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Visitor Attraction Model of Trade and Service Facilities at the Business Unit Level in the Planned Government Centre Area of Serang Regency

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ABSTRAK

Estimasi dampak lalu lintas kawasan rencana Pusat Pemerintahan Kabupaten Serang memerlukan model tarikan untuk seluruh tata guna lahan penyusunnya, termasuk perdagangan dan jasa yang mendominasi koridor Jalan Raya Serang-Jakarta. Penelitian ini menyusun model tarikan pengunjung dari 138 unit usaha pada sembilan jenis kegiatan di 27 desa Kecamatan Ciruas dan Kragilan, dengan variabel terikat jumlah pengunjung per hari dan tiga variabel bebas berupa luas parkir, luas bangunan, serta jumlah pegawai. Analisis dilakukan pada tingkat unit usaha, berbeda dengan praktik lazim yang mengagregasi data ke tingkat desa dan menyusutkan sampel menjadi 27 amatan. Ketiga variabel bebas berkorelasi positif dan signifikan terhadap variabel terikat, yaitu 0,875 untuk luas parkir, 0,730 untuk luas bangunan, dan 0,552 untuk jumlah pegawai. Model regresi berganda menghasilkan koefisien determinasi 0,836, namun koefisien jumlah pegawai berbalik menjadi negatif dan signifikan ($B = -28{,}182$; $p < 0{,}001$). Penambahan kendali jenis usaha menaikkan koefisien determinasi menjadi 0,862 tanpa memulihkan tanda koefisien, dan transformasi logaritma atas ketiga prediktor hanya memindahkan pembalikan tanda. Spesifikasi linear juga gagal uji Breusch-Pagan ($LM = 847{,}2$; $p < 0{,}001$) dan didominasi 14 unit pasar yang bila dikeluarkan menurunkan koefisien kemiringan 78 persen. Model elastisitas $\ln Y = 2{,}068 + 0{,}501 \ln X$ dengan X berupa luas parkir merupakan satu-satunya spesifikasi yang memenuhi seluruh kriteria, dengan koefisien determinasi 0,372 dan Breusch-Pagan $p = 0{,}320$. Elastisitas 0,501 menunjukkan hasil yang menurun: penggandaan luas parkir menaikkan jumlah pengunjung sekitar 41 persen.

ABSTRACT

Estimating the traffic impact of the planned Serang Regency Government Centre requires attraction models for every constituent land use, including the trade and service facilities that dominate the Serang-Jakarta arterial corridor. This study develops a visitor attraction model from 138 business units across nine activity types in Ciruas and Kragilan Districts, using daily visitor counts as the dependent variable and three independent variables: parking area, building area, and number of employees. The analysis works at the business unit level, unlike the common practice of aggregating to village level, which reduces the sample to 27 observations. All three independent variables correlate positively and significantly with the dependent variable, at 0.875 for parking area, 0.730 for building area, and 0.552 for employees. Multiple regression yields a coefficient of determination of 0.836, yet

the employee coefficient turns negative and significant (B = -28.182; p < 0.001). Adding business type controls raises the coefficient of determination to 0.862 without restoring the sign, and logarithmic transformation of all three predictors merely relocates the reversal. The linear specification also fails the Breusch-Pagan test (LM = 847.2; p < 0.001) and is dominated by 14 market units whose removal lowers the slope by 78 percent. The elasticity model ln Y = 2.068 + 0.501 ln X, with X the parking area, is the only specification satisfying every criterion, with a coefficient of determination of 0.372 and Breusch-Pagan p = 0.320. The elasticity of 0.501 implies diminishing returns: doubling parking area raises visitor numbers by about 41 percent.

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1. INTRODUCTION

Preparing a traffic impact analysis document for an area requires estimates of trip attraction from every constituent land use, not only from the planned principal activity. Regulation of the Minister of Transportation Number PM 17 of 2021 on the Implementation of Traffic Impact Analysis (Kementerian Perhubungan Republik Indonesia, 2021) establishes the calculation of trip generation and trip attraction magnitudes as a core component of such a document. In the planned Government Centre area of Serang Regency, trade and service activities dominate the Jalan Raya Serang-Jakarta corridor, so their contribution to the traffic load of the area cannot be ignored.

This need is all the more pressing because relocating a government centre is not merely a change of office location; it triggers land use transformation in the surrounding territory. Syaban and Appiah-Opoku (2024) documented the land use transitions that accompanied construction of the new capital city in East Kalimantan, while Tukimun et al. (2022) formulated an integrated and environmentally sound transport infrastructure concept for the new capital area. Setiawan et al. (2025) noted that long-horizon infrastructure projects such as capital relocation are vulnerable to changes of regime and shifting policy priorities. In the Ciruas and Kragilan districts, trade and service activities have already grown ahead of the government plan, so a model is needed to establish baseline conditions before the new area begins operating.

Attraction modelling for trade and service land use in Indonesia has been carried out in a variety of settings. Darwis et al. (2022) modelled attraction in a central business area in Morotai, while Susilo et al. (2026) examined weekly traditional markets in Palu City. Studies of other land uses show comparable approaches, including housing (Da Cruz et al., 2023; Fajrinia et al., 2025), educational facilities (Andriani & Mulyawan, 2020), and government offices (Fery hs et al., 2026; Ramadhan et al., 2026; Syamsuddin et al., 2026). Outside Indonesia, modelling based on household surveys (Aboelenen et al., 2021) and regression on residential trip data (Mohammed et al., 2025) occupies an equivalent position as a mainstream approach.

