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Three Essays on Transportation Investment, Regional Development Economics, and Industrial Location

교통투자, 지역경제 및 기업입지에 관한 에세이

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농경제사회학부 지역정보 전공

이 유 진

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지도 교수 김 의 준

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이 유 진

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위 원 장 ______________________ (인)

부위원장 ______________________ (인)

위　　원 ______________________ (인)

위　　원 ______________________ (인)

위　　원 ______________________ (인)

Abstract

Economic efficiency and equity are two major issues in transportation investment and regional development. Economic growth and regional economic disparity are expected outcomes of transportation investment. While the economic efficiency and equity are often traded-off, the increase in factor mobility could positively affect in regional economies in terms of both the efficiency and equity. Hence, focusing on economic growth, regional economic disparity, and reallocation of factor inputs in relation with transportation invest, this paper attempts to make answers to the following research questions in three composing essays. First, how do we increase the marginal economic benefit of the investments in road and railroad networks? Second, what are the spatial economic impacts of HSR investment in terms of economic efficiency and equity? Third, what are the determinants of firm relocation, and which factors attract relocating firms into the region?

The first essay analyzes the spatial economic impacts of road and railway accessibility levels on manufacturing outputs, with a focus on substitution and complementarity of the intra- and the inter-modal relationship. In a Translog production function framework, *ceteris paribus*, railroad accessibility has positive effects on the marginal value added of local manufacturing industries with respect to both of road and railroad variables, enjoying increasing returns to scale. However, road accessibility could positively influence only on the marginal value added with respect to the railroad variables, holding decreasing returns to scale. This implies that there is not a competing but a complementary relationship between the two transportation modes in terms of increasing manufacturing production.

The second essay is to develop a framework for economic analysis of high-speed railroad of Korea (KTX) and estimate the dynamic economic effects of transportation project on the economic growth and the regional disparity in Korea. The framework is composed of a Spatial Computable General Equilibrium (SCGE) model and a micro-simulation module or transportation model of highway and railroad networks. The latter module measures a change in interregional accessibility by highway and railroad line, while the SCGE model estimates the spatial economic effects of the transportation projects on the GDP and the regional distribution of wages. The results indicate that while the development of Honam KTX increase national economic output, regional disparity in terms of GRDP increases, and economic growth effect concentrate to Seoul Metropolitan Area (SMA). However, the increase in factor mobility by time reduces the regional disparity and alleviates the divergence of regional economies as well as enhances economic output.

The third essay aims to analyze the determinants of firm relocation decisions. Using a panel dataset of manufacturing establishments in South Korea, a two-step decision making process of relocation (whether to relocate and where to relocate) is analyzed. Results indicate that inter-industry agglomeration attracts relocating firms, but intra-industry agglomeration and local competition discourages their entry. This pattern is more prominent among firms with prior experience of move(s), consistent with product life cycle theory. In general, sector-specific wage and land price discourages the entry of relocating firms, but multi-plant firms show less aversion to high own-sector wage, indicating that the wage of multi-plant firms could be more affected by other branches rather than local plants in their own sector. High sector-specific wage serves as pull factors for firms in high-tech and medium-high tech manufacturing sectors. This implies that local wage level in its own sector signals for the quality of local labor force, expected benefits from qualified labor input would exceed the cost in higher technology intensive industries. Large firms tend to have greater tolerance for relocation distances and land price, because they face more difficulty in finding premises satisfying their demand.

Keyword: Transportation investment, Spatial accessibility, Transportation networks, Economic impact analysis, SCGE model, Firm relocation
Student Number: 2011-31025

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Chapter 1. Introduction

1.1. Research Background and Purpose

Two major goals of transportation investment are improvement in economic efficiency and equity in both developing and developed countries (Geurs *et al.*, 2016). The provision of transportation infrastructure and improvements in transportation accessibility are expected to increase market efficiency (in terms of goods and production factors) and induce agglomeration externalities, as well as raise productivity of private investments by lowering transportation costs (Melo *et al.*, 2013). However, empirical evidence of the wider economic impacts of transportation investment varies, which implies that an increase in transportation capital is not necessarily a sufficient condition for economic growth. Several authors suggest that development potential, as observed in economic, institutional conditions and investment policy, affects the intensity – and often the direction – of the economic benefit derived from transportation investment. In other words, the marginal economic benefit from transportation investment depends on supply (e.g. endowment of transportation capital in various forms) and demand factors (e.g. economic scale and the size of transportation demand) as well as their accompanying policies and institutional conditions. Focusing on supply-side conditions, benefits from transportation investment depend on the interplay between new and existing transportation infrastructure. On the one hand, the extension of transportation links or connections between separate networks may lead to network economies and, generate greater demand across the entire network (Banister, Thurstain-Goodwin, 2011). On the other hand, as several authors argue (Rietveld and Nijkamp, 1993; Vickerman, 1997) marginal benefits from transportation investment could diminish with the quantity of transportation capital stock. In addition, inter-modal competition and consequent loss of efficiency could emerge if the roles of different transportation are duplicative or conflicting. In this sense, interactions between internal and competing transportation modes account for much of the variation in the marginal economic effect of transportation investment. The investigation of intra- and inter-modal relationships in private sector outputs can provide insight into the competitive or complimentary nature of transportation infrastructure and its implications for transportation investment policy.

The other aim of transportation investment is the reduction in regional disparity, which is often viewed as a trade-off with economic efficiency. By reallocating economic activities in a more efficient way, transportation investment produces both distributive and generative effects. From new economic geography (NEG) perspective, reducing transportation costs to below a critical degree could lead to a cumulative causation mechanism and the concentration of economic activity to a region with initial advantage, in a cumulative causation mechanism in the region with initial advantage(Krugman, 1991). In particular, because high-speed rail (HSR) is characterized by a hub-and-spoke structure that tends to concentrate access improvements in hub regions of major railroad stations and their surroundings, the advent of HSR could intensify spatial disparities related to the opportunity potential of economic interactions (Monzon *et al.*, 2013; Vickerman, 2015). Empirical studies show that the opening of HSR networks tends to penalize regions with poor connections to the HSR station due to relative declines in accessibility (Martínez Sánchez-Mateos and Givoni, 2012). In addition, the provision of the HSR network and services often comes at the expense of conventional railroads in terms of budget support and service level (Martínez Sánchez-Mateos and Givoni, 2012).

According to the national rail network construction plan of Korea (2016-2025), by 2025, all Korean cities will be accessible by HSR from any other city in 90 minutes or less, and local access to the HSR network will be expanded. Hence, it is timely to analyze the spatial impacts of HSR development in terms of both economic efficiency and equity. A region-level analysis will allow the identification of the regions that win and those that lose as a result of the investment. In addition to assessing static regional disparities, policy attention should be paid to the following questions: whether the degree of disparity increases (divergence) or decreases (convergence) over time; and how to relieve the regional disparity associated with transportation investment.

The literature suggests that flexibility in the factor market, as represented by interregional mobility of production factors, will reduce regional economic disparities in income (Puga, 2002; Niebuhr and Schlitte, 2004) and employment (Beg, 1995) by permitting a better allocation of resources. In a small country such as Korea, the inter-regional mobility of labor inputs is higher than that of capital inputs because the former is supported not only by migration but also by commuting. Therefore, the improvements in interregional accessibility resulting from transportation investment will increase labor mobility. In this way, the regional economic disparity caused by transportation investment at initial stages would be relieved by the increase in labor mobility. However, capital inputs, especially fixed capital assets, are relatively immobile because their spatial reallocation is accompanied by firm relocations. Since 2005, the Korean government has subsidized firms that relocate from the Seoul Metropolitan Area (SMA) to outside the SMA to reduce regional economic disparity through the reallocation of economic activities and resources. However, the reality of sunk costs makes firm relocation relatively uncommon in manufacturing sectors. The policy implications of the improved allocation of economic activities and factor inputs across regions, in terms of spatial and institutional conditions, will be revealed through and analysis of firms' relocation behavior, which is composed of decisions about whether and where to move.

From the overview above, we derive the following research questions about transportation investment and regional development in terms of economic efficiency and equity:

(1) How do we increase the marginal economic benefit of the investments in road and railroad networks?

(2) What are the spatial economic impacts of HSR investment in terms of economic efficiency and equity?

(3) What are the determinants of firm relocation and which factors attract relocating firms into the region?

This paper addresses these research issues in the following chapters. The first issue is discussed through an analysis of the impacts of road and railroad accessibility on manufacturing outputs, with a focus on the interactions of intra- and inter-modal accessibility. We estimate the production function specifying interplays between transportation accessibilities and regional conditions such as population density, and we analyze by region the marginal value added through the improvements in road and railroad accessibility. We then discuss the conditions for improving the economic benefits from investments in both road and railroad infrastructure based on regional difference in marginal economic benefits.

The second issue is addressed by analyzing the spatial economic impact of transportation investment at a general equilibrium. This paper analyzes the regional economic growth and distribution effects of the HSR network of Korea (KTX) on regional economies by developing a framework for economic analysis of highway and railroad projects that uses a computable general equilibrium model (CGE model) and incorporates a Micro-simulation Module of Railroad and Highway Networks. More specifically, by applying different scenarios of intensity and scope of factor mobility, we investigate the variation in regional economic growth and regional disparity caused by the allocation of production factors.

The third issue is discussed by analyzing the determinants of firm relocation and location choice, focusing on firm−level and region−level attributes and policy instruments used to subsidize firm relocations. A nested logit model structure is applied to analyze the two stages of a firm relocation decision, −whether to relocate and where to relocate, using a panel dataset of manufacturing establishments in Korea (1996~2014) in the estimation. To provide policy implications customized to a target group of firms, we further analyze the differences in firm−level attributes that contribute to relocation behavior, such as the size, type, prior experience(s) of moving and technology intensiveness of the industry. Figure 1.1 presents the structure of the paper with specifications of analysis method corresponding to each research question.

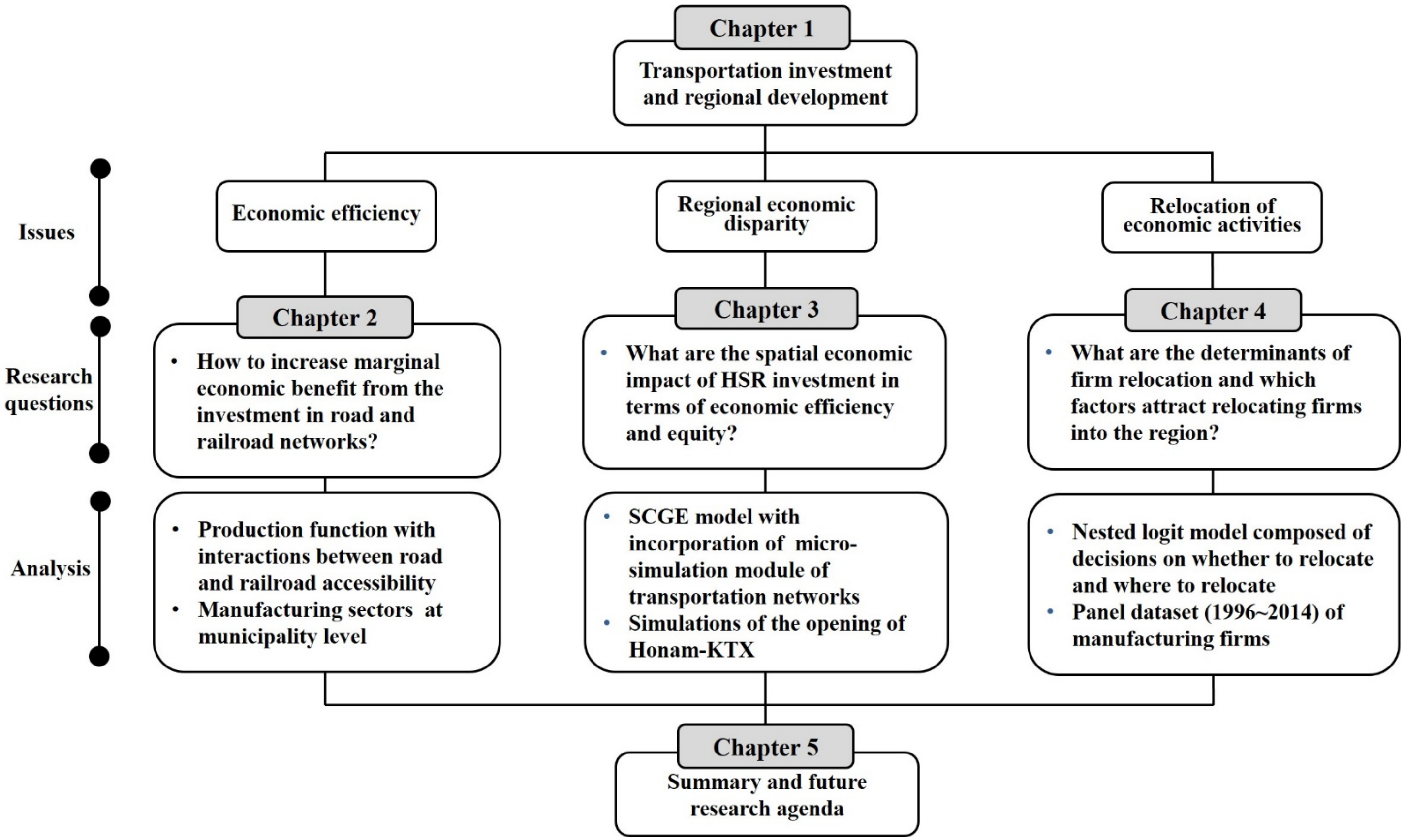


Figure 1.1 Structure of the Paper

1.2. Organization

This paper consists of five chapters. Chapter 1 describes the background and the purpose of the paper. Chapter 2 analyze the spatial impact of road and railroad accessibility on manufacturing output, with the focus on the interactions of intra- and inter-modal accessibility. Chapter 3 develop a framework for economic analysis of highway and railroad projects using a general equilibrium model and analyze regional economic growth and distribution effect from high-speed railroad network of Korea (KTX) on regional economies. Chapter 4 analyzes firm relocation decisions focusing on the variation depending on prior experience of relocations, firm type, size of employment, and industrial classification. Chapter 5 summarizes previous results and discusses policy implications for regional development

Chapter 2. Spatial Economic Impact of Road and Railroad Accessibility on Manufacturing Output: Inter-modal Relationship between Road and Railroad

2.1. Introduction

The benefits from investment in transportation infrastructure tend to surpass the consumer surplus related to travel time and cost saving, due to the existence of market imperfections and border effects (Vickerman, 2007; Lakshmanan, 2011; Hof *et al.*, 2012). These excess benefits, generally conceived as indirect economic benefits of transportation investments, are transmitted through various channels. For instance, the improvement in transportation accessibility promotes interregional integration and market expansion, thereby enabling firms to exploit economies of scale. Due to intensified competition, restructurings of economic activities occur, further increasing regional productivity. In addition, the increase in the "effective density" (Graham and Melo, 2011) of economic activities generates agglomeration benefits; access to specialized producer services, urban infrastructure and amenities (including public service, knowledge, and information) improves; and knowledge exchange is enhanced due to the broadened opportunity for face-to-face contacts. Furthermore, as the commutable area is expanded, the opportunity for a better worker-job match also increases, especially for skilled positions.

Over the past few decades, numerous attempts have been made to quantify the indirect benefits from transportation investments. Macroeconomic modeling using a production function approach has been one of the most widely adopted methods, and the marginal benefit from investment in transportation infrastructure has been measured using output elasticity. However, as Vickerman (2006) pointed out, the scale of the indirect economic impact does not depend solely on the size of the infrastructure provision, so simple output elasticity cannot be a representative figure. Indeed, the assessments of the indirect impact of transportation investments have shown widely varying and case specific results (Vickerman, 2006; Nash, 2009; Melo *et al.*, 2013). In this sense, it would be more practical to focus on the variation of wider economic benefits and investigate the mechanism determining the scale of the impact. In particular, the multi-modal nature of transportation infrastructures should be taken into account, since the integrated use of different transportation systems would lower the optimal transportation cost for a given set of origin and destination; furthermore, the marginal benefit from transportation infrastructure could vary depending on the substitution and complementarity of the inter-modal relationship.

Our main objective here is to analyze the spatial economic impact of road and railroad accessibility on manufacturing output, taking into account the interaction between road and railroad facilities. Following this objective, our contributions are twofold. First, we shed light on the changing nature of the marginal benefit from road and railroad infrastructure depending on local attributes. This marginal value added is derived based on an estimation of a Translog production function wherein interactions of intra- and inter-modal accessibility are specified. It allows us to elucidate variation in the spatial economic impact of road and railroad accessibility. In particular, by investigating the substitution and complementarity between road and railroad in production activities, we aim to disentangle two main forces determining the marginal benefit from transportation investment: diminishing returns to transportation capital stock and increasing returns due to better connectivity through an integrated transportation network.

Second, we attempt to eliminate potential bias in estimating the linkage between transportation investment and private output by using road and railroad accessibility measures instead of the quantity of transportation capital stock. Being a performance measure, an accessibility index better captures the quality of transportation network, represented by travel speed. It also accounts for the spillover of investment effects through networks, which is rarely addressed using investment variables. Despite the growing interest in accessibility as a measure to assess the benefit of transportation investment, the use of accessibility measures to estimate economic effects remains sparse (López, 2007; Gutiérrez *et al.*, 2010). Moreover, the accessibility measures in previous studies have not successfully taken into account either inter-modal interaction or spillover of investment effects using the full range of networks[1]. The accessibility index applied in this paper is based on the shortest inter-zone travel time using road and railroad networks[2] and time decay functions estimated using actual travel data. The routes with shortest travel time are identified using the network analysis tool of the GIS package. Here, the railroad travel routes are partly covered by road transportation because the railroad network is not sufficiently complete to support door-to-

[1] For example, Forlund and Johnson (1995) measured accessibility as the driving speed on a road segment weighted by the share of road coverage to the total area in the municipality. The SASI model (Wegener and Bökemann, 1998; Fürst *et al.*, 1999; Bröcker *et al.*, 2001) applied more comprehensive measures of accessibility within the European continent by taking into account political and cultural barriers as well as travel time or cost, but our work is distinguished from this because we consider the travel time of all origin-destination pairs (in the SASI model, travel time or cost to get to a predefined set of destinations was exclusively considered) and adopt travel time decay parameters based on actual travel data.

[2] The transportation networks used in this paper are composed of road links and railroad segments which are in operation. Accordingly, short-term impacts of transportation investment derived from construction-related activities (e.g. increase in regional output and employment due to growth of external demands) in excluded in our analysis.

door travel in and of itself.

The empirical analysis in this paper focuses on 24 manufacturing industries in 239 cities and counties in South Korea. The rest of the paper is organized as follows. Chapter 2.2 briefly reviews literature on the economic benefits from transportation investment and their measurement methods. Chapter 2.3 defines the concept of accessibility and describes the process of developing accessibility indexes. Chapter 2.4 discusses the framework for the analysis and evaluates the marginal value added of local manufacturing industries with respect to road and railroad accessibility based on the estimation of a Translog production function. Chapter 2.5 summarizes the findings and discusses further research avenues.

2.2. Literature Reviews

Over the past few decades, there have been numerous attempts to quantify the benefits of transportation investments. Table 2.1 summarizes these evaluation methods.

Table 2.1 Evaluation Methods of the Benefit from Transport Infrastructure

Methods	Measurement of benefit
Cost−benefit analysis (CBA)	Direct cost savings or consumer surpluses emerged on the link under study
Production function approach	Rates of return on transport investment or the change in productivity of other factors
Economic potential approach	Change in accessibility level across regions connected via new and existing transport network
Regional econometric inter−industry model (REIM)	Trade gain and the change in regional industrial output driven by the improvement in interregional economic distance (Yamano *et al.*, 2005)
Multi−regional computable general equilibrium (CGE) model	The change in regional welfare (Bröcker, 1998; Bröcker, 2002), labor market (Oosterhaven and Elhorst, 2003), and level of GDP (Kim, 2004; Kim, 2009) triggered by transport cost savings

Despite its popularity due to easy application, CBA does not fully capture economic benefits of transportation infrastructure beyond direct user benefits (Lakshmanan, 2011). In order to assess the indirect economic impact of transportation investment, macroeconomic modeling of the causal linkage between transportation and economy has been widely used. A production function approach using the quantity of transportation investment or the stock level of infrastructure as a key variable is a representative method. The advantage of the production function approach is its simple logic and easy interpretation. Without the need to model a detailed account of transmission channels, the overall impact of transportation infrastructure on the economy is described by a simple output elasticity value.

However, the production function approach has often been criticized due to lack of consideration of network properties of transportation infrastructure, which could lead to biased estimation results. Spatial external effects of transportation investment emerge due to the connectivity between new and existing infrastructure, which is rarely captured in this model (Rietveld and Nijkamp, 1993; Lakshmanan *et al.*, 2001). In order to explain the spatial externality of transportation investment, some studies have employed spatial lag variables in their models (Boarnet, 1996; Moreno and Lopez-Bazo, 2007; Chen and Haynes, 2015). However, the impact of a transportation capital tends to spread through interconnected transportation networks, not just spills over into adjacent areas. In this sense, a transportation accessibility index can be used in place of the transportation capital variable. The accessibility index is a better option than the endowment of transportation capital, because it is measured by travel time or distance over the route, accounting for the performance of transportation infrastructure. The SASI model introduced by

Wegener and Bökemann (1998) is a representative case adopting this approach.

Another advantage of the accessibility index is that it describes the volume of the "economic potential" enjoyed by a region through access to economic activities across space (Keeble *et al.*, 1982). Hence, the change in the accessibility index has often been considered as the economic gain from investment in transportation infrastructure (Vickerman, 1999; Gutiérrez, 2001). While this method is highly effective if the focus is on the regional distribution of benefits from transportation investment (e.g. gaining/losing regions, the main beneficiary of the investment), the accessibility index does not provide enough information on the absolute scale of the economic benefits such as GDP.

Regional econometric input-output model (REIM) is an integrated version of input-output (IO) and econometric models. The economic impact of transportation investment on regional trade and industrial structures is analyzed by performing counter factual simulations of accessibility improvements using economic distance-based trade models. The merit of REIM is that the time-varying cumulative effect of transportation investment is observed with the use of time series expenditure information. However, like the other IO-based approaches, REIM has a limitation in accounting for the supply-side contributions of transportation infrastructure to regional economy, as well as the price effect on interregional trades. These features are better captured within the computable general equilibrium (CGE) framework in which the economy is treated as an integrated system of interrelated markets, and the equilibrium of all variables is determined simultaneously (Haddad and Hewings, 2001).

Under the CGE model structure, transportation cost is perceived as an obstacle to interregional trade in the form of iceberg trade cost (Bröcker, 1998; Bröcker, 2002), an impediment to production due to congestion cost (Conrad and Heng, 2002), or limited opportunity to achieve better economic performance through interregional interactions (Kim *et al.*, 2009). The merit of the CGE approach is that it comprehensively accounts for the change in various indicators of regional and national economy. However, an elaborate sub-model describing the change in interregional transportation cost is a prerequisite for the validity of the CGE model. In this regard, the estimation of the impact of transportation investment on regional economy is worthwhile not only as a mean of ex-ante analysis for an investment project but as a basis for a CGE simulation.

