

Article

Determinants of Rail Transit Adoption Among Private Vehicle Users in Klang Valley, Malaysia: An Extended Theory of Planned Behaviour Analysis

Jie Shang ^{1,2,*} , Tun Ahmad Adlan Asma'an Jamaluddin ¹, Muhamad Nazri Borhan ^{1,3} , Fazilatulaili Ali ⁴ , Jianqiu Chen ^{2,5} and Ahmad Nazrul Hakimi Ibrahim ^{1,3,*} 

¹ Department of Civil Engineering, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia, Hulu Langat 43100, Malaysia; p125657@siswa.ukm.edu.my (T.A.A.A.J.); mnazri_borhan@ukm.edu.my (M.N.B.)

² College of Traffic and Transportation, Nanning University, Nanning 530299, China; chenjianqiu@unn.edu.cn

³ Smart and Sustainable Township Research Centre, Faculty of Engineering & Built Environment, Universiti Kebangsaan Malaysia, Hulu Langat 43100, Malaysia

⁴ Department of Defence Science, Faculty of Defence Science and Technology, National Defence University of Malaysia, Kuala Lumpur 57000, Malaysia; fazilatulaili@upnm.edu.my

⁵ Guangxi Key Laboratory of International Join for China-ASEAN Comprehensive Transportation, Nanning University, Nanning 530299, China

* Correspondence: p127623@siswa.ukm.edu.my (J.S.); nazrulhakimi@ukm.edu.my (A.N.H.I.)

Abstract

Private vehicle overreliance in Klang Valley, Malaysia contributes to severe traffic congestion, air pollution, and carbon emissions, yet public transport modal shift remains far below national policy targets. This study extends the Theory of Planned Behaviour (TPB) by incorporating two external constructs, environmental concern (EC) and technology adoption (TA), to investigate the behavioural intention of 483 private vehicle users to switch to rail transit. Hypotheses were tested using partial least squares structural equation modelling (PLS-SEM). The results show that, with the exception of subjective norm ($\beta = 0.064$, $p = 0.180$), all constructs exert significant positive effects on behavioural intention. Technology adoption emerged as the strongest direct predictor ($\beta = 0.417$), followed by perceived behaviour control ($\beta = 0.340$). Environmental concern operated exclusively through indirect pathways, mediated by attitude and perceived behaviour control, and exhibited the largest effect size on the TPB components ($f^2 = 0.380$ – 0.449 , large effect).

Keywords: Theory of Planned Behaviour; behavioural intention; environmental concern; technology adoption; modal shift; rail transit; PLS-SEM; Malaysia



Academic Editor: Luigi dell'Olio

Received: 4 June 2026

Revised: 3 July 2026

Accepted: 8 July 2026

Published: 10 July 2026

Copyright: © 2026 by the authors.

Licensee MDPI, Basel, Switzerland.

This article is an open access article distributed under the terms and conditions of the [Creative Commons Attribution \(CC BY\)](https://creativecommons.org/licenses/by/4.0/) license.

1. Introduction

The rapid global expansion of road transport, particularly private car usage, has significantly contributed to environmental and noise pollution, the depletion of non-renewable resources, and traffic congestion [1], undermining the quality of urban life. In Malaysia, this trend is especially pronounced: by 2019, there were 33.3 million registered vehicles against a population of only 32.6 million [2]. Despite a marginal increase in public transport ridership from 17% in 2010 to approximately 20% in recent years [3,4], these figures remain far below Malaysia's National Energy Policy targets of 40% public transport use by 2040 and 50% by 2050, and they starkly contrast usage rates in Singapore (64%), Hong Kong (74%), and London (90%) [5].

The consequences of overreliance on private vehicles are severe. The Road Transport Department recorded 545,588 road accidents in 2022, including 5671 fatalities. Traffic congestion in Klang Valley imposes substantial economic costs: an estimated 1.3–1.5 million vehicles enter Kuala Lumpur daily [6], and drivers lost an average of 84 h to congestion in 2025 according to the TomTom Traffic Index [7], representing a significant drain on productivity and quality of life. Traffic congestion disproportionately affects the 9.13 million residents of Klang Valley, approximately one third of Malaysia's population [8], and contributes to chronic air quality deterioration, with PM2.5 hourly readings regularly exceeding the World Health Organization guideline of 25 $\mu\text{g}/\text{m}^3$ [9]. Developing an effective rail transit system represents one of the most viable strategies to address these challenges, as public transport has been shown to reduce fuel consumption, CO₂ emissions, and road accidents [10]. However, achieving a modal shift requires a thorough understanding of what drives private vehicle users to switch to rail transit. Among the critical service attributes that influence such decisions are cost, travel time [11], frequency, reliability [12], and safety and comfort [13]. To the best of the authors' knowledge, no prior study has examined the behavioural intention of private vehicle users in Klang Valley to switch to rail transit as a primary and exclusive focus. While several Malaysian studies have included private vehicle users as part of broader samples (see Table 1), none has targeted this group exclusively or examined the role of technology adoption as an external TPB predictor in this context. Technology adoption is conceptually distinct from related constructs such as service convenience or perceived ease of use in that it specifically captures active engagement with digital tools, including mobile ticketing, real-time applications, and social media information, as facilitators of modal shift decisions. Drawing on the Theory of Planned Behaviour (TPB) [14] as its theoretical foundation, this study extends the model by incorporating environmental concern and technology adoption as external constructs. The primary objective is to identify the psychological and contextual determinants of rail transit adoption among private vehicle users, with the aim of providing actionable evidence for policymakers, transport authorities, and service providers. The remainder of this paper is structured as follows. Section 2 reviews the relevant literature and develops the research hypotheses. Section 3 describes the research methodology. Section 4 presents and discusses the empirical results. Section 5 concludes the paper with theoretical contributions, practical implications, and directions for future research.

Table 1. Summary of previous studies on TPB and public transportation.

No.	Paper	Country	Type of Respondent	Theory	Additional Factors	Findings
1	Zhang et al. [15]	China	PT and PV users	TPB	PN, Habit, DN	PN and SN influence BI
2	Fu and Juan [16]	China	PT and PV users	TPB	Habit, Satisfaction	ATT, SN, habit and satisfaction influence BI
3	Lo et al. [17]	Netherlands	PT and PV users	Ext. TPB	PN, DN, Habit	ATT, PBC and DN influence BI
4	Bamberg et al. [18]	Germany	PT and PV users	Ext. TPB	PN, DN	PN influences BI
5	Donald et al. [10]	UK	PT and PV users	Ext. TPB	MN, EC, DN	ATT, SN and PBC influence BI
6	Ali et al. [19]	Japan	PT and PV users	Ext. TPB	APT, TCC, PN, EC	ATT, SN, PBC, PN, APT and EC influence BI
7	Zailani et al. [20]	Malaysia	PT and PV users	Ext. TPB	Past behaviour	ATT, PBC and past behaviour influence BI
8	Eriksson and Forward [21]	Sweden	PT and PV users	Ext. TPB	DN	ATT, SN, PBC and DN influence BI
9	Ng and Phung [9]	Vietnam	PT and PV users	Ext. TPB	SS, PN, DN, EC	ATT, PBC, PN, EC and DN influence BI
10	Borhan et al. [5]	Libya	PT and PV users	Ext. TPB	NS, TR, EI	ATT, SN, TR, NS and EI influence BI
11	Arslannur and Tortum [22]	Turkey	PT and PV users	Ext. TPB	PN, PA, EC, BC, Habit	ATT, PN, PA influence PT; habit, BI and BC influence behaviour; EC not significant
12	Chia et al. [23]	Malaysia	PT and PV users	TPB	Reliability, Fares, Safety, Security	Reliability, fares, service and security influence BI
13	Irtema et al. [24]	Malaysia	PT and PV users	Ext. TPB	Involvement, Perceived Value, Satisfaction, SQ	Involvement, perceived value, satisfaction and SQ influence BI; negative relationship between perceived value and satisfaction
14	Madha et al. [25]	Malaysia	PT and PV users	Ext. TPB	NS, TR, EI, Situational Factors	ATT, SN, PBC influence BI; NS, TR, EI influence ATT, SN, PBC indirectly; situational factors not significant
15	Kalhor et al. [26]	Malaysia	PT and PV users	Ext. TPB	EC	ATT, SN, PBC influence BI; EC influences ATT and indirectly influences BI
16	This study	Malaysia	PV Users	Ext. TPB	EC and TA	—

ATT: attitude; SN: subjective norm; PBC: perceived behaviour control; BI: behaviour intention; PV: private vehicle; PT: public transport; PN: personal norm; DN: descriptive norm; EC: environmental concern; MN: moral norm; NS: novelty seeking; TR: trust; EI: external influence; PA: private agency; BC: behaviour capacity; SQ: service quality; SS: service satisfaction; APT: access by public transport; TCC: travel cost consciousness; TA: technology adoption; Ext. TPB: Extended Theory of Planned Behaviour.

