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

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Sri Lanka

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Department of Computer Science and Engineering

University of Moratuwa

Sri Lanka

December 2020

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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

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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

INTRODUCTION

1.1. Background

A road that consists minimum of two lanes to each direction and separates each directional lane by a median strip to avoid grade crossing, gates to control entries and exits, especially designed curves, and steep grades to provide driving comfort and safety, are considered as expressways. From 1930 to 1932, Germans built a road to match these requirements and it is considered the first expressway in the world. (The Editors of Encyclopaedia Britannica, 2018) Kottawa to Pinnaduwa expressway with 95.3km opened to the public on 27th November 2011 and it was the first expressway built in Sri Lanka. As of November 2020, Sri Lanka has 276.3km long three main connecting Hambantota to Kottawa (E01 - Southern Highway (SE)), Kottawa to Kerawalapitiya (E2 - Outer Circular Highway (OCH)) and Peliyagoda to Katunayake (E03 - Colombo-Katunayake Expressway (CKE)). (Expressway Operation Maintenance And Management Division, 2020)

Expressway users have to pay a toll each time they use the expressway, and the revenue model is implemented mainly to manage the demand, congestion, and generate income for maintenance. (Persad, Walton, & Hussain, 2007) Both Manual Toll Collection (MTC) and Electronic Toll Collection (ETC) methods are practicing in Sri Lanka but the users who use E03 can only use the ETC at the moment. E03 ETC system uses Radio-Frequency Identification (RFID) technology to detect ETC users and to motivate users to use ETC, Road Development Authority (RDA) offers a special 10% discount.

Even though the ETC is implemented on E03, there are queues at the toll counters during peak hours. As a temporary measurement, RDA extended the number of counters, but it doesn't provide a solution to the problem. Also, most regular expressway users like bus and lorry drivers seems rejecting the existing ETC method due to higher one-time cost. As at 2015, 67.8% of the users have aware of the ETC method. (Rodrigo & Edirisinghe, 2015) Other countries like the United States, China, Japan, etc. are managing the traffic with the use of Artificial Intelligence (AI). It is important to manage expressway traffic effectively and it will save the time of

thousands and will directly impact on the reduction of the greenhouse effect. To increase the efficiency of the existing expressway system in Sri Lanka, it is important to have a proper real-time traffic management system with a more user-friendly toll collection system backed by a data-driven traffic analysis system which can provide more user friendly ETC experience.

1.2. Motivation

Sri Lankan expressway map has about 28 interchanges and over 56 counters which are operating with the MTC method. Only 03 interchanges and 06 counters operate with ETC where over 500 employees working daily on a shift basis just to issue tickets and collect tolls in MTC counters, and it is human resource wastage. The current MTC system is unable to maintain a vehicle-based data warehouse. Therefore, the RDA loses more valuable data that can be used for traffic analysis, real-time traffic management, traffic prediction, user-based traffic analysis, etc. for existing and future highway development projects.

Daily driving about 25km, by using E03 from home to the office would take about 75 minutes and the average speed would be 20kmph. It will take additional 15 minutes on average for a normal road. There are queues at the entrance and the exits of E03 and on average, users have to spend 20 minutes in the queues but once enter the expressway, users can drive at the maximum speed because the highway is not using at its maximum potential. Current expressway system does not encourage users to use the expressway during off-peak hours. Instead, it gives 50LKR off between 2200hrs to 0600hrs.

The existing ETC model is also having some issues like drivers have to maintain some distance between vehicles at the gates, only one gate at each entrance and the exit, higher charges for regular users, issues with obtaining and maintaining the ETC card. Developed and developing countries are using more advanced traffic management systems and some countries have replaced the RFID-based ETC system with Automatic number-plate recognition (ANPR) based ETC systems. An advanced,

user-friendly, Information Technology (IT) based system with a business-oriented approach can provide a solution to these issues.

1.3. Problem Statement

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. The MTC counters are expensive to operate as it is a labor-intensive process. While several studies done in Sri Lanka suggest the use of ETC due to its benefits, most users prefer postpaid toll collection due to lack of awareness and a higher one-time cost of ETC (Rodrigo & Edirisinghe, 2015). Also, an analysis by NCHRP in the USA suggests several best practices to maximize the traffic flow on existing expressways, such as congestion pricing and real-time travel management. However, other recommendations like the use of shoulders as lanes and reversible lanes cannot be applied in Sri Lankan expressways due to their construction. Therefore, it is imperative to identify ways to increase the number of highway users while decreasing the waiting time at the entry/exit counters.

What is the level of user acceptance of congestion and subscription-based highway toll collection with ANPR technology in Sri Lanka?

1.4. Research Objectives

The following objectives are set to be achieved from the study.

- To identify potential systems that can be used in Sri Lankan highway performance improvement.
- To evaluate and understand the user acceptance of ANPR based congestion pricing system in E02 and E03.
- To evaluate the user acceptance of subscription-based toll collection method in E02 and E03.
- To provide insights to the relevant authorities based on research findings.

This research plans to explore the potential for introducing ETC technologies and subscription business models based on congestion pricing for the Sri Lankan highways. The proposed model could adopt ANPR technology to reduce congestion, and enable real-time traffic management, encourage users to use highways during off-peak hours, and encourage them to switch to ETC. Therefore, all stakeholders could enjoy benefits such as time and fuel-saving, less congestion, and emission of greenhouse gases.

1.5. Research Scope

The theoretical study will consist of identifying the most suitable ETC method for Sri Lanka. The subscription business model is becoming an attractive business model and it will be a new concept to the expressway management. The benefits of the combination of the business model with ANPR technology will be further analyzed.

This study will focus on the regular expressway users and the users who avoid expressways due to higher charges. The relevant data will be collected with literature and the best practices of other countries. The expressway users age should be between 25 – 60. The private vehicle owners who drive and hire a driver to drive their vehicle, taxi drivers, office transport providers, public transport providers, and delivery drivers consider as the key audience of the study.

1.6. Research Significance

There is a gap in the literature to prove that the existing ETC method is the most suitable and acceptable toll collection option for Sri Lankan expressway users. Also, the subscription-based toll collection method is a newer concept to the world and there is less literature as well as use cases available. The new subscription-based, congestion pricing will encourage users to use the expressways more in off-peak hours and attract more non - expressway users due to its benefits. Also, there is less research done on Artificial Intelligence-based, subscription and congestion pricing control mechanisms in Sri Lanka.

1.7. Outline

The rest of the report has structured as follows: Chapter 02 consists of the literature review by focusing on the research model. Chapter 03 consists of the research method definition based on the Technology Acceptance Model (TAM). The regression method used for Data Analysis in Chapter 04. The research findings, conclusions, and limitations were discussed in Chapter 05.

LITERATURE REVIEW

2.1. Chapter Introduction

Research findings, arguments, and the facts will provide a strong background to the study. 2.2 describes the present situation, issues, and solutions proposed to the expressway system in Sri Lanka. 2.3 describes the presently available toll collection methods and best practices implemented by other countries. 2.4 will go in-depth about the present RFID based ETC method. Also, the section will cover the pros and cons of the existing system. 2.5 discuss the proposed ANPR technology. 2.6 will cover the need for a congestion pricing model. 2.7 discuss the subscription business model. 2.8 theoretically brief about the suggested system. 2.9 covers the theoretical framework to be used. 2.10 describes the way to calculate the user satisfaction of existing toll collection mechanism.

2.2. Expressways in Sri Lanka

OCH and CKE both expressways designed and built with two lanes per each side with a of 2800 vehicles per hour per lane. Even though the records indicate that the per hour vehicle consumption rate of both CKE and OCH are lower, there is congestion in Kadawatha, Kaduwela, Kothalawala, Athurugiriya & Kottawa, Paliyagoda, and Ja-Ela interchanges (ICS). (Figure 2.2.1 and Figure 2.2.2) (Faidutti, n.d.) According to the RDA publication in 2019, toll gates except for Kottawa (morning) and Peliyagoda (evening) exceed the maximum capacity of the toll gate. Also, Kottawa (morning) and Peliyagoda (evening) operating at the near maximum potential. (Figure 2.2.1) Even though RDA Sri Lanka has identified a smaller number of toll gates as their issue, the actual issue is visible with the ETC usage. Peliyagoda exit ETC counter records the highest number of users during the morning peak time, but it only serves 41.2% of its capacity. According to the study done by Rodrigo and Edirisinghe (2015), indicates that 67.8% of users aware of the ETC method in Sri Lanka. Therefore, the existing ETC system has the potential to serve more customers and it will save investments on expanding the number of MTC lanes.

Expressway	IC	Peak time	No. of toll lanes	Given capacity of toll lane vehicles per hour		Actual traffic per hour		Remarks
				ETC	MTC	ETC	MTC	
OCH, E02	Kadawatha	Morning	Entrance -3 Exit - 5	N/A	360 (for entry)	-	528	Entry booth no - 3
		Evening	Entrance - 3 Exit - 6			-	400	Entry booth no - 3
	Kottawa	Morning	Entrance - Exit -	N/A	360 (for entry)	-	337	Entry booth no - 5
		Evening	Entrance - Exit -			-	395	Entry booth no - 5
CKE, E03	Peliyagoda	Morning	Exit 5 (MTC – 4, ETC – 1)	1100	240	453	286	Available number of toll lanes are insufficient
		Evening				150	228	
	Ja-Ela	Morning	Entrance – 2 (MTC 1, ETC 1)	1100	360	253	415	
		Evening	Exit – 2 2 (MTC 1, ETC 1)		240	160	341	

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

Expressway	Critical IC	Peak	Peak Days	Toll Plaza (Entrance/ Exit)	Peak time		Remarks
					From	To	
OCH, E02	Kadawatha	Morning	Monday	Entrance	7.00am	9.30am	N/A
		Evening	Friday	Entrance	4.00pm	9.00pm	
	Kottawa	Morning	Monday	Entrance	7.00am	8.00am	
		Evening	Friday	Entrance	5.00pm	9.30pm	
CKE, E03	Peliyagoda	Morning	Monday	Exit Plaza	7.30am	9.30am	Insufficient Lanes
		Evening	Friday	Exit Plaza	4.30pm	6.00pm	
	Ja-ela	Morning	Monday	D - Entrance Plaza	7.30am	9.30pm	Insufficient Entrance and exit lanes
		Evening	Friday	A - Exit Plaza	4.30pm	7.30pm	

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

2.3. Expressway Toll Collection Methods

Expressway tolls can collect manually or electronically. With the advancement of technology, various MTC & ETC methods have been developed and implemented successfully by most countries.

MTC is easy to set up but costly to operate. In the MTC model, drivers have to stop their vehicles at the entrance (except Peliyagoda) to collect the ticket and again stop at the exit to pay the toll in cash. The average service time of MTC counters in Kottawa, Kahathuduwa, Gelanigama, Dodangoda, Welipenna, Kurundugahahathakma, and Pinnaduwa is 18 seconds. (Kumari et al., 2015)

Germany has successfully implemented a global position system (GPS) based toll collection system for commercial trucks since 2005. Also, Hong Kong, Taiwan, Switzerland, and Singapore have studied and planned the implementation of a GPS technology based ETC system. The onboard unit (OBU) will be given to the users and when the vehicle comes to the charging zone, OBU uses vehicle location coordinates and contact the toll booth wirelessly via GSM module. (Lu et al., 2010)

Multi-Lane Free Flow (MLFF) or Open Road Tolling is also the most desirable tolling mechanism worldwide. The toll will be calculated by using gantries instead of toll plazas. (*Genvict - Free Flow Tolling, Single-Lane/Multi-Lane Free Flow Tolling System, SLFF, MLFF*, n.d.) The MLFF system is advanced compared to the existing RFID-based toll system implemented in CKE. The vehicle will be identified by using an RFID tag and/ or ANPR technology. MLFF enables dynamic pricing, and it also can manage the maximum per hour lane traffic of 2200 vehicles. (*Multi-Lane Free-Flow Tolling System (MLFF) - Aleatica Labs.*, n.d.) MLFF can consider as the automation of the existing system, but it will not attract more users due to higher charges.

Several studies have developed some ETC models based on QR and Barcode technology. According to Suryawanshi et al. (2017), the vehicle owner should register the vehicle by downloading the application. Then the user can select either pre-paid or post-paid option and top-up the account. Then the user will get a QR code, and it should mount on the windscreen. A high-quality camera fixed at the toll gate will

capture the QR code each time the user uses the expressway and process with the toll fee collection. Also, a similar method was proposed by Manoj et al., (2018) with a barcode attached to vehicle insurance paper. The user must top up the insurance balance and each time the user exits from the expressway, the unique number will read, and the toll will be deducted from the insurance balance accordingly. By using the digital image procession technique, the barcode attached to the windscreen can be scanned and processed with the toll collection. (Hari Charan et al., 2019) These proposed methods are easy and cost-efficient to implement but they have security and durability issues. Even though they provide a temporary solution to the toll gate congestion problem, when considering the long run, a better AI-based system will add more benefits in handling congestions at toll gates.

2.4. RFID Technology

RFID is a contactless technology that uses radio frequency signals and space coupling to identify objects. Active RFID tags and the Passive RFID tags are the main two types of RFID tags available. Active tags need a battery to operate, the tag can transmit the signal, up to 100m read range and it is expensive but can last about 10 years. Passive tags do not require any batteries and it reflects radio signals from the reader. The reader range is about 5m, inexpensive, and lightweight. Also, a passive tag will last about 7 years. Therefore most expressways use passive technology for expressway toll collections. (Kale, 2016)

RFID technology used in expressways consists of a tag, reader, and antenna. The vehicle owner should purchase the RFID tag and place it on their windscreen. The tag will be marked with ID & password and information related to the vehicle will be stored in the service provider's database. When a vehicle with an e-tag comes to the toll gate (figure 2.4), the signal field of the antenna will collect the data and process it to the payments. If the balance is insufficient, the user has to proceed with MTC. (Ren & Gao, 2009)

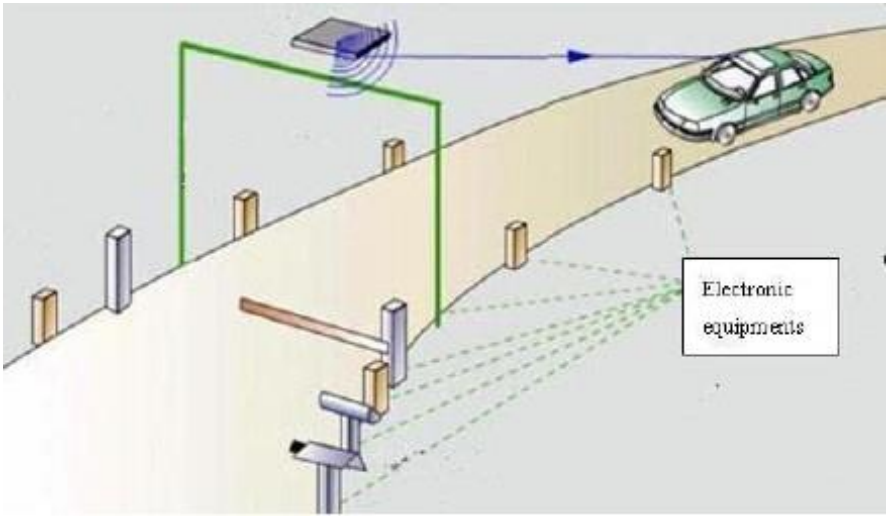

Figure 2. 1: RFID reader reads the vehicle equipped with RFID tag.

RFID passive technology used in CKE and users can obtain the e-tag for free from the highway operations management unit. Other countries are using more advanced technologies to manage their ETC systems. RDA is also looking for new technologies to replace with existing RFID technology and to implement on all existing expressway network. (Asian Development Bank, 2018) The registration and account balance maintaining process for the existing ETC service is a time-consuming task. Drivers need to maintain at least 20 meters distance between two vehicles, and they should reduce the speed to 15kmph. If the driver is unable to maintain the balance, the toll gate operates as an MTC gate. (*Guidelines to Registering and Using ETC on Katunayake Expressway [E03]*, n.d.)

2.5. ANPR Technology

The advancement of computer vision related artificial neural network (ANN) innovations in image text recognition systems enables Automatic Number Plate Recognition (ANPR) or Automatic License Plate Recognition (ALPR) technology. Most researchers use Python and MATLAB based technologies for their ANPR algorithm development.