Most of these studies face the same limitation, namely a small sample size caused by aggregating data to the administrative level. Aggregating business units to the village level shrinks hundreds of observations to a few dozen, reducing the degrees of freedom while eliminating the between-unit variability that is in fact the principal source of information. Goh et al. (2023) showed that standard trip rates need to be adjusted to the local development context, and such adjustment requires observations at the facility level. De Oliveira et al. (2022) took the same approach in freight attraction modelling by treating the commercial business unit as the observation unit, and Doulabi (2020) used data at facility resolution to adjust standard trip rates to the local context.

A second limitation concerns the choice of explanatory variables. Parking area, building area, and number of employees are commonly used together because all three are easy to measure and are theoretically related to activity intensity. All three are also manifestations of the same business scale, so they are strongly intercorrelated. The resulting multicollinearity does not lower the coefficient of determination; instead it corrupts the estimation of individual coefficients to the point where a coefficient sign may reverse relative to theory. Kalnins and Praitis Hill (2025a, 2025b) even question the logical basis for using standard thresholds to diagnose this condition, which makes examination of substantive symptoms all the more important. Ghaemi Rad (2026) recommends a staged diagnostic procedure that inspects the structure of the relationships among variables before the final specification is fixed, and this is the procedure applied in the present study.

This study develops a visitor attraction model for trade and service facilities in the planned Government Centre area of Serang Regency at the business unit level. Analysis at unit resolution preserves the full variability among facilities and yields a sample size far larger than aggregation to the village level. The study also tests systematically whether the coefficient sign reversal encountered can be remedied by adding business type controls or by transforming the variables, before the final specification is adopted.

2. METHODS

2.1 Study Location and Object

The study was located in Ciruas District and Kragilan District, Serang Regency, Banten Province, covering 27 villages in total with an area of 7,290.4 ha. The planned government centre area of 60 ha lies in Kaserangan Village and Cisait Village, on the arterial road corridor connecting Serang and Jakarta. Village boundaries were taken from the administrative files issued by Badan Informasi Geospasial (the Geospatial Information Agency), which follow the Regulation of the Minister of Home Affairs, in the WGS 1984 UTM Zone 48S projection so that areas are computed in metric units.

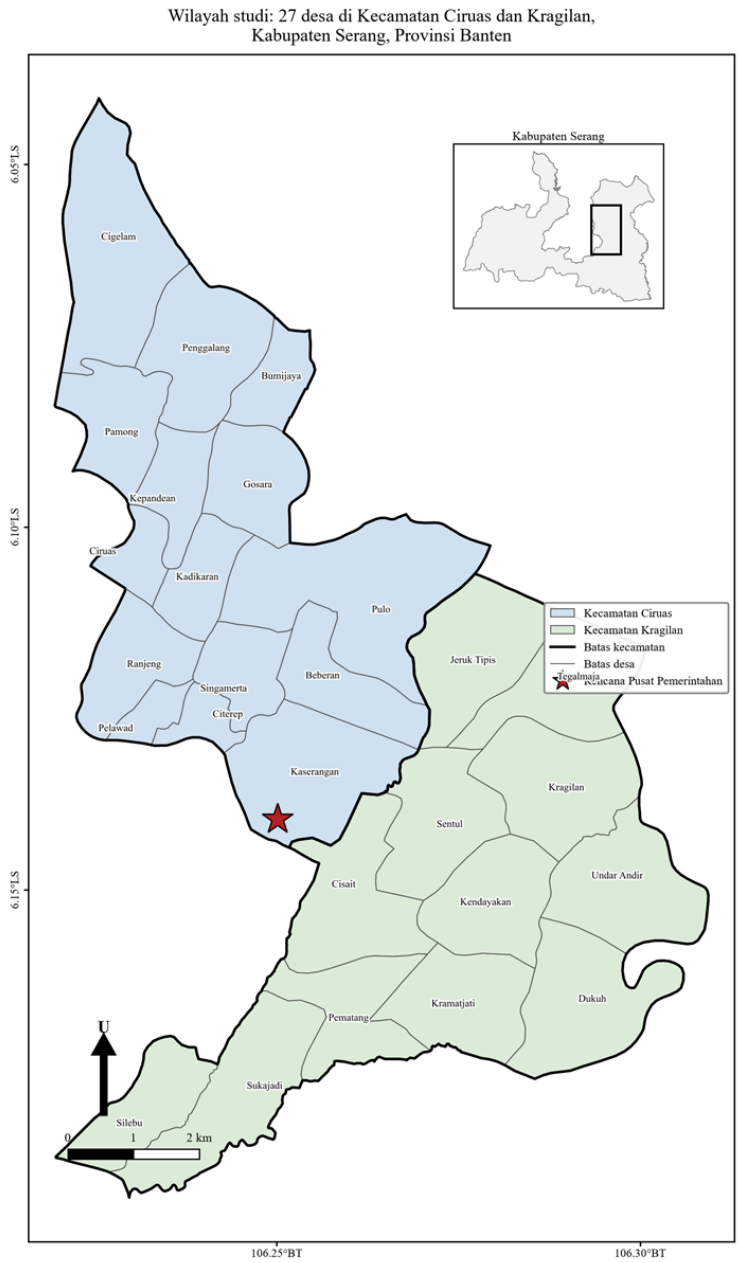


Figure 1. Study area and location of the planned Government Centre of Serang Regency

Figure 1 presents the location of the study area together with the site of the planned government centre, which lies on the boundary between the two districts.