However, a single estimate of output elasticity hardly clarifies the underlying mechanism of the output growth or productivity enhancement. In response to this criticism, some authors suggested models specifying interactions between key variables. For example, Canning and Bennathan (2000) focused on the interaction between transportation infrastructure and other variables, such as physical and human capital and the endowment of the transportation capital itself, to explain the variation in output elasticity with respect to transportation investment across countries. By estimating a production function for a panel of countries over 40 years, diminishing marginal returns to transportation infrastructure was observed, while the private capital and human capital turned out to increase the productivity of the infrastructure. This finding implies that infrastructure investment does not guarantee economic growth in and of itself, but the interaction between other factors could affect the size of the economic impact, consistent with Rietveld and Nijkamp (1993).

Hence, the focus should be on the factors affecting marginal benefit from transportation infrastructure. Rietveld and Nijkamp (1993) stated that the marginal effect of transportation investment would be inversely proportional to the endowment of transportation infrastructures. However, the law of diminishing returns to transportation infrastructure does not always hold, because the benefit from better connectivity might cancel out the disadvantage associated with the diminishing marginal returns (Melo *et al.*, 2013)[3]. Provided that transportation of goods and people is often completed by a joint network of different means of transportation, the marginal economic impact of investment in a transportation mode would depend on the service level of other modes as well. In particular, if the relationship between two different transportation modes is complementary, a synergetic effect would emerge due to further improvement in connectivity by using an integrated transportation network. In contrast, as the substitutability between the modes increases, it is more likely that "diminishing marginal returns" dominate.

The results of earlier works show that the roles of roads and railroads can be either substitutable or complementary, depending on factors such as technology level, travel mileage, trip purpose, and regional background. Oum (1979) demonstrated that the inter-modal relationship in Canadian freight transportation services has changed from complementary to competitive since the 1960s due to

[3] From this perspective, the "diminishing returns to transportation investment" would be valid when the quantity and quality of transportation infrastructure are beyond a certain level and the marginal benefit from connectivity improvement is low. Accordingly, it seems sensible to think that the marginal gain from transportation investment is increasing in earlier stages of transportation development but decreasing in later stages, as suggested by Moreno and López-Bazo (2007).

substantial growth of highway transportation technology. However, inter-modal relationship could be affected by the availability of alternative transportation modes. By estimating a Scandinavian freight demand model, Rich *et al.* (2011) showed that "structural inelasticity" referring to the exclusive use of a single mode of freight transportation (trucks, in particular) due to the lack of alternative modes (e.g. rail and ships) reduced the inter-modal substitutability. While the share of truck-dominated freight transportation tended to decline by shipping distance, the sensitivity to distance varied across commodity groups (Rich *et al.*, 2011; Nolan and Skotheim, 2008). The shift to other modes, such as rail and ships, was distinct in the shipment of low-value goods and bulk products, whereas the mode choice for high-value commodities was less dependent on travel distances. Meanwhile, inter-modal substitutability in production might vary across regions (Bianco *et al.*, 1995). Though Bianco *et al.* did not provide a lucid explanation, differences in geographical constraints or industrial structure could be a potential source of this variation.

Based on the logic that transportation improvements increase the 'effective density' of economic activities (Graham, 2007), the effect of spatial concentration of economic activities could be equivalent to that of the increase in transportation accessibility.

Thus, urban agglomeration could be another critical factor explaining the variation in marginal benefits from transportation infrastructure. Studies in the field of new economic geography can help us understand the relationship between the spatial concentration of activities and transportation cost savings. One of the initial studies, Krugman (1991), suggested a two-region model, where region A is dominated by the agricultural sector and characterized by constant returns to scale and immobile workers, and region B is dominated by the manufacturing sector with increasing returns to scale and mobile workers. Assuming high reliance on manufacturing products and reduced transportation cost, region B exploits economies of scale due to the increase in market size and attracts firms and labors. In addition, the reduction of the local price index, explained by the variety of local products, is equivalent to the increase in real wage. Accordingly, region B attracts more workers in the long term, causing a 'circular causation' of agglomeration. On the other hand, Tabuchi (1998) showed that dispersion force outweighs agglomeration under sufficiently low transportation costs by incorporating intra-regional land rent and commuting cost into Krugman's model. When transportation cost is intermediate, agglomeration takes place due to interregional wage differentials, as in Krugman. However, when interregional transportation costs become low enough, the diseconomies of urban scale (e.g. rent competition) nullify the benefit from agglomeration; consequently, firms and workers disperse. From this perspective, the advantage derived from market proximity could be easily replaced by an easy access to market using transportation networks. For example, if the cost of agglomeration exceeds its benefits, firms could locate in regions with lower densities of economic activities but higher levels of transportation accessibility.

From the literature above, we can hypothesize that marginal returns to transportation accessibility depend on the accessibility level of two transportation modes (i.e., road and rail) as well as the intensity of urban agglomeration. The marginal benefit from transportation accessibility would decrease as the level of spatial concentration of economic activities increases. However, the direction of marginal effect of the accessibility would vary by the level of network connectivity and the inter-modal relationship of the study area. If the transportation network is highly saturated in terms of connectivity, and the roles of different transportation modes are substitutable, the marginal gain from an improvement in transportation accessibility would be relatively low.

2.3. Spatial Accessibility Index of Road and Railroad

As discussed earlier, an accessibility index can be effectively used to estimate the economic impact of transportation investment, because it measures the "opportunity potential" through spatial interactions or contacts with economic activities (Kim *et al.*, 2004; Kim and Hewings, 2011; Lee and Kim, 2014). In this paper, the accessibility indexes using road and railroad networks are used to analyze the spatial economic impact of these two transportation infrastructures and the interaction between them. We applied the generalized concept of the indicator described as:

$$Acc_i = \sum_j M_j f(C_{ij}) \tag{2.1}$$

Acc_i : Accessibility of an origin place

M_j : Mass of a destination place

$f(C_{ij})$: Decay function of the generalized traveling cost from an origin to a destination place

In general, the mass of a destination is measured by its population, implying that the attractiveness of a place depends on its population size. However, the pulling force of destination might be restricted if the load capacity of transportation facility accommodating travel demands from origins is insufficient. In particular, limited load capacity of a vehicle could be an issue in the case of rail transit due to regulations regarding frequency of operation. In this paper, we assume that an interregional interaction via road transportation is free from a capacity limit, but opportunity of the interaction could be restricted when railroad transportation is used.

The generalized travel cost is commonly measured by travel time or distance. If the data allow, the time measure is preferred, as it accounts for the difference in speed by transit modes and geographical conditions. In this paper, inter−zonal travel is assumed to be completed by reaching the centroid of a destination zone, after departing from the centroid of an origin place. Assuming rational travel behavior, the route with shortest travel time is selected with the aid of a network analysis [4] tool provided by geographic information systems (GIS). In particular, travel time via railroad includes access time to/from stations using the road network, so the calculation is given by:

[4] The network analysis is implemented using network files on road and railroad with the information about the length and speed of each link.

$$T_{ij}^{Railroad} = min\ (T_{is}^{Road} + T_{ss'}^{Railroad} + T_{s'j}^{Road})\ \ (\forall s,\ s \neq s')\ \ (2.2)$$

$T_{ij}^{Railroad}$: The shortest travel time from zone i to zone j using railroad transportation

T_{is}^{Road} : The shortest travel time from the centroid of zone i to station s using road network

$T_{ss'}^{Railroad}$: The shortest travel time from a station (s) to another station (s') using railroad transportation

$T_{s'j}^{Road}$: The shortest travel time from station s' to the centroid of zone j using road network

An ignorance of intra-zonal travel time would penalize the accessibility level of large cities (Bruinsma and Rietveld, 1998 pp.40-41). Following Gutiérrez (2011), intra-zonal travel times are calculated as:

$$T_{ii} = \left(\frac{A_i}{3.14}\right)^{1/2} \div IS_i \qquad (2.3)$$

T_{ii} : Internal travel time of zone i

A_i : Area of zone i

IS_i : Average road speed within zone i.

Given that the spatial unit is set to the local level (city and county), intra-zone travel using railroad is likely uncommon. Therefore, the internal travel times in the railroad O-D matrix are substituted by the corresponding elements of the road transportation O-D matrix. In this paper, origin-destination pairs are composed of 246 cities and counties, and the maximum inter-zone travel times are 480 minutes and 634 minutes for road and railroad transportation respectively; the maximum railroad travel time is greater due to its limited ability to provide door-to-door travel.

The decay function describes the resistance to travel by the increase in generalized transportation cost. The impendence is affected by trip purpose, transportation mode, spatial scope of travel, and unique characteristics of travelers and destination regions (Geurs and Ritsema van Eck, 2001; Rosik *et al.*, 2015). Thus, the selection of a proper function and its parameter(s) that fit the actual travel behavior is required. Geurs and Ritsema van Eck (2001) provided an extensive review of different types of decay functions showing that inverse power functions declined too rapidly at short distances, whereas Gaussian functions did so at longer distances. Instead, log-logistic and negative exponential functions fitted well to travel behaviors observed in their case study. In this paper, the negative exponential function, a widely used form in national level analysis (Rosik *et al.*, 2015), is applied (eq. 2.4):

$$f(C_{ij}) = \exp(-\beta \times T_{ij}) \ , (\beta > 0) \tag{2.4}$$

Rosik *et al.* (2015) listed the value of the parameters used in accessibility studies on a national scale, ranging from 0.009 to 0.049. In general, travel for local activities (e.g. shopping) correspond to relatively large parameter values, while activities with broader market coverage (e.g. commuting) correspond to smaller values. In addition, the perception of distance (or time) may vary across countries, depending on cultural and geographical background. Therefore, it would not always be desirable to rely on a parameter given by previous studies, although there may exist some 'generally adopted' parameters. Indeed, the importance of the empirical data-based decay parameter has been emphasized for the sake of plausible results (Geertman and Van Eck, 1995; Geurs and Ritsema van Eck, 2001; Geurs and Van Wee, 2004).

We estimate decay parameters for road and railroad transportation respectively as the impedance levels are expected to be different between the two.[5] Using an O−D travel matrix composed of 246 zones provided by the 2012 Korean National Travel Survey and inter−zonal travel time (discussed in next paragraph), the exponents (β) are estimated as follows:

$$lnOD_{ij} = \alpha_i lnM_i + \alpha_j lnM_j - \beta T_{ij} \tag{2.5}$$

OD_{ij} : The number of travelers between zone i and zone j

, and it is driven by equation (2.6).

$$OD_{ij} = {M_i}^{\alpha_i} {M_j}^{\alpha_j} \exp(T_{ij})^{-\beta} \tag{2.6}$$

Regional population is used to control the attractiveness of origin and destination (represented by M_i and M_j)[6]. O−D pairs with a value smaller than 1 or larger than 50,000 are excluded to avoid distortion due to outliers. The estimation results are presented in Table 2.2.

---

[5] Using the data from the Dutch National Travel Survey, Geurs and Ritsema van Eck (2001) showed that trips using cars were more sensitive to travel time compared to those using public transportation for every trip purpose analyzed (work, recreation, shopping, social).

[6] Employment is applied as well, but the estimation results show that the estimates of time decay parameters (β) are almost indifferent to three decimal points, so they are not reported here.

Table 2.2 Estimation Results of Decay Parameter for Road and Railroad Transportation

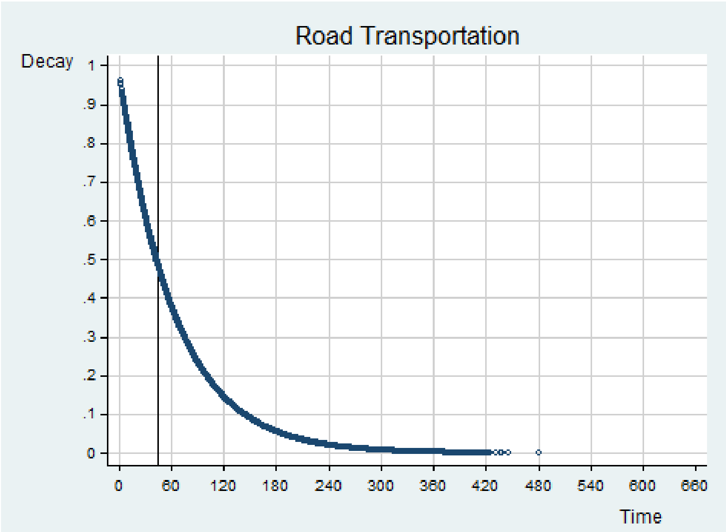
		Road		Railroad	
		Automobile	Automobile and bus	High speed rail (HSR)	HSR and conventional railroad[7]
Estimates	α_i	0.346*** (0.004)	0.347*** (0.004)	0.176*** (0.002)	0.160*** (0.007)
	α_j	0.153*** (0.004)	0.178*** (0.004)	0.000*** (0.000)	0.154*** (0.006)
	β	0.017*** (0.000)	0.017*** (0.000)	0.002*** (0.000)	0.009*** (0.000)
Adjusted R−Square		0.859	0.879	0.715	0.345
Number of O−D pairs observed		48,129	51,706	11,519	20,473

***: statistically significant at 1% level

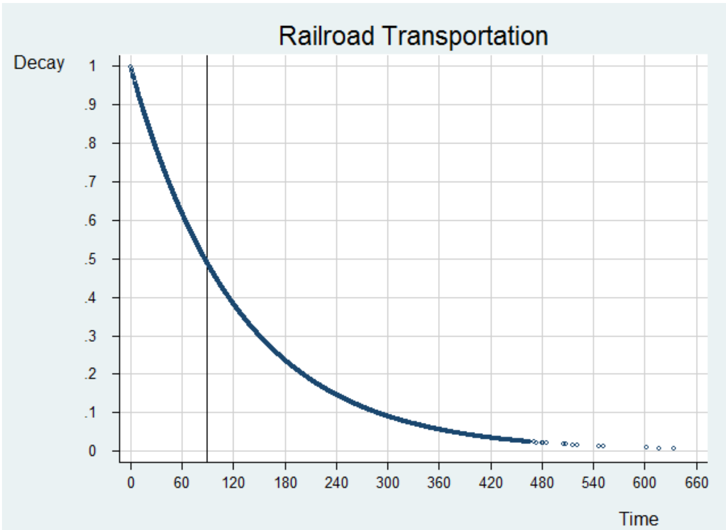
The results show that trip demand using roads is more sensitive to travel time compared to railroads. In particular, in the case of exclusive use of high speed rail (HSR), designed for rapid transportation between spatially remote regions, the parameter value is much lower compared to other cases. This indicates that the trip demand of railroad transportation declines very slowly against the increase in travel distance. In this paper, 0.017 and 0.009 are applied for the decay parameters of road and railroad

[7] In this study, the scope of railroad transportation excludes subways, which is closer to intra−urban transit rather than interregional one. Therefore, the OD pairs connecting metropolitan areas covered by subways are not counted.

transportation respectively[8].



(1) Road



(2) Railroad

Figure 2.1 Travel Time Decay in Spatial Interaction for Road and Railroad Transportation

[8] Note that the railroad networks used for our analysis are composed of both HSR and conventional railroads.

Figure 2.1 illustrates the travel time decay in the spatial interaction function applied to the data. The decay is more precipitous for the case of road transportation. The likelihood of interaction between regions within a 45-minute distance decreases by half for road users, whereas decay of 50% is generated between regions within a 90-minute distance for those who mainly use railroad transport. The degree of decay is almost indifferent over a 300-minute distance for the case of road transportation, implying that road transportation is barely used for travel of more than a five-hour distance. On the other hand, time decay exists even at more than a seven-hour distance in railroad transportation. These figures suggest that the likelihood of road travel is more time-sensitive and railroad transportation is preferred by long-distance travelers.

Equations (2.7) and (2.8) formulate the index of accessibility of zone i using road and railroad transportation. As mentioned, measurement of the mass of a destination region is twofold: when it comes to road accessibility, population size is applied, while the maximum number of passengers carried per day is used to calculate railroad accessibility[9].

---

[9] The time tables for high speed and conventional trains on weekdays and

ACC_i^{Road}

$$= Pop_i \times exp(-0.017 \times T_{ii}^{Road}) + \sum_j Pop_j \times exp(-0.017 \times T_{ij}^{road}) \quad (2.7)$$

$ACC_i^{Raiload}$

$$= Pop_i \times exp(-0.017 \times T_{ii}^{Road}) + \sum_j Capacity_{ij} \times exp(-0.009 \times T_{ij}^{Raiload}) \quad (2.8)$$

Pop_i : Population size of zone i

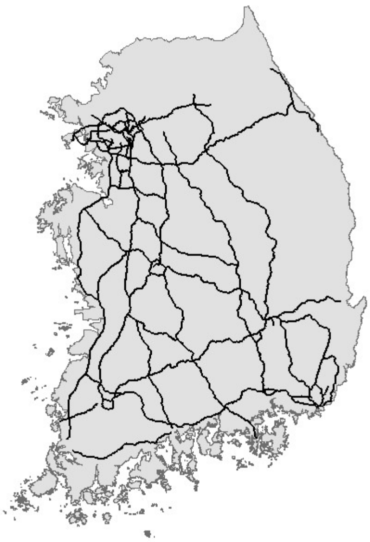
$Capacity_{ij}$: Daily load capacity of railroad transportation connecting between zone i and j

2.4. Impact of Road and Railroad Accessibility on Manufacturing Productivity

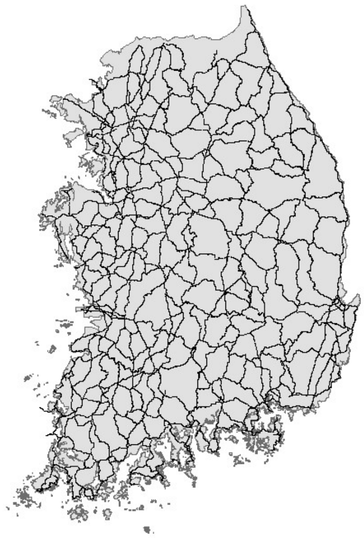
In South Korea, transportation investment has been concentrated on the road network; the total length of the road network has increased almost fourfold in the last 50 years, while the growth of the railroad network has been less than 150%. Consequently, the role of the road network in passenger and freight transportation has increased substantially. As shown in Figure 2.2, road networks are interconnected at national and local levels (panel (1) to (3)), whereas railroad networks connect major traffic nodes

average seat capacity by type of vehicle were used to calculate daily load capacity of the HSR transit at every origin-destination pair.

(panel (4)).

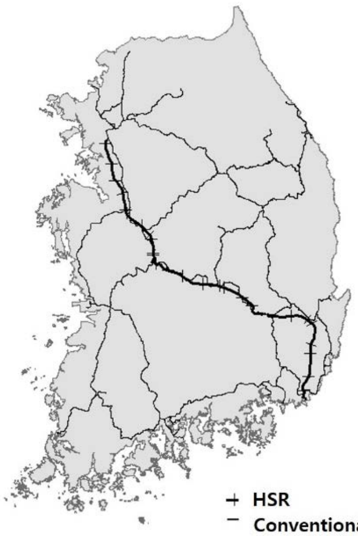


(1) Highway
(max. average speed=100km/h)



(2) National highway
(max. average speed=80km/h)

(3) Local road
(max. average speed=65km/h)



(4). Railroad

Figure 2.2 Road and Railroad Networks in South Korea (in 2012)

The majority of traffic has been concentrated on the northwest-southeast axis, connecting two largest cities, so HSR was developed in response to the excess traffic demands on this axis. Since the inception of the Korean Train Express (KTX) service in 2004, the HSR networks have been gradually improving in South Korea. At the beginning of 2015, the service mileage reached 988 km, and 55.5% of cities and counties were accessible to HSR station(s) within an hour. The number of daily passengers was 155,937, and the average length of haul per trip was 261.52 km. Based on the number of commuter pass holders, at least 5.01% of trips using KTX were for commuting purposes, and 93.66% of the commuting trips were between 50 and 200 km. The relocation of businesses and public administration activities led by decentralization policy of Korean government since the early of 2000s have raised the dependency on KTX for commuting or business trip purposes. In this sense, the development of KTX network would have contributed to firm productivity by facilitating face-to-face interactions and the use of producer services (Blum *et al.*, 1997) and allowing better worker-job match (Vickerman, 2006). Concerning the economic effect of KTX investment, Ueda *et al.* (2015) compared a counterfactual "without KTX" scenario to a "with KTX" scenario within a spatial CGE framework, focusing on intercity transportation cost. They showed that the production outputs of the industrial sector increased by 0.24 ~ 0.30 %, which was great, in relative terms, than the case of HSR projects in Japan and Taiwan.

In this paper, we analyze the spatial economic impact of both road and railroad accessibility, by positing that the marginal effect of transportation accessibility using road and railroad networks on manufacturing value added varies across space depending on quantitative and qualitative aspects of transportation capital and urban agglomeration. We pay special attention to intra- and inter-modal interaction effects, referring to situations in which the marginal effect of transportation accessibility is affected by the change in the accessibility level using the mode itself or that using the other mode. A positive intra-modal interaction effect describes 'increasing returns to transportation capital' due to better connectivity, while a negative intra-modal interaction effect is relevant to 'diminishing returns to transportation capital'. In this sense, the identification of intra-modal effect would provide supporting or opposing evidences for further investment in a specific mode of transportation capital. On the other hand, an inter-modal interaction effect focuses on the complimentary or substitutive relationship between different modes of transportation infrastructure. A complimentary inter-modal relationship indicates that marginal benefit from the investment in a specific mode of transportation infrastructure would further increase by developing other transportation modes as well. In contrast, if substitutive inter−modal relationship is dominant, the marginal benefit from the investment in a specific mode of transportation infrastructure would be adversely affected by the accessibility level using the other transportation mode.

In this paper, the effects of road and railroad accessibility on manufacturing productivity are specified within the framework of the Translog production function in order to allow flexibility in input substitution. In addition to two fundamental input factors, labor and capital, transportation accessibility and population density, a proxy for spatial concentration of urban activities (Ciccone and Hall, 1996; Melo *et al.*, 2009), are included. A dummy variable indicating metropolitan areas (excluding the capital city) is used to improve model fit by controlling unobserved effects associated with local government policies[10]. The sign of the estimates of interaction terms indicates whether the component variables positively or negatively affect the marginal effect of transportation accessibility. Output elasticity with respect to the accessibility of each mode is derived from values of municipality−level variables. The Translog

[10] The size of interest group (dummy=1) is 81, or 34.18% of sample size.

production function for an industry within a region is specified as:

$$
\begin{aligned}
ln\,VA_i^{\mathrm{r}} = {} & \alpha_0 + \alpha_1 lnL_i{}^r + \alpha_2 ln\mathrm{K_i}{}^r + 0.5\alpha_{11}(lnL_i{}^r)^2 + 0.5\alpha_{22}(ln\mathrm{K_i}{}^r)^2 \\
& + \alpha_{12} lnL_i{}^r ln\mathrm{K_i}{}^r + \beta_1 lnRoad^r + \beta_2 lnRail^r + \beta_3 lnRoad^r lnRail^r \\
& + \beta_4(lnRoad^r)^2 + \beta_5(lnRail^r)^2 \gamma_1 lnPop^r + \gamma_2 lnPop^r lnRoad^r \\
& + \gamma_3 lnPop^r lnRail^r + \delta_1 Station^r + \delta_2 Station^r lnRoad^r lnRail^r \\
& + \delta_3 Metro + \varepsilon_i \qquad (2.9)
\end{aligned}
$$

$VA_i{}^{\mathrm{r}}$: Aggregated value added of industry *i* within region *r*

$L_i{}^{\mathrm{r}}$: Total labor input of industry *i* within region *r*

$K_i{}^{\mathrm{r}}$: Total capital input of industry *i* within region *r*

Emp^r : Population density of region *r*

$Road^r$: Road accessibility index of region *r*

$Rail^r$: Railroad accessibility index of region *r*

$Station^r$: Number of rail stations located in region *r* and the spatially adjacent regions[11]

$Metro$: Dummy variable indicating metropolitan areas (excluding the capital city)

If the production function in equation (2.9) is assumed to

[11] Provided that the spatial coverage of HSR is broader than that of the regular railroad, HSR stations within geographically adjacent regions are counted in addition to the conventional train stations within the region itself.

satisfy the homogeneity of degree one in primary factor inputs including additivity and symmetry conditions, such restrictions on the parameters are expressed in equation (2.10). A cost−share equation subject to the usual symmetry, input−price homogeneity, and duality conditions is obtained by partially differentiating equation (2.9) with respect to the factor inputs under Shephard' s lemma. A cost share equation subject to the usual symmetry, input−price homogeneity, and duality conditions is obtained by partially differentiating the Translog production function with respect to the price of each factor input under Shephard' s lemma. The cost share of labor inputs to the total production costs is given by equation (2.11). Due to data availability, the total cost for primary inputs is replaced with value added in practice.

$$\alpha_{11} + \alpha_{12} = \alpha_{22} + \alpha_{12} = 0,\ \alpha_1 + \alpha_2 = 1 \tag{2.10}$$

$$\frac{\partial C_i{}^r}{\partial P_{Li}{}^r}\frac{P_{Li}{}^r}{C_i{}^r} = \frac{P_{Li}{}^r L_i{}^r}{C_i{}^r} = \frac{P_{Li}{}^r L_i{}^r}{VA_i{}^r} = S_{L_i^r} = \alpha_1 + \alpha_{12} lnK_i{}^r + \alpha_{11} lnL_i{}^r \tag{2.11}$$

P_{Li}^r : Price of labor of industry i within region r

C_i^r : Total cost of primary inputs of industry i within region r

The parameters of the Translog production function are estimated jointly through an iterative seemingly unrelated regression approach for the production function and a factor share equation of labor in Equation (2.11), where the factor share equation of capital is deleted to avoid a singularity problem.