ANPR technology uses the scanned image of the number plate and convert it to a text and use the text as the vehicle identification at the toll gates. Therefore, users do not need to mount RFID e-tag, barcode or QR codes on their windscreen. Similar to the other methods, the user has to register for the service and since the service is cloud-

based, customers can get more real-time details online. ANPR algorithms can divide into four parts. They are (1) Vehicle image capture (2) Number plate detection (3) Character segmentation and (4) Character recognition. As shown in figure 2.5.1, the process flows. (Patel et al., 2013)

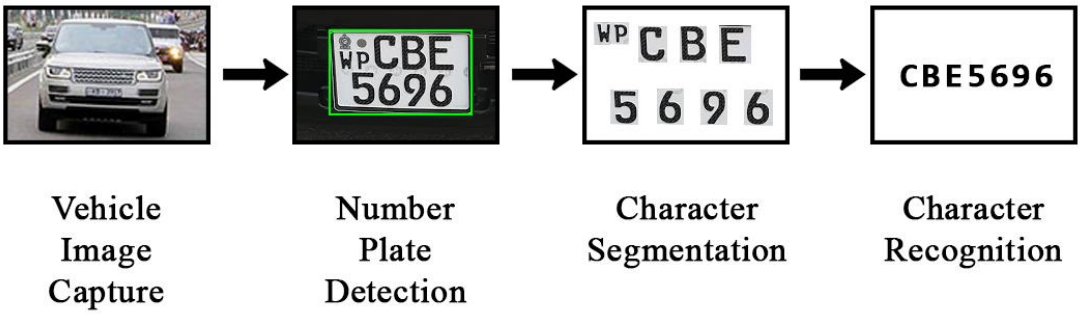

Figure 2. 2: How ANPR technology works

The benefits to the users of having ANPR are faster and more accurate service than existing MTC and RFID based system, fuel and time saving, easy to monitor the available balances, and e-bill services. The RDA also get benefits from ANPR over other technologies. With limited human interaction and automated capabilities, the toll collection cost will become lower. Also, the number of expressway users can be increased without expanding the entrance and the exit plazas. Also, real-time traffic data will enable real-time traffic monitoring and analyzing capabilities. (Takbhate, 2014) The ANPR technology can be seen in MLFF systems.

The number plate system practices in Sri Lanka are different from other countries. Hence, RDA Sri Lanka must develop and practice ANN by using local numberplates. Several types of vehicle number plate systems are currently using in Sri Lanka. Presently Sri Lanka issues a combination of English letters and numbers on vehicle number plates. But previously Sri Lanka had the only number-based license plate system. Earlier, the number-based system has “Sri” letters as to separate numbering system but later the authorities have introduced a dash (“-”) system. Even though these different formats, it is possible to improve the accuracy of the already developed license plate recognition algorithm. (Wijetunge & Ratnaweera, 2011) The proposed

system currently can be seen at the newly opened Kerawalapitiya exit toll plaza, but it only displays the vehicle number on the screen at the moment.

Technical assistance report (2018) published by ADB also recognized and proposed RDA Sri Lanka to use a better toll collection system than existing passive RFID based and MTC systems. Therefore, the ANPR based system would be the most suitable and cost-effective solution.

2.6. Expressway Toll Collection Methods and Congestion Pricing

Toll payments at MTC diversified from cash to credit cards and mobile QR based payments in countries like China. (Wang et al., 2020) But MTC counters in Sri Lanka only accept cash. Various papers suggest many online and mobile-based, prepaid and post-paid solutions for ETC payments. ETC in Sri Lanka is a pre-paid, RFID-based solution and the users have to top up their account via bank transfer.

According to the technical assistance report (2018) for the expressway operations improvement project in Sri Lanka, the current toll rates are calculated based on fixed and variable fees. Those fees should base on project-specific parameters like traffic volume, construction cost, and recovery period. But the existing toll policy and rates are not reasonable due to a few reasons. (i) Different fees charge at different expressways. (ii) The future expansion of the expressway doesn't have any toll rate policy. (iii) The existing toll rate calculation does not consider the vehicle volume, maintenance cost, and augmentation of expressway capacity. (iv) Inflation does not consider when calculating the toll fee. (v) The impact of new toll collection technologies should be incorporated.

The United States counts for 40% of congestion due to bottlenecks at the toll plazas. (Kuhn, 2010) To overcome this issue, the US has identified congestion pricing as a solution, and they have successfully implemented it. (Trepanier et al., 2011) Congestion pricing or value pricing enables moving the rush hour expressway traffic to the other transportation modes or off-peak hours. Initially, the US drivers have questions and concerns about the newly implemented system but later they have adopted the system, and they stopped overusing the expressway during the rush hour period and they planed their activities more during the off-peak hours. (*What Is*

Congestion Pricing? - Congestion Pricing - FHWA Office of Operations, n.d.) There are four congestion pricing methods. (i) Facility-based schemes will collect the expressway tolls at a single point or multiple points concerning distance traveled. (ii) Cordons are an area-based toll collection method where users have to pay for crossing the cordon in inbound, outbound, or both directions. (iii) Zonal schemes are also called area charges and users need to pay the toll to enter or exit the specific zone. (iv) Distance-based schemes charge the toll according to the linear or non-linear distance traveled. (Palma & Lindsey, 2009) The congestion-based pricing system is more suitable for E02 and E03 and RDA Sri Lanka is considering on implementing the congestion based pricing system on highly congested expressways. (RDA Sri Lanka, 2019)

The success of the implementation of congestion pricing is varying due to the user's acceptability factors. (Selmoune et al., 2020)

2.7. Subscription Business Model

Instead, of paying for the product or service each time the customer uses it, the subscription business model allows users to register and use the product or the service at regular intervals. (Longanecker, 2015) According to the Letht (2016), there are benefits of having a subscription model for both users as well as the service providers.

The benefits of having a subscription model for users/drivers are as follows.

- Convenience: If the users use a product or service regularly, instead of paying regularly, they can make one-time payment and use the service without any interruption.

- Money saving: Since the users can access to unlimited usage (most of the time), the unit cost would be very lower.

The benefits of having a subscription model for the service provider (RDA) is as follows.

- Financial and efficiency: The users will pay for the product or the service even before they use it. Also, the next period of income can predict based on past

transactions. Therefore, the fixed income can use as an investment for the betterment of service.

- Loyalty: Can have a loyal user base who purchase the subscription each period. Also, with the automatic renewal option, the customer does not need to make any purchase decisions.

- Differentiation: Differentiation is the key to attract more users and the model might attract new users due to the features and benefits of the proposed system.

According to Zwilling (2015), there are nine variations visible in the subscription business model. They are, (i) Membership website model: This model is suitable for a niche market where members can gain from members by interacting with each other. Rare car collectors, woodwork enthusiasts are examples. (ii) All-you-can-eat content model: With the subscription, the users will get an opportunity to use all available resources. Netflix and Hulu are the most successful service providers in this segment. The railway department, Sri Lanka also issues a monthly subscription-based ticket. Anyone with a ticket (train season) can travel between the two mentioned destinations anytime, any number of times per day. (iii) Private club model: the opposite of all you can eat model where the product is limited and exclusive. (iv) Front-of-the-line model: For those who need a relatively complex product or service, but you do not like to wait in the queue but need to access it without waiting. (v) Consumables model: For the products or services which are daily essentials and run out with the consumption like groceries and cosmetics. Birchbox in cosmetics is an example of the model. (vi) Surprise box model: This model enables people to select goods for you and the curated boxes will be sent to you each period. BarkBox for dog treats, SpicySubscriptions for lovemaking, and Standard Cocoa for the people who love chocolate are the successful examples in the category. (vii) Simplifier model: The service providers like pet grooming, window cleaning, bookkeeping schedule the service. (viii) Network model: The service will improve with the number of platform users became popular with dating sites, LinkedIn, Zipcar (car-sharing service) (ix) Peace-of-mind model: An insurance service providing model that let the user know about their house, kids, etc.

are safe. The all-you-can-eat subscription model with congestion pricing can be used with the expressway toll collection system in Sri Lanka.

2.8. Proposed System

A subscription-based tolling system should implement on top of an advanced technical tolling system. MLFF is already implemented in many countries successfully. It is also equipped with ANPR technology and congestion pricing-related traffic management. Therefore, the MLFF mechanism can consider with a subscription payment system instead of a regular payment system. Therefore, the study is focusing on the user acceptance of an automated, congestion-based, subscription payment collection system. The proposed system is not suitable for non-regular expressway users. A limited number of MTC gates should operate to provide service for them. (*Genvict - Free Flow Tolling, Single-Lane/Multi-Lane Free Flow Tolling System, SLFF, MLFF*, n.d.)

2.9. Technology Acceptance Model

Technology Acceptance Model (TAM) developed to predict the user behavior of either accept or reject the particular information system. (F D Davis, 1985)

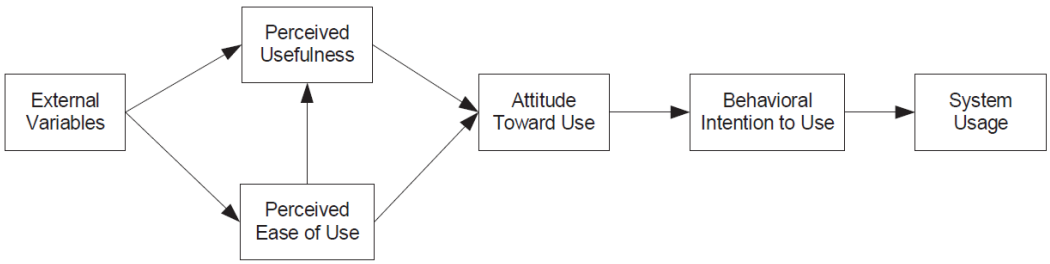

Figure 2. 3: Source: Original Technology Acceptance Model by Davis, 1985

Based on the initial version of TAM (figure 2.8.1), a similar relationship can identify with the proposed user acceptance of subscription-based toll collection method. But according to Rodrigo & Edirisinghe (2015), educational background and the purpose of use has shown a relationship with ETC acceptance in Sri Lanka. Hence the effect of moderate variables like age, and experience has to be considered in the technology

acceptance model. Therefore, according to the Unified Theory of Acceptance and Use of Technology (UTAUT) by Venkatesh et al. (2016), the model can be considered with its moderate variables.

2.10. Customer Satisfaction Score (CSAT)

CSAT score will provide a general idea about the level of customer satisfaction of a given product or service. The score lies between 0% to 100%, where it provides a general idea about the satisfaction level. (Bleuel, 2019)

The CSAT score can be calculate with following equation and if the CSAT score is 80% or higher, the satisfaction level of the offered service is considered to be high. (Mesevage, 2021)

$$\text{CSAT (\%)} = \frac{\text{Total Response Scores Given}}{\text{Total Possible Response Scores}} \times 100$$

The CSAT scoring system can be used to analyze the level of customer satisfaction with the existing expressway and the toll collection mechanism.

RESEARCH METHODOLOGY

3.1. Introduction

This chapter gives a thumbnail sketch of the way how the research was conducted to achieve the mentioned research objectives. This chapter includes the development of the conceptual framework, questionnaire development, sample selection, and data collection based on the empirical studies.

3.2. Conceptual Framework

The proposed system is different from the existing toll collection methods. Also, the proposed system involves the latest technology as well as the business concepts. By using the proposed system, expressway users would receive benefits, but it is a must to identify the user acceptance of the proposed system.

Since TAM is focused on the user acceptance of the new technology/ IT solutions, by focusing on the factors introduced by the TAM model (Davis, 1989) can be considered when developing the conceptual framework.

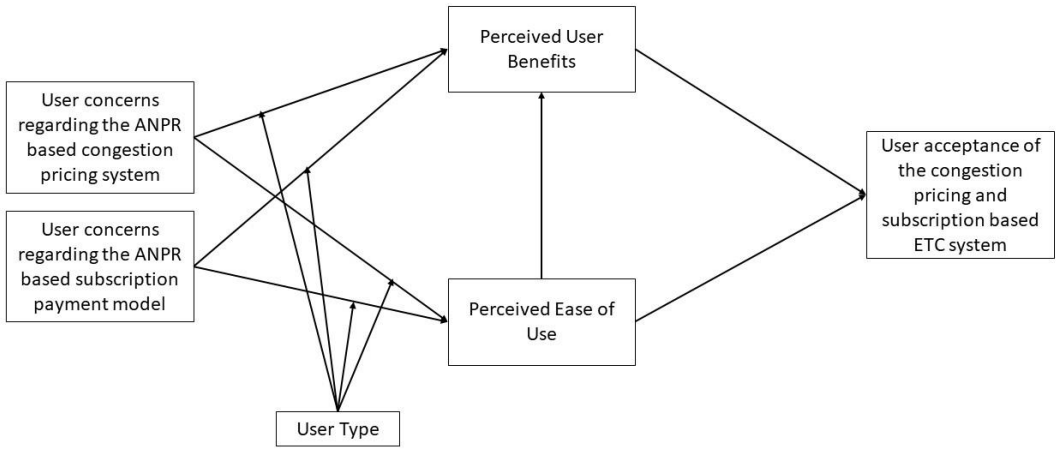

Figure 3.1: Conceptual Framework

3.3. Hypothesis Development

Based on the conceptual framework (figure 3.2.1), following hypothesis can be derived.

Hypothesis 1 (H1): User concerns regarding the ANPR based congestion pricing acceptance has a positive effect on perceived ease of use.

Hypothesis 2 (H2): User concerns regarding the ANPR based congestion pricing acceptance has a positive effect on perceived user benefits.

Hypothesis 3 (H3): User concerns regarding the ANPR based subscription model acceptance has a positive effect on perceived ease of use.

Hypothesis 4 (H4): User concerns regarding the ANPR based subscription model acceptance has a positive effect on perceived user benefits.

Hypothesis 5 (H5): Perceived ease of use has a positive effect on perceived user benefits.

Hypothesis 6 (H6): Perceived ease of use has a positive effect on user acceptance of the proposed system.

Hypothesis 7 (H7): Perceived user benefits have a positive effect on user acceptance of the proposed system.

Hypothesis 8 (H8): The user type of the expressway moderates the relationship between the user concerns regarding the ANPR based congestion pricing acceptance and their perceived benefits.

Hypothesis 9 (H9): The user type of the expressway moderates the relationship between the user concerns regarding the ANPR based congestion pricing acceptance and their perceived ease of use.

Hypothesis 10 (H10): The user type of the of expressway moderates the relationship between the user concerns regarding the ANPR based subscription payment acceptance and their perceived benefits.

Hypothesis 11 (H11): The user type of the expressway moderates the relationship between the user concerns regarding the ANPR based subscription payment acceptance and their perceived ease of use.

All the variables discussed above cannot be measured directly and the typical data analytics models cannot be used for the analysis. Therefore, by using the concept of Latent Variables, we can develop the analysis. *"The many, as we say, are seen but not known, and the ideas are known but not seen" (Plato, The Republic)*. A latent variable is a variable which cannot be observed but can be detected by the effects on variables that are observable.(Ma & Liu, 2011)

3.4. Latent Variables

The study aims to develop relationships between constructs that determine the user acceptance of subscription-based highway toll collection with ANPR technology in Sri Lanka. With the support of the literature survey, the study could identify that the below-mentioned constructs could influence directly or indirectly on the user acceptance of the proposed model. Also, the MLFF systems behave the same except for the toll collection mechanism.

3.4.1. User concerns regarding the ANPR based congestion pricing system.

The passive RFID-based ETC system in CKE is a very simple toll collection method. Other countries are operating more advanced systems to manage their ETC traffic flow. Therefore, RDA has decided to adopt a new ETC method. (Asian Development Bank, 2018) With the existing ETC system, the users have to maintain the minimum account balance to use the ETC counter. The ETC account top-up process is also a time-consuming task. The existing ETC users must maintain 20 meters distance between two vehicles to avoid system interruptions.

3.4.2. User concerns regarding the subscription model.

The subscribers of any product or service expect a better end-to-end experience as well as tangible benefits like lower cost and increased personalization from automated subscriptions. With the benefits of the subscription services, the subscription e-commerce market has grown by over 100 percent from 2011 to 2016 worldwide. (Tony Chen, Ken Fenyo, Sylvia Yang, 2018) Initially, the software and e-commerce industry took advantage of the subscriber business model but the new routes, other sectors also entering to the subscription business model.(*11 Interesting Recent Statistics on the Subscription Business Model*, n.d.)