The objects of the study are the trade and service business units recorded in the area survey. Initial data collection yielded 143 units. A consistency check identified five pairs of rows that were identical across all quantitative attributes, namely village, parking area, building area, number of employees, and number of visitors, but were recorded under two different business type tables. In three of these pairs the business names were written differently, for example Warung Grosir Kembar and Grosir Sembako Kembar, so they most likely refer to a single physical unit. The second row of each pair was removed to prevent double counting. The final sample comprises 138 business units across nine activity types distributed over all 27 villages.

2.2 Variables And Data Colletion

The dependent variable is the number of visitors per day, expressed in persons. It should be emphasised that this unit denotes a number of people, not a number of vehicles in passenger car units. The resulting model is therefore a visitor attraction model, and converting it into vehicle attraction would require additional information on travel mode and vehicle occupancy, which was not collected in this survey.

The three independent variables observed are parking area (X1, m2), building area (X2, m2), and number of employees (X3, persons). The data were obtained through field measurement and confirmation with business managers. The nine activity types covered are repair workshops, salons and barbershops, food stalls, markets and supermarkets, building material stores, clothing stores, furniture stores, motorcycle dealerships, and general provision stores.

2.3 Analytical Technique

The analysis proceeded in six stages. The first stage compiled descriptive statistics by business type in order to examine the variability of the visitor to employee ratio across activity types. The second stage estimated a simple regression model for each independent variable separately, to obtain a reference for the sign and magnitude of the coefficients before the variables were combined.

The third stage estimated a multiple linear regression model with all three independent variables entered simultaneously, together with the calculation of tolerance and variance inflation factor for each variable.

$$Y = a + b1X1 + b2X2 + b3X3$$

The fourth stage tested two remedial attempts addressing the anomaly found in the third stage. The first attempt added eight business type dummy variables, with repair workshops as the reference category, and then tested the significance of this addition through a partial F test and by comparing the Akaike and Bayesian information criteria. The second attempt applied a logarithmic transformation to the dependent variable and to all independent variables, producing an elasticity model while also addressing the skewness of the distributions.

The fifth stage tested the regression assumptions for each specification. Homoscedasticity was tested with the Breusch-Pagan test, residual normality with the Shapiro-Wilk test, and the influence of individual observations with the Cook distance at the 4/n threshold. The effect of the large-scale business category was examined by re-estimating the model with all units in the market and supermarket category excluded.

The sixth stage selected the final model on the basis of three conditions that had to be satisfied simultaneously: all coefficients significant and carrying theoretically expected signs, the homoscedasticity assumption satisfied, and no single observation dominating the estimation. All computations were performed directly from the business unit data and can be reproduced from the data file accompanying this manuscript.

3. RESULT AND DISCUSSION

3.1 Characteristics of the Business Unite

Table 1 presents descriptive statistics for the four study variables. In aggregate, the 138 business units provide 8,920 m2 of parking area with 23,197 m2 of building area, employ 562 people, and attract 12,014 visitors per day.

Table 1. Descriptive statistics of the study variables (N = 138)

Variable	Minimum	Maximum	Mean	Standard deviation
Parking area (m2)	4	1.200	64,64	148,67
Building area (m2)	20	3.000	168,09	407,38
Number of employees (persons)	1	40	4,07	5,45
Number of visitors (persons/day)	8	2.500	87,06	252,93

