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Beyond Travel Time and Cost: Perception-Based Determinants of Public Intention to Use the LRT Mutiara Line in Penang

Syed Shaufiq Shahredza Syed Baharuddin[1], Abdul Khabir Rahmat[1,*], Mohd Azril Ismail[2]

[1] Malaysia Institute of Transport (MITRANS), Universiti Teknologi MARA (UITM), 40450 Shah Alam, Selangor, Malaysia
[2] School of Technology Management and Logistics, UUM College of Business, Universiti Utara Malaysia, Malaysia

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ABSTRACT

The proposed LRT Mutiara Line is a major rail transit initiative intended to improve cross-channel connectivity between Penang Island and Seberang Perai. Understanding public readiness to adopt the system is critical for effective transport planning. Grounded in the Theory of Planned Behaviour (TPB), this study examines how perception-based belief structures are associated with behavioural intention to use the future LRT, focusing on environmental concern, perceived life impact, travel time reduction, and cost reduction. A questionnaire survey of 270 commuters in the Penang metropolitan area was analysed using Partial Least Squares Structural Equation Modelling (PLS-SEM). The findings indicate that environmental concern and perceived life impact are significantly associated with intention to use the future LRT, whereas perceived travel time and cost reduction show no significant associations. The model explains 50.3% of the variance in behavioural intention, suggesting that experiential and sustainability-related beliefs may play a more prominent role than traditional efficiency considerations when evaluating planned rail systems. These findings extend TPB in a transport infrastructure context by highlighting a shift in belief salience under conditions of operational uncertainty. The absence of significant associations for travel time and cost suggests that commuters may rely more on anticipated experience and environmental value when assessing infrastructure that has not yet been implemented. From a practical perspective, the results indicate that policy communication strategies may benefit from emphasising commuting experience, reliability narratives, and environmental framing rather than focusing solely on efficiency metrics. Corridor-based engagement initiatives and employer travel demand programmes may help translate positive perception into behavioural readiness. The findings should be interpreted as associative due to the cross-sectional design but provide important insights into perception-driven intention formation for planned rail transit systems.

* *Corresponding author.*
E-mail address: abdulkhabir@uitm.edu.my

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1. Introduction

Urban transport systems in rapidly developing metropolitan regions face increasing pressure from traffic congestion, rising private vehicle ownership, and environmental challenges. Rail-based public transport systems are widely recognised as a sustainable solution to urban mobility problems due to their high passenger capacity, operational reliability, and lower environmental impact compared to private vehicles [1], [2]. As metropolitan areas continue to expand, the success of major transport infrastructure projects depends not only on system performance but also on public acceptance and willingness to adopt new mobility options.

Penang represents a distinctive urban transport setting in Malaysia, consisting of Penang Island as a major economic centre and Seberang Perai on the mainland as a rapidly growing residential and industrial area. Daily commuting between these two regions relies heavily on road-based transport infrastructure, particularly the bridges connecting the island and mainland. This dependency has contributed to recurring traffic congestion, travel time uncertainty, and increasing commuting stress among road users.

To address these challenges, the proposed LRT Mutiara Line has been planned to enhance cross-channel connectivity and improve mobility efficiency within the Penang metropolitan area. Beyond improving transport capacity, the rail system is expected to support sustainable urban development and reduce reliance on private vehicles. However, the effectiveness of such infrastructure investments ultimately depends on whether commuters are willing to adopt the new system once it becomes operational [3].

Traditional transport studies on mode choice and public transport adoption often emphasise operational attributes such as travel time, cost, accessibility, and service reliability [4], [5]. While these factors remain important, recent research suggests that behavioural intention toward public transport use is also influenced by perception-based considerations, including environmental awareness and anticipated improvements in daily commuting experience [6], [7]. These perception-driven factors may be particularly relevant in metropolitan corridors where congestion and commuting stress are persistent concerns.

In the Penang cross-channel commuting context, where travel conditions are constrained by limited connectivity between the island and mainland, commuters may evaluate rail transit alternatives not only in terms of efficiency but also in terms of environmental responsibility and quality-of-life improvements. Understanding these perception-based determinants is therefore important for transport planners and policymakers seeking to promote public transport adoption.