3.4.3. Perceived user/driver benefits

If a particular Information Technology system is useful and it will improve the performance of users' particular tasks, then there is a higher possibility of accepting it by the user. The degree to which user believe that by using the proposed system, he/she can enhance his or her task performance is measured with ten Likert scale statements.(Fred D. Davis, 1989)

3.4.4. Perceived ease of use

The main reason to develop a particular system by using information technology is to provide an effortless experience for users who previously had a complex process. The degree to which an individual accepts the suggested system can measure with ten Likert scale statements. If the potential user believes that the proposed system is easier than the existing one, there is a higher possibility of accepting the proposed system by the user. (Fred D. Davis, 1989)

3.4.5. User Type

According to the study done by Rodrigo & Edirisinghe (2015), most users who drive delivery vehicles and buses are happy to use MTC as their payment method as they can keep cash in hand. Some expressway users drive the vehicle while others hire drivers to drive the vehicles. Some users use their own vehicle while others use rented or company-provided vehicles. The frequency of expressway usage is also differing from the user type.

3.4.6. User acceptance of subscription based (proposed) ETC system.

The existing payment collection system has been developed based on the project-by-project basis. Therefore, the toll rates differ among expressways. Also due to the limitations with the existing fee calculation system, it is recommended to have a better toll calculation system. (Asian Development Bank, 2018) Due to higher prices, most bus drivers avoid ETC due to a large amount of one-time payment. (Rodrigo & Edirisinghe, 2015) With the subscription-based payment method, regular expressway users will get a low-cost solution.

3.5. Operationalization Table

Construct	Dimension/ Variable	Indicators	Measurement Scale
User satisfaction measurement (of existing system)	User satisfaction measure of existing service and pricing - CSAT (Bleuel, 2019) (ETC/MTC system) – [CS]	Easiness of use	5 Point – Likert Scale
		Use again	
		Overall opinion of service	
		Recommend to others	
		Market Price	
		Total cost of use	
		Value for money	
User concerns regarding the ANPR based congestion pricing system over existing flat pricing and subscription model	Influencing Factors in Congestion Pricing Acceptability (Selmoune et al., 2020) – [CPA]	Factor of fairness	5 Point – Likert Scale
		Personal privacy	
		Increasing of risk	
		Public Attitudes	
		Variable Pricing System.	
		Impacts on Traffic	
	Factors for purchase motives among users of digital platform-based subscription services - (Kim & Kim, 2020) – [PS]	Hedonic	
		Economic	
		Convenient	
		Innovative	
Perceived user benefits (usefulness)	Perceived usefulness (Fred D. Davis, 1989) – [PUP/PUS]	Quality of Work	5 Point – Likert Scale
		Control over Work	
		Work More Quickly	
		Critical to My Job	
		Increase Productivity	
		Job Performance	
		Accomplish More Work	
		Effectiveness	
		Makes Job Easier	
		Useful	
Perceived ease of use	Perceived ease of use (Fred D. Davis, 1989) – [PEUP/PEUS]	Cubersome	5 Point – Likert Scale
		Ease of Learning	
		Frustrating	
		Controllable	
		Rigid & Inflexible	
		Easy to Become Skillful	
		Easy to Use	
User acceptance of proposed system	TAM (Fred D. Davis, 1989) [UA]	Relevancy	5 Point – Likert Scale
		Need of Innovation	
		User Satisfaction	
		Acceptance of proposed system	

Table 3. 1: Operationalization Table

3.6. Questionnaire Development

All the selected constructs of the study are latent variables. They were defined in a manner of measuring them by identifying them through a literature survey. The statements were formed by addressing each indicator. Statements were developed by using the five-point Likert scale. In addition to that, few questions were included to collect some demographic information. Later this information was used to test the relationships among latent variables.

3.7. Population and Sample Size

According to the data available from the RDA as of 2018, the number of users in the E02 and E03 expressway can be denoted as follows. Also based on the linearity, the 2020 users can be predicted as well.

Type	Year	E02	E03
Actual	2011	8,531	-
	2012	9,458	-
	2013	11,737	15,194
	2014	19,095	18,401
	2015	27,736	20,782
	2016	44,384	23,974
	2017	52,977	25,844
	2018	60,524	27,971
Forecasted	2019	68,762	34,714
Forecasted	**2020**	**76,948**	**38,934**

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

According to the predicted value, the daily average of E02 & E03 users as a population is 115,882. There are assumptions behind the predicted population, and they are as follows. (i) All the users are using the expressway one time per day. (ii) Due to COVID-19 pandemic, the predicted value can be varying.

As per the Determining Sample Size for Research Activities by Robert & Daryle (1970), the relationship between the population and the sample size calculation table can be used as 384. The stratified random sampling (SRS) technique can use as the

sample selection method. Also, based on the usage and the vehicle type, the sample was selected.

3.8. Collection of data

The questionnaire was distributed only in electronic format due to the pandemic situation in the country. To capture a certain audience of the sample, the questionnaire was translated to Sinhala and collect their responses.

3.9. Summary

Chapter 03 starts with the justification of the conceptual framework. It also justifies the reasons to include the moderator variable. Then the operationalization of the selected variables questionnaire development has been justified. Also, the sample selection strategy, the data collection, and data analysis methods were clearly described.

DATA ANALYSIS

4.1. Introduction

The purpose of the study is to determine whether the Sri Lankan expressway users (E02 and E03) are ready to accept the subscription-based toll collection system. Here the study as a part of the survey, user satisfaction with the existing toll collection mechanism is also measured.

4.2. Data Cleansing

The data collection was done by using an online questionnaire with all mandatory fields. The selected sample consists of less-educated parties (professional drivers who drive buses, vans, lorries, and cars) who are not familiar with filling questionnaires. Therefore, the responses were collected by explaining the questionnaire in Sinhalese. Hence all the data collected without having any missing values. While the data processing stage, all the entries filled by people who are aged less than 25 and older than 60 were removed. Also, the people who are not using the expressway at least once a month was removed. After the data cleaning process, 205 responses were available to conduct the analysis.

4.3. Normality of the Data

Parametric statistical tests can use if the population is normally distributed. A normally distributed dataset should have a perfectly symmetrical and bell-shaped curve. Also, the mean, median, and mode should equal. Visual graphs like the P-P plot, Q-Q plot, the stem-leaf plot can draft to test the normality, but the visual methods are less reliable. (Ghasemi & Zahediasl, 2012)

Using the SPSS software version 25, a simple statistical test performed on the data set to check for the normality of the dataset. The generated report can be found in Appendix B. The acceptable values for skewness are considered between -2 to +2. (Medrano et al., 2014) The acceptable range of Kurtosis is ranging between -3 to +3. (Mohd Razali & Bee Wah, 2011)

As per the Appendix B table, all skewness values are in the acceptable range. The Kurtosis value of the statement PEUS6 is not acceptable.

- PEUS6: *I find it easy to become skillful to use the automatic toll gates with a subscription-based toll collection system.*

If the responses do not distribute correctly, we can expect higher Kurtosis values. Table 4.1 illustrates the frequency of each respondence received for PEUS6.

Response	Frequency	Percent	Valid Percent	Cumulative Percent
Strongly Disagree	2	1	1	1
Disagree	3	1.5	1.5	2.4
Neutral	41	20	20	22.4
Agree	146	71.2	71.2	93.7
Strongly Agree	13	6.3	6.3	100
Total	205	100	100	

Table 4. 1: Frequency statistics of the indicator PEUS6

The statement PEUS6 records 71.2% as "Agree" responses, and the data is not normal. The "Perceived Ease of Use of Subscription" is measured with seven statements, and the statement PEUS6 will remove from further analysis.

4.4. Reliability and Validity Test

The results of the study should be reliable and valid for further statistical analysis of the collected sample dataset. Reliability is necessary but not sufficient factor for the validity.

4.4.1. Test for Reliability

The data collection should be consistent, and if the same outputs can be obtained with the same methods under the same circumstances, the assessment is considered reliable. By using the Cronbach's Alpha value, we can check the reliability of the study. If Cronbach's alpha value is between 0.6 - 0.7, then it denotes the acceptable level of reliability. If the value is 0.8 or higher, then it is considered a very good level of reliability. But the values higher than 0.95 are not a good value. (Ursachi et al., 2015)

Construct	Cronbach Alpha	No. of Items
CS	0.708	7
CPA	0.553	7
PS	0.780	7

PUP	0.897	10
PUS	0.869	10
PEUP	0.651	7
PEUS	0.580	6
UA	0.799	4

Table 4. 2: Initial reliability results

As per the values received for each construct in table 4.2, both CPA (Congestion Pricing Acceptability) and PEUS (Perceived Ease of Use of Subscription-based toll) are not reliable. Therefore, to make the dataset reliable for further analysis, following statements had to be removed.

- Congestion Based Pricing Acceptability [CPA]
    - [CPA7] - The traffic jam near expressway toll booths will cause environmental pollution.
- Perceived Ease of Use - Subscription [PEUS]
    - [PEUS1] – I find it inconvenient to use automatic toll gates with a subscription-based toll collection system.
    - [PEUS3] – Using automatic toll gates with a subscription-based toll collection system is often frustrating.
    - [PEUS5] – The automatic toll gates with subscription-based toll collection system are rigid and inflexible to interact with

After removing each statement, the Cronbach alpha value was calculated. Table 4.3 consists of Cronbach alpha values after refining the questionnaire. The reliability test results can be found under Appendix C.

Construct	Cronbach Alpha	No. of Items
CS	0.708	7
CPA	0.600	6
PS	0.780	7
PUP	0.897	10

PUS	0.869	10
PEUP	0.651	7
PEUS	0.736	3
UA	0.799	4

Table 4. 3: Final reliability scores after removing selected items.

4.4.2. Test for Validity

The study should be valid in the form of construct validity, internal validity, and external validity. The questionnaire was developed and modified by using the literature review and other published data sources. Therefore, the content validity is there with the research. Factor analysis will perform on the constructs to check the validity. Principal component factor analysis process used for extracting new components with Direct Oblimin Rotation. If the eigenvalue is greater than 1, such initial components were selected. Measures with less than 0.5-factor values were removed from further analysis as well.

- **Factor Analysis for CS**

As per the table 4.4, there are two factors exceeding the eigenvalue greater than 1.

	Total	% of Variance	Cumulative %
1	2.561	36.590	36.590
2	1.409	20.123	56.712
3	.738	10.536	67.248
4	.670	9.568	76.816
5	.614	8.778	85.594
6	.570	8.147	93.741
7	.438	6.259	100.000

Extraction Method: Principal Component Analysis.

Table 4. 4: Total Variance Explained in Customer Satisfaction Indicators (Initial Eigenvalues)

	C-CS-1	C-CS-2
CS1	.626	-.467
CS2	.544	-.560
CS3	.725	-.354
CS4	.631	.163

CS5	.666	.263
CS6	.496	.585
CS7	.510	.560

Extraction Method: Principal Component Analysis.

Table 4. 5: Component Table

According to the above results, CS7 is removed due to cross loaded with more than one factor.

C-CS-1	**C-CS-2**
CS1	CS6
CS2	
CS3	
CS4	
CS5	

Table 4. 6: New variables for functional values

- **Factor Analysis for CPA**

Component	Total	% of Variance	Cumulative %
1	1.999	33.322	33.322
2	1.327	22.117	55.440
3	.863	14.385	69.825
4	.758	12.632	82.457
5	.562	9.369	91.826
6	.490	8.174	100.000

Extraction Method: Principal Component Analysis

Table 4. 7: Total Variance Explained in Congestion Pricing Acceptability (Initial Eigenvalues)

Two factors exceeding the eigenvalue greater than 1 can be found on table 4.7. Therefore, there are two variables named C-CPA-1 and C-CPA-2 as in table 4.8.

	C-CPA-1	C-CPA-2
CPA1	.528	-.206
CPA2	.648	-.276
CPA3	.571	-.572
CPA4	.544	.641

CPA5	.535	.669
CPA6	.627	-.148

Extraction Method: Principal Component Analysis.

Table 4. 8: Rotated Component Metrix for CPA

Both CPA4 and CPA5 are removed due to cross loaded with more than one factor. All the indicators fall into the C-CPA-1 variable.

- **Factor Analysis for PS**

Component	Total	% of Variance	Cumulative %
1	3.063	43.755	43.755
2	.883	12.610	56.365
3	.825	11.784	68.149
4	.683	9.762	77.911
5	.657	9.391	87.302
6	.477	6.820	94.122
7	.411	5.878	100.000

Extraction Method: Principal Component Analysis.

Table 4. 9: Total Variance Explained in Purchase of Subscriptions. (Initial Eigenvalues)

Only one factor exceeding the eigen value of 1. Therefore, only one variable selected to proceed with.

	Component
	1
PS1	.582
PS2	.649
PS3	.693
PS4	.690
PS5	.762
PS6	.669
PS7	.565

Extraction Method: Principal Component Analysis.

Table 4. 10: Rotated Component Metrix for PS

All the indicators in component matrix (table 4.10) are exceeding the value 0.5. Hence all items will select for further analysis.

- **Factor Analysis for PUP**

Component	Total	% of Variance	Cumulative %
1	5.226	52.261	52.261
2	.933	9.327	61.588
3	.812	8.121	69.709
4	.605	6.054	75.763
5	.531	5.310	81.072
6	.467	4.669	85.741
7	.420	4.202	89.943
8	.371	3.713	93.656
9	.325	3.247	96.903
10	.310	3.097	100.000

Extraction Method: Principal Component Analysis.

Table 4. 11: Total variance explained in perceived usefulness of congestion-based toll pricing system. (Initial Eigenvalues)

Only one factor exceeding the eigen value of 1. Therefore, only one variable can be selected.

	Component
	1
PUP1	.719
PUP2	.689
PUP3	.751
PUP4	.638
PUP5	.792
PUP6	.724
PUP7	.694
PUP8	.689
PUP9	.735
PUP10	.784

Extraction Method: Principal Component Analysis

Table 4. 12: Rotated Component Metrix for PS

All the indicators in component matrix (table 4.12) are exceeding the value 0.5. Hence all items will select for further analysis.

- **Factor Analysis for PUS**

Component	Total	% of Variance	Cumulative %
1	4.655	46.548	46.548
2	1.247	12.470	59.017
3	.782	7.817	66.834
4	.683	6.827	73.661
5	.636	6.357	80.018
6	.533	5.334	85.352
7	.477	4.767	90.119
8	.380	3.799	93.918
9	.317	3.170	97.088
10	.291	2.912	100.000

Extraction Method: Principal Component Analysis.
Table 4. 13: Total variance explained in perceived usefulness of subscription-based toll pricing system. (Initial Eigenvalues)

There are two new variables named as C-PUS-1 and C-PUS-2 (table 4.13)

	Component	
	1	2
PUS1	.645	.311
PUS2	.649	-.176
PUS3	.690	.493
PUS4	.655	-.331
PUS5	.746	-.022
PUS6	.731	-.373
PUS7	.681	-.379
PUS8	.758	-.274
PUS9	.576	.528
PUS10	.671	.359

Extraction Method: Principal Component Analysis.

Table 4. 14: Rotated Component Metrix for PUS

Indicator PUS9 is removed due to cross loaded with more than one factor. All the indicators fall into the C-PUS-1 variable. Hence other indicator items will select for further analysis.

- **Factor Analysis for PEUP**

Component	Total	% of Variance	Cumulative %

1	2.517	35.950	35.950
2	1.514	21.625	57.575
3	.883	12.618	70.193
4	.618	8.834	79.027
5	.528	7.537	86.564
6	.505	7.210	93.774
7	.436	6.226	100.000

Extraction Method: Principal Component Analysis.

Table 4. 15: Total variance explained in perceived ease of use of congestion-based toll pricing system. (Initial Eigenvalues)

There are two new variables named as C-PEUP-1 and C-PEUP-2 (table 4.16)

	Component	
	C-PEUP-1	C-PEUP-2
PEUP1	.274	.607
PEUP2	.714	-.283
PEUP3	.221	.799
PEUP4	.777	-.050
PEUP5	.435	.549
PEUP6	.765	-.151
PEUP7	.711	-.317

Extraction Method: Principal Component Analysis.

Table 4. 16: Rotated Component Metrix for PEUP

All the indicators satisfy the level of acceptance and as per the table 4.17, the indicators fall in to two selected variables.

C-PEUP-1	**C-PEUP-2**
PEUP2	PEUP1
PEUP4	PEUP3
PEUP6	PEUP5
PEUP7	

Table 4. 17: New variables for functional values

- **Factor Analysis for PEUS**

Component	Total	% of Variance	Cumulative %
1	1.969	65.643	65.643

2	.581	19.378	85.021
3	.449	14.979	100.000

Extraction Method: Principal Component Analysis.

Table 4. 18: Total variance explained in perceived ease of use of subscription-based toll pricing system. (Initial Eigenvalues)

Only one factor exceeding the eigen value of 1. Therefore, only one variable can be selected.

