International Research Journal of Multidisciplinary Scope (IRJMS), 2024; 5(3):785-797

Original Article | ISSN (O): 2582-631X DOI: 10.47857/irjms.2024.v05i03.0880

Adults' Perceptions on Factors Contributing to Traffic Congestion in Edutown, Bandar Baru Bangi

Mohd Haniff Osman[1]*, Luqman Hakim Shah Dikie[2]

[1]Applied and Computational Engineering Mathematics, Department of Engineering Education, Faculty of Engineering and Built Environment, National University of Malaysia, Bangi, Selangor, Malaysia, [2]Smart and Sustainable Township Research Centre, Faculty of Engineering and Built Environment, National University of Malaysia, Bangi, Selangor, Malaysia. *Corresponding Author's Email: haniff68@ukm.edu.my

Abstract

As land use patterns continue to evolve and traffic demands increase in Edutown Bandar Baru Bangi, Selangor, road congestion has become a persistent issue. The development of educational, residential, and commercial areas has contributed to the influx of vehicles on the roads, further exacerbating the traffic situation. Efforts to assess the impact of these factors on traffic are crucial in finding solutions to alleviate congestion in the area. Thus, this study seeks to evaluate the impact of educational, residential, and commercial areas that contributed to the increased traffic flow, leading to road congestion, particularly at the roundabout leading to the Bangi Plaza Toll. Through an online questionnaire survey involving 385 working adults from the area, perceptions regarding 11 potential causes of congestion were gathered. Using AMOS Graphic, Confirmatory Factor Analysis (CFA) was employed to quantify the contribution of land use and travel demand to traffic congestion at the specified roundabout. The CFA results indicated favourable goodness-of-fit indices affirming the measurement models' effectiveness in explaining the relationship between land use patterns, travel demand, and traffic congestion at the roundabout leading to Bangi Plaza Toll. These findings provide valuable insights for policymakers to devise effective short- and long-term solutions for alleviating traffic congestion in Bandar Baru Bangi, surpassing the efficacy and sustainability of existing strategies.

Keywords: CFA, Land Use, Roundabout, Traffic Congestion, Traffic Demand, Township.

Introduction

As urbanisation intensifies globally, traffic congestion is prevalent in numerous major cities worldwide. According to data from Tom Tom (1), adults commuting to their workplace in Kuala Lumpur, Malaysia, spent 81 hours in traffic congestion, resulting in considerable time investment and a financial toll. The associated cost due to congestion amounted to RM 224 (~USD$ 49) in petrol expenses, reflecting the economic impact of traffic-related delays. Furthermore, the environmental repercussions are significant, with 198 kilograms of CO_2 emission during these congested commuting hours. This example highlights the tangible effects of urbanisation on traffic congestion, showcasing how it impacts individuals' time and finances and contributes to environmental pollution. It underscores the need for sustainable transportation solutions to address these challenges in rapidly growing urban areas.

Traffic congestion perception is a complex issue that has been examined in a few studies. Road users in Ile-Ife, Nigeria, perceived traffic congestion based on their personal experiences and observations (2). In Karachi, Pakistan, drivers' emotional responses shaped their perception of traffic (3). Additionally, this study found that perception can evolve with driving experience. Further highlighting the complexity of this issue, research in Medea, Algeria, identified numerous interconnected factors influencing drivers' perceptions, including vehicle condition, road quality, and weather (4).

A prior study discovered that working adults believe traffic congestion in urban areas is caused by various factors rather than a single root cause (5). These factors include but are not limited to land use patterns, changes in travel demand and the population growth (6, 7). Land use patterns refer to the arrangement and distribution of different types of land uses, such as residential, commercial, and industrial, within a geographical area. These patterns significantly impact traffic as they determine the proximity and accessibility of

(Received 2nd April 2024; Accepted 13th July 2024; Published 30th July 2024)

different destination. A study conducted in Kuala Lumpur, Malaysia found that areas with a high proportion of commercial land use experienced the highest levels of traffic congestion (8). The relationship between land use and traffic congestion sources is corroborated by the latest evidence (9). This study highlighted commercial land use's significant contribution to traffic congestion, particularly in urban areas with developed public transit systems and higher population density. Areas with denser educational land use and those distant from government institutional land uses are prone to experience severe traffic congestion during peak hours (9). Moreover, the extent of land allocated for scientific and educational purposes and the density of the working population significantly contributed to shaping the concentration of traffic flow during peak periods (10).

The intricate relationship between land use patterns and traffic congestion, particularly the pivotal role of built environments in shaping mobility patterns and congestion dynamics, has been extensively explored in previous research (11). The road network design and land use patterns can impact vehicle miles travelled (VMT), significantly contributing to traffic congestion. The study found that compact, mixed-use development with a well-connected road network can reduce VMT and traffic congestion, while sprawled development with a poorly connected road network can increase VMT and traffic congestion.

Population growth significantly influences the spatial distribution of traffic congestion in urban areas (12). This study observed a tendency for congestion to migrate from central business districts to suburban and peripheral areas as population numbers increase within an area. Furthermore, the rising population may also increase vehicle ownership, leading to an even greater demand for transportation and exacerbating congestion problems on already congested road networks (13). As areas experience population growth, congestion-reducing measures such as road pricing and public transportation improvements may become less effective due to increasing demand for transportation services (14). This increased demand can outpace the capacity improvements provided by these measures.

The relationship between travel demand and traffic congestion in downtown urban settings can be addressed through demand management strategies, including the implementation of a new management system (15). In fact, the increasing use of private vehicles in cities has led to a growing demand for parking space and road network capacity, resulting in traffic congestion (16). A case study in the UK provides a practical perspective on the dynamics between travel demand and traffic congestion in a modern city (17). The authors of this study stressed that future travel demand is anticipated to be primarily driven by demographic changes, including population growth. The living and working locales of the additional population will significantly influence travel mode choices between car-based and public transport (18). Together, the author underscores the complex interplay between travel demand and traffic congestion, highlighting the critical role of strategic policy implementation in fostering sustainable urban mobility. Note that, understanding the nuances of travel demand, including the triggers for peak and off-peak travel times, is crucial for effective traffic congestion management (19). It is implied that a comprehensive grasp of the travel demand dynamics can facilitate more informed and strategic infrastructure development and implementation of regulatory measures to alleviate congestion.

