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Returning to Public Transportation in Transitioning Out of COVID-19: Effects of Passenger Satisfaction on Frequency of Use of Rail Transport

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ABSTRACT: As travel restrictions ease amid the COVID-19 pandemic, a revival of traffic congestion is observed caused by the increased use of private vehicles. To help alleviate this, return to public transport use is encouraged. Given the positive relationship between passenger satisfaction and their recurrent use of public transit, it is then recommended to improve the service quality offered by these systems. This paper illustrates the use of a combination of principal component analysis and ordinal logistic regression in determining how satisfaction with rail transport service quality affects passengers' usage frequency with Bangkok's mass rapid transit system as a case study. The results show that satisfaction with ticket sales, station facilities, station staff, public relations, and rolling stock significantly affect passengers' recurrent use of the rail transport system. It is also determined that among these indicators, the station facilities, rolling stock, and station staff are found to contribute greatly to the marginal effects on the probability of observing more frequent use compared to less frequent use. It is then recommended that these factors be prioritized and further improved to produce higher levels of passenger satisfaction, and consequently, increased ridership of the rail transport system. The findings of this study can also be beneficial for public agencies and rail transport operators with regard to policy and decision making amid and in the transition out of the COVID-19 pandemic.

KEYWORDS: Passenger Satisfaction; Frequency of Use; COVID-19; Rail Transport; Ordinal Logistic Regression

1. INTRODUCTION

The COVID-19 pandemic has caused transit ridership to decrease significantly worldwide (Jenelius and Cebecauer, 2020; Qi et al., 2023; Xin et al., 2021; Chang et al., 2021; Pozo et al., 2022). The mass rapid transit system in Bangkok, Thailand is no exception with capacities dropping by 30%-40% due to social distancing measures (Siridhara, 2021). As the number of cases decrease and restrictions ease, traffic congestion is again felt by motorists. To help alleviate this, it is purposed that public transport ridership, especially train ridership, be boosted. With the influx of foreign travelers and the additional extension lines being in full operation, it is anticipated that the number of passengers increase and even exceed those of pre-pandemic levels (Katharangsiporn, 2022).

The goal of increased ridership is also in line with the numerous plans and development strategies of Thailand's Ministry of Transport such as the National Strategy 2018-2037 (NESDC, 2018) and the Thai Transport Infrastructure Development Plan 2015-2022 (OTP, 2015) which state the need to create and develop more public transportation infrastructures such as rail transport systems for easier mobility, accessibility, and economic development. Some performance indicators that determine if such goals are met is through people's satisfaction with public services and transit ridership (Liangrokapart, 2021).

Previous research has shown that there is a positive relationship between the frequency of use of passengers and their level of satisfaction with regard to the rail transport system service quality. Agarwal (2008), Kriswardhana et al. (2018), and Yilmaz et al. (2021) have found that the probability of passengers to travel by train increases the more satisfied they are with its service quality. Other researches by Wonglakorn et al. (2021) and Wang et al. (2020) support this conclusion that ridership is significantly affected by the level of satisfaction of the passengers with the rail transport service quality.

Considering the alleviation of road traffic congestion amid the COVID-19 pandemic, government goals on transit ridership, and the positive relationship between frequency of use and satisfaction with rail transport systems, the specific objectives of this study are as follows:

- To determine how satisfaction with service quality affect how frequent passengers use the rail transport;
- To identify which of the service quality indicators of rail transport most significantly affects the frequency of use of its passengers; and
- To estimate the probability of frequency of use given the satisfaction with service quality of rail transport.

While several studies have been conducted on the passenger satisfaction of rail transport systems in Thailand (Samithtiphechawong and Srising, 2020; Chongsanguan et al., 2016; Chaisomboon et al., 2020), limited research has focused on its relationship with passenger's frequency of use (Wonglakorn et al., 2021). A gap is also observed in the study of passenger satisfaction with rail transport amid the COVID-19 pandemic. This study contributes to the current knowledge through the illustration of the use of a combination of principal component analysis (PCA) and ordinal logistic regression (OLR) in the development of a quantitative model based on Bangkok's mass rapid transit system to analyze the effect on the frequency of use of passengers of rail transport systems given their level of satisfaction with service quality. Since service providers look into customer satisfaction for areas of improve-

ment in their systems, the findings of this study can also be beneficial for public agencies and rail transport operators with regard to policy and decision making especially in increasing train ridership amid the COVID-19 pandemic.

The rest of this paper is organized as follows: Section 2 presents the relevant information on Bangkok's mass rapid transit system, the impact of COVID-19 pandemic on the transportation sector in Bangkok, and literature on service quality and customer satisfaction; Section 3 explains in detail the data collection and analysis; Section 4 discusses the results found; and Section 5 summarizes the conclusions and recommendations.

2. LITERATURE REVIEW

2.1 Bangkok Mass Rapid Transit System

The Mass Rapid Transit Master Plan for the Bangkok Metropolitan Region (M-MAP) prepared by the Office of Transport and Traffic Policy and Planning is composed of 8 primary routes with a total length of approximately 556 km. This 20-year development plan for the rail transport system from 2010 to 2029 consists of two commuter lines, one airport rail link, five transit lines, and five feeder lines (JICA, 2019). The current condition of the system is summarized in Table 1 as modified from the study of Vichiensan et al. (2022). In this study, eight of the currently operating heavy rail lines from the mass rapid transit system were evaluated.

