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Navigating Urban Mobility: The Relationship between Car Consumption and Public Transport Usage in Malaysia

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Abstract: Increasing private-owned cars in Malaysia has, thus far, contributed to growing congestion, environmental pollution, and decreasing public transport utilization. Car ownership has become possible through economic growth, and convenience and status attached to cars triggered tendencies from shifting to public transit. This development contradicts investments in public transport and aggravates environmental problems. This paper examines the relationship between private car ownership and public transport usage in Malaysia from 2000 to 2022, concentrating on intercity bus services, KTM commuters, and light rail transit. The results indicate that with increased riders for intercity buses and KTM commuter services, car usage drops, while that of light rail may raise car ownership. The study emphasizes the need to upgrade intercity and KTM services to mitigate the pressures of car ownership and calls for further research into the role of light rail.
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Keywords: *Car Consumption, Public Transport Usage, Intercity Bus, KTM Commuter, Light Rail Transit (LRT).*

1. Introduction and Background

The rapid rise in private vehicle ownership has had far-reaching implications for the usage of public transport and overall urban mobility in Malaysia. With economic growth, rising income levels have made car ownership more achievable for many people, resulting in a substantial increase in the number of private vehicles on the road. This has resulted in a lot of urban problems such as traffic congestion, environmental degradation, and a steep decline in the use of public transport. Several factors, especially convenience, perceived status, and comfort associated with private car ownership, make them prefer private transport over public transport. It has been researched that when more and more Malaysians choose to travel by private vehicle, the demand for public transport diminishes, worsening traffic congestion and further burdening urban infrastructure. (Md. Aftabuzzaman, 2023). Also, the shift to private cars undercuts the investment in public transport systems. When passengers go down, revenues drop too, making it hard for public transit operators to maintain and upgrade services. This decline in the use of public transport underutilizes services like buses and trains, resulting in financial losses and efficiency losses in operations. Besides, this preference for private cars exacerbates environmental problems, as private vehicles generally emit more per capita than mass transit options. This is more worrisome in urban areas, as the increased vehicular emission is a major source of air pollution problems, thus affecting public health. One of the modes used to try and reduce this trend is making public transport more appealing to people by improving the frequency, reliability, and affordability of service.

Subsidized fares, enhanced connectivity through quality services, integrated transport systems, and other policy measures have thus become the essential ingredients for making this alternative of public transport viable, more effective, efficient, as well as attractive to car owners (Berggren, 2015). In Malaysia, the rising trend in private car ownership poses very serious problems for the country's public transportation system. The more people use private transport, the less public transport there is, aggravated by a host of problems that include traffic congestion, environmental pollution, and even the underutilization of infrastructure for public transportation. Tackling such issues would require a much deeper understanding of how car consumption impacts public transport use and eventually come up with strategies that would induce a shift away from private vehicles to more environmentally friendly transport modes. This paper is structured into the following key sections to comprehensively discuss the effect of car consumption on public transportation systems in Malaysia, comprising intercity public buses, KTM Commuters, and Light Rail Transit. The following section includes a literature review with the formulation of hypotheses relevant to this study. The methodology section explains the research design, data collection, and analytical procedures. Section four presents the analysis results, giving insight into the relationship between the use of private cars and public transport. Finally, the paper shall summarize the findings, their implications, and recommendations for policy and further research.

2. Literature Review

This literature review examines the intricate relationship between the growing reliance on private vehicles and the declining use of public transportation systems. This dynamic is particularly pronounced in urban areas such as Malaysia, where increased car ownership poses significant challenges to public transport systems, traffic congestion, environmental sustainability, and overall urban mobility.

Intercity Bus: It is crucial to analyze how the trends in private vehicle ownership relate to public transit means, especially between cities; for example, intercity buses are more affected. It is well-known that the global increase in automobile ownership, particularly within developing countries has significantly led to reduced use of public transport systems such as intercity buses. According to Newman and Kenworthy (1999), increasing wealth and car availability reduce the need for buses. Thus, the need to travel using roads has greatly changed due to automobiles being more flexible than intercity buses, more comfortable, and even easier to use. Cervero (2003) elaborates how traveling by car allows people to make their choice about going anywhere without many restrictions unlike when they are using public transport like intercity bus services. The demand for intercity bus services has significantly dropped due to the growing accessibility and affordability of cars. As documented by Fravel (2012) and Levinson (2013), an increase in car ownership is associated with a decrease in bus ridership, especially in areas where cars are considered more feasible and appealing modes of transportation.