2. Literature Review

The Theory of Planned Behaviour (TPB) has been widely applied to investigate public transport use intention across diverse geographic and cultural contexts. Table 1 summarises fifteen representative studies that have employed TPB or its extensions in public transportation research. While many of these studies enriched the baseline model by incorporating external factors such as personal norm, environmental concern, habit, travel cost, and descriptive norm, none have examined technology adoption as an additional predictor, and none have focused exclusively on private vehicle users in Klang Valley, Malaysia. This study addresses both gaps by proposing an extended TPB model that incorporates environmental concern and technology adoption as external constructs.

2.1. Theory of Planned Behaviour (TPB) and Its Extensions

The Theory of Planned Behaviour (TPB), developed by Ajzen [14], is an extension of the Theory of Reasoned Action that incorporates perceived behaviour control as an additional predictor of intention and behaviour [27]. TPB posits that behaviour is driven by behavioural intention, which is jointly determined by three constructs: attitude, subjective norm, and perceived behaviour control [28]. The theory has been widely applied across psychology, health, education, and transportation research [29] and remains one of the most frequently used frameworks in public transport behaviour studies [9,18,19,26]. The three core TPB constructs—attitude, subjective norm, and perceived behaviour control—are reviewed in turn below.

Attitude refers to an individual's positive or negative evaluation of a behaviour [30]. In the transportation context, favourable attitudes towards rail transit are typically shaped by perceptions of reliability, affordability, ease of use, and environmental benefits. Ahmed et al. [31] found that young, lower-income drivers are particularly likely to develop positive attitudes towards switching their mode of transport.

Subjective norm reflects the perceived social pressure to perform or not perform a given behaviour [32]. Influences from family, friends, colleagues, and broader social expectations can either encourage or discourage public transport use [30].

Perceived behaviour control (PBC) denotes the perceived ease or difficulty of performing a behaviour, shaped by past experience and anticipated barriers [33]. In the public transport context, relevant factors include the accessibility of rail services, familiarity with the system, and the convenience of routes and schedules.

Although TPB has received substantial empirical support [32,34], the relative influence of its three components varies considerably across geographic and cultural contexts [33,35–37], underscoring the value of context-specific investigation. Many studies have therefore enriched the model by incorporating additional external predictors [9,19,29], and prior research confirms that doing so enhances the predictive effectiveness of TPB [30]. Following this tradition, this study introduces two external factors, technology adoption and environmental concern, into the TPB model. Based on the foregoing review, the following hypotheses are proposed.

H1. *Attitude is positively related to behaviour intention.*

H2. *Subjective norm is positively related to behaviour intention.*

H3. *Perceived behaviour control is positively related to behaviour intention.*

2.2. Technology Adoption

The digitalisation of public transport has generated growing interest in how technology shapes travel decisions [38]. Digital tools, including mobile phones, electronic

payment systems, and real-time information services, can reduce travel times and lower the perceived effort of using public transit [39]. In Malaysia, the integration of smart ticketing by the Prime Minister's Department in 2010 marked an early step in this direction. Fontes et al. [40] demonstrated that the transition from traditional to mobile payment ticketing positively influences individuals' intention to use public transport. Similarly, Kang et al. [41] established that the convenience afforded by smart ticketing affects behavioural intention to use public transport. Following the COVID-19 pandemic, the adoption of digital transport tools accelerated further as users sought more efficient and contactless travel experiences [42]. Social media constitutes another dimension of technology adoption: it serves as a channel through which information about transport options reaches potential users [43], and viral social media content has been shown to influence mode choice intentions [44].

While established technology acceptance frameworks such as the Technology Acceptance Model (TAM) [45] and the Unified Theory of Acceptance and Use of Technology (UTAUT) [46] offer comprehensive models of technology adoption, this study does not adopt them as standalone frameworks. TAM and UTAUT were developed primarily for workplace technology adoption and do not fully capture the context-specific digital touchpoints of public transit services. Moreover, treating TA as an external TPB construct rather than a parallel framework allows direct comparison with the established TPB components and avoids model overcomplexity [40,41].

In this study, technology adoption is conceptualised as a unidimensional construct encompassing three interrelated digital affordances of rail transit services: mobile ticketing, real-time service applications, and social media information. Although these elements may appear distinct, they share a common underlying mechanism—the use of digital technology to reduce informational and transactional barriers to rail transit use [42]. This conceptualisation is supported by the high internal consistency of the TA construct in the pilot test ($\alpha = 0.876$) and the final measurement model ($CR = 0.945$, $AVE = 0.777$), confirming that the items converge on a single latent dimension. This approach is consistent with prior studies that have incorporated technology-related variables as unidimensional TPB extensions without invoking the full TAM or UTAUT structure [42,44]. Based on this evidence, the following hypothesis is proposed.

H4. *Technology adoption is positively related to behaviour intention.*

2.3. Environmental Concern

Environmental concern reflects an individual's awareness of and sensitivity to environmental issues [47] and is widely recognised as a key motivator for pro-environmental behaviour change [48]. The transportation sector is a major contributor to global carbon emissions, which reached a record high of 37.4 billion tonnes in 2023 [49], reinforcing the urgency of modal shift towards public transport as a means of reducing emissions [50].

Prior research indicates that environmental concern does not directly determine transport behaviour; rather, it operates indirectly through the core TPB components [51]. Ng and Phung [9] confirmed this mediation pattern in Hanoi, Vietnam, finding that environmental concern influenced behavioural intention through attitude and perceived behaviour control. Bamberg et al. [18] obtained comparable results in Germany, with attitude and subjective norm serving as mediators. Wang et al. [52] further showed that environmental concern indirectly influenced the intention to adopt hybrid vehicles via attitude, subjective norm, and perceived behaviour control. Across these studies, environmental concern consistently emerges as the most influential antecedent of the three TPB components. Based on this evidence, the following hypotheses are proposed.

H5. *Environmental concern is positively related to attitude.*

H6. *Environmental concern is positively related to subjective norm.*

H7. *Environmental concern is positively related to attitude.*

2.4. Conceptual Framework

Figure 1 presents the conceptual framework developed for this study. The framework positions environmental concern (EC) as an exogenous construct that influences the three core TPB components, which are attitude (AT), subjective norm (SN), and perceived behaviour control (PBC), through direct paths (H5–H7). Technology adoption (TA) is introduced as a second external construct with a direct path to behavioural intention (BI) (H4). AT, SN, and PBC, in turn, are hypothesised to predict behavioural intention (BI) directly (H1–H3), with EC also exerting an indirect effect on BI through these mediating constructs. Together, the seven hypotheses constitute the extended TPB (ETPB) model tested in this study.

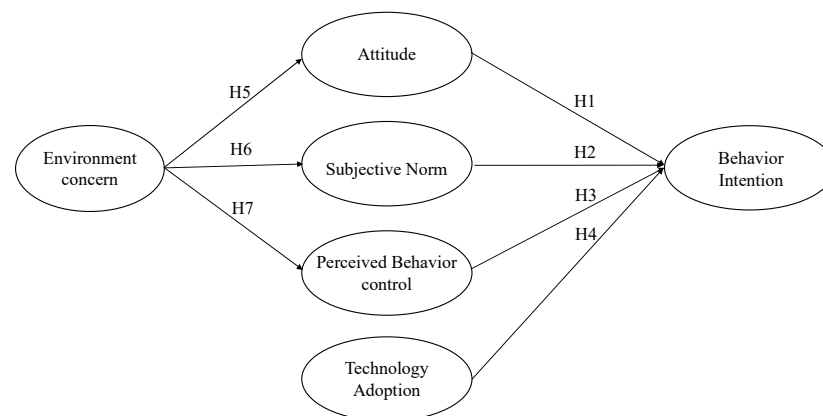


Figure 1. Conceptual framework and the relationships between the proposed hypotheses.

3. Methodology

3.1. Study Area: Klang Valley

Klang Valley is Malaysia's principal urban conurbation and economic centre, encompassing the Federal Territory of Kuala Lumpur and surrounding cities in Selangor, including Petaling Jaya, Shah Alam, Klang, Gombak, Hulu Langat, and Sepang [8]. According to the Department of Statistics Malaysia (DOSM) [53], Klang Valley had a population of 9.13 million in 2022, representing approximately one third of the national total. The area is served by an integrated rail transit network comprising light rail transit (LRT), mass rapid transit (MRT), and monorail lines [26], as illustrated in Figure 2.

