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The Influence of Accessibility on Vehicle Trip-Generation and Trip-Attraction at Higher Education Institutions in Tulungagung Regency

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ABSTRACT
The rapid development of higher education institutions in Tulungagung Regency has increased student mobility, leading to traffic congestion around campus areas. This study aims to rigorously examine the extent to which accessibility influences vehicle trip generation and attraction, with accessibility measured through travel distance, public transportation availability, road conditions, and travel costs. Data were obtained from 650 students selected proportionally from three universities and analyzed using Partial Least Squares–Structural Equation Modelling (PLS-SEM) with SmartPLS. The results indicate that accessibility has a strong, positive, and significant effect on trip generation and trip attraction ($\beta = 0.752$, $p < 0.001$), accounting for 56.6% of the variation in travel patterns. All indicators meet the validity and reliability criteria. These findings suggest that improved accessibility enhances mobility intensity in areas surrounding higher education institutions. The study concludes that strategic improvements in public transportation, road infrastructure, and travel cost management are crucial to reducing congestion and promoting sustainable mobility. The contribution of this research lies in providing empirical evidence on the relationship between accessibility and travel behavior within higher education areas, offering policymakers practical insights for designing effective transportation plans.

Keywords: *Accessibility; Trip Generation; Trip Attraction; PLS-SEM; Higher Education; Transportation Planning.*

1. Introduction

As a regional education hub in East Java, Tulungagung Regency has experienced significant growth in its higher education sector. This development is marked by the presence of multiple universities, including Sayyid Ali Rahmatullah State Islamic University (UIN SATU) Tulungagung, Bhinneka PGRI University, and Tulungagung University. According to 2023 data, the area has recorded an average annual growth rate of 8% in student population, concurrently driving increased mobility and transportation demands in urban zones [1].

This growth has resulted in severe traffic congestion, particularly around higher education institutions during peak hours. The traffic saturation ratio has reached 0.47, very close to the road capacity threshold of 0.5, driven by poorly managed vehicle trip generation and attraction. This phenomenon underscores the urgent need for trip-generation-based transportation planning in educational districts [2][3].

In transportation planning, trip generation and trip attraction are key variables influenced by the educational land-use pattern [4][5]. The effectiveness of these two variables depends heavily on the level of accessibility, that is, the ability to reach destinations via the available transportation infrastructure [6], which serves as the primary driver of overall mobility [7].

To quantify the causal relationship between accessibility and trip generation and attraction, this study adopts Structural Equation Modelling (SEM) as its primary analytical framework. The

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selection of SEM is justified by its unique capabilities to: (1) model complex latent constructs like accessibility through multi-indicator measurement [8]; (2) analyze nonlinear relationships and moderation effects commonly present in transportation systems [9]; and (3) accommodate measurement error inherent in travel behaviour data [10]. This approach enables empirical verification of the theoretical model while overcoming limitations of conventional parametric statistical techniques in addressing the dynamic characteristics of vehicle movement patterns in educational zones.

This study represents the first research to integrate vehicle trip-generation and attraction modelling with Structural Equation Modelling (SEM), incorporating accessibility variables for higher education institutions in Tulungagung Regency. The study aims to support the formulation of evidence-based transportation policies in the region [11][12].

2. Material and Method

Transportation is the process of moving goods or services from one place to another, where the destination is considered to have greater utility or perceived value than the point of origin. It serves an essential function in enhancing mobility, enabling economic activities, and linking spatial areas across both urban and regional settings [13].

One of the fundamental elements in transportation planning is the examination of trip generation and trip attraction. These aspects are essential, as they provide the foundation for understanding and modelling the movement of people and goods across a region. Trip generation describes the number of trips that begin within a particular zone, while trip attraction refers to the number of trips that terminate in that zone [14].

The present study employs Structural Equation Modelling (SEM), a statistical methodology that represents variable relationships through a series of linear equations. SEM has gained wide application across the social sciences and business research, particularly for analyzing causal pathways, direct and indirect associations, and mediation and moderation mechanisms [15].

The software applied in this study is SmartPLS, which facilitates the analysis of complex structural models comprising multiple indicators and latent variables. The model developed in this research incorporates several direct and indirect relationships among variables, along with mediation testing, all of which can be effectively examined through the PLS-SEM approach. [16].

This study was conducted at three higher education institutions in Tulungagung, namely Universitas Islam Negeri (UIN) Sayyid Ali Rahmatullah Tulungagung, Universitas Bhinneka PGRI Tulungagung, and Universitas Tulungagung.