Traffic congestion in urban areas is not only a hallmark of Kuala Lumpur but also significantly impacts townships located on the outskirts of the city centre (20). One such township is Edutown Bandar Baru Bangi. Bandar Baru Bangi is an affluent township about 26 kilometres south of Kuala Lumpur. Within Bandar Baru Bangi and its surrounding areas are notable educational institutions, including universities, colleges, and training centres. Moreover, Bandar Baru Bangi is also home to several industrial sites and businesses, further adding to the hustle and bustle of the area. These establishments attract workers and visitors, increasing commercial activity and economic development within the vicinity.

Bandar Baru Bangi's transformation into an ideopolis that encompasses knowledge, business, and networks has significantly altered its land use patterns and physical developments (21). By integrating institutions, residential areas, commercial zones, industries and social spaces the goal is to promote innovation attract skilled individuals and improve the quality of life for residents. However, while offering many advantages, Bandar Baru Bangi has experienced mixed traffic challenges due to its specific characteristics. These include a high concentration of commuters (students, faculty, and staff) traveling daily to and from educational institutions, limited public transportation options, increased traffic from delivery services, and limited parking.

Traffic congestion faced by residents of Bandar Baru Bangi is not solely attributable to the increasing population but is also exacerbated by poorly maintained roads (22). Furthermore, transportation facilities in Bandar Baru Bangi have been implemented without adequate consideration for intermodal integration. This lack of integration has resulted in a challenging traffic situation for residents of Bandar Baru Bangi, who often find themselves stuck in traffic more frequently than in average townships. A survey reveals that Bandar Baru Bangi residents experience traffic congestion for three distinct, painful durations: 10–20 minutes, 20 minutes to 1 hour and 1 hour or more (23).

Despite the ongoing efforts to enhance road infrastructure and public transportation, the residents of Bandar Baru Bangi continue to grapple with daily traffic woes, especially near pivotal junctions such as the roundabout near the Outbound Bangi Plaza Toll. Figure 1 shows a map depicting land use near the busiest roundabout in Bandar Baru Bangi. The existing research predominantly focuses on infrastructural developments, overlooking the perceptions and experiences of the working adults directly affected by this issue. This gap in the research landscape hinders the formulation of effective, people-centric traffic reduction strategies.

Consequently, the present study aims to delve deeper into working adults' perceptions regarding traffic congestion in Bandar Baru Bangi. It seeks to identify the perceived factors contributing to traffic congestion, focusing on the roles of land use and travel demand in shaping these perceptions. Understanding working adults' perceptions regarding traffic congestion holds theoretical and practical significance. Theoretically, it contributes to the broader discourse on urban development and traffic management. Practically, it aids in formulating policies grounded in the residents' lived experiences, thereby enhancing the effectiveness of traffic reduction strategies and fostering a sustainable and environmentally friendly urban habitat.

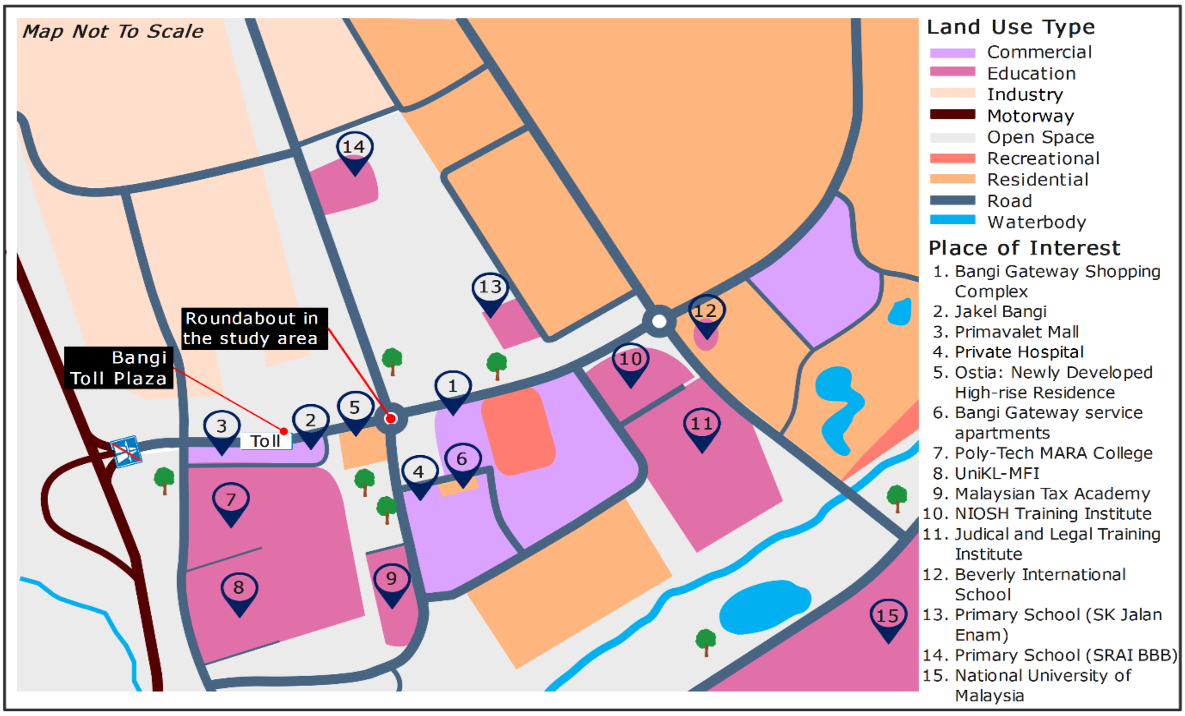

Figure 1: Location Map Displaying Points of Interest within the Roundabout Area

Table 1: Items of Two Constructs

Construct		Item	Code
Land Use	i.	Bangi Gateway business area contributes to traffic congestion.	LU1
	ii.	Jakel Bangi business area contributes to traffic congestion.	LU2
	iii.	Factories near the roundabout contribute to traffic congestion.	LU3
	iv.	Educational institutions contribute to traffic congestion in Bandar Baru Bangi.	LU4
	v.	The opening of high-rise residences in Bandar Baru Bangi is increasing the number of road users.	LU5
Travel Demand	i.	Commercial vehicles during peak hours cause traffic congestion.	TD1
	ii.	Population growth naturally affects traffic congestion.	TD2
	iii.	Roundabout congestion during peak hours as staff and students travel to and from educational institutions.	TD3
	iv.	The morning lecture/school timetable contributes to slow traffic congestion at the roundabout during morning hours.	TD4
	v.	Business activities in Bandar Baru Bangi increasing the number of vehicles at the roundabout.	TD5
	vi.	The residents' preference for driving instead of using public services worsens congestion at the roundabout.	TD6

Methodology

This study employed a cross-sectional survey design to explore the perceptions of working adults residing in Bandar Baru Bangi regarding land use and travel demand factors that could be contributors to traffic congestion in the township. Data collection was conducted through a self-administered online questionnaire.

