A STUDY ON SUBSCRIPTION BASED TOLL COLLECTION SCHEME FOR SRI LANKAN EXPRESSWAYS.

Liyana Arachchige Chinthaka Asiri Sandaruwan

Reg. No. 199127B

Degree of Master of Business Administration in Information Technology

Department of Computer Science and Engineering

University of Moratuwa

Sri Lanka

December 2020

A STUDY ON SUBSCRIPTION BASED TOLL COLLECTION SCHEME FOR SRI LANKAN EXPRESSWAYS.

Liyana Arachchige Chinthaka Asiri Sandaruwan

Reg. No. 199127B

The dissertation was submitted to the Department of Computer Science and Engineering of the University of Moratuwa in partial fulfilment of the requirement for the Degree of Master of Business Administration in Information Technology.

Department of Computer Science and Engineering

University of Moratuwa

Sri Lanka

December 2020

DECLARATION

I declare that this is my own work, and this thesis does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

Also, I hereby grant to University of Moratuwa the non-exclusive right to reproduce and distribute my thesis/dissertation, in whole or in part in print, electronic or other medium. I retain the right to use this content in whole or part in future works (such as articles or books).

……

Liyana Arachchige Chinthaka Asiri Sandaruwan 19-06-2021

(Signature of the candidate) Date:

The above candidate has carried out research for the Masters thesis under my supervision.

23-06-2021

…… ……

Professor Chandana Perera Date

Signature of the Supervisor

…… ……

(Co-supervisor Name) Date

Signature of the Co-Supervisor

COPYRIGHT STATEMENT

I hereby grant the University of Moratuwa the right to archive and to make available my thesis or dissertation in whole or part in the University Libraries in all forms of media, subject to the provisions of the current copyright act of Sri Lanka. I retain all proprietary rights, such as patent rights. I also retain the right to use in future works (such as articles or books) all or part of this thesis or dissertation.

19-06-2021

ABSTRACT

People use highways mainly to save time by avoiding traffic jams. When it comes to Sri Lankan expressways, people lose their gained time at the counters due to long queues, especially during peak hours. To overcome this issue, RDA Sri Lanka increased the number of toll plazas, but it did not provide a solution to the issue. Also, the E02 and E03 expressways do not operate at their maximum traffic handling potential. Several studies and best practices by other countries suggest several best practices to maximize the traffic flow on existing expressways, such as congestion pricing and real-time travel management. This study aims to evaluate a system to increase expressway usage while decreasing the queues at the toll plazas. Based on the literature, quantitative research was conducted by using an online questionnaire by using a stratified random sampling technique. The data analysis demonstrated that there is a relationship among the variables and satisfies the TAM model. Therefore, as a solution to the stated issue, a subscription-based toll collection method can be implemented on E02 and E03. Also, the toll pricing should calculate by using the congestion pricing technique.

Keywords: Subscription-Based Expressway Tolls, Congestion Pricing, ANPR Technology, Expressway

ACKNOWLEDGEMENT

I would love to express my heartfelt gratitude to my supervisor, Senior Professor Chandana Perera, Department of Mechanical Engineering, Faculty of Engineering, Sri Lanka Institute of Information Technology, for his continuous support, kind advice, and attention given throughout my research journey as well as in the academics.

Further, I would like to thank Dr. Adeesha Wijayasiri, Dr. Dilum Bandara, and Dr. Kutila Gunasekera for their valuable feedback and support given throughout my research. Furthermore, I would like to express my appreciation to all academic and non-academic staff at the Department of Computer Science and Engineering, University of Moratuwa.

I am most grateful to my loving wife, Ayodya who were always encouraging, supporting, and motivating me throughout my MBA process. Also, I would like to thank my MBA friends who encourage me throughout the academic journey.

Finally, I would love to thank my parents and brother for their support, love, and encouragement given throughout my MBA journey.

