Forecasting Private Vehicle Ownership and Its Effect to Public Transportation Planning in Banda Aceh, Indonesia

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Abstract. This paper analyses trends in private vehicle ownership in developing countries, namely in Indonesia. In the last few years private vehicle ownership has increased very sharply in line with economic growth, rapid urbanization growth, significant population growth and ineffective and efficient transportation system services. In 2011, Indonesia's population had reached more than 240 million people, more than 17 million private vehicles and more than 11 million drivers. As usual, income has become a major factor influencing private vehicle ownership. However, population growth also affects ownership of the number of private vehicles. Besides other factors such as government policies, vehicle financing, household characteristics and travel behaviour. Therefore this paper tries to analyse the level of income and the level of population growth and also other factors that affect vehicle ownership in Indonesia, especially in the western part of Indonesia, the city of Banda Aceh. The city of Banda Aceh is located in the westernmost region of the archipelago, a city that is growing after the earthquake and Tsunami. Banda Aceh city has population more than 223,446 in 2010 and increase 10 per cent for the last five years. Private vehicle mode ownership is related to negative impact as well as congestions, accidents, unavailability of parking lots, noise, health problem, pollutions and other problem. Seeing the many negative effects of increasing the number of private vehicle ownership so that it becomes an arduous task for policy makers. The results of the study show that there is a strong relationship between income growth and population growth with the level of private vehicle ownership.

1. Introduction

Today, in many developing countries, vehicle growth has been getting higher and higher, until the end of this decade, in line with the rapid economic growth [1]. In previous research projects that have been done that is sustainable mobility project (World Business Council for Sustainable Development) projected that within five years there will be a surge in vehicle significantly, especially as the state of India, China, Vietnam, Brazil, Pakistan and others.

At the same time, in Indonesia the Central Statistics Agency or BPS stated that the sum of motorized modes in 2019 reached 114,209,266 units consisting of 12,599,138 passenger cars, 2,398,846 buses, 6,235,136 freight cars, and 92,976,240 motorcycles.

If the inhabitant of Indonesia in 2014 was 254.9 million (Sensus 2014), the choice of motorized vehicles mode in Indonesia achieved more than around 450 vehicles each 1.000 people. A sum of these modes is a distinct problem associated to sustainable transportation. A large number of uses of
private modes by residents can cause congestion, accidents, reduce productivity, noise, health problems, anxiety disorders, air pollution and also other environmental problems. Increased congestion and reduce the speed of the vehicle which is very influential on vehicle movement. Along with increasing private vehicle ownership can lead to considerable travel demand and will require more capacity and road networks as well.

The increasing of ownership motorized vehicles or private mode will definitely affect and bring economic growth to the country. Economic growth in Indonesia, among year 2000 to 2004, economic recovery happened with an average growth of Gross Domestic Product (GDP) at 4.6% each year [2]. Thereafter, GDP growth accelerated (with the exception of 2009, in consequence of the condition global financial crisis and lack of condition, Indonesia's GDP growth fell down to 4.6%, a figure that is still amazing) and peaked at 6.5% in year 2011. However, after the year 2011 the development of the Indonesian economy began to decline seriously. Among the year 2011 to 2015 Indonesia's economic growth steady. When appealed with the growth of motorized vehicles, it can be deduced while the growth rate of high motorized vehicles mode at the end of these ten years actually has an effect on slowdown of Gross Domestic Product or GDP.

By looking at the history and trends of the high rate of growth of personal vehicle modes and the effects that will emerge as a result, conducting a study on this issue is very important and urgent to assess the extent of the effect of ownership of motor modes (private vehicles) on the development and economic growth in the region or otherwise. A few of prior studies have tried to estimate a model to forecast and predict the growth of motorized vehicles mode, which of the results can be adopted as a good guidance for transportation planning. Development of motorized vehicles mode from different countries, mostly emerging states, was concluded following the S curve [3]. In several countries, studies on the relationship model of motor vehicle growth with socioeconomic as independent or exogenous variables and also other variables as well as vehicle type, etc. have also been widely studied [4]. In other developing countries such as countries in the Latin American continent, a relationship model has been made to foresee growth in vehicle ownership (motorbikes and passenger cars) by considering the level of income of the population. Where the level of increasing in individual income is closely related to the number of levels vehicle ownership [5]. In the world’s leading economic growth pioneers such as India, China with very rapid economic growth which has a very high per capita income (GDP) followed by a very high number of vehicle ownership [6]. From several published research studies it can be concluded there is a very tough association among vehicle growth and socioeconomic variables, especially per capita income (GDP).