This study aims to examine the determinants of public intention to use the proposed LRT Mutiara Line by applying Partial Least Squares Structural Equation Modelling (PLS-SEM). Specifically, the study investigates the influence of environmental concern, perceived life impact, travel time reduction, and cost reduction on behavioural intention to use the future LRT system. This study contributes to transport behaviour literature in three ways. First, it examines intention formation in a pre-implementation rail infrastructure context. Second, it refines the application of the Theory of Planned Behaviour by demonstrating the dominance of perception-based belief structures over instrumental efficiency beliefs. Third, it introduces the cross-channel commuting perspective as a contextual explanation for perception-driven public transport adoption.

2. Literature Review

2.1 Behavioural Intention in Public Transport Adoption

Behavioural intention is widely used as a predictor of transport mode adoption, particularly when evaluating new transport infrastructure that has not yet been implemented. The Theory of Planned Behaviour (TPB) provides a theoretical foundation for understanding how attitudes and perceived benefits influence intention to adopt new mobility options [3]. In transport research, behavioural intention is commonly used to assess potential ridership and public acceptance of rail transit systems.

Traditional transport studies have emphasised operational attributes such as travel time, travel cost, accessibility, and reliability in explaining transport mode choice [4], [5]. These variables remain important in urban commuting contexts. However, recent studies suggest that perception-based factors increasingly shape public transport adoption decisions, particularly in metropolitan areas experiencing congestion and environmental challenges [19], [22].

The growing emphasis on perception-driven mobility behaviour reflects a shift in transport research toward understanding commuter experience, sustainability awareness, and anticipated lifestyle improvements associated with public transport systems.

2.2 Environmental Concern and Sustainable Transport Adoption

Environmental concern has become an important determinant of sustainable mobility behaviour in urban environments. Rail transit systems are commonly associated with lower emissions and improved environmental performance compared to private vehicle use [1], [10]. As cities seek to reduce carbon emissions and promote sustainable transport, environmental awareness has been shown to influence behavioural intention toward public transport adoption.

Recent empirical studies using structural equation modelling confirm that environmental concern significantly predicts public transport usage intention, particularly in developing metropolitan regions [20]. Environmental perception may therefore function not only as an attitudinal factor but also as a motivating force encouraging commuters to shift from private vehicles to rail-based transport systems.

In metropolitan corridors experiencing congestion and air quality concerns, environmental awareness may reinforce public acceptance of rail transit infrastructure.

2.3 Perceived Life Impact and Commuting Experience

Commuting experience and quality-of-life considerations have received increasing attention in transport behaviour research. Rail transit systems are often associated with reduced commuting stress, improved comfort, and more predictable travel conditions [13]. These experiential benefits may influence behavioural intention independently of operational performance.

Recent studies on travel satisfaction and well-being indicate that commuting conditions significantly affect subjective well-being and transport mode preference [21]. Perceived improvements in daily travel routines, work–life balance, and commuting comfort may therefore influence intention to adopt new public transport systems.

In cross-channel commuting environments such as the Penang Island–Seberang Perai corridor, where congestion-related stress is common, perceived life impact may represent an important determinant of public acceptance of rail transit systems.

2.4 Travel Time Reduction and Public Transport Choice

Travel time has long been considered a central variable in transport mode choice research. Rail systems are frequently promoted for their ability to provide predictable travel times and reduce congestion-related delays [4], [15]. Travel time reliability, in particular, has been shown to influence transport decisions in urban commuting contexts [18].

However, recent empirical findings suggest that perceived reliability and commuting experience may outweigh nominal travel time savings in shaping behavioural intention [18], [22]. In situations where travel time savings are uncertain or incremental, commuters may prioritise comfort, reliability, and perceived benefits instead.

This indicates that travel time reduction may not always be the dominant determinant of intention to adopt new rail systems.

2.5 Cost Reduction and Transport Behaviour

Transport cost is another commonly examined determinant of public transport adoption. Affordable fares and reduced commuting expenses are often cited as incentives for shifting from private vehicles to public transport [15]. From an economic perspective, cost reduction should increase the attractiveness of public transport alternatives.

Nevertheless, behavioural studies indicate that perceived financial benefits may not always be the primary determinant of intention, particularly when commuters evaluate transport systems based on comfort, reliability, or environmental considerations [17], [22]. In infrastructure projects aimed at improving commuting experience rather than solely reducing expenses, cost considerations may play a secondary role.