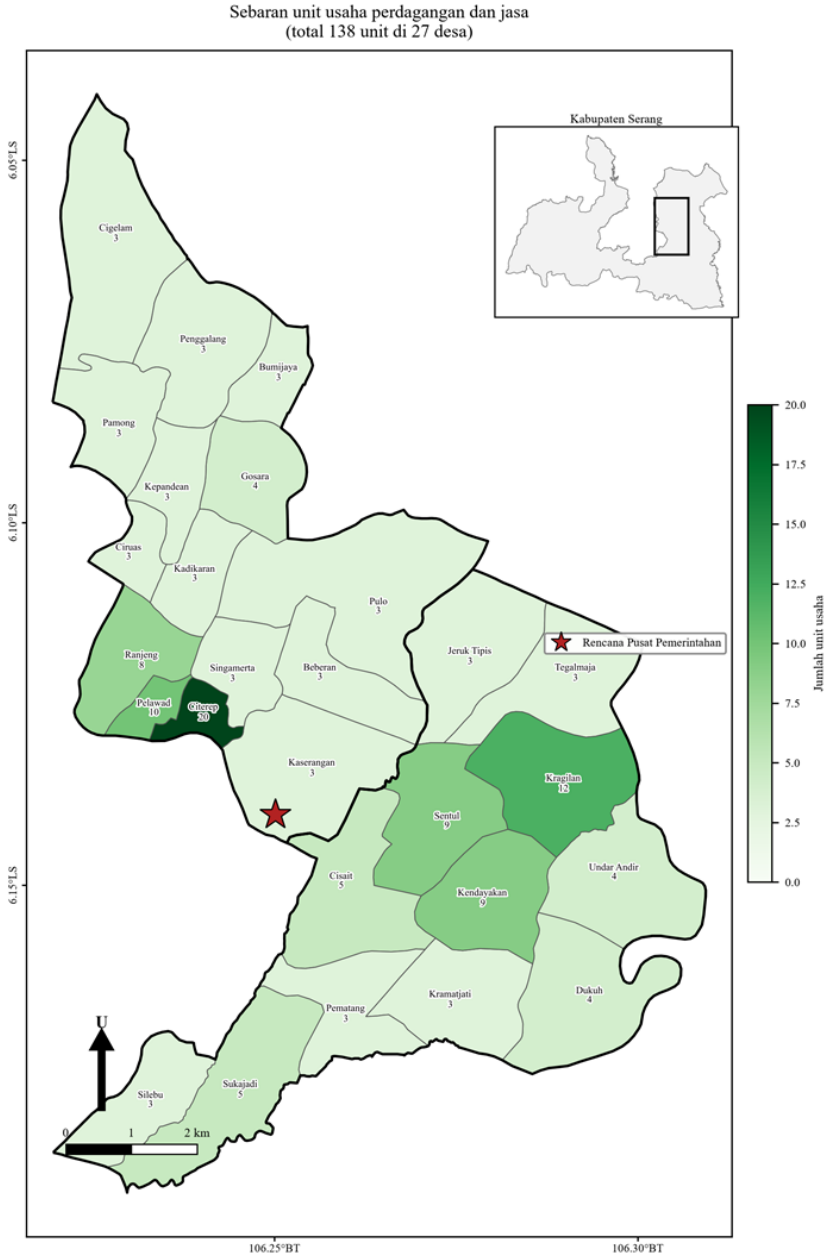


Figure 2. Distribution of trade and service business units by village

Figure 2 shows that the business units are concentrated in the villages traversed by the main corridor. Citerep Village records 20 units, followed by Kragilan Village with 12 units and Pelawad Village with 10 units, whereas villages in the northern part of the study area generally have only three units. This pattern reinforces the inference that accessibility is the main determinant of the location of trade and service activities.

The distribution of the dependent variable is strongly right-skewed, with a skewness of 7.71. Its median is only 39 visitors per day, far below the mean of 87.06, indicating that a small number of large-scale facilities attract the majority of visitors.

Table 2 shows that the visitor to employee ratio differs sharply across business types. Motorcycle dealerships employ an average of 12.2 people yet attract only 63.8 visitors per day, giving a ratio of 5.2. Food stalls employ an average of 2.0 people but attract 52.7 visitors per day, a ratio of 26.8. This variability must be taken into account when the number of employees is used as a predictor.

It should be noted that the market and supermarket category in the source file is not homogeneous. The category contains large public markets such as Pasar Ciruas with 2,500 visitors per day alongside supermarket outlets, shophouse complexes, and shops that attract only 60 to 220 visitors per day. The mean value for this category conceals very wide variability, and the dummy variable representing it in the remedial tests merges activity types that are in fact distinct. This grouping follows the source file and was left unchanged so that the results remain traceable, but it constitutes one limitation of the study.

Table 2. Average characteristics by business type

Business type	n	Employees	Visitors	Ratio	Building (m2)
Repair workshop	27	2,3	18,5	8,2	55
Beauty salon and barbershop	27	1,9	16,8	8,7	37
Warung (small food stall)	27	2,0	52,7	26,8	38
Market and supermarket	14	12,0	492,1	41,0	861
Building materials store	10	5,4	65,5	12,1	226
Clothing store	10	2,8	62,5	22,3	87
Furniture store	8	3,2	40,0	12,3	152
Motorcycle dealership	8	12,2	63,8	5,2	321
Sundry goods shop (toko pracangan)	7	3,1	91,4	29,1	101

The ratio expresses the number of visitors per day per employee.

3.2 Correlation Analysis and Simple Models

Table 3 presents the Pearson correlation matrix together with the estimation results of the simple regression model for each independent variable. All three independent variables are positively and significantly correlated with the number of visitors, and every coefficient in the simple models carries a positive sign.

Table 3. Correlation with the dependent variable and simple regression results

Variable	r	B	Sig.	R squared
Parking area (X1)	0,875	1,489	<0,001	0,766
Building area (X2)	0,730	0,453	<0,001	0,532
Number of employees (X3)	0,552	25,609	<0,001	0,305

The correlations among the independent variables are also high: 0.884 between parking area and building area, 0.795 between parking area and number of employees, and 0.912 between building area and number of employees. The three variables therefore carry largely overlapping information. Parking area is the strongest single predictor, with a coefficient of determination of 0.766.

3.3 Multiple Linear Regression Model

The estimation results for the model containing all three independent variables are presented in Table 4.

Table 4. Multiple linear regression results (N = 138)

Variable	B	Standard error	t	Sig.
(Constant)	49,746	12,575	3,96	<0,001
Parking area (X1)	1,736	0,127	13,63	<0,001
Building area (X2)	0,237	0,069	3,44	0,001
Number of employees (X3)	-28,182	3,969	-7,10	<0,001

R squared = 0.836; adjusted R squared = 0.833; F(3;134) = 228.4; Sig. < 0.001; standard error of the estimate = 103.43.

The coefficient of determination of 0.836 appears satisfactory, yet the coefficient for the number of employees is negative and highly significant. Read literally, each additional employee lowers the number of visitors by 28.182 people per day. This reading contradicts the simple model in Table 3, which yields a positive coefficient of 25.609 for the same variable. A sign reversal of this magnitude is a symptom of multicollinearity, not a substantive finding.