Once the production function is estimated, the output elasticities of road and railroad transportation accessibility take the form of the partial differentiation of the value added with respect to the level of accessibility (equations (2.12) and (2.13)). The marginal value added associated with a one-unit increase in the accessibility level is calculated using the elasticity value as in equations (2.14) and (2.15).

$$\eta_{Road}{}^{r} = \frac{\partial VA^r}{\partial Road^r}\frac{Road^r}{VA^r}$$
$$= \beta_1 + \beta_3 lnRail^r + 2\beta_4 lnRoad^r + \gamma_2 lnPop^r + \delta_2 Station^r lnRail^r \qquad (2.12)$$

$$\eta_{Rail}{}^{r} = \frac{\partial VA^r}{\partial Rail^r}\frac{Rail^r}{VA^r}$$
$$= \beta_2 + \beta_3 lnRoad^r + 2\beta_5 lnRail^r + \gamma_3 lnPop^r + \delta_2 Station^r lnRoad^r \qquad (2.13)$$

$$MVA_{Road^r} = \frac{\partial VA^r}{\partial Road^r} = \eta_{Road^r} \times \frac{VA^r}{Road^r} \qquad (2.14)$$

$$MVA_{Rail^r} = \frac{\partial VA^r}{\partial Rail^r} = \eta_{Rail^r} \times \frac{VA^r}{Rail^r} \qquad (2.15)$$

Estimation

The Translog production function of local manufacturing industries is estimated using a sample composed of 239 cities and counties and 24 industries (sample size=2,108)[12]. Table 2.3 gives the summary statistics and a description of the variables used in this paper[13]. Based on the distribution of mean and median of the value added, employment, and the capital stock in the sample, it is conceivable that the size of manufacturing activity is unbalanced across municipalities and industries. The railroad accessibility index is smaller than the road accessibility index because of the assumption that the intensity of interregional attraction is limited by load capacity of railroad facilities connecting them. Both the road and railroad accessibility indices show left−skewed distributions, but the latter has higher skewness. This indicates that spatial gap of accessibility is more evident with respect to railroad transportation due to the difference in quality of connection to railroad facilities as well as load capacity.

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[12] Among the 251 cities and counties in South Korea, those without manufacturing activities and those located in insular areas are excluded.
[13] The figures shown in Table 1 are different from national averages as they are weighted by the number of industries within the spatial unit.

Table 2.3 Table 2.3 Descriptive Statistics of Variables (Year: 2012)

Variable	Description	Mean	Median	S.D.
VA	Value added (unit: 1 billion $)	0.180	0.028	0.883
L	Number of employees (unit: 1000 people)	1.198	0.378	2.951
K	Material fixed capital (unit: 1 billion $)	0.170	0.026	0.652
Road	Index of road accessibility (unit:1 million people·minute)	8.140	5.673	5,607
Rail	Index of railroad accessibility (unit: 1 million people·minute)	1.683	1.283	1.446
Pop	Population density (unit: 1,000 people/km^2)	4.231	0.601	6.266
Station	Count of rail stations in the own and neighboring regions	1.142	1.000	0.976

Concerning the impact analysis of transportation infrastructure, the possibility of reverse causality or simultaneity has been often suggested (e.g. Rietveld and Boonstra, 1995; Canning and Bennathan, 2000; Pereira and Jorge, 2005; Chen and Haynes, 2015). While transportation infrastructure may affect local economic output by reducing transportation cost and increasing productivity, the improvement in economic output might also affect transportation capital stock by inducing transportation demand. However, the linkage described latter would be not too problematic in present analysis, because the accessibility index used here relies on the quality of transportation networks rather than being a simple function of the stock level of transportation infrastructure. For example, due to network aspects of transportation infrastructure, a provision or a maintenance of transportation infrastructure in a region could affect the transportation accessibility in any remote region and *vice versa*. In this sense, the feedback from economic output on transportation accessibility would be less clear than in the cases using a quantity measure of transportation infrastructure.

To provide statistical evidence that the relationship between transportation accessibility and economic output is hardly bidirectional, endogeneity tests are conducted by comparing two estimation results from ordinary least squares and IV (Instrument Variable) approach (Table 2.4). Concerning logical and statistical relations, the number of establishments of manufacturing and service industries and the number of stations of a HSR line connecting two largest cities are selected for IVs of road accessibility and railroad accessibility, respectively. By implementing F-tests for the joint significance of coefficients on IVs, null hypotheses that the IVs are weak are rejected at the 1% of significance level in both cases of road and railroad accessibility. Consequently, a Wu-Hausman (WH) test and a Durbin-Wu-Hausman (DWH) test with a null hypothesis that regressors including road and railroad accessibilities are exogenous are implemented. By failing to reject the null hypothesis at conventional significance level in both tests, we do not consider endogeneity issue in following impact analysis of road and railroad accessibility on manufacturing output.

Table 2.4 Validity Checks for Instrument Variables and Endogeneity Tests

		Test	Statistic	p−value
Validity of IVs (H_0: IVs are weak)	Road accessibility	F−test	10.450***	0.000
	Railroad accessibility	F−test	88.074***	0.000
Endogeneity test (H_0: Regressors are exogenous)		WH (F−test)	0.897***	0.509
		DWH (χ−test)	1.771***	0.413

***: statistically significant at 1% level

Table 2.5 presents the results of the production function estimation. Besides a full model (model 1) in the form of equation (2.9), two restricted models focusing on the interaction effect between specific factors – inter−modal interaction (model 2) and interrelationship between transportation accessibility and urban agglomeration (model 3) are estimated.

Table 2.5 Estimation of Production Function of Manufacturing Industries

Equation form	Model 1		Model 2 (γ_2=0 and γ_3=0)		Model 3 (β_4=0, β_5=0 and δ_2=0)	
Variable	Estimate	S.E.	Estimate	S.E.	Estimate	S.E.
lnL	0.813***	0.008	0.811***	0.008	0.812***	0.008
lnK	0.187***	0.008	0.189***	0.008	0.188***	0.008
$(\ln L)^2$	0.109***	0.002	0.109***	0.002	0.109***	0.002
$(\ln K)^2$	0.109***	0.002	0.109***	0.002	0.109***	0.002
lnL*lnK	−0.109***	0.002	−0.109***	0.002	−0.109***	0.002
lnRoad	1.304+	0.907	1.457**	0.644	−0.687***	0.242
lnRail	−1.426***	0.378	−0.648**	0.295	−0.855***	0.273
lnRoad*lnRail	0.066**	0.034	0.057*	0.034	0.056***	0.018
$(\ln Road)^2$	−0.067**	0.034	−0.068**	0.029	−	−
$(\ln Rail)^2$	0.016	0.018	−0.008	0.016	−	−
lnPop	0.442***	0.169	0.007	0.006	0.588***	0.155
lnPop*lnRoad	−0.004	0.013	−	−	−0.022**	0.009
lnPop*lnRail	−0.026***	0.009	−	−	−0.017***	0.007
Station	0.137	0.112	0.184***	0.111	0.016***	0.009
Station* lnRoad*lnRail	−0.001	0.000	−0.001+	0.000	−	−
Region	−0.052***	0.019	−0.034**	0.018	−0.064***	0.018
Intercept	1.29	6.317	−5.436	4.265	12.943***	3.773
Restriction 1	1226.033***	224.4	1112.422***	227.3	1219.238***	224.8
Restriction 2	3943.15**	1902.9	2991.298	1925.2	3934.681**	1903.1
Restriction 3	9782.537***	2424.3	8495.256***	2458.9	9722.48***	2428.1
Adj. r−square	0.919		0.919		0.919	
Sample size	2,108		2,108		2,108	

***: statistically significant at 1% level; **: statistically significant at 5% level;
*: statistically significant at 10% level; +: statistically significant at 20% level

Despite the negative estimates of railroad accessibility index appearing in all models, it is hasty to conclude that the increase in railroad accessibility adversely influences manufacturing productivity, because the ultimate influence is determined by the parameters of interaction terms as well. The estimates of the interaction term between the two types of accessibility are positive and statistically significant in all models. This implies that the roles of road and railroad are close to complementary. Accordingly, *ceteris paribus*, the marginal contribution of railroad accessibility to manufacturing industries would be higher in regions with well-connected road networks. However, the number of rail stations within the municipality itself and neighboring municipalities slightly attenuates the complementary relationship between road and railroad accessibility[14]. In other words, regions with relatively poor access to railroad facilities are likely to have weaker inter-modal complementarity, being closer to a state of "structural inelasticity" due to the lack of alternative transportation modes (Rich *et al.*, 2011).

As shown in model 1 and 3, manufacturing activities seem to benefit from an urbanization economy in general. However, the interaction terms of population density and transportation accessibility have negative coefficients, indicating that the marginal gain from urban scale diminishes as the accessibility level increases. The reduction in transportation costs improves accessibility to commodity markets and urban amenities, allowing the benefit from

[14] The p-value of estimates of the interaction terms composed of the number of rail stations and the two types of accessibility are 0.27 and 0.138 in model 1 and 2 respectively.

larger urban scale. In addition, it leads to the expansion of the commutable area and facilitates interaction among firms and labor, in turn broadening labor pools and providing a source of innovation. In other words, proximities between economic entities in time and space dimensions are substitutable for each other, though not completely. In this regard, Graham (2007) emphasized the role of transportation accessibility based on the equivalence of the improvement in transportation accessibility and the increase in the effective density of urban activities.

The empirical findings from the three models are by and large consistent across models, though the model complexity comes at the expense of the statistical significance of some variables (e.g. the squared term of railroad accessibility and the interaction between population density and road accessibility). Hence, for the sake of full information, we discuss the marginal productivity effects of road and railroad accessibility based on the result of model 1. The impact of transportation accessibility on regional economy can be assessed based on the output elasticity value in terms of manufacturing value added as follows:

$$\eta_{Road^r} = 1.304 - 0.134 lnRoad^r + 0.065 lnRail^r - 0.004 lnPop^r \\ -0.0005 lnRail^r Station^r$$

$$\eta_{Rail^r} = -1.434 + 0.066 lnRoad^r + 0.032 lnRail^r - 0.026 lnPop^r$$
$$-0.0005 lnRoad^r Station^r$$

The output elasticity with respect to road accessibility evaluated at the sample mean of exogenous variables is 0.116, higher than the case of railroad accessibility, 0.046. The output elasticity values with respect to road and railroad accessibility, evaluated at the mean condition for the 239 cities and counties are summarized in Table 2.6. The increase in productivity of local manufacturing industries due to a one percent increase in the level of road accessibility ranges from −0.027% to 0.356%, showing a slightly higher deviation than those of railroad accessibility, ranging between −0.153% and 0.139%.

Table 2.6 Output Elasticities with respect to Road and Railroad Accessibility by Region

Road accessibility		Railroad accessibility	
Average	0.116	Average	0.046
Maximum	0.356	Maximum	0.139
Minimum	−0.027	Minimum	−0.153

Figure 2.3 shows the estimated output elasticity respect to road and railroad accessibility for our sample municipalities. The observations are categorized into three groups according to the sign

of the output elasticity values with respect to road accessibility and railroad accessibility respectively: those having positive output elasticity values with respect to accessibility of both transportation modes (upper−right side), those having a positive output elasticity with respect to railroad but a negative elasticity with respect to road accessibility (upper−left side), and those having a positive output elasticity with respect to road accessibility exclusively (lower−right side). The majority of municipalities are expected to benefit from the improvement in both road accessibility and railroad accessibility. While only 5% of observations show negative output elasticity with respect to road accessibility, maintaining positive returns to railroad accessibility, a negative influence in terms of manufacturing outcome is expected for 20% of them due to the enhancement of railroad accessibility.

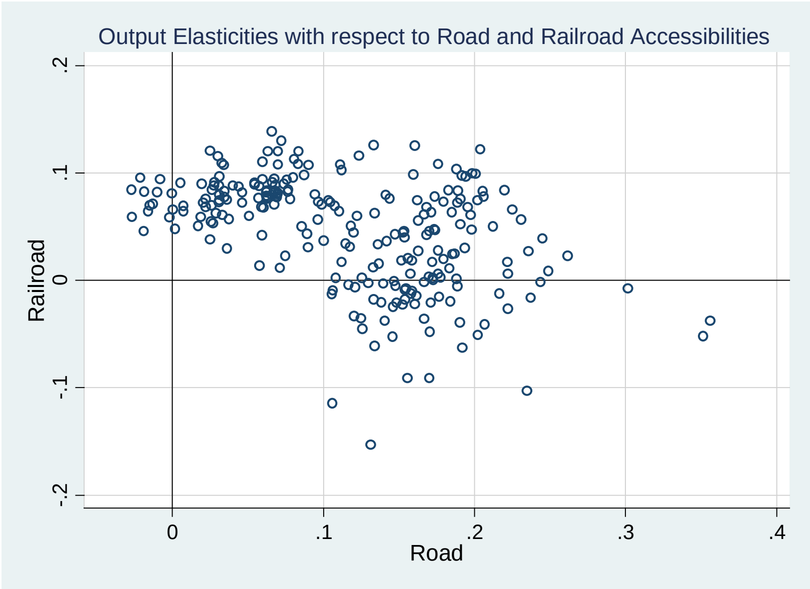
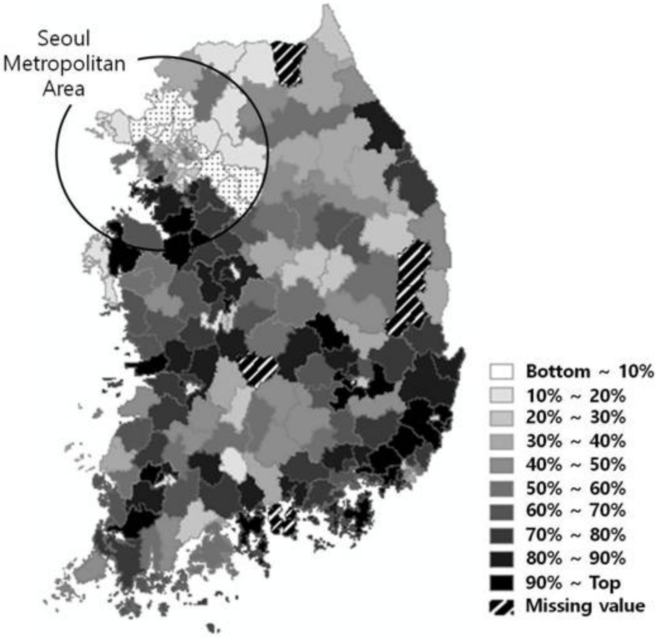
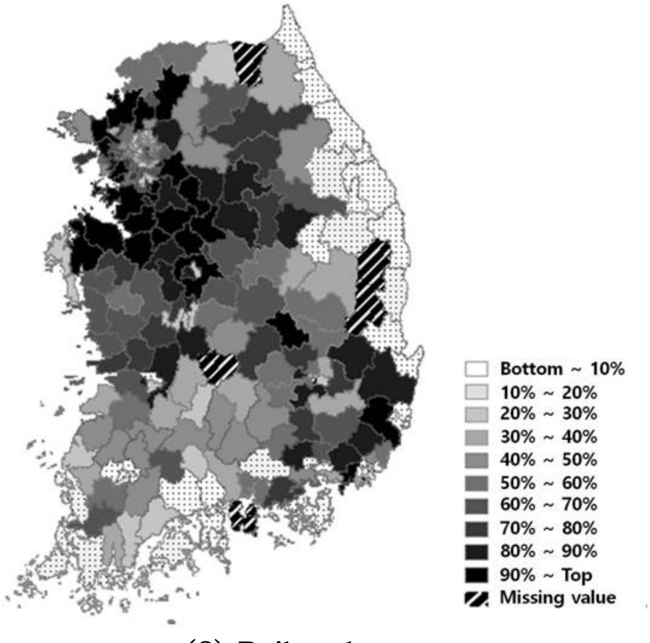


Figure 2.3 Estimated Output Elasticities with respect to Road and Railroad Accessibility

To discuss the local variation of the sign and the magnitude of impact from road and railroad accessibility, marginal value added with respect to each type of accessibility is used. The marginal value added at local level is calculated by multiplying the initial value added aggregated by local manufacturing industry and the output elasticity. Figure 2.4 illustrates the marginal value added of road and railroad accessibility at local level. The darker the background color, the greater the marginal value added; dot-fillings indicate negative marginal value added in local manufacturing sectors.



(1) Road

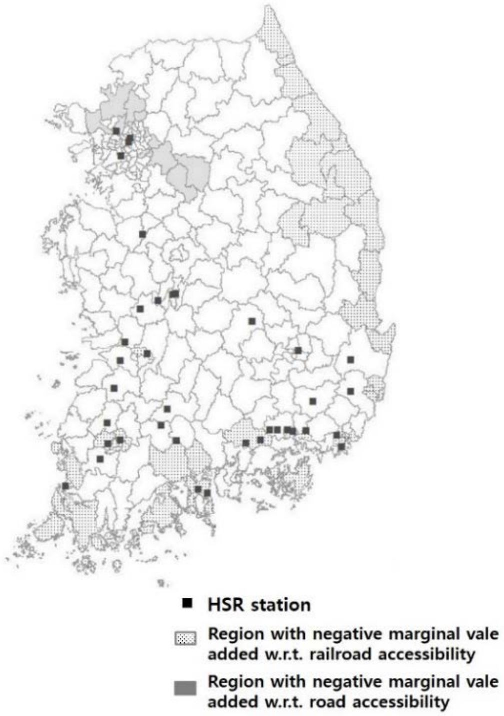


(2) Railroad

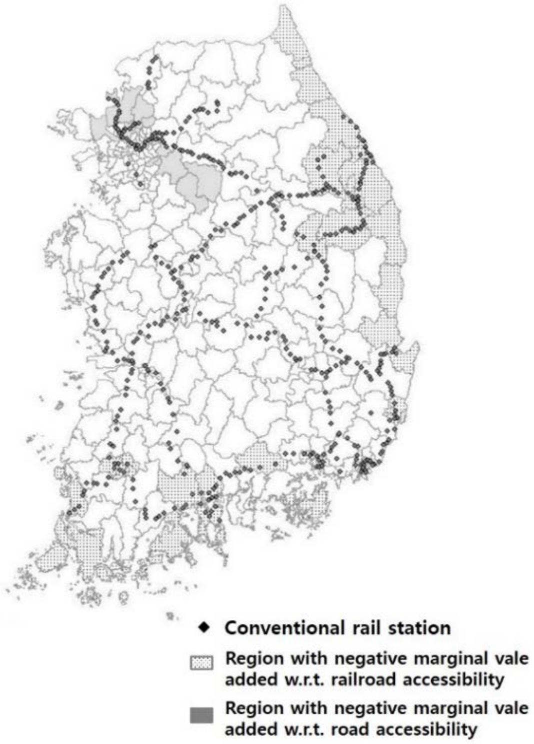
Figure 2.4 Marginal Value Added with respect to Road and Railroad Accessibility

The presence of negative marginal value added implies that the higher level of accessibility is not necessarily desirable in terms of regional economic gain, as often suggested in literature (e.g. Givoni, 2006; Van den Berg and Pol, 1998; Thompson, 1995). The potential interpretations of the negative output effect of railroad accessibility are as follows. First of all, the majority of eastern coastal regions (excluding a few of them located in south-eastern side) and part of southern coastal regions of South Korea, characterized by limited quantity and quality of production factors, lower level of industrial agglomeration, and remoteness to larger markets concentrated in the Seoul Metropolitan Area (SMA), have been unfavorable location for manufacturing industries. This implies limited ability to exploit the opportunity potential for higher industrial output; the underutilization of railroad accessibility would mean a 'relatively excessive level of accessibility' for their economic status.

Nonetheless, focusing on other aspects of the network quality aside from travel speed, these regions might be in an inferior position. As shown in Figure 2.5, the railroad transportation of regions with negative marginal value added with respect to the increase in railroad accessibility (dotted areas) is dominated by conventional railroad instead of HSR. Besides, even in the existence of HSR stations, they tend to be terminus point lacking of further connection to other HSR lines. Represented by node C1 ~ C3 in the illustration of national railroad network (Figure 2.6), they are characterized both by remoteness from first-tier city on the network and disconnection to other HSR lines. The former issue is relevant to territorial polarization between first- and lower-tier cities due to the advent of HSR (Garmendia *et al.*, 2012). Regarding to the latter issue, importance of diversity of alternative routes (or accessible destinations) has been emphasized by several authors, as "potential number of economic linkages" affects the scale of positive externalities of transportation (Vickerman, 1997; Laird *et al.,* 2005; Givoni and Banister; 2012). In this sense, the benefit from improvement in railroad networks could be concentrated in the core (node A1) or major access points (nodes B1 ~ B3).



(1) HSR stations



(2) Conventional rail stations

Figure 2.5 Spatial Distributions of HSR Stations and Conventional Rail Stations

Furthermore, due to geographical features such as mountainous terrain and coastal topography and their location along the edge of the territory, the regions are rather isolated from the rest of the country, especially from the SMA. Narrowing the opportunity to interact with other parts of the nation, this can be another source of disadvantage in terms of economic potential.