Given the importance of forecasting the development of motorized vehicles mode, this paper purpose will examine the association among the expansion of private vehicles and economic growth by the primary indicator of GDP per capita. In this part of the study the researcher tried to take the place of study in the city of Banda Aceh because in this city the trend of vehicle growth tends to increase. To maintain the growth of transportation in cities that are environmentally friendly and also sustainable, it is highly recommended to use public transportation such as Bus, BRT, LRT, MRT and other public transportation which are more effective and efficient. This is very strongly recommended by transportation experts in the world to realize a better transportation system.

2. Data and Methodology
The methodology for the estimation of the parameters and for the forecast of car ownership adopts a simple linear regression pattern. A model was assessed using cross section time-series data on vehicle ownership in Banda Aceh city and makes up of population growth, private vehicle ownership as well as economic progress by instrument of gross regional product (GRP).

The analysis reaches out since the start of the 1990s until the now. We were enforced by the lack of the studies in the field of urban transportation planning in Banda Aceh and were restricted to data from
the authority Indonesia Statistic Board or BPS. The next two paragraphs will present the data and theoretical framework for the methodology constituting the core of this research.

2.1. Study Area Description
Banda Aceh city is posited in the western Indonesia and was founded in 814 years ago with an area region of 61, 36 km2 (2,369 sq. mi). This city is one of the oldest cities in Indonesia. The 2017 domestic population census appraised total population to be approximately 238.814 and with density population 3.892/km2 (10,080/sq. mi).

![Figure 1. Map of Banda Aceh indicating road networks and urban development](image)

2.2. Growth of private vehicle in Indonesia
Over the last 25 years, the number of private vehicle in Indonesia has been increasing from 1.54 million in 1990 to 5.92 million in 2014. If such trends continue, Indonesia will face increased energy consumption, traffic congestion and pressure on the hinterlands of expanding urban areas. The national car ownership level – 200 vehicles/1000 inhabitants in 2014 – is still below.

Compared to the average car ownership level in the developed countries. While there has been a general increase in motorization rate for Indonesia as a whole (see motorization evolution – Figure 2), there are considerable differences in ownership at a more regional and local level. The goal of the research is to predict and apply the model to generate forecasts across Indonesia’s counties, by taking into account evolution of population, gross regional product and historical car ownership data. Indonesia is divided into 34 province areas.

In order to have a more consistent database, we obtained values of the missing data by means of regression analysis for each of counties. On a national scale, the maximum level of car ownership is reached in the capital city, rising from approximate 100 cars / 1000 inhabitants at the beginning of the 1990s to more than 430 cars/ 1000 inhabitants in 2014.

![Figure 2. GDP summary statistics Indonesia (World Bank)](image)
The maximum level is represented by GRP per capita in Banda Aceh, which is nowadays higher than the other city in the province, contributing to almost 25% to Aceh Province’s gross domestic product (GDP). The next section lays out the theoretical framework for the methodology that was established to achieve current research objectives.

2.3. *Ordinary Least Square (OLS) approach for Modeling Vehicle Ownership Estimations*
The rate of increasing vehicle ownership in emerging countries is notably boost by potential market demand; this intends that a growing in vehicle ownership is tightly associated to the stage of consumer wealth and motivation for buying [6]. The variable income almost better reflect aggregate potential demand.

Consequently, researchers and scientist could use income per capita as an economic factor in regression functions in emerging states. The Ordinary Least Square (OLS) function is widely adopted to estimate associations among private vehicle mode ownership and economic factors. The association of growing motor vehicle ownership per 1,000 people was estimated by the Ordinary Least Square (OLS) for modeling vehicle ownership predictions. The data was analyzed and regression model estimated by adopted statistical software SPSS IBM version 25.

3. Result and Discussion

In this study using the regression method is the method of multiple linear regression equations. Where to use the income and population growth attributes as independent variables or exogenous variables (X\(_1\) and X\(_2\)). Using vehicle ownership parameters as the dependent variable or endogenous variable (Y). This study was conducted to predict the impact of income and population variables on the level of vehicle ownership.

The results of the analysis can be seen as in Table 1, namely Analysis of variance, Table 2 is the value of coefficient and Table 3 is the Summary Model. The regression results can be seen in the following equation.

\[
Y = 12.237 + 0.510(X_1) + 0.798(X_2) \quad (a)
\]

Where:
- \(Y\) = Car ownership
- \(X_1\) = Income growth
- \(X_2\) = Population growth

The coefficient value of the independent income variable (X1) is positive and the coefficient value of the independent variable is positive, which means that the independent variable has a positive effect on the dependent variable (Y) or vehicle ownership. And the higher the amount of income and population increases, the higher the number of vehicle ownership.