TABLE OF CONTENTS

DECLARATION III
COPYRIGHT STATEMENT IV
ABSTRACT V
ACKNOWLEDGEMENT VI
TABLE OF CONTENTS VII
LIST OF FIGURES IX
LIST OF TABLES X
LIST OF ABBREVIATIONS XIII
INTRODUCTION 1
1.1. Background 1
1.2. Motivation 2
1.3. Problem Statement 3
1.4. Research Objectives 3
1.5. Research Scope 4
1.6. Research Significance 4
1.7. Outline 5
LITERATURE REVIEW 6
2.1. Chapter Introduction 6
2.2. Expressways in Sri Lanka 6
2.3. Expressway Toll Collection Methods 9
2.4. RFID Technology 10
2.5. ANPR Technology 11
2.6. Expressway Toll Collection Methods and Congestion Pricing 13
2.7. Subscription Business Model 14
2.8. Proposed System 16
2.9. Technology Acceptance Model 16
2.10. Customer Satisfaction Score (CSAT) 17
RESEARCH METHODOLOGY 18
3.1. Introduction 18
3.2. Conceptual Framework 18
3.3. Hypothesis Development 18
3.4. Latent Variables 20

3.4.1. User concerns regarding the ANPR based congestion pricing system. 20
3.4.2. User concerns regarding the subscription model. 20
3.4.3. Perceived user/driver benefits 21
3.4.4. Perceived ease of use 21
3.4.5. User Type 21
3.4.6. User acceptance of subscription based (proposed) ETC system. 21
3.5. Operationalization Table 21
3.6. Questionnaire Development 23
3.7. Population and Sample Size 23
3.8. Collection of data 24
3.9. Summary 24
DATA ANALYSIS 25
4.1. Introduction 25
4.2. Data Cleansing 25
4.3. Normality of the Data 25
4.4. Reliability and Validity Test 26
4.4.1. Test for Reliability 26
4.4.2. Test for Validity 28
4.5. Descriptive Analysis 35
4.5.1. Expressway User Satisfaction 35
4.5.2. Age 36
4.5.3. Gender 36
4.5.4. Expressway User Type 37
4.5.5. Expressway Usage Time 38
4.5.6. Expressway Usage Frequency 39
4.5.7. Vehicle Type 40
4.5.8. Expressway user monthly income 41
4.6. Descriptive Statistics 41
4.7. Inferential Analysis 44
4.7.1. Correlation Analysis 44
4.7.2. Simple Regression Analysis 46
4.7.3. Multiple Linear Regression to Compute the Model Relationship 59
4.7.4. Hypothesis Testing 60

4.8. Summary of the Findings and Discussion 63
4.9. Summary 65
CONCLUSION AND RECOMMENDATIONS 67
5.1. Introduction 67
5.2. Conclusions and Implications 67
5.3. Recommendations to the Expressway Development Unit at RDA 68
5.4. Limitations and Future Research 68
REFERENCES 70
APPENDIX A: QUESTIONAIRE 73
APPENDIX B: NORMALITY OF THE DATA 79
APPENDIX C: RELIABILITY AND VALIDITY 80
APPENDIX D: DATA ANALYSIS 90

LIST OF FIGURES

Figure 2. 1: RFID reader reads the vehicle equipped with RFID tag 11
Figure 2. 2: How ANPR technology works 12
Figure 2. 3: Source: Original Technology Acceptance Model by Davis, 1985 16

Figure 3.1: Conceptual Framework 18

Figure 4. 1: Age composition 36
Figure 4. 2: Gender distribution 37
Figure 4. 3: User type distribution 38
Figure 4. 4: Usage time distribution 38
Figure 4. 5: Expressway usage distribution 39
Figure 4. 6: Vehicle type used 40
Figure 4. 7: User income distribution 41
Figure 4. 8: Boxplot for variables 43
Figure 4. 9: Scatter plot for PUS by PU with User Type as moderator 59

LIST OF TABLES

Table 2. 1: E02 and E03 Traffic Data (RDA Sri Lanka, 2019) 7
Table 2. 2: E02 and E03 Traffic Data (RDA Sri Lanka, 2019) 8

Table 3. 1: Operationalization Table..... 22
Table 3. 2: Population Forecast (Source: Ministry of Highways & Road Development and Petroleum Resources Development, 2018)..... 23