However, some segments of society like lower-income earners, young travelers, and people without any means of transport still depend on intercity buses. Increased car ownership does not negate their presence on intercity buses according to Mouwen and Rietveld (2013). Li and Zang (2022) investigate how changes in car ownership costs and fuel prices influence the demand for intercity buses. The findings indicate that higher car costs lead to increased bus ridership, highlighting the competitive dynamic between these two modes of transport. A travel mode shift from intercity buses to cars will have far-reaching environmental effects, including more greenhouse gas emissions, traffic jams, and higher land requirements for roads and parking spaces. Chen and Green (2024) investigate the influence of economic conditions on travel choices, finding that increased car ownership costs and fuel prices have led to a rise in intercity bus ridership. Their research highlights how economic pressures make buses a more appealing option for cost-sensitive travelers. According to Banister (2008), intercity bus travel should be sustained and enhanced as an environmentally friendly alternative. In a way, increased car ownership has diminished public bus services which raises concerns about social justice because it has left behind only a few modes of transport for those who are either non-drivers or cannot afford their private vehicles. Accessible public transit is key to promoting social inclusion and mobility equity, Pucher & Buehler (2010). To account for the reduction of bus use due to increased car ownership, different policy interventions have been suggested like bus service subsidies, congestion charges, or investments in public transport infrastructure. Litman (2019) talks about how such measures could encourage a switch back to public transport. Given the growing worries about global climate change and urban traffic congestion, it may be time to relaunch intercity bus services. As Levinson et al. (2013) indicate, these buses could find their rightful place in the market if they underwent modernization through cleaner technologies adoption, improved service quality, and better coordination with other forms of transport.

H1: The relationship between Intercity Bus usage and Car Consumption

KTM Commuter: Understanding the relationship between KTM Berhad's (KTMB) train services and car consumption is crucial in the field of transport studies. By investigating this correlation, it will be easy to know how different rail services can affect the private use of smaller automobiles as far as urbanization mobility theme, environmental friendliness or even economic efficiency comes in. In the end, well-established and operational vehicles such as those operated by KTM can reduce the dependency on their cars drastically. The buses may serve as coordinate transportation means for the transformers that commute from faraway places in case, they want to avoid traffic jams. When there are frequent trains which are very reliable and well interlinked with other modes of transport, it significantly discourages driving. Studies have shown that when there are better quality rail systems then people get rid of their cars; for instance, many people do not possess multiple vehicles if they can access high-quality rail services since it seems like car ownership does not make sense when using trains these days for either long distance or everyday traveling (Wong et al., 2014; Rahman et al., 2021). Long-distance train services can reduce congestion on the roads. This is because if people use trains, they will not have to travel in cars, which means there will be fewer vehicles on the road, thus leading to less traffic and fast traveling. For instance, it has been found that if more people use rail services, this will lead to less congestion and improve urban movement generally. For KTMB (Keretapi Tanah Melayu Berhad), railways are one of the best options for tackling traffic jams on important routes and in city centers (Hussain & Zailani, 2017; Lee & Koo, 2018). There are also numerous other advantages of increased use of trains when it comes to the environment. Compared with private cars, trains emit less per person; that's why they are a more sustainable means of transport. Research indicates that enhancing railway services lowers vehicle emissions and consequently has smaller environmental footprints. Train services can also save money by reducing car usage. Thus, transport authorities can build their rail infrastructure and keep roads in better shape thereby reducing private individuals' spending on repair of their vehicles, fueling them, and paying for their parking spaces (Abdullah, 2019; Lim &Tan, 2023).

The following are suggested ways of maximizing national-wide advantages resulting from railway networks that would affect automobile utilization patterns: Increased frequency and reliability of trains; and integration of the rail network with local bus services. Improving the accessibility of train stations and providing ample parking around strategic railway hubs could facilitate such a shift (Yusof, 2020). Economic factors, including fuel prices, vehicle ownership costs, and the overall economic climate, significantly affect commuter decisions and car consumption. The fluctuations in fuel prices and car ownership costs impact commuting patterns. The rising of fuel prices and higher car maintenance costs have led to a reduction in car usage for commuting, with many individuals opting for public transportation or alternative commuting methods (Chen& Green,2024). Li and Zang (2022) investigate the effects of smart commuting technologies, including real-time traffic management and ride-sharing apps, on car consumption. They find that these technologies can reduce the need for personal vehicle ownership by making alternative commuting options more convenient and efficient.
H2: The relationship between KTM Commuter usage and Car Consumption

Light Rail Transit (LRT): Transportation researchers have been interested in the effects of Light Rail Transit (LRT) systems on car usage. Understanding how light rail transit (LRT) systems influence car usage is important for several reasons. In this regard, contemplating the various impacts of LRT services on the uptake of private cars can enable one to have an insight into urban mobility, environmental issues, as well as economic feasibility. According to Cervero & Duncan (2006), light rail systems possess great potential for creating substantial reductions in vehicle ownership or the increase in both ownership and use of cars. Studies show that effective LRTs eventually reduce car ownership and usage. For example, the largest LRT networks usually correspond to substantial reductions in driving among urban inhabitants who find traveling by bus or train more convenient than using their vehicles (Cervero & Duncan 2006). Moreover, when new LRT lines are formed, a transition from automotive dependence to mass transport dependency is encouraged. The service of LRT (Light Rail Transit) is a choice instead of driving, as it is used in urban areas where LRT connects to all crucial parts such as employment centers and other important destinations (Givoni & Rietveld, 2014). In addition, LRT can decongest roads by providing another means of transport other than cars. To reduce this problem, effective LRT services bring about a lesser number of vehicles thus reducing traffic jams and traveling time.