2.1. Population and Sample

The population of this research comprises students from three higher education institutions located in Tulungagung Regency, namely :

- UIN Sayyid Ali Rahmatullah Tulungagung (22.000 students)
- Universitas Bhinneka PGRI Tulungagung (2.005 students)
- Universitas Tulungagung (1.800 students)

The total population (N) consists of 25,805 students.

This research employed purposive sampling, a non-probability sampling technique in which respondents are deliberately selected based on their relevance to the research objectives. The researcher predetermined the characteristics of the participants to ensure consistency with the study's goals. To determine the appropriate sample size, the Isaac and Michael sample size table (see Table 1) was employed, offering standardized guidelines based on population size and the desired confidence level.

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Table 1. Determination of Sample Size

N	S		
	1%	**5%**	**10%**
2800	537	310	247
3000	543	312	248
3500	558	317	251
4000	569	320	254
4500	578	323	255
5000	586	326	257
6000	598	329	259
7000	606	332	261
8000	613	334	263
9000	618	335	263
10000	622	336	263
15000	635	340	266
20000	642	342	267
30000	649	344	268

Source: Sugiyono, 2011

The sample size was determined using the Isaac and Michael Table with a 1% margin of error, yielding a total of 647 respondents. This figure was subsequently rounded to 650 respondents. To guarantee adequate representation from each higher education institution, the study employed a proportional random sampling technique.

2.2. Instruments and Variables

The questionnaire in this study was carefully designed to measure the indicators of the two main variables: Accessibility (X1) and Trip Generation and Trip Attraction (Y1). Each item in the questionnaire, whether a question or a statement, was developed based on the operational definitions of the variables outlined in Table 2. This table provides a clear explanation of how each variable and its respective dimensions are measured, including the specific indicators used to represent the constructs of accessibility, trip generation, and attraction. Moreover, the logical structure of the relationships between variables and indicators is visually illustrated in Figure 1, which presents the theoretical model. This diagram outlines the measurement flow, starting with the indicators that define the latent variables X1 and Y1 and proceeding to the hypothesized causal relationship between them. Hence, the questionnaire serves as a critical tool for collecting empirical data that directly reflects the conceptual and theoretical framework described in Table 2 and Figure 1.

Table 2. Operational Definition of Variables

Accessibility (X1)	Trip Generation and Attraction (Y1)
Travel distance from residential zones to Higher Education Institutions [17] Availability of public transportation [18] Condition of main roads leading to Higher Education Institutions [19] Transportation cost [20]	Number of vehicles generated by students [14] Daily travel frequency [20] Travel time patterns (peak hours) [20] Additional trip purposes around the Higher Education Institutions [17]

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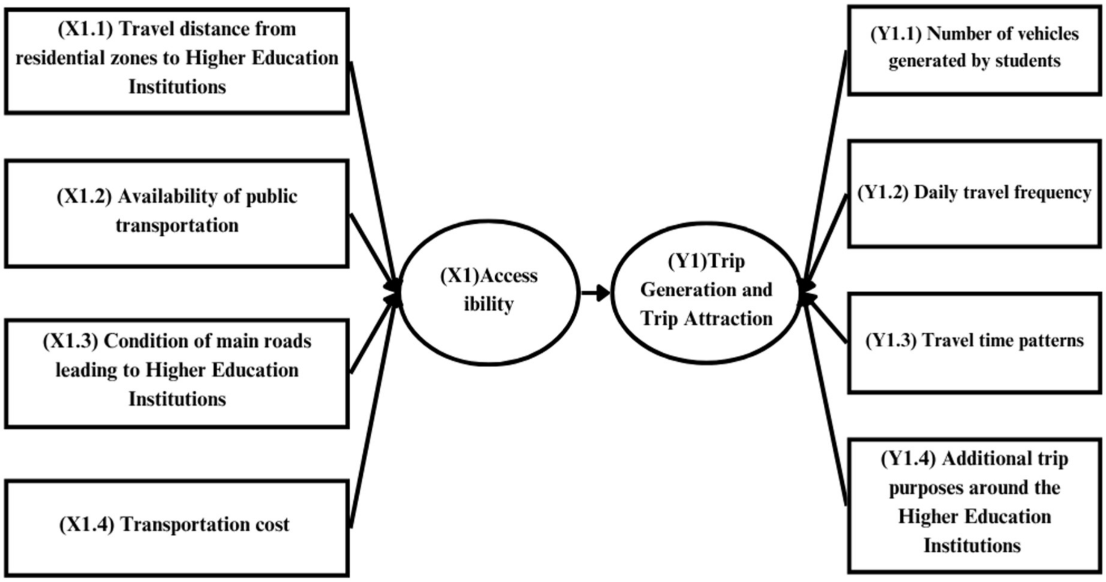