The questionnaire was developed based on a comprehensive literature review of items (statement) across two constructs; land use and travel demand, that can exacerbate township traffic congestion (24–26). The questionnaire consisted of five items for each of the constructs. A description of 11 items of interest in this study is provided in Table 1.

Before data collection, a pilot test with a small group of participants was conducted to identify and address any potential design bias in the initial questionnaire. For the pilot study, Cronbach's alpha reliability test was used to determine the reliability of two constructs. The final version of the questionnaire still consisted of the 11 items and demonstrated strong inter-item reliability scores (measured using Cronbach's alpha): 0.887 and 0.812 for land use and travel demand, respectively. This reliability coefficient exceeds the accepted threshold of 0.7 (27), enabling us to proceed with the questionnaire distribution phase.

This study employed a random sampling method during the questionnaire distribution phase to mitigate sampling bias and ensure the representativeness of our study's sample. Respondents were asked to express their opinions and perceptions on various items related to land use and travel demand constructs, contributing valuable insights to our research on traffic congestion in townships. Using a 5-point Likert scale, ranging from 'Strongly Disagree' to 'Strongly Agree,' allowed us to quantify and analyse the nuanced responses of our respondents, enhancing the depth and accuracy of our study's results.

In this study, we employed Confirmatory Factor Analysis (CFA) as an analytical tool to delve into the intricate factors contributing to traffic congestion in the specific area in Bandar Baru Bangi, as perceived by its residents. CFA offers a structured framework for exploring the intricate relationships between observed variables, primarily survey items, and the latent variables we have identified as crucial in our study, namely land use and traffic demand factors. By utilising CFA, we aimed to rigorously examine and validate how the observed variables serve as reliable indicators of the underlying latent variables, shedding light on the complexities of traffic congestion dynamics in the township setting.

CFA empirically tests the measurement model, which consists of latent and observed variables. The hypothesis confirmatory measurement model's adequacy was evaluated using goodness-of-fit statistics such as the chi-square statistic, comparative fit index (CFI) and root mean square error of approximation (RMSEA). This process can reduce the number of observed variables, and relationships between observed and latent variables can be tested. CFA via AMOS Graphics was engaged in this study to assess the validity of the confirmatory measurement model and examine how different latent variables interrelate and influence traffic congestion based on the driver's perceptions.

Results

The sample for this study was drawn from adult residents of Bandar Baru Bangi aged 18 years and older. Participants were recruited through the Bangi Community Facebook group and a total of 385 individuals completed the questionnaire. This sample size is expected to reduce the margin of sampling error. Participants were informed of the study objectives and provided informed consent prior to participating in the study. Confidentiality was maintained throughout the study; no identifying information was collected from participants. Of the 385 respondents surveyed 67.5% were male. 32.5% were female. The largest age group was 21-40, which accounted for 62.3% of participants, followed by 31-40 (18.9%) and 41-50 (16.4%). The smallest age groups were 18-20 (0.5%) and over 50 (1.8%). Figure 2 illustrates the age and gender distribution of the participants.

The majority, comprising 315 respondents (or approximately 81.8%), work in Bandar Baru Bangi, while the remaining 70 (or approximately 18.2%) work outside Bandar Baru Bangi. Regardless of the workplace location, cars (around 57%) are the most preferred vehicle for daily use, followed by motorcycles (around 31%), as summarised in Table 2. Conversely, the van is the least popular vehicle in both categories. 12.2% of the respondents use vans daily, while not used by respondents working outside Bandar Baru Bangi, registers 0% usage. Table 2 also provides a comparative analysis of the driving experience durations based on the workplace location of the respondents. A significantly higher number of respondents working in Bandar Baru Bangi (169 individuals, representing 43.9%) have less than three years of driving experience, indicating a predominance of relatively new drivers. This percentage starkly contrasts respondents working outside Bandar Baru Bangi, where only eight respondents, constituting 2.1%, fall into this category. The number of respondents with 3-5 years of driving experience is relatively low in both groups, with a slightly higher count for respondents working in Bandar Baru Bangi, where 42 respondents (10.9%) have a driving experience falling within this range. Transitioning to the more seasoned group with over five years of driving experience, a substantial number of respondents from both groups find themselves in this category. However, the distribution is markedly different; while those working outside Bandar Baru Bangi, 53 individuals (13.8%) have over five years of driving experience, respondents working in Bandar Baru Bangi exhibit a much higher concentration of experienced drivers, with 104 respondents representing a significant 27% of the sample.

Table 2: Daily Vehicle Types and Years of Driving Experience across Various Workplace Locations

		Location of workplace			
		Somewhere in Bandar Baru Bangi (315)		**Outside Bandar Baru Bangi (70)**	
		Count	Proportion, %	Count	Proportion, %
Daily use vehicle	Car	156	40.5%	62	16.1%
	Motorcycle	112	29.1%	8	2.1%
	Van	47	12.2%	0	0.0%
Driving experience	Less than three years	169	43.9%	8	2.1%
	3-5 years	42	10.9%	9	2.3%
	More than five years	104	27.0%	53	13.8%