3.2. Sample and Data Collection

This study employed a quantitative cross-sectional survey targeting private vehicle users in Klang Valley. A bilingual (Malay and English) questionnaire was developed by adapting validated instruments from prior studies [9,18,19,52]. The instrument comprises two sections: Section A captures respondent demographics, and Section B measures the latent constructs of the extended TPB model using a five-point Likert scale (1 = strongly disagree; 5 = strongly agree). Content validity was established through expert review, followed by a pilot test with 50 randomly selected respondents in Bandar Baru Bangi, Selangor [54]. Items with unsatisfactory reliability were removed or revised based on pilot feedback. In particular, the perceived behaviour control scale was reduced from six to four items following the removal of two items with low item–total correlations.

This study involved only self-reported, anonymous travel behaviour data, with no sensitive personal information collected; participation was entirely voluntary, with informed consent obtained prior to completion. The study therefore qualified as minimal-risk research, exempt from formal ethical review.

Six trained enumerators administered the survey over two months (12 January–15 March 2024), distributing 600 questionnaires to respondents located within a 4–6 km radius of rail transit stations who had not used rail transit in the preceding six months or had never used it. The 4–6 km radius was selected to target respondents for whom rail transit constituted a realistic modal alternative, while the non-use criterion ensured that the sample comprised genuine potential switchers rather than existing transit users. A total of 483 usable responses were retained, yielding an effective response rate of 80.5%. Table 2 summarises the survey constructs and pilot test reliability results.

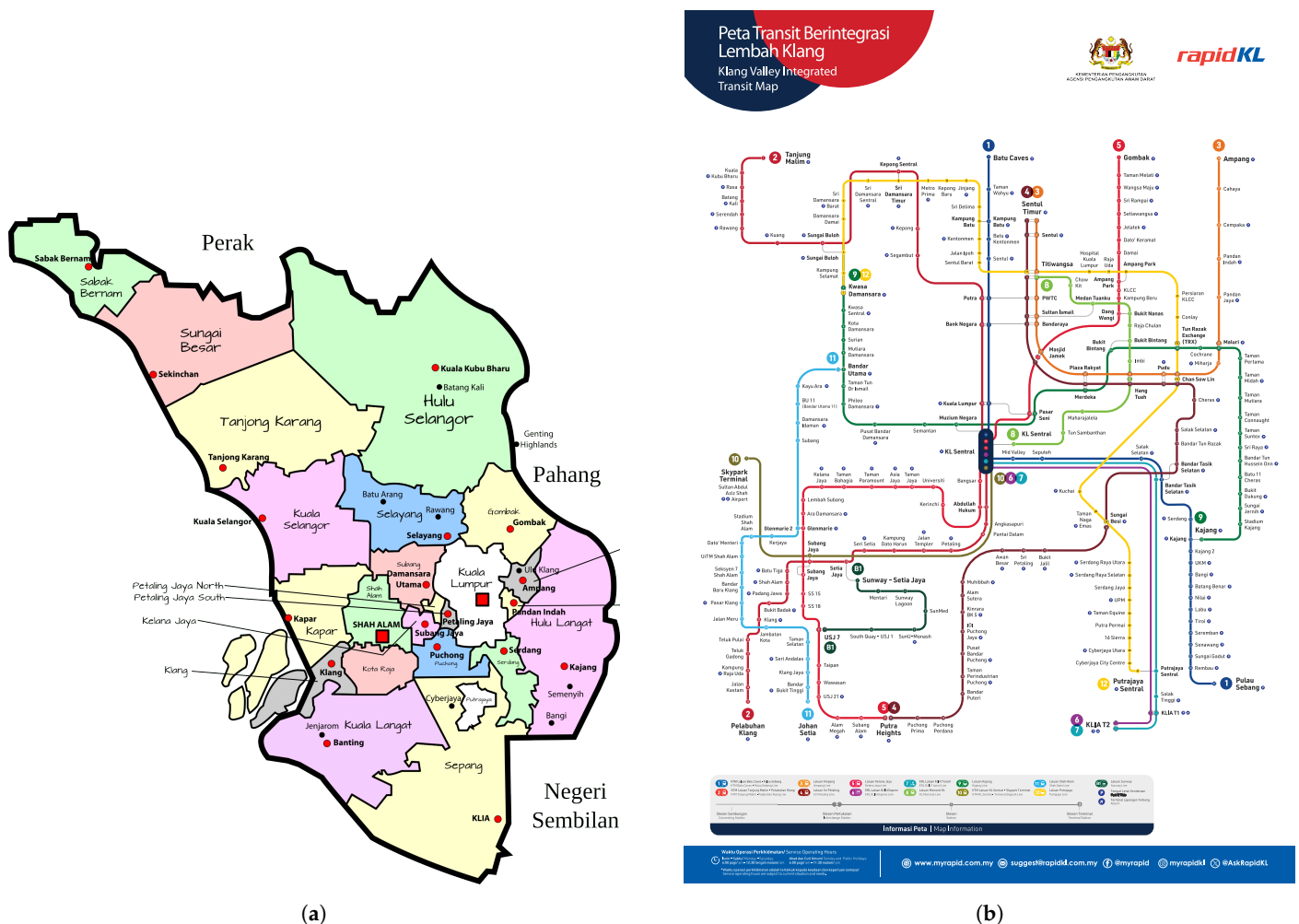


Figure 2. Study area and rail transit network in Klang Valley. (a) Klang Valley administrative boundary. Adapted from Wikimedia Commons (https://commons.wikimedia.org/wiki/File:Klang_valley_map.svg, accessed on 1 July 2026), CC BY-SA 4.0. District labels added by the authors. (b) Integrated rail transit network.

3.3. Statistical Analysis

This study employed partial least squares structural equation modelling (PLS-SEM) for parameter estimation, using the SmartPLS software. PLS-SEM was preferred over covariance-based SEM (CB-SEM) for several reasons. The data exhibited non-normal distributions, with 12 of the 31 indicator variables showing absolute skewness values exceeding 1.0 (range: -1.390 to -0.487), violating the multivariate normality assumption

required by CB-SEM. In addition, the model structure is relatively complex, incorporating two external constructs alongside the baseline TPB, and the study has an exploratory character in extending TPB to a new Malaysian context—both conditions under which PLS-SEM is particularly appropriate [55]. Although the hypothesised relationships are derived from established TPB theory, giving the study a confirmatory orientation, the extension of the baseline model with two new external constructs in a previously unstudied context also introduces an exploratory dimension. This dual character is consistent with the application of PLS-SEM, which is recommended for studies that combine confirmatory hypothesis testing with exploratory model extension [55]. The analytical procedure followed two stages: the assessment of the measurement model (reliability and validity of constructs), followed by the evaluation of the structural model (path coefficients and model fit).

Table 2. Survey constructs and pilot test reliability.

Construct	No. of Items	Cronbach's Alpha
Attitude	4	0.698
Subjective norm	5	0.752
Perceived behaviour control	6	0.651
Technology adoption	5	0.876
Environmental concern	6	0.796
Behavioural intention	7	0.856

All items were adapted from Ali et al. [19], Bamberg et al. [18], Ng and Phung [9], and Wang et al. [52].

The structural model specifies the relationships among latent variables [56]:

$$\eta_j = \sum_{i=1}^q \beta_{ij} \eta_i + \sum_{k=1}^r \gamma_{jk} \xi_k + \zeta_j \quad (1)$$

where η_j is the j -th endogenous latent variable, β_{ij} is the path coefficient between endogenous variables, ξ_k is the k -th exogenous latent variable, γ_{jk} is its path coefficient to η_j , and ζ_j is the corresponding error term.

The reflective measurement model relates each observed indicator to its latent construct as follows:

$$Y_{ij} = \lambda_{ij} \xi_j + \varepsilon_{ij} \quad (2)$$

where Y_{ij} is the i -th observed indicator of construct j , λ_{ij} is its factor loading, ξ_j is the j -th latent construct, and ε_{ij} is the measurement error.

All constructs in this study are operationalised using reflective measurement models, in which observed indicators are conceptualised as manifestations of their underlying latent constructs [55]. Model fit was evaluated using the coefficient of determination (R^2), predictive relevance (Q^2 , via blindfolding), and effect size (f^2) [55]. Discriminant validity was assessed using the heterotrait–monotrait ratio (HTMT) and the Fornell–Larcker criterion [57]. Common method variance (CMV) was assessed using Harman's single-factor test, in which the first unrotated factor accounted for 50.32% of the total variance, marginally exceeding the conventional 50% threshold. To provide a more robust assessment, full collinearity variance inflation factors (VIFs) were additionally examined [55]. All VIF values fell below the threshold of 3.3, ranging from 1.566 (EC) to 2.965 (TA), indicating that common method bias did not pose a serious concern for the interpretation of the structural model results.