Figure 1. Theoretical Model Linking Accessibility to Trip Generation and Trip Attraction

2.3. Research Hypotheses

Based on the developed theoretical framework, the research on the Influence of Accessibility on Vehicle Trip Generation and Attraction at higher education institutions in Tulungagung Regency proposes structural relationship hypotheses. The primary hypothesis (H) states that Accessibility (X1) has a significantly positive influence on Trip Generation and Attraction (Y). This means that the higher the level of accessibility around a higher education institution, the higher the frequency of trips generated from the institution's area and the number of trips attracted to that area [17].

3. Result and Discussion

3.1. Evaluation of the Measurement Model

Outer model analysis determines how each indicator is related to its latent variable.

a. Validity Test

An indicator is considered valid when its loading factor value exceeds 0.60. Therefore, any indicator with a loading factor below 0.60 will be excluded from the model [15]. Reflective indicator validity is determined by analyzing the relationship between individual item scores and the scores of their corresponding constructs. In a reflective measurement model, variations in one indicator are expected to be accompanied by changes in other indicators within the same construct. This relationship is presented in Figure 2 (Outer Model) and further detailed in Table 3 (Outer Loadings).

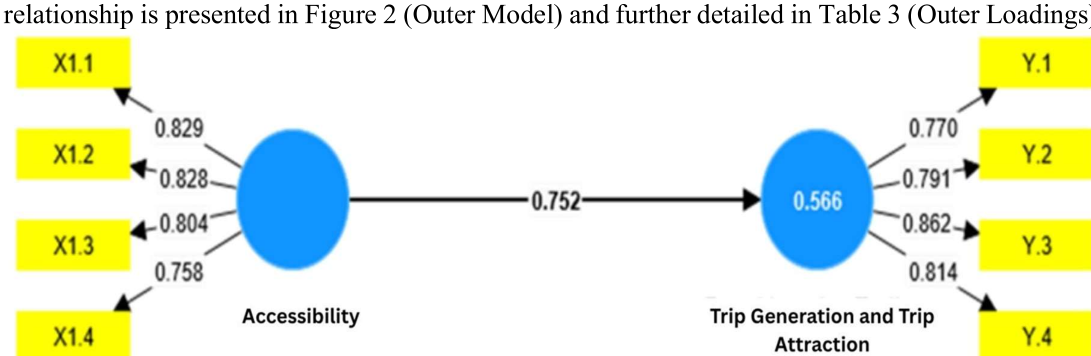

Figure 2. Outer Model

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Table 3. Outer Loading

Variable	Results
X1.1 < Accessibility	0,829
X1.2 < Accessibility	0,828
X1.3 < Accessibility	0,804
X1.4 < Accessibility	0,758
Y.1 < Trip Generation and Trip Attraction	0,770
Y.2 < Trip Generation and Trip Attraction	0,791
Y.3 < Trip Generation and Trip Attraction	0,862
Y.4 < Trip Generation and Trip Attraction	0,814

According to Table 3, all indicators of the research variables meet the criteria for convergent validity. These indicators are supported by the loading factor values of each item, all of which exceed the minimum benchmark of 0.60, indicating a strong linkage between the indicators and their corresponding latent constructs [15]. Apart from the loading factor, convergent validity was also assessed using the Average Variance Extracted (AVE) to ensure consistency in measurement. The AVE results indicate that both research variables exceed the recommended cutoff of 0.50 (X = 0.73; Y = 0.68). The combination of these two approaches provides strong evidence that the measurement instrument has adequate validity for further analysis, as shown in Table 4 (AVE Test Results)

Table 4. Average Variance Extracted (AVE) Test Results

Variable	Average variance extracted (AVE)
Accessibility	0,648
Trip Generation and Trip Attraction	0,656

According to the results displayed in Table 4, each research variable fulfils the requirements for convergent validity. This conclusion is supported by the Average Variance Extracted (AVE) values, which for all variables are greater than the minimum cutoff of 0.50 [15].

b. Discriminant Validity Test

To evaluate discriminant validity, this study applies the Fornell-Larcker Criterion, which is among the most widely used approaches in structural equation modelling. This method examines the degree to which a latent construct is distinct from other constructs within the model. The assessment is carried out by comparing the square root of the Average Variance Extracted (√AVE) for each variable with its correlations to other variables in the structural model. Discriminant validity is confirmed when the √AVE of a construct is greater than its correlations with any other construct, signifying that each variable represents a unique and separate conceptual dimension [15]. This finding reinforces the validity of the measurement model and confirms that overlapping constructs are not mistakenly interpreted as separate ones. The detailed results of the AVE values and the inter-variable correlations are presented in Table 5 (Fornell-Larcker Criterion).