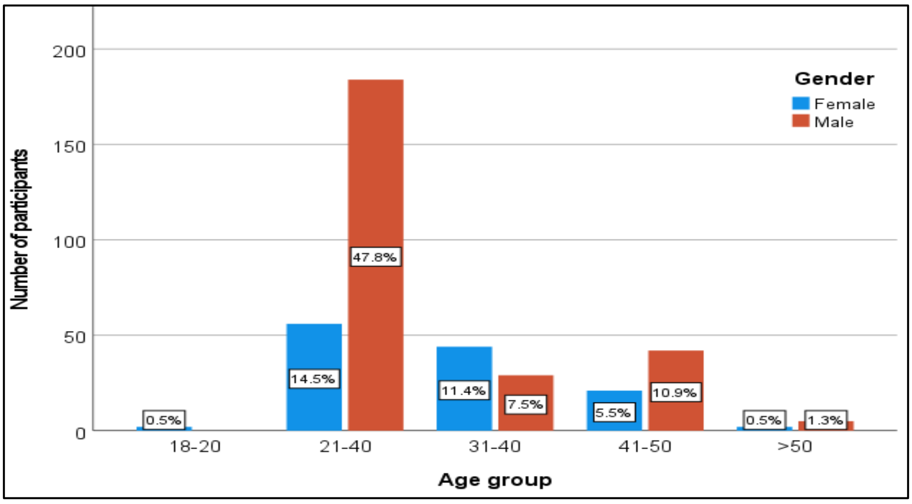

Figure 2 Distribution of Participants by Age Group and Gender

Before proceeding with CFA, assessing the observed variables' normality is crucial. The assumption of normality is a fundamental requirement in CFA, as it ensures the validity of the parameter estimates and model fit indices. Violations of normality can potentially bias the results and lead to inaccurate interpretations. The skewness values of the observed variables in this study ranged from -1.491 to -0.203, indicating a negatively skewed distribution. The kurtosis values ranged from -1.069 to 1.859, with a multivariate kurtosis of 39.988 (Table 3).

Given that the observed variables in our analysis exhibit non-normal distributions, we employed ML bootstrapping to account for the departure from normality and assess the uncertainty associated with the maximum likelihood (ML) estimates. By applying ML-bootstrapping, available in the AMOS Graphics program, this study resampled from the dataset using the bootstrap procedure, generating multiple bootstrap samples. This approach allowed this study to consider the non-normality in our data and provided more robust estimates while quantifying the variability and uncertainty associated with the model parameters.

This study's primary interest in CFA is determining how the (first) measurement model could adequately describe the sample data. In this study, the number of estimated parameters (n = 23) was smaller than the degrees of freedom (df = 43), suggesting that the model was over identified (Table 4). This label implies that the model had more observed variables and information available than the minimum necessary for estimation, allowing for rigorous model evaluation and assessment of goodness-of-fit. The overall chi-square value (187.485), together with its degrees of freedom [43] and probability value (0.000), are provided as an overview of the model fit (see a screenshot of AMOS output given in Table 3).

Displayed in Figure 3 are the standardised factor loadings derived from AMOS Graphics employing ML-bootstrapping estimation, illustrating the arrows representing the relationships from latent variables to observed one. The analysis reveals loadings ranging from 0.560 (for *LU5*) to 0.782 (for *LU1*) for the five variables related to *Land Use*. All loadings are significant at the level of significance of 0.05 ($p < 0.05$). Using the rules of thumb in (28), these findings suggest that five observed variables are reliable indicators of their corresponding latent factor. The factor loadings for the six variables on *Travel Demand* are 0.354 (*TD2*) and 0.777 (*TD5*). Although variable *TD2* displayed a relatively weak loading, it still contributes to the measurement model, albeit to a lesser extent.

Table 3: Descriptive Statistics and Normality Tests for Observed Variables

Variable	min	max	skew	c.r.	kurtosis	c.r.
TD6	1.000	5.000	-1.491	-7.699	1.859	4.800
TD5	1.000	5.000	-1.124	-5.802	.974	2.516
TD4	1.000	5.000	-.303	-1.565	-.927	-2.394
TD3	1.000	5.000	-.873	-4.509	.094	.242
TD2	1.000	5.000	-1.216	-6.280	1.367	3.531

Variable	min	max	skew	c.r.	kurtosis	c.r.
TD1	1.000	5.000	-1.263	-6.521	1.207	3.117
LU5	1.000	5.000	-1.004	-5.187	.993	2.563
LU4	1.000	5.000	-.448	-2.313	-.589	-1.520
LU3	1.000	5.000	-.729	-3.764	-.296	-.764
LU2	1.000	5.000	-.281	-1.453	-.973	-2.513
LU1	1.000	5.000	-.203	-1.046	-1.069	-2.761
Multivariate					39.998	14.958

Table 4: Computation of degrees of freedom and overall model result

Number of distinct sample moments	66
Number of distinct parameters to be estimated	23
Degrees of freedom [66-23]	43
Result [Default model]	Minimum was achieved
Chi-square	187.485
Degrees of freedom [66-23]	43
Probability level	.000

