Thesis Summary
論文内容の要旨

Title of Dissertation 論文題目

Dynamics in Development of Urban Transportation Markets and Transportation Investment Strategy in Developing Countries（都市交通市場の発展過程の動学分析ならびに開発途上国における交通投資戦略）

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1. Background and research objectives

Many cities in Asian developing countries currently experience rapid motorization after relatively stable economic growth over the past decades. With an increasing use of cars, they struggle with numerous transportation problems including heavy road congestion. Currently, as there is a growing concern about infrastructure investments in Asian regional economies, these countries have to invest strategically in their transportation markets to mitigate those problems.

A desirable strategy for investing capital stock in developing transportation markets could effectively incorporate the developmental stage of urban transportation markets. For example, transportation investments could have different impacts on trends in transportation patterns of cities if they occurred in another stage of rapidly growing transportation markets. This implies that appropriate timing of transportation investments in the development of urban transportation markets is important to achieve sustainability in urban transportation in developing countries. However, there is a lack of research linking empirical findings on the *development of urban transportation markets* (mostly observed in developed economies) with examining policy impacts, particularly to inform *transportation investment strategies in developing countries*.

The study investigates changes in *trends* (e.g., average changes over 10 years) for *sizes* and *shares* of the urban transportation market. Then, the market size represents the city's developmental stage of transportation, while the market share trends indicate the changes in the city's overall transportation pattern (modal share). As a result, this analytical framework is useful to understand the relationship between the developmental stages of urban transportation markets and transportation investments.

Thus, the study first aims to obtain the empirical evidence and a possible theoretical mechanism of changes in trends for sizes and shares in the urban transportation market. The results here will prepare a framework that explains the dynamics in trends of urban transportation markets and the associated empirical evidence. Second, the study aims to analyze effects of transportation investments on the modal share trends for the transportation markets that are at different developmental stages to inform transportation investment decisions in developing countries.

2. Dynamics in the development of urban transportation markets

The study preliminarily argued the measure of urban transportation markets. Specifically, the study examined the relationship between the travel time expenditures and improvements to transportation infrastructures in the long run. The results indicated that we could use the distance traveled as a measure of passenger transportation markets even in the long run.

2.1 Market size trends

The study analyzed the dynamics in the transportation market size trends by assuming that the city's distance traveled per capita represents the consumption level in the city's transportation market. First, it set a hypothesis for the long-run growth of a city's distance traveled. Namely, cities with shorter distances traveled per capita might have had higher growth rates of distance traveled per capita in the past, and vice versa; consequently, the initial gap of distance traveled per capita across cities could have narrowed over time under current transportation technologies (i.e., car and modern transit in the postwar developed economies). Next, the study verified the convergence of distance traveled per capita empirically using a global city dataset that covers developed economies from 1960 to 2000. The results showed that distance traveled per capita converged in the postwar period across cities with/without controls that represent cities' characteristics. The clear convergence pattern of per capita distance traveled means that the level of a city's per capita distance traveled strongly explained its long-run growth rate. Further, a lower population density of a city increased the growth rate of per capita distance traveled; U.S. cities had a higher growth rate in the postwar period.

The results may imply that the long-run growth rates of city's distance traveled per capita (i.e., changes in trends of the market size) could decrease with increases in the city's distance traveled per capita.

2.2 Modal share trends focusing on the supply

As an approach to explaining the city's modal share trends, the study analyzed trends in the supply of urban transportation markets. Here, the study assumed a distributed lag structure for explaining the supply of transportation services (e.g., vehicle-kilometer as the public transit services supply; further, a road traffic capacity as road services supply). This structure could be particularly applicable to the transportation markets that are rapidly growing. For example, in such markets, an additional (even higher) supply of transportation services typically requires the time to build transportation infrastructures. Meanwhile, this structure might be less the case in slowly growing transportation markets because changing only more variable inputs can adjust their levels of services supply. Finally, the study considers a series of mean-zero shocks that are uncorrelated with one another as disturbances in explaining the supply. The shocks on the services supply are assumed to be a result of exogenous impacts on the capital stock of transportation markets.