2.2 COVID-19 Impact on the Transportation in Bangkok

Thailand reported its first COVID-19 case in January of 2020, only the second country to do so after the first case was found in China. Since then, there have been 4,681,309 confirmed cases (as of September 30, 2022) with 32,764 deaths (WHO, 2022). Numerous restrictions have been placed including those that apply to public transportation such as mandatory wearing of masks, temperature checks upon entry to train stations, and social distancing.

Amid the COVID-19 pandemic, public transportation capacity decreased by approximately 30-40% due to social distancing measures. Demand also significantly reduced attributing to the increased work-from-home setup of businesses as well as the fear of passengers to contract the virus by using public transport (Siridhara, 2021). A report by BTS (2022), the concessionaire of Bangkok's Green Line Skytrain core network, noted the decrease in ridership where the average weekday ridership that was usually more than 700,000 trips dropped to almost half in fiscal year 2020 to 2021. A study by Zubair et al. (2022) which focused on the impact of the pandemic on the mode choice in Bangkok, also found that there is a decrease in the use of public transportation during the pandemic as compared to before, while private car use, paratransit, and active modes of travel increased. The same study also found that a significant amount of mass transit users pre-pandemic shifted to private modes of transport during the pandemic.

Considering the congestion before, during, and slowly out of the pandemic, it can be seen in Figure 1 that hourly congestion levels were high pre-pandemic (year 2019), then significantly decreased in 2021. However, these are now seen to be increasing again, almost nearing pre-pandemic values. With this trend, it is important to further promote the use of and gain back the trust in public transportation amid and out of the pandemic. One way is to increase passenger satisfaction through the improvement of service quality.

2.3 Service Quality

Service quality is an instrument used to evaluate how successful customers' needs are met (Wonglakorn et al., 2021). While there is no universal standard as to how service quality is to be measured nor is there consensus as to the specific dimensions it should encompass (Vicente et al., 2020), several theoretical frameworks have been developed as a criterion in evaluating the service quality of rail transport systems. Parasuraman et al. (1988) developed SERVQUAL which consists of the categories tangibles, reliability, responsiveness, assurance, and empathy. Cavana et al. (2007) extended the SERVQUAL to include the additional dimensions of comfort, connection, and convenience. Prasad and Shekar (2010) also proposed to extend the SERVQUAL by adding service product, social responsibility, and service delivery. Other stud-

Line	System	Section	Opening Year	Distance (km)
Dark Green	Heavy Rail	Initial Section	1999	6.5
		South Extension 1	2009	7.5
		South Extension 2	2013	
Light Green	Heavy Rail	Initial Section	1999	17
		East Extension 1	2011	5.3
		East Extension 2	2018	13
		North Extension 1	2019	19
		North Extension 2	2020	
Blue	Heavy Rail	Initial Extension	2004	20
		South Extension	2019	14
		West Extension	2019	13
Airport Rail Link	Heavy Rail	East Section	2010	28.5
Purple	Heavy Rail	North Section	2016	23
Dark Red	Heavy Rail	North Section	2021	26
Light Red	Heavy Rail	West Section 1	2021	15
Pink	Monorail	Full Line	(2023)	34.5
Yellow	Monorail	Full Line	(2023)	30.4
Orange	Heavy Rail	East Section	(2025)	21.2

Note: (Expected opening year)

Table 1. Current condition of the M-MAP.