Although public transport adoption has been widely studied, limited empirical research has examined perception-based determinants of rail transit adoption in cross-channel commuting environments, particularly in Southeast Asian metropolitan regions. The proposed LRT Mutiara Line provides a unique opportunity to investigate how environmental concern and perceived life impact interact with traditional operational factors such as travel time and cost in shaping behavioural intention. In the TPB framework, environmental concern and perceived life impact reflect attitudinal belief structures, while travel time and cost represent instrumental evaluations associated with behavioural intention formation.

Table 1
Literature Summary

Study	Context	Key Variables	Method	Key Findings	Relevance
Wang et al. (2021)	Urban rail adoption	Service perception, intention	SEM	Perceived service quality influences rail adoption	Supports intention modelling
Nguyen et al. (2022)	Sustainable transport	Environmental concern	SEM	Environmental awareness predicts public transport intention	Supports environmental construct

Li et al. (2020)	Metro systems	Travel time perception	Behavioural modelling	Perceived reliability more important than time savings	Supports time-reduction finding
De Vos (2020)	Travel satisfaction	Well-being	Review	Commuting experience influences mode preference	Supports life-impact construct
Zhang & Chen (2023)	Public transport behaviour	Psychological factors	SEM	Perception-based benefits influence adoption decisions	Supports perception-driven model
Redman et al. (2013)	Public transport quality	Service attributes	Review	Experience influences adoption	Foundational reference

The literature summarised in Table 1 highlights two broad streams of research in public transport adoption. The first stream focuses on operational determinants of transport behaviour, including travel time, cost, and service attributes, which have traditionally been central to transport demand modelling and mode choice analysis [4], [5], [15]. These studies establish the importance of efficiency-related variables in influencing commuters' transport decisions.

The second stream of research emphasises perception-based and psychological determinants of transport behaviour, including environmental concern, travel satisfaction, and quality-of-life considerations [6], [21], [22]. Recent studies suggest that commuters increasingly evaluate transport systems not only based on efficiency but also on sustainability, comfort, and overall commuting experience. This shift reflects broader changes in urban mobility behaviour, where experiential and environmental factors play a more prominent role in shaping public transport adoption.

Despite the growing body of research on public transport intention, limited empirical studies have examined the combined influence of environmental perception, life-impact perception, and traditional operational factors within a cross-channel commuting context. The proposed LRT Mutiara Line in Penang provides a relevant case for examining how these factors jointly influence behavioural intention to adopt rail transit. The present study therefore integrates perception-based constructs with operational considerations using a PLS-SEM framework to provide a more comprehensive understanding of intention formation.

2.6 Conceptual Framework and Hypotheses

Based on the literature reviewed, behavioural intention to use public transport is influenced by both operational considerations and perception-based factors. While traditional transport studies emphasise travel time and cost as key determinants of mode choice [4], [15], recent research highlights the importance of environmental awareness and perceived improvements in commuting experience in shaping public transport adoption [20], [21], [22].

In the context of the proposed LRT Mutiara Line, perception-based benefits such as environmental sustainability and improvements in daily commuting experience may play an important role in influencing public intention to use the system. At the same time, operational considerations such as perceived travel time reduction and cost reduction remain relevant variables in transport behaviour research.

Accordingly, this study proposes a conceptual framework in which environmental concern, perceived life impact, travel time reduction, and cost reduction are hypothesised to influence behavioural intention to use the future LRT Mutiara Line.

2.6.1 Hypotheses Development

2.6.1.1 Environmental Concern

Environmental concern has been shown to influence individuals' willingness to adopt sustainable transport modes [10], [20]. Rail transit systems are commonly perceived as environmentally friendly alternatives to private vehicles, particularly in congested metropolitan regions. In this study, environmental concern is expected to positively influence intention to use the future LRT.

H1: Environmental concern positively influences intention to use the future LRT Mutiara Line.

2.6.1.2 Perceived Life Impact

Perceived improvements in commuting experience, including reduced stress and increased comfort, have been associated with public transport adoption [21]. Quality-of-life considerations may therefore influence commuters' evaluation of rail transit alternatives.

H2: Perceived life impact positively influences intention to use the future LRT Mutiara Line.

2.6.1.3 Travel Time Reduction

Travel time reduction is traditionally considered an important determinant of transport mode choice [4]. Rail systems are often promoted for their reliability and ability to reduce congestion-related delays [18]. Therefore, perceived travel time reduction is expected to influence intention to use the LRT.