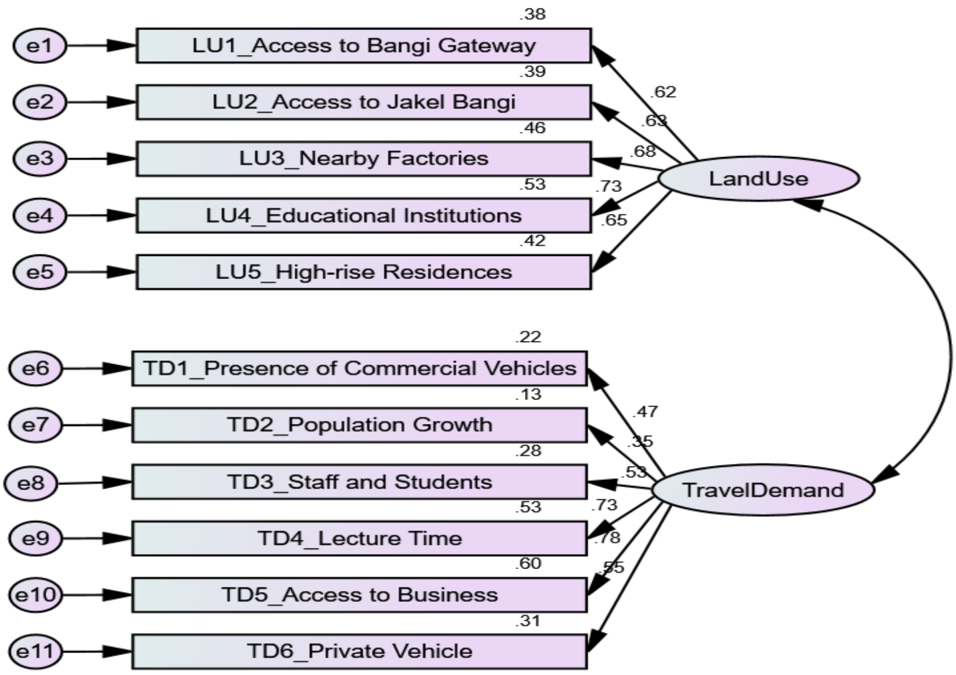

Figure 3: Initial CFA Model Standardised Estimates for Traffic Congestion

Table 5: Initial CFA Model Fit Summary

Fit Indices	Achieved value	Threshold	Evaluation
CMIN/df ($\frac{\chi^2}{df}$)	14.26	=<2	Misfit
CFI	.765	>=.9	Poor
TLI	.631	>=.9	Inadequate
RMSEA	.154	=<.08	Poor
GFI	.765	>=.9	Poor

In Figure 3 the numbers displayed at the upper right-hand corner of each observed variable represent the squared multiple correlations of each variable. For instance, the squared multiple correlations for *LU2* stands at 0.59, indicating that 59% of the variance in *LU2* can be attributed to *Land Use*. The remaining 41% of the variance in *LU2* is explained by the unique factor e1, signifying the measurement error. Across the *Land Use* items, squared multiple correlations vary from 0.31 for

LU5 to 0.61 for *LU1*. Similarly, squared multiple correlations for the *Travel Demand* items range from 0.09 for *TD3* to 0.60 for *TD5*.

The model fit indices (Table 5) indicate that the initial measurement model did not achieve an adequate fit. The chi-square statistic is significant (χ^2 = 342.985, p < .01) and CMIN/df (Likelihood-radio Chi-Square/degree of freedom) of 14.26, indicating a lack of exact fit. The Comparative Fit Index (CFI) is 0.765, falling below the recommended threshold of 0.90, suggesting a poor fit. The Tucker-Lewis Index (TLI) is 0.631, indicating a subpar fit. The root mean square error of approximation (RMSEA) is 0.154 (90% CI: 0.139, 0.169), exceeding the recommended threshold of 0.1 and further supporting the conclusion of a poor fit. The Goodness-of-Fit Index (GFI) is 0.765; falling below the desired threshold of 0.90, further corroborating the model's poor fit. Overall, based on the combination of fit indices, it can be concluded that the hypothesised model did not achieve an adequate fit to the observed data. Because the initial model does not fit well, this study modified the model based on the standardised residual covariance (e.g., modification indices) to improve the model fit and better capture the relationships among the variables of interest.

The Modification Indices (MIs) and Par Change for possible co variances for the initial measurement model are listed in Table 5. Par Change denotes the expected parameter adjustment upon implementing this modification in the model. Examining the MIs in Table 6, four parameters showed substantial values i.e., MIs of values >10, representing the covariance between items *LU1* and *LU2* (e1 and e2: MI = 54.484), between items *LU5* and *TD6* (e5 and e11: MI = 19.473), between items *TD2* and *TD4* (e7 and e9: MI = 13.401) and between items *TD2* and *TD3* (e7 and e8: MI = 10.963). Hence, four modified measurement models were proposed in this study. Model M_1 is the result of including a correlated error between errors of item *LU1* and item *LU2* in the initial model; Model M_2 added the path between errors of item *LU5* and item *TD6* into M_1; Model M_3 included a correlated error between items *TD2* and *TD4* into M_3; Model M_4 included a correlated error between items *TD2* and *TD3* into M_3.

A theoretical rationale for capturing unexplained covariance between these observed variables in the measurement model is discussed. The substantial covariance observed between variables *LU1* and *LU2* may be attributed to their strategic spatial distribution and complementary services. These business areas: Jakel Bangi and Bangi Gateway, strategically located near the roundabout, attract significant vehicular traffic in both directions. Moreover, these establishments' complementary services or products encourage inter-movement, resulting in heightened traffic interactions. As such, it seemed to make sense that we included a covariance between the errors for *LU1* and *LU2* in the initial measurement model.

Table 6: Modification Indices of Co-variances for the Hypothesised Model

			M.I.	**Par Change**
e9	<-->	e11	4.490	-.138
e7	<-->	e9	13.401	-.217
e7	<-->	e8	10.963	.214
e5	<-->	TravelDemand	5.214	.040
e5	<-->	LandUse	5.049	-.064
e5	<-->	e11	19.473	.242
e5	<-->	e9	8.589	-.154
e5	<-->	e7	3.991	.186
e4	<-->	e6	9.216	-.176
e2	<-->	TravelDemand	4.390	-.048
e2	<-->	LandUse	4.268	.078
e2	<-->	e8	8.187	-.215
e2	<-->	e4	4.795	-.143
e1	<-->	e11	5.758	-.187
e1	<-->	e10	4.314	-.123

			M.I.	Par Change
e1	<-->	e9	8.308	.217
e1	<-->	e5	7.019	-.168
e1	<-->	e2	54.484	.609

Next, the inclusion of covariance between errors for *LU5* and *TD6* may stem from underlying factors such as socioeconomic status or urban development policies, which influence both the construction of high-rise residences and residents' preference for private vehicle ownership, thereby creating a linkage between spatial development and transportation choices. Including covariance between errors for *TD2* and *TD4* reflects a plausible interdependence in their influences on traffic congestion. This correlation may signify synergistic travel patterns, where population growth could lead to an increased demand for higher education institutions, resulting in intensified morning lectures and subsequent traffic congestion at the roundabout during peak commuting hours. Like the previous scenario, population growth fosters increased demand for educational institutions, leading to heightened staff and student commuting (refer to an observed variable *TD3*). In contrast, the presence of these institutions, in turn, attracts individuals, contributing to population growth. This interdependent nature establishes a reciprocal cycle of travel demand, thereby justifying the inclusion of covariance between errors for *TD2* and *TD3* in the initial measurement model.