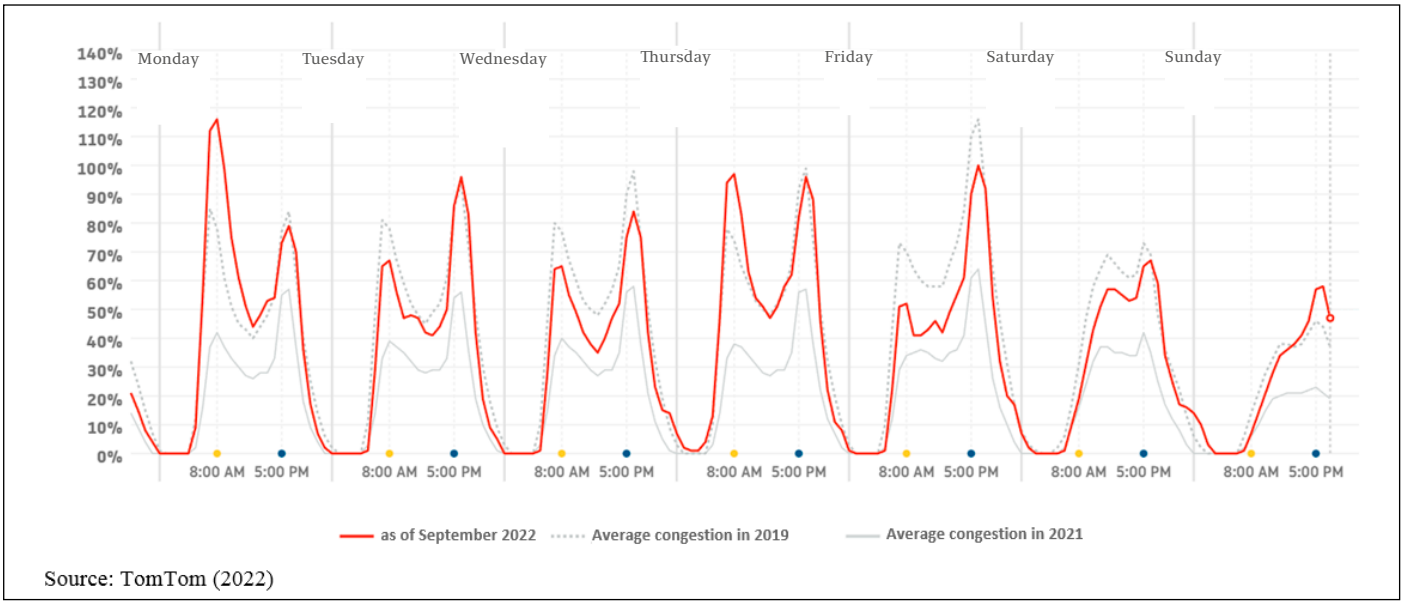

Figure 1. Hourly congestion levels in Bangkok.

		References									
Service Quality Indicators		**a**	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**
On-board experience	Cleanliness	x		x	x		x		x	x	x
	Comfort		x	x		x				x	x
	Accessibility (physical)	x		x					x		x
	On-board information	x		x			x		x		x
	Safety	x	x	x		x	x		x	x	x
	Temperature				x				x		x
Service delivery	Reliability					x	x		x		x
	Punctuality	x	x	x	x	x	x		x	x	x
	Frequency	x	x				x		x	x	x
	Travel time								x		x
	Network coverage	x		x	x						x
	Stop location		x						x	x	x
	Station parking			x				x	x		x
	Waiting time	x			x				x		x
Waiting conditions	Waiting conditions	x	x	x						x	x
	Information at stops	x					x		x	x	x
	Safety at stops					x	x	x	x	x	x
	Cleanliness at stops						x	x	x	x	x
Customer service	Staff behavior and attitude	x	x		x	x		x	x	x	x
	Personnel skills					x		x	x	x	x
	Complaint handling					x		x	x	x	x
Costs	Value	x	x		x					x	
	Types of tickets and passes	x	x								
	Ticket selling network			x				x		x	x

Note: a = Tyrinopoulos and Antoniou (2008), b = Githui, Okamura, & Nakamura (2010), c = Mohammad Das et al. (2013), d = Grujicic et al. (2014), e = Chowdhury, Alam, & Ahmed (2015), f = van Lierop, Badami, & El-Geneidy (2018), g = Kriswardhana, Hayati, & Septiana (2017), h = Chaisomboon, Jomnonkwao, & Ratanavaraha (2020), i = Jomnonkwao, Champahom, & Ratanavaraha (2020), j = CEN/TC 320 (2002)

Table 2. Service quality indicators summarized from literature.

ies developed their own list of service quality indicators as deemed fit for their respective study areas (de Oña et al., 2015; Eboli et al., 2016; Saw et al., 2020; Wang et al., 2020; Agarwal, 2008).

In the current study, service quality indicators were collected and summarized from literature. This includes past research on service quality and customer satisfaction as well as standards on quality determinants of public transportation such as the EN 13816:2002 Standard (CEN/TC 320, 2002). The significant indicators reviewed are summarized in Table 2. These are factors relating to on-board experience of passengers, service delivery, waiting conditions, customer service,

and costs. Given the limited research in Thailand, the service quality indicators need to be verified to be suitable for the study area. Expert consensus was then organized through a series of on-site and online meetings with experts from private and public sectors in Bangkok.

2.4 Customer Satisfaction and Frequency of Use

In the context of rail transportation, customer satisfaction can be defined as the feeling of passengers towards how their actual experience meet their expected service quality (Ali et al., 2021; Wonglakorn et al., 2021; Wang et al., 2020). It has also been found that customer satisfaction is an effective performance indicator of service quality (Trompet et al., 2013; Ngoc et al., 2017; Liangrokapart, 2021). That is, the quality of services being provided in rail transport can be evaluated by measuring how satisfied the passengers are. To further increase the level of satisfaction of customers, it is recommended that the quality of service be improved such that their expectations are met.

Researchers have also found that the more satisfied passengers are with the service quality of rail transport, the more likely the existing ones will keep using the service and the number of future customers will increase (Wang et al., 2020; Wonglakorn et al, 2021). This positive relationship suggests that the transit ridership can be improved by meeting the service quality expectations of the target customers of rail transport. In this study, the effects of the satisfaction with several service quality indicators on the frequency of use of passengers are assessed. The service quality indicators that have significantly greater impacts are also identified.

3. METHODOLOGY

3.1 Data Collection

The data was collected from eight lines of Bangkok's mass rapid transit system in November of 2021. This includes the sky trains Green and Gold Lines operated by the BTS Group Holdings Public Company Limited (BTS), metro Blue and Purple Lines operated by the Bangkok Expressway and Metro Public Company Limited (BEM), and Airport Rail Link and Red Line operated by the State Railway of Thailand (SRT). Collecting data from lines served by all three train operators in Bangkok allows for the general analysis of rail transport service quality and reduction of operator-related bias. More details on the selected rail lines are shown in Table 3.