H3: Perceived travel time reduction positively influences intention to use the future LRT Mutiara Line.

2.6.1.4 Cost Reduction

Transport cost is another commonly examined factor influencing public transport adoption [15]. Lower commuting expenses are generally expected to increase the attractiveness of public transport alternatives.

H4: Perceived cost reduction positively influences intention to use the future LRT Mutiara Line.

The conceptual framework of this study positions behavioural intention to use the future LRT Mutiara Line as the endogenous variable, influenced by four exogenous constructs: environmental concern, perceived life impact, travel time reduction, and cost reduction. The framework integrates perception-based determinants with traditional transport variables to provide a comprehensive understanding of public transport adoption intention. Based on the conceptual framework and hypotheses developed from the literature review, a questionnaire-based empirical study was conducted to examine public intention to use the proposed LRT Mutiara Line

3. Methodology

3.1 Research Design

This study adopts a quantitative research design to examine public intention to use the proposed LRT Mutiara Line connecting Penang Island and Seberang Perai. A structured questionnaire survey

was used to collect data on commuters' perceptions of environmental concern, life impact, travel time reduction, cost reduction, and behavioural intention to use the future LRT system.

Since the LRT Mutiara Line is still in the planning stage, behavioural intention was used as a proxy for future public transport adoption, consistent with behavioural transport research examining planned infrastructure systems [3], [7].

3.2 Data Collection

Data were collected through a questionnaire survey administered to respondents in the Penang metropolitan area. The survey targeted commuters who regularly travel within or between Penang Island and Seberang Perai. A total of 270 valid responses were obtained and used for analysis.

The questionnaire consisted of four main sections:

- Section A: Demographic information
- Section B: Behavioural intention to use public transport
- Section C: Travel time perception
- Section D: Financial impact perception
- Section E: Life impact perception
- Section F: Environmental concern

Perception-based items were measured using a five-point Likert scale ranging from strongly disagree to strongly agree. The questionnaire items were adapted from established transport behaviour and sustainability perception studies.

3.3 Measurement of Constructs

Four exogenous constructs and one endogenous construct were included in the model:

- Environmental Concern (3 indicators)
- Life Impact (3 indicators)
- Travel Time Reduction (single indicator)
- Cost Reduction (single indicator)
- Behavioural Intention (single indicator)

Environmental concern and life impact were modelled as reflective constructs, as the indicators represent manifestations of underlying perceptions. Travel time reduction, cost reduction, and behavioural intention were operationalised using single-item measures reflecting concrete perceptions.

Several questionnaire items captured objective travel conditions, such as travel time and monthly transport cost, using ordinal categories. These variables were treated as descriptive indicators rather than reflective measurement items to avoid mixing measurement logic in the structural model.

3.4 Sampling Method

A non-probability sampling approach was adopted in this study. Respondents were selected using purposive sampling, targeting individuals who regularly commute within the Penang metropolitan area, including travel between Penang Island and Seberang Perai. This approach was considered appropriate because the study focuses on perceptions of potential LRT users rather than the general population.

Purposive sampling is commonly used in transport behaviour studies when the objective is to capture responses from specific user groups relevant to the planned transport system [7]. The

sampling strategy ensured that respondents had commuting experience relevant to the proposed LRT corridor. Although the sampling approach does not allow full population generalisation, it is appropriate for exploratory behavioural modelling using PLS-SEM.

3.5 Data Analysis Method

This study employed Partial Least Squares Structural Equation Modelling (PLS-SEM) using SmartPLS software to analyse the relationships between constructs. PLS-SEM is suitable for exploratory behavioural research and perception-based models, particularly when the objective is prediction and theory development rather than theory confirmation [7].

The analysis was conducted in two stages:

1. Measurement model assessment
2. Structural model assessment

The measurement model was evaluated using outer loadings, composite reliability (CR), average variance extracted (AVE), and discriminant validity using the HTMT criterion. The structural model was assessed using path coefficients, bootstrapped t-values, coefficient of determination (R^2), effect size (f^2), and predictive relevance (Q^2).

Bootstrapping with 5,000 resamples was performed to test the significance of the hypothesised relationships.

3.6 Justification for PLS-SEM

PLS-SEM was selected because the study focuses on predicting behavioural intention using perception-based constructs and includes both multi-item and single-item measures. The method is robust for behavioural research involving latent variables and does not require strict normality assumptions [7].

