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Research article

Spatial econometric analysis of automobile and motorcycle traffic on Indonesian national roads and its socio-economic determinants: Is it local or beyond city boundaries?

Firman Permana Wandani^a, Maimunah Siti^b, Masashi Yamamoto^c, Yuichiro Yoshida^{d,*}

^a Ministry of Public Works, Jl. Pattimura No.20, Bina Marga building fifth floor, South Jakarta 12110, Indonesia

^b Ministry of Transportation, Jalan Medan Merdeka Barat No. 8, Jakarta Pusat 10110, Jakarta, Indonesia

^c Center for Far Eastern Studies, University of Toyama, 3190 Gofuku, Toyama 930-8555, Japan

^d Graduate School for International Development and Cooperation, Hiroshima University, 1-5-1 Kagamiyama, Higashi-Hiroshima, Hiroshima-ken 739-8529, Japan

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ABSTRACT

The purpose of this paper is to verify the justification provided for a centralized national road policy in Indonesia, namely, that trips on national roads are typically inter-urban, by measuring the spatial dimensions of automobile and motorcycle trips on national roads in Indonesia. The study finds that motorcycle trips are characteristically local; by contrast, automobile trips extend beyond city boundaries, although to a limited extent. The results suggest the decentralization of transportation policies for the development and maintenance of national roads by granting autonomy to local governments when no fiscal externality exists. The results also indicate that road capacity, gasoline prices, income, population and worker density, city size, and the number of public buses are strong predictors of vehicle kilometers traveled.

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1. Introduction

Primary purpose of this paper is to investigate the spatial extent of vehicle trips made on national roads in Indonesia, specifically to test whether such trips extend beyond city boundaries. The argument that national roads are typically used for long- to medium-distance trips beyond municipal boundaries represents the basis for the present centralized road construction and management policy. To verify the foundation of this argument, this paper uses spatial econometric models to investigate the spatial dimensions of automobile and motorcycle trips on national roads between neighboring cities in Indonesia. The study finds that traffic on national roads in Indonesia is essentially local. The results also indicate that road capacity, gasoline prices, income in the region, population and

worker density, city size, and the number of public buses have a significant coefficient on vehicle kilometers travelled (VKT).

In Indonesia, national roads are primarily developed and maintained by the central government. The recent movement toward decentralization has also given rise to arguments in Indonesia that local governments should have greater autonomy in transportation. National road networks are designed to facilitate not only intracity but also intercity trips. This argument provides the basis for the central control of national road policy. The traffic volume of private vehicles in one city is potentially affected by corresponding volumes in neighboring cities, as residents often make intercity trips for work, study, business, and other pursuits. The principle aim of this paper, therefore, is to evaluate the justification for a centrally controlled national road policy by investigating the spatial dimensions of trips on national roads in Indonesia.

Vehicle trips in this study are represented by the VKT by automobiles and motorcycles. Studies in this context that have used VKT include Su [1], Senbil et al. [2], Wen et al. [3], Duranton and Turner [4], and Mulley and Tanner [5]. Of these works, the most similar to ours is that by Su, who used urban spatial characteristics to

* Corresponding author.

E-mail addresses: myam@eco.u-toyama.ac.jp (M. Yamamoto), yuichiro@hiroshima-u.ac.jp (Y. Yoshida).

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predict VKT per capita, with the results indicating that road density and city size have a positive impact on VKT per capita. Duranton and Tanner attempted to use GDP, income, demographic characteristics, and the price of fuel to predict VKT. Wen, Chiou, and Huang subsequently concluded that income had a negative relationship with VKT, males used motorcycles more often than females, a larger number of commuting and recreational days increased VKT, and the frequency of motorcycle usage was positively correlated with motorcycle engine size. In addition, Duranton and Turner examined the effect of road infrastructure (measured as the number of kilometers of lanes) on VKT and found, *inter alia*, that VKT increases in proportion to the kilometers of roadway lanes on interstate highways in the United States. However, to the best of our knowledge, the literature lacks a study on whether the spatial extent of the vehicle trips on national roads extends beyond city boundaries, thereby justifying the centralization of road construction and management policy.

The results show, on the one hand, that motorcycle trips are characteristically local because there is no sign of spatial correlation with neighboring cities for such trips. On the other hand, automobile trips are often made across city boundaries. However, the models yield only small spatial correlations in automobile trips among neighboring cities. When only a small portion of trips is beyond city boundaries, fiscal externality is not an issue because the leakage of road service benefits to out-of-city travelers is limited; thus, there is no distortion of the local government's incentive to invest in road construction and maintenance. Decentralizing urban transportation policy for national road development and maintenance and granting autonomy to local governments will generate a welfare gain for the Indonesian economy, as local solutions may be more effective in solving the traffic problems of individual cities.