4. Results and Discussion

4.1. Demographic Profile of Respondents

Table 3 summarises the demographic profile of the 483 respondents. The sample skewed female (64.8%) and young, with 77.4% aged 35 years or below. The majority held

university-level qualifications (52.2%) and were employed in the private sector (38.9%) or public sector (22.8%) or were students (22.2%). Over half (52.6%) earned below RM4850 per month, and 22.6% reported no income. Regarding proximity to rail transit, 45.3% of respondents lived more than 1000 m from the nearest station, which is consistent with the study's focus on habitual private vehicle users with limited day-to-day exposure to rail services. The demographic composition of the sample warrants discussion in relation to the study's key constructs. The overrepresentation of younger respondents (77.4% aged 35 or below) and highly educated participants (52.2% with university-level qualifications) may have inflated the TA construct scores, as younger and more educated individuals tend to be more comfortable with digital technologies [39]. Similarly, the high proportion of female respondents (64.8%) may have influenced the EC construct, given evidence that women tend to express stronger environmental concern than men in transport contexts [47]. The relatively weak effect of SN may also partly reflect the dominance of younger respondents, for whom peer influence on transport decisions may operate differently than for older commuters. These compositional characteristics should be noted as potential sources of bias when generalising the findings beyond the sampled population, and future studies should employ stratified sampling to ensure a more representative distribution across age, gender, and education groups.

Table 3. Demographic profile of respondents ($n = 483$).

Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	170	35.2
	Female	313	64.8
Age (years)	13–17	12	2.5
	18–35	362	74.9
	36–55	100	20.7
	>56	9	1.9
Education level	Primary school	2	0.4
	High school	87	18.0
	College/diploma	142	29.4
	Degree/Master's/PhD	252	52.2
Employment status	Public sector	110	22.8
	Private sector	188	38.9
	General labourer	5	1.0
	Self-employed	26	5.4
	Student	107	22.2
	Retired	2	0.4
	Homemaker	22	4.6
	Unemployed	13	2.7
Monthly income (RM)	Others	10	2.1
	<4850	254	52.6
	4850–10,959	67	13.9
	>10,959	5	1.0
	Irregular income	48	9.9
Distance to nearest rail transit station (m)	No income	109	22.6
	<200	89	18.4
	200–400	70	14.5
	400–700	55	11.4
	700–1000	50	10.4
	>1000	219	45.3

4.2. Measurement Model

The measurement model was assessed for reliability and validity across two configurations: the baseline TPB model (comprising AT, SN, PBC, and BI) and the extended model (ETPB, additionally including EC and TA). Since the four shared constructs were operationalised using identical items, their measurement properties are identical across both models (Tables 4 and 5).

4.2.1. Factor Loadings and Reliability

The factor loadings for all constructs meet or approach the recommended threshold of 0.70 [58]. As shown in Tables 4 and 5, Cronbach's alpha ranges from 0.811 to 0.929 and the composite reliability (CR) ranges from 0.861 to 0.945, both comfortably exceeding the minimum criterion of 0.70 [55]. One EC item (EC3) exhibited a loading of 0.545, below the 0.70 threshold. However, following Hair et al. [55], items with loadings between 0.40 and 0.70 may be retained if their removal does not improve the construct's AVE beyond the 0.50 threshold and if they contribute unique theoretical content. EC3 measures awareness of vehicle-related air pollution, a dimension that is conceptually distinct from the energy and carbon emission items captured by the remaining EC indicators. Removing EC3 would reduce the content validity of the EC construct by eliminating its environmental health dimension. The construct's overall reliability remained acceptable ($\alpha = 0.811$, CR = 0.861, AVE = 0.522), confirming that EC3's retention does not compromise the measurement quality.

Table 4. Factor loadings, reliability, and validity—TPB model.

Construct	Factor Loading	Cronbach's α	ρ_A	CR	AVE
AT	0.883–0.890	0.903	0.904	0.932	0.775
SN	0.786–0.833	0.869	0.872	0.905	0.656
PBC	0.803–0.906	0.884	0.887	0.920	0.743
BI	0.729–0.890	0.929	0.931	0.943	0.704

AT: attitude; SN: subjective norm; PBC: perceived behaviour control; BI: behavioural intention; CR: composite reliability; AVE: average variance extracted.

Table 5. Factor loadings, reliability, and validity—ETPB model.

Construct	Factor Loading	Cronbach's α	ρ_A	CR	AVE
AT	0.883–0.890	0.903	0.904	0.932	0.775
BI	0.729–0.890	0.929	0.931	0.943	0.704
EC	0.545–0.883	0.811	0.870	0.861	0.522
PBC	0.803–0.906	0.884	0.887	0.920	0.743
SN	0.786–0.833	0.869	0.872	0.905	0.656
TA	0.724–0.928	0.926	0.935	0.945	0.777

AT: attitude; BI: behavioural intention; EC: environmental concern; PBC: perceived behaviour control; SN: subjective norm; TA: technology adoption; CR: composite reliability; AVE: average variance extracted.

4.2.2. Validity

Convergent validity was assessed using the average variance extracted (AVE). All AVE values ranged from 0.522 to 0.777, exceeding the minimum threshold of 0.50 [55].

Discriminant validity was evaluated using two criteria. First, the heterotrait–monotrait ratio (HTMT) was examined, with all values required to fall below the conservative threshold of 0.90 [55]. As shown in Tables 6 and 7, all HTMT values satisfied this threshold in both models. The highest value observed was 0.890 (PBC–BI in both models), which remains within the acceptable range. Second, the Fornell–Larcker criterion requires that the square root of each construct's AVE exceeds its highest interconstruct correlation [57]. As shown

in Tables 8 and 9, this condition was satisfied for all constructs in both models. Collectively, the measurement model meets all reliability and validity requirements.

Table 6. Heterotrait–monotrait ratio (HTMT)—TPB model.

	AT	BI	PBC	SN
AT				
BI	0.765			
PBC	0.748	0.890		
SN	0.723	0.789	0.808	

AT: attitude; SN: subjective norm; PBC: perceived behaviour control; BI: behavioural intention.

Table 7. Heterotrait–monotrait ratio (HTMT)—ETPB model.

	AT	BI	EC	PBC	SN	TA
AT						
BI	0.765					
EC	0.603	0.604				
PBC	0.748	0.890	0.618			
SN	0.723	0.789	0.627	0.808		
TA	0.722	0.889	0.593	0.835	0.809	

AT: attitude; SN: subjective norm; PBC: perceived behaviour control; BI: behavioural intention; EC: environmental concern; TA: technology adoption.

Table 8. Fornell–Larcker criterion—TPB model.

	AT	BI	PBC	SN
AT	0.880			
BI	0.703	0.839		
PBC	0.671	0.807	0.862	
SN	0.649	0.714	0.713	0.810

Diagonal values (bold) represent square roots of AVE; off-diagonal values are interconstruct correlations. AT: attitude; SN: subjective norm; PBC: perceived behaviour control; BI: behavioural intention.

Table 9. Fornell–Larcker criterion—ETPB model.

	AT	BI	EC	PBC	SN	TA
AT	0.880					
BI	0.703	0.839				
EC	0.525	0.532	0.723			
PBC	0.671	0.807	0.543	0.862		
SN	0.649	0.714	0.557	0.713	0.810	
TA	0.665	0.824	0.529	0.754	0.727	0.881

Diagonal values (bold) represent square roots of AVE; off-diagonal values are interconstruct correlations. AT: attitude; SN: subjective norm; PBC: perceived behaviour control; BI: behavioural intention; EC: environmental concern; TA: technology adoption.

4.3. Structural Model

4.3.1. Path Coefficients and Hypothesis Testing

Tables 10 and 11 report the structural model results for the TPB and ETPB models, with the path coefficients visualised in Figures 3 and 4.

In the baseline TPB model, all three constructs are significant predictors of BI, namely AT ($\beta = 0.222$, $t = 4.217$, $p < 0.001$), SN ($\beta = 0.211$, $t = 4.094$, $p < 0.001$), and PBC ($\beta = 0.508$, $t = 9.472$, $p < 0.001$), supporting H1, H2, and H3. The model explains 71.9% of the variance in BI ($R^2 = 0.719$).