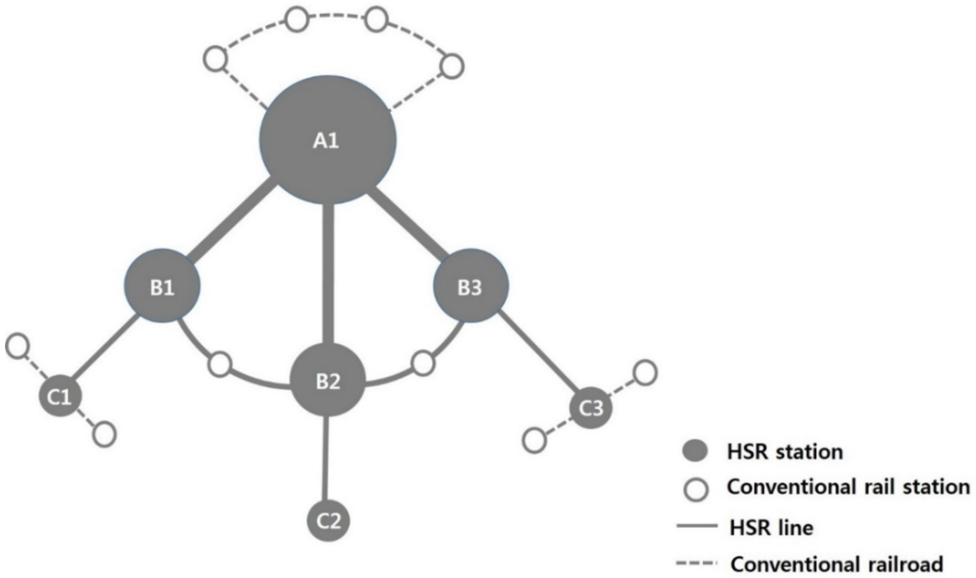


Figure 2.6 A Diagram of the Hierarchical Structure of HSR Stations in the National Railroad Network

Meanwhile, a negative output effect of road accessibility is found in the northern and eastern parts of the SMA having outstanding road accessibility but poor railroad accessibility[15]. Negative externality due to congestion would be expected here, because high volume of traffic to/from the capital and other parts of the nation is mainly served by local road networks. In this case, an improvement in railroad accessibility could be a solution[16]. Interestingly, no regions show a negative elasticity value for both road and railroad accessibility. This implies that regions with supersaturated status in terms of both road and railroad accessibility are not found yet in South Korea.

The marginal value added with respect to railroad accessibility turns out to be highest (upper 10%) among cities and counties located in the south of the SMA, which is characterized by high accessibility using road networks, and relatively lower population density, around 500 people per square kilometer. Manufacturing industries with high value added (e.g. electronics) are intensively

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[15] Since no HSR line passes through the area, access to HSR network is indirectly served by road or the conventional railroad network with a low level of load capacity and speeds.

[16] Recall that railroad accessibility depends on inter-station load capacity and travel time, while road accessibility is measured based on population size of destination and travel time. In order to relieve congestion, development of alternative routes would be more effective than reduction of travel time on the shortest-time-path. Contrary to negative marginal value added with respect to road accessibility, the marginal effect with respect to railroad accessibility is quite high, consistent with earlier findings (Vickerman *et al.*, 1999) that transportation improvement contributes to regional development when it leads to elimination of a bottleneck.

located due to the advantage of land prices and proximity to the capital area, which is a hub of knowledge production and main offices. There is no strong tendency of diminishing returns to railroad accessibility. Rather, the economic benefit tends to accrue to major rail stations, including intersecting points of rail lines. In addition, the complementary relationship between road and railroad accessibility holds regarding the externalities to manufacturing value added. In particular, the integration with local transportation networks seems to enhance the efficiency of HSR services.

However, concerning the marginal value added with respect to road accessibility, regions with a moderate-high level of railroad accessibility but deficient road accessibility turn out to be more advantageous. This result implies two things: overall accessibility using road networks is beyond a critical level, so the additional improvement brings a limited economic benefit to South Korea; nonetheless, the improvement in road accessibility would be beneficial to local private outcomes when it leads to better connectedness to railroad networks and eventually facilitates the use of railroad services.

This suggests that cross-modal development is a critical factor in increasing the marginal benefit from transportation infrastructure; a synergetic effect is expected due to the expansion of opportunities for economic linkages and the increase in transportation efficiency by the use of integrated networks. Such network integration requires the development of an intermodal transportation infrastructure (tracks and terminals) and services, and is often supported by information and communication technology for the efficient management of the integrated transportation system. To fully exploit the benefit from the development of integrated transportation networks, the following efforts are required. On the supply side, the concurrent development of railroad and road infrastructure could be effectively done by the cooperation between governmental initiatives and subsequent investment by private agents. Overlapping investments in road and railroad should be avoided to effectively increase the benefit from intermodal integration. On the demand side, the improvement in local transportation networks linking major intermodal intersecting points to local markets and inter−modal connection in terms of frequency, capacity, and on−time reliability are required to further increase the use of an integrated system.

2.5. Conclusion

This paper analyzes the spatial economic impacts of road and railway accessibility levels on manufacturing output, with the focus on substitution and complementarity of the intra- and the inter-modal relationship. In a Translog production function framework, *ceteris paribus*, railroad accessibility has positive effects on the marginal value added of local manufacturing industries with respect to both road and railroad variables, enjoying increasing returns to scale. However, road accessibility could positively influence only on the marginal value added with respect to the railroad variables, holding decreasing returns to scale. This implies that there is not a competing but a complementary relationship between the two transportation modes in terms of increasing manufacturing production.

A future research agenda could entail quantifying of the road accessibility index with congestion effects considered. In this paper, the population of the destination is utilized to represent the mass of attraction, and planning speed is applied to calculate road travel time based on the assumption that the road infrastructure is under-saturated without traffic delay. As shown in Graham (2007), road traffic congestion negatively influences agglomeration benefits; thus, it would be meaningful to compare the productivity effect of transportation accessibility with/without consideration of the road traffic congestion. In addition, improvements in road and railroad accessibility affect the spatial mobility of labor and capital as well as population; therefore, it would be useful to analyze the spatial economic impact of transportation accessibility under an equilibrium state by developing a simultaneous system in which the production function and the functions of factor mobility and migration are interacted.

Chapter 3. Impact of Railroad Investments on Regional Economies: an Approach of Spatial CGE Model with a Micro-simulation Module of Railroad and Highway Networks

3.1. Introduction

Economic benefits from transportation investments can be classified into direct and indirect ones. The former includes time benefits for people and freight, while the latter are defined as the consequences of the reduction in transportation cost for production and location decisions of people and firms. In particular, academic emphasis has been made on identifying the indirect effects to affect the spatial concentration of economic activity. It would be necessary to establish a quantitative tool to calibrate these indirect effects of infrastructure projects if the government is willing to assess the development priorities in terms of economic efficiency and income distribution. In a sense that the benefits and costs of projects are generated through the production and consumption linkages among economic agents, their outcome should be measured in a systematic and general approach to take into account not only direct but also indirect effects.

This paper is focused on the estimation of indirect impacts of high speed rail (HSR) network in Korea, developing a framework for an economic analysis of highway and railroad projects using a general equilibrium model. This approach integrates a transportation model of highway and railroad with a Spatial Computable General Equilibrium (SCGE) model of 16 provinces. The former model measures spatial accessibility by each highway and railroad project, while the latter one estimates the urban and regional economic impacts of the transportation investments on the urban and regional growth. This integrated SCGE model specifies behaviors and choices of economic agents of seven producers, one household and one regional government for each province. The simulations on the opening of a HSR line assuming different degree of factor (i.e. labor and capital) mobility allow policy makers to appraise the transportation project based on economic growth and regional income variation in the short and long runs.

3.2. Literature Reviews

3.2.1. Spatial Economic Impact of Railroad Investment

There have been numerous attempts to analyze the wider economic impacts of railroad investment, which include more than just the direct user benefits of transportation cost savings. In terms of the impact’ s spatial scale, non-transportation benefits from railroad investment can be classified into the following categories:

(1) economic growth (increase in GDP) at the macro level, (2) agglomeration of economic activities and labor market efficiency at the meso level, and (3) the impacts on land and property values at the local level. (Banister and Thurstain-Goodwin, 2011) However, there seems to be disagreement about the validity of macro-scale effects. While the national average effect of transportation investment can be positive, marginal benefits of additional transportation investment are not necessarily observed at the same scale (Berechman, 1994). Moreover, the net benefit across a broader spatial scale could be a combination of the gains in some regions and the losses in the other regions. For example, an economic evaluation of Dutch Rail projects connecting rural Northern Netherlands with the urbanized Randstad area using the SCGE model shows that a decrease in travel time along the rail line would redistribute jobs throughout the Netherlands, reducing jobs in regions not receiving a direct benefit from the projects. Likewise, application of SCGE model in Koike *et al.* (2015), investments in the HSR network were expected to decrease the economic gross output of some regions despite increases in the national of both Japan and Taiwan. In fact, several authors have argued that transportation investment *per se* is not a sufficient condition for economic development (Rietveld and Nijkamp, 1993; Banister and Berechman,

2000). An environment with supportive economic and investment conditions, as well as political and institutional conditions is emphasized as an important precondition for economic growth resulting from the provision of transportation infrastructure (Banister and Berechman, 2000), underpinning regional variations in the size of the economic benefits derived from transportation investment.

In particular, spatial variations in the economic impact of HSR investment result from one of three main sources : spatially uneven changes in accessibility, the position of the city in the HSR network, or inherent differences in development potential. Regarding the first source of variation, accessibility increases are impacted by the presence or geographical proximity of an HSR station. In fact, several studies show that accessibility improvement depends on the presence or geographical proximity of an HSR station. Martínez Sánchez-Mateos and Givoni (2012) note that HSR investment could be disadvantageous to regions without a direct connection to HSR networks because they are likely to experience a relative decline in accessibility to major cities. Based on empirical evidence from the opening of a new HSR line in Spain, the author explain how the shift in travel demand and public funds to the new HSR line and the consequential decrease in the service levels of conventional lines penalized cities connected only to conventional railroad network. Monzón *et al.*, (2013) assessed the spatial impact of HSR extensions in Spain based on the observed change in the accessibility index and concluded that areas surrounding HSR stations would be the major accessibility beneficiaries, while emergence of shadow areas isolated from the improvement in accessibility would inevitably emerge. They explained that the size of the shadow areas would depend on the quality of the transportation network connecting them to the nearest HSR station. Hernández and Jiménez (2014) showed that changes in accessibility level caused by the introduction of new HSR lines can further affect local budgets. The results of difference-in-difference estimations indicate that the development of an HSR network in Spain increased local revenues and the local fiscal gap, and these effects were prominent among municipalities located within 5 km of an HSR station.

Nonetheless, some studies show that the economic impact of HSR development could differ even among cities with HSR stations, due to their relative position within the HSR network. For example, the benefit of HSR investment may not be sufficiently large for intermediate stations. As Vickerman (2015) notes, stops at intermediate stations, especially in the case of high-speed travel, tend to be restricted by the emphasis on rapid connections between major city-stations; this has led to the stagnation of travel demand to- and from- intermediate stations, contradicting the significant growth in passenger volume toward major stations. In addition, intermediate stations are often located outside of urban-hubs to avoid development constraints. Consequently, the utilization of HSR services would be limited without the integration of a local transportation network to support access to the station.

Concerning development potential, scholars seem to agree that initial scale of a local economy, which is in turn associated with the demand and opportunities for new business, is an important condition for achieving economic growth effect as an outcome of railroad investment. While the economic benefits of HSR tend to be concentrated in major cities with rich arrays of economic activities (Vickerman, 2015), some authors anticipate that small cities on the HSR network within 100 km of a metropolitan center could be developed as metropolitan sub-centers (Garmendia *et al.*, 2012a; Garmendia *et al.*, 2012b). Albalate and Bel (2012) stated that the regions with comparative disadvantage may suffer a loss of economic activities. However, when changes in welfare (e.g. household income) are of concern, as opposed to output growth, there may be different implications of a territorial shift in economic activities. Chen and Holl (2011) analyzed the town-level economic impacts of the introduction of HSR services in the UK, differentiating towns by their access to HSR stations and the time-distance from London. While towns with an HSR station within one hour distance of London tended to benefit in terms of local value added, those without an HSR station but located within one hour distance of London showed relatively higher household income levels, suggesting a commuting pattern from non-HSR towns to HSR-towns. Preston and Wall (2008) performed ex-ante and ex-post analyses of locations with HSR services in UK, and they concluded that the development gains would be more dependent upon supportive planning policies, than on the advent of HSR services.

3.2.2. Transportation CGE Models

CGE models have been widely used to investigate the indirect economic impact of transportation investment on regional economies. The general features of these models (hereafter called transportation CGE models) are described as follows:

(1) General equilibrium: The economic decisions of all agents within the system jointly satisfy system constraints, and

extra demand does not exist in any market (Robinson, 1989).

(2) Comparative statistics[17]: A policy impact is assessed by comparing the value of target variables at equilibrium before and after the implementation of the policy, assuming everything else is unchanged. Policy shock is generally represented by changes in a set of parameters or exogenous variables in the model. Therefore, the behavior of economic agents within the system must be described in the form of numerical equations based on theoretical foundations. Exogenous parameters are derived by calibration procedures or estimations using statistical data from a benchmark period.

(3) Ex-ante appraisal: By taking a comparative statistical approach, future impacts of transportation investment are anticipated within a predefined system of equations based on data predictions (Bröcker *et al.*, 2003). Accordingly, this can be an effective tool for evaluating policy alternatives; the impact of each alternative is analyzed by running a simulation differentiated by the specific policy stimuli.

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[17] In the case of a dynamic CGE model, the model specification is partly changed by the time period of analysis, taking forward-looking or backward-looking approach.

(4) Multi-regional structure: Regional disaggregation is generally adopted in transportation CGE models because investments in transportation infrastructure would generate spatially different effects based on the nature of the fixed location. Furthermore, the distributive effect of transportation investment that results from the redistribution of economic activities (Nijkamp and Rietveld, 1993) is explained by changing economic variables across regions, which requires the model's regional disaggregation.

As shown in Table 3.1, studies using a transportation CGE model to assess the economic impact of transportation investment are classified by how they define the role of transportation infrastructure in the economy. First, a reduction in interregional transportation costs has been especially underscored in European CGE models, which paid attention to transportation margins as a component of the price of commodities. Imperfect substitutability is assumed between locally produced goods and imports from other regions in the production of composite goods, and the optimal proportion between them is selected based on the principle of cost minimization. That is, the relative prices of goods produced locally and in the other regions, depend on transportation margins, which are critical in determining their demand. In this case, transportation investment and the consequent reduction in transportation costs could lead to price competitiveness and an increase in the demand for commodities produced in the respective region. To model transportation costs, iceberg-type specification has been widely adopted (Samuelson, 1954): a portion of the transported good is assumed to be used up during transportation (Bröcker, 1998a; Bröcker, 1998b; Oosterhaven and Knaap, 2003). Alternatively, the transportation cost for every origin-destination pair can be modeled explicitly; researchers use a transportation network database to estimate interregional transportation costs (Bröcker, 2001; Bröcker and Shcneekloth, 2005; Haddad and Hewings, 2005) and calculates the transportation coefficient driven by interregional trade data (Buckley, 1992) to indirectly assess transportation cost.

The alleviation of congestion is another important source of transportation investment's economic benefit. The basic assumptions are as follows: 1) transportation cost is determined as a function of transportation volume, the service level of transportation capital in the private sector (i.e., trucks and other vehicles) and prices of substitutive transportation services; 2) an increase in transportation capital has both positive and negative effects on the amount of transportation services by the increasing input and congestion externalities, respectively; 3) hence, deviation from the optimal transportation capital stock allocation will reduce efficiency in transportation services and raise transportation costs as a function of transportation volume and the price of transportation services provided. An increase in transportation investment is assumed to increase the level of transportation services, reducing congestion and transportation costs.

Transportation infrastructure can be conceived of as a production factor for transportation sector. For example, Chen and Haynes (2013, 2015) made an assumption that the output of the transportation service sector is used as an input to produce goods in non-transportation sectors. In this model structure, regional disaggregation is unnecessary because substitution between locally produced commodities is not considered and gross output is determined by endowment of transportation capital *per se*, not regional distribution.

From the viewpoint of transportation investment increasing industrial output by enhancing productivity, transportation accessibility is assumed to be the channel through which economic benefit is transmitted. Since accessibility improvements could lead to the agglomeration of economies and location efficiency in industrial activity (Kim *et al.*, 2004), a production function using the accessibility variable and conventional factor inputs can be specified in the CGE model. By capturing the effect of the quality of transportation infrastructure and the effect of investment on cross-regional spillover through the transportation network, the accessibility variable could be a good replacement for transportation investment quantity. In this case, the effect of transportation investment is assessed in two stages: using transportation network information as a benchmark, the accessibility level is used to estimate a production function; and the accessibility level projection altered by transportation investment, is then injected into the CGE model, and baseline equilibrium solutions and the counter-factual scenario are compared.

Table 3.1 Application of CGE Model to Analyze the Economic Impacts of Transportation Investment

Role of transportation infrastructure	Application
Reduction in interregional transportation cost	− Evaluation of welfare effects of investment in trans−European transportation network (Bröcker *et al.*, 2003) − Evaluation of transportation pricing policies and transnational road infrastructure (Bröcker, 2006) − Economic evaluation of Dutch Rail Proposal (Oosterhaven and Knaap, 2003) − Analysis of the social return and cohesion effect of the TEN−T priority list of projects (Bröcker *et al.*, 2010) − Evaluation of economic effects of transportation cost reductions through price and income channels (Haddad and Hewings, 2005)
Dissolution of traffic congestion and productivity gain	− Identification of optimal capacity of transportation infrastructure (Conrad, 1997) − Analysis of the effect of road investment on road infrastructure in terms of social cost of congestion with simulations of financing policies (Conrad, 2002)
Increase in public transportation capital stock	− Evaluation of the economic impact of public transportation capital stock on road, air, transit, and water transportation (Chen and Haynes, 2013) − Evaluation of the regional impact of public transportation infrastructure at multilevel geographic scales (Chen and Haynes, 2015)
Improvement in accessibility	− Estimation of the dynamic economic effects of a highway project in terms of growth and regional disparity (Kim *et al.*, 2004) − Investigation of the synergetic effect of investment in highways (Kim *et al.*, 2009) − Economic evaluation of tax policy to finance the provision of highway networks (Kim *et al.*, 2011)

Since each of the abovementioned approaches has different assumptions about the key role of transportation infrastructure, one should consider the advantages and limitations of these approaches and the environmental setting of the study area to adopt the most appropriate approach. A transportation cost-oriented approach would be highly suitable if transportation cost accounts for a relatively large portion of commodity price and the spatial scale of impact analysis is broad. In addition, since reductions in transportation costs are assumed to primarily affect substitution between goods produced in different regions, this approach would be more suitable for a case with many component regions. If the study area is composed of only a few regions, price competitiveness in terms of inter-regional trade may be less critical. For example, the use of a transportation cost-oriented approach in CGEurope models (Bröcker, 2006; Bröcker and Schneekloth, 2006) covering hundreds of EU regions at the NUTS 3 level seems to be proper, as it explains the emergence of gaining and losing regions as a result of the development of the Trans-European Transport Network. However, this approach requires a rigorous dataset to estimate transportation cost function parameters and elasticity of substitution and share parameters, which is more costly than an interregional input-output (IO) table based CGE model. Given the huge effort required by the data-gathering process, the use of this approach would be justified only if the model specification captures actual behaviors of economic agents within the system. This approach may not be the best alternative to analyze the regional economic impact of HSR development in Korea. First, the development of the HSR network is more closely related to improvements in passenger transportation, not freight transportation. In addition, interregional trade would be less elastic to transportation costs in small countries such as Korea. Last, the presence of officially published IO tables enables us to model the interregional structure without relying on a costly estimation process.

The second approach focuses on the alleviation of traffic congestion and can be an effective tool for evaluating transportation investment policies from the perspective of the social cost of congestion. However, the model has not yet been expanded to apply to multi-regional and multi-modal model specifications. For example, it is challenging to model the shifts in traffic demand from other regions or transportation modes caused by the provision of transportation infrastructure. In addition, efforts to set the values of key parameters (such as transportation demand in response to traffic congestion, the transition of public transportation capital to the productivity of transportation service sectors, and the definition of traffic congestion) from a rigorous data set or knowledge from other fields (e.g., transportation engineering) would be needed to encourage the practical use of this approach.

The third approach explains the role of public transportation infrastructure as an input of the transportation service sectors and is intuitive and practical to implement. However, this approach is better for explaining the net economic impact of transportation investments aggregated at a national or macro−regional level than for observing gains and losses through a multi−regional model. Chen and Haynes (2015) adopted a spatial econometric CGE model to address the spatial spillover of labor and capital across regional boundaries –substitution or complementarity between production factors in neighboring regions; however, the spillover effect of regional transportation capital endowments was not taken into account. In addition, limiting transportation capital contributions to transportation service sectors might cause broader economic impacts, such as productivity increases and the emergence of agglomeration economies in other industrial sectors, to be overlooked.

The final approach emphasizes the role of transportation infrastructure as a facilitator of agglomeration economies and productivity as a result of enhanced opportunities or interaction between economic activities. The external shock is injected into the production module instead of composite goods made of commodities produced in different regions. This approach is suitable to this study area, as transportation cost has a less critical role in the determination of commodity prices and international trade dependency is relatively high. An approach oriented toward production function has often been criticized because a single output elasticity value does not represent the variation in output growth effects observed in transportation infrastructure. This study differs from prior studies in that it specifies interactions between transportation accessibility and other region−level variables, such as production factor endowments and employment density, to explain regional variations among the marginal contributions of transportation infrastructure. Accordingly, the transportation model (which is later incorporated into an SCGE framework) captures spatially differentiated economic growth patterns among regions, caused not only by differences in accessibility improvements but also by differences in output elasticity with respect to changes in transportation networks. Moreover, this study addresses changes in the regional economic impact of increase in factor mobility in transportation infrastructure over time by running simulations with varying factor mobility restrictions across regions and industrial sectors. By doing so, we aim to predict whether the regional economic benefit gap in transportation investment is widening over a longer time span.

3.3. Model

3.3.1. Overview

The transportation-SCGE model consists of two sub-models; a transportation model and a SCGE model. The transportation model calibrates the spatial accessibility of the highway and railroad based on the minimum distances or travel times among 237 city and county zones, while the SCGE model estimates the economy-wide impacts of the highway and railroad investment expenditures and the accessibility on the spatial economies at a 16-province division of the country. The impacts of the transportation infrastructure to economic sectors can be examined in two ways such as changes in the construction investment expenditure and the transportation capital stock, and changes in the spatial accessibility level. However, the latter is the fundamental outcome of transportation investment which results from capitalized an increase in the level of accessibility as a form of land rent and consumer surplus (Banister and Berechman, 2000). It affects location of households and firms, and the levels of factor productivity and agglomeration economies. The welfare gains occur to consumers and producers through the spatial rearrangement of economic activities to relocate to the place maximizing utility and profit levels. The changes in accessibility, by definition, result from either change in regional population size or change in the network, and affect the urban activities, exerting circulative pressure on the changes themselves in turn (Shefer and Shefer, 1999). Consequently, the economic gains depend on not only the location but also the connectivity of the transportation link with others. In this paper, the following steps are involved in estimating the economic impacts of transportation investments from the spatial accessibility.