Table 5. Fornell Lacker

Variable	Accessibility	Trip Generation and Trip Attraction
Accessibility	**0,805**	
Trip Generation and Trip Attraction	0,752	**0,810**

The results in Table 5 demonstrate that the AVE for each variable surpasses its correlations with other constructs, thereby confirming that the discriminant validity requirement is satisfied. These

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Publish: 25-11-2025 |

variables suggest that they are appropriate for further analytical procedures. Moreover, beyond the Fornell-Larcker criterion, discriminant validity was additionally examined using Cross Loadings, whereby an indicator is considered valid if its loading on the assigned construct is greater than its loadings on any other construct [15]. The outcomes of the cross-loading analysis are presented in Table 6 (Cross-Loading Results).

Table 6. Cross Loading Results

Indicator	Accessibility	Trip Generation and Trip Attraction
X1.1	**0,829**	0,619
X1.2	**0,828**	0,623
X1.3	**0,804**	0,555
X1.4	**0,758**	0,619
Y.1	0,685	**0,770**
Y.2	0,536	**0,791**
Y.3	0,622	**0,862**
Y.4	0,571	**0,814**

c. Reliability Test

Reliability testing assesses the accuracy and consistency of a measurement instrument in evaluating latent constructs [15]. This study evaluates reliability using the Composite Reliability (CR) coefficient, with 0.70 as the threshold. The corresponding results are provided in Table 7 (Composite Reliability Test Results).

Table 7. Composite Reliability Test Results

Variable	Composite reliability (rho_c)
Accessibility	0,880
Trip Generation and Trip Attraction	0,884

As indicated in Table 7, the constructs in this study are reliable, with Composite Reliability values consistently above the recommended cutoff of 0.70 [15]. Furthermore, to strengthen the assessment of internal consistency, a Cronbach's Alpha test was performed; the results are reported in Table 8.

Table 8. Cronbach's Alpha Test Results

Variable	Cronbach's alpha
Accessibility	0,819
Trip Generation and Trip Attraction	0,825

As reported in Table 8, the constructs within this study fulfill the reliability requirement, with Cronbach's Alpha coefficients consistently above 0.60.

3.2. Structural Model Evaluation (Inner Model)

a. Coefficient of Determination Test (R^2)

After the estimated model satisfies the Outer Model criteria, the subsequent stage is the evaluation of the Structural Model (Inner Model). The R-square (R^2) values, which represent the proportion of variance attributable to the endogenous constructs as explained by the exogenous variable, is detailed in Table 9, under the Coefficient of Determination Test.

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Table 9. Coefficient of Determination Test

Variable	Rsquare	R-squared adjusted
Trip Generation and Trip Attraction	0,566	0,566

As presented in Table 9, the Adjusted R-Square value for the Trip Generation and Trip Attraction construct is 0.566, which reflects a strong model fit. The Trip Generation and Trip Attraction indicate that the independent variables in the model explain 56.6% of the variance in both.

b. F Square Test

To evaluate the relative influence of independent latent variables on the dependent latent variable, the f-square test is used. In line with established criteria, an f^2 coefficient of 0.35 indicates a strong effect, 0.15 a moderate effect, and 0.02 a weak effect. This analysis offers a deeper insight into the substantive significance of each predictor within the structural framework [15], as presented in Table 10 (F-Square Test).

Table 10. F Square Test

Variable	F square
Accessibility > Trip Generation and Trip Attraction	1,305

As presented in Table 10, the fsquare value for the Trip Generation and Trip Attraction variables is 1.305. The value indicates that the independent variables exert a substantial influence on Trip Generation and Trip Attraction.

c. Q Square Test

Q-square predictive relevance (Q^2) is utilized to evaluate the extent to which PLS models possess predictive capability. A Q-square coefficient greater than zero indicates that the model is relevant for prediction, suggesting its adequacy for forecasting endogenous constructs. As per established criteria, Q^2 values of 0.02, 0.15, and 0.35 are interpreted as indicative of weak, moderate, and strong predictive relevance [15]. The detailed Q-square values for each construct are presented in Table 11 (Q^2 Test).