Scholars have shown that cities having strong LRT systems experience fewer road traffic jams compared to those without such services (Buehler & Pucher, 2012). For instance, the extension of the Portland MAX light rail line not only resulted in a decrease in traffic congestion but also improved movement within the city boundaries. As stated by some recent investigations, current metro systems serve as a practical substitute for individual vehicles hence reducing the use of cars. This leads to a decrease in vehicle miles traveled (VMT) due to LRT and promotes sustainable urban commuting. The presence of these systems in cities has evidenced fewer car trips and less traffic jams (Litman, 2021). The environment is significantly affected by increased LRT use. LRT (Light Rail Transit) produces lower emissions per passenger than private cars hence creating a more sustainable form of transport. Research indicates that by improving LRT services, it is possible to reduce vehicular emissions and the ecological footprint of transportation (Litman 2015). LRT systems are also vital in CO_2 emission reduction especially when they are coupled with smart city infrastructure (Li and Zhang, 2022).

Economically speaking, enhanced LRT services could offer substantial savings in costs. People can save money on vehicle maintenance, fuel, and parking among other things. Likewise, a reduction in car usage leads to the construction and maintenance of roads reducing their wear and tear as such governments will spend less on this (Cervero & Kockelman, 1997). Several strategies can be used to maximize the benefits of LRT systems and their impact on car consumption. Increasing the frequency, reliability, and coverage of LRT service is vital. Integration with other public transport services like buses or bike-sharing can facilitate the shift from cars towards public transport modes. Similarly to this (Cervero, 2013), easy access to LRT stations as well as adequate parking places at main centers could further encourage this move.
H3: The relationship between Light Rail Transit (LRT) usage and Car Consumption

3. Research Methodology

The study uses a quantitative research design to explore the relationship between car consumption and public transport usage, focusing specifically on intercity public buses, KTM commuters, and light rail systems. Data analysis is performed using EViews statistical software. The design incorporates regression and correlational analysis to identify and measure the relationships between the dependent variable (car consumption) and the independent variables (intercity bus usage, KTM Commuters usage, and light rail (LRT) usage.

Conceptual framework: The conceptual framework for a study entitled "Navigating Urban Mobility: The Relationship between Car Consumption and Public Transport Usage in Malaysia" has three variables representing various relationships concerning public transport and car consumption. A conceptual structure synthesizes correlated parts and variables that assist in remedying real-life issues. It is the last lens used to see through the deductive resolution of a known problem (Imenda, 2014). The starting point in developing a conceptual framework is a deduction that there exists a problem and this can necessitate some processes, procedures, functional approaches, models, or theories for solving it (Zackoff et al., 2019). Intercity bus usage, KTM (Keretapi Tanah Melayu) commuter usage, and Light Rail usage as independent variables are presented in Figure 1. These are different types of public transportation that are thought to impact the dependent variable, Car Consumption. The framework suggests that increased use of intercity bus usage, KTM usage, and light rail usage can potentially help to lower car consumption levels. The arrows within the framework indicate expected cause-and-effect relationships whereby increasing options for public transport will reduce car consumption.