(1) calculation of an interregional minimum distance matrix (travel time) by railroad project

(2) calculation of an accessibility index by railroad project

(3) injection of the new accessibility to the SCGE model

(4) calibration of the economic indirect impacts of the railroad project on regional economies

3.3.2. Transportation Model

The transportation model calculates the changes in the accessibility resulting from the highway and railroad system development. The accessibility is an indicator of the level of services provided by a transportation network, implying the "opportunity potential" through spatial interactions or contacts with economic activities (Kim *et al.*, 2004; Kim and Hewings, 2011; Lee and Kim, 2014). The determinants of the accessibility are the levels of activities at the destination and transportation cost between the origin and the destination. The generalized description of the indicator is given by:

$$Acc_i = \sum_j M_j f(C_{ij}) \tag{3.1}$$

Acc_i : Accessibility of origin (zone i)

M_j : Level of activities of destination (zone j)

$f(C_{ij})$: Decay function of generalized travel cost from zone i to zone j

The level of activities of a destination is commonly measured by population, assuming the mass of economic activities are closely related to its population size. However, the opportunity of spatial interaction can be limited by travel capacity on the path. Given that the frequency of operation and the load capacity of vehicle can be constraints for the amount of railroad traffic, the population is replaced by the daily load capacity on the path for the case of railroad transportation.

The decay function describes to travel by the increase in the generalized travel cost. The travel cost is generally represented by travel time or distance. In this paper, inter-zone travel time is derived from the shortest route algorithm in ARC-GIS, and intra-zone travel time is calculated based on the radius of the zone, with the assumption that the zone is in a circular shape, and average road travel speed within the zone, referring to Gutiérrez (2011). To describe the decrease in spatial interactions by travel cost, the negative exponential function (equation 3.2), a widely used form in national level analysis (Rosik *et al.*, 2015), is applied as a decay function.

$$f(C_{ij}) = \exp(-\beta \times T_{ij}) \ , \ (\beta > 0) \qquad (3.2)$$

T_{ij} : Travel time between zone i and zone j

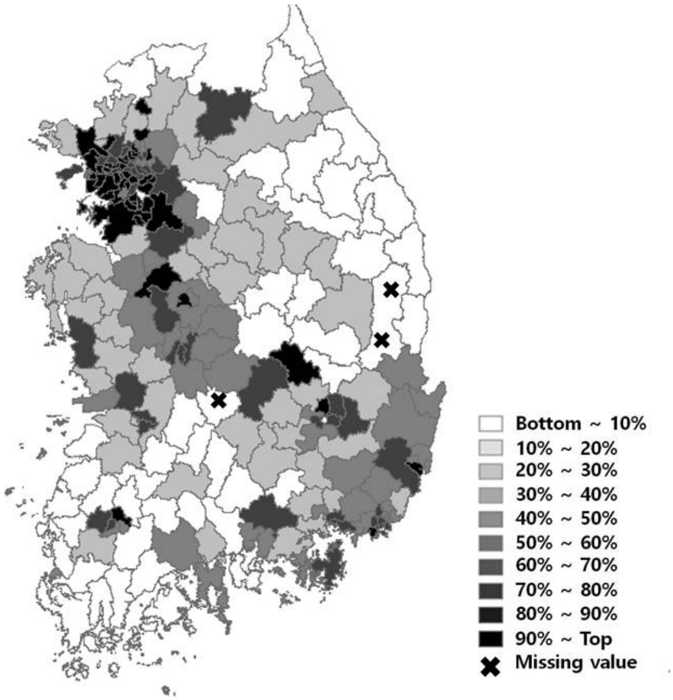
The decay parameter β is estimated for road and railroad transportation using inter-zone travel time and O-D travel flow data provided by Korean National Travel Survey. Equation 3.3 and 3.4 describe the measurement of accessibility index for road and railroad transportation, respectively. Figure 3.1 shows spatial accessibility of highway and railroad network calculated at 237 transportation zone (city and county) scale. The accessibility at the provincial scale used in the CGE model is a weighted average of the levels at the transportation zone (city and county) scale.

$$ACC_i^{Road} = Pop_i \times exp\left(-0.017 \times T_{ii}{}^{Road}\right) + \sum_j Pop_j \times exp\left(-0.017 \times T_{ij}{}^{road}\right) \quad (3.3)$$

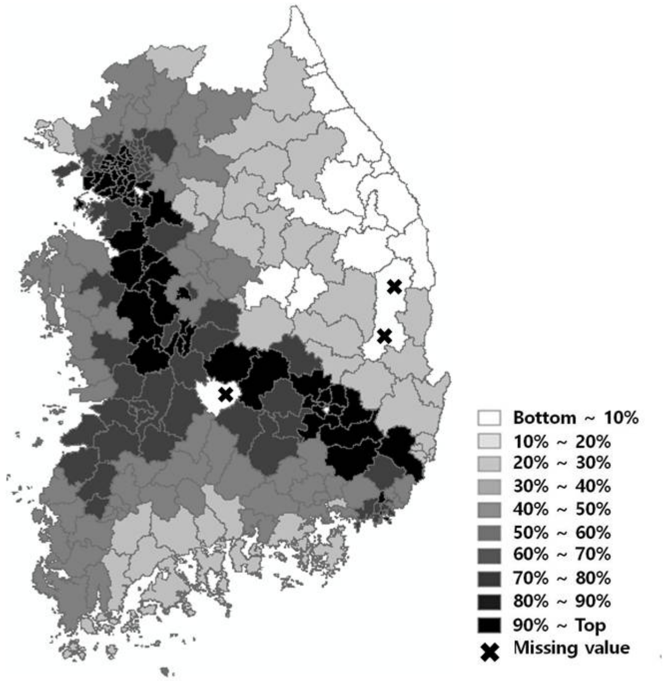
$$ACC_i^{Raiload} = Pop_i \times exp\left(-0.017 \times T_{ii}{}^{Road}\right) + \sum_j Capacity_{ij} \times exp\left(-0.009 \times T_{ij}{}^{Raiload}\right) \quad (3.4)$$

Pop_i : Population size of zone i

$Capacity_{ij}$: Daily load capacity of railroad transportation connecting between zone i and j



(1) Highway



(2) Railroad

Figure 3.1. Spatial Accessibility of Highway and Railroad Network

3.2.3. SCGE Model

The SCGE model estimates the effect of the spatial accessibility of transportation networks on economic growth and regional disparities in Korea. The structure of the CGE model follows the neoclassical elasticity approach of Robinson (1989), specifying the behavior of supply and demand of producers, households, and the government in the real economy and determining prices and quantities simultaneously. The supply side is concerned with the producers' behavior in demanding factor inputs and supplying products, while the demand side with the final demands of the above three economic agents. The agent is assumed to be a price-taker, and the equilibrium price is obtained by clearing any excessive demand in labor, capital, and commodity markets.

There are 16 provinces based on 237 cities and counties in Korea, and in each province, production activity is divided into seven industrial sectors: agriculture and mining, information-technology manufacturing, bio-technology manufacturing, nano-technology manufacturing, mechanical-technology manufacturing, construction, and services. Each industry is assumed to produce a single representative good under constant returns to scale and perfect competition in the commodity and labor markets.[18] The gross output by region and sector is determined by a two-level production function of value-added and composite intermediate inputs. The value-added is estimated by the translog production function of labor, capital stock, two accessibility variables of the highway and the railroad, while the intermediate inputs are derived from the multiregional input-output coefficients. The infrastructure data in monetary terms can give a misleading interpretation of the infrastructure endowment, so we use the accessibility index variable in order to take into account the potential use of the highway infrastructure (Rietveld and Bruinsma, 1998). The functional form of the production for four manufacturing sectors is as followings, while those of three non-manufacturing sectors are specified in the Cobb-Douglas technology due to data limitation.

[18] It would be possible to develop monopolistically competitive model that incorporates the increasing returns to scale and imperfect competition through disaggregating production inputs into variable inputs and fixed inputs. But this approach may have the drawback such that the results could vary with the types of assumptions including Cournot competition and Eastman-Stykolt collusive behavior (Brown and Stern, 1989; Harris, 1984).

$$
\begin{aligned}
ln\,VA_i{}^{\mathrm{r}} = {} & \alpha_0 + \alpha_1 lnL_i{}^r + \alpha_2 ln\mathrm{K_i}{}^r + 0.5\alpha_{11}(lnL_i{}^r)^2 + 0.5\alpha_{22}(ln\mathrm{K_i}{}^r)^2 \\
& + \alpha_{12} lnL_i{}^r ln\mathrm{K_i}{}^r + \beta_1 lnEmp^r + \beta_2 lnEmp^{r2} + \beta_3 lnRoad^r + \beta_4 lnRail^r \\
& + \beta_5 lnRoad^r lnRail^r + \beta_6 Road^{r2} + \beta_7 Rail^{r2} + \gamma_1 lnL_i{}^r lnRoad^r \\
& + \gamma_2 lnK_i{}^r lnRoad^r + \gamma_3 lnL_i{}^r lnRail^r + \gamma_4 lnK_i{}^r lnRail^r \\
& + \delta_1 lnEmp^r lnRoad^r + \delta_2 lnEmp^r lnRail^r + \delta_3 lnEmp^r lnRoad^{r2} \\
& + \delta_4 lnEmp^r lnRail^{r2} + \varepsilon_i \qquad (3.4)
\end{aligned}
$$

$VA_i{}^{\mathrm{r}}$: Value added of industry *i* in region *r*

$L_i{}^{\mathrm{r}}$: Labor input of industry *i* in region *r*

$K_i{}^{\mathrm{r}}$: Capital stock of industry *i* in region *r*

Emp^r: Total employment in region *r*

$Road^r$: Road accessibility index of region *r*

$Rail^r$: Railroad accessibility index of region *r*

Once the production function in equation (3.5) is estimated, the output elasticity values of highway and railroad transportation accessibility are derived by taking a partial differentiation of the value added with respect to the two types of accessibility. Equation (3.6) and (3.7) describe the output elasticity of highway accessibility and that of railroad accessibility.

$$\eta_{Road}{}^{r} = \frac{\partial VA^r}{\partial Road^r}\frac{Road^r}{VA^r}$$

$$= \beta_3 + \beta_5 lnRail^r + 2\beta_6 lnRoad^r + \gamma_1 lnL_i{}^r + \gamma_2 lnK_i{}^r + \delta_1 lnEmp^r$$

$$+\delta_3 lnEmp^r lnRoad^r \qquad (3.6)$$

$$\eta_{Rail}{}^{r} = \frac{\partial VA^r}{\partial Rail^r}\frac{Rail^r}{VA^r}$$

$$= \beta_4 + \beta_5 lnRoad^r + 2\beta_7 lnRail^r + \gamma_3 lnL_i{}^r + \gamma_4 lnK_i{}^r + \delta_2 lnEmp^r$$

$$+\delta_4 lnEmp^r lnRail^r \qquad (3.7)$$

In our SCGE framework, the value added elasticity with respect to highway and railroad accessibility in province level, the average elasticity value of component transportation zones, are applied to model the external shock of transportation investment. Table 3.2 shows regional variation in value added elasticity of highway and railroad accessibility inject to the SCGE model.

Table 3.2 Value added Elasticity of Highway and Railway Accessibility

Macro-region	Province	Value-added elasticity of accessibility	
		Highway	Railroad
Capital Area	Seoul	0.100	0.053
	Inchon	0.066	0.058
	Kyunggi	0.062	0.073
Central Area	Daejon	0.088	0.028
	Chung-buk	0.074	0.070
	Chung-nam	0.102	0.069
Western Area	Kwangju	0.056	-0.017
	Jeon-buk	0.091	0.036
	Jeon-nam	0.068	0.011
Eastern Area	Daegu	0.090	0.011
	Kyung-buk	0.073	0.042
	Busan	0.060	0.018
	Ulsan	0.069	0.007
	Kyung-nam	0.064	0.032
Mountain Area	Kangwon	0.008	0.039

The labor and the capital stock are aggregated by province. We assume that the endowment of both production factors is fixed within the province and the industry during the same period, but factor mobility increase with time. The change in factor mobility by time is discussed in detail and applied in simulation part (chapter 3.4.2). The labor demand by region and industry is derived from the producers' value added maximization, the first-order condition of the model, while labor supply depends on the population size. Under the neoclassical closure rule for the labor market, the average wage level by region is derived from balancing out total labor demand with total labor supply that is fixed for each period[19].

The regional gross output is transformed into foreign exports and domestic sales of supply. The latter includes the regional exports to other regions. The optimal division of the regional gross output into two types of commodities is determined by profit maximization in a Constant Elasticity of Transformation (CET) function. The ratio of exports to gross output depends on the relative ratio of the price of domestic goods to the domestic price of foreign exports. The total demands for goods and services by region and industry consist of intermediate demands, total consumption expenditures of households, the government consumption expenditures, and the regional investments. Such demands should be satisfied with foreign imports and domestic sales of supply. In minimizing cost with the Armington function, regional demands for foreign imports are determined by domestic sales and by the relative price of domestic goods to the world market price.

Each household in a province is assumed to supply capital and labor. The income of households is composed of returns on factor

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[19] Beside the neoclassical macroeconomic closure rule, there are a few alternatives to specify an interaction of wage with labor market clearing such as Kaldorian and Keynesian as shown in Rickman and Treyz (1993).

inputs of production and lump-sum transfers from the government. After paying income taxes and saving, the household allocates total consumption expenditures into individual goods and services under the maximization of Cobb-Douglas type utility. The governments in this paper consist of the national government and 16 province governments. The regional government is a consolidated government combining provincial (state) government and the municipalities of city and county. The national and regional governments levy taxes on households, producers and foreign imported goods; they spend current consumption and investment expenditures, transferring payments to the both producers and the households.

In terms of the macroeconomic closure rule for the capital market, aggregate savings determine investments. There is only one capital market, and the savings consist of four main sources including household savings, corporate savings of regional production sectors, private borrowings from abroad, and government savings. There are no financial assets in the model, so overall consistency requires equating total domestic investment to net national savings plus net capital inflows. The equilibrium between demand and supply can be achieved by a fully flexible adjustment of price in response to excessive demand, while the change in the price level yields information on economic agents' decision–making. The SCGE model of this paper has been calibrated to reproduce as a benchmark equilibrium, the multiregional Social Accounting Matrix (SAM) of 2005. The SAM is developed by incorporating the survey commodity flows and household expenditure with regional data on government revenues and expenditures, and on savings and investments. The SAM consists of eight accounts such as production factors (labor and capital), households, production, the governments, investment, capital, inventory, and the rest of world. The non–elasticity parameters such as tax rates, saving and consumption propensities, and shift and share parameters are determined from the SAM, while elasticity parameters including the substitution between domestic supply and foreign exports or between domestic demand and foreign imports are estimated with time series data or derived from a few previous works and references. The exogenous variables include world market prices, population, and government expenditure, and the *numeraire* of the model is set as the price of foreign exchange in nominal terms. Major equations applied in our SCGE model is summarized in Table 3.3.

Table 3.3 Major Equations of SCGE Model

Output	Output = *Leontief* (Value added, Intermediate demand)
Value added	Value added = *Translog* (Labor input, Physical capital stock, Total employment density, Spatial accessibility index of highway, Spatial accessibility index of railroad)
Supply	Output = *CET* (Foreign exports, Domestic supply)
Domestic supply	Domestic supply = *CET* (Regional exports, Intraregional supply)
Demand	Demand = *Armington* (Foreign imports, Domestic demand)
Domestic demand	Domestic demand=*CD* (Regional imports, Intraregional supply)
Regional incomes	Regional incomes = Wage + Capital returns + Government subsidies
Consumption by commodity	Consumption by commodity = *CC* (Price, Incomes)
Private savings	Household savings = *PS* (Income, Saving rate)
Government revenues	Government revenues = Indirect tax + Direct tax + Tariff
Government expenditures	Government use of funds = Government current expenditure + Government savings + Government investment expenditure + Government subsidies
First order condition for profit maximization (labor input)	Labor supply × Return from labor input = Value added from labor input
First order condition for profit maximization (capital input)	Capital supply × Return from capital input = Value added from capital input

Labor market equilibrium	Labor demand = Labor supply
Capital market equilibrium	Private savings + Government savings + Foreign savings = Total private investments
Commodity market equilibrium	Supply of commodities = Demand for commodities
Government	Government use of fund = Government revenues
Capital stock	Capital stock = Depreciated lagged capital stock + New investments

3.4. Indirect Economic Impacts of Railroad Network

3.4.1. Korean High-Speed Railroad

Figure 3.2 shows Korean railroad networks, composed of conventional railroad and HSR. Korean High-Speed Railroad (KTX hereafter) has been running from Incheon International Airport with two major stops at Seoul Station and Yongsan Station towards metropolitan cities such as Busan, Deagu, Gwangju, Daejon and Ulsan, and will be extended to Gangneung by 2018 Pyeongchang Winter Olympic Games venue. The KTX started the services in 2004 with a maximum operating travel speed of 305 km/hr (designed travel speed is 350 km/hr). In principle, KTX is composed of two primary lines; Seoul-Busan line (Northwest-Southeast corridor; Kyungbu-KTX) and Seoul (Yongsan)-Kwangju (Northwest-Southwest corridor; Honam-KTX) line. The former is identical to a traditional spatial-development-corridor, and has promoted economic interactions between capital area and other three major metropolitan cities. The latter one, developed more recently, links less developed Southwestern area to the capital and other major cities. The provision of Honam-KTX aims to vitalize the economies of this lagging region and further achieve balanced economic growth across regions. Figure 3.3 shows the change in spatial accessibility of railroad by the development of Honam-KTX line.

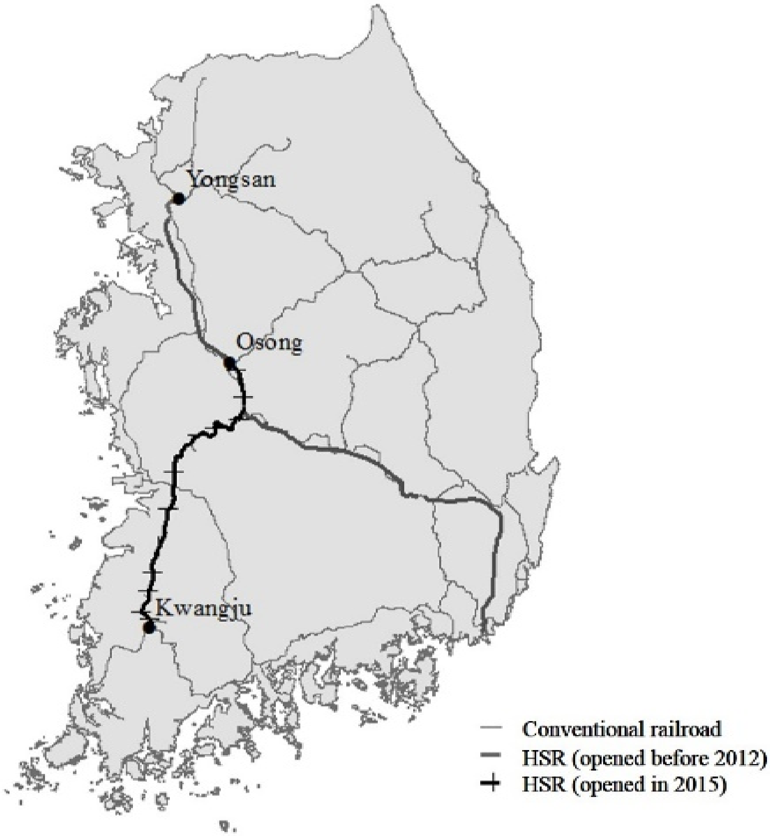

Figure 3.2 New Development of Honam-KTX Line

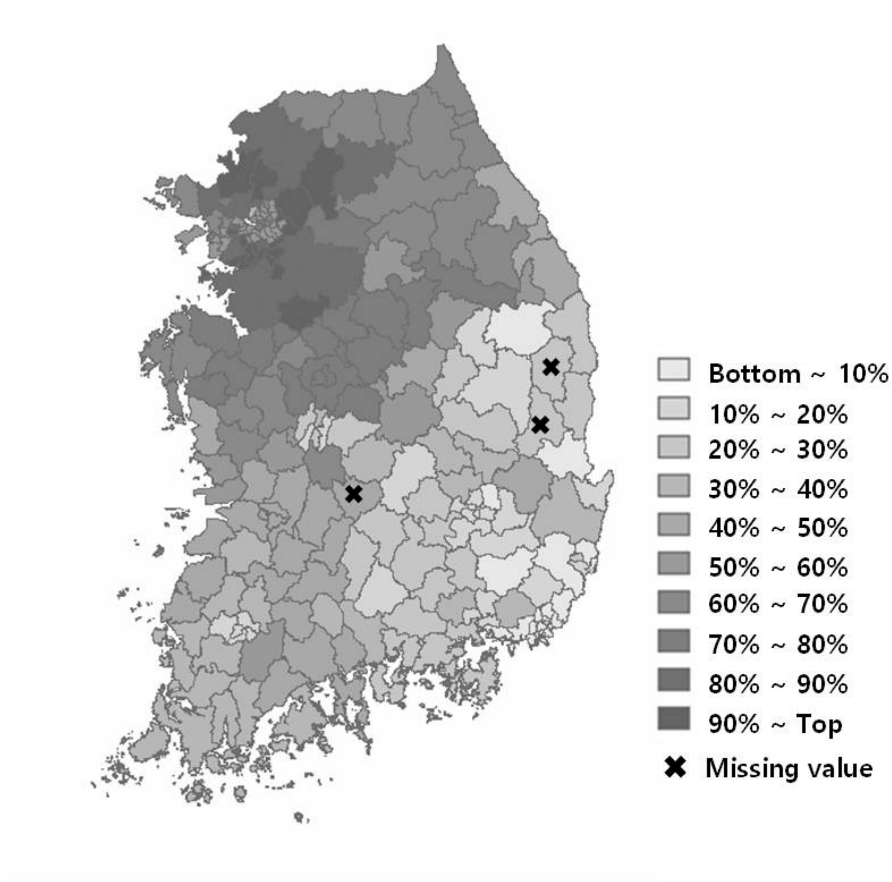

Figure 3.3 Change in Spatial Accessibility of Railroad by New Development of Honam−KTX Line

3.4.2. Simulation

The transport−SCGE model is applied to new development of Honam−KTX (Seoul−Kwangju) line in order to estimate the economic contribution of the railroad on regional economic growth and disparities in Korea. It is one of transportation investment projects designed to support the Western Coastal Development Corridor that focuses on the promotion of the China−Korea trade and economic cooperation. Since the analysis in this paper is only concerned with indirect economic impacts of the project, we do not take into account costs of construction and operation as well as direct economic benefits (i.e. time savings, reduction in accidental and environmental costs) in the computation. Such indirect effects are measured by the change in regional value added in this paper.

Production factors are generally assumed to become more mobile in the longer period of analysis (Li and Rose, 1995). In our model, both labor and capital are assumed to be immobile across regions and industries in the short term, but they are allowed to move across regions, triggered by the decrease in transportation cost. Inter-industrial mobility of production factors are assumed to increase too as an adjustment process. Redistribution of production factors involved with transportation investment would further affect the efficiency and equity of regional economies. To investigate indirect impacts of transportation investment on regional economies, and compare those by the degree of factor mobility, we set five different simulation options as follow[20]:

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[20] Underlying assumption is that the mobility of labor inputs are generally greater than that of capital inputs, because the latter is mostly composed of tangible fixed assets by definition and incurs the loss of sunken cost when they are spatially reallocated. In addition, due to industry-specific requirements in terms of skills and equipment, inter-regional factor mobility would be greater than inter-industrial factor mobility especially in small countries such as Korea.

(1) Option 1: Both labor inputs and capital inputs are immobile across provinces and industrial sectors

(2) Option 2: Labor inputs are mobile across provinces, but capital inputs are immobile across provinces and industrial sectors

(3) Option 3: Both labor inputs and capital inputs are mobile across provinces, but immobile across industrial sectors

(4) Option 4: Labor inputs are mobile across provinces and industrial sectors, but capital inputs are mobile across provinces only

(5) Option 5: Labor inputs are mobile across provinces, but capital inputs are immobile across industrial sectors and provinces.