The summary of goodness-of-fit indices for the original and all modified models is provided in Table 7. Table 7 reveals that the goodness-of-fit indices suggest a satisfactory fit for modified model M4. The values for CFI= 0.40 TLI= 0.916, GFI=0.918 and RMSEA=0.081. Thus, a modification for model fitness for M4 was not necessary. The final model, M4, is displayed in Figure 4. Since M_4 shows adequate fit, the next step was to test the convergent validity of the data. Composite reliability (CR) and Average Variance Extracted (AVE) were employed to assess the convergent validity of the *Land Use* and *Travel Demand* constructs in evaluating drivers' perceptions of traffic congestion at a roundabout.

Table 7: Goodness-of-Fit Statistics for the Modified Measurement Models

Model	Modification	χ^2	df	CMIN/ df	CFI	TLI	RMSEA	GFI
M0	Initial model	187.485	43	4.360	.788	.730	.145	.815
M1	M0+correlated errors of LU1 and LU2	123.367	42	2.937	.881	.844	.110	.870
M2	M1+correlated errors of LU5 and TD6	106.177	41	2.590	.905	0.872	0.100	.890
M3	M2+correlated errors of TD2 and TD4	95.135	40	2.378	.919	.889	0.093	.900
M4	M3+correlated errors of TD2 and TD3	80.008	39	2.051	.940	.916	0.081	.918
	Criterion for goodness of fit	-	-	-	>=0.9	>=0.9	=<0.1	>=0.9

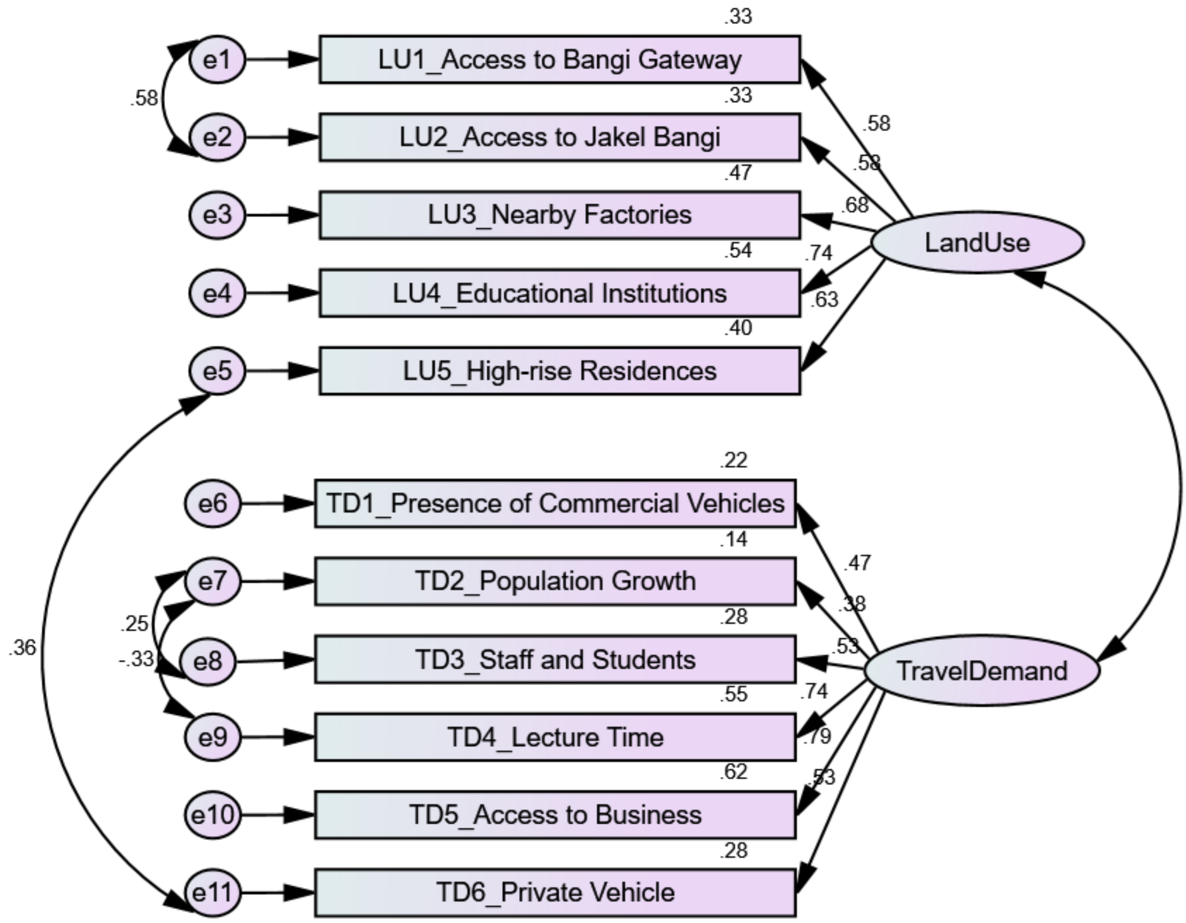

Figure 4: Modified CFA Model with Land Use and Travel Demand Factors

The *Land Use* construct, comprising five measurement items, demonstrates a CR value of 0.715, which is deemed acceptable regarding internal consistency and reliability. Similarly, the *Travel Demand* construct, encompassing six measurement items, presents a CR value of 0.750, reinforcing the internal consistency of its indicators. In the context of AVE, the *Land Use* exhibits a value of 0.428, and the *Travel Demand* shows a value of 0.347. While these AVE values are slightly below the recommended threshold of 0.5 for strong convergent validity, it is crucial to consider the broader context of this research. The CR values for both constructs are well above the generally accepted threshold of 0.7 (28), indicating that observed variables within each construct are coherent and consistently contribute to measuring their respective latent constructs.

The standardised loading factor values for each item are described in Table 8. All items under the *Land Use* construct exhibit moderate to strong standardised factor loadings, ranging from 0.576 to 0.737. These factor loadings suggest that each item has a substantial relationship with the underlying construct. The higher the standardised factor loading, the stronger the connection between the item and the construct it is intended to measure. The fact that all factor loadings are above 0.5 indicates that the items are making meaningful contributions to measuring the *Land Use* construct.

The standardised factor loadings in the *Travel Demand* construct vary, ranging from 0.380 to 0.785. While the factor loadings for *TD1* and *TD2* are slightly lower, *TD4* and *TD5* demonstrate high factor loadings. A high loading value indicates that the items *TD4* and *TD5* are strongly related to the underlying construct. Overall, the factor loadings of *Travel Demand* suggest that most items capture the intended latent construct.