PLS-SEM is also appropriate when examining public acceptance of planned infrastructure systems, where the research objective is to understand intention formation rather than to confirm an established theoretical model.

4. Results

4.1 Respondent Profile

A total of 270 valid responses were obtained for analysis. The respondents consist of commuters within the Penang metropolitan area, including those travelling within Penang Island and between Penang Island and Seberang Perai. The demographic section of the questionnaire captured information such as gender, age group, employment status, and commuting characteristics.

The sample represents individuals with relevant commuting experience in the study area, making the data suitable for examining perception-based intention to use the proposed LRT Mutiara Line.

4.2 Measurement Model Assessment

The measurement model was evaluated in terms of indicator reliability, internal consistency reliability, convergent validity, and discriminant validity.

For reflective constructs, all outer loadings exceed the recommended threshold of 0.70, indicating satisfactory indicator reliability. Composite reliability values for environmental concern

and life impact exceed 0.80, demonstrating strong internal consistency. The average variance extracted (AVE) values are above 0.50, confirming convergent validity.

Discriminant validity was assessed using the heterotrait–monotrait (HTMT) criterion. All HTMT values are below the conservative threshold of 0.85, indicating that the constructs are empirically distinct.

Travel time reduction, cost reduction, and behavioural intention were modelled as single-item constructs; therefore, internal consistency reliability and AVE were not assessed for these constructs.

Table 2
Indicator Reliability and Convergent Validity

Construct	Indicator	Outer Loading	Composite Reliability (CR)	AVE
Environmental Concern	EC1	0.859	0.896	0.741
	EC2	0.884		
	EC3	0.836		
Life Impact	LI1	0.923	0.931	0.819
	LI2	0.903		
	LI3	0.886		
Time Reduction	TR	1.000	–	–
Cost Reduction	CR	1.000	–	–
Intention	INT	1.000	–	–

Single-item constructs (Time Reduction, Cost Reduction, and Intention) were not assessed using internal consistency reliability or AVE, as such measures are not applicable to single-indicator constructs.

Table 3
Discriminant Validity – HTMT Criterion

Constructs	1	2	3	4	5
1. Environmental Concern	–				
2. Life Impact	0.645	–			
3. Time Reduction	0.422	0.365	–		
4. Cost Reduction	0.418	0.339	0.504	–	
5. Intention	0.735	0.689	0.312	0.298	–

4.3 Structural Model Assessment

The structural model was evaluated using path coefficients, bootstrapped t-values, coefficient of determination (R^2), effect sizes (f^2), and predictive relevance (Q^2). Bootstrapping with 5,000 resamples was used to test the significance of the hypothesised relationships.

The model explains 50.3% of the variance in behavioural intention to use the future LRT Mutiara Line ($R^2 = 0.503$), indicating substantial explanatory power.

Environmental concern shows a positive and statistically significant effect on intention ($\beta = 0.409$, $p < 0.001$), supporting H1. Perceived life impact also exhibits a significant positive effect on intention ($\beta = 0.292$, $p < 0.001$), supporting H2.

In contrast, perceived travel time reduction ($\beta = 0.063$, $p = 0.264$) and perceived cost reduction ($\beta = 0.041$, $p = 0.417$) do not show statistically significant effects on intention. Therefore, H3 and H4 are not supported.

Effect size analysis indicates that environmental concern exerts a medium-to-large effect on intention ($f^2 = 0.223$), while life impact demonstrates a moderate effect ($f^2 = 0.124$). The effects of travel time reduction and cost reduction are negligible.

Predictive relevance was assessed using blindfolding. The Q^2 value for behavioural intention is 0.354, indicating strong predictive relevance of the model.

Table 4
Structural Model Results

Hypothesis	Path	β	t-value	p-value	Result
H1	Environmental Concern → Intention	0.409	7.326	< 0.001	Supported
H2	Life Impact → Intention	0.292	5.106	< 0.001	Supported
H3	Time Reduction → Intention	0.063	1.118	0.264	Not supported
H4	Cost Reduction → Intention	0.041	0.812	0.417	Not supported

5. Discussion

This study examined the determinants of public intention to use the proposed LRT Mutiara Line connecting Penang Island and Seberang Perai. The findings demonstrate that perception-based factors, particularly environmental concern and perceived life impact, play a more prominent role in shaping behavioural intention than traditional operational considerations such as travel time and cost reduction.