	Component
	1
PEUS2	.798
PEUS4	.787
PEUS7	.844

Extraction Method: Principal Component Analysis.

Table 4. 19: Rotated Component Metrix for PEUS

All the indicators in component matrix (table 4.19) are exceeding the value 0.5. Hence all items will select for further analysis.

- **Factor Analysis for UA**

Component	Total	% of Variance	Cumulative %
1	2.498	62.449	62.449
2	.695	17.381	79.830
3	.439	10.967	90.796
4	.368	9.204	100.000

Extraction Method: Principal Component Analysis.

Table 4. 20: Total variance explained in user acceptance of proposed model. (Initial Eigenvalues)

Only one factor exceeding the eigen value of 1. Therefore, only one variable can be selected.

	Component
	1
UA1	.832
UA2	.759
UA3	.783
UA4	.786

Extraction Method: Principal Component Analysis.

Table 4. 21: Rotated Component Metrix for UA

All the indicators in component matrix (table 4.21) are exceeding the value 0.5. Hence all items will select for further analysis.

Higher Cronbach alpha value (table 4.3) and corrected item to total correlations indicated better internal consistency among indicators. (Nunnally J C, 1978)

4.5. Descriptive Analysis

The intention of performing the descriptive analysis on the collected data set is to reveal the hidden insights. All the analyses were made by using the IBM SPSS version 25 and Microsoft excel 365.

4.5.1. Expressway User Satisfaction

By calculating the CSAT score from the CS data, the user satisfaction score can be obtained. The CSAT score is 53.2%, and it is lower than the acceptable value of 80%. Also, it means that most users do not like the existing toll collection mechanism. Therefore, to encourage non-expressway users and to reach the optimal expressway usage, it is recommended to attract more recurring users.

4.5.2. Age

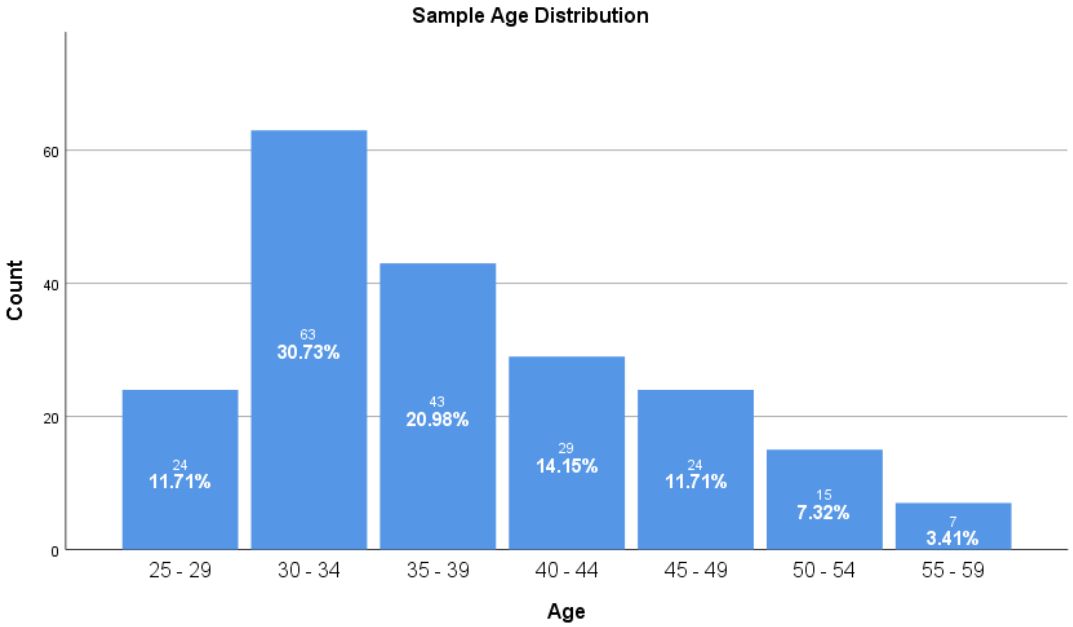

Figure 4. 1: Age composition

Figure 4.1 describes the age distribution of the survey participants. The participants who are age below 25 and above 60 were deleted during the data cleaning stage. Most respondents are from the age 30 – 34 categories, and it represents 30% (63 out of 205) of the total. 11% of respondents (24 out of 205) fall into the age group of 25 – 29 and 45 - 49. 21% of respondents (43 out of 205) fall into the age group of 35 – 39. 7% of respondents (15 out of 205) fall into the age group 50-54. 3% of the respondents (7 out of 205) fall into the age group 55 – 59.

4.5.3. Gender

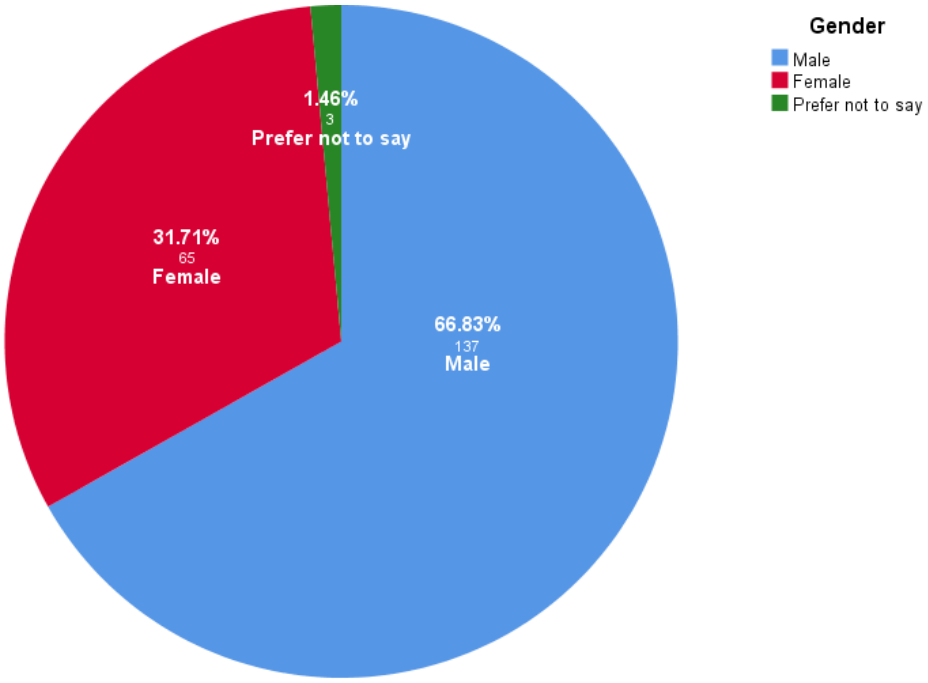

Figure 4. 2: Gender distribution

Figure 4.2 describes the gender distribution of the survey participants. 67% of the respondents (137 out of 205) were male, and 32% were (65 out of 205) female. 1% of the respondents (3 out of 205) were not interested in disclosing their gender.

4.5.4. Expressway User Type

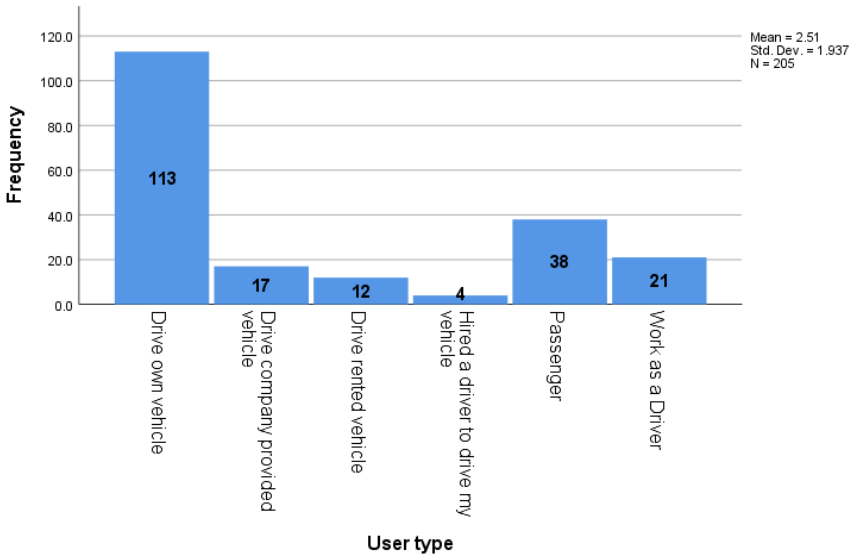

Figure 4. 3: User type distribution

Figure 4.3 describes the expressway user type distribution of the survey participants. 113 out of 205 respondents drive their vehicle. 17 out of 205 respondents drive company-provided vehicles. 12 out of 205 respondents drive rented vehicles. 4 out of 205 respondents hired a driver to drive their vehicle. 38 out of 205 respondents mentioned that they are passengers. 21 out of 205 respondents were professional drivers.

4.5.5. Expressway Usage Time

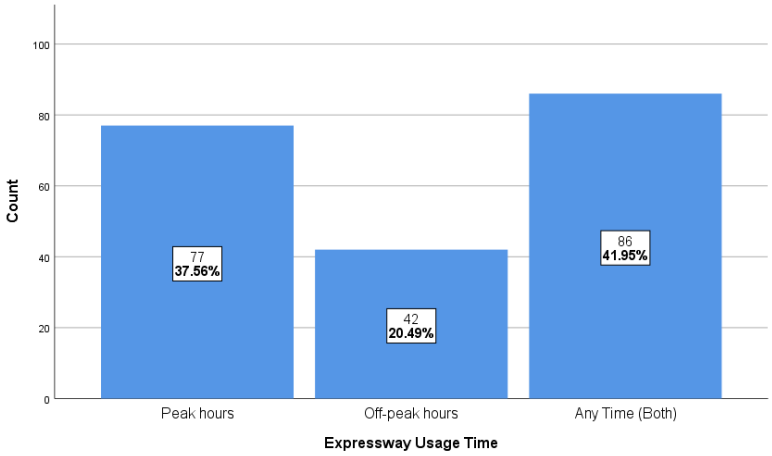

Figure 4. 4: Usage time distribution

Figure 4.4 describes the expressway usage time distribution of the survey participants. 38% of the respondents (77 out of 205) use the expressway during peak hours where 20% of the respondents (41 out of 205) use it during off-peak hours. 42% of respondents state that they use the expressway during both peak and off-peak hours.

4.5.6. Expressway Usage Frequency

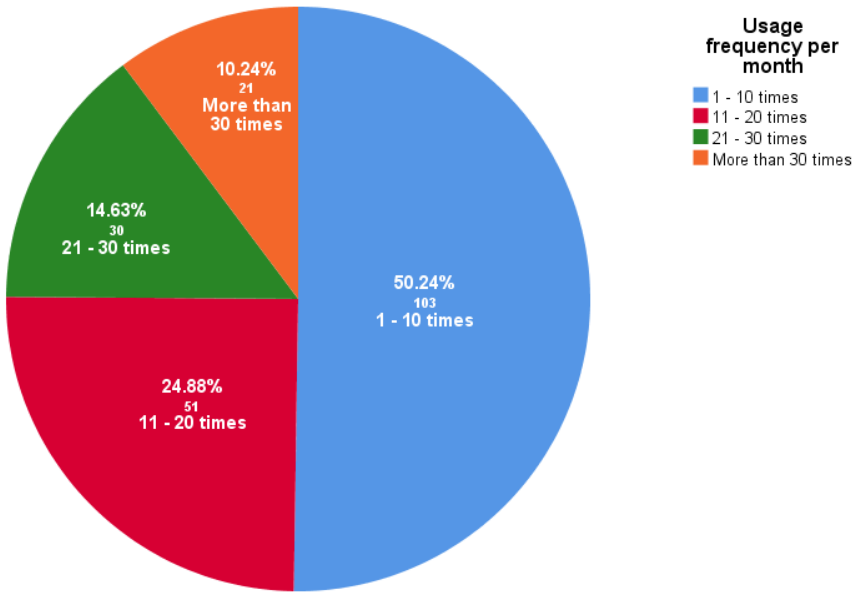

Figure 4. 5: Expressway usage distribution

Figure 4.5 describes the number of time expressway used per month. Half of the survey participants (103 out of 205) are using 1 – 10 times per month. 25% of the survey participants (51 out of 205) using the expressway 11 – 20 times per month. 15% of the survey participants (30 out of 205) are using the expressway 21 – 30 times per month. 10% of the survey participants (21 out of 205) are using the expressway more than 30 times per month.

4.5.7. Vehicle Type

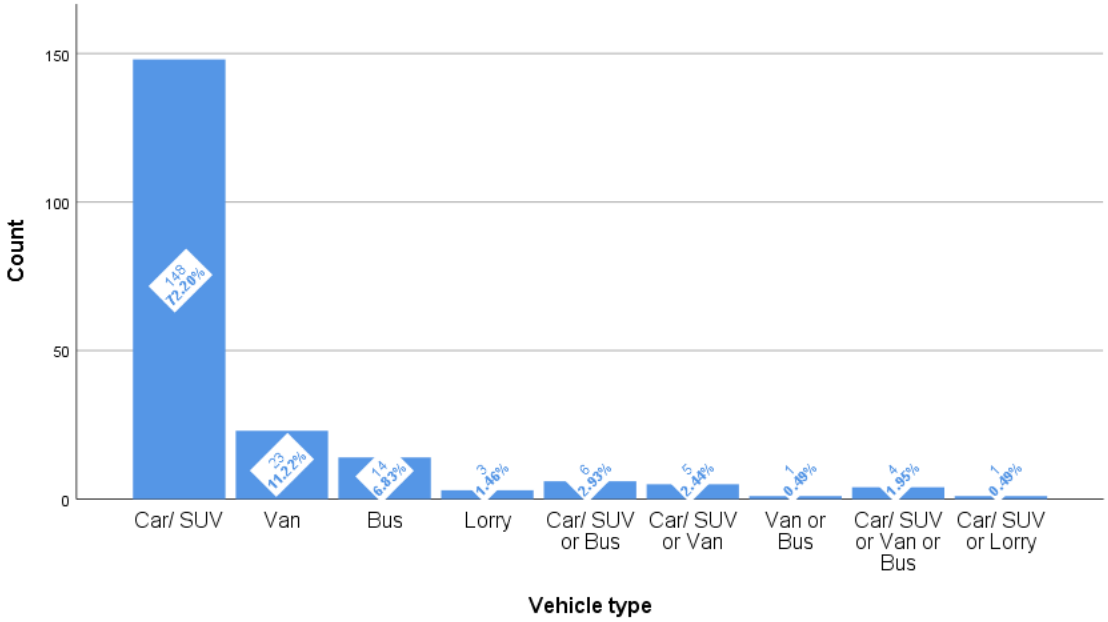

Figure 4. 6: Vehicle type used.

Figure 4.6 describes the vehicle type usage distribution of the survey participants. 72% of the survey participants (148 out of 205) are using car/ SUV as the expressway transportation mode. 11% of the survey participants (23 out of 205) are using Van as the expressway transportation mode. 6% of the survey participants (14 out of 205) are using the bus as the expressway transportation mode. 1% of the survey participants (3 out of 205) are using lorry as the expressway transportation mode. 3% of the survey participants (6 out of 205) are using car/ SUV or bus as the expressway transportation mode. 2% of the survey participants (5 out of 205) are using car/ SUV or van as the expressway transportation mode.

4.5.8. Expressway user monthly income

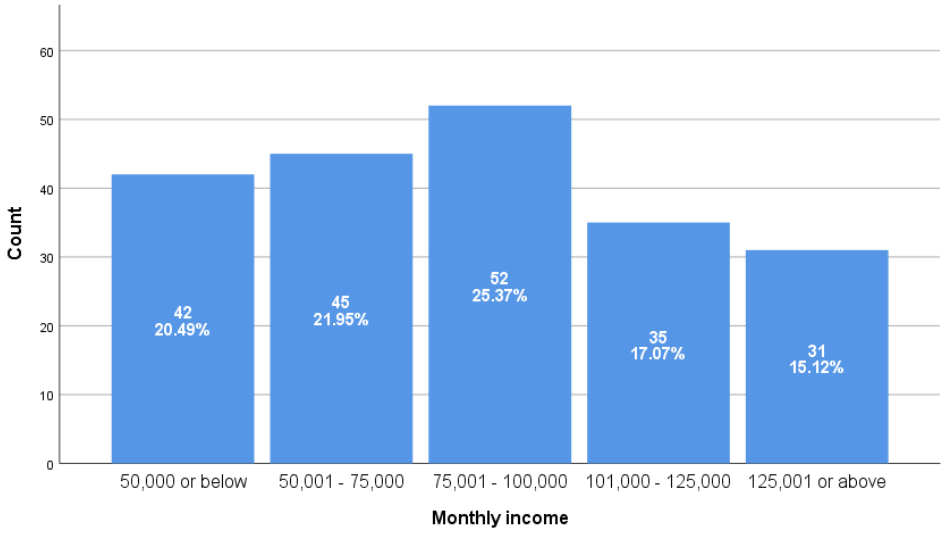

Figure 4. 7: User income distribution

Figure 4.6 describes the vehicle type usage distribution of the survey participants. 25% of the survey participants (52 out of 205) are earning between 75,000LKR – 100,000LKR. 21% of the survey participants (42 out of 205) are earning below 50,000LKR. 22% of the survey participants (45 out of 205) are earning between 50,001LKR – 75,000LKR. 17% of the survey participants (35 out of 205) are earning between 100,001LKR – 125,000LKR. 15% of the survey participants (31 out of 205) are earning 125,001LKR or more.