Table 4. 1: Frequency statistics of the indicator PEUS6..... 26
Table 4. 2: Initial reliability results..... 27
Table 4. 3: Final reliability scores after removing selected items..... 28
Table 4. 4: Total Variance Explained in Customer Satisfaction Indicators (Initial Eigenvalues)..... 28
Table 4. 5: Component Table..... 29
Table 4. 6: New variables for functional values 29
Table 4. 7: Total Variance Explained in Congestion Pricing Acceptability (Initial Eigenvalues)..... 29
Table 4. 8: Rotated Component Metrix for CPA 30
Table 4. 9: Total Variance Explained in Purchase of Subscriptions. (Initial Eigenvalues)..... 30
Table 4. 10: Rotated Component Metrix for PS 30
Table 4. 11: Total variance explained in perceived usefulness of congestion-based toll pricing system. (Initial Eigenvalues) 31
Table 4. 12: Rotated Component Metrix for PS 31
Table 4. 13: Total variance explained in perceived usefulness of subscription-based toll pricing system. (Initial Eigenvalues) 32
Table 4. 14: Rotated Component Metrix for PUS..... 32
Table 4. 15: Total variance explained in perceived ease of use of congestion-based toll pricing system. (Initial Eigenvalues) 33
Table 4. 16: Rotated Component Metrix for PEUP 33

Table 4. 17: New variables for functional values 33
Table 4. 18: Total variance explained in perceived ease of use of subscription-based toll pricing system. (Initial Eigenvalues) 34
Table 4. 19: Rotated Component Metrix for PEUS 34
Table 4. 20: Total variance explained in user acceptance of proposed model. (Initial Eigenvalues) 34
Table 4. 21: Rotated Component Metrix for UA 35
Table 4. 22: Descriptive statistics for variables 42
Table 4. 23: Correlation table 45
Table 4. 24: Model summary for CPA vs PEUP 46
Table 4. 25: ANOVA for CPA and PEUP 46
Table 4. 26: Coefficient table for CPA and PEUP 47
Table 4. 27: Model summary for CPA and PUP 47
Table 4. 28: ANOVA for CPA and PUP 48
Table 4. 29: Coefficient table for CPA and PUP 48
Table 4. 30: Model summary for PS and PEUS 48
Table 4. 31: ANOVA for PS and PEUS 49
Table 4. 32: Coefficient table for PS and PEUS 49
Table 4. 33: Model summary for PS and PUS 50
Table 4. 34: ANOVA for PS and PUS 50
Table 4. 35: Coefficient table for PS and PUS 50
Table 4. 36: Model summary for PEU and PU 51
Table 4. 37: ANOVA for PEU and PU 51
Table 4. 38: Coefficient table for PEU and PU 52
Table 4. 39: Model summary for PEU and UA 52
Table 4. 40: ANOVA for PEU and UA 52
Table 4. 41: Coefficient table for PEU and UA 53
Table 4. 42: Model summary for PU and UA 53
Table 4. 43: ANOVA for PU and UA 54
Table 4. 44: Coefficient table for PU and UA 54
Table 4. 45: Model Summary 55
Table 4. 46: Model description 55

Table 4. 47: Test(s) of highest order unconditional interaction(s) 55
Table 4. 48: Model Summary 56
Table 4. 49: Model description 56
Table 4. 50: Test(s) of highest order unconditional interaction(s) 56
Table 4. 51: Model Summary 57
Table 4. 52: Model description 57
Table 4. 53: Test(s) of highest order unconditional interaction(s) 57
Table 4. 54: Model Summary 58
Table 4. 55: Model description 58
Table 4. 56: Test(s) of highest order unconditional interaction(s) 58
Table 4. 57: Model Summary 59
Table 4. 58: ANOVA Table 60
Table 4. 59: Coefficients Table 60
Table 4. 60: Hypothesis Summary 65

LIST OF ABBREVIATIONS

SE	-	Southern Highway
OCH	-	Outer Circular Highway
CKE	-	Colombo-Katunayake Expressway
MTC	-	Manual Toll Collection
ETC	-	Electronic Toll Collection
RFID	-	Radio-Frequency Identification
MLFF	-	Multi-Lane Free Flow
ORT	-	Open Road Tolling
RDA	-	Road Development Authority
ANPR	-	Automatic number-plate recognition
IC	-	Interchanges
ANN	-	Artificial Neural Network
AI	-	Artificial Intelligence
ADB	-	Asian Development Bank