5.1 Environmental Concern as a Primary Driver

Environmental concern emerges as the strongest determinant of intention to use the future LRT. This suggests that commuters perceive the LRT not only as a transport alternative but also as a contribution to environmentally sustainable mobility. The finding is consistent with recent studies indicating that environmental awareness positively influences public transport adoption in urban environments [20].

In the Penang context, where congestion and vehicle emissions are visible daily challenges, environmental considerations may reinforce support for rail-based transport systems. The relatively

large effect size observed for environmental concern indicates that sustainability-related perceptions may play an important role in shaping public acceptance of the LRT Mutiara Line.

5.2 Role of Perceived Life Impact

Perceived life impact also shows a significant positive relationship with behavioural intention. This indicates that commuters evaluate the proposed LRT in terms of potential improvements in daily commuting experience, including reduced stress, increased comfort, and more predictable travel conditions.

This finding aligns with recent research emphasising the relationship between commuting experience, travel satisfaction, and subjective well-being [21]. In congested commuting environments, improvements in commuting experience may be valued as highly as operational efficiency. The result suggests that rail transit systems may be perceived as lifestyle-enhancing infrastructure rather than merely mobility solutions.

In the cross-channel commuting corridor between Penang Island and Seberang Perai, where travel conditions are often constrained by congestion, perceived improvements in commuting experience may represent a meaningful motivation for adopting rail transit.

5.3 Limited Influence of Travel Time and Cost Reduction

Contrary to traditional transport modelling assumptions, perceived travel time reduction and cost reduction do not significantly influence intention to use the future LRT. While travel time and cost remain central variables in mode choice theory [4], the findings suggest that commuters may prioritise reliability, comfort, and environmental value over marginal improvements in travel time or commuting expenses.

Recent transport behaviour studies similarly indicate that perception-based benefits may outweigh purely operational considerations in shaping public transport adoption decisions [22]. In the Penang context, where congestion-related travel time variability is common, commuters may perceive rail transit as a more reliable and less stressful alternative rather than focusing solely on travel time savings.

This finding suggests that transport planning narratives centred exclusively on travel time and cost savings may not fully capture the motivations behind public transport adoption in metropolitan commuting environments.

5.4 Cross-Channel Commuting Behaviour in Geographically Constrained Corridors

The Penang Island–Seberang Perai corridor represents a geographically constrained commuting environment characterised by limited crossing infrastructure, directional peak congestion, and strong bridge dependency. Such structural conditions shape commuting behaviour differently from conventional urban corridors where multiple route alternatives are available. In cross-channel settings, travel uncertainty is often driven less by average travel time and more by reliability concerns, bottleneck effects, and perceived vulnerability to disruption.

These characteristics may explain the stronger role of perception-based determinants observed in this study. When commuters operate within constrained mobility systems, anticipated experience—such as reduced stress, reliability, and environmental value—may become more salient than incremental changes in travel time or cost. The reliance on a small number of crossing points

can heighten sensitivity to reliability narratives, reinforcing the importance of experiential expectations in intention formation.

Furthermore, cross-channel commuting involves psychological dimensions related to spatial separation between residence and employment centres. The transition between island and mainland environments may amplify awareness of congestion, travel fatigue, and environmental impact, which in turn strengthens sustainability-related and quality-of-life evaluations of rail transit alternatives. This suggests that perception-driven intention may be particularly pronounced in metropolitan regions where physical geography constrains mobility choices.

By situating the findings within the cross-channel commuting context, the study highlights how geographic structure can influence the hierarchy of transport beliefs. This perspective supports the interpretation that perception-based factors may dominate behavioural readiness toward planned rail systems in constrained corridors, refining behavioural transport models beyond efficiency-focused assumptions.

6. Implications for Transport Planning and Policy

The findings have several implications for transport planning and public communication strategies. First, promoting the environmental benefits of rail transit may enhance public acceptance of the LRT Mutiara Line. Second, highlighting improvements in commuting experience, such as comfort and reduced stress, may be more effective than focusing solely on efficiency metrics.

These results suggest that public transport adoption strategies should integrate sustainability messaging and commuter experience considerations alongside traditional operational performance indicators.