Table 11. Q Square Test

Variable	SSO	SSE	Q^2 (=1SSE/SSO)
Accessibility	2600,000	2600,000	0,000
Trip Generation and Trip Attraction	2600,000	1662,087	0,361

As shown in Table 11, the Q^2 value for the Trip Generation and Trip Attraction construct is 0.361. According to the predictive relevance criteria, this value indicates a high level of predictive accuracy, suggesting that the independent variables incorporated into the model possess strong explanatory power with respect to the dependent construct.

d. T Significance Test

To evaluate the significance of the path coefficients in the structural model, the analysis was conducted using variables that satisfied the validity requirements. This procedure aims to determine whether the hypothesised relationships among latent variables are positive or negative, and to assess their statistical significance. A relationship is deemed statistically significant when the p-value is less than 0.05 and the absolute t-statistic is at least 1.96 [15]. Specifically, if the t-statistic exceeds the critical value ($|t| \geq 1.96$), the relationship between constructs is deemed significant; otherwise, it is considered nonsignificant when the t-statistic falls below this threshold. The results of this analysis are illustrated in Figure 3 (Outer Model) and summarised in Table 12 (Hypothesis Testing for Direct Effects).

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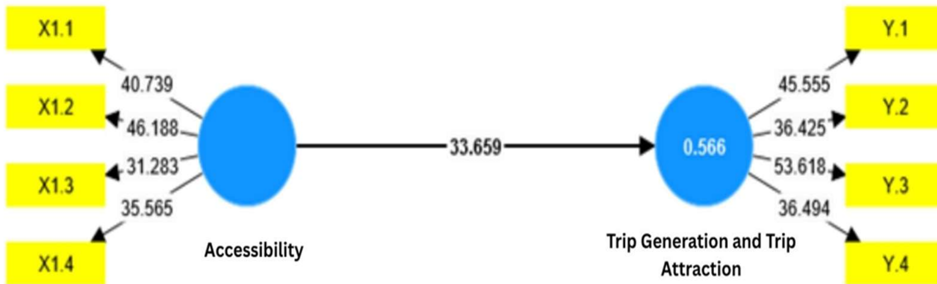

Figure 3. Outer Model

Table 12. Hypothesis Testing for Direct Effects

Variable	Original sample (O)	T statistics (|O/STDEV|)	P values
Accessibility > Trip Generation and Trip Attraction	0,752	33,659	0,000

According to the results summarized in Table 12, accessibility has a positive, statistically significant influence on Trip Generation and Trip Attraction. This conclusion is supported by the original sample estimate of 0.752, which evidences a strong positive relationship between the constructs. Additionally, the t-statistic of 33.659, which substantially exceeds the 1.96 critical value at the 5% level of significance, affirms the robustness of this relationship [15][17]. Therefore, the proposed hypothesis (H) stating that accessibility positively influences Trip Generation and Trip Attraction is supported. This finding is consistent with transportation theory, which suggests that improved accessibility increases the intensity of human mobility, both from points of origin (Trip Generation) and toward destinations (Trip Attraction).

4. Conclusion

This study confirms that accessibility significantly influences trip generation and Trip Attraction among students in Tulungagung Regency. Key accessibility-related factors, including travel distance, availability of public transportation, road conditions, and transportation costs, collectively explain 56.6% of the variation in travel patterns. The results of the PLS-SEM analysis reveal a strong positive relationship ($\beta = 0.752$), and all measurement indicators, including vehicle volume and trip frequency, meet the required validity (Average Variance Extracted > 0.5) and reliability (Composite Reliability > 0.7) standards.

These findings underscore the importance of improving accessibility through adequate public transport services, enhanced road infrastructure, and affordable transportation costs to mitigate traffic congestion driven by high student mobility. Therefore, urban planners and policymakers are encouraged to implement strategic measures, such as optimising public transportation routes, managing traffic flow during peak hours, and enhancing pedestrian and cycling infrastructure around campuses.

To strengthen the implications of this research, comparative studies in other regions or educational zones are recommended to validate the consistency of findings and provide broader generalizability. Additionally, this study acknowledges its limitations, particularly its focus on cross-sectional data from a specific region and its reliance on self-reported travel behaviour, which may not accurately capture seasonal or long-term changes.

Future research should incorporate longitudinal data, explore the role of multimodal transportation integration, and examine the long-term impact of accessibility improvements on sustainable urban mobility and land-use planning.

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