The survey questionnaire (Appendix A) is composed of 2 sections. In the first section, the respondents were asked their socio-demographic characteristics (e.g., gender, age, monthly income) and travel information (e.g., trip purpose, frequency of use). In the second section, the respondents were asked to rate their level of satisfaction with the different service quality indicators using a Likert scale with 1 being very dissatisfied and 5 very satisfied. The list of the service quality indicators was obtained from related literature and validated through face-to-face and online meetings with experts in the public and private sectors in Bangkok.

A total of 1905 usable responses were collected. The demographics of the respondents are presented in Table 4. It can be seen that the majority of responses came from the working individuals (87.9%). This is expected as the data collection was conducted during the COVID-19 pandemic when studies were held online and leisure travels were discouraged.

3.2 Data Analysis

Both principal component analysis (PCA) and ordinal logistic regression (OLR) were used in analyzing the data. PCA was used to determine the underlying dimensions of the service quality indicators earlier identified (Bezerra and Gomes, 2015) while OLR was used to analyze the relationship between the ordinal dependent variable (frequency of use) and multiple independent variables (satisfaction with different service quality indicators).

Classification		Frequency	Percentage
Gender	Female	1060	55.6%
	Male	845	44.4%
Age	<= 20 years old	202	10.6%
	21 - 30 years old	709	37.2%
	31 - 40 years old	583	30.6%
	41 - 50 years old	219	11.5%
	> 50 years old	192	10.1%
Monthly Income	<= 15,000 Baht	403	21.2%
	15,001-30,000 Baht	879	46.1%
	30,001-50,000 Baht	430	22.6%
	50,001-70,000 Baht	159	8.3%
	> 70,000 Baht	34	1.8%
Trip Purpose	Shopping	139	7.3%
	Study	91	4.8%
	Work or Business	1675	87.9%

Table 4. Demographics of respondents.

The PCA aims to produce a simpler grouping of the service quality indicators (called principal components), which will be utilized as independent variables (or covariates) of the consequent regression analysis. With the use of PCA, multicollinearity, which can cause inaccuracy with the parameter estimates of the regression analysis, can be reduced

Train Line	Route	Number of Stations	Daily Ridership (approximate)	
			Pre-pandemic (2019)	During pandemic (2021)
Green Line (Sukhumvit Line)	Khu Khot - Kheha	47	740,000[a]	400,000[a]
Green Line (Silom Line)	National Stadium – Bang Wa	13		
Gold Line	Krung Thon Buri – Khlong San	3		
Blue Line	Tha Phra – Tao Poon – Lak Song	38	300,000 – 400,000[b]	76,000 - 116,000[b]
Purple Line	Khlong Bang Phai – Tao Poon	16		
Airport Rail Link	Phaya Thai – Suvarnabhumi	8	70,000[c]	10,000[c]
Red Line (Dark)	Bang Sue - Rangsit	10		3,000[c]
Red Line (Light)	Bang Sue – Taling Chan	4		

Sources: a = BTS (2022), b = BEM (2022), c = SRT (2021).

Table 3. Information on the analyzed train lines.

(Perez, 2017). The principal components that result from the PCA can also account for the correlations among the variables and make easier the interpretations of the underlying concepts within the data (Saw et al., 2020). Using Kaiser's stopping rule, which states that factors with eigen values greater than 1.00 will be considered (Brown, 2009a), a total of 7 principal components were extracted. The oblimin oblique rotation procedure was utilized (Brown, 2009b) and loadings of greater than 0.32 were deemed significant (Samuels, 2016).

The principal components (service quality indicators) extracted are the ticket sales (TS), stations facilities (SF), station safety and security (SSS), station staff (SS), public relations (PR), rolling stock (RS), and ride comfort (RC). TS includes the factors that are related to both the methods of sales as well as the worth of the ticket price itself. This indicator encompasses the satisfaction with the equipment used such as the working condition and availability of self-service automatic ticket machines, convenience of buying tickets, varieties of top-up options both online and at the station cashier booths, the appropriateness of the ticket price based on distance traveled and ride comfort, and the protection of the rights of passengers in terms of ticket cancellation and refunds.

The SF indicator reflects the satisfaction with the easy and convenient access to the station, availability of parking spaces such as park-and-ride facilities that meet even peak hour demand, walkways and pick-up/drop-off areas, clarity of directional signs and station maps, passenger display information and audio announcements, automatic ticket gate services, sufficient platform space for waiting passengers, vertical transport systems such as elevators and escalators, and other facilities such as wheelchair ramps for the disabled, ATMs, and shops. The SSS covers the satisfaction with the station cleanliness and availability of trash bins, efficient ventilation and air-conditioning system, presence of security surveillance (security guards, safety zone markings, baggage inspection), and safety from crime and theft especially in poorly lit areas and blink spots at the stations.

The SS indicator focuses on how passengers are satisfied with station personnel services. This includes cashiers at ticket booths, those that help guide tourists, the elderly, and the disabled, baggage inspectors, and staff that assist in crowd and queue control during peak hours. Passenger satisfaction with the politeness and enthusiasm of staff when asked for their assistance, as well as their attitude and competence in providing accurate information were evaluated. PR is another indicator which covers the satisfaction with the availability of passenger information in various sources, notifications of delay and disruption, and efficiency of making complaints and how they are handled.

RS comprises of the satisfaction with operation-related factors such as punctuality and frequency of train arrivals, delay management, and sufficiency and cleanliness of seats and handrails inside the trains. Lastly, the RC indicator pertains to the satisfaction with ease and comfort of using an application complete with up-to-date service information, inclusivity of train facilities for the disabled, the elderly, and pregnant women, and on-board ambiance, safety, and security. A summary of all seven service quality indicators is shown in Table 5.