Table 5. Multicollinearity test results

Variable	Tolerance	VIF
Building area (X2)	0,0990	10,10
Number of employees (X3)	0,1668	6,00
Parking area (X1)	0,2178	4,59

Table 5 reports variance inflation factors between 4.59 and 10.10. These values are far lower than those found for office land use, but building area has already reached the lenient threshold in common use, and all three exceed the strict threshold of 2.5. More decisive is the substantive symptom, since the sign reversal in Table 4 occurs even though the numerical diagnostics are only moderate.

3.4 Testing of Remedial Measures

The variation in the ratio of visitors to employees in Table 2 raises the suspicion that the sign reversal arises from omitting business type. This suspicion was tested by adding eight business type dummy variables to the model. The addition raised the coefficient of determination from 0.836 to 0.862 and proved statistically meaningful, with F(8;126) of 2.96 at a p value of 0.004. The Akaike information criterion fell from 1,675.9 to 1,668.1, whereas the Bayesian information criterion rose from 1,687.6 to 1,703.2.

Even so, the coefficient for the number of employees remained negative and in fact grew slightly larger, reaching -30.643 with a p value below 0.001. The hypothesis that business type heterogeneity is the sole cause of the sign reversal is therefore rejected. Business type does explain part of the variation, but it does not restore the coefficient sign.

A second attempt applied a logarithmic transformation to all variables. The resulting elasticity model has a coefficient of determination of 0.647, with residuals far closer to normal than those of the linear model, as shown by the drop in residual skewness from 7.71 on the original variables to 0.78. The sign reversal, however, did not disappear; it merely shifted. In the logarithmic model the coefficient for the number of employees becomes positive at 0.534, while the coefficient for parking area reverses to -0.590. Variance inflation factors in this model range from 7.80 to 15.68, higher than in the linear model.

Both remedial attempts show that the sign reversal stems neither from the functional form nor from the omission of business type, but from overlapping information among the independent variables. As long as the three variables are retained together, one of them will carry a coefficient whose sign runs counter to its simple relationship.

3.5 Assumption Testing and Diagnosis of Influential Observations

Before the final model was adopted, the linear specification was tested against the regression assumptions. The results reject the adequacy of the linear form. The Breusch-Pagan test on the linear model with parking area as the sole predictor yields an LM statistic of 847.2 with a p value indistinguishable from zero, so homoscedasticity is convincingly rejected. The Shapiro-Wilk test rejects residual normality ($W = 0.693$; $p < 0.001$).

The consequences of heteroscedasticity on this scale are fundamental. The standard errors, the t values, and every statement of significance in the linear model become invalid, however high its coefficient of determination may appear. The value of 0.766 cannot serve as a basis for model selection.

The diagnosis of influential observations reinforces this rejection. Pasar Ciruas, with a parking area of 1,200 m2 and 2,500 visitors per day, has a Cook distance of 23.30, more than eight hundred times the 4/n threshold. When all 14 units in the market and supermarket category are removed, the slope coefficient collapses from 1.489 to 0.323, a decline of 78 percent, and the coefficient of determination falls from 0.766 to 0.236. The relationship that appears strong in the linear model largely reflects a handful of large-scale markets rather than the general pattern of trade and service business units.

3.6 Elasticity Model

The logarithmic transformation of the dependent and independent variables produces a specification that satisfies the assumptions. Table 6 presents the estimation results.

Table 6. Estimation results of the elasticity model (N = 138)

Variable	b	Standard error	t	Sig.
(Constant)	2,068	0,189	10,92	<0,001
ln parking area	0,501	0,056	8,98	<0,001

R squared = 0.372; adjusted R squared = 0.368; Breusch-Pagan p = 0.320; maximum Cook distance = 0.33.

The recommended final model takes the following form, where Y denotes the number of visitors per day and X denotes the parking area in square metres.

$$\ln Y = 2.068 + 0.501 \ln X, \quad \text{or equivalently} \quad Y = 7.91 X^{0.501}$$

The Breusch-Pagan test on this model does not reject homoscedasticity ($p = 0.320$), and the maximum Cook distance falls from 23.30 in the linear model to 0.33. Both improvements show that the logarithmic transformation resolves the error variance problem and at the same time tames the influence of large-scale units.

The coefficient of 0.501 is an elasticity. Every 10 percent increase in parking area is associated with a 4.9 percent increase in the number of visitors. An elasticity close to 0.5 means that the number of visitors grows roughly in proportion to the square root of the parking area, so diminishing returns apply: doubling the parking area does not double the number of visitors but raises it by about 41 percent. This property is invisible in the linear model, which instead assumes a constant increment of 1.489 visitors for every square metre regardless of the scale of the facility.

Table 7. Comparison of all model specifications tested

Specification	R squared	Max VIF	Sign consistent with theory	Breusch-Pagan	Max Cook distance
Linear, three predictors	0,836	10,10	No	rejected	-
Linear, business type control	0,862	18,15	No	rejected	-
Log-log, three predictors	0,653	15,68	No	rejected	1,15
Linear, parking area only	0,766	n.a.	Yes	rejected	23,30
Log-log, parking area only	0,372	n.a.	Yes	accepted	0,33

The last row is the selected model, the only specification that satisfies all of the criteria. The coefficient of determination in the two log-log rows refers to ln Y and is therefore not directly comparable with the coefficient of determination of the models estimated in the original scale.