The coefficient value of the income variable is 0.51 and the coefficient value of the population growth variable is 0.79. Which means that if the number of vehicle ownership goes up by one unit, the income variable will rise by 0.51 assuming the value of the population variable is fixed or unchanged. If vehicle ownership goes up by one unit, then the population variable goes up by 0.79 assuming a fixed income variable. The table of Analysis of variance can be seen as in the table below.

| Model      | Sum of Squares | df | Mean Square | F     | Sig.   |
|------------|----------------|----|-------------|-------|--------|
| Regression | 1026.840       | 3  | 342.280     | 3.40  | 0.000* |
| Residual   | 431.841        | 495| 0.872       |       |        |
| Total      | 1458.681       | 498|             |       |        |
Table 2. Coefficients

| Model | Unstandardized Coefficients | Standardized Coefficients | t       | Sig. |
|-------|-----------------------------|---------------------------|---------|------|
|       | B                           | Std. Error                | Beta    | t    | Sig. |
| 1     | 12.237                      | 1.479                     | 0.798   | 8.962| 0.000|
|       | 0.798                       | 0.058                     | 0.000   | 14.600| 0.000|
|       | 0.000                       | 0.052                     | 0.000   | 0.008| 0.994|
|       | 0.510                       | 0.064                     | 0.227   | 8.118| 0.000|

From the summary table can be predicted based on the value of F that simultaneously the independent variables together affect the dependent variable. Or in other words that joint ownership of a vehicle is influenced by income and population. The value of R square is 70% which states that the model displays goodness of fit.

Table 3. Model Summary

| Model | R     | R Square | Adjusted R Square | Std. Error of the Estimate |
|-------|-------|----------|-------------------|---------------------------|
| 1     | 0.893 | 0.704    | 0.702             | 0.934                     |

4. Conclusion

This research was conducted to evaluate the effect of income and vehicle ownership on the demand for the number of trips in one of the developing cities in the western part of Indonesia, the city of Banda Aceh. Where during the state of society is highly dependent on private vehicles. This study uses a questionnaire survey data. The study was conducted to provide a means of transport that effectively and efficiently in the present and future. The results of this study revealed that some of the following:

- The level of income of the population and the level of vehicle ownership are very likely to influence the demand for travel in a city
- A positive value on the regression equation states that the higher the level of income and ownership of the vehicle, the higher the level of demand for travel
- Nevertheless, the trip is expected to increase by 8.4 units when car ownership goes up by 1 unit.
- The coefficient expressed that the car ownership had a higher effect on trip than income.

The investments and government spending on public facility of transportation, especially BRT and railways for example; metro line and elevated rails, is allowed to contribute for reducing any kinds of externalities like congestion, emissions, and so accidents. As have already examined, adopt from vehicle global warming emission standards and incentives for purchasing transportation modes that generate less carbon dioxide or CO₂ per mile will certainly assist in creating urban is more resilient and sustainable. Qualify strain should be paid on incorporating sustainable transport planning with urban planning of new cities, and by fixed land use and investigating the connection among spatial development and transport.

In area of the city, some of the people consider the car and public transport both are best transport choices. Beside of them draw a comparison among car and public transport concerning travel fare, travel duration and so on, and choice the best option. In some of areas, travelers do not have a poor reflection of the public transport, regardless of their like or dislike of the vehicle. To reduce and eliminate the effects of transportation activities, such as congestion, accidents, air pollution, noise, respiratory problems, anxiety disorders, and other health problems, the government or policymakers
have issued several policies that can overcome this problem. Mainly, how the government and policymakers together, in this case, promote the use of public transportation, especially in the city center because it is considered public transportation can provide benefits such as time savings, healthier, environmentally friendly and lower operational costs compared to private vehicles. So that the transfer of mode from private mode to public mode can be accomplished. Nevertheless, appropriate implement of city planning, environment and transport policies is vital for minimizing emission which frequently often induces to health and environment disadvantages. More of research stressed that transportation planning must be promoted in relation with the land use development plans and it is a necessary of sustainable transportation while keep in mind the defiance headed by Indonesia transportation area. It is recommended that there is public controversy over city development and transportation sustainability in the rapid growing urban of Indonesia. This extra research is required to realize the traffic and transportation scenario now day and assess transformation in city transport policies.

Acknowledgements
Authors are thankful to Universitas Syiah Kuala for support and sponsorship the publication.

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