When these changes in the accessibility level of the railroad are injected to the SCGE model, a set of new equilibrium are generated for the quantities and prices. The price levels of commodities and services are adjusted to equate supply and demand, satisfying the price normalization rule subject to the numeraire. The simulation exercises demonstrate how the railroad project is effective in terms of economic growth and regional disparities.

Table 3.4 shows the change in regional value-added involved with the development of Honam-KTX line for each simulation option. Compared to the base line (prior to the development), most of provinces experiences the increase in GRDP. The national GDP growth rate is lowest in simulation option 1, indicating the national economic growth effect increases with factor mobility across provinces and industrial sectors. In addition, factor mobility is favorable in terms of economic equity. The simulation option 1, characterized by immobility of production factors shows that economic growth is concentrated to the capital and central areas, while western and eastern areas experience lower growth or even the loss of GRDP. However, in the other simulation options wherein partial or full mobility of production factors is allowed, provinces with above-average level of growth in GRDP in simulation option 1 are facing the alleviation of the economic growth effect. In contrast, among the provinces with below-average level of growth in GRDP in simulation option 1, the economic growth effect increases as factor mobility is allowed.

In order to measure the equity-side effect of the railroad development, we applied cohesion indices listed in Lopez *et al.* (2008) – variation coefficient, correlation coefficient between relative change and the level, and correlation coefficient between absolute change and the level. Variation coefficients measure the level of disparity in GRDP under different simulation options; the greater value indicates less uneven distribution of GRDP. Focusing on cohesion effect in dynamic perspective, the latter two indices are calculated as the correlation between the GRDP prior to the railroad development and the change in GRDP (either relative or absolute change) after the development; the positive value indicates the increase in regional disparity and the negative value indicates the decrease in regional disparity involved with the transportation investment.

Table 3.5 shows the cohesion indices applied to the development of Honam-KTX line. First, the variation coefficients by simulation options indicate that the advent of the new HSR line increases the disparity in GRDP (Baseline vs. simulation option 1), but the disparity is narrowed down as factor mobility increases (simulation option 1 vs. simulation option 2~5). In particular, the equity level is improved more with inter-provincial factor mobility but without inter-industry factor mobility. The use of correlation coefficient between the level and relative change leads to similar findings; while the investment in the Honam-KTX line have diverging economic effect, the gap in regional value added decreases with factor mobility across provinces and industries.

However, correlation coefficient between the level and absolute change indicates that factor mobility contributes to the divergence of GRDP. Regarding this issue, Lopez *et al.* (2008) argued that cohesion effect of transportation investment should be analyzed with diverse indices, because the use of different measures can often lead to the opposite findings. In our simulation results, the difference between cohesion effect using correlation coefficient between GRDP and level change and that between GRDP and percentage change are relevant with initial difference in the scale of regional economy. This implies that although the increase in factor mobility generates distributive effect of economic growth, lagging regions without enough ability to exploit the improvement in transportation accessibility might not always be beneficiary from the investment.

In sum, the findings from our analysis indicate that the investment in high speed railroad positively affects national economic growth but negatively influence on regional distribution of the growth effect. The improvement in factor mobility alleviates regional income disparity, and regional economic growth effect is shifted to other provinces which were less benefited from the transportation investment at initial period. However, the redistribution of economic benefit tends to be accrued to the provinces closely connected to the high speed railroad network and possessing the ability to exploit the enhancement of spatial accessibility.

Table 3.4 Simulation Result on Regional Value-Added by Period (unit: %)

Macro-region	Province	Option 1	Option 2	Option 3	Option 4	Option 5
Assumption on labor mobility		Immobile	Within industry	Within industry	Between industries	Between industries
Assumption on capital mobility		Immobile	Immobile	Within industry	Within industry	Between industries
Capital Area	Seoul	0.005	0.010	0.012	0.014	0.019
	Inchon	0.014	0.025	0.026	0.021	0.022
	Kyunggi	0.084	0.038	0.037	0.042	0.032
Central Area	Daejon	0.001	0.028	0.026	0.018	0.023
	Chung-buk	0.033	0.031	0.029	0.027	0.025
	Chung-nam	0.052	0.044	0.045	0.031	0.027
Western Area	Kwangju	-0.020	0.032	0.030	0.009	0.015
	Jeon-buk	-0.001	0.017	0.016	0.015	0.018
	Jeon-nam	-0.024	0.025	0.022	0.010	0.015
Eastern Area	Daegu	-0.005	0.010	0.007	0.015	0.019
	Kyung-buk	0.006	0.035	0.035	0.016	0.018
	Busan	-0.004	0.011	0.009	0.010	0.014
	Ulsan	-0.053	0.040	0.038	-0.003	0.002
	Kyung-nam	-0.003	0.018	0.015	0.009	0.012
Mountain Area	Kangwon	0.003	0.013	0.014	0.017	0.023
Island	Jeju	0.002	0.000	-0.005	0.014	0.019
National		0.018	0.024	0.024	0.020	0.021

Table 3.4 Simulation Result on Regional Value-Added by Period (unit: %)

	Baseline	Option 1	Option 2	Option 3	Option 4	Option 5
Variation coefficient (%)	97.403	97.428	97.400	97.401	97.410	97.408
Correlation coefficient (level vs. relative change)		0.431	0.072	0.122	0.343	0.272
Correlation coefficient (level vs. absolute change)		0.622	0.753	0.779	0.811	0.930

3.5. Summary and Further Research Directions

This paper develops a framework for economic analysis of high-speed railroad of Korea (KTX) in order to estimate the dynamic economic effects of transportation project on the economic growth and the regional disparity in Korea. The framework is composed of a Spatial Computable General Equilibrium (SCGE) model and a micro-simulation module or transportation model of highway and railroad networks. The latter module measures a change in interregional accessibility by highway and railroad line, while the SCGE model estimates the spatial economic effects of the transportation projects on the GDP and the regional distribution of wages. The results indicate that while the development of Honam-KTX increases national economic output, regional disparity in terms of GRDP increases as well, and economic growth effect concentrate to the capital region and adjacent areas. However, the increase in factor mobility by time reduces the regional disparity and alleviates the divergence of regional economies. The increase in factor mobility is desirable in terms of the growth of national economic output as well, indicating the enhancement of factor mobility leads to better allocation of resources, and contribute to economic performance (Begg, 1995).

There are two further research issues regarding the SCGE modeling. One is that the recursive integrated transport-SCGE model can be transformed into a long-term optimization model based on the notions of rational expectations. The dynamic optimization model requires a large numbers of variables, and some of the parameters are likely to be statistically insignificant or to be guesstimates. It also has practical problems such as the limits of computation and the regional data for forecasting the control variables. This simulation contributes to the identification of the optimal allocation of railroad investments over time and space and measures their contribution to a reduction in regional disparities under constant economic growth. Another extension is to develop a framework to estimate economic effects of railroad linkages between North and South Korea on national economies. The possible access to the high-speed railroad of China may change the economic benefits of railroad projects and affect the priorities for construction. The network effects in this case are likely to be much larger than any other domestic link projects.

Chapter 4. The Impacts of Firm Aging on Location Preference: an Analysis of Manufacturing Firm Relocation in South Korea

4.1. Introduction

In several ways, the location choice of relocating firms provides useful information that is difficult to capture by analyzing only the location behavior of start-up firms. First, as 'a capital investment project' with the objective of maximizing net present value (Nakosteen and Zimmer, 1987), firm relocations can better signal the spatial benefits that supposedly outweigh relocation costs. Second, relocating firms are more likely to locate within a 'spatial margin of profitability' because start-up firms tend to possess less information on possible location options and are largely affected by arbitrary factors such as home township of the entrepreneur in their location choice (Boschma and Lambooy, 1999). In addition, a firm's relocation pattern often accounts for the evolution of their location preference and a shift between production processes, as suggested by product life cycle theory. Furthermore, firm relocation affects inter-regional income inequality by incurring losses or gains in local business and employments.

In recent decades, there has been a resurgence of studies on firm relocation (Mariotti, 2005) focusing on regional patterns of firm migration (Pellenbarg, 2005) determinants of firm mobility at either the firm or spatial level (Van Dijk and Pellenbarg, 1999; Brouwer *et al.*, 2004; Maoh and Kanaroglou, 2007; Knoben and Oerlemans, 2008; Nguyen *et al.*, 2013; Weterings, 2014; Foreman-Peck and Nicholls, 2015), spatial determinants of firm in-migration (Holl, 2004; Manjón-Antolín and Arauzo-Carod, 2011), the origin-destination flow of firm relocation (Arauzo-Carod *et al.*, 2015), relocation distances (Knoben, 2011; Weterings and Knoben, 2013; Hong, 2014), and the effect of firm relocation on firm performance (Knoben and Oerlemans, 2005; Macuchova, 2015). To date, however, very little attention has been paid to the role that firm level attributes play in firm relocation behavior. A notable exception is Kronenberg (2013) who takes into account differences in relocation behavior (both the decision to move and the consequent location choice) by the firms' industrial classification based on factor and knowledge intensiveness. In addition, to the best of the authors' knowledge, the relocation behavior of firms with prior moving experience has not yet been investigated. The number of prior relocations, for instance, makes it possible to explore changes in a firm's location preference by age[21]. According to the product

[21] Although the influence of a firm's age on its location behavior could

life cycle approach in economic geography (e.g. Duranton and Puga, 2001; Frenken *et al.*, 2011), the prior source of firm innovation tends to differ between young and old firms (e.g. product-oriented versus process-oriented), leading to a change in optimal location strategies at different firm ages.

This paper aims to analyze firm relocation[22] decisions by focusing on variations in prior relocation experience, firm type, size of employment, and industrial classification. Using a panel dataset of manufacturing establishments in South Korea, we analyze a two-step decision making process of relocation (whether to relocate and where to relocate). A key finding of this paper shows that firms tend to move from diversified areas to more specialized areas within their own sector, and this tendency is strengthened with firms' maturity in terms of the stage of their life cycle. In addition, the effects on a relocation decision of sector-specific wage level, land price, and distance from original location depend on 1) whether the factor serves as a cost or a benefit (e.g., labor cost versus quality of labor force) and 2) the difficulty of finding available qualified factor input (e.g., premises suitable for a firm's demands).

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also be examined by dividing the sample into subgroups of firms based on their age, we do not have a priori information on the cut-off age at which a change in a firm's location behavior is observed.

[22] In this paper, the notion of firm relocation is confined to inter-municipal changes in the address of the establishment.

This paper is organized as follows: in chapter 4.2, we propose research hypotheses on the basis of a theoretical background review; chapter 4.3 describes our research framework and estimation model, and presents and discusses the results; and chapter 4.4 summarizes the paper and discusses a future research agenda.

4.2. Theoretical Background

4.2.1. Firm Location Theories

Different theories and models of industrial location exist in the literature. A comprehensive review of firm relocation by Mariotti (2005) lists the theories closely related to firm relocations: the 1) neoclassical approach, 2) behavioral approach, 3) institutional approach, and 4) evolutionary approach. In neoclassical location theory, firms are assumed to have full information and to behave rationally with the principles of profit maximization. This theory models optimal location choices, focusing on the minimization of transportation and factor input costs (Von Thunen, 1926; Weber, 1929; Moses, 1958) or the maximization of potential market demand for the firm's goods or services (Hotelling, 1929; Hoover, 1948). Within the neoclassical framework, the optimal location for a firm is thought to be fixed. However, once changes in the firm's internal and external factors cause its current location to deviates from the spatial margins of profitability, it is supposed to move to another location where the profitability condition is satisfied.

In behavioral location theory, firms are assumed to have limited information and bounded rationality. According to Pred (1996), location choices depend on the general availability of information and the firm's specific ability to use information. Because access to information is spatially differentiated, firms located in central areas are in a better position to obtain access to relevant information. A location choice that falls within spatial margin of profitability increases a firm' s chances of survival and prosperity. However, the location of a new firm tends to be quite random because it is highly affected by arbitrary factors (e.g., the hometown of the entrepreneur). Moreover, due to bounded rationality and limited location alternatives, firms are more likely to settle for a sub-optimal, rather than optimal location. In contrast to the perspective of neoclassical location theory, relocation costs are significant and affect a firm's location choice. Firms are more likely to choose a location near to original site due to familiarity and ease of geographical orientation.

While booth neoclassical and behavioral location theories consider firms to be active decision-making agents in a static environment, the institutional location theory focuses on the external or institutional factors of economic activities (Brower *et al.*, 2004). Firm location behavior is considered to be determined by interactions between firms, rather than by the behavior of individual firms. This theory emphasizes embeddedness in social institutions or networks and interplay with other economic entities within the network; therefore, the notion of the institution is intrinsically territorial (Boschma and Frenken, 2009).

Compared to the other location theories mentioned above, evolutionary location theory is relatively new. By taking a dynamic perspective, this theory explains the spatial distribution of economic activity as a historical process. Spin-offs from parent firms are an important source of industrial clusters. Due to path dependence and place-dependence (Martin and Sunley, 2006), clusters are self-reproducing even without localization economies (Klepper, 2007). Particularly in emerging industrial sectors, first-generation firms are mostly spin-offs from related industries, so regions with industries related to the new industry are in a better position to create the new industry. Firm relocation has not yet been intensively studied from the evolutionary location perspective, but relevant theories on product life cycle (chapter 4.2.2) explain firm relocation as a change in the demand for agglomeration economies.

4.2.2. Dynamic Perspective of Agglomeration Economies and Firm Relocation

The product life cycle approach links product life cycle theory to economic geography, suggesting that firm locations change as the industry evolves from an explorative to a mature stage in its life cycle (Frenken *et al.*, 2011). According to this theory, emerging industries benefit from being located in metropolitan areas characterized by easy access to qualified production factors, an abundance of early users and institutional backup. However, as the industry moves to a mature stage of its life cycle, it is more likely to be attracted to peripheral areas where wage levels and land prices are lower and environmental regulations are less stringent. Duranton and Puga (2001) developed a dynamic equilibrium model showing that firms stay in diversified cities until they find an ideal process, but they then relocate to a specialized city and switch to mass production. Underlying this idea is the fact that locations in diversified areas are advantageous for firms searching for an optimal production process. However, these firms can benefit more from cost-reducing localization economies once they shift to the mass production stage. Duranton and Puga (2001) provided empirical evidence that over 70% of French firms have relocated from an area with above-median diversity to an area with above-median specialization. In particular, the relocation pattern from diversified areas to specialized areas was prominent among firms engaged in more innovative and agglomerative activities.

Similarly, in empirical studies of firm location in Portugal (Holl, 2004) and Catalonia (Manjón-Antolín and Arauzo-Carod, 2011), there was a significant positive association between industrial diversity and firm entry for start-ups, but not for relocating firms. More recently, Hong (2014) examined the determinants of firm relocation beyond commuting distances based on the notion that such firm relocations could be justified by positive agglomeration externalities that exceed the costs associated with distant relocation. Consistent with the product life cycle theory, these results indicate that the probability of relocating beyond commuting distances is higher when the new site alternative has a larger share of local industry employment. This pattern is clearer among older firms. The production life cycle approach is useful in explaining the stylized pattern of firm relocation, 'from core (diversified cities) to periphery (specialized cities)', based on the evolution of a firm's location preference caused by changes in its production and cost strategies.

4.2.3. Hypothesis

On the basis of theoretical background and previous findings from literature, we explore firms' relocation decisions by focusing on changes in location preference at different firm maturity levels and across location behavior idiosyncrasies. According to production life cycle theories and empirical evidence of the patterns of firm relocations, entrepreneurs would attempt to leave diversified areas once the benefit from inter-industry knowledge spillover in the early life cycle stages disappears; in later stages of the product life cycle, firms are expected to relocate more often to places where they can benefit from intra-industry externalities.

However, it is questionable whether firm preference for intra-industry spillover, as observed after the nursery phase, persists over time. Given that over-specialization in their own industry could adversely affect firms by narrowing their knowledge bases and generating inertia (Maskell and Malmberg, 2007), some firms might avoid industrial specialization, especially those afraid of locked-in. While firms are likely to relocate in seeking for intra-industry spillover once they pass the early stage of a product life cycle, the benefit from localized economies would diminish in the long term as they face the risk of lock-in. Accordingly, we hypothesize that firms relocate from diversified to specialized areas in earlier period of their life cycle, but subsequent relocations are in the direction of less intra-industry agglomeration.

Due to the heterogeneous nature of firms, there are no absolute age criteria identifying life cycle stages. In this situation, the number of prior experiences with relocation could indicate a firm's relative position in its own life cycle, as the number of relocation experiences increases with firm age. Therefore, the research scheme in this paper is to compare firm relocation behavior based on the number of prior relocation experience(s). In addition, we aim to analyze industrial location preference, as differentiated by firm-level attributes, by comparing relocation behaviors across firm types, employment sizes, and levels of technology intensiveness.

4.3. Analysis

4.3.1. Research Framework

We investigate how a firm's location choice changes over time by analyzing relocation behavior, compared to the initial stage of entry into the market, firm relocation accounts for changes in location preference and demand for external resources. In our framework, firm relocation is conceived as an outcome of two inter-related decisions: 'whether to move' and 'where to move.' A major advantage of this approach is that we can analyze both the drivers of a firm's departure (push factors) and the attractions for a firm's entry into a region (pull factors). Due to differences between mobile and immobile firms, pull factors might not necessarily oppose push factors. Another benefit is the ability to account for both firm- and spatial-level factors. Compared to count data models, which use the number of relocating firms (Holl, 2004; Manjón-Antolín and Arauzo-Carod, 2011) or origin-destination flows (Arauzo-Carod *et al.*, 2015), this method enables us to control for the effects of firm-level attributes on decisions to move.

In particular, we compare firm relocation behaviors depending on prior relocation experience. After controlling for time-specific effects, difference between observed relocation patterns from the sample in different time periods are interpreted as changes in relocation patterns as the firm grows. Another alternative is to compare relocation behaviors of sub-samples of firms classified by age. However, this could raise selection issues: older firms could be inherently different from younger firms simply because they have survived more time. Our method is advantageous because the observations are almost identical, which controls for time-constant individual effects. In addition, we analyze firm relocation behavior using sub−samples categorized by employment size, technology intensiveness based on industrial classification, and firm type (single−plant/ multi−plant) to examine differences in firm location preference.

4.3.2. Model Structure

The first−stage decision concerns ‘current place (stay)’ against ‘alternative places (move)’, or vice versa, and the second−stage decision is hardly independent of the first−stage decision. To model a decision behavior specified by a two− or multi−level decision tree, we apply a nested logit model with a relaxed IIA assumption. In our case, the nesting structure is composed of the binary choice to stay or move at the upper level and the multinomial location choice at the lower level as shown in Figure 4.1.

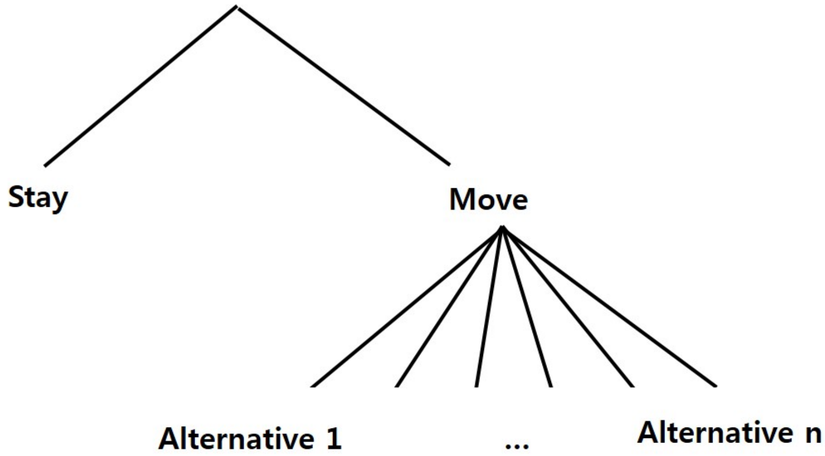

Figure 4.1The Nesting Structure of Firm Relocation Decision

Given rational behavior by economic entities, we assume that a firm chooses the location that yields the greatest value. Firms evaluate each location alternative, including the current location, based on the value, which is partly deterministic (explained by observed characteristics of alternatives) and partly random (associated with unobserved attributes of the alternatives). The value of choosing location l (V_l) is denoted as:

$$V_l = \alpha X_r + \beta Y_l + \varepsilon_l \tag{4.1}$$

where the deterministic component includes a vector of explanatory variables determining whether to relocate (X_r) and a vector of explanatory variables determining where to relocate (Y_l). ε_l is the error term.

The probability of choosing location alternative *l*, $p(l)$, is defined as:

$$p(l) = p(m) \cdot p(l|m) \tag{4.2}$$

where $p(m)$ is the probability of choosing to relocate, and $p(l|m)$ is the probability of choosing location *l* conditional on having decided to relocate. The conditional probability of location *l* being chosen is described as:

$$p(l|m) = \frac{\exp(\beta Y_l)}{\sum_{l=1}^{L} \exp(\beta Y_l)} \tag{4.3}$$

where L is the number of available location alternatives. The probability of choosing to relocate depends on both the characteristics commonly applied to the choice at the upper nest and the expected utility of the choice of location within the lower nest, known as 'inclusive value':

$$p(m) = \frac{\exp(\delta I + \alpha X_r)}{1 + \exp(\delta I + \alpha X_r)} \tag{4.4}$$

where I is the inclusive value, denoted as $I = ln\left(\sum_{l=1}^{L} exp(\beta Y_l)\right)$, and δ is the estimated coefficient of the inclusive value. The parameter of the inclusive value (δ) is supposed to have a value between zero and one. A δ value closer to zero indicates a higher correlation between unobserved factors within each nest, supporting the relevance of the nested model structure. On the other hand, when the value of δ is one, there is considered to be no correlation within nests, and the probabilities are indifferent to those estimated using a simple logit model.

The parameters of the nested model are estimated using a full-information maximum-likelihood (FIML) estimation process. By utilizing all the information, FIML is in a better position relative to sequential estimation, in which the estimates at upper nests are less efficient (although consistent) due to the use of inclusive value calculated based on the estimates of lower nests (Hensher, 1978).

4.3.3. Data and Variables

The data-set we use in this paper is obtained from the Report on Korean Mining and Manufacturing Survey for the period 1996-2014. The use of these data is appropriate to observe individual firms' relocation behavior, as it contains firms' identification codes and information on the municipalities in which the firms are located at the end of each year. Among firms observed in consecutive years in the record, those that display change in current location information (at the municipal level) compared to the previous year are considered to have relocated in that calendar year. Thus, a location change within a municipality is not counted as relocation.

Figure 4.2 describes the process of data set construction. We have two issues in this process. First, there is imbalance between ‘events’ and ‘nonevents’, as our initial sample (n=662,503) contains only 10,648 firms with relocation experience during the analyzed period (only 1.61% of the total). King and Zeng (2001) note that the use of ‘rare event data’ might be problematic due to underestimation of the probability of rare events and the inefficiency associated with spending resources to collect data without much information: the marginal contribution of ‘nonevents’ to information about explanatory variables’ content decreases as their number exceeds the number of ‘events.’ They suggest a practical solution: randomly sampling of ‘nonevents’ at minimally sufficient quantities while ensuring sufficiently narrow confidence intervals. They also comment that collecting more than approximately two to five times more ‘nonevents’ than ‘events’ is undesirable. We randomly select 42,592 ‘nonevents’ while fixing the number of ‘events’, to 20% of the sample.