OLR was used to determine the relationship between the frequency of use of passengers and their satisfaction with the service quality of the mass rapid transit system. The flow of methods used for the OLR is shown in Appendix B. The following assumptions of OLR were first tested:

- The dependent variable is ordinal;
- The independent variables may be continuous, categorial, or ordinal;
- There is no multi-collinearity; and
- The model follows the proportional odds model.

In this study, the dependent variable is how frequent the passengers use the service. The ordinal values of the frequency of use are indicated as follows: 1 – less than once a week, 2 – once or twice a week, 3 –three to four times per week, 4 – more than 4 times per week. This assumption meets the OLR requirement that the dependent variable must be measured on an ordinal level. The second assumption of having independent variables that are either continuous, categorical, or ordinal is met by using the averaged the levels of satisfaction of the items that highly load on each principal component (Bezerra and Gomes, 2015).

The multicollinearity assumption was checked and it was found that the independent variables were not highly correlated with each other. The fourth assumption (proportional odds or parallel lines assumption) assumes that the predictors have equal impact across all thresholds (Cohen et al., 2003). This means that the values of the parameter estimates are the same for all logit equations and only the threshold values change. These thresholds need not be spaced equally considering that only the ordinal nature of the variable is assumed (Cohen et al., 2003). The result of the test of parallel lines shown in Table 6 meets this criterion. The sig. value of 0.203 indicates failure to reject the null hypothesis that the location parameters or slope coefficients are the same across the response categories with 95% confidence.

Component	Service Quality Indicator		Description
1	TS	Ticket Sales	TS indicates the satisfaction on the method of sales of tickets as well as the value of money of the ticket prices.
2	SF	Station Facilities	SF indicates the satisfaction on the accessibility of the station, quality and availability of facilities, information available for users, and station inclusivity to people with disabilities.
3	SSS	Station Safety and Security	SSS pertains to the satisfaction on how safe and secured passengers feel when using the rail transport services.
4	SS	Station Staff	SS relates to the satisfaction of respondents regarding the personality, politeness, and service offered by staffs at the station.
5	PR	Public Relations	PR indicates the satisfaction with information dissemination, unusual events notification, and complaints handling.
6	RS	Rolling Stock	RS pertains to the satisfaction with the operations of the rail transport system and readiness and cleanliness of the trains.
7	RC	Ride Comfort	RC relates to the inclusivity of train facilities, ambiance, and safety and security inside the trains.

Table 5. Service quality indicators.

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Null Hypothesis	4214.259			
General	4196.170	18.089	14	.203

Table 6. Test of parallel lines.

Indicators (Cronbach's alpha)	TS (0.680)	SF (0.926)	SSS (0.908)	SS (0.945)	PR (0.946)	RS (0.915)	RC (0.902)	Communalities
Ticket Sales (TS)								
Sales equipment		0.691						0.469
Method of sales		0.721						0.562
Top-up options		0.421						0.315
Cost/distance		0.363						0.331
Value of comfort		0.548						0.433
Passenger rights		0.735						0.583
Station Facilities (SF)								
Accessibility	0.488							0.648
Parking	0.583							0.656
Walkways	0.653							0.708
Pick-up/drop-off	0.695							0.674
Directional information	0.773							0.709
Travel information	0.833							0.705
Ticket gates	0.788							0.732
Waiting area	0.801							0.738
Vertical transport	0.739							0.700
Other facilities	0.615							0.510
Station Safety and Security (SSS)								
Station cleanliness							-0.600	0.747
Air quality							-0.679	0.785
Station safety							-0.672	0.787
Station security							-0.655	0.732
Station Staff (SS)								
Staff personality				0.873				0.844
Staff attitude				0.905				0.887
Staff competence				0.898				0.889
Public Relations (PR)								
Information availability					-0.884			0.798
Notifications					-0.919			0.858
Complaint channels					-0.974			0.892
Complaint management					-0.973			0.894
Rolling Stock (RS)								
Punctuality						-0.655		0.729
Frequency						-0.632		0.722
Delay management						-0.578		0.742
Train cleanliness						-0.591		0.711
Ride Comfort (RC)								
Service application			-0.566					0.585
Universal design			-0.656					0.705
On-board air quality			-0.706					0.739
On-board safety			-0.751					0.772
On-board security			-0.736					0.758
Eigen values	16.273	2.220	1.993	1.859	1.705	1.248	1.104	
% variance	42.823	5.842	5.243	4.892	4.487	3.284	2.905	
% cumulative	42.823	48.665	53.909	58.801	63.288	66.572	69.477	

Kaiser-Meyer-Olkin measure of sampling adequacy (KMO) = 0.955, Bartlett's Test of Sphericity sig. = 0.000

Table 7. PCA results.