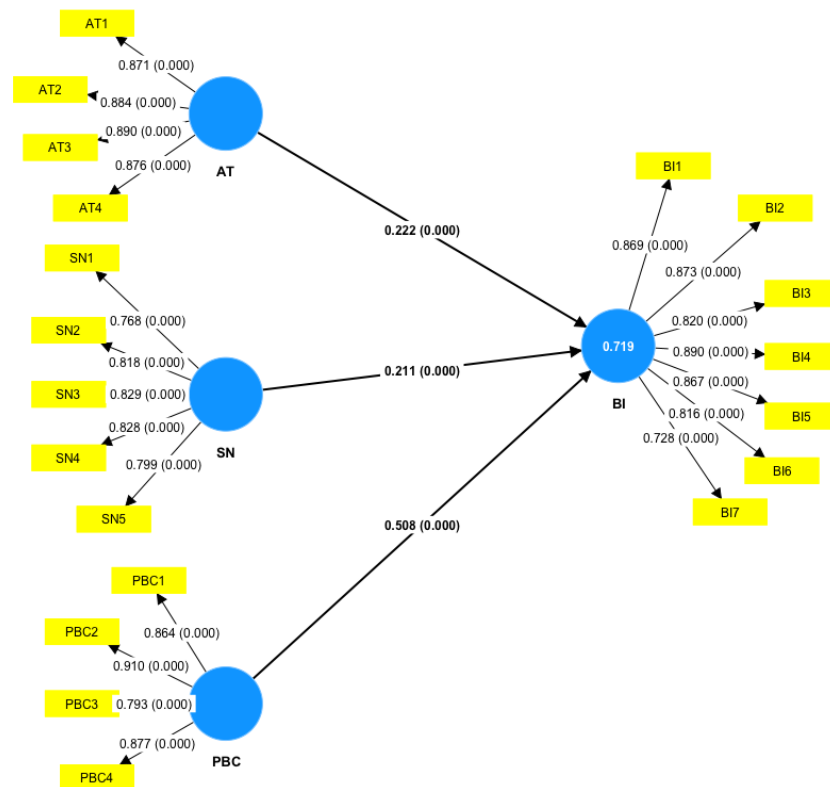


Figure 3. Path coefficients for the baseline TPB model. AT: attitude; SN: subjective norm; PBC: perceived behaviour control; BI: behavioural intention.

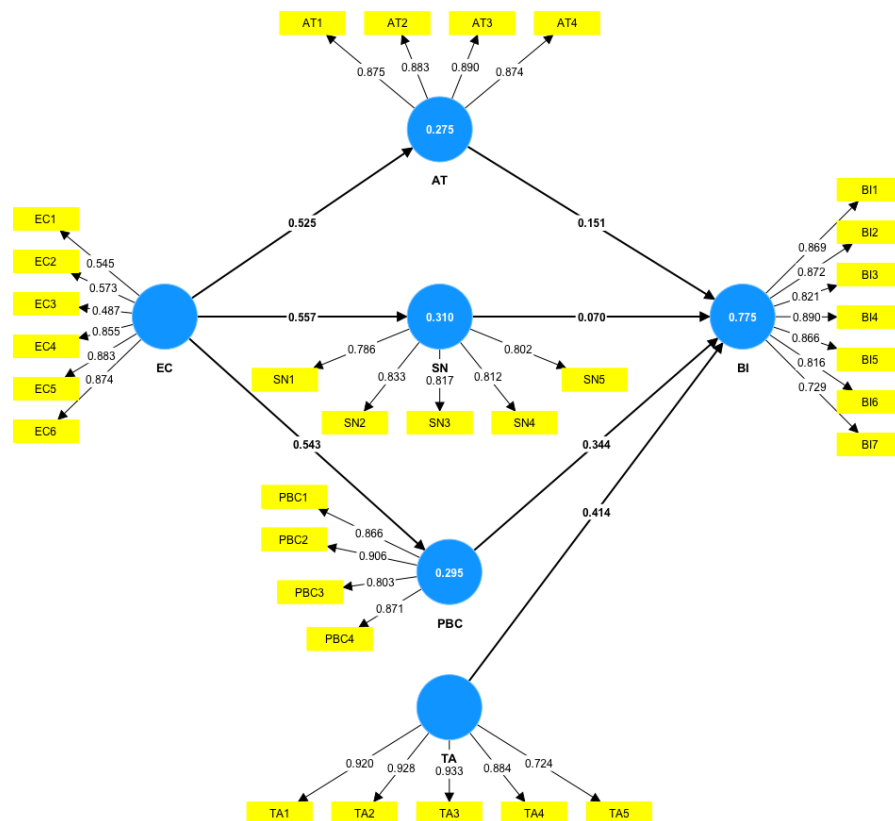


Figure 4. Path coefficients for the extended TPB (ETPB) model. AT: attitude; SN: subjective norm; PBC: perceived behaviour control; BI: behavioural intention; EC: environmental concern; TA: technology adoption.

In the ETPB model, the path coefficients for AT, PBC, and TA on BI are positive and statistically significant ($p < 0.001$), supporting H1, H3, and H4. SN is the sole non-significant predictor of BI ($\beta = 0.064$, $t = 1.340$, $p = 0.180$); H2 is therefore not supported. With respect to the antecedents of the TPB components, EC shows strong positive and significant relationships with AT ($\beta = 0.525$, $t = 12.800$, $p < 0.001$), SN ($\beta = 0.557$, $t = 13.511$, $p < 0.001$), and PBC ($\beta = 0.543$, $t = 13.656$, $p < 0.001$), supporting H5, H6, and H7.

A mediation analysis was conducted using bootstrapping with 5000 resamples to obtain bias-corrected 95% confidence intervals for the indirect effects [55]. The results confirmed that EC exerts a significant indirect effect on BI via AT ($\beta_{indirect} = 0.087$, 95% CI [0.041, 0.142]) and via PBC ($\beta_{indirect} = 0.190$, 95% CI [0.128, 0.258]). The total indirect effect of EC on BI was also significant ($\beta_{indirect} = 0.277$, 95% CI [0.209, 0.350]). Both confidence intervals exclude zero, confirming the significance of these indirect pathways. SN does not mediate the EC-BI relationship despite the significant EC $\rightarrow$ SN direct path, because SN itself does not significantly predict BI in the ETPB model ($\beta = 0.064$, $p = 0.180$).

Comparing the two models, SN is a significant predictor of BI in the baseline TPB ($\beta = 0.211$, $p < 0.001$) but becomes non-significant in the ETPB ($\beta = 0.064$, $p = 0.180$), suggesting that the introduction of EC and TA may account for some of the variance previously associated with SN.

Table 10. Structural model results—TPB.

Hyp.	Path	β	SD	t	p	Result	R^2	Q^2
H1	AT $\rightarrow$ BI	0.222	0.053	4.217	0.000	Supported		
H2	SN $\rightarrow$ BI	0.211	0.051	4.094	0.000	Supported	0.719	0.711
H3	PBC $\rightarrow$ BI	0.508	0.054	9.472	0.000	Supported		

β : standardised path coefficient; SD: standard deviation; R^2 : coefficient of determination; Q^2 : predictive relevance (blindfolding). AT: attitude; SN: subjective norm; PBC: perceived behaviour control; BI: behavioural intention.

Table 11. Structural model results—ETPB.

Hyp.	Path	β	SD	t	p	Result	R^2	Q^2	f^2
H1	AT $\rightarrow$ BI	0.153	0.044	3.523	0.000	Supported	0.775	0.604	0.049
H2	SN $\rightarrow$ BI	0.064	0.048	1.340	0.180	Not supported			0.007
H3	PBC $\rightarrow$ BI	0.340	0.056	6.056	0.000	Supported			0.183
H4	TA $\rightarrow$ BI	0.417	0.055	7.510	0.000	Supported			0.271
H5	EC $\rightarrow$ AT	0.525	0.041	12.800	0.000	Supported	0.275	0.267	0.380
H6	EC $\rightarrow$ SN	0.557	0.041	13.511	0.000	Supported	0.310	0.302	0.449
H7	EC $\rightarrow$ PBC	0.543	0.040	13.656	0.000	Supported	0.295	0.288	0.418

Hyp.: hypothesis; β : standardised path coefficient; SD: standard deviation; R^2 and Q^2 for H1–H4 apply to the BI endogenous variable; R^2 and Q^2 for H5–H7 apply to AT, SN, and PBC, respectively; f^2 : effect size. AT: attitude; SN: subjective norm; PBC: perceived behaviour control; BI: behavioural intention; EC: environmental concern; TA: technology adoption.

4.3.2. Model Fit and Predictive Accuracy

The coefficient of determination (R^2) for BI increased from 0.719 (TPB) to 0.775 (ETPB), a relative improvement of 7.8% (calculated as $\Delta R^2 / R^2_{TPB}$), indicating that EC and TA contribute meaningfully to explaining the variance in behavioural intention [55]. The effect size (f^2) values confirm that EC exerts the largest influence on the TPB components ($f^2 = 0.380$ – 0.449 , large effect), followed by TA on BI ($f^2 = 0.271$, large effect) and PBC on BI ($f^2 = 0.183$, medium-to-large effect), based on the thresholds proposed by Cohen [59] ($f^2 \geq 0.02$ small; ≥ 0.15 medium; ≥ 0.35 large).

The predictive relevance index Q^2 decreased from 0.711 (TPB) to 0.604 (ETPB); however, both values substantially exceed zero, confirming the adequate predictive relevance in both models [55]. This decrease is attributable to the increased model complexity in the ETPB, whereby the blindfolding procedure distributes estimation across a greater number of endogenous constructs, which can reduce Q^2 even as R^2 improves. The overall pattern of higher R^2 with adequate Q^2 supports the conclusion that the ETPB provides a more comprehensive explanation of behavioural intention than the baseline TPB.