Then, the study empirically analyzed the factors that have affected the urban rail supply in Tokyo, Japan, with a time-series dataset covering the period 1950–2010. A direct model of urban rail supply was developed, incorporating the demand and service level for urban rail travel, conditions of alternative

urban transportation modes, and socioeconomic conditions as explanatory variables. The model was estimated using the Bayesian model averaging approach, which provided robust estimation results. Additionally, a model framework that considers the planning process (i.e., distributed lag model) of urban rail supply was applied. The results showed that the supply of urban rail services was in response to the increase in urban rail demand such that urban rail demand strongly "induced" urban rail supply. Additionally, the negative reaction of urban rail supply to car ownership was robustly estimated. Through the planning process, rail demand growth in Tokyo has been strongly translated into the growth in supply; this might have worked as one of the critical factors for the establishment of a rail-oriented Tokyo.

The results may imply that the induced investments (i.e., direct effects of public transit/car travel demand on the public transit/road services supply) could be one of the important mechanisms in the services supply, particularly in rapidly growing transportation markets.

Furthermore, the study experimentally estimated a model of the transportation services supply with the global-city dataset, assuming the distributed lag structure. The results showed that there was a significant positive effect of a (lagged) demand ratio of public transit/car travel on the supply ratio of public transit services/roads. Further, the size of this effect decreased with increases in the city's distance traveled per capita. In actuality, the results with the global-city dataset may lead to the observed facts in trends of the city's modal share (measured by the share of car distance traveled in the city's total distance traveled) in developed economies. Namely, overall changes in modal shares have decreased with increases in the city's distance traveled per capita in the postwar period.

3. Transportation investment strategy in developing countries
3.1 Developing a transportation model

The study developed a dynamic transportation model that can analyze trends of urban transportation markets. Specifically, the model explains changes in levels of transportation services supply, with explaining changes in travel demand (resulting from consumers' choices) and the service level of transportation (from aggregate-level transportation network equilibrium). Namely, the model enables the endogenous network change with the common assumption of transportation modeling. At the same time, the model dynamically determines the distance traveled per capita in a city, which constrains the level of its transportation market size at each period.

In particular, the study assumed the distributed lag structure for transportation services supply for conducting the simulations in developing transportation markets. Thus, the study estimated the supply model, considering the induced investments and those interactions with the city's distance traveled per capita.

Because the transportation model analyzes the market trends, the model could be inherently suitable for analyzing developing transportation markets, whose trends are expected to change significantly. Then, the model analyzes the processes for such markets to reach the state that is relatively steady. Note that the patterns of urban transportation would evolve mostly during such developmental processes.

3.2 Effects of transportation investments

The transportation model was used to analyze the effects of transportation investments on the modal share trends for the transportation markets that are at different developmental stages. In the policy analysis, the study introduced an exogenous impact on the capital stock of transportation markets. For example, this impact could adequately explain the transportation investment with financial supports by foreign institutions in developing countries.

In general, the simulation results showed that (large-scale) public transit investments could have larger negative impacts on the city's car share at steady states if such investments occurred in the transportation markets whose sizes are smaller. The results imply that the policy strategy pursuing public transit investments could work well in the transportation markets whose sizes are relatively small in developing countries. For example, the estimate suggests that secondarily developed cities in Southeast Asian developing countries could currently correspond to this type.

However, this might not always be the case in the transportation markets that have already developed to some degree in developing countries. For example, the estimate suggests that most developed cities in Southeast Asian developing countries could currently correspond to this type. The research included a case study in a Southeast Asian emerging megacity where car use rapidly increased during these two decades. The results showed that possible large-scale public transit investments might not sufficiently change its transportation pattern from the current condition, while such investments might have changed it more significantly if they had occurred ten or twenty years earlier. Thus in such cities, much expectations on public transit investments might be risky; an integrated policy strategy covering instruments on demand and others as well, including those with financial supports by foreign institutions, could gradually mitigate transportation problems.

4. Conclusions

The study showed the empirical evidence based on a framework that explains the dynamics in trends of urban transportation markets and obtained transportation investment strategy in developing countries. Essentially, with decreasing growth in urban transportation markets, the chance to change overall transportation patterns will gradually decrease; additionally, there could be a strong inertia in transportation investments, such that they tend to follow the demand growth particularly during the developmental process of urban transportation markets. For example, if the initial investment was intended to accommodate demand growth in the corresponding period, then future investments were generated by the demand that was made possible by the initial investment. Thus, early transportation investments could naturally have a strong power determining future transportation patterns, and the strategy in developing countries needs to consider this. Future work should investigate fundamental factors behind the mechanism of transportation services supply in developing markets: to what extent the mechanism relates to institutional characteristics in investing capital stock for public transit and road services.

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