The next issue relates to the overabundance of available location options for relocating firms. There are 235 municipalities, so each relocating firm has 234 municipalities to choose from. Limited computing power makes a smaller number of location alternatives preferable. McFadden (1978) demonstrated that a random sample of alternatives can replace a full set of choices with no loss of estimate consistency. We construct a set of alternatives by performing stratified random sampling for each relocating firm. As a result, each relocating firm is designed to have 10 location alternatives, which are composed of one ‘actual’ choice (observed in data) and ten ‘hypothetical’ choices drawn from all the available choices.

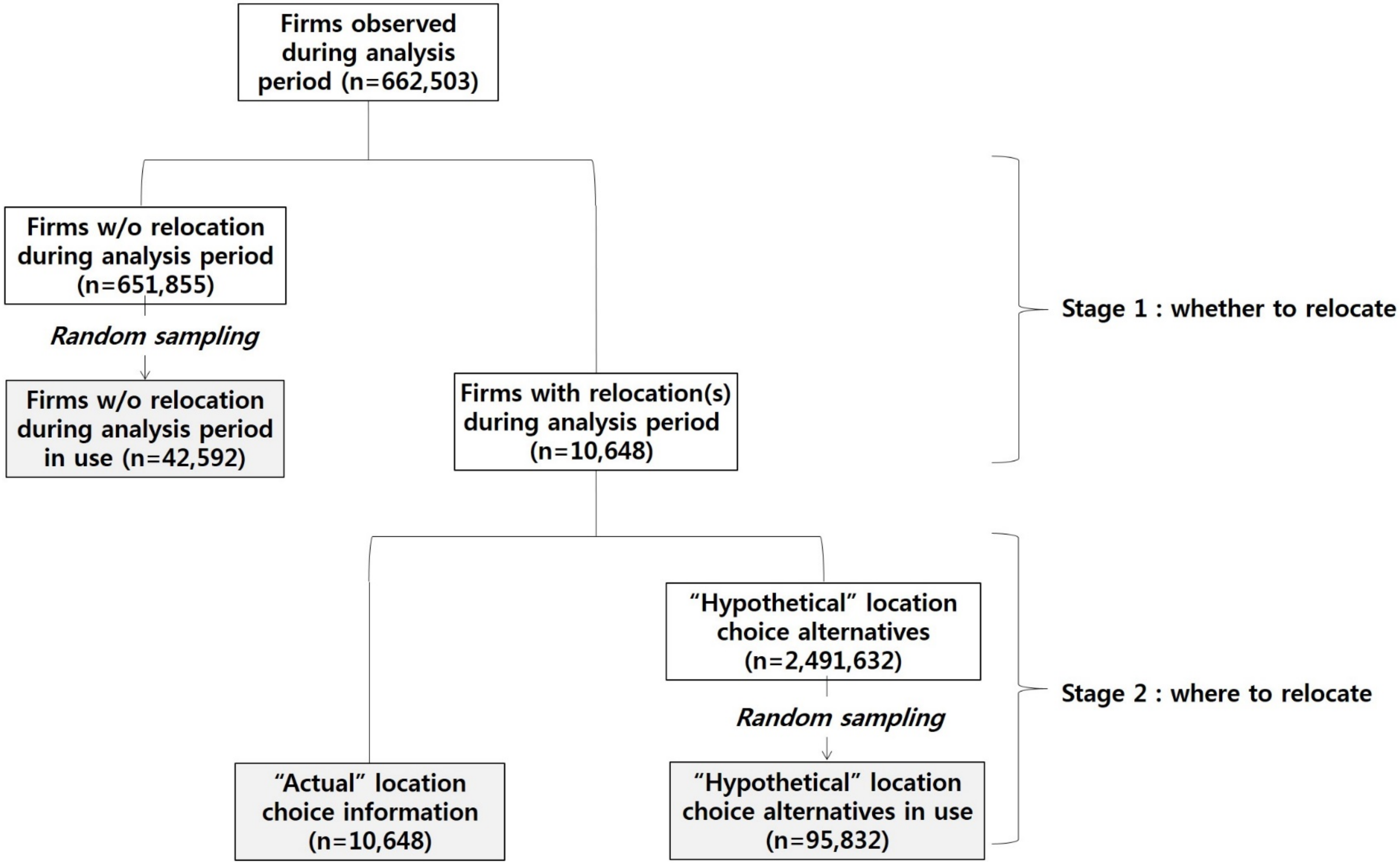

Figure 4.2 Process of Data Set Construction

As previously mentioned, the relocation decision is a two-step process, but the process does not necessarily occur in sequential order. In the first stage, a firm's decision of 'whether to move' is determined by factors specific to the firm- and its current location. The determinants of firm relocation can be described as 'keep' and 'push' factors (i.e. restrictive and driving forces). At the firm level, keep factors are likely to be related to the firm's visible or invisible relocation cost, while push factors are explained by the firm's response to changing internal or external conditions that could be better fulfilled in another place. According to the literature, there is general agreement that firm age and size are negatively related to the likelihood of firm relocation. Brouwer *et al.* (2004) hypothesized that firm's mobility decreases with age of the firm, in the sense that older firms are more likely to be involved in localized networks based on long-term trust-based relationships. This hypothesis was confirmed by multiple researchers (Lee, 2008; Kronenberg, 2013; Foreman-Peck and Nicholls, 2015). The notion that firm size, measured as the number of employees, lowers the firm's likelihood of relocation is based on the following arguments: (1) the sunk cost of moving (i.e., capital investment in the initial place) tends to be lower for small firms; (2) it is easier for small firms to obtain premises that meet their requirements; (3) organizational problems in the relocation process are greater for larger firms; (4) and large firms are likely able to cope with the accommodation problems caused by firm expansion without changing location (Van Dijk and Pellenbarg, 2000; Brouwer *et al.*, 2004). These arguments are supported by several empirical analyses (Van Dijk and Pellenbarg, 2000; Brouwer *et al.*, 2004; Lee, 2008; Knoben and Oerlemans, 2008; Weterings, 2014). However, Foreman-Peck and Nicholls (2015) focused on small- and medium-sized firms with less than 250 employees and showed that the probability of relocation increased with the growth of the firm's size. They explained that, when controlling for firm age, a positive association between firm size and mobility could reflect past growth. A change in firm size, in both positive and negative directions, was shown to increase the possibility of firm relocation as a response to changes in the demand for the premises (Brouwer *et al.* 2004; Kronenberg, 2013; Foreman-Peck and Nicholls, 2015). Based on the knowledge provided by the literature, we use firm age (AGE), size (SIZE), annual growth rate of employment (LGROW) and variation in number of employees (LVAR) as firm-level explanatory variables of the likelihood of firm relocation.

Regarding the spatial determinants of firm relocation, we consider 1) market opportunity, 2) industrial agglomeration, and 3) factor cost. Market opportunity is determined by the size of demand in the current region and in external regions. The former is measured by population density (POPDEN). The latter, market potential (MARKET), is calculated as the sum of populations in all other regions weighted by need for travel (distance from the own region) and is described by equation (4.5).

$$MARKET_i = \sum_j Pop_j \cdot exp(-0.017 \times Time_{ij}) \quad (4.5)$$

$MARKET_i$: Market potential of municipality i

POP_j: Population size of municipality j

$Time_{ij}$: Shortest travel time between municipality i and j using road networks.

Regarding the effect of industrial agglomeration on firm relocation, we focus on knowledge externalities from within the same industry, cross-fertilization of ideas with different industrial sectors, innovation facilitated by local industrial competition and access to producer services. Industrial specialization is measured by municipal employment density within the industry and is based on two-digit industrial classification codes (SPEC). As in Gleaser *et al.* (1992), competition in local industry is measured by the ratio of the number of firms per worker in the city-industry to the number of firms per worker in the entire nation. Industrial diversification is measured by the inverse of Hirschman-Herfindahl index (DIV) and is based on four-digit industrial classification codes.[23] Access to producer services is measured by employee density in producer service industries (PROD). The cost of production factors includes labor costs and land costs. An average of local wages in manufacturing industries (LWAGE) is used as a proxy for labor cost. The cost of land is measured by the municipal average of officially assessed land values (LANDP). In contrast to firm-level variables, we have no *a priori* knowledge of the effects of municipality-level variables on firm mobility, because favorable attributes of a space (e.g. the quality of labor and urban agglomeration) can be counterbalanced by the high price of factor inputs or negative congestion externalities caused by competitive demand.

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[23] Beaudry and Schiffauerova (2009) show that a 4-digit or finer level of industrial classification is required to distinguish localized economies from the effects of industrial diversity. This paper applies 4-digit industrial classification for the creation of an industrial diversity index, but 2-digit industrial classification is used to measure the degree of industrial specialization, to minimize null values in the specialization index (employment density of the industry) at the municipality level of geographical aggregation. The Pearson correlation coefficient between the indices of industrial specialization and industrial diversity equals 0.069, indicating that potential problems of collinearity can be ignored.

The second stage of a firm's relocation decision process concerns the choice of 'where to move.' The same municipality-level variables of alternative locations (including both 'actual choice' and 'non-chosen alternatives') as those applied in the first stage are used to explain the location choice of relocating firms.[24] Additionally, the distance from the original firm location is controlled. As opposed to previous studies using Euclidian distance to explain the distance-barrier (Arauzo-Carod *et al.*, 2015; Kronenberg, 2013), we apply the shortest road travel time between the origin and destination municipalities (TIME), which is obtained by performing a network analysis using the GIS program. Korea has used regulatory policies and economic incentives to redistribute industrial activities to peripheral regions, and flight from the capital to non-capital areas is often observed in firm relocation patterns in areas with developed economies (e.g. the Netherlands (Van Dijk and Pellenbarg, 2000)). To this point, it is important to note whether firms are moving towards non-capital areas. Therefore, we used an origin-destination pair dummy indicating whether the

[24] The characteristic of origin place could be also controlled by the difference between old and new location (e.g. Hong, 2014) or by the concurrent use of old and new location variables (e.g. Arauzo-Carod *et al.*, 2015). However, we exclude old location variables in the second stage choice model (where to move) because these are already taken into account in the first-stage choice (whether to move) and are considered hardly independent of the second-stage choice in the nested logit model structure.

flow is from SMA to non−SMA (FLOW).[25] Table 4.1 provides the summary statistics and a description of the variables used in this paper.

[25] The effects of regulatory policies and economic incentives on the redistribution of industrial activities to peripheral regions are further discussed in Appendix 4A.

Table 4.1 Descriptive Statistics of Variables (Sample size=10,648)

Stage	Level	Variable	Description	Mean	S.D.	Min.	Max.
Stage 1: Whether to move	Firm	AGE	Firm age	9.4	7.5	1.0	57.0
		SIZE	Number of employees	31.0	64.4	10.0	3182.0
		LGROW	Annual growth rate of employment	0.2	1.2	−0.9	97.5
		LVAR	Change in the size of employment in absolute value	0.3	1.1	0.0	97.5
	Local	MARKET_O	Market potential index of firm’ s original location (×0.001)	15088.0	8787.0	221.7	72439.7
		POPDEN_O	Population density of firm’ s original location (unit: 1,000 people/km^2)	7859.0	7036.7	30.8	32479.1
		SPEC_O	Employment density of firm’ s sector of firm’ s original location (unit: people/km^2)	91.3	192.4	0.002	3385.6
		COMP_O	Local competition of industry of firm’ s original location	1.4	1.5	0.1	31.6
		DIV_O	Industrial diversity index of firm’ s original location	27.1	11.4	1.2	58.8
		PROD_O	Density of employees in producer service sectors of firm’ s original location (unit: people/km^2)	282.2	661.2	0.05	6262.8
		LWAGE_O*	Average of local wage of manufacturing sectors of firm’ s original location (unit: $1,000)	18.3	3.5	7.1	34.3
		LANDP_O*	Average of officially assessed land value of original location (unit: $1,000/㎡)	0.6	0.9	0.001	8.0

Table 4.1 Descriptive Statistics of Variables (Sample size=10,648) (continued)

Stage	Level	Variable	Description	Mean	S.D.	Min.	Max.
Stage 2: Where to move	Local	MARKET_D	Market potential index of the alternative location (×0.001)	13015.7	8974.1	220.1	72439.7
		POPDEN_D	Population density of the alternative location (unit: 1,000 people/km^2)	5147.3	6522.8	37.0	28231.5
		SPEC_D	Employment density of firm's sector of the alternative location (unit: people/km^2)	63.7	145.4	0.001	2867.9
		COMP_D	Local competition of industry of the alternative location	1.1	0.8	0.1	17.2
		DIV_D	Industrial diversity index of the alternative location	27.7	11.4	1.3	58.8
		PROD_D	Density of employees in producer service sectors of the alternative location (unit: people/km^2)	172.8	492.2	0.1	6262.8
		LWAGE_D*	Average of local wage of manufacturing sectors of the alternative location (unit: $1,000)	17.5	3.2	7.6	32.1
		LANDP_D*	Average of officially assessed land value of the alternative location (unit: $1,000/$m^2$)	0.4	0.7	0.001	7.5
		TIME	Shortest road travel time between firm' s original location and the location alternative (unit: minutes)	30.4	37.7	2.3	391.3
		FLOW	An origin−destination pair dummy indicating whether the flow is from SMA to non−SMA	0.1	0.3	0	1

* Price values are converted into 2010 constant prices

4.3.4. Estimation

Table 4.2 presents the results of our model. The estimated inclusive value is 0.744, indicating that the use of a hierarchical nested logit model structure is appropriate. Beginning with the firm's decision regarding whether to move, we find that firm age and size have a negative effect on the propensity to relocate, indicating that older and larger firms tend to adapt themselves to their current site and are reluctant to move because of the expected loss of local connectedness and unrecoverable investments they have already made in the current location. In contrast, firms experiencing changes in the employment size, especially in a positive direction, are more likely to move due to their need for new space with better accommodation. While market potential and interplay with other municipalities functions as a keep factor, the market size of the firm's own municipality (measured by population density) increases the likelihood that a firms will move out. Likewise, in the location choice stage, firms prefer municipalities with greater market potential but lower population density. This finding indicates that market potential growth caused by inter-municipal transportation improvement could contribute to hosting manufacturing firms, but highly dense areas are not attractive. This is true at least for firms in manufacturing industries, probably because of congestion externalities.

High own-sector specialization lowers the probability that firms will move to other municipalities. In contrast, industrial diversity increases firms' propensity to leave their current municipality. However, in location choice stage, both own-sector specialization and industrial diversity tend to attract relocating firms. This finding implies that industrial diversity not only provides the opportunity and knowledge through cross-industry fertilization but also imposes negative externalities (e.g., congestion cost and lack of expected pecuniary advantages from industrial specialization). The mixed results of push and pull effects may be attributable to inherent differences between relocating firms and staying firms.

Local industrial competition serves as a push factor, although it does not significantly affect the entry of relocating firms. This result is inconsistent with empirical findings that industrial competition fosters the growth of industries in cities (Glaeser *et al.*, 1992) and the total factor productivity of firms (Nickell, 1996). However, a firm's preference for (or avoidance of) local competition varies by its ability to compete with other firms (e.g. market share, technical monopoly) or industry-specific factors (e.g., the importance of imitation and innovation). Access to producer services increases a firm's probability of leaving its current municipality but tends to attract relocating firms, as shown by Holl (2004). This finding could be explained by the close connection between the spatial concentration of producer service sectors and bid-rent. While avoidance of higher rent could raise the probability of firm relocation in municipalities with greater access to producer services, the location choice observed by relocating firms could be positively impacted by easy access to producer services.

Average wage levels in local manufacturing industries are negatively associated with the likelihood that firms will stay in the current municipality, but do not significantly affect the location choice of relocating firms. Rising land price increases the probability of firms moving out of a municipality but decrease the likelihood that relocating firms choose the municipality. Greater distance from a firm's original location lowers the likelihood that the municipality will host the relocating firm.

Table 4.2 Estimation Results of Firm Relocation Decision

Stage	Level	Variable	Coefficient		S.E.
Stage 1: Whether to move (1: move, 0: stay)	Firm	AGE	−0.029	***	0.002
		ln(SIZE)	−0.041	**	0.020
		LGROW	0.236	***	0.028
		LVAR	0.001	*	0.000
	Munici−pality	ln(MARKET_O)	−1.581	***	0.069
		ln(POPDEN_O)	1.410	***	0.072
		ln(SPEC_O)	−0.262	***	0.012
		COMP_O	0.144	***	0.016
		ln(DIV_O)	0.197	***	0.025
		ln(PROD_O)	0.060	***	0.020
		ln(LWAGE_O)	0.021	***	0.006
		ln(LANDP_O)	0.427	***	0.030
Stage 2: Where to move	Munici−pality	ln(MARKET_D)	0.593	***	0.021
		ln(POPDEN_D)	−0.658	***	0.027
		ln(SPEC_D)	0.570	***	0.013
		COMP_D	−0.014		0.014
		ln(DIV_D)	0.250	***	0.021
		ln(PROD_D)	0.133	***	0.018
		ln(LWAGE_O)	0.006		0.005
		ln(LANDP_O)	−0.497	***	0.027
		TIME	−0.046	***	0.001
		FLOW	0.521	***	0.040
Model fit summary		Inclusive value	0.744	***	0.017
		Sample size			53,240
		Log likelihood			−12,893
		AIC			25,865

Table 4.3 Number of Prior Experience of Moves

Experience	Counts	Share
1	6,567	93.08%
2	457	6.48%
3	30	0.43%
4	1	0.01%

To analyze changes in firm location preference over time, we compare firms that relocate for the first time and those with prior relocation experience. The sample is confined to firms who relocated more than twice during the period of analysis, due to the concern that firms with a single relocation experience might be inherently different from those with multiple moving experiences of move. In addition, we exclude firms created before 1996 to avoid having firms relocated before 1996 in the sample. Among the 7,055 firms that relocated during the period of analysis, 488 firms (6.92%) have multiple relocation experiences (see Table 4.3).

Table 4.4 Summary Statistics of Firms without and with Experience(s) of Move

			(1) Without experience of move (n=378)				(2) With experience(s) of move (n=482)			
Stage	Level	Variable	Mean	S.D.	Min.	Max.	Mean	S.D.	Min.	Max.
Stage 1: Whether to move	Firm	AGE	4.8	3.0	1.0	16.0	8.5	3.8	2.0	18.0
		SIZE	24.1	28.8	10.0	444.0	32.1	34.4	10.0	444.0
		LGROW	0.2	0.5	−0.7	3.5	0.1	0.5	−0.8	5.2
		LVAR	0.3	0.4	0.0	3.5	0.3	0.4	0.0	5.2
	Local	MARKET_O	11590.9	8465.0	320.1	72439.7	15485.5	8693.0	537.9	44030.0
		POPDEN_O	4372.4	6316.0	31.7	28231.5	7165.3	6762.7	30.8	28123.2
		SPEC_O	71.7	205.8	0.0	2852.1	87.3	202.9	0.0	2867.9
		COMP_O	1.1	0.7	0.1	6.8	1.4	1.4	0.1	31.6
		DIV_O	25.8	12.6	1.2	58.8	27.2	11.3	1.4	58.8
		PROD_O	142.8	548.0	0.0	5791.1	307.9	714.6	0.1	6163.0
		LWAGE_O*	18.1	2.9	9.6	30.9	20.0	3.0	10.6	32.8
		LANDP_O*	0.7	1.0	0.0	7.5	0.6	0.8	0.0	5.3
Stage 1: Where to move	Local	MARKET_D	15475.1	8103.2	746.8	41289.5	15922.2	8983.8	221.7	44030.0
		POPDEN_D	8282.0	7022.8	44.6	27296.1	7327.5	6838.3	43.8	28123.2
		SPEC_D	107.6	224.5	0.1	2735.9	82.3	106.3	0.0	715.7
		COMP_D	1.4	1.4	0.1	18.0	1.4	1.8	0.1	31.6
		DIV_D	27.2	10.8	2.7	55.6	27.6	10.9	2.9	58.8
		PROD_D	340.6	839.8	0.2	6262.8	290.4	610.2	0.2	4313.4
		LWAGE_D*	17.0	2.8	9.1	26.5	18.9	2.6	9.5	31.1
		MARKET_D	15315.8	8389.1	220.1	42842.1	15584.6	9756.8	762.8	72439.7

Table 4.4 provides summary statistics of both groups of firms with prior experience(s) of moving. The average values of firm age, employment size, annual growth rate of employment, population density, index of industrial specialization and local average wage are significantly different between the two groups. Specifically, firms with prior experience(s) of moving are generally older and larger in employment size, but have lower employment growth rates compared to those without relocation experience. While firms without prior moving experience relocate from municipalities with a lower degree of industrial specialization to those with a higher degree of specialization on average, the relocation patterns of firms with prior experience(s) of moving are in the opposite direction in terms of the change in intra-industry agglomeration): those firms move toward lower degrees of industrial agglomeration.

The estimation results of firm relocation decisions based on prior experience(s) of moving are presented in columns (1) and (2) of Table 4.5. Between firms with and without prior experience(s) of moving, own-industry specialization and location choice influence relocation decisions in opposite directions: intra-industry agglomeration reduces the likelihood that firms without prior relocation experience will leave their current municipality but increases the probability that firms with relocation experience(s) will move; highly specialized municipalities attract first-time relocating firms in the industry, but discourages the relocation of firms with prior moving experience(s) into the municipality. The differences in these two pairs of estimates are significant. This finding indicates that firms in relatively early stages of their life cycle prefer locations with high specialization in their own industry because they expect to benefit from localized economies. However, firms in later stages of their life cycle, as represented by those with prior experience of relocation(s), tend to avoid locations with own-industry agglomeration. This finding is probably due to negative externalities, such as lock-in. Thus, our research hypothesis is satisfied. We also find that firms with prior experience(s) of moving are less affected by relocation distance when they make a location choice. A potential explanation could be that the extent to which firms are spatial embedded, as observed in dependence on localized networks may decrease as firms age, because of growth in the ability to utilize source of knowledge, whether internal or external (beyond their proximity).

The above analyses explain the general relocation behaviors of firms and their changes over time, but they do not fully cover the difference in location preference by firm-specific variables. We investigate the difference in firm relocation decisions based on 1) firm type, 2) industrial classification[26] and 3) firm size. Beginning with a comparison of the relocation behavior of multi-plant firms and single-plant firms (columns (3) and (4) in Table 4.5), we find the influence of own-industry agglomeration on relocation decision to be greater among single-plant firms, although estimates of this variable in the location choice stage are not significantly different between two types of firms. This finding is consistent with Brown and Rigby (2009), who showed that own-sector labor market pooling and knowledge spillovers positively affect the productivity of single-plant firms, but the effects are not significant for multi-plant firms, except for those in scale-based industries. Potential interpretations of this finding may include the following: 1)multi-plant firms tend to have higher dependence on internal resources and the ability to utilize them, and 2) relocation decisions by multi-plant firms are more affected by external factors (e.g., interplay with other institutions and negotiation with headquarters, branches, or other related economic actors), as suggested by the institutional location theory. In addition, average wages in local manufacturing industries serve as a push-factor for single-plant firms, but not for multi-plant firms. It seems that while the average wage of local

[26] Technology classification of manufacturing industries (OECD, 2009) is applied as in Kronenberg (2013).

manufacturing industries imposes a cost burden on single-plant firms, multi-plant firms are relatively unaffected by it, because the salaries of those firms tend to be determined in balance with the wage levels of other branches, rather than solely with local manufacturing establishments.