Most items exhibit significant factor loadings in *Land Use* and *Travel Demand* constructs, indicating that they effectively measure their respective constructs. These factor loadings support the convergent validity of the modified measurement model. Additionally, combining this information with CR and Average AVE values will provide a comprehensive assessment of the validity of both constructs. Overall, these factor loadings positively indicate the relationship between the items and their respective constructs in the research model in Figure 4.

Table 8: Standardised Regression Weights, Composite Reliability (CR) and Average Variance Extracted (AVE, Revised Measurement Model, *M4*)

Items	Standardised Factor Loading	Composite Reliability (CR)	Average Variance Extracted (AVE)
LandUse		0.715	0.428
LU1	.576		
LU2	.577		
LU3	.684		
LU4	.737		
LU5	.681		
TravelDemand		0.750	0.347
TD1	.465		
TD2	.380		
TD3	.530		
TD4	.741		
TD5	.785		
TD6	.527		

Discussion

In this study, we aimed to validate two key factors contributing to traffic congestion in Edutown Bandar Baru Bangi from the perception of working adults: land use and travel demand. Through CFA, we examined the underlying structure of these factors and their relationship to observed variables representing various aspects of land use and travel demand, mainly focusing on the roundabout leading to Bangi Plaza Toll.

CFA results have shown that five and six items used in a questionnaire to measure the *Land Use* and *Travel Demand* factors conform to their unidimensionality criteria. The CFA findings indicate that all the items *LU1* to *LU5* significantly contribute to the *Land Use* component. The factor loadings for these items are notably high, ranging from 0.57 to 0.73. For example, respondents believe that the presence of two shopping malls near the roundabout is variable leading to traffic congestion at the Bangi Toll Plaza. This result aligns with findings in (6) showing increased traffic delays during busy shopping times due to challenges faced by drivers navigating crowded areas and finding parking spots. In addition, mall entrances play a crucial role in influencing traffic flow and congestion within shopping malls. In this study, respondents were concerned about the potential traffic congestion due to the development of high-rise residences within a one-kilometre radius of a critical gateway to Bandar Baru Bangi. This finding corresponds with research in (29) which suggests that an influx of new residents into these high-rise buildings will likely worsen the existing traffic congestion, complicating navigation of the area. Item *LU3*, which is also deemed suitable to measure *Land Use* is in agreement with findings in (30), which showed that heavy vehicles using roads as an entrance to industry areas from the highway can create bottlenecks, especially during peak traffic hours. The increase in heavy vehicles on roads can lead to a domino effect, causing congestion to spill over onto the connecting roads and exacerbating the overall traffic problem in the area.

CFA also revealed that all six items' loading for *Travel Demand* factor were acceptable. The items *TD4* and *TD5* that exhibited the highest factor loadings most effectively explained the construct. For example, an abundance of institutions attracts many students, faculty and staff members who commute regularly leading to traffic congestion at the roundabout near the Bangi Toll Plaza. Moreover, the proximity distance between educational institutions and residential areas significantly impacts traffic congestion. It is evident that when institutions are located near residential areas, there is a pronounced increase in traffic congestion during peak hours. This scene is mainly due to the higher volume of private vehicles transporting students to and from institutions and the increased presence of public transportation and pedestrians.

The findings from this study hold implications for urban planning and policy development specifically in areas such as land use planning, regulations and traffic management strategies. Effective traffic management measures are vital in regions with levels of commercial activity. Such strategies could involve enhancing road infrastructure to support increased traffic flow well as implementing coordinated traffic signal systems at roundabouts to optimize traffic movement. Apart from that, local authorities may need to reconsider the large commercial and residential developments near critical gateways, particularly in scale, density, and overall impact on traffic flow. Urban planners might consider decentralizing educational institutions instead of concentrating them in one area. This approach could spread out traffic flow across various points while alleviating congestion in specific areas. By taking a proactive and comprehensive approach, local authorities can ensure that new developments near critical gateways are well-planned, sustainable, and do not exacerbate existing traffic problems. This initiative aims to create a liveable environment that is easily accessible, for all residents.

Conclusion

This study conducted a confirmatory factor analysis to explore working adults' perceptions regarding factors contributing to traffic congestion in a township with numerous educational institutions, mainly focusing on the roundabout leading to the Bangi Plaza Toll. The results of the CFA unveiled that the constructs of land use and travel demand effectively elucidate the variance observed in 11 causes associated with traffic congestion, as perceived by respondents. Educational facilities, the opening of high-rise residences, the travel of staff and students to and from educational institutions, and business activities within the township emerged as the most influential activities contributing to the perceived causes of traffic congestion at the specified roundabout. These findings underscore the significance of understanding the interplay between travel demand dynamics, land use patterns and their implications for traffic congestion management in townships with concentrated educational and commercial activities. Future urban planning and transportation policies should consider these factors to effectively manage traffic flow and improve overall traffic conditions in the township. Investing in infrastructure improvements such as widening roads, adding traffic signals, or implementing intelligent traffic management systems could also enhance the efficiency of the roundabout and reduce delays for drivers (31). By addressing traffic congestion, the community can work together to create a more sustainable and efficient transportation system for all residents and commuters.

Abbreviations

Nil.

Acknowledgement

We extend our gratitude to the UKM Dana Pecutan Penerbitan (PP-FKAB 2024) for covering the Article Processing Charges for this manuscript. This research forms part of a final year project submitted as partial fulfilment of the requirements for a bachelor’s degree in civil engineering at the National University of Malaysia.

Author Contributions

Luqman initiated the central research idea, formulated the research design, conducted the study, and drafted the original manuscript. Meanwhile, Haniff contributed to the theoretical framework, oversaw research progress, guided the review process, made revisions, and endorsed the article for submission.

Conflict of Interest

The authors agree that this research was conducted in the absence of any self-benefits, commercial or financial conflicts and declare absence of conflicting interests with the funders.

Ethics Approval

Not applicable.

Funding

No funding received by any government or private concern.