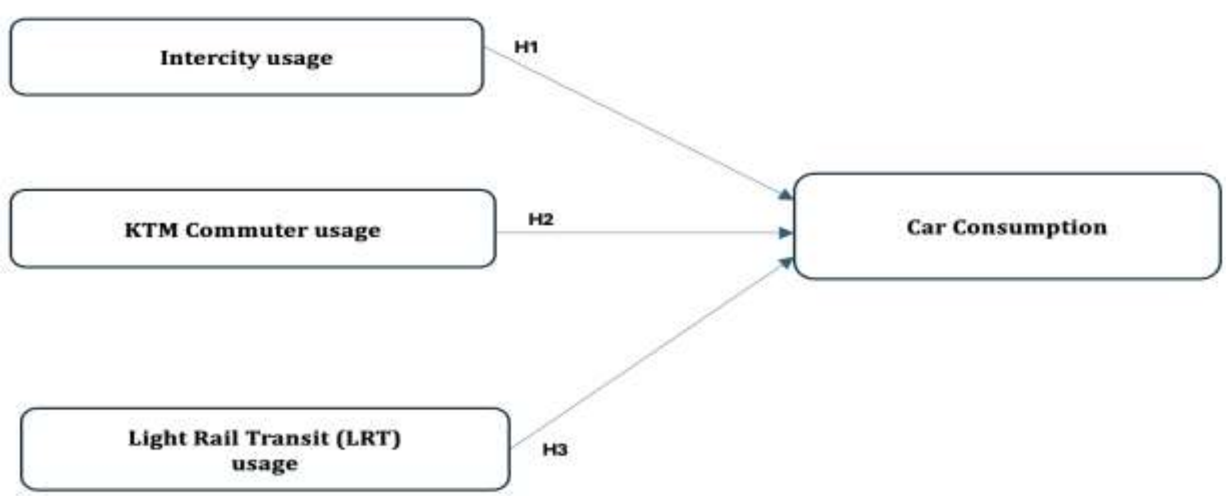


Figure 1: Conceptual framework

Data collection and tabulation: The data for this study is the secondary data obtained from the Ministry of Economy's website. This study observed 23 years of car consumption and the other three public transport (Intercity bus, KTM Commuter, and Light Rail) usage in Malaysia from 2000 until 2022. Table 1 displays the dependent variable and the independent variables. This study uses a regression model to quantify the impact of car consumption on public transport usage. This analysis can help determine whether increased car ownership correlates with decreased public transport use (Mokhtarian & Cao, 2008). Since the raw data of all variables are not in the same unit, hence all the data need to be put "ln" to make sure all the values are close to each other and easy to calculate then generate the results.

Descriptive analysis: Also known as descriptive analytics or descriptive statistics, is the process of using statistical techniques to describe or summarize a set of data. It also helps to describe, or usefully illustrate data points for patterns to develop that meet all the data's requirements. It is the process of using both recent and old data to find trends and relationships. It is often called the most basic data analysis since it identifies trends and relationships without going any further (Villegas, 2024). Descriptive analysis is usually used to measure the frequency, tendency (mean, median, and mode), dispersion or variation (range, variance, and standard deviation), and to find out the data's normality (skewness, and kurtosis). In this study, a descriptive analysis will be used to analyze the secondary data obtained, calculating its tendency, and dispersion and determine whether the data is normal or not by looking at the results of skewness and kurtosis. There will be some visual representations using a few suitable charts that can help in understanding the data better. Other than that, one of the key components of descriptive analysis, the correlation matrix is being explored in this study. A correlation matrix is particularly used when examining the relationships between multiple variables. It is a table that displays the correlation coefficients between pairs of variables, providing a quantitative measure of the strength and direction of their relationships. Each cell in the correlation matrix represents the correlation coefficient between two variables, which ranges from -1 to 1. A value close to 1 indicates a strong positive correlation, meaning that as one variable increases, the other variable also tends to increase. Conversely, a value close to -1 indicates a strong negative correlation, meaning that as one variable increases, the other tends to decrease. A value around 0 suggests no significant linear relationship between the variables. During the on the role of public transport consumption in increasing public transport, a correlation matrix can help identify the relationships between different public transport options (intercity bus, KTM, and light rail) and car consumption. For example, if the correlation coefficient between light rail usage and car consumption is strongly negative, it suggests that increased use of light rail is associated with a reduction in car usage.

Multiple linear regression: Multiple Linear Regression (MLS) involves analyzing two or more independent variables in cases where only one dependent variable is used. As articulated by Berger, J. (2008), multiple regression is an adaptable technique for analyzing data that could be useful whenever a quantitative variable needs to be compared to any other element. One can investigate the impacts of one or more variables, with or without the effects of other factors taken into consideration, and relationships can be nonlinear. Independent variables can either be quantitative or qualitative. One crucial step when conducting the MLS analysis is to test the independent and dependent variables for their assumptions. Statistic Solution (2011) explains that five assumptions must be considered: firstly, there must be a linear relationship between the independent and dependent variables. Secondly, the residuals (the difference between observed values and actual values) are normally distributed. Thirdly, the independent variables must not influence one another, otherwise known as multicollinearity. The fourth assumption is that observations must be independent of one another; any observations resulting from a delayed function of previous observations are hints of autocorrelation. The final assumption is that the variance of the residuals must be consistent across all independent variables. A residual scatterplot that shows a discernible pattern may suggest the presence of heteroscedasticity. After all the assumptions are met, the variables are then inserted into the MLS model. The following model is based on the research paper from Uyanık and Güler (2013):

$$Yi = \beta 0 + \beta 1X1 + \beta 2X2 + \cdots + \beta nXn + ei \quad (1)$$

Where:
Yi: Dependent variable
Xn: Independent variable
βn: Parameter to be estimated (slope coefficients)
β0: Constant value (y-intercept)
ei: Model's error term
n: Number of variables

In the context of this research, the model is as follows:

$$Yi = \beta 0 + \beta 1X1 + \beta 2X2 + \beta 2X2 + \beta 3X3 + \beta 4X4 + ei \qquad (2)$$

Where:
Yi: Car consumption
$X1$: Intercity
$X2$: KTM
$X3$: Light rail
β0: Constant value (y-intercept)
ei: Model's error term

Econometric analysis: The third phase of the research methodology involves econometric analysis, which is a crucial component of this study. This phase works in conjunction with the descriptive analysis and correlation matrix conducted in the earlier stages. This analysis aims to discern the relationships among the independent variables; Intercity bus usage, KTM Commuter usage, and Light Rail usage and to pinpoint the most significant factor contributing to car consumption in Malaysia. By employing econometric models, the study can quantify these relationships and assess their impact on public transport usage. In this phase, the study tests three hypotheses related to car consumption and its relationship with different modes of transportation: Intercity bus usage, KTM Commuter usage, and Light Rail usage.