Table 7 shows that the selected model in fact has the lowest coefficient of determination among all specifications tested. Even so, it is the only model in which every coefficient carries the theoretically expected sign while also satisfying the homoscedasticity assumption. The higher coefficients of determination obtained by the other specifications come at the cost of valid inference and therefore cannot serve as a basis for model selection.

3.7 The Meaning of the Coefficient Sign Reversal

The principal finding of this study is not the magnitude of the coefficients but the failure of the multiple model to yield interpretable coefficients despite its high explanatory power. The pattern matches what was found for office land use within the same study area. Kristiawan et al. (n.d.) report variance inflation factors reaching 660.7 with the land area coefficient reversing to negative, even though all predictors correlated above 0.98 with the dependent variable. The similarity of the pattern across two different land uses shows that the problem is structural and inheres in the choice of variables rather than in the characteristics of a single activity type.

The source of the problem can be traced to the fact that parking area, building area, and number of employees are three manifestations of a single latent dimension, namely the scale of the business. When all three enter the same equation, the model is forced to separate contributions that are empirically inseparable. One variable then carries a negative coefficient as an arithmetic adjustment to another variable that absorbs most of the information, rather than as a reflection of a causal relationship.

Fery hs et al. (2026) faced a comparable model selection problem at the Tenayan Raya integrated office complex. They tested twelve model combinations against seven diagnostic criteria and ultimately selected a single-predictor model with a value of 0.981, even though their two-predictor model reached 0.995. That higher model failed the t test rather than the multicollinearity test. The two studies differ in the binding criterion, but they agree on one point: the model with the highest coefficient of determination is not the model finally adopted. It is the battery of diagnostic tests, not explanatory power alone, that determines the choice.

3.8 Implications of Selecting Parking Area as the Predictor

The selection of parking area as the sole predictor brings practical advantages beyond statistical considerations. Parking area can be measured directly from satellite imagery or site plan drawings without interviewing business operators, unlike the number of employees, which requires confirmation and varies with the business season. Preparers of analisis dampak lalu lintas (andalalin, traffic impact analysis) documents can therefore apply this model at the planning stage, when operational data are not yet available.

The relationship between parking area and the number of visitors also has a clear behavioural basis. Facility providers set parking capacity on the basis of expected demand, so parking area records the operator's anticipation of visit volume. The relationship runs in both directions and must be treated with care, because parking area can at the same time limit the number of visits that can be served. The model is better understood as a prediction tool than as a causal statement.

Alternative approaches available in the literature offer different treatments of similar problems. Abu-Eisheh and Irshaid (2020) and Irshaid and Abu-Eisheh (2023) use an adaptive neuro-fuzzy inference system that imposes no assumption about functional form, while Yang et al. (2020) develop a data-driven approach. Shahri and Ghannadi (2023), together with Reda et al. (2023), apply geographically weighted regression to handle spatial non-stationarity, and Nourmohammadi et al. (2025) test the transferability of models across regions. More recent work draws on semi-passive smartphone-based data (Ali et al., 2026) and on the generation of synthetic travel data where access to real data is limited (Wu et al., 2026). Saeidian (2024) shows that modelling for specific user groups requires explanatory variables different from those of aggregate models, while Hajimoradi (2025) integrates several modes within a single national network framework. These methods promise higher accuracy, but they produce models that are more difficult for regional preparers of andalalin documents to replicate.

3.9 Limitations of the Study

The most fundamental limitation lies in the unit of the dependent variable. The number of visitors is expressed in persons per day rather than in passenger car units per hour, the unit required for road segment performance analysis as specified in the Pedoman Kapasitas Jalan Indonesia

(Indonesian Highway Capacity Guidelines; Direktorat Jenderal Bina Marga, 2023). Converting between the two requires mode share data and vehicle occupancy rates, neither of which was collected in this survey. The resulting model provides an estimate of visit intensity, and its use in road capacity calculations requires a separate conversion step.

One value of an independent variable needs to be disclosed. The source file flags the parking area of the Indomaret Sentul outlet, recorded as 500 m2, as anomalous because it exceeds the outlet's own building area of 150 m2, whereas comparable outlets in other villages record 60 m2 and 120 m2. The value was nevertheless retained, because only with it can the parking area recapitulation in the source document be reconciled. This observation combines a large parking area with few visitors, which pushes the slope coefficient downward.

The second limitation concerns the strongly skewed distribution of the dependent variable. Fourteen units in the market and supermarket category attract an average of 492.1 visitors per day, far above the other business types, and the largest unit records 2,500 visitors per day. These units exert high leverage on the parameter estimates. Third, this study did not count vehicles and therefore cannot verify the relationship between the number of visitors and the traffic volume they generate. Fourth, the data were collected in a single survey period, so daily and seasonal variation was not captured.

The final limitation concerns the replicability of the survey. The counting dates and the number of observation days were not recorded in the available database, so daily variation cannot be separated from the reported values. All estimates in this paper were recomputed from the business unit data matrix and can be traced back to the accompanying data file.

4. CONCLUSION

The visitor attraction model for trade and service facilities in the planned Government Centre area of Serang Regency takes an elasticity form, ln Y = 2.068 + 0.501 ln X, where Y is the number of visitors per day and X is the parking area in square metres, estimated on 138 business units. An elasticity of 0.501 means that a 10 percent increase in parking area is associated with a 4.9 percent increase in the number of visitors, and that doubling the parking area raises the number of visitors by about 41 percent. This diminishing returns property is not visible in the linear specification.