References

1. TomTom Traffic. Kuala Lumpur traffic. 2023. Available from: https://www.tomtom.com/traffic-index/kuala-lumpur-traffic/.
2. Ajayi FO, Olawole MO. Road users' perceptions of causes and effects of traffic congestion in Ile-Ife, Nigeria. Ife Social Sciences Review. 2018; 26:114–27.
3. Memon RM, Khiani RK, Ali S, Mustafa T, Pasha YN. Traffic congestion issues, perceptions, experience and satisfaction of car drivers/owners on urban roads. Mehran University Research Journal of Engineering and Technology. 2020; 39(3):489–505.
4. Benzerga L. Employing exploratory factors analysis to determine the causes of the traffic congestion crisis from the viewpoint of small vehicle drivers a case study in the municipality of Medea. Algerian Scientific Journal. 2022; 17(1):534–555.
5. Al-Qadery SMMA, Muhibbullah M. People's perception on urban traffic congestion; a case study on Chittagong Metropolitan City, Bangladesh. Chittagong University Journal of Biological Sciences. 2013; 3(1):149–60.
6. Kumaat M, Mulyono AT, Sjafruddin A, Setiadji BH. Congestion as a result of school and shopping center activity. International Journal of Science and Engineering. 2015; 9:106–12.
7. Emam Hammad AM. Application of planning standards for land uses of schools and educational facilities to reduce educational mobility as means to reduce traffic congestion in Cairo. MSA Engineering Journal. 2023; 2(3):39–67.
8. Yap JY, Omar N, Ismail I. A study of traffic congestion influenced by the pattern of land use. IOP Conf Ser Earth Environ Sci. IOP Publishing; 2022; 1022(1):12035.
9. Bao Z, Ou Y, Chen S, Wang T. Land use impacts on traffic congestion patterns: a tale of a Northwestern Chinese City. Land. 2022; 11(12):2295.
10. Wang D, Chen H, Li C, Liu E. Exploring the relationship between land use and congestion source in Xi'an: a multisource data analysis approach. Sustainability. 2023; 15(12):9328.
11. Kanyepe J, Tukuta M, Chirisa I. Urban land-use and traffic congestion: mapping the interaction. Journal of Contemporary Urban Affairs. 2021; 5(1):77–84.
12. Çolak S, Lima A, González MC. Understanding congested travel in urban areas. Nat Commun. 2016; 7(1):10793.
13. Oscar Agyemang O, Obiri Y, Ernest G, George A. Rising car ownership and traffic congestion in the University of Cape Coast campus. International Journal of Research in Science & Engineering. 2022; 2(04):10–21.
14. Ibrahim AN, Borhan MN, Osman MH, Mat Yazid MR, Md. Rohani M. The influence of service quality on user's perceived satisfaction with light rail transit service in Klang Valley, Malaysia. Mathematics. 2022; 10(13).
15. Zhao Y, Triantis K, Edara P. Evaluation of travel demand strategies: a microscopic traffic simulation approach. Transportation. 2010; 37:549–71.
16. Fiedler D, Čáp M, Čertický M. Impact of mobility-on-demand on traffic congestion: simulation-based study. 2017 IEEE 20th International Conference on Intelligent Transportation Systems. IEEE; 2017.
17. Metz D. Demographic determinants of daily travel demand. Transport Policy. 2012; 21:20–5.
18. Ismail A, Hashi HF. Modelling of transportation policies to encourage shifting from private car to the public transport usage in Putrajaya. Jurnal Kejuruteraan. 2015; 27:15–21.
19. Chakrabartty A, Gupta S. Traffic congestion in the metropolitan city of Kolkata. Journal of Infrastructure Development. 2014; 6(1):43–59.
20. Mat Yazid MR, Abu Taib K, Mohd Fauzi RS, Abdul Rashid NA, Bastam MN. Effectiveness of traffic management at Kajang SILK highway. Jurnal Kejuruteraan. 2022; 34(2):231–8.
21. Idrus S, Hadi AS, Harman Shah AH, Rainis R. Urbanization in Malaysia: transition from hierarchical function to network-based function. Perspektif Jurnal Sains Sosial dan Kemanusiaan. 2013; 5(2):44–59.
22. Amran NSA. Neighbourhood quality and residents' satisfaction on public facilities in Bandar Baru Bangi, Selangor [MSc]. Universiti Sains Malaysia; 2016. https://www.academia.edu/29203274/neighbourhood_quality_and_residents_satisfaction_on_public_facilities_in_bandar_baru_bangi_selangor
23. Shafii H, Md. Jahi J, Latiff A. Penunjuk kualiti hidup di taman perumahan penduduk di Bandar Baru Bangi, Selangor, Malaysia. Journal of Techno-Social. 2009; 1(1):1–15.
24. Ali N, Javid MA, Hussain SA, Rahim A. Understanding traffic congestion from stakeholders' perceptions in the central area of Lahore, Pakistan. Journal of Applied Engineering Science. 2021; 19(1):125–36.
25. Kitamura R, Mokhtarian PL, Laidet L. A micro-analysis of land use and travel in five neighborhoods in the San Francisco Bay Area. Transportation (Amst). 1997; 24(2):125–58.
26. Kuzmyak JR. Land use and traffic congestion. Arizona; United States; 2012. Available from: https://rosap.ntl.bts.gov/view/dot/24022.
27. Cheung GW, Cooper-Thomas HD, Lau RS, Wang LC. Reporting reliability, convergent and discriminant validity with structural equation modeling: a review and best-practice recommendations. Asia Pacific Journal of Management. 2024; 41:745–83.
28. Ullman JB. Structural equation modelling. In: Tabachnick BG, Fidell LS, editors. Using multivariate statistics. 6th ed. Boston, MA: Pearson Education, Inc.; 2013; p. 681–785.
29. Djoeffan SH, Burhanidin H, Weishaguna W. Effect of high rise building against transportation in campus area. J Phys Conf Ser. 2019; 1375(1):12027.
30. Moridpour S, Mazloumi E, Mesbah M. Impact of heavy vehicles on surrounding traffic characteristics. J Adv Transp. 2014; 49.
31. Ismail A, Ali S, Ladin M, Yahia H. Evaluating the performance of traffic flow in four intersections and two roundabouts in Petaling Jaya and Kuala Lumpur using Sidra 4.0 software. Jurnal Teknologi. 2015; 72(4):421–7.