The OLR model can be developed using Equation 1 (Orme and Combs-Orme, 2009)

$$Logit\,[Prob(Y \leq j)] = t_i - (\beta X_1 + \beta X_2 + \cdots + \beta X_k) \quad \text{Equation 1}$$

where Y is the dependent variable with ordinal values j, X represents the independent variables, and t_j is the threshold. Since OLR considers the dependent variable as ordinal values, it produces the cumulative probabilities and odds-ratios based on these cumulative probability value s which is contrary to binary and multinomial logistic regression which calculate the direct individual probabilities of the levels of the dependent variable (Orme and Combs-Orme, 2009). The odds-ratio and estimated cumulative probability can be calculated using Equations 2 and 3, respectively. In this study, the estimated probabilities are also explained through the values of the odds-ratios generated from the model.

$$Odds - ratio = e^{Logit} \quad \text{Equation 2}$$

$$Estimated\ cumulative\ probability = odds - ratio\ /\ (1 + odds - ratio) \quad \text{Equation 3}$$

4. RESULTS AND DISCUSSION

4.1 Principal Component Analysis

The adequacy of the PCA was confirmed using the Kaiser-Meyer-Olkin measure of sampling adequacy (KMO) and Bartlett's Test of Sphericity. The KMO was determined to be 0.955, meaning that the data is suitable for the PCA method (Wang et al., 2020). The Bartlett's Test of Sphericity resulted in a sig. value of 0.000, indicating the effectiveness of the PCA (Bezerra and Gomes, 2015).

It is important to note that one variable was excluded (onboard information) due to its being a complex variable i.e., it loads highly on more than one principal component. A solution resulting in a simple structure (Brown, 2009b) representing 69.477% of total variance was obtained (Table 7). The internal consistency using Cronbach's alpha was determined to be greater than 0.60 for all service quality indicators, indicating the validity of measures used (Ursachi et al., 2015).

4.2 Ordinal Logistic Regression

According to the model fitting information in Table 8, the OLR model presents a significant improvement when compared with the baseline intercept-only model. The goodness-of-fit result in Table 9 showing a Pearson sig. value of 0.095 indicates that the data also fits the model well.

The result of the OLR at 95% confidence is shown in Table 10. It can be seen that the significant factors affecting frequency of use of passengers are ticket sales, station facilities, station staff, public relations, and rolling stock. Consistent with the research of Wang et al. (2020) who investigated the impact of service quality and customer satisfaction on the intention to reuse the urban rail transit in China, the authors also found that factors related to fare policy, quality of tangible equipment, planning, and reliability of the service promote passengers' recurrent use.

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	4680.803			
Final	4214.259	466.544	7	.000

Table 8. Model fitting information.

	Chi-Square	df	Sig.
Pearson	4641.981	4517	.095
Deviance	4046.056	4517	1.000

Table 9. Goodness-of-fit.

The finding that the levels of satisfaction with station safety and security and ride comfort is not significant may suggest that these factors are deemed as a minor concern in regard to the passenger's frequency of use in the setting of Bangkok. A contrasting view is seen in other researches such as one in China by Dong et al. (2021) which showed that passengers' feeling of safety enhanced their overall satisfaction with public transport in post-COVID-19 pandemic, and notes that this relates to their confidence in the use of it. In Germany, the decline in public transport use amid the lockdowns is partly attributed to how less comfortable stable public transport users felt during the pandemic (Eisenmann et al., 2021). Another differing view is from the study of Beck, Hensher, & Nelson (2021) where the authors assessed different pandemic waves in Australia and found that higher concern with public transport crowding and hygiene equates to more trips, but notes that this may be an indication of captive use.

In the local setting, a study conducted by Zubair et al. (2022) in Thailand explains that the priorities of passengers in their mode choice now focus on pandemic-related factors such as social distancing, wearing of face masks, and infection concerns from pre-pandemic considerations of travel time savings, safety and security, and comfort. In addition, Wang et al. (2020) expounds that comfort and safety were not the most important attributes, as opposed to developed countries, because passengers can tolerate these conditions

		Estimate	Std. Error	Wald	Sig.	95% Confidence Interval		e^{β}
						Lower Bound	Upper Bound	
Threshold	[Frequency of use = 1]	6.140	.467	172.780	.000	5.224	7.055	
	[Frequency of use = 2]	7.421	.476	243.396	.000	6.489	8.353	
	[Frequency of use = 3]	8.688	.487	317.869	.000	7.733	9.643	
Location	TS	-.538	.094	33.049	.000	-.721	-.354	0.584
	SF	.683	.124	30.506	.000	.441	.925	1.980
	SSS	.133	.118	1.270	.260	-.098	.364	1.142
	SS	.442	.103	18.351	.000	.240	.645	1.556
	PR	.331	.086	14.922	.000	.163	.500	1.393
	RS	.466	.124	14.145	.000	.223	.709	1.593
	RC	.206	.123	2.820	.093	-.034	.447	1.229

R^2 Cox and Snell = 0.217, R^2 Nagelkerke = 0.232, and R^2 McFadden = 0.089

Table 10. Parameter estimation.

and so they tend to pay less attention to these indicators. On a positive note, the result may also suggest that passengers are already satisfied with the quality of these indicators that it may be deemed insignificant to their frequency of use; especially that passengers already expect that they will be comfortable when riding trains and sees this as an advantage of the service (Trepáčová et al., 2020). This presents the disparity with other modes such as buses wherein comfort level is recommended to be improved to enhance the service quality of public transportation as perceived by passengers (Hasan, Whyte, & Al Jassmi, 2021).