4.6. Descriptive Statistics

All the selected indicators describe each variable. By considering the composite variable of each factor, the study can perform statistical tests to generate insights. The cleaned dataset can analyze with measures of dispersion and measures of central tendencies. All the variables measured using a five-point Likert scale which is 1 - "strongly disagree", 2 - "disagree", 3 - "neutral", 4 - "agree", and 5 - "strongly agree". After cleaning the dataset and performing reliability and validity test on the dataset, there were 205 responses and a total of 50 statements as indicators.

Variable	N	Minimum	Maximum	Mean	Std. Deviation
CPA	205	1.75	5.00	3.472	.59677
PS	205	2.14	5.00	3.662	.41668
PU	205	2.16	4.90	3.704	.41678
PUP	205	1.10	5.00	3.634	.52534
PUS	205	2.22	5.00	3.772	.43610
PEU	205	1.88	5.00	3.592	.40304
PEUP	205	1.43	5.00	3.407	.43982
PEUS	205	2.00	5.00	3.775	.50655
UA	205	1.00	5.00	3.590	.55827

Table 4. 22: Descriptive statistics for variables

As per table 4.22, the Congestion Pricing Acceptability (CPA) variable records a mean of 3.472 with 0.597 of standard deviation. Hence, 68% of the responses are within 3.472 ± 0.597 (between 2.875 – 4.069 on the Likert scale). The Purchase of Subscriptions (PS) variable records a mean of 3.662 with 0.417 of standard deviation. Hence 68% of the responses are within 3.662 ± 0.417 (between 3.245 – 4.079 on the Likert scale). The Purchase of Subscriptions (PS) variable records a mean of 3.662 with 0.417 of standard deviation. Hence 68% of the responses are within 3.662 ± 0.417 (between 3.245 – 4.079 on the Likert scale).

The Perceived Usefulness of Congestion Pricing (PUP) variable records a mean of 3.634 with 0.525 of standard deviation. Hence 68% of the responses are within 3.634 ± 0.525 (between 3.109 – 4.159 on the Likert scale). The Perceived Usefulness of Subscription Pricing (PUS) variable records a mean of 3.772 with 0.436 of standard deviation. Hence 68% of the responses are within 3.772 ± 0.436 (between 3.336 – 4.208 on the Likert scale). The Perceived Usefulness (PU) variable in overall records a mean of 3.704 with 0.417 of standard deviation. Hence 68% of the responses are within 3.704 ± 0.417 (between 3.287 – 4.121 on the Likert scale).

The Perceived Ease of Use of Congestion Pricing (PEUP) variable records a mean of 3.407 with 0.44 of standard deviation. Hence 68% of the responses are within 3.407 ± 0.44 (between 2.967 – 3.847 on the Likert scale). The Perceived Ease of Use of

Subscription Pricing (PEUS) variable records a mean of 3.775 with 0.558 of standard deviation. Hence 68% of the responses are within 3.775 ± 0.558 (between 3.217 – 4.333 on the Likert scale). The Perceived Ease of Use (PEU) variable in overall records a mean of 3.592 with 0.403 of standard deviation. Hence 68% of the responses are within 3.592 ± 0.403 (between 3.189 – 3.995 on the Likert scale).

The User Acceptance of the Model (UA) dependent variable records a mean of 3.509 with 0.558 of standard deviation. Hence 68% of the responses are within 3.509 ± 0.558 (between 2.951 – 4.067 on the Likert scale).

All the variables of the study can be denoted with a box plot.

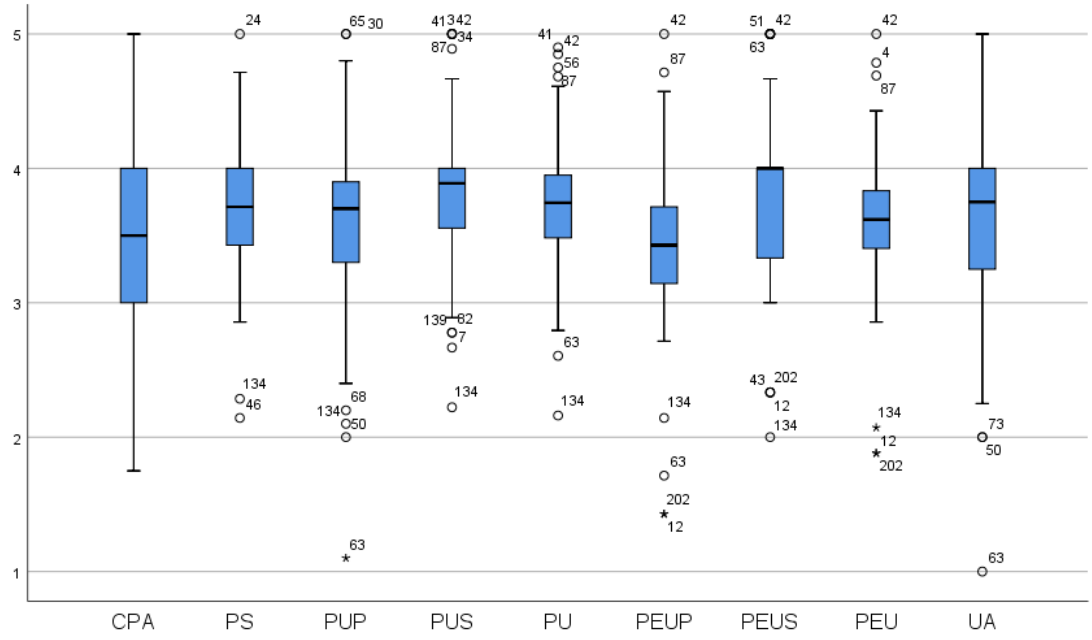

Figure 4. 8: Boxplot for variables

As per the above representation, all the variables fall into the "neutral" to "agree" stage in the Likert scale. Therefore, almost all responses received in favor of the suggested system and its attributes.

The 134th respondent was a professional driver and according to the previous study carried out by Rodrigo & Edirisinghe (2015), professional drivers did not like the electronic toll collection mechanism established in Colombo - Katunayake expressway. The 63rd respondent did not like the congestion-based toll mechanism

(PUP, PEUP, and UA). Hence, he mentioned that he does not like the overall concept. 202nd respondent was an off-peak expressway user, and he drives his car 1 – 10 times per month on expressways. His response on congestion-based pricing was fair. Since he is using the expressway only during off-peak hours, he might not interest in a different pricing strategy no paying a higher/ lower price. Respondent number 42 was a young female, and her perceived ease of use for a congestion-based subscription toll system denotes her perception. Even though figure 4.8 indicates few out liars to have an unbiased outcome, it is better to keep all the inputs.

The descriptive statistics provide a general overlook of the study variables but, further analysis is required to understand the relationship between dependent and independent variables.

4.7. Inferential Analysis

Descriptive statistics describe the collected dataset, and inferential statistics will make predictions on them. Regression and correlation analysis methods can use to make necessary inferences.

4.7.1. Correlation Analysis

The correlation matrix denotes the dependencies between both dependent and independent variables. Bivariate Pearson correlation analysis can use for analysis, and it is subject to a two-tailed significance at a higher level with '$p < 0.01$'. As per Aczel & Sounderpandian (2006), if the correlation coefficient (r) where $r = \pm 1$, there is a higher perfect correlation. If the value is between 0.75 and 1.00, then there will be a strong positive relationship will exist. If the value is between 0.5 – 0.74, then there is a moderate positive relationship. If the valuer is between 0 and 0.49, then a week relationship exists. If the values are negative, it means the relationship is negative.

Table 4.23 illustrates the Pearson Correlation values and respective p-values. The relationship between each variable is described to match with the conceptual framework (figure 3.2.1). All the variable satisfies the expected significant level. Hence all values are acceptable for further analysis. As per the results obtained, correlations with the hypothesis can obtain.

		PUP	PUS	**PU**	PEUP	PEUS	**PEU**	**UA**
CPA	Pearson Correlation	.233**			.249**			
	Sig. (2-tailed)	.001			.000			
PS	Pearson Correlation		.531**			.377**		
	Sig. (2-tailed)		.000			.000		
PU	Pearson Correlation							.805**
	Sig. (2-tailed)							.000
PEU	Pearson Correlation			.468**				.272**
	Sig. (2-tailed)			.000				.000

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 4. 23: Correlation table

Correlation with each hypothesis can illustrate as follows.

- H1: User concerns regarding the ANPR based congestion pricing system (CPA) has a week positive relationship with perceived ease of use. (PEUP)
- H2: User concerns regarding the ANPR based congestion pricing system (CPA) has a week positive relationship with perceived user benefits (PUP)
- H3: User concerns regarding the ANPR based subscription model (PS) has a week positive relationship with perceived ease of use (PEUS).
- H4: User concerns regarding the ANPR based subscription model (PS) has a moderate positive relationship with perceived user benefits (PUS).
- H5: Perceived ease of use (PEU) has a week positive relationship with perceived user benefits (PU).
- H6: Perceived ease of use (PEU) has a week positive relationship with user acceptance of the subscription based ETC system (UA).
- H7: Perceived user benefits (PU) has a strong positive relationship with user acceptance of the subscription based ETC system (UA).

As per the results obtained in table 4.23, hypothesis; H1, H2, H3, H4, H5, H6 and H7 can be accepted with 0.01 level of significant.

4.7.2. Simple Regression Analysis

Single datapoint statistic can obtain with correlation but, it does not imply causation. Regression can use to develop a line and predict the causal effect on variables. The R squared value measurements can use to explain the variance for a dependent variable which is explained by an independent variable (coefficient of determination). The ANOVA table can use to determine the significance of regression equation variability between dependent and independent variables.

4.7.2.1 The relationship between Congestion Pricing Acceptability (CPA) and Perceived Ease of Use of Congestion Pricing (PEUP)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.249[a]	.062	.057	.42699

a. Predictors: (Constant), CPA

Table 4. 24: Model summary for CPA vs PEUP

As per the table 4.24, the R value of 0.249 represents a week correlation and R^2 value illustrates the variance (0.062). It means 6.2% of variation of PEUP could be explained by the CPA.

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.451	1	2.451	13.443	.000[b]
	Residual	37.010	203	.182		
	Total	39.461	204			

a. Dependent Variable: PEUP

b. Predictors: (Constant), CPA

Table 4. 25: ANOVA for CPA and PEUP

As per the table 4.25, the F value is 13.443 and the model is significant at the level of 0.0000.

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.770	.176		15.697	.000
	CPA	.184	.050	.249	3.667	.000

a. Dependent Variable: PEUP

Table 4. 26: Coefficient table for CPA and PEUP

The Beta value of the coefficient table is 0.249 and it denotes positive relationship between CPA and PEUP. Therefore, when CPA increases, PEUP will increase.

The regression equation will be in the form of,

Dependent Variable *(y)* = Slope *(m)* x Independent Variable *(x)* + The Intercept *(c)*

Therefore, the equation for the linear regression line would be (slope = 0.184 and intercept = 2.77),

PEUP *(y)* = 0.184CPA*(x)* + 2.77

4.7.2.2 The relationship between Congestion Pricing Acceptability (CPA) and Perceived User Benefits of Congestion Pricing (PUP)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.233[a]	.054	.050	.51215

a. Predictors: (Constant), CPA

Table 4. 27: Model summary for CPA and PUP

As per the table 4.27, the R value of 0.233 represents a week correlation and R^2 value illustrates the variance (0.054). It means 5.4% of variation of PUP could be explained by the CPA.

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	3.054	1	3.054	11.644	.001[b]
	Residual	53.247	203	.262		

	Total	56.301	204			

a. Dependent Variable: PUP

b. Predictors: (Constant), CPA

Table 4. 28: ANOVA for CPA and PUP

As per the table 4.28, the F value is 11.644 and the model is significant at the level of 0.0010.

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.922	.212		13.806	.000
	CPA	.205	.060	.233	3.412	.001

a. Dependent Variable: PUP

Table 4. 29: Coefficient table for CPA and PUP

The Beta value of the coefficient table is 0.233 and it denotes positive relationship between CPA and PUP. Therefore, when CPA increases, PUP will increase.

The regression equation will be in the form of,

Dependent Variable *(y)* = Slope *(m)* x Independent Variable *(x)* + The Intercept *(c)*

Therefore, the equation for the linear regression line would be (slope = 0.205 and intercept = 2.922),

PUP *(y)* = 0.205CPA*(x)* + 2.922

4.7.2.3 The relationship between Subscription Model Acceptability (PS) and Perceived User Benefits of Perceived Ease of Use (PEUS)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.377[a]	.142	.138	.47041

Predictors: (Constant), PS

Table 4. 30: Model summary for PS and PEUS

As per the table 4.30, the R value of 0.377 represents a week correlation and R^2 value illustrates the variance (0.142). It means 14.2% of variation of PEUS could be explained by the PS.

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	7.423	1	7.423	33.545	.000[b]
	Residual	44.922	203	.221		
	Total	52.345	204			

a. Dependent Variable: PEUS

b. Predictors: (Constant), PS

Table 4. 31: ANOVA for PS and PEUS

As per the table 4.31, the F value is 33.545 and the model is significant at the level of 0.0000.

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.099	.291		7.206	.000
	PS	.458	.079	.377	5.792	.000

a. Dependent Variable: PEUS

Table 4. 32: Coefficient table for PS and PEUS

The Beta value of the coefficient table is 0.377 and it denotes positive relationship between PS and PUES. Therefore, when PS increases, PEUS will increase.

The regression equation will be in the form of,

Dependent Variable *(y)* = Slope *(m)* x Independent Variable *(x)* + The Intercept *(c)*

Therefore, the equation for the linear regression line would be (slope = 0.458 and intercept = 2.099),

PEUS*(y)* = 0.458PS*(x)* + 2.099

4.7.2.4 The relationship between Subscription Model Acceptability (PS) and Perceived User Benefits of Subscription (PUS)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.531[a]	.282	.279	.37038

a. Predictors: (Constant), PS

Table 4. 33: Model summary for PS and PUS

As per the table 4.33, the R value of 0.531 represents a moderate correlation and R^2 value illustrates the variance (0.282). It means 28.2% of variation of PUS could be explained by the PS.

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	10.950	1	10.950	79.822	.000[b]
	Residual	27.848	203	.137		
	Total	38.798	204			

a. Dependent Variable: PUS

b. Predictors: (Constant), PS

Table 4. 34: ANOVA for PS and PUS

As per the table 4.34, the F value is 79.822 and the model is significant at the level of 0.0000.

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.737	.229		7.572	.000
	PS	.556	.062	.531	8.934	.000

a. Dependent Variable: PUS

Table 4. 35: Coefficient table for PS and PUS

The Beta value of the coefficient table is 0.531 and it denotes positive relationship between PS and PUS. Therefore, when PS increases, PUS will increase.

The regression equation will be in the form of,

Dependent Variable *(y)* = Slope *(m)* x Independent Variable *(x)* + The Intercept *(c)*

Therefore, the equation for the linear regression line would be (slope = 0.556 and intercept = 1.737),

PUS *(y)* = 0.556PS*(x)* + 1.737

4.7.2.5 The relationship between Perceived Ease of Use (PEU) and Perceived User Benefits (PU)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.468[a]	.219	.215	.36932

a. Predictors: (Constant), PEU

Table 4. 36: Model summary for PEU and PU

As per the table 4.36, the R value of 0.468 represents a moderate correlation and R^2 value illustrates the variance (0.219). It means 21.9% of variation of PU could be explained by the PEU.