Hypothesis 1:
H0: There is no significant relationship between intercity bus usage and car consumption.
H1: There is a significant relationship between intercity bus usage and car consumption.

Hypothesis 2:
H0: There is no significant relationship between KTM Commuter usage and car consumption.
H1: There is a significant relationship between KTM Commuter usage and car consumption.

Hypothesis 3:
H0: There is no significant relationship between light rail usage and car consumption.
H1: There is a significant relationship between light rail usage and car consumption.

In each case, a statistical test will be conducted to determine whether to accept the null hypothesis or the alternative hypothesis. The choice between the two will depend on the p-value obtained from the test. If the p-value is less than a predetermined significance level (often 0.05), the null hypothesis is rejected in favor of the alternative hypothesis. Conversely, if the p-value is greater than the significance level, there is not enough evidence to reject the null hypothesis. The variables used in the model to study the factors relationship between car consumption and Intercity Bus Ridership, KTM Commuter Ridership, and Light Rail Ridership usage as per economic theories. Hence, we combine these factors into a multiple linear regression model, represented by the equation:

$$CC = f\,(I, KTM, LR)$$

$$lnCC = \beta_0 + \beta_1 ln\,(I) + \beta_2 ln\,(KTM) + \beta_3 ln\,(LR) + \varepsilon \quad [3]$$

Where:

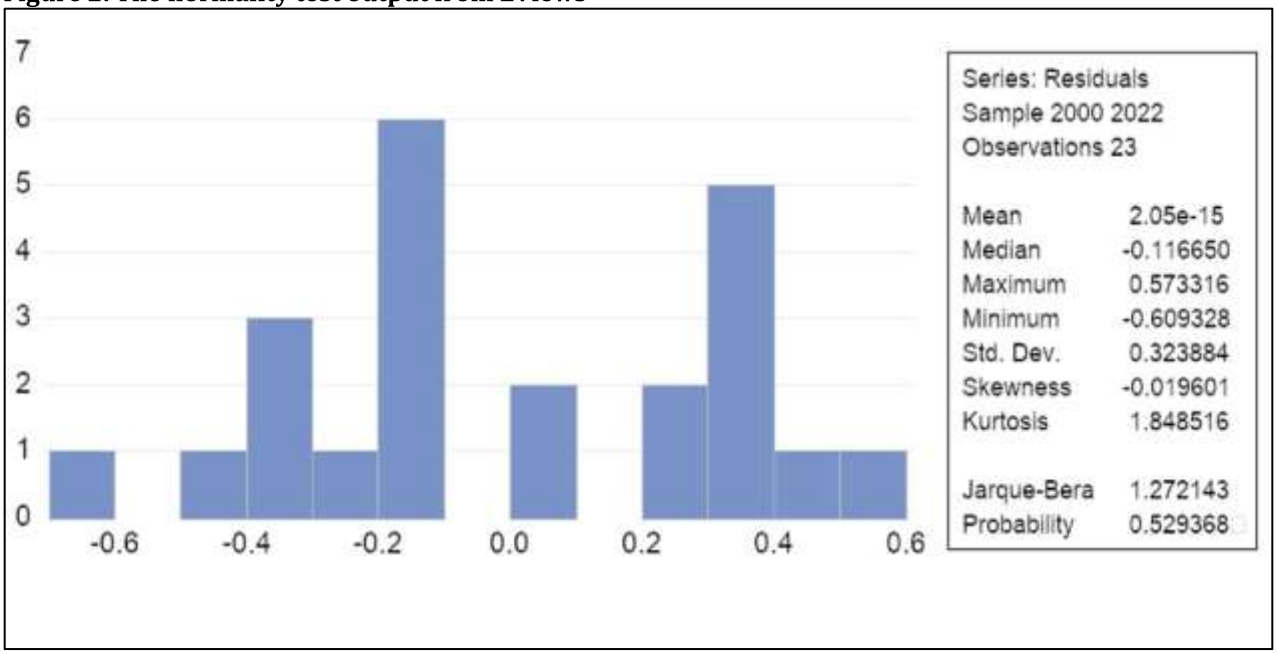
Ln (CC)	= log Car Consumption
β_0	= constant term
$\beta_1\beta_2\beta_3\beta_4$	= coefficient of independent variables
Ln (I)	= Log Intercity
Ln (KTM)	= Log KTM
Ln (LR)	= Log light rail
ε	= Error terms

4. Results

In this section, there is a detailed exploration of the results obtained from a series of tests conducted on the collected data. These tests were designed in alignment with the stated hypothesis. The results are described in detail, providing a comprehensive analysis of the outcomes derived from various studies. EViews, a statistical software, was utilized to determine the relationship between the independent and dependent variables. This approach ensures a thorough and objective examination of the data.