Looking at the signs of the estimates, the directions of the estimate values of all independent variables except TS are positive. This indicates that a passenger is more likely to have higher frequency of use the higher his/her level of satisfaction is in station facilities, station staff, public relations, and rolling stock. It is interesting to note that the estimate value for ticket sales was found negative. Such finding may be attributed to how the data showed high frequency of use irrespective of the low satisfaction level with this indicator. In interpreting this result, it is important to consider the relationship between the dependent and independent variables while taking note of passenger consumer behavior (Bezerra and Gomes, 2015) as well as differences in culture (Wang et al., 2020).

Studies in the Thailand setting support the finding that ticket sale factors, especially fare prices, are deemed insignificant by public transport passengers. Research on the service quality of public road transit found that Thai passengers who avail of the services are least satisfied with public transport fares (Ueasangkomsate, 2019). Another study which surveyed the elderly users of public transport in Thailand found that irrespective of the importance performance analysis approach used, affordability of public transport is not of utmost significance to passengers (Chaisomboon et al., 2020). Inmor et al. (2021), upon studying the passenger behavioral response to off-peak fare reduction in the Airport Rail Link in Bangkok, also found that some demographic groups of passengers (those who are in the older generations, have higher income, and attained higher educational attainment) opt for higher ticket prices even when offered fare reduction if they change their travel time period. Considering these behaviors of passengers in Thailand and the results of the regression analysis, it can be inferred that regardless of the passengers' low satisfaction with ticket sales, high frequency of use can still be observed. The negative sign of the estimate of ticket sales may not necessarily indicate that an increase in the level of satisfaction with ticket sales results in higher probability of having less frequent use of the service. However, it can be estimated that higher levels of satisfaction with the other significantly influencing indicators such as station facilities, station staff, public relations, and rolling stock even when coupled with a low level of satisfaction with ticket sales can result to more recurrent use of the service.

The magnitude of the marginal effects on the probability of observing more frequent use of service compared to less frequent use can be observed in the odd-ratio values. For better visualization, Figure 2 presents the principal components with varying marginal effects. Figure 2a shows the station facilities with 1.980 odds-ratio. It can be seen that the platform offers sufficient space for demand with clear floor markings and monitor showing the schedule and other announcements. Figure 2b provides visualization of the rolling stock (odds-ratio of 1.593) with ample seating space, hand rails, and on-board information to passengers. Lastly, Figure 2c presents an example of public relations (odds-ratio of 1.393) listing the online channels and phone contact information for news and updates on the train line.

Interpreting the service indicator with the greatest odds-ratio as an example, an increase in the level of satisfaction with station facilities would result in a 98% increase in odds. This result is similar to the findings of Wonglakorn et al. (2021) where the researchers have found that the station factor should be prioritized to increase passenger satisfaction and consequently, loyalty among existing and future customers of rail transport systems.

Rolling stock and station staff, the indicators with the next highest marginal effects, have odds-ratios of 1.593 and 1.556, respectively. This result indicates that the factors relating to the operations of the mass rapid transit system (punctuality, frequency, delay management) and station staff attitudes toward passengers are deemed to have great effects on how frequent the services are used with values of 59.3% and 55.6%, respectively. Given that majority of the passengers were workers, it is suggested that the system operations be further improved during the peak periods of going to and leaving from work, alike to the recommendations of Hasan, Whyte, & Al Jassmi (2021). Similar interpretation can be made concerning the odds-ratios of the other service quality indicators.

5. CONCLUSION AND RECOMMENDATION

Return to public transport use is recommended as increased traffic congestion levels is again observed in transitioning out of the COVID-19 pandemic. Considering the positive relationship of recurrent use of public transportation and customer satisfaction, this paper investigates how satisfaction with service quality affects passenger's frequency of use in the case of Bangkok's mass rapid transit system using principal component analysis and ordinal logistic regression. The service quality indicators that were found to significantly affect

(a) Station facilities (odds-ratio: 1.980)

(b) Rolling stock (odds-ratio: 1.593)

(c) Public relations (odds-ratio: 1.393)

Source: Authors

Figure 2. Principal components of varying odds ratios.

the frequency of use are the factors related to ticket sales, station facilities, station staff, public relations, and rolling stock. The results of the analysis also suggest that higher levels of satisfaction with the positively influencing indicators station facilities, station staff, public relations, and rolling stock even when coupled with a low level of satisfaction with ticket sales can result to more recurrent use of the service. It was also determined that station facilities has the highest marginal effect on the probability of observing more frequent use compared to less frequent use (98%), followed by rolling stock (59.3%) and station staff (55.6%). It is recommended that these service quality indicators be prioritized and further improved to produce higher levels of passenger satisfaction, and consequently, more recurrent use of the rail transport system. It is also suggested that the findings of this study be used for policies and decision making of public transit operations especially amid that COVID-19 pandemic.

For future research, it is recommended that other types of rail transport systems and public transport modes such as regional rails, buses, and trams be studied. It is also beneficial to consider the effects of the respondents' socio-demographics to determine the differences among the characteristics of the population with regard to their levels of satisfaction and public transport use.