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	7.748	1	7.748	56.804	.000[b]
	Residual	27.688	203	.136		
	Total	35.436	204			

a. Dependent Variable: PU

b. Predictors: (Constant), PEU

Table 4. 37: ANOVA for PEU and PU

As per the table 4.37, the F value is 56.804 and the model is significant at the level of 0.0000.

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.967	.232		8.483	.000

	PEU	.484	.064	.468	7.537	.000

a. Dependent Variable: PU

Table 4. 38: Coefficient table for PEU and PU

The Beta value of the coefficient table is 0.468 and it denotes positive relationship between PEU and PU. Therefore, when PEU increases, PU will increase.

The regression equation will be in the form of,

Dependent Variable *(y)* = Slope *(m)* x Independent Variable *(x)* + The Intercept *(c)*

Therefore, the equation for the linear regression line would be (slope = 0.484 and intercept = 1.967),

PU *(y)* = 0.484PEU*(x)* + 1.967

4.7.2.6 The relationship between Perceived Ease of Use (PEU) and User Acceptance of Proposed System (UA)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.272[a]	.074	.070	.53851

a. Predictors: (Constant), PEU

Table 4. 39: Model summary for PEU and UA

As per the table 4.39, the R value of 0.272 represents a moderate correlation and R^2 value illustrates the variance (0.074). It means 7.4% of variation of UA could be explained by the PEU.

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4.712	1	4.712	16.247	.000[b]
	Residual	58.869	203	.290		
	Total	63.580	204			

a. Dependent Variable: UA

b. Predictors: (Constant), PEU

Table 4. 40: ANOVA for PEU and UA

As per the table 4.40, the F value is 16.247 and the model is significant at the level of 0.0000.

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.236	.338		6.613	.000
	PEU	.377	.094	.272	4.031	.000

a. Dependent Variable: UA

Table 4. 41: Coefficient table for PEU and UA

The Beta value of the coefficient table is 0.272 and it denotes positive relationship between PEU and UA. Therefore, when PEU increases, UA will increase.

The regression equation will be in the form of,

Dependent Variable *(y)* = Slope *(m)* x Independent Variable *(x)* + The Intercept *(c)*

Therefore, the equation for the linear regression line would be (slope = 0.377 and intercept = 2.236),

UA *(y)* = 0.377PEU*(x)* + 2.236

4.7.2.7 The relationship between Perceived User Benefits (PU) and User Acceptance of Proposed System (UA)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.805[a]	.648	.647	.33186

a. Predictors: (Constant), PU

Table 4. 42: Model summary for PU and UA

As per the table 4.42, the R value of 0.805 represents a strong correlation and R^2 value illustrates the variance (0.648). It means 64.8% of variation of UA could be explained by the PU.

Model	Sum of Squares	df	Mean Square	F	Sig.

1	Regression	41.225	1	41.225	374.334	.000[b]
	Residual	22.356	203	.110		
	Total	63.580	204			

a. Dependent Variable: UA

b. Predictors: (Constant), PU

Table 4. 43: ANOVA for PU and UA

As per the table 4.43, the F value is 374.334 and the model is significant at the level of 0.0000.

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.404	.208		-1.946	.053
	PU	1.079	.056	.805	19.348	.000

a. Dependent Variable: UA

Table 4. 44: Coefficient table for PU and UA

The Beta value of the coefficient table is 0.805 and it denotes positive relationship between PU and UA. Therefore, when PU increases, UA will increase.

The regression equation will be in the form of,

Dependent Variable *(y)* = Slope *(m)* x Independent Variable *(x)* + The Intercept *(c)*

Therefore, the equation for the linear regression line would be (slope = 1.079 and intercept = -0.404),

UA *(y)* = 1.079PU*(x)* – 0.404

4.7.2.8 The relationship between Congestion Pricing Acceptability (CPA) and Perceived User Benefits of Congestion Pricing (PUP) moderates by expressway user type

As per the 4.7.2.2, there is a week correlation between CPA and PUP. But the relationship is significant, and the relationship can denote as follows.

PUP *(y)* = 0.205CPA*(x)* + 2.922

As per the SPSS module development by A Hayes (2013), the moderator effect can be calculated by using 'model 1' conceptual diagram.

R	R-sq	MSE	F	df1	df2	p
.2418	.0584	.2637	4.1588	3.0000	201.0000	.0069

Table 4. 45: Model Summary

As per the table 4.45, the significance level ($p<0.01$) of the moderation between CPA and PUP exists. Also, the R value of 0.242 represents a week correlation and R^2 value illustrates the variance (0.584). It means 5.8% of variation of PUP could be explained by the CPA.

	coeff	se	t	p	LLCI	ULIC
constant	2.9276	.3374	8.6770	.0000	2.2623	3.5929
CPA	.1910	.0957	1.9960	.0473	.0023	.3798
UserType	-.0035	.1122	-.0314	.9749	-.2247	.2177
Int_1	.0060	.0319	.1875	.8514	-.0569	.0688

Table 4. 46: Model description

Product terms key: Int_1: CPA *(x)* x UserType *(w)*

	R2-chng	F	df1	df2	p
X*W	.0002	.0352	1.0000	201.0000	.8514

Table 4. 47: Test(s) of highest order unconditional interaction(s)

As per the tables 4.46 and 4.47, the respective p values for User Type and Int_1 is exceeding the acceptable significance level.

4.7.2.9 The relationship between Congestion Pricing Acceptability (CPA) and Perceived Ease of Use of Congestion Pricing (PEUP) moderates by expressway user type

As per the 4.7.2.1, there is a week correlation between CPA and PEUP. But the relationship is significant, and the relationship can denote as follows.

PEUP *(y)* = 0.184CPA*(x)* + 2.77

As per the SPSS module development by A Hayes (2013), the moderator effect can be calculated by using ‘model 1’ conceptual diagram.

R	R-sq	MSE	F	df1	df2	p
.2695	.0726	.1821	5.2488	3.0000	201.0000	.0017

Table 4. 48: Model Summary

As per the table 4.48, the significance level ($p<0.01$) of the moderation between CPA and PEUP exists. Also, the R value of 0.2695 represents a week correlation and R^2 value illustrates the variance (0.0726). It means 7.3% of variation of PEUP could be explained by the CPA.

	coeff	se	t	p	LLCI	ULIC
constant	2.6763	.2803	9.5469	.0000	2.1235	3.2290
CPA	.1939	.0795	2.4382	.0156	.0371	.3507
UserType	.0385	.0932	.4127	.6803	-.1453	.2222
Int_1	-.0044	.0265	-.1664	.8680	-.0566	.0478

Table 4. 49: Model description

Product terms key: Int_1: CPA *(x)* x UserType *(w)*

	R2-chng	F	df1	df2	p
X*W	.0001	.0277	1.0000	201.0000	.8680

Table 4. 50: Test(s) of highest order unconditional interaction(s)

As per the tables 4.49 and 4.50, the respective p values for User Type and Int_1 is exceeding the acceptable significance level.

4.7.2.10 The relationship between Subscription Model Acceptability (PS) and Perceived User Benefits of Subscription (PUS) moderates by expressway user type

As per the 4.7.2.4, there is a moderate correlation between PS and PUS. But the relationship is significant, and the relationship can denote as follows.

PUS *(y)* = 0.556PS*(x)* + 1.737

As per the SPSS module development by A Hayes (2013), the moderator effect can be calculated by using ‘model 1’ conceptual diagram.

R	R-sq	MSE	F	df1	df2	p
.5581	.3115	.1329	30.3111	3.0000	201.0000	.0000

Table 4. 51: Model Summary

As per the table 4.51, the significance level ($p<0.01$) of the moderation between PS and PUS exists. Also, the R value of 0.5581 represents a moderate correlation and R^2 value illustrates the variance (0.3115). It means 31.2% of variation of PUS could be explained by the PS.

	Coeff	se	t	p	LLCI	ULIC
constant	2.4662	.3607	6.8378	.0000	1.7550	3.1774
PS	.3461	.0982	3.5238	.0005	.1524	.5398
UserType	-.2852	.1106	-2.5785	.0106	-.5033	-.0671
Int_1	.0821	.0301	2.7240	.0070	.0227	.1415

Table 4. 52: Model description

Product terms key: Int_1: PS *(x)* x UserType *(w)*

	R2-chng	F	df1	df2	p
X*W	0254	7.4204	1.0000	201.0000	.0070

Table 4. 53: Test(s) of highest order unconditional interaction(s)

As per the tables 4.52 and 4.53, the respective p values for User Type and Int_1 is below the acceptable significance level. Hence, the model is acceptable and there’s an interaction.

4.7.2.11 The relationship between Subscription Model Acceptability (PS) and Perceived Ease of Use of Subscription (PEUS) moderates by expressway user type

As per the 4.7.2.3, there is a moderate correlation between PS and PEUS. But the relationship is significant, and the relationship can denote as follows.

$PEUS(y) = 0.458PS(x) + 2.099$

As per the SPSS module development by A Hayes (2013), the moderator effect can be calculated by using ‘model 1’ conceptual diagram.

R	R-sq	MSE	F	df1	df2	p
0.3865	0.1494	0.2215	11.7675	3.0000	201.0000	0.0000

Table 4. 54: Model Summary

As per the table 4.54, the significance level ($p<0.01$) of the moderation between PS and PEUS exists. Also, the R value of 0.3865 represents a moderate correlation and R^2 value illustrates the variance (0.1494). It means 14.9% of variation of PEUS could be explained by the PS.

	coeff	se	t	p	LLCI	ULIC
constant	2.2816	0.4656	4.9000	0.0000	1.3635	3.1998
PS	0.3939	0.1268	3.1059	0.0022	0.1438	0.6439
UserType	-0.0698	0.1428	-0.4890	0.6254	-0.3514	0.2117
Int_1	0.0247	0.0389	0.6340	0.5268	-0.0520	0.1013

Table 4. 55: Model description

Product terms key: Int_1: PS *(x)* x UserType *(w)*

	R2-chng	F	df1	df2	p
X*W	0.0017	0.4020	1.0000	201.0000	0.5268

Table 4. 56: Test(s) of highest order unconditional interaction(s)

As per the tables 4.55 and 4.56, the respective p values for User Type and Int_1 is exceeding the acceptable significance level.

As per figure 4.9, the people who rent vehicles are having less impact on PUS by PS. The people who use the expressway as passengers are having the highest impact on PUS by PS. Since the existing expressway tolling system is a time-consuming process, the passengers might show higher perceived user benefits.

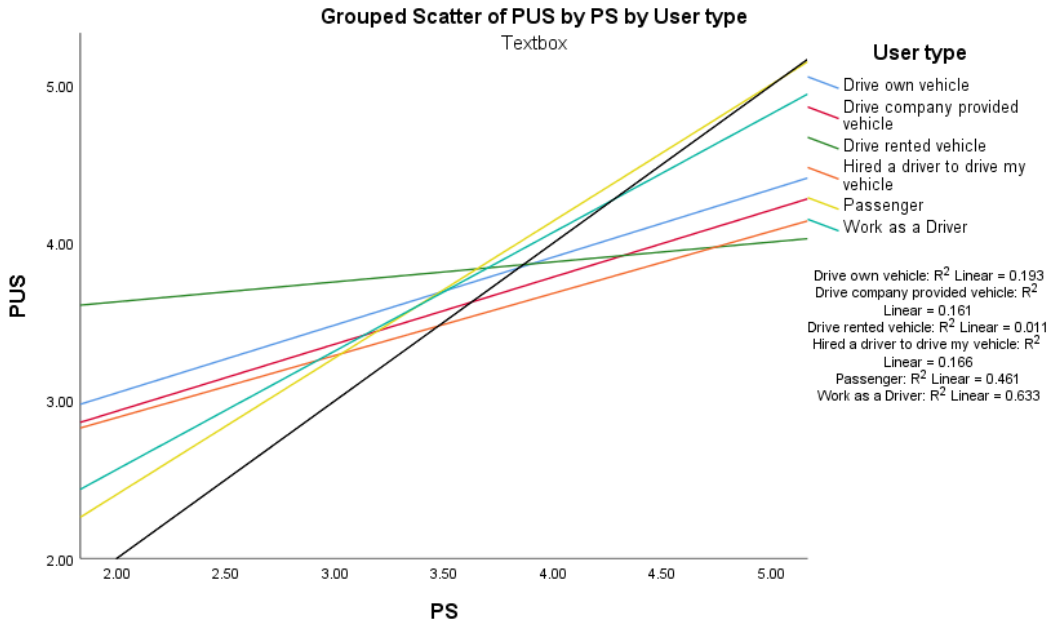

Figure 4. 9: Scatter plot for PUS by PU with User Type as moderator

4.7.3. Multiple Linear Regression to Compute the Model Relationship

Multiple regression concept can be used to calculate the relationship of the developed model.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.828[a]	.686	.680	.31576

a. Predictors: (Constant), PEU, CPA, PS, PU

Table 4. 57: Model Summary

As per the table 4.57, there's a positive relationship between independent variables (CPA, PS, PU, PEU) and dependent variable (UA). The correlation of the model indicates by the R value (0.828) and there's a strong positive relationship. R^2 value illustrates the variance (0.686). It means 68.6% of variation of dependent variable (UA) could be explained by the independent variables (CPA, PS, PU, PEU).

Model	Sum of Squares	df	Mean Square	F	Sig.

1	Regression	43.639	4	10.910	109.419	.000[b]
	Residual	19.941	200	.100		
	Total	63.580	204			

a. Dependent Variable: UA

b. Predictors: (Constant), PEU, CPA, PS, PU

Table 4. 58: ANOVA Table

As per the table 4.58, the F value is 109.419 and the overall model is significant at the level of 0.0000.

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	.107	.259		.415	.679		
	CPA	.085	.038	.091	2.225	.027	.935	1.070
	PS	-.210	.062	-.157	-3.413	.001	.742	1.348
	PU	1.229	.065	.917	18.867	.000	.664	1.507
	PEU	-.165	.063	-.119	-2.609	.010	.751	1.332

a. Dependent Variable: UA

Table 4. 59: Coefficients Table

As per the above table 4.59, the Beta values of both CPA and PU is positive, and it denotes a positive relationship towards dependent variable. The Beta value of both PS and PEU is negative, and it denotes a negative relationship towards dependent variable. Also, the variables are significant at the level of $p < 0.05$.

4.7.4. Hypothesis Testing

The hypothesis will be tested by using the questionnaire data. The results may justify whether to accept or reject each hypothesis. As discussed in chapter three, there are eleven hypotheses, and the results for each mentioned below.

Hypothesis 1 (H1): User concerns regarding the ANPR based congestion pricing acceptance has a positive effect on perceived ease of use.

As per the ANOVA table in 4.25, the result is significant at the level of 0.000, which is less than 0.05. Therefore, the null hypothesis can be rejected, and the alternate hypothesis can be accepted with a 95% level of confidence. Furthermore, the correlation coefficient is 0.249. Hence, there is a week, significant relationship between CPA and PEUP.

Hypothesis 2 (H2): User concerns regarding the ANPR based congestion pricing acceptance has a positive effect on perceived user benefits.

As per the ANOVA table in 4.28, the result is significant at the level of 0.001, which is less than 0.05. Therefore, the null hypothesis can be rejected, and the alternate hypothesis can be accepted with a 95% level of confidence. Furthermore, the correlation coefficient is 0.233 Hence, there is a week, significant relationship between CPA and PUP.

Hypothesis 3 (H3): User concerns regarding the ANPR based subscription model acceptance has a positive effect on perceived ease of use.

As per the ANOVA table in 4.31, the result is significant at the level of 0.000, which is less than 0.05. Therefore, the null hypothesis can be rejected, and the alternate hypothesis can be accepted with a 95% level of confidence. Furthermore, the correlation coefficient is 0.377. Hence, there is a week, significant relationship between PS and PEUS.

Hypothesis 4 (H4): User concerns regarding the ANPR based subscription model acceptance has a positive effect on perceived user benefits.

As per the ANOVA table in 4.34, the result is significant at the level of 0.000, which is less than 0.05. Therefore, the null hypothesis can be rejected, and the alternate hypothesis can be accepted with a 95% level of confidence. Furthermore, the correlation coefficient is 0.531. Hence, there is a moderate, significant relationship between PS and PUS.

Hypothesis 5 (H5): Perceived ease of use has a positive effect on perceived user benefits.

As per the ANOVA table in 4.37, the result is significant at the level of 0.000, which is less than 0.05. Therefore, the null hypothesis can be rejected, and the alternate hypothesis can be accepted with a 95% level of confidence. Furthermore, the correlation coefficient is 0.467. Hence, there is a week, significant relationship between PEU and PU.