Descriptive analysis: The Jarque-Bera test is used in this study to confirm if the residuals of the regression model comply with the assumption of normality. The test assesses the skewness and kurtosis of the residuals, serving as a statistical measure of whether the distribution diverges from normality. A small p-value from the Jarque-Bera test indicates a departure from normality, while a larger p-value implies that the residuals might follow a normal distribution. The analysis of the residuals reveals that the mean is nearly zero, indicating that the predictions from the model are unbiased. Jarque-Bera statistic is used to test whether the data has skewness and kurtosis matching a normal distribution. Here, the Jarque-Bera statistic is 1.27, and the associated probability is 0.53. Since the probability is more than the p-value 0.05, we fail to reject the null hypothesis in which the residuals are normally distributed. Besides, a skewness of -0.02 is very close to zero, which means that the data is almost symmetric. Meanwhile, a kurtosis of 1.85 is less than 3 means that the distribution has lighter tails and a flatter peak than the normal distribution. (see figure 2)

Figure 2: The normality test output from EViews



Correlation Matrix: Table 1 explains the correlation matrix for Ln (Car Consumption), Ln Intercity, Ln KTM, and Ln Light Rail reveals that Ln (Car Consumption) negatively correlates with all public transport variables, with coefficients of -0.6026 with Ln Intercity, -0.5561 with Ln KTM, and -0.3298 with Ln Light Rail, indicating that higher car consumption is linked to lower use of these transport modes. Conversely, Ln Intercity and Ln Light Rail show a strong positive correlation of 0.9018, suggesting that increases in one are closely associated with increases in the other. Similarly, Ln KTM exhibits high positive correlations with Ln Intercity (0.8127) and Ln Light Rail (0.8763), indicating robust relationships between these public transport modes.

Table 1: Correlation Matrix

	Ln (Cars Consumption)	Ln Intercity	Ln KTM	Ln Light Rail
Ln (Cars Consumption)	1			
Ln Intercity	-0.602613716	1		
Ln KTM	-0.556107913	0.812706275	1	
Ln Light Rail	-0.329801987	0.901784264	0.876255398	1

Multiple linear regression: A multiple linear regression analysis was conducted to investigate the relationship between car consumption and several independent variables, including intercity (I), KTM Commuter (KTM) and light rail (LR). The results show that the independent variables in this case study, particularly the LR (light rail) might have a positive correlation with CC (car consumption). In contrast, there is a negative relationship between I (intercity) and KTM Commuter with CC (car consumption). The study will include an in-depth discussion of the constant terms related to each independent variable.

Interpretation of each coefficient based on the given values: The results explain that (see Table 2) a 1 percent increase in Intercity services results in a significant 95.07 percent decrease in car consumption, highlighting a strong inverse relationship between Intercity services and car use. This suggests that expanding Intercity bus services effectively reduces reliance on private vehicles. In contrast, a 1 percent increase in KTM services leads to a 50.74 percent decrease in car consumption, indicating a moderate inverse relationship. Although KTM services also reduce car usage, their impact is less dramatic than that of Intercity services. Conversely, a 1 percent increase in Light Rail services is associated with a 111.66 percent increase in car consumption, revealing a positive correlation. This unexpected result suggests that Light Rail services might be less effective at reducing car use or that increased Light Rail services might correlate with higher overall travel demand, including greater car use.

R-squared and adjusted r-squared:

R^2 = 0.604822

Based on the value of R-squared, approximately 60.48% of the variation in Car Consumption can be explained by the changes in Intercity bus, KTM, and Light Rail and the balance 39.52% can be explained by other factors.

$Adjusted\ R^2$ = 0.542426

Based on the value of Adjusted R-squared, approximately 54.24% of the variation in Car Consumption can be explained by the changes in Intercity bus, KTM and Light Rail and the balance 45.76% can be explained by other factors.

T-test for intercity: Using the t-test result as a basis, the Intercity t-test probability is lower than the 5% level of significance. Therefore, we discard H_0, meaning that there is an important link between Intercity bus and Car Consumption. Urbanization is the process by which a greater proportion of the population moves to live in cities, leading to an increase in the size and growth rate of urban areas. This phenomenon influences commuting patterns heavily, as it often leads to more dispersed work and living environments. Cities expand into suburbs and exurbs thereby making people cover longer distances between homes and places of work. For many people, commuting has become an essential daily activity due to the complexity and scale involved in an urban environment. Public transport systems do not always meet the demands of rapidly growing urban populations resulting in increased travel durations, crowded services, and bad schedule timings. Hence reliable, flexible, and convenient transport options for commuting have become very important now more than ever before. Often this gap might be filled by private cars whose owners can go about their business at will on time and route-wise.