4.4. Discussion

This study applied the Extended Theory of Planned Behaviour (ETPB) to investigate the behavioural intention of private vehicle users in Klang Valley, Malaysia to switch to rail transit. Two external constructs, environmental concern (EC) and technology adoption (TA), were incorporated into the baseline TPB. With the exception of subjective norm, all constructs demonstrated significant and positive relationships with behavioural intention, and the ETPB explained 7.8% more variance in BI than the baseline TPB (R^2 : 0.775 vs. 0.719), consistent with evidence that model extensions enhance predictive effectiveness [60].

Environmental concern. EC exhibited the largest effect size among all constructs on the TPB components ($f^2 = 0.380\text{--}0.449$, large effect) [59], but influenced BI exclusively through indirect pathways mediated by attitude and perceived behaviour control. This finding aligns with studies conducted in Vietnam [9] and China [52], which similarly found that EC does not directly predict BI but operates through attitudinal and control-related mechanisms. The absence of a significant mediation pathway through subjective norm, despite the significant $EC \rightarrow SN$ direct path, reflects SN's overall non-significance as a predictor of BI in the ETPB model. These results suggest that raising environmental awareness among private vehicle users could indirectly promote rail transit adoption by strengthening positive attitudes and perceptions of behavioural control.

Technology adoption. TA was the strongest direct predictor of BI ($\beta = 0.417$, $f^2 = 0.271$, large effect), underscoring the importance of digital infrastructure in shaping transport behaviour. This finding contrasts with those of Chan et al. [61], who found no significant effect of technology on public transport intention among university students in a controlled setting, but it corroborates Nikolaidou and Papaioannou [44], who demonstrated that social media content, particularly viral posts, meaningfully influences mode choice in open commuting contexts. The difference may reflect the broader and more diverse commuter population examined in the present study. This stronger influence of TA relative to SN may reflect the distinct mechanisms through which each construct shapes behavioural intention: digital tools directly lower the transactional and cognitive costs of modal shift by providing immediate and accessible travel information, whereas social normative pressure in the Malaysian context may paradoxically reinforce private car use given its strong social status symbolism [3]. The result highlights the potential of digital engagement strategies, including app-based services and social media campaigns, to accelerate rail transit adoption.

Attitude and perceived behaviour control. Both AT ($\beta = 0.153$) and PBC ($\beta = 0.340$) were significant predictors of BI, consistent with the broad TPB literature [26,33]. PBC exerted a notably stronger effect than AT, suggesting that reducing perceived barriers, such as poor station accessibility, infrequent services, and high transfer complexity, may be more effective in promoting modal shift than attitudinal campaigns alone.

Subjective norm. SN was not a significant predictor of BI in the ETPB model ($\beta = 0.064$, $p = 0.180$), although it was significant in the baseline TPB ($\beta = 0.211$, $p < 0.001$). This shift warrants careful interpretation. One plausible explanation is shared variance: TA, EC, and PBC may capture variance in BI that was previously attributed to SN in the baseline

model, as these constructs all relate to social, environmental, and control-related influences on travel decisions. A suppression effect is also possible, whereby the introduction of EC and TA attenuates the independent contribution of SN to BI [55]. This pattern is consistent with Ng and Phung [9], who similarly found SN to be non-significant in a Southeast Asian public transport context. Beyond statistical explanation, this result warrants cultural interpretation: although Malaysia scores relatively high on collectivism in Hofstede's cultural dimensions [62], which would theoretically predict a stronger role for SN, private car ownership carries strong social status symbolism in the Malaysian context [3]. Social pressure may therefore tend to reinforce car use rather than encourage switching to rail transit, which may partly explain why the influence of EC and TA appears to override normative pressure in the extended model. This interpretation contrasts findings from Norway [36] and Thailand [63], where social influence played a more prominent role, possibly reflecting the different social connotations of private car ownership in these contexts.

Policy implications. The findings carry several practical implications for transport authorities, service providers, and policymakers. At the digital engagement level, service providers should invest in the continuous improvement of rail transit applications, incorporating real-time congestion data, online ticketing, and multi-language support [41,42], and engage social media influencers to promote rail transit adoption [44]. Specifically, this includes the development of integrated multimodal journey planning platforms combining real-time train schedules, feeder bus connections, and first- and last-mile routing, as well as the expansion of contactless and account-based intelligent ticketing systems that reduce boarding friction. At the infrastructure level, service providers should prioritise improvements that lower perceived barriers to rail use, including expanded feeder bus networks, enhanced pedestrian connectivity, and park-and-ride facilities [64], alongside more frequent and reliable train scheduling. At the policy level, government subsidies and fare structures comparable to those in Singapore can reduce economic barriers to modal shift [65]. Although EC influences BI only indirectly, targeted environmental awareness campaigns may nonetheless strengthen pro-transit attitudes and perceived behavioural control over the longer term. Together, these measures address the digital, infrastructural, and economic barriers to rail transit adoption identified by the ETPB model.

5. Conclusions

This study extended the Theory of Planned Behaviour with two additional constructs, environmental concern (EC) and technology adoption (TA), to examine the intention of private vehicle users in Klang Valley, Malaysia to switch to rail transit. The measurement model demonstrated satisfactory reliability and validity across all constructs. The structural model results showed that TA was the strongest direct predictor of behavioural intention ($\beta = 0.417$), followed by PBC ($\beta = 0.340$) and AT ($\beta = 0.153$), while EC exerted the largest indirect effect via AT and PBC ($f^2 = 0.380\text{--}0.449$). Subjective norm was non-significant in the extended model, a finding attributed partly to the social status symbolism of private car ownership in the Malaysian context. The ETPB achieved an R^2 of 0.775, representing a 7.8% relative improvement over the baseline TPB, confirming that incorporating external constructs meaningfully enhances the explanatory power. These findings offer actionable guidance for policymakers, rail transit operators, and urban planners seeking to promote rail transit adoption intention among private vehicle users in developing-country contexts.

Limitations. This study has three principal limitations. The sample was geographically constrained to Klang Valley and drawn from private vehicle users within a 4–6 km radius of rail stations, which may have introduced proximity bias and limits generalisability to other Malaysian regions or to non-users residing further from the network. Additionally, the survey relied entirely on self-reported responses collected at a single point in time,

which precludes causal inference. Although CMV was formally assessed using Harman's single-factor test and full collinearity VIFs (Section 3.3), and the results suggest that it does not pose a serious threat to the findings, the cross-sectional nature of the data remains a limitation for establishing causal relationships. A further limitation concerns the notable gender imbalance in the sample, with female respondents comprising 64.8% of the total, which may introduce response bias into the attitudinal and normative constructs measured.

Future research directions. Future studies should address the methodological constraints identified above by adopting wider geographic sampling frames, longitudinal designs, and stratified sampling strategies across age, gender, and education groups to improve generalisability, causal inference, and sample representativeness. The ETPB framework could also be enriched by incorporating additional external constructs such as service quality, habit strength, perceived safety, or moral norms, which may further explain private vehicle users' reluctance to switch to rail transit. Finally, comparative studies across Southeast Asian cities with varying levels of public transport development and cultural profiles would provide broader insights for regional transport planning policy.

Author Contributions: Conceptualisation, T.A.A.A.J.; methodology, J.S. and T.A.A.A.J.; software, T.A.A.A.J.; validation, F.A.; formal analysis, T.A.A.A.J.; investigation, J.S.; resources, J.S.; data curation, F.A.; writing—original draft preparation, T.A.A.A.J.; writing—review and editing, J.S.; visualisation, J.S.; supervision, M.N.B., J.C. and A.N.H.I.; project administration, A.N.H.I.; funding acquisition, J.C. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the 2025 Guangxi University Young and Middle-Aged Teachers' Research Foundation Capacity Enhancement project (2025KY1212).

Institutional Review Board Statement: Ethical review and approval were waived for this study because the research involved only anonymous, self-reported questionnaire data on travel behaviour and perceptions from voluntary adult participants. No sensitive personal information, biological samples, medical records, or identifiable private data were collected, and no experimental intervention or manipulation was conducted. The study therefore falls within the category of minimal-risk research, which is typically exempt from formal institutional ethical review under Malaysian research ethics guidelines. Informed consent was obtained from all participants prior to survey completion.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding authors. The data are not publicly available due to privacy restrictions, as the dataset contains individual-level survey responses collected under the assurance of confidentiality given to participants during data collection.

Acknowledgments: The authors would like to thank the anonymous reviewers for their constructive suggestions and comments. During the preparation of this manuscript, the authors used Claude (Anthropic, San Francisco, CA, USA) to assist with grammar and spelling checks and manuscript formatting. The authors have reviewed and edited all outputs and take full responsibility for the content of this publication.