Grounded in the Theory of Planned Behaviour (TPB), this study provides insights into how belief-based evaluations shape behavioural intention toward planned rail transit infrastructure. The findings indicate that perception-based constructs—specifically environmental concern and perceived life impact—are significantly associated with intention to use the future LRT Mutiara Line. These constructs reflect attitudinal belief components within TPB, suggesting that commuters evaluate rail adoption not only through instrumental efficiency considerations but also through anticipated experiential and sustainability benefits.

The absence of significant associations between perceived travel time and cost reduction and behavioural intention suggests a potential rebalancing of belief salience in pre-implementation transport contexts. When operational performance remains uncertain, commuters may rely more heavily on experiential expectations and normative sustainability beliefs rather than traditional instrumental evaluations. This finding extends TPB by indicating that belief hierarchies may shift depending on infrastructure maturity and certainty of service attributes.

Furthermore, the results contribute to behavioural transport literature by highlighting the importance of contextual factors in shaping intention formation. In geographically constrained commuting environments such as cross-channel metropolitan corridors, perceptions related to reliability, stress reduction, and environmental responsibility may function as dominant evaluative criteria. This suggests that transport behaviour models should incorporate experiential and sustainability dimensions alongside conventional efficiency variables when examining intention toward planned rail systems.

The study therefore refines the application of TPB in transport infrastructure research by demonstrating that perception-driven belief structures may play a stronger role than instrumental efficiency beliefs in shaping behavioural readiness prior to system implementation. This perspective

provides a theoretical basis for understanding why traditional determinants such as travel time and cost may exhibit weaker associations in early adoption contexts.

7. Conclusion

This study examined the determinants of public intention to use the proposed LRT Mutiara Line connecting Penang Island and Seberang Perai. Using a PLS-SEM approach, the study investigated the influence of environmental concern, perceived life impact, travel time reduction, and cost reduction on behavioural intention to adopt the future rail transit system.

The findings indicate that environmental concern and perceived life impact are significant predictors of intention to use the LRT, while perceived travel time reduction and cost reduction do not show statistically significant effects. These results suggest that commuters evaluate the proposed LRT not only as a transport alternative but also as a contributor to environmental sustainability and improvements in commuting experience.

The study contributes to public transport adoption literature by demonstrating the importance of perception-based determinants in shaping behavioural intention within a cross-channel commuting context. By integrating sustainability perception and quality-of-life considerations with traditional transport variables, the study provides a more comprehensive understanding of intention formation toward rail transit adoption.

From a practical perspective, the findings suggest that transport planners and policymakers should emphasise environmental benefits and commuting experience improvements when promoting the LRT Mutiara Line. Communication strategies that focus solely on travel time and cost savings may not fully capture the motivations influencing public acceptance of the system.

Overall, the study provides empirical insights into public perception of the proposed LRT Mutiara Line and highlights the importance of perception-driven factors in encouraging future public transport adoption.

8. Limitations and Future Research

Despite providing useful insights into public intention to use the proposed LRT Mutiara Line, this study has several limitations that should be acknowledged.

First, the study employed a non-probability sampling approach, focusing on commuters within the Penang metropolitan area. While this approach is appropriate for exploratory behavioural modelling using PLS-SEM, the findings may not be fully generalisable to the entire population of Penang residents or future LRT users. Future studies may consider probability-based sampling techniques to enhance representativeness.

Second, behavioural intention was used as a proxy for actual transport behaviour, as the LRT Mutiara Line is still in the planning stage. Although intention is widely used in transport behaviour research, actual ridership behaviour may differ once the system becomes operational. Longitudinal studies examining actual usage patterns after implementation would provide valuable validation of the findings.

Third, several constructs in the model, including travel time reduction, cost reduction, and behavioural intention, were measured using single-item indicators. While single-item measures are acceptable for concrete constructs, future research may consider multi-item measurement scales to further strengthen construct reliability and measurement robustness.

Fourth, the study focused on perception-based determinants and selected operational variables. Other factors that may influence public transport adoption, such as service reliability, accessibility,

land-use integration, and social influence, were not included in the model. Future research could incorporate these variables to develop a more comprehensive behavioural model of rail transit adoption.

Future research may also explore comparative studies across different metropolitan regions or transport corridors to examine whether perception-based determinants of rail transit adoption vary across urban contexts. Such studies would contribute to a deeper understanding of public transport acceptance in rapidly urbanising cities.

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