Table 4.6 presents estimation results of firm relocation behaviors that differ by the level of knowledge and technology intensiveness. Firms in high-tech industries are distinguished from others in their relocation decision responses to local competition in their own industry. Local industrial competition reduces the probability of relocation only for firms in sectors of high technology intensiveness sectors, and avoidance of competition is greater among firms with lower technology intensiveness. In the location choice stage, industrial competition discourages the entry of relocating firms into the municipality, but the deterrence effect is not significant for firms in high-tech manufacturing industries. This finding might be interpreted as firms in industries with higher technology intensiveness benefiting more from the innovation opportunities fostered by local industrial competition than do firms in lower technology intensive industries. Another possible explanation might be that local industrial competition, as measured by the ratio of the number of firms per worker in the city-industry to the number of firms per worker in the entire nation, could be the outcome of governmental encouragement of clustering (e.g. lower rent and tax rate for firms located in industrial parks). In this case, the benefit seems to be counterbalanced by the avoidance of relocating to areas with high local industrial competition.

Table 4.7 shows relocation behaviors by different firm sizes. The push effect of land price increases with firm size. On the other hand, the deterring effect of land price on firms' choice of new location diminishes by firm size. From these findings, we can infer that larger firms would have more difficulty paying for the use of premises and searching for alternative premises: because of their larger demand for land, the relocation decisions of large firms would be more elastic to changes in land prices (a proxy of both price and rent of building or premises) in their current municipality; however, once a large firm decides to relocate, the choice of new location would be less sensitive to land prices because searching for the 'right' premises is generally more difficult for larger firms (due to regulations and narrower options for large-scale sites).

Larger firms tend to be less affected by the distance between the original location and new location alternatives. This finding can be interpreted with an extended resource-based view of firms, suggesting that firms in relatively resource-deprived areas would be more likely to search for a new location in resource-abundant areas and therefore outside their original region (Knoben, 2011). The difficulty in obtaining premises suitable for their demands explain why larger firms tend to relocate over longer distances than smaller firms.

Table 4.5 Estimation Results of Firm Relocation Decision Depending on Prior Experience of Relocation and by Firm Type

Stage	Variable	(1) No experience			(2) With experience			(3) Multi−plant firm			(4) Single−plant firm		
		Coef.		S.E.	Coef.		S.E.	Coef.		S.E.	Coef.		S.E.
Stage 1: Whether to move (1: move, 0: stay)	AGE	−0.032		0.027	0.153	***	0.018	−0.027	***	0.006	−0.030	***	0.002
	ln(SIZE)	−0.164		0.126	0.273	**	0.113	−0.228	***	0.060	−0.015		0.021
	LGROW	0.581	***	0.155	−0.266	**	0.126	0.004		0.009	0.502	***	0.030
	LVAR	0.001		0.004	−0.002		0.004	0.000		0.000	0.000	*	0.000
	ln(MARKET_O)	−1.004	***	0.364	−1.530	***	0.356	−1.513	***	0.250	−1.459	***	0.068
	ln(POPDEN_O)	0.624		0.383	1.107	***	0.382	1.337	***	0.262	1.234	***	0.071
	ln(SPEC_O)	−0.171	***	0.061	0.142	**	0.073	−0.155	***	0.051	−0.310	***	0.012
	COMP_O	0.221	**	0.093	0.010		0.053	0.197	***	0.054	0.096	***	0.015
	ln(DIV_O)	0.148		0.134	−0.075	*	0.119	0.099		0.101	0.146	***	0.025
	ln(PROD_O)	0.207	**	0.103	−0.055		0.095	−0.038		0.079	0.130	***	0.019
	ln(LWAGE_O)	0.029		0.031	−0.040	*	0.023	−0.035		0.023	0.010	**	0.006
	ln(LANDP_O)	0.083		0.159	−0.234		0.149	0.570	***	0.115	0.356	***	0.030

Table 4.5 Estimation Results of Firm Relocation Decision Depending on Prior Experience of Relocation and by Firm Type (continued)

Stage	Variable	(1) No experience			(2) With experience			(3) Multi−plant firm			(4) Single−plant firm		
		Coef.		S.E.	Coef.		S.E.	Coef.		S.E.	Coef.		S.E.
Stage 2: Where to move	ln(MARKET_D)	0.608	***	0.119	0.530	***	0.090	0.491	***	0.075	0.634	***	0.020
	ln(POPDEN_D)	−0.555	***	0.143	−0.492	***	0.102	−0.673	***	0.109	−0.745	***	0.026
	ln(SPEC_D)	0.398	***	0.057	−0.112	**	0.036	0.606	***	0.052	0.577	***	0.012
	COMP_D	−0.130	**	0.053	−0.047		0.031	−0.147	**	0.067	−0.009		0.013
	ln(DIV_D)	0.340	***	0.113	0.412	***	0.080	0.255	**	0.082	0.231	***	0.020
	ln(PROD_D)	0.134		0.096	0.218	***	0.065	0.147	**	0.070	0.113	***	0.017
	ln(LWAGE_D)	0.057	**	0.028	0.028	*	0.015	0.040	**	0.020	0.008	*	0.005
	ln(LANDP_D)	−0.409	***	0.148	−0.248	***	0.092	−0.420	***	0.103	−0.481	***	0.025
	TIME	−0.076	***	0.006	−0.055	***	0.004	−0.030	***	0.002	−0.052	***	0.001
Mode fit summary	Inclusive value	0.655	***	0.066	0.908	***	0.069	0.772	***	0.056	0.770	***	0.013
	Sample size	1,897			2,416			4,896			48,344		
	Log likelihood	−4,549			−1,307			−1,659			−24,253		
	AIC	1,826			2,686			3,396			48,585		

Table 4.6 Estimation Results of Firm Relocation Decision by Industry

Stage	Variable	(1) High−tech			(2) Medium−high tech			(3) Medium−low tech			(4) Low−tech		
		Coef.		S.E.	Coef.		S.E.	Coef.		S.E.	Coef.		S.E.
Stage 1: Whether to move (1: move, 0: stay)	AGE	−0.039		0.005	−0.035	***	0.003	−0.033	***	0.003	−0.023	***	0.003
	ln(SIZE)	0.001		0.046	−0.138	***	0.034	−0.126	***	0.042	−0.092	**	0.040
	LGROW	0.005		0.009	0.469	***	0.051	0.380	***	0.056	0.454	***	0.056
	LVAR	0.000		0.000	−0.001	***	0.000	0.003	***	0.001	0.006	***	0.001
	ln(MARKET_O)	−1.724	***	0.221	−1.369	***	0.116	−1.061	***	0.128	−1.752	***	0.125
	ln(POPDEN_O)	1.505	***	0.229	1.141	***	0.121	0.783	***	0.136	1.632	***	0.132
	ln(SPEC_O)	−0.385	***	0.032	−0.232	***	0.023	−0.149	***	0.025	−0.413	***	0.025
	COMP_O	−0.115	***	0.035	0.144	***	0.024	0.155	***	0.034	0.211	***	0.048
	ln(DIV_O)	−0.008		0.064	0.068		0.049	0.053		0.050	0.124	***	0.045
	ln(PROD_O)	0.154	***	0.052	0.073	**	0.034	0.025		0.038	0.174	***	0.036
	ln(LWAGE_O)	−0.031	**	0.015	0.012		0.011	−0.023	**	0.012	0.019	**	0.009
	ln(LANDP_O)	0.349	***	0.078	0.440	***	0.053	0.423	***	0.058	0.337	***	0.056

Table 4.6 Estimation Results of Firm Relocation Decision by Industry (continued)

Stage	Variable	(1) High-tech			(2) Medium-high tech			(3) Medium-low tech			(4) Low-tech		
		Coef.		S.E.	Coef.		S.E.	Coef.		S.E.	Coef.		S.E.
Stage 2: Where to move	ln(MARKET_D)	0.682	***	0.057	0.671	***	0.032	0.602	***	0.035	0.667	***	0.042
	ln(POPDEN_D)	−0.319	***	0.072	−0.721	***	0.043	−0.809	***	0.048	−0.782	***	0.054
	ln(SPEC_D)	0.484	***	0.031	0.555	***	0.021	0.544	***	0.024	0.623	***	0.027
	COMP_D	−0.016		0.025	−0.084	***	0.025	−0.016		0.029	−0.192	***	0.048
	ln(DIV_D)	0.269	***	0.051	0.169	***	0.035	0.186	***	0.039	0.261	***	0.040
	ln(PROD_D)	0.085	*	0.046	0.155	***	0.028	0.105	***	0.032	0.014		0.033
	ln(LWAGE_D)	0.051	***	0.014	−0.019	**	0.009	0.028	***	0.010	0.001		0.010
	ln(LANDP_D)	−0.634	***	0.069	−0.542	***	0.043	−0.452	***	0.048	−0.313	***	0.051
	TIME	−0.056	***	0.002	−0.046	***	0.001	−0.047	***	0.001	−0.054	***	0.002
Mode fit summary	Inclusive value	0.733	***	0.035	0.809	***	0.023	0.810	***	0.026	0.704	***	0.025
	Sample size	5,465			15,921			15,860			15,994		
	Log likelihood	−3,614			−8,471			−6,697			−6,782		
	AIC	7305			17,020			13,472			13,643		

Table 4.7 Estimation Results of Firm Relocation Decision by Firm Size

Stage	Variable	(1) Less than 20			(2) 20~49			(3) 50~99			(4) 100~		
		Coef.		S.E.	Coef.		S.E.	Coef.		S.E.	Coef.		S.E.
Stage 1: Whether to move (1: move, 0: stay)	AGE	−0.035	***	0.003	−0.027	***	0.003	−0.022		0.005	−0.023	***	0.006
	ln(SIZE)	−0.198	***	0.092	−0.132	*	0.079	−0.606	***	0.194	−0.430	***	0.116
	LGROW	2.425	***	0.074	−0.339	***	0.053	−0.692	***	0.099	−1.314	***	0.202
	LVAR	0.018	***	0.004	0.027	***	0.002	0.015	***	0.002	0.000		0.000
	ln(MARKET_O)	−1.361	***	0.099	−1.544	***	0.109	−1.520	***	0.222	−0.827	***	0.291
	ln(POPDEN_O)	1.166	***	0.104	1.336	***	0.114	1.323	***	0.229	0.665	**	0.310
	ln(SPEC_O)	−0.326	***	0.017	−0.292	***	0.020	−0.200	***	0.042	−0.236	***	0.058
	COMP_O	0.063	***	0.020	0.163	***	0.025	0.131	**	0.058	0.245	***	0.093
	ln(DIV_O)	0.161	**	0.037	0.153	***	0.041	0.078		0.077	−0.214	**	0.101
	ln(PROD_O)	0.157		0.027	0.066	**	0.032	0.094		0.066	0.037		0.093
	ln(LWAGE_O)	0.027	***	0.008	−0.001		0.009	−0.053	***	0.019	−0.061	**	0.024
	ln(LANDP_O)	0.305	***	0.043	0.377	*	0.098	0.453	***	0.048	0.473	***	0.136

Table 4.7 Estimation Results of Firm Relocation Decision by Firm Size (continued)

Stage	Variable	(1) Less than 20			(2) 20~49			(3) 50~99			(4) 100~		
		Coef.		S.E.	Coef.		S.E.	Coef.		S.E.	Coef.		S.E.
Stage 2: Where to move	ln(MARKET_D)	0.638	***	0.028	0.635	***	0.032	0.677	***	0.063	0.590	***	0.099
	ln(POPDEN_D)	−0.763	***	0.036	−0.770	***	0.042	−0.642	***	0.085	−0.544	***	0.135
	ln(SPEC_D)	0.607	***	0.017	0.557	***	0.019	0.475	***	0.038	0.528	***	0.060
	COMP_D	0.033	**	0.017	−0.039	*	0.022	−0.139	***	0.051	−0.505	***	0.104
	ln(DIV_D)	0.208	***	0.028	0.252	***	0.033	0.290	***	0.064	0.238	***	0.099
	ln(PROD_D)	0.098	***	0.023	0.140	***	0.027	0.121	**	0.055	0.102	**	0.089
	ln(LWAGE_D)	−0.004		0.007	0.016	*	0.008	0.023	***	0.016	0.053	***	0.026
	ln(LANDP_D)	−0.507	***	0.036	−0.473	***	0.040	−0.403	***	0.082	−0.396		0.129
	TIME	−0.057	***	0.001	−0.048	***	0.001	−0.038	***	0.002	−0.029	***	0.002
Mode fit summary	Inclusive value	0.777	***	0.019	0.556	***	0.778	0.022	***	0.047	0.637	***	0.057
	Sample size	25,559			19,079			5,242			3,360		
	Log likelihood	−12,112			−9,329			−2,308			−1,173		
	AIC	24,303			18,736			4,694			2,423		

4.4 Conclusions

This paper analyzes firm relocation decisions to explain the impact of firm maturity on location preference. Using a panel dataset of manufacturing establishments in South Korea, we analyze a two-step relocation decision-making process (whether to relocate and where to relocate). The results indicate that, in general, both intra- and inter-industry agglomerations attract relocating firms, but local competition discourages their entry. The influence of firm age on location preference is analyzed by comparing the relocation behaviors of first-time relocating firms and those with prior experience of moving. Firms in relatively early stages of their life cycle tend to relocate to municipalities with high specialization in their own industry; those in later stages of their life cycle are more likely to avoid locations with intra-industry agglomeration. This finding implies that firms benefit from localized economies as they pass the nursery phase in their life cycle, which is consistent with product life cycle theory. However, the benefit may not persist over time because industrial specialization could generate negative externalities such as lock-in.

Focusing on firm-level differences, the relocation decisions of multi-plant firms are less affected by intra-industry agglomeration and average wage levels in local manufacturing industries; local industrial competition generally increases the likelihood of a firm leaving its current municipality but affects firms in high-tech industries in the opposite direction. This finding indicates that the benefit from local competition received by firms in technology-intensive industries will counterbalance the negative externalities from competition between firms in the same industry. Large firms tend to have greater tolerance for relocation distance and land price because they face more difficulty in finding premises that satisfy their demands.

As for further research agenda, it could be worthwhile to analyze the differences in firms' location choice based on the motivation for relocation. Since a firm relocation can be either an adaptive behavior to changes in internal or external conditions (Pellenbarg 2005) or a strategy to exploit spatial advantages provided by a specific site (Figueiredo *et al.*, 2002), generalized interpretations of firm relocation behavior without sufficient consideration of the drivers of relocation could be misleading. In addition, we could extend this view to recursive relocations: aside from their connection to firm maturity in its own product life cycle, recursive relocations can also be an outcome of dissatisfaction with previous relocation(s). For example, if a firm fails to acquire an expected benefit from a relocation or faces an adverse effect, it could attempt to relocate again to compensate for the failure. Furthermore, there could be systematic differences between firms with recursive relocations and others (e.g. financial instability, ownership of premises, and real estate arbitrage). Therefore, an inclusive approach taking into account the motivations and potential heterogeneity of recursive firm relocations would be needed.

Appendix 4A

The purpose of this appendix is to analyze changes in firm relocation pattern in response to the implementation of policy strategies to promote firm movement from the Seoul Metropolitan Area (SMA) to the non-SMA during the period of observation. Since the 1960s, there has been social awareness of overcrowding in the capital area, the loss of development potential in non-capital areas, and inefficiency of public investment. Accordingly, policy regulation of the metropolitan area has been introduced and expanded. Table 4A.1 summarizes policy measures that have been imposed to decentralize manufacturing activities. In 1994, along with the revision of the Metropolitan Area Maintenance Planning Act, regulatory policies to decentralize manufacturing activities into non-SMA were introduced. Regulations on land use and the imposition of upper limits on the total number of manufacturing facilities in the SMA are examples. In 1999, a conclusive set of policy measures to promote firm relocations heading towards non-SMA was imposed. Composed of partial tax exemptions, financing support, public agency services on sales of factory sites and authorization of urban development rights for firms relocating to non-SMA, the policies imposed in this period are supportive rather than regulatory. In 2004, the government enacted a special national development, act to lead local–government–initiated development in balanced way. The accompanying policies are subsidy measures to financially support firm relocations by reimbursing relocation costs, such as expenses associated with land use, construction, facilities, employment and staff training.

Compared to previously imposed measures, the subsidy policies incurred a substantial government spending. For this reason, it is worthwhile to evaluate the subsidy measures by analyzing their effects on the spatial patterns of firm relocations. In particular, the expansion and contraction of subsidy measures could have affected policy outcomes in terms of the decentralization of industrial activities. Figure 4A.1 illustrates changes in policies during the period of analysis (1997–2014), which is composed of four phases: prior to introduction, initial stage, expansion, and contraction. The first phase (1997–2003) is defined as the period before the policy introduction. The second phase (2004–2007) is defined as the initial four years after the introduction of the policies. The third phase (2008–2010) is defined as the period of subsidy expansion (e.g., expansion of eligibilities for recipients, increases in the upper limit of subsidies, and extension of the period). The fourth phase (2011–2014) is defined as the period of contraction of the subsidies. In this phase, strict policies regarding eligibility and the amount of subsidies are applied, as are detailed regulations according to firm size and location.

Table 4A.1 Policy Measures to Deconcentrate Manufacturing Activities into non−SMA

Policy measure	Description	Period
Regulation of land use	Division of SMA into overcrowded areas, growth management areas, and nature conversation areas to regulate land use (including those for manufacturing facilities) by the area	1994 ~
Regulation of the total number of manufacturing facilities	Setting upper limits of the establishment and expansion of factories within the SMA and each province	1994 ~
Restriction of the designation of industrial area	Restriction of the designation of industrial area and the supply of industrial sites	1994 ~
Regulation of the establishment and expansion of manufacturing activities	Regulation of the establishment and expansion of industrial parks and factories in accordance with firm size and the source of investment	1994 ~
Partial tax exemption	Temporary exemption from corporate tax, income tax, acquisition tax, and registration tax for firms relocating from SMA to non−SMA	1999 ~
Financing support	Loans provided by government−affiliated organizations for firms relocating from SMA to non−SMA	1999 ~
Purchase of factory sites by the public	Public agency service on sales of factory sites for firms relocating from SMA to non−SMA	1999 ~
Authorization of urban development rights	Authorization of firms relocating from overcrowded areas to non−SMA satisfying the conditions of employment and age to develop the surrounding area; governmental support for the construction of public infrastructure	1999 ~
Subsidies for firm relocation	Subsidies provided to firms relocating from SMA to non−SMA for expenses associated with land use, construction and facilities, employment, and training of staff	2004 ~

1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
1st Phase: Before introduction																	
							2nd Phase: Initial period										
											3rd Phase: Expansion of subsidy						
														4th Phase: Contraction of subsidy			

Figure 4A.1 Definition of Phases of the Policies on Subsidies for Firm Relocation during the period of 1997 to 2014

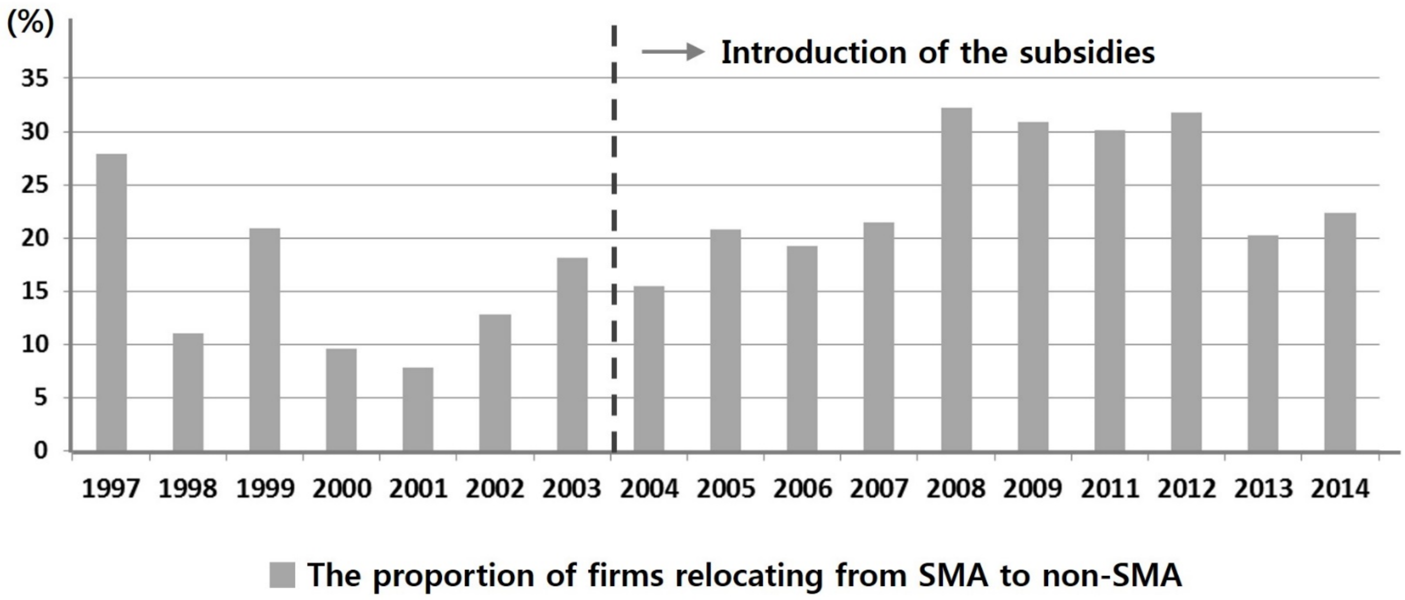

Figure 4.2 Change in the Proportion of Firms Relocating from SMA to non−SMA by Year

Analysis

In this appendix, the effect of subsidies is discussed by analyzing (1) the effect of introducing the set of subsidies on firm relocation from SMA to non-SMA and (2) the effect of changes in subsidies on relocation into non-SMA by eligible firms. Table 4A.2 shows the pattern of firm relocation between SMA and non-SMA during the period 1997 to 2014. Among the total relocating firms, 21.25% of firms previously located in the SMA moved to non-SMA and the other 78.75% relocated within the SMA. The relocation pattern of firms that are eligible to receive governmental subsidies (see Table 4A.3) indicates that the portion of firms relocating to non-SMA (among those previously located in the SMA) is 35.77%, higher than that of all firms, regardless of their qualification for the subsidy.

Table 4A.2 illustrates changes in the proportions of firm relocations from the SMA to non-SMA among those previously located in the SMA during the period 1997 to 2014. Before the introduction of the subsidy in 2004, the annual average proportion of firm relocations from the SMA to non-SMA among those previously located in the SMA is 12.9%, and it increases to 16.7% after 2004. Although this figure seems to support the effectiveness of the subsidy, the effects of other variables should be controlled.

Therefore, the effect of the subsidy is analyzed by comparing the estimates of the dummy variable indicating a relocation flow from SMA to non-SMA among the groups classified as follows.

(1) Group 1: Before the introduction of the subsidies + firms with eligibility for the subsidy recipient

(2) Group 2: Before the introduction of the subsidies + firms without eligibility for the subsidy recipient

(3) Group 3: After the introduction of the subsidies + firms with eligibility for the subsidy recipient

(4) Group 4: After the introduction of the subsidies + firms without eligibility for the subsidy recipient

Table 4A.4 shows the estimation results of firm relocation decisions by the combination of period and eligibility for the subsidy recipient. The estimates for the dummy variable indicates the origin-destination pair departing from SMA and arriving to non-SMA (FLOW) is greatest among group 1, followed by group 2, group 3, and group 4. The sizes of the four estimates are significantly different from each other. This indicates that the likelihood of firms relocating from SMA to non-SMA was greater before the introduction of the set of subsidies, *ceteris paribus*.

Turning our attention to the effect of the expansion and contraction of subsidies on the spatial pattern of firm relocation, we compare the estimated results of the relocation decisions of firms in different phases of the subsidy policies, as shown in