T-test for KTM: The result of the t-test shows that the probability t-test for KTM is less than a 5% significance level. As such, we reject H_0, which means that there is a significant relationship between KTM commuter and Car Consumption. The influence of commuter preferences on the relationship between KTM commuter and car consumption is striking. Many commuters opt for KTM services since they are convenient, affordable, and reliable at the same time. It is on these grounds; that it is common in urban areas where people face traffic jams every day. In other words, on congested roads with more deliveries ahead, timely arrival or call ahead can help decrease the number of vehicles by allowing rapid transit trains like KTM to stop at every station without worrying about costs because they have been paid for all passengers through their tickets before arriving at any station along its route from different terminals. To drive through such busy streets using personal cars would surely be so stressful for anybody living there for years since everyone knows how miserable it becomes during peak hours. Therefore, a decrease in transportation can also help the environment as well as make it easier for people to take their trains instead of purchasing tickets beforehand.

T-test for light rail: Grasping from the t-test statistic, the probability t-test for Light Rail is below a 5% significance level. Thus, we reject H_0, meaning there is a strong association between Light Rail and Car Consumption. An increase in both car consumption and light rail train usage can arise due to factors like urban expansion, where growing populations increase the need for various transportation systems, economic factors such as rising incomes that promote car and bus use at the same time as low fuel prices that also encourage their consumption. Integrated modes of transport could also lead to an increase in the use of both when people drive to light rail stations. Besides, traffic congestion may cause people to utilize public transport while events or tourism can be seen to stimulate simultaneously car rentals and train' use. Finally, changing travel preferences and awareness of environmental issues may lead individuals to use cars or trains depending on the situation hence contributing to their simultaneous rise.

F-test: A statistical hypothesis testing test statistic known as the F-statistic is utilized to evaluate the level to which various models are a good match for the data. For the aim of putting the hypothesis of the population mean vector to the test, the F-statistic is utilized as a generalized test statistic. To demonstrate that the estimation model is significant for at least one independent variable, the statistical significance level for this test has been set at 5%. This level of significance indicates that the test is statistically significant. The following is the process of assessing the hypothesis using the F-test on our estimation model:

$$H_0 = \beta_1 = \beta_2 = \beta_3 = 0$$
$$H_1 = At\ least\ one\ \beta_n\ not\ equal\ to\ 0$$

The p-value of the F-test for our estimation equation is 0.00428, which is less than the significance level of α = 0.05. Therefore, we reject the null hypothesis and conclude that the model is valid, as at least one independent variable is significant in predicting car consumption in Malaysia. Consequently, car consumption, our dependent variable, can be explained by the intercity bus, KTM Commuter, and light rail in Malaysia from 2000 to 2022.

Econometric analysis: The analysis of econometrics shown in Table 2 below from the regression results provides a comprehensive understanding of the impact of different public transport modes on car consumption. The coefficient for LN_INTERCITY is -0.950769, with a standard error of 0.232740, a t-statistic of -4.085111, and a p-value of 0.0006. This negative coefficient indicates that a 1% increase in intercity public transport usage is associated with a 0.951% decrease in car consumption, a statistically significant relationship given the low p-value. Similarly, the coefficient for LN_KTM is -0.507395, with a standard error of 0.188489, a t- statistic of -2.691912, and a p-value of 0.0144. This result suggests that a 1% increase in KTM Commuter usage leads to a 0.507% decrease in car consumption. This relationship is also statistically significant, indicating that increased usage of KTM services effectively reduces car consumption. In contrast, the coefficient for LN_LIGHT_RAIL is 1.116603, with a standard error of 0.328859, a t-statistic of 3.395309, and a p-value of 0.0030. This positive coefficient indicates that a 1% increase in light rail usage is associated with a 1.117% increase in car consumption, a statistically significant relationship. This result suggests that, in this context, light rail systems may not be as effective in reducing car usage, possibly due to factors such as limited coverage or accessibility issues. The model's R-squared value is 0.604822, indicating that approximately 60.48% of the variation in car consumption can be explained by all independent variables in the equation. Another 39.52% cannot influence the change in car consumption due to missing independent variables (factors) that are not included in the model. The model has a very high explanatory power as the R^2 is more than 50%. The adjusted R-squared value is 0.542426, which accounts for the number of predictors in the model and suggests substantial explanatory power. The F- statistic of 9.693212, with a p-value of 0.000428, indicates that the overall model is statistically significant, meaning that the independent variables collectively have a significant impact on car consumption.