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

AT	Attitude
AVE	Average variance extracted
BI	Behavioural intention
CMV	Common method variance
CR	Composite reliability

DOSM	Department of Statistics Malaysia
EC	Environmental concern
ETPB	Extended Theory of Planned Behaviour
HTMT	Heterotrait–monotrait ratio
IEA	International Energy Agency
LRT	Light rail transit
MOT	Ministry of Transport Singapore
MRT	Mass rapid transit
PBC	Perceived behaviour control
PLS-SEM	Partial least squares structural equation modelling
PM2.5	Particulate matter with diameter $\leq 2.5 \mu\text{m}$
PT	Public transport
PV	Private vehicle
RTD	Road Transport Department
SEM	Structural equation modelling
SN	Subjective norm
TA	Technology adoption
TAM	Technology Acceptance Model
TPB	Theory of Planned Behaviour
TRA	Theory of Reasoned Action
UTAUT	Unified Theory of Acceptance and Use of Technology
WHO	World Health Organization

References

1. Urbanek, A. Potential of modal shift from private cars to public transport: A survey on the commuters' attitudes and willingness to switch—A case study of Silesia Province, Poland. *Res. Transp. Econ.* **2021**, *85*, 100956. [\[CrossRef\]](#)
2. Mohamad, M.K. Kenderaan Lebih Banyak Daripada Penduduk Malaysia. Kosmo Digital, 1 February 2023. Available online: <https://www.kosmo.com.my/2023/02/01/kenderaan-lebih-banyak-daripada-penduduk-malaysia/> (accessed on 3 July 2024).
3. Chiu Chuen, O.; Karim, M.R.; Yusoff, S. Mode choice between private and public transport in Klang Valley, Malaysia. *Sci. World J.* **2014**, *2014*, 394587. [\[CrossRef\]](#) [\[PubMed\]](#)
4. Mahammad Zin, N.A. *Urban Transport System in Greater Kuala Lumpur*; Report Presented at the ESCAP Workshop on Sustainable Urban Transport; United Nations ESCAP: Bangkok, Thailand, 2018; p. 24.
5. Borhan, M.N.; Ibrahim, A.N.H.; Miskeen, M.A.A. Extending the theory of planned behaviour to predict the intention to take the new high-speed rail for intercity travel in Libya: Assessment of the influence of novelty seeking, trust and external influence. *Transp. Res. Part A Policy Pract.* **2019**, *130*, 373–384. [\[CrossRef\]](#)
6. Mustafa, Z. Government Committed to Solving KL Traffic Congestion Issue. 23 January 2024. Available online: <https://paultan.org/2024/01/23/govt-committed-to-solving-kl-traffic-congestion-issue/> (accessed on 1 July 2026).
7. TomTom. *TomTom Traffic Index: Kuala Lumpur*; TomTom: Amsterdam, The Netherlands, 2025. Available online: <https://www.tomtom.com/traffic-index/kuala-lumpur-traffic/> (accessed on 1 July 2026).
8. Makmom Abdullah, A.; Armi Abu Samah, M.; Yee Jun, T. An Overview of the Air Pollution Trend in Klang Valley, Malaysia. *Open Environ. Sci.* **2012**, *6*, 13–19. [\[CrossRef\]](#)
9. Ng, P.Y.; Phung, P.T. Public transportation in Hanoi: Applying an integrative model of behavioral intention. *Case Stud. Transp. Policy* **2021**, *9*, 395–404. [\[CrossRef\]](#)
10. Donald, I.J.; Cooper, S.R.; Conchie, S.M. An extended theory of planned behaviour model of the psychological factors affecting commuters' transport mode use. *J. Environ. Psychol.* **2014**, *40*, 39–48. [\[CrossRef\]](#)
11. Göransson, J.; Andersson, H. Factors that make public transport systems attractive: A review of travel preferences and travel mode choices. *Eur. Transp. Res. Rev.* **2023**, *15*, 32. [\[CrossRef\]](#)
12. Morton, C.; Caulfield, B.; Anable, J. Customer perceptions of quality of service in public transport: Evidence for bus transit in Scotland. *Case Stud. Transp. Policy* **2016**, *4*, 199–207. [\[CrossRef\]](#)
13. Ibrahim, A.N.H.; Borhan, M.N.; Yusoff, N.I.M.; Ismail, A. Rail-based public transport service quality and user satisfaction—A literature review. *Promet-Traffic Transp.* **2020**, *32*, 423–435. [\[CrossRef\]](#)
14. Ajzen, I. From Intentions to Actions: A Theory of Planned Behavior. In *Action Control: From Cognition to Behavior*; Kuhl, J., Beckmann, J., Eds.; Springer: Berlin/Heidelberg, Germany, 1985; pp. 11–39. [\[CrossRef\]](#)

15. Zhang, D.; Schmöcker, J.D.; Fujii, S.; Yang, X. Social norms and public transport usage: Empirical study from Shanghai. *Transportation* **2016**, *43*, 869–888. [\[CrossRef\]](#)
16. Fu, X.; Juan, Z. Understanding public transit use behavior: Integration of the theory of planned behavior and the customer satisfaction theory. *Transportation* **2017**, *44*, 1021–1042. [\[CrossRef\]](#)
17. Lo, S.H.; van Breukelen, G.J.P.; Peters, G.J.Y.; Kok, G. Commuting travel mode choice among office workers: Comparing an Extended Theory of Planned Behavior model between regions and organizational sectors. *Travel Behav. Soc.* **2016**, *4*, 1–10. [\[CrossRef\]](#)
18. Bamberg, S.; Hunecke, M.; Blöbaum, A. Social context, personal norms and the use of public transportation: Two field studies. *J. Environ. Psychol.* **2007**, *27*, 190–203. [\[CrossRef\]](#)
19. Ali, N.; Nakayama, S.; Yamaguchi, H. Using the extensions of the theory of planned behavior (TPB) for behavioral intentions to use public transport (PT) in Kanazawa, Japan. *Transp. Res. Interdiscip. Perspect.* **2023**, *17*, 100742. [\[CrossRef\]](#)
20. Zailani, S.; Iranmanesh, M.; Masron, T.A.; Chan, T.H. Is the intention to use public transport for different travel purposes determined by different factors? *Transp. Res. Part D Transp. Environ.* **2016**, *49*, 18–24. [\[CrossRef\]](#)
21. Eriksson, L.; Forward, S.E. Is the intention to travel in a pro-environmental manner and the intention to use the car determined by different factors? *Transp. Res. Part D Transp. Environ.* **2011**, *16*, 372–376. [\[CrossRef\]](#)
22. Arslannur, B.; Tortum, A. Public Transport Modeling for Commuting in Cities with Different Development Levels Using Extended Theory of Planned Behavior. *Sustainability* **2023**, *15*, 11931. [\[CrossRef\]](#)
23. Chia, Y.P.; Tan, P.Y.; Ho, M.Y. A Study on Factors Influences Behaviour Intention towards Passenger Rail Transportation. *E3S Web Conf.* **2019**, *136*, 04085. [\[CrossRef\]](#)
24. Irtema, H.I.M.; Ismail, A.; Borhan, M.N.; Das, A.M.; Alshetwi, A.B.Z. Case study of the behavioural intentions of public transportation passengers in Kuala Lumpur. *Case Stud. Transp. Policy* **2018**, *6*, 462–474. [\[CrossRef\]](#)
25. Madha, A.; Dhafir, H.; Dawood, A. Factors Affecting Public Transport in Petaling Jaya, Malaysia: An Extension of the Theory of Planned Behaviour. In Proceedings of the World Congress on Civil, Structural, and Environmental Engineering (CSEE'16), Prague, Czech Republic, 30–31 March 2016. [\[CrossRef\]](#)
26. Kalhor, M.; Yong, H.N.A.; Ramendran, C. Understanding the factors affecting pro-environment behavior for city rail transport usage: Territories' empirical evidence—Malaysia. *Sustainability* **2021**, *13*, 12483. [\[CrossRef\]](#)
27. Liao, C.; Chen, J.L.; Yen, D.C. Theory of planning behavior (TPB) and customer satisfaction in the continued use of e-service: An integrated model. *Comput. Hum. Behav.* **2007**, *23*, 2804–2822. [\[CrossRef\]](#)
28. Karimy, M.; Zareban, I.; Araban, M.; Montazeri, A. An extended theory of planned behavior (TPB) used to predict smoking behavior among a sample of Iranian medical students. *Int. J. High Risk Behav. Addict.* **2015**, *4*, e24715. [\[CrossRef\]](#) [\[PubMed\]](#)
29. Borhan, M.N.; Ibrahim, A.N.H.; Miskeen, M.A.A.; Rahmat, R.A.O.K.; Alhodairi, A.M. Predicting car drivers' intention to use low cost airlines for intercity travel in Libya. *J. Air Transp. Manag.* **2017**, *65*, 88–98. [\[CrossRef\]](#)
30. Ibrahim, A.N.H.; Borhan, M.N.; Yunin, N.A.M. Getting young drivers to buckle up: Exploring the factors influencing seat belt use by young drivers in Malaysia. *Sustainability* **2021**, *13*, 162. [\[CrossRef\]](#)
31. Ahmed, F.; Catchpole, J.; Edirisinghe, T. Understanding Young Commuters' Mode Choice Decision to Use Private Car or Public Transport from an Extended Theory of Planned Behavior. *Transp. Res. Rec.* **2021**, 2675, 200–211. [\[CrossRef\]](#)
32. Ajzen, I. The theory of planned behavior. *Organ. Behav. Hum. Decis. Processes* **1991**, *50*, 179–211. [\[CrossRef\]](#)
33. Shaaban, K.; Maher, A. Using the theory of planned behavior to predict the use of an upcoming public transportation service in Qatar. *Case Stud. Transp. Policy* **2020**, *8*, 484–491. [\[CrossRef\]](#)
34. Ajzen, I. The theory of planned behaviour: Reactions and reflections. *Psychol. Health* **2011**, *26*, 1113–1127. [\[CrossRef\]](#) [\[PubMed\]](#)
35. Li, L.; Xiong, J.; Chen, A.; Zhao, S.; Dong, Z. Key Strategies for Improving Public Transportation Based on Planned Behavior Theory: Case Study in Shanghai, China. *J. Urban Plan. Dev.* **2015**, *141*, 04014031. [\[CrossRef\]](#)
36. Nordfjærn, T.; Şimşekoğlu, Ö.; Rundmo, T. The role of deliberate planning, car habit and resistance to change in public transportation mode use. *Transp. Res. Part F Traffic Psychol. Behav.* **2014**, *27*, 90–98. [\[CrossRef\]](#)
37. Hauslbauer, A.L.; Schade, J.; Drexler, C.E.; Petzoldt, T. Extending the theory of planned behavior to predict and nudge toward the subscription to a public transport ticket. *Eur. Transp. Res. Rev.* **2022**, *14*, 5. [\[CrossRef\]](#)
38. Durand, A.; Zijlstra, T.; Hamersma, M.; Hoen, A.; van Oort, N.; Hoogendoorn-Lanser, S.; Hoogendoorn, S. "Who can I ask for help?": Mechanisms behind digital inequality in public transport. *Cities* **2023**, *137*, 104335. [\[CrossRef\]](#)
39. Durand, A.; Zijlstra, T.; van Oort, N.; Hoogendoorn-Lanser, S.; Hoogendoorn, S. Access denied? Digital inequality in transport services. *Transp. Rev.* **2022**, *42*, 32–57. [\[CrossRef\]](#)
40. Fontes, T.; Costa, V.; Ferreira, M.C.; Shengxiao, L.; Zhao, P.; Dias, T.G. Mobile payments adoption in public transport. *Transp. Res. Procedia* **2017**, *24*, 410–417. [\[CrossRef\]](#)
41. Kang, A.S.; Jayaraman, K.; Soh, K.L.; Wong, W.P. Convenience, flexible service, and commute impedance as the predictors of drivers' intention to switch and behavioral readiness to use public transport. *Transp. Res. Part F Traffic Psychol. Behav.* **2019**, *62*, 505–519. [\[CrossRef\]](#)