Hypothesis 6 (H6): Perceived ease of use has a positive effect on user acceptance of the proposed system.

As per the ANOVA table in 4.40, the result is significant at the level of 0.000, which is less than 0.05. Therefore, the null hypothesis can be rejected, and the alternate hypothesis can be accepted with a 95% level of confidence. Furthermore, the correlation coefficient is 0.272. Hence, there is a week, significant relationship between PEU and UA.

Hypothesis 7 (H7): Perceived user benefits have a positive effect on user acceptance of the proposed system.

As per the ANOVA table in 4.43, the result is significant at the level of 0.000, which is less than 0.05. Therefore, the null hypothesis can be rejected, and the alternate hypothesis can be accepted with a 95% level of confidence. Furthermore, the correlation coefficient is 0.805. Hence, there is a strong, significant relationship between PU and UA.

Hypothesis 8 (H8): The user type of the expressway moderates the relationship between the user concerns regarding the ANPR based congestion pricing acceptance and their perceived benefits.

As per the ANOVA table in 4.47, the result is not significant at the level of 0.851, which is greater than 0.05. Therefore, the null hypothesis can be accepted, and the alternate hypothesis can be rejected with a 95% level of confidence.

Hypothesis 9 (H9): The user type of the expressway moderates the relationship between the user concerns regarding the ANPR based congestion pricing acceptance and their perceived ease of use.

As per the ANOVA table in 4.50, the result is not significant at the level of 0.868, which is greater than 0.05. Therefore, the null hypothesis can be accepted, and the alternate hypothesis can be rejected with a 95% level of confidence.

Hypothesis 10 (H10): The user type of the of expressway moderates the relationship between the user concerns regarding the ANPR based subscription payment acceptance and their perceived benefits.

As per the ANOVA table in 4.53, the result is significant at the level of 0.007, which is less than 0.05. Therefore, the null hypothesis can be rejected, and the alternate hypothesis can be accepted with a 95% level of confidence. Furthermore, the correlation coefficient is 0.558. Hence, there is a moderate, significant relationship between PS and PUS, and user type moderates the relationship.

Hypothesis 11 (H11): The user type of the expressway moderates the relationship between the user concerns regarding the ANPR based subscription payment acceptance and their perceived ease of use.

As per the ANOVA table in 4.56, the result is not significant at the level of 0.527, which is greater than 0.05. Therefore, the null hypothesis can be accepted, and the alternate hypothesis can be rejected with a 95% level of confidence.

4.8. Summary of the Findings and Discussion

As per the 1.4 research objective (2) and based on research findings, there is user acceptance of ANPR-based congestion pricing system for E02 and E03. According to table 4.22, the mean of the CPA is 3.472 where the standard deviation records as 0.5967 where over 68% of users respond between 2.875 and 4.069.

Also, as per the 1.4 research objective (3) and based on research findings, there is user acceptance of ANPR-based, subscription-based toll collection system for E02 and E03. According to table 4.22, the mean of the PS is 3.662, where standard deviation records

as 0.4167 where over 68% of users respond between 3.245 and 4.079. When compared with CPA, there is higher user acceptance for subscription-based toll collection methods.

Hypothesis Testing Summary

No	Hypothesis	Null Hypothesis (H_0)	Alternative Hypothesis (H_1)
H1	User concerns regarding the ANPR based congestion pricing acceptance has a positive effect on perceived ease of use.	Rejected	Accepted
H2	User concerns regarding the ANPR based congestion pricing acceptance has a positive effect on perceived user benefits.	Rejected	Accepted
H3	User concerns regarding the ANPR based subscription model acceptance has a positive effect on perceived ease of use.	Rejected	Accepted
H4	User concerns regarding the ANPR based subscription model acceptance has a positive effect on perceived user benefits.	Rejected	Accepted
H5	Perceived ease of use has a positive effect on perceived user benefits.	Rejected	Accepted
H6	Perceived ease of use has a positive effect on user acceptance of the proposed system.	Rejected	Accepted
H7	Perceived user benefits have a positive effect on user acceptance of the proposed system.	Rejected	Accepted

H8	The user type of the expressway moderates the relationship between the user concerns regarding the ANPR based congestion pricing acceptance and their perceived benefits.	Accepted	Rejected
H9	The user type of the expressway moderates the relationship between the user concerns regarding the ANPR based congestion pricing acceptance and their perceived ease of use.	Accepted	Rejected
H10	The user type of the of expressway moderates the relationship between the user concerns regarding the ANPR based subscription payment acceptance and their perceived benefits.	Rejected	Accepted
H11	The user type of the expressway moderates the relationship between the user concerns regarding the ANPR based subscription payment acceptance and their perceived ease of use.	Accepted	Rejected

Table 4. 60: Hypothesis Summary

4.9. Summary

The focus of this chapter is to analyze the data to achieve the objectives of the study. At the data cleaning process, the reliability and validity of the dataset were tested. Also, the normality of the dataset was tested. Then, by using the demographic data, the sample was analyzed. At the final stage, the correlation analysis and regression

analysis methods were used to understand the relationships. Based on the results, the hypothesis was tested.

CONCLUSION AND RECOMMENDATIONS

5.1. Introduction

This chapter would discuss all the conclusions extracted from the data analysis stage. As per the research objectives, the subscription-based toll system and the mechanism selected by referring to already implemented, successful toll collection methods and literature suggestions. Then the study focuses on how to implement the traffic analysis. Finally, the study focuses on the limitations and further research areas.

5.2. Conclusions and Implications

E02 and E03 expressway enables people to enter Colombo city with ease. There is congestion during peak hours at the entrance and exit toll plazas due to manual ticketing systems. RFID-based ETC system introduced in E03 as a solution but due to the limitations, it was not a successful solution. Both E02 and E03 operating presently without reaching their optimal vehicle handling capacity. ADB project lends a hand in the expansion of E02 and E03. They have also identified the issues with the present tolling mechanism. As per the research findings, people do not satisfy with the existing toll collection system. The CSAT below 80% is considered as an unsatisfied service, and the existing toll collection CSAT score is 53.2%.

As per the research findings, most of the users like to have a subscription-based tolling mechanism. Also, most of the expressway users are cost-conscious and they like to maximize their savings.

As the outcome of the research study, E02 and E03 expressway users are not satisfied with the existing tolling mechanism. According to the technology acceptance model, the proposed congestion-based and subscription-based highway toll collection mechanism with ANPR technology are accepting by the users. According to the conceptual framework, "User Type" is identified as the moderator variable, but it only moderates the relationship between the user concerns regarding the ANPR-based subscription payment acceptance and their perceived benefits. There is no moderator effect by "User Type" on the relationship between the user concerns regarding the ANPR-based subscription payment acceptance and their perceived ease of use. Also,

there is no moderator effect by "User Type" on the relationship between the user concerns regarding the ANPR-based congestion pricing acceptance and their perceived benefits. Also, there is no moderator effect by "User Type" on the relationship between the user concerns regarding the ANPR-based congestion pricing acceptance and their perceived ease of use.

5.3. Recommendations to the Expressway Development Unit at RDA

As explained in Chapter 02, there is an immense requirement on changing the expressway toll mechanism used in E02 and E03. Therefore, with the use of Artificial Intelligence (AI) and other business technology advancements, it is recommended to develop a new tolling mechanism. As per the research findings and the best implementation practices by other countries, subscription-based, congestion pricing influenced automatic toll collection mechanism would be suitable to replace with existing MTC and RFID based ETC system. Also, the ANPR technology would be the most appropriate technology to implement toll automation. Many Sri Lankan researchers have built ANPR models to implement on the expressways, and many studies are recommending how to implement the AI-based toll collection mechanism. With the successful implementations done in MLFF technology, it is recommended RDA study the MLFF mechanism. Then RDA can implement a subscription-based, automated toll collection system with congestion pricing options. The often expressway user can select the subscription payment option. The non-often expressway users may not tend to purchase the subscription-based system, therefore there should be an option for them to select ETC or MTC method with regular congestion-based pricing.

5.4. Limitations and Future Research

The focus of the study is to understand the user acceptance of the proposed system. Due to certain issues, the following limitations can be identified.

- The age of the sample was defined as 25 – 60 at the beginning. But E02 and E03 are using by all people irrespective of age.
- The education level of the user would influence the user acceptance of the proposed system. The study did not consider the user education level factor.
- The study focuses on the people who currently are using E02 and E03. It does not consider the potential people who are omitting the expressway.
- The proposed system can introduce on E01 – Sothern expressway, under developing Central expressway (04), and proposed expressway projects like Rathnapura expressway.
- The data collection was not perfect for some respondents and due to misunderstandings of certain terms used by the study.

By considering the limitations mentioned above, research recommendations can describe as follows.

- Future researchers can test for the moderation effect for age, gender and educational level.
- Future researchers can focus on potential user groups including those who are not using E02 & E03 and consider all expressways in Sri Lanka.
- Future researchers who intend to develop the expressway pricing system can consider the congestion pricing when preparing the pricing mechanism with a subscription-based toll collection system.
- Future researches who plans to develop ANPR system, it is recommend to study on developing integrated system by considering proposed system.

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APPENDIX A: QUESTIONAIRE

For each statement below, select the option that describes your experience with the current expressway toll pricing and toll collection system. Please mark 'X' in the appropriate box. Use the following rating scale:						
1–Strongly Disagree 2–Disagree 3–Neither Disagree nor Agree 4 – Agree 5–Strongly Agree		1	2	3	4	5
Section 01						
CS1	The existing toll collection system(s) used in expressway is easy to use	☐	☐	☐	☐	☐
CS2	The expressway toll collection mechanism encourage me to use the expressway again	☐	☐	☐	☐	☐
CS3	I am satisfied with the existing expressway toll collection mechanism.	☐	☐	☐	☐	☐
CS4	I am satisfied with the expressway toll rates	☐	☐	☐	☐	☐
CS5	By using toll roads (expressways) over other non-toll roads, I can save some money	☐	☐	☐	☐	☐
CS6	I received value for money service from expressways	☐	☐	☐	☐	☐
CS7	I recommend others to use the toll roads (expressway) over non-toll roads	☐	☐	☐	☐	☐

For each statement below, select the option that describes your knowledge and concerns regarding the congestion-based pricing and subscription services. Please mark 'X' in the appropriate box. Use the following rating scale:
Peak hours: 7.00am to 9.30am (morning) and 4.00pm to 9.30pm (evening)
Congestion pricing: Users have to pay a higher fee during peak hours and a lesser fee during off-peak hours.
Subscription-based payments: Pay fixed monthly rental to use the selected service at given conditions.

	1–Strongly Disagree 2–Disagree 3–Neither Disagree nor Agree 4 – Agree 5–Strongly Agree	1	2	3	4	5
	Section 02					
CPA1	I am willing to provide my travel records without any of my personal information to the government for further expressway developments.	☐	☐	☐	☐	☐
CPA2	It is fair to have a variable pricing system for expressway tolls according to the time of use. (peak hours and off peak hours)	☐	☐	☐	☐	☐
CPA3	I am willing to pay a higher fee for peak hours and a lesser fee for off-peak hours for my expressway travel	☐	☐	☐	☐	☐
CPA4	I am certain that government will use the expressway revenue to develop and maintain the roads and facilities.	☐	☐	☐	☐	☐
CPA5	I am satisfied with the effort government put to promote the electronic toll collection (ETC) system in Colombo - Katunayake expressway.	☐	☐	☐	☐	☐
CPA6	The price difference and less traffic will encourage me to use the expressway during off-peak hours.	☐	☐	☐	☐	☐
CPA7	The traffic jam near expressway toll booths will cause environmental pollution.	☐	☐	☐	☐	☐
PS1	I am curious about new subscription-based services	☐	☐	☐	☐	☐
PS2	Subscription-based services are reasonably priced	☐	☐	☐	☐	☐
PS3	Subscription services provide the proper benefit of discounts	☐	☐	☐	☐	☐
PS4	Subscription services enable more reasonable purchases than general ones	☐	☐	☐	☐	☐
PS5	Subscription-based services enable a convenient way to purchase and use	☐	☐	☐	☐	☐
PS6	Subscription-based purchases enable a quick and easy process	☐	☐	☐	☐	☐
PS7	Subscription-based services provide a pleasant and enjoyable experience	☐	☐	☐	☐	☐

For each statement below, select the option that describes your level of perceived usefulness of congestion based toll pricing system and subscription-based toll collection system.
Peak hours: 7.00am to 9.30am (morning) and 4.00pm to 9.30pm (evening)
Congestion pricing: Users have to pay a higher fee during peak hours and a lesser fee during off-peak hours.
Subscription-based payments: Pay fixed monthly rental to use the selected service at given conditions.
Automatic toll gates: Toll gates at the expressway entry/exit points will automatically open when you arrive without any human interaction.
Please mark 'X' in the appropriate box. Use the following rating scale:

1–Strongly Disagree 2–Disagree 3–Neither Disagree nor Agree 4 – Agree 5–Strongly Agree		1	2	3	4	5
Section 03						
PUP1	Automatic toll gates with congestion pricing based toll fee system will improve the quality of my expressway journey	☐	☐	☐	☐	☐
PUP2	Automatic toll gates with congestion pricing based toll fee system will give me control over my journey	☐	☐	☐	☐	☐
PUP3	Automatic toll gates with congestion pricing based toll fee system will work more quickly	☐	☐	☐	☐	☐
PUP4	Automatic toll gates with a congestion pricing based toll fee system will be a critical factor in my expressway journey	☐	☐	☐	☐	☐
PUP5	Automatic toll gates with a congestion pricing based toll fee system will increase the productivity of my journey	☐	☐	☐	☐	☐
PUP6	Automatic toll gates with a congestion pricing based toll fee system will increase my travel performances	☐	☐	☐	☐	☐
PUP7	Automatic toll gates with a congestion pricing based toll fee system will enable me to travel more using the expressway	☐	☐	☐	☐	☐
PUP8	Automatic toll gates with a congestion pricing based toll fee system will enhance the effectiveness of my journey	☐	☐	☐	☐	☐
PUP9	Using automatic toll gates with a congestion pricing based toll fee system would be easier to enter and exit from the toll gates	☐	☐	☐	☐	☐
PUP10	Overall, I find the automatic toll gates with a congestion pricing based toll fee system will be useful	☐	☐	☐	☐	☐
PUS1	Automatic toll gates with a subscription-based toll collection method will improve the quality of my expressway journey fee payments	☐	☐	☐	☐	☐
PUS2	Automatic toll gates with a subscription-based toll collection system will give me control over my journey fee payments	☐	☐	☐	☐	☐
PUS3	Automatic toll gates with a subscription-based toll collection system will work more quickly	☐	☐	☐	☐	☐

PUS4	Automatic toll gates with a subscription-based toll collection system will be a critical factor in my expressway journey fee payments	☐	☐	☐	☐	☐
PUS5	Automatic toll gates with a subscription-based toll collection system will increase the productivity of my journey	☐	☐	☐	☐	☐
PUS6	Automatic toll gates with a subscription-based toll collection system will increase my travel performances	☐	☐	☐	☐	☐
PUS7	Automatic toll gates with a subscription-based toll collection system will enable me to travel more using the expressway	☐	☐	☐	☐	☐
PUS8	Automatic toll gates with a subscription-based toll collection system will enhance the effectiveness of my journey	☐	☐	☐	☐	☐
PUS9	Using automatic toll gates with a subscription-based toll collection system would be easier to pay the toll fee	☐	☐	☐	☐	☐
PUS10	Overall, automatic toll gates with a subscription-based toll collection system will be useful	☐	☐	☐	☐	☐

For each statement below, select the option that describes your level of perceived ease of use of congestion based toll pricing system and subscription-based toll collection system.
Peak hours: 7.00am to 9.30am (morning) and 4.00pm to 9.30pm (evening)
Congestion pricing: Users have to pay a higher fee during peak hours and a lesser fee during off-peak hours.
Subscription-based payments: Pay fixed monthly rental to use the selected service at given conditions.
Automatic toll gates: Toll gates at the expressway entry/exit points will automatically open when you arrive without any human interaction.
Please mark 'X' in the appropriate box. Use the following rating scale:

1–Strongly Disagree 2–Disagree 3–Neither Disagree nor Agree 4 – Agree 5–Strongly Agree	1	2	3	4	5

Section 04						
PEUP1	I find it inconvenient to use automatic toll gates with a congestion pricing based toll fee system	☐	☐	☐	☐	☐
PEUP2	Learning to use automatic toll gates with a congestion pricing based toll fee system is easy for me	☐	☐	☐	☐	☐
PEUP3	Using automatic toll gates with a congestion pricing based toll fee system is often frustrating	☐	☐	☐	☐	☐
PEUP4	I find it easy to control my usage of automatic toll gates with a congestion pricing based toll fee system	☐	☐	☐	☐	☐
PEUP5	The automatic toll gates with a congestion pricing based toll fee system are rigid and inflexible to interact with	☐	☐	☐	☐	☐

PEUP6	I find it easy to become skillful to use the automatic toll gates with a congestion pricing-based toll fee system	☐	☐	☐	☐	☐
PEUP7	Overall, I find the automatic toll gates with a congestion pricing-based toll fee system are easy to use.	☐	☐	☐	☐	☐
PEUS1	I find it inconvenient to use automatic toll gates with a subscription-based toll collection system	☐	☐	☐	☐	☐
PEUS2	Learning to use automatic toll gates with a subscription-based toll collection system is easy for me	☐	☐	☐	☐	☐
PEUS3	Using automatic toll gates with a subscription-based toll collection system is often frustrating	☐	☐	☐	☐	☐
PEUS4	I find it easy to control my usage of automatic toll gates with a subscription-based toll collection system	☐	☐	☐	☐	☐
PEUS5	The automatic toll gates with subscription-based toll collection system are rigid and inflexible to interact with	☐	☐	☐	☐	☐
PEUS6	I find it easy to become skillful to use the automatic toll gates with a subscription-based toll collection system	☐	☐	☐	☐	☐
PEUS7	Overall, I find the automatic toll gates with a subscription-based toll collection system are easy to use.	☐	☐	☐	☐	☐

For each statement below, select the option that describes your expectations regarding proposed congestion based, subscription payment tolling system. Please mark 'X' in the appropriate box. Use the following rating scale:

Peak hours: 7.00am to 9.30am (morning) and 4.00pm to 9.30pm (evening)

Congestion pricing: Users have to pay a higher fee during peak hours and a lesser fee during off-peak hours.

Subscription-based payments: Pay fixed monthly rental to use the selected service at given conditions.

Automatic toll gates: Toll gates at the expressway entry/exit points will automatically open when you arrive without any human interaction

1–Strongly Disagree 2–Disagree 3–Neither Disagree nor Agree 4 – Agree 5–Strongly Agree	1	2	3	4	5

Section 05

UA1	I feel that the congestion-based subscription toll collection system is relevant and worth trying	☐	☐	☐	☐	☐
UA2	Sri Lankan expressway needs such innovations	☐	☐	☐	☐	☐
UA3	Proposed system will lead to better user satisfaction	☐	☐	☐	☐	☐
UA4	Proposed system is better than the existing toll collection mechanism	☐	☐	☐	☐	☐

For each statement below, please mark 'X' in the appropriate box. **Peak hours:** 7.00am to 9.30am (morning) and 4.00pm to 9.30pm (evening)										
Section 06										
1	Gender			☐ Male		☐ Female		☐ Prefer not to say		
2	Age	Below 25 ☐	25-29 ☐	30-34 ☐	35-39 ☐	40-44 ☐	45-49 ☐	50-54 ☐	55-59 ☐	60+ ☐
3	Currently I pay expressway tolls with		☐ MTC (Manual toll collection) system			☐ ETC (Electronic toll collection) system				
4	Expressway usage frequency per month		Never ☐	1 – 10 ☐	11 – 20 ☐	21 – 30 ☐	30+ ☐			
5	Expressway user type		Drive own vehicle ☐	Hired a driver to drive my vehicle ☐	Drive company provided vehicle (passenger or goods) ☐	Drive rented vehicle ☐	Work as a Driver ☐	Passenger ☐		
6	Vehicle type		Car/Cab ☐	Van ☐	Bus ☐	Lorry ☐				
7	Monthly income		Below Rs.50,000 ☐	50,001 – 75,000 ☐	75,001 – 100,000 ☐	100,001 – 125, 000 ☐	Above 125,000 ☐			

APPENDIX B: NORMALITY OF THE DATA

	N		Mean	Median	Mode	Std. Deviation	Skewness	Std. Error of Skewness	Kurtosis	Std. Error of Kurtosis	Minimum	Maximum
	Valid	Missing										
CS1	205	0	3.36	3.00	4	0.814	-0.575	0.170	-0.140	0.338	1	5
CS2	205	0	3.38	3.00	3	0.768	-0.444	0.170	0.366	0.338	1	5
CS3	205	0	3.32	3.00	4	0.818	-0.591	0.170	-0.340	0.338	1	5
CS4	205	0	3.39	4.00	4	0.887	-0.669	0.170	-0.136	0.338	1	5
CS5	205	0	3.49	4.00	4	0.861	-0.442	0.170	-0.206	0.338	1	5
CS6	205	0	3.62	4.00	4	0.774	-0.694	0.170	0.696	0.338	1	5
CS7	205	0	3.88	4.00	4	0.711	-0.653	0.170	1.755	0.338	1	5
CPA1	205	0	3.44	4.00	4	0.909	-0.484	0.170	0.149	0.338	1	5
CPA2	205	0	3.57	4.00	4	0.935	-0.317	0.170	-0.464	0.338	1	5
CPA3	205	0	3.25	3.00	4	0.951	-0.344	0.170	-0.477	0.338	1	5
CPA4	205	0	3.14	3.00	3	1.100	-0.195	0.170	-0.608	0.338	1	5
CPA5	205	0	3.23	3.00	4	1.068	-0.334	0.170	-0.610	0.338	1	5
CPA6	205	0	3.62	4.00	4	0.767	-0.294	0.170	-0.204	0.338	2	5
CPA7	205	0	3.93	4.00	4	0.760	-0.890	0.170	1.430	0.338	1	5
PS1	205	0	3.61	4.00	4	0.629	-0.422	0.170	0.055	0.338	2	5
PS2	205	0	3.58	4.00	4	0.619	-0.417	0.170	-0.076	0.338	2	5
PS3	205	0	3.59	4.00	4	0.706	-0.493	0.170	0.508	0.338	1	5
PS4	205	0	3.62	4.00	4	0.665	-0.699	0.170	0.301	0.338	2	5
PS5	205	0	3.77	4.00	4	0.563	-0.495	0.170	0.629	0.338	2	5
PS6	205	0	3.76	4.00	4	0.583	-0.513	0.170	0.674	0.338	2	5
PS7	205	0	3.71	4.00	4	0.664	-0.412	0.170	0.294	0.338	2	5
PUP1	205	0	3.68	4.00	4	0.793	-0.440	0.170	0.489	0.338	1	5
PUP2	205	0	3.57	4.00	4	0.728	-0.671	0.170	0.855	0.338	1	5
PUP3	205	0	3.71	4.00	4	0.709	-0.514	0.170	0.772	0.338	1	5
PUP4	205	0	3.47	4.00	4	0.758	-0.557	0.170	0.327	0.338	1	5
PUP5	205	0	3.62	4.00	4	0.714	-0.691	0.170	0.687	0.338	1	5
PUP6	205	0	3.55	4.00	4	0.689	-0.595	0.170	0.512	0.338	1	5
PUP7	205	0	3.58	4.00	4	0.735	-0.714	0.170	0.845	0.338	1	5
PUP8	205	0	3.61	4.00	4	0.689	-0.765	0.170	1.351	0.338	1	5
PUP9	205	0	3.77	4.00	4	0.737	-0.712	0.170	1.391	0.338	1	5
PUP10	205	0	3.78	4.00	4	0.731	-0.620	0.170	0.907	0.338	1	5
PUS1	205	0	3.86	4.00	4	0.619	-0.406	0.170	0.756	0.338	2	5
PUS2	205	0	3.75	4.00	4	0.652	-0.332	0.170	0.267	0.338	2	5
PUS3	205	0	3.86	4.00	4	0.653	-0.704	0.170	1.911	0.338	1	5
PUS4	205	0	3.62	4.00	4	0.707	-0.491	0.170	0.096	0.338	2	5
PUS5	205	0	3.72	4.00	4	0.609	-0.421	0.170	0.362	0.338	2	5
PUS6	205	0	3.79	4.00	4	0.613	-0.747	0.170	1.208	0.338	2	5
PUS7	205	0	3.71	4.00	4	0.626	-0.424	0.170	0.355	0.338	2	5
PUS8	205	0	3.78	4.00	4	0.532	-0.753	0.170	1.094	0.338	2	5
PUS9	205	0	3.88	4.00	4	0.610	-0.323	0.170	0.631	0.338	2	5
PUS10	205	0	3.87	4.00	4	0.644	-0.654	0.170	1.929	0.338	1	5
PEUP1	205	0	2.89	3.00	2	0.933	0.070	0.170	-0.777	0.338	1	5
PEUP2	205	0	3.67	4.00	4	0.783	-0.589	0.170	1.006	0.338	1	5
PEUP3	205	0	3.07	3.00	3	0.872	0.136	0.170	-0.924	0.338	1	5
PEUP4	205	0	3.57	4.00	4	0.680	-1.300	0.170	2.618	0.338	1	5
PEUP5	205	0	3.31	3.00	4	0.804	-0.741	0.170	-0.126	0.338	1	5
PEUP6	205	0	3.60	4.00	4	0.682	-1.087	0.170	2.142	0.338	1	5
PEUP7	205	0	3.73	4.00	4	0.611	-0.686	0.170	1.690	0.338	1	5
PEUS1	205	0	3.12	3.00	4	0.970	-0.150	0.170	-0.928	0.338	1	5
PEUS2	205	0	3.79	4.00	4	0.605	-0.403	0.170	0.566	0.338	2	5
PEUS3	205	0	2.91	3.00	2	0.940	0.069	0.170	-0.891	0.338	1	5
PEUS4	205	0	3.68	4.00	4	0.658	-0.597	0.170	1.096	0.338	1	5
PEUS5	205	0	3.44	4.00	4	0.870	-0.667	0.170	-0.019	0.338	1	5
PEUS6	205	0	3.80	4.00	4	0.611	-1.298	0.170	4.177	0.338	1	5
PEUS7	205	0	3.86	4.00	4	0.614	-0.167	0.170	0.198	0.338	2	5
UA1	205	0	3.62	4.00	4	0.714	-0.691	0.170	0.687	0.338	1	5
UA2	205	0	3.55	4.00	4	0.689	-0.595	0.170	0.512	0.338	1	5
UA3	205	0	3.58	4.00	4	0.735	-0.714	0.170	0.845	0.338	1	5
UA4	205	0	3.61	4.00	4	0.689	-0.765	0.170	1.351	0.338	1	5

APPENDIX C: RELIABILITY AND VALIDITY

Reliability scores received for each construct as follows.

Scale: Customer Satisfaction [CS]

Case Processing Summary

		N	%
Cases	Valid	205	100.0
	Excluded[a]	0	.0
	Total	205	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.708	7

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
CS1	21.08	8.876	.423	.674
CS2	21.05	9.365	.348	.692
CS3	21.12	8.388	.535	.644
CS4	21.05	8.498	.446	.668
CS5	20.94	8.418	.486	.657
CS6	20.81	9.407	.333	.696
CS7	20.55	9.553	.348	.691

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
24.43	11.590	3.404	7

Scale: Congestion Pricing Acceptability [CPA]

Case Processing Summary

		N	%
Cases	Valid	205	100.0
	Excluded[a]	0	.0
	Total	205	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.553	7

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
CPA1	20.75	9.141	.303	.505
CPA2	20.62	8.796	.355	.484
CPA3	20.94	9.075	.289	.510
CPA4	21.05	8.282	.338	.488
CPA5	20.96	8.768	.273	.518
CPA6	20.57	9.315	.370	.487
CPA7	20.26	10.920	.027	.600

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
24.19	11.635	3.411	7

Scale: Purchase Motives Subscription Services [PS]

Case Processing Summary

		N	%
Cases	Valid	205	100.0
	Excluded[a]	0	.0
	Total	205	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.780	7

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
PS1	22.02	6.681	.440	.765
PS2	22.06	6.555	.495	.754
PS3	22.04	6.111	.544	.744
PS4	22.01	6.309	.525	.748
PS5	21.87	6.438	.613	.734
PS6	21.87	6.641	.508	.752
PS7	21.92	6.621	.423	.769

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
25.63	8.508	2.917	7

Scale: Perceived Usefulness - Congestion Pricing [PUP]

Case Processing Summary

		N	%
Cases	Valid	205	100.0
	Excluded[a]	0	.0
	Total	205	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.897	10

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
PUP1	32.66	22.187	.640	.888
PUP2	32.77	22.815	.611	.889
PUP3	32.63	22.547	.676	.885
PUP4	32.87	22.997	.554	.893
PUP5	32.72	22.204	.726	.882
PUP6	32.79	22.863	.647	.887
PUP7	32.77	22.749	.615	.889
PUP8	32.73	23.099	.608	.889
PUP9	32.58	22.481	.655	.886
PUP10	32.56	22.159	.712	.882

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
36.34	27.599	5.253	10

Scale: Perceived Usefulness - Subscription [PUS]

Case Processing Summary

		N	%
Cases	Valid	205	100.0
	Excluded[a]	0	.0
	Total	205	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.869	10

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
PUS1	33.97	15.068	.555	.859
PUS2	34.09	14.884	.558	.859
PUS3	33.98	14.661	.607	.855
PUS4	34.21	14.627	.553	.860
PUS5	34.12	14.692	.655	.851
PUS6	34.05	14.762	.633	.853
PUS7	34.12	14.902	.584	.857
PUS8	34.06	15.075	.669	.852
PUS9	33.96	15.405	.489	.864
PUS10	33.96	14.822	.581	.857

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
37.83	18.119	4.257	10

Scale: Perceived Ease of Use - Congestion Pricing [PEUP]

Case Processing Summary

		N	%
Cases	Valid	205	100.0
	Excluded[a]	0	.0
	Total	205	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.651	7

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
PEUP1	20.96	7.322	.255	.656
PEUP2	20.18	7.247	.384	.607
PEUP3	20.79	7.522	.250	.652
PEUP4	20.28	7.135	.518	.573
PEUP5	20.54	7.299	.353	.617
PEUP6	20.25	7.286	.469	.586
PEUP7	20.12	7.774	.390	.611

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
23.85	9.478	3.079	7

Scale: Perceived Ease of Use - Subscription [PEUS]

Case Processing Summary

		N	%
Cases	Valid	205	100.0
	Excluded[a]	0	.0
	Total	205	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.580	6

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
PEUS1	17.68	4.857	.344	.525
PEUS2	17.01	6.064	.282	.551
PEUS3	17.89	4.580	.448	.466
PEUS4	17.12	5.506	.430	.495
PEUS5	17.36	5.604	.220	.581
PEUS7	16.94	6.222	.219	.571

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
20.80	7.269	2.696	6

Scale: User acceptance of proposed system [UA]

Case Processing Summary

		N	%
Cases	Valid	205	100.0
	Excluded[a]	0	.0
	Total	205	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.799	4

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
UA1	10.74	2.862	.668	.720
UA2	10.81	3.125	.570	.768
UA3	10.79	2.934	.601	.754
UA4	10.75	3.051	.608	.751

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
14.36	4.987	2.233	4

Reliability tests made after refining the questionnaire.

Scale: COngestion Pricing Acceptability [CPA] Except CPA7

Case Processing Summary

		N	%
Cases	Valid	205	100.0
	Excluded[a]	0	.0
	Total	205	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.600	6

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
CPA1	16.82	8.551	.290	.560
CPA2	16.69	8.067	.373	.526
CPA3	17.01	8.426	.288	.562
CPA4	17.12	7.657	.337	.543
CPA5	17.03	7.832	.326	.547
CPA6	16.64	8.693	.362	.537

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
20.26	10.920	3.305	6

Scale: Perceived Ease of Use - Subscription [PEUS] Except PEUS1, PEUS3 & PEUS5

Case Processing Summary

		N	%
Cases	Valid	205	100.0
	Excluded[a]	0	.0
	Total	205	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.736	3

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
PEUS2	7.54	1.220	.542	.672
PEUS4	7.64	1.132	.531	.689
PEUS7	7.47	1.133	.612	.589

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
11.33	2.309	1.520	3

APPENDIX D: DATA ANALYSIS

CSAT Score calculation

	CS1	CS2	CS3	CS4	CS5	CS6	Total
Freequency of 4	96	87	96	103	98	114	594
Freequency of 5	6	8	4	9	17	16	60
Total	102	95	100	112	115	130	654
Total Responces	205	205	205	205	205	205	1230

CSAT Score **53.2%**