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Table 2: Results of Multiple Linear Regression by Using EViews

Dependent Variables: LN_CARS_CONSUMPTION_
Method: Least Squares
Date: 07/15/24. Time: 01.15
Included observations: 23

Variable	**Coefficient**	**Std. Error**	**t-statistic**	**Prob.**
LN_INTERCITY	-0.950769	0.232740	-4.085111	0.0006
LN_KTM	-0.507395	0.188489	-2.691912	0.0144
LN_LIGH_RAIL	1.116603	0.328859	3.395389	0.0030
C	9.355662	1.284142	7.285533	0.0000
R-squared	0.604822	**Mean dependent var**		11.62344
Adjusted R-squared	0.542426	**S.D dependent var**		0.515220
S.E. of Regression	0.348517	**Akaike info creation**		0.886511
Sum squared resid	2.307816	**Schwarz criterion**		1.083988
Log-likelihood	-6.194874	**Hannan-Quinn criteria.**		0.936176
F-statistic	9.693212	**Durbin-Watson stat**		0.673236
Prob(F-statistic)	0.000428			

Discussion

The regression analysis reveals that increasing intercity bus usage and KTM Commuter usage drastically decreases car consumption. More specifically, a 1% increase in intercity transport usage corresponds to a 0.951% decrease in car consumption, and a 1% increase in KTM Commuter corresponds to a 0.507% decrease. The relationships are statistically significant with p-values of 0.0006 and 0.0144, respectively. Results suggest that these modes of transport all make useful contributions to reducing car use and can contribute to the alleviation of urban traffic congestion. Light rail use, however, is associated with a car consumption increase of 1.117%, suggesting that light rail may not be so useful in reducing car use, perhaps because of low coverage or accessibility. The R-squared value is 0.604822, indicating that the independent variables explain approximately 60.48% of the variation in car consumption. This indicates high explanatory power, which is confirmed by an Adjusted R-squared of 0.542426 with an F-statistic of 9.693212 and a p-value of 0.000428. Overall, there is very great potential for both intercity and KTM services in reducing car consumption, but further study of light rail systems needs to be conducted.

5. Managerial Implications and Recommendations

In the regression analysis, it is seen that intercity and KTM Commuter usage significantly decrease car consumption; this proves to be efficient in reducing personal vehicle use. Light rail use is positively related to car consumption, which may be due to limited coverage or poor connectivity. Therefore, if managers are to have the best impact on car use, they should first focus on the expansion and integration of intercity and KTM services and secondly review and improve light rail coverage and connectivity. Further research is required to determine the factors that affect the effectiveness of light rail and to find other variables influencing car consumption. When analyzing the connection between car usage and public transport in urban settings, quantitative methods typically suggest an inverse relationship. These approaches often assume that public transport is universally accessible, and that income level is the main factor influencing its use. However, these assumptions oversimplify complex behaviors, as individuals may choose between transport options based on their specific situations, and access to public transport can vary widely. Moreover, these models tend to assume that preferences are rational and remain consistent over time, overlooking emotional or habitual factors. The next study by the researcher should consider variations in infrastructure, behavioral and socioeconomic factors, and temporal changes, and complement quantitative data with qualitative insights.

In addition, several promotional and incentive policies can be carried out to increase the use of public transport for a better shift away from dependency on cars. Managers should focus on the following things to maximize the reduction in car consumption: First, they should improve the coverage, frequency, and reliability of the intercity and KTM services so that they are much better than driving. Second, light rail systems will have more power to reduce car use if their limitations are addressed. This can be further explored to identify the underlying issues with light rail services and increased car consumption. With the explanation power of 60.48% of the model, managers can exploit other causative factors to car consumption like urban planning and socio-economic conditions. Incentives aimed at the use of all forms of public transport will still be necessary to attract people away from cars and into more sustainable forms of transportation. Also, integrating different means of transport such as park-and-ride facilities can help in making transitions smoother between modes. Sustainability is supported by leveraging technology for real-time tracking and data-driven route optimization as well as investing in green emission transport. Additionally, awareness campaigns, workplace programs, and better urban design that favors walking or cycling would also encourage people to use public transport instead of traveling in their cars.

Conclusion

In terms of car consumption against public transport usage, some important lessons in urban mobility are thrown out. Generally, when there was more increase in the number of public transportation facilities, like Intercity bus and KTM services, car consumption decreased. The well-developed public transport system, easily available, reduces dependence on private vehicles and thus helps in lessening traffic congestion. This contributes to environmental sustainability. Conversely, a different effect pattern was found for Light Rail services, whose increase showed an increase in car consumption. The evidence here is that Light Rail does not always effectively reduce car use or, indeed, that its expansion can be linked to increased overall travel demand—including car use. These findings underline the need to enhance public transport systems to encourage a shift from private vehicle use. Strategies should be focused on the improvement of the quality, accessibility, and integration of public transport, in a way that creates a more balanced and sustainable urban mobility environment.

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