42. Rosa, G. Use of modern technologies by public transport passengers during the COVID-19 pandemic. *Procedia Comput. Sci.* **2022**, *207*, 3584–3593. [CrossRef] [PubMed]
43. Wahab, N.A.; Othman, M.S.; Muhammad, N. The Influence of the Mass Media in the Behavior Students: A Literature Study. *Int. J. Acad. Res. Bus. Soc. Sci.* **2017**, *7*, 873–882. [CrossRef] [PubMed]
44. Nikolaidou, A.; Papaioannou, P. Social media and transport choices: How social media can affect Tripmakers' choices. *WIT Trans. Ecol. Environ.* **2017**, *226*, 605–616. [CrossRef]
45. Davis, F.D. Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Q.* **1989**, *13*, 319–340. [CrossRef] [PubMed]
46. Venkatesh, V.; Morris, M.G.; Davis, G.B.; Davis, F.D. User Acceptance of Information Technology: Toward a Unified View. *MIS Q.* **2003**, *27*, 425–478. [CrossRef]
47. Bouscasse, H.; Joly, I.; Bonnel, P. How does environmental concern influence mode choice habits? A mediation analysis. *Transp. Res. Part D Transp. Environ.* **2018**, *59*, 205–222. [CrossRef]
48. Bamberg, S.; Ajzen, I.; Schmidt, P. Choice of Travel Mode in the Theory of Planned Behavior: The Roles of Past Behavior, Habit, and Reasoned Action. *Basic Appl. Soc. Psychol.* **2003**, *25*, 175–187. [CrossRef] [PubMed]
49. International Energy Agency (IEA). *CO2 Emissions in 2023*; IEA: Paris, France, 2024. Available online: <https://www.iea.org/reports/co2-emissions-in-2023> (accessed on 22 February 2026).
50. Redman, L.; Friman, M.; Gärling, T.; Hartig, T. Quality attributes of public transport that attract car users: A research review. *Transp. Policy* **2013**, *25*, 119–127. [CrossRef]
51. Heath, Y.; Gifford, R. Extending the Theory of Planned Behavior: Predicting the Use of Public Transportation. *J. Appl. Soc. Psychol.* **2002**, *32*, 2154–2189. [CrossRef]
52. Wang, S.; Fan, J.; Zhao, D.; Yang, S.; Fu, Y. Predicting consumers' intention to adopt hybrid electric vehicles: Using an extended version of the theory of planned behavior model. *Transportation* **2016**, *43*, 123–143. [CrossRef]
53. Department of Statistics Malaysia (DOSM). *Population and Demography*; DOSM: Putrajaya, Malaysia, 2022. Available online: <https://www.dosm.gov.my> (accessed on 15 November 2025).
54. Ibrahim, A.N.H.; Borhan, M.N.; Mat Yazid, M.R.; Hassan, S.A.; Arham, A.F.; Hashim, S. Modelling of Passenger Satisfaction and Reuse Intention with Monorail Services in Kuala Lumpur, Malaysia: A Hybrid SEM-ANN Approach. *Mathematics* **2023**, *11*, 3361. [CrossRef]
55. Hair, J.F.; Risher, J.J.; Sarstedt, M.; Ringle, C.M. When to use and how to report the results of PLS-SEM. *Eur. Bus. Rev.* **2019**, *31*, 2–24. [CrossRef]
56. Bollen, K.A. *Structural Equations with Latent Variables*; John Wiley and Sons: New York, NY, USA, 1989.
57. Fornell, C.; Larcker, D.F. Evaluating Structural Equation Models with Unobservable Variables and Measurement Error. *J. Mark. Res.* **1981**, *18*, 39–50. [CrossRef]
58. Henseler, J.; Ringle, C.M.; Sinkovics, R.R. The use of partial least squares path modeling in international marketing. *Adv. Int. Mark.* **2009**, *20*, 277–319. [CrossRef]
59. Cohen, J. *Statistical Power Analysis for the Behavioral Sciences*, 2nd ed.; Lawrence Erlbaum Associates: Hillsdale, NJ, USA, 1988.
60. Palat, B.; Paran, F.; Delhomme, P. Applying an extended theory of planned behavior to predicting violations at automated railroad crossings. *Accid. Anal. Prev.* **2017**, *98*, 174–184. [CrossRef] [PubMed]
61. Chan, T.J.C.; Halmee, M.; Samson, J. Factors Influencing Behavioural Intention to Use Public Transport among University Students. In *Proceedings of the International Conference on Communication, Language, Education and Social Sciences (CLESS 2022)*; Atlantis Press SARL: Amsterdam, The Netherlands, 2023.
62. Hofstede, G.; Hofstede, G.J.; Minkov, M. *Cultures and Organizations: Software of the Mind*, 3rd ed.; McGraw-Hill: New York, NY, USA, 2010.
63. Kaewklungklom, R.; Satiennam, W.; Jaensirisak, S.; Satiennam, T. Influence of psychological factors on mode choice behaviours: Case study of BRT in Khon Kaen City, Thailand. *Transp. Res. Procedia* **2017**, *25*, 5072–5082. [CrossRef]
64. De Groot, J.; Steg, L. General beliefs and the theory of planned behavior: The role of environmental concerns in the TPB. *J. Appl. Soc. Psychol.* **2007**, *37*, 1817–1836. [CrossRef]
65. Ministry of Transport Singapore (MOT). *Singapore Land Transport Master Plan 2040*; MOT: Singapore, 2023. Available online: https://www.lta.gov.sg/content/ltagov/en/who_we_are/our_work/land_transport_master_plan_2040.html (accessed on 2 May 2026).

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.