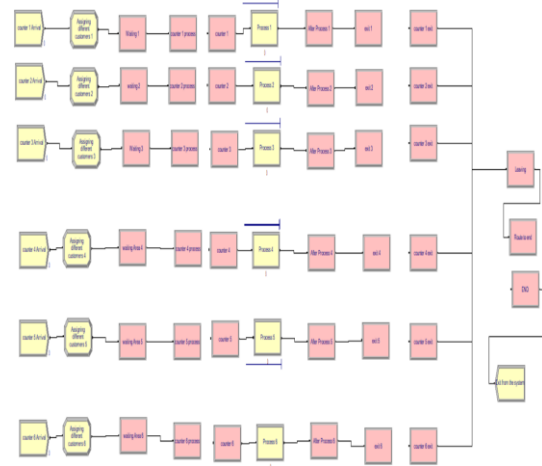


Figure 3: Model with adding extra route development in Arena

Table 2: Comparison of the Existing and Proposed Model (Where M2, M3, M4, M5, M6 and M7 are the six models with the seven counters and M8 is the model with the extra route)

Parameters	Existing model (M1)	Model with adding new counter						Model with adding an extra route (M8)
	(M1)	(M2)	(M3)	(M4)	(M5)	(M6)	(M7)	(M8)
Number in	1804	2024	2011	2056	2060	2213	2154	1788
Number out	1633	1870	1822	1899	1897	1907	1923	1654
Counter 1(Minutes)	9.8389	8.1673	7.8531	7.8138	7.9477	8.9473	7.8350	7.3874
Counter 2(Minutes)	2.4511	2.2193	2.4389	1.3342	1.1191	1.6510	0.9252	1.5532
Counter 3(Minutes)	2.3248	10.0110	10.3587	5.7377	7.0192	11.3400	14.4115	4.8334
Counter 4(Minutes)	12.3569	4.8173	2.0086	2.3979	7.1444	5.3486	1.6982	2.2352
Counter 5(Minutes)	11.0716	5.6638	15.5394	4.1265	9.2200	12.2028	5.1356	8.8916
Counter 6(Minutes)	7.7253	3.1967	2.9890	1.7628	2.5960	4.1745	4.7515	1.6456
Counter 7(Minutes)		0.0132	0.00105166	8.6014	2.5779	31.2067	26.7458	-
Percentage of Customers Served (%)	80.52%	92.39%	90.60%	92.36%	92.08%	86.17%	89.27%	92.50%

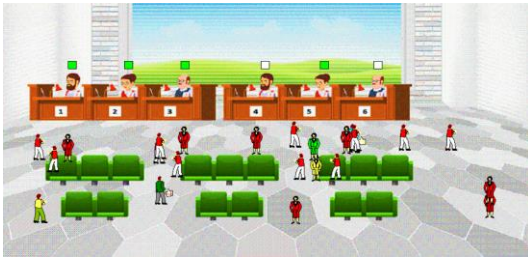


Figure 4: Model with adding extra route demonstration in Arena

5 CONCLUSION AND RECOMMENDATION

The study analyzes and simulates the one-day passport issuing service performance in the Department of Immigration and Emigration in Sri Lanka. The Arena simulation model was used to analyze the existing queuing system's performance. It concluded that the highest number of waiting times and long queues occur in counters 4, 5, and 6.

Thus, four solutions were proposed to reduce the waiting times. Conducted a feasibility study, and adding a new counter and adding a new route were identified as the immediate optimal solutions for the existing system. Results of the proposed models concluded that those are the best-fitted models to implement. Since the long waiting time is a huge problem for the Department of Immigration and Emigration, adding a new route is selected as the feasible and immediate solution for implementation.

The limited available time for the study was a limitation that led to a restricted no of observations. The accuracy can be increased through the

increment of data or the collection of data on different weekdays.

In future research, it is recommended to do more observation of the situation that happens in this system. Therefore, it would be a more accurate determination of the real situations when the percentage of the situation to be happening likely can be predicted or calculated well and at the same time, the best alternative can be raised, which can help to overcome the problems that occur in the system fully. Other than waiting time, future researchers could also consider the utilization rate for each counter and optimize the for each staff. The one-day passport issuing service needs to reduce waiting time, and at the same time, the staff should be fully utilized. In future discussions can also be considered all the costs that are involved to solve the problems that happen in the system.

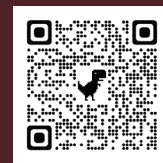
REFERENCES

- Akhavian, R., & Behzadan, A. H. (2014). Evaluation of queuing systems for knowledge-based simulation of construction processes. *Automation in Construction*, 47, 37-49.
- Hasugian, I. A. (2020, May). Simulation of queuing system for customer service improvement: a case study. In *IOP Conference Series: Materials Science and Engineering* (Vol. 851, No. 1, p. 012030). IOP Publishing.
- Lim, J., Azriani, N., & Nor, M. (2016). Simulation by Queuing System at Immigration Department. *International Academic Research Journal of Social Science*, 2(1), 112-119.

“

To become the premier Applied Science Faculty that enriches the Sri Lankan community with graduates of vibrant intellectuality, outstanding professionalism and brilliant personality.

”



@Wayamba University of Sri Lanka



@wayambauniversityofsrilank8752



@WYBofficial



@wayambauniversity