The linear specification was rejected despite its higher coefficient of determination. The Breusch-Pagan test rejects homoscedasticity with an LM statistic of 847.2, so all standard errors and the significance statements based on them are invalid. That model is also dominated by 14 market units: excluding them reduces the slope coefficient by 78 percent and the coefficient of determination from 0.766 to 0.236. The model with the highest explanatory power is not the model fit for use.

The multiple regression model with three predictors yields a coefficient of determination of 0.836, but the coefficient of the number of employees reverses to negative at -28.182 even though its simple correlation is positive at 0.552. This sign reversal cannot be repaired by adding a business type control, which raises the coefficient of determination to 0.862 without changing the sign, nor by logarithmic transformation, which merely shifts the sign reversal to the parking area variable. Overlapping information among the independent variables is the cause.

Analysis at the business unit level yields 138 observations, more than five times the 27 observations that remain after aggregation to the village level. Unit-level resolution preserves the

between-facility variation that is the model's principal source of information, so this approach is recommended for similar studies.

Further research is recommended to collect mode share and vehicle occupancy data so that the visitor attraction model can be converted into a vehicle attraction model expressed in passenger car units, and to carry out direct vehicle counts in order to verify the relationship between visit intensity and the traffic volume generated.

AUTHOR CONTRIBUTIONS

Tony Kristiawan designed the study, conducted the field survey, performed the statistical analysis, and drafted the manuscript. Leksmono Suryo Putranto supervised the research, advised on the modelling methodology, and critically revised the manuscript. Haris Muhammadun supervised the research, validated the analysis, and reviewed the manuscript. All authors have read and approved the final manuscript.

CONFLICT OF INTEREST

The authors declare no conflict of interest with respect to the research, authorship, or publication of this article.

DATA AVAILABILITY

The facility characteristics and traffic count data underlying all analyses reported in this article are available from the corresponding author upon reasonable request.

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REFERENCES

Aboelenen, K. E., Mohammad, A. N., Elgaar, M. I., & Choe, P. (2021). Trip generation rates using household surveys in the State of Qatar. *Journal of Traffic and Logistics Engineering, 9*(1), 10–19. https://doi.org/10.18178/jtle.9.1.10-19

Abu-Eisheh, S., & Irshaid, M. (2020). Modelling trip generation using adaptive neuro-fuzzy inference system in comparison with traditional multiple linear regression approach. *International Journal of Simulation: Systems, Science & Technology, 21*(2), 17.1–17.6. https://doi.org/10.5013/IJSSST.a.21.02.17

Ali, A., Flaata, E. H., Torset, T., Hess, S., & Choudhury, C. F. (2026). Investigating the impact of inferring trip purposes in a daily trip generation model. *Transportation Research Part C: Emerging Technologies*. https://doi.org/10.1016/j.trc.2026.105619

Andriani, S., & Mulyawan, I. (2020). Pemodelan bangkitan perjalanan pelajar di Kota Pariaman. *Jurnal Ilmiah Rekayasa Sipil, 17*(2), 172–179. http://ejournal2.pnp.ac.id/index.php/jirs

Da Cruz, M. F., Arifianto, A. K., & Sa'dillah, M. (2023). Analisis bangkitan perjalanan berbasis rumah tangga (Studi kasus: Perumahan Karangploso View, Kabupaten Malang). *Prosiding SENTIKUIN, 6*, D12.1–D12.15. https://pro.unitri.ac.id/index.php/sentikuin/article/view/448

Darwis, F., Djafar, A., & Mulya, E. R. (2022). Analysis of trip attraction models in Morotai CBD (Central Business District). *Techno: Jurnal Penelitian, 11*(2), 105–114. https://doi.org/10.33387/tjp.v11i2.5439

de Oliveira, L. K., de Araujo, G. G. F., Bertoncini, B. V., Pedrosa, C. D., & da Silva, F. G. F. (2022). Modelling freight trip generation based on deliveries for Brazilian municipalities. *Sustainability, 14*(16), Article 10300. https://doi.org/10.3390/su141610300

Direktorat Jenderal Bina Marga. (2023). *Pedoman Kapasitas Jalan Indonesia (PKJI)* (No. 09/P/BM/2023). Kementerian Pekerjaan Umum dan Perumahan Rakyat. https://binamarga.pu.go.id/index.php/nspk/detail/09pbm2023-pedoman-kapasitas-jalan-indonesia-

Doulabi, S. (2020). *Contextual adjustment of the ITE trip generation rates using Wi-Fi and Bluetooth technologies* [Master's thesis, Louisiana State University]. https://doi.org/10.31390/gradschool_theses.5064

Fajrinia, C. P., Upa, V. A., & Putra, D. M. (2025). Analisis bangkitan perjalanan dari Perumahan Griya Aster Kecamatan Legok Kabupaten Tangerang. *INNOVATIVE: Journal of Social Science Research, 5*(3), 1892–1903. https://j-innovative.org/index.php/Innovative

Fery hs, L., Sentosa, L., & Wibisono, G. (2026). Pemodelan tarikan perjalanan komplek perkantoran terpadu Tenayan Raya. *Jurnal RAB Construction Research, 11*(1), 297–305. https://doi.org/10.36341/racic.v11i1.7205

Ghaemi Rad, T. (2026). A diagnostic framework for selecting spatial regression models in urban accessibility studies. *Earth Observation and Geomatics Engineering*. https://doi.org/10.22059/eoge.2026.414997.1225