In the following section, we begin by introducing the current status of road transportation in Indonesia in detail. Section 3 presents our data, and Section 4 specifies the spatial econometric models to be estimated. Section 5 discusses the results, and finally, Section 6 concludes.

2. Road conditions and traffic in Indonesian cities

Studies tracking the usage of private automobiles and motorcycles could become an important input for urban transportation policy because the rapid motorization of urban areas is a common development in many modern Indonesian cities. In contrast to the motorization of developed countries, both cars and motorcycles play important roles in the motorization process in many developing countries. For this reason, many large Asian cities, such as Bangkok, Jakarta, and Hanoi, have become motorcycle cities and are referred to by certain transportation experts as “traffic disaster cities” [10]. As Kenworthy's study noted, there is typically only one meter of road space per capita in developing countries, compared with five to eight meters per capita in developed countries; because of this extremely low ratio of road availability per capita in developing nations, their motorization creates severe traffic congestion. Kenworthy [10] also observed that many individuals in developing countries, who had previously walked, operated non-motorized vehicles, or used low-cost public transportation, have migrated to the use of motorcycles; the author argued that this migration was not only a result of individual decisions but also was promoted by governmental policies that encouraged road building, vehicle ownership, urbanization, and suburbanization. Moreover, as Dimitrou [11] demonstrated, the rapid rates of motorization in Asia are closely related to the region's economic growth rates.

The rapid motorization of Indonesia's cities can be observed by examining the average speed of vehicles in large, medium-sized and small cities. The average vehicular speed in large cities declined significantly from 2007 to 2010: in Surabaya, the average vehicular

speed fell from 24 km/h to 21 km/h, and in Medan, the average vehicular speed decreased from 39.4 km/h to 23.4 km/h. This decrease in speed can also be observed in small and medium-sized cities such as Padang, where the average vehicular speed declined dramatically from 40.9 km/h in 2007 to 30.9 km/h in 2010, and in Padang Panjang, where the average vehicular speed declined from 38.8 km/h in 2007 to 25.62 km/h in 2010. The number of private vehicles in Indonesia has increased significantly, more than doubling from approximately five million in 2003 to nearly 12 million in 2009. The number of motorcycles increased even more rapidly during the same period, growing from some 23 million to 60 million in only seven years. Conversely, during the same period, the total road length in Indonesia only increased by approximately 35%, from 328,314 km to 446,278 km. The increase in the number of private vehicles has been associated with a rise in the number of accidents, especially accidents involving motorcycles, which increased 17 times, from 9386 to 164,431, from 2003 to 2011.¹ Information regarding the demand for travel by car and motorcycle and the correlations among cities in terms of travel can provide better inputs for regulators to craft policies that more effectively manage the motorization process.

Prior to an analysis of the model and the regression results, a separate assessment of each of the variables used in the model, particularly the variables derived from the road data, can provide basic information on the road transportation conditions in Indonesia's urban areas. More than 50% of both Indonesia's national economic activity and population is concentrated on the Island of Java; for this reason, it is common to discuss and analyze Indonesia in terms of Java and outer Java, a term used to refer to the other Indonesian islands. Another term that is frequently used is “large cities”, which are defined as cities with a population of at least 500,000. Cities with populations of fewer than 500,000 are categorized as medium-sized and small cities.

As shown in Tables 1 (a) and 2 (b), the mean VKT value for motorcycles is almost three times greater for cities in Java than those in outer Java; however, this difference is statistically insignificant due to substantial variation across cities. The mean VKT value for motorcycles is five times greater in large cities than in small and medium-sized cities; however, even this large difference is not statistically significant. Similarly, the difference in the mean VKT values for cars between Java and outer Java is statistically insignificant, despite that this difference is greater than the difference in the mean VKT values for motorcycles between the regions. Differences in the mean VKT values for cars for different city sizes are also statistically insignificant at the 5% level. For our model to correctly identify the determinants of VKT, therefore, we need to incorporate the following characteristics of cities in addition to size and geographical location.

The difference in the International Roughness Index (IRI) between Java and outer Java is also not statistically significant; in particular, the condition of national roads in urban areas in both Java and outer Java is fair because the mean value remains stable at approximately 5 m/km. However, this value is only meaningful within city limits. Large cities do not differ to a statistically significant degree from small and medium-sized cities with respect to IRI. Thus, the IRI values in Indonesian cities do not vary significantly with respect to geography or city type.

These tables also show that, on the one hand, the mean national road capacity of cities in Java is almost twice that of those in outer Java, but this difference is not statistically significant. On the other hand, the mean national road capacity of large cities is approximately three times greater than that of small and medium-sized cities, and this difference is statistically significant at the 1% level. This indicates

¹ The source of these data is the Ministry of Transportation of Indonesia.

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