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APPENDIX A. SURVEY QUESTIONNAIRE (TRANSLATED FROM THAI TO ENGLISH)

Staff Only

Date (MM/DD/YY): ____/____/_____ Questionnaire No.: ☐☐☐ Rail Route: ☐ Green Line ☐ Blue Line ☐ Purple Line

Origin Station: _____ Destination Station: _____ ☐ ARL ☐ Gold Line ☐ Red Line ☐ Others _____

Part 1: Respondent and Travel Information

1. Gender ☐ Male ☐ Female ☐ Prefer not to say

2. Age ☐ ≤ 20 years old ☐ 21-30 years old ☐ 31-40 years old
☐ 41-50 years old ☐ > 50 years old

3. Monthly Income ☐ ≤ 15,000 Baht/month ☐ 15,001 – 30,000 Baht/month
☐ 30,001 – 50,000 Baht/month ☐ 50,001 – 70,000 Baht/month
☐ > 70,000 Baht/month

4. Travel Purpose ☐ Work/Business ☐ Study ☐ Shopping ☐ Others: _____

5. Mode of travel before using the service (can have more than one answer)
☐ Walk ☐ Motorcycle Taxi ☐ Motorcycle ☐ Private Car
☐ Taxi ☐ Public Van ☐ Public Bus
☐ Rail Transit: _____ ☐ Others: _____

6. Mode of travel after using the service (can have more than one answer)
☐ Walk ☐ Motorcycle Taxi ☐ Motorcycle ☐ Private Car
☐ Taxi ☐ Public Van ☐ Public Bus
☐ Rail Transit: _____ ☐ Others: _____

7. Regular travel period (can have more than one answer)
☐ 00:00-06:00 ☐ 06:01-09:00 ☐ 09:01-12:00 ☐ 12:01-16:00
☐ 16:01-19:00 ☐ 19:01-21:00 ☐ 21:01-23:59

8. Reasons for using the service (can have more than one answer)
☐ To avoid traffic congestion ☐ To save travel time
☐ To save travel cost ☐ For safety
☐ Train route coverage area (accessibility) ☐ Train punctuality (reliability)
☐ Ability to transfer to another transport system ☐ Promotion/discount
☐ Others: _____

9. Frequency of using the service
☐ Less than once a week ☐ Once or twice a week
☐ Three to four times per week ☐ More than four times per week
☐ Others: _____

Part 2: Customer Satisfaction

Please put ✓ in the level that corresponds to your satisfaction.

2.1 Satisfaction with Ticket Price and Sales

Item	Satisfaction Level				
	Extremely Satisfied	Very Satisfied	Satisfied	Dissatisfied	Very Dissatisfied
Serviceability and readiness to use of ticket booths and automatic ticket vending machines					
Convenient and fast methods of selling and paying for tickets					
Various convenient methods for topping up tickets such as ticket booths, automatic ticket vending machines, mobile application, and internet banking					
Appropriateness of ticket price for traveling distance					
Appropriateness of ticket price for service comfort and convenience					
Fairness and appropriateness of the protection of passengers' rights such as in ticket cancellation and ticket refunding					

2.2 Satisfaction with Transit Station

Item	Satisfaction Level				
	Extremely Satisfied	Very Satisfied	Satisfied	Dissatisfied	Very Dissatisfied
1. Satisfaction with facilities at the station					
Ease and convenience to access a station					
Proper Park-and-Ride (P&R) facilities that are ready to use					
Proper walkway available and ready to use					
Convenient and safe passenger pick-up point/s					
Clear directional signs and maps showing the routes inside the station					
Display information and audio announcement about travel information and necessary travel advices such as the next station, route, warnings and precautions					
Automatic ticket gates in service and ready for use					
Sufficient and suitable spaces for waiting for trains at the platform					
Availability and readiness to use of escalator/s and elevator/s and wheelchair ramps for the handicapped					
Other facilities that are adequate and appropriate such as ATMs, shops, and convenience stores					
2. Satisfaction with security and safety at the station					
Cleanliness of stations and surrounding areas					
Efficiency of ventilation system/ air conditioning system (no unpleasant odors and have right temperature)					
Safety in using the service with presence of security guards, yellow lines indicating safety zones at platforms, and passenger baggage inspection					
Safety from crime and theft especially in dimly lit areas and blind spots					

3. Satisfaction with staff at the station					
Staff personality and dress-code					
Polite and enthusiastic service/assistance					
Provision of accurate information when asked for help and effective problem solving					
4. Satisfaction with public relations, information provision, and complaint handling					
Accessibility and convenient channels to information and news on services					
Clear and up-to-date notification of delays/disruptions/unusual events					
Channels and ease of filing for complaints					
Ability to resolve complaints quickly and effectively					

2.3 Satisfaction of Rolling Stock

Item	Satisfaction Level				
	Extremely Satisfied	Very Satisfied	Satisfied	Dissatisfied	Very Dissatisfied
Service punctuality					
Frequency of operations during peak and off-peak hours					
Management of delay/disruption/unusual incidents					
Vehicle cleanliness (inside and outside the trains)					
Sufficiency, availability, and cleanliness of seating and handrails					
Display information and audio announcement inside the trains about travel information and necessary travel advices such as the next station, route, warnings and precautions					
Application that provides sufficient, complete, and real-time service information					
Adequacy and appropriateness of other facilities inside the trains such as seats for the disabled, the elderly, and pregnant women, and lock for wheelchairs					
Efficiency of ventilation system/ air conditioning system (no unpleasant odors and have right temperature) inside the trains					
Safety in using the service with presence of security (e.g., guard, camera) on the trains and inspection of suspicious or foreign objects					
Safety from crime and theft inside the trains					

APPENDIX B. STUDY METHODOLOGY OF THE OLR MODEL