Goh, B. H., Yuen, C. W., & Onn, C. C. (2023). Improvement of trip generation rates for mixed-use development in Klang Valley, Malaysia. *Scientific Reports, 13*, Article 2699. https://doi.org/10.1038/s41598-023-29748-w

Hajimoradi, M. (2025). *Long-distance travel in Canada: Multimodal modeling with a national network* [Master's thesis, University of Waterloo]. https://hdl.handle.net/10012/22543

Irshaid, M., & Abu-Eisheh, S. (2023). Application of adaptive neuro-fuzzy inference system in modelling home-based trip generation. *Ain Shams Engineering Journal, 14*, Article 102523. https://doi.org/10.1016/j.asej.2023.102523

Kalnins, A., & Praitis Hill, K. (2025a). Additional caution regarding rules of thumb for variance inflation factors: Extending O'Brien to the context of specification error. *Quality & Quantity, 59*(Suppl. 1), 291–314. https://doi.org/10.1007/s11135-024-01980-0

Kalnins, A., & Praitis Hill, K. (2025b). The VIF score: What is it good for? Absolutely nothing. *Organizational Research Methods, 28*(1). https://doi.org/10.1177/10944281231216381

Kementerian Perhubungan Republik Indonesia. (2021). *Peraturan Menteri Perhubungan Nomor PM 17 Tahun 2021 tentang Penyelenggaraan Analisis Dampak Lalu Lintas*. https://peraturan.bpk.go.id/Details/284234/permenhub-no-17-tahun-2021

Kristiawan, T., Putranto, L. S., & Muhammadun, H. (n.d.). *Model tarikan perjalanan fasilitas perkantoran di kawasan rencana Pusat Pemerintahan Kabupaten Serang* [Unpublished manuscript]. Universitas Tarumanagara.

Mohammed, A. A., AlSagheer, M. A., & Almabrouk, B. M. (2025). Developing a trip generation model for South Tripoli using linear regression analysis: A case study of residential travel behaviour. *Comprehensive Journal of Science, 10*(38), 1116–1144. https://doi.org/10.65405/phywk519

Nourmohammadi, F., Rashidi, T. H., & Saberi, M. (2025). Spatial transferability of pedestrian trip generation models. *Transportation Research Part A: Policy and Practice*. https://doi.org/10.1016/j.tra.2025.104618

Ramadhan, R., Fasdarsyah, & Muthmainnah. (2026). Analisis model tarikan transportasi pada zona perkantoran pemerintahan Kabupaten Pidie Jaya. *RekaRacana: Jurnal Teknik Sipil, 12*(2), 150–157. https://doi.org/10.26760/rekaracana.v12i2.150

Reda, A. K., Tavasszy, L., Gebresenbet, G., & Ljungberg, D. (2023). Modelling the effect of spatial determinants on freight (trip) attraction: A spatially autoregressive geographically weighted regression approach. *Research in Transportation Economics, 99*, Article 101296. https://doi.org/10.1016/j.retrec.2023.101296

Saeidian, P. (2024). *Trip production models for persons with disabilities* [Master's thesis, Utah State University]. https://doi.org/10.26076/316d-5e78

Setiawan, A., Wahyudi, H., Putra, A., & Rahayu, S. (2025). Beyond the long-term infrastructure project: Survival analysis on monetary institution and capital city relocation. *Jurnal Ilmu Sosial dan Ilmu Politik, 28*(3), 336–356. https://doi.org/10.22146/jsp.97648

Shahri, M., & Ghannadi, M. A. (2023). Explanatory analyses of work trip generation using mixed geographically weighted regression (MGWR). *ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences, X-4/W1-2022*, 707–714. https://doi.org/10.5194/isprs-annals-X-4-W1-2022-707-2023

Susilo, M., Patunrangi, J., & Ramlan, R. (2026). Pemodelan tarikan pergerakan pada pasar tradisional mingguan di Kota Palu. *Paulus Civil Engineering Journal, 8*(3), 302–311. https://doi.org/10.52722/rvf73p48

Syaban, A. S. N., & Appiah-Opoku, S. (2024). Unveiling the complexities of land use transition in Indonesia's new capital city IKN Nusantara: A multidimensional conflict analysis. *Land, 13*(5), Article 606. https://doi.org/10.3390/land13050606

Syamsuddin, Sufrianto, & Kusuma, E. W. (2026). Analisis tarikan perjalanan pegawai Kantor Gubernur Sulawesi Tenggara. *Sultra Civil Engineering Journal, 7*(1), 720–728. https://jurnal-unsultra.ac.id/index.php/scej/article/view/1486

Tukimun, Soeri, V., & Suharto. (2022). Konsep perencanaan infrastruktur transportasi smart, integrated sustainable & environment friendly di kawasan Ibu Kota Negara (IKN) Nusantara. *Kurva S: Jurnal Keilmuan dan Aplikasi Teknik Sipil, 10*(2), 59–75. http://ejurnal.untag-smd.ac.id/index.php/TEKNIKD

Wu, Y., Qin, Z., & Ma, Z. (2026). A representativeness-privacy-utility evaluation framework for synthetic trip data generation. *Artificial Intelligence for Transportation, 7*, Article 100075. https://doi.org/10.1016/j.ait.2026.100075

Yang, F., Li, L., Ding, F., Tan, H., & Ran, B. (2020). A data-driven approach to trip generation modeling for urban residents and non-local travelers. *Sustainability, 12*(18), Article 7688. https://doi.org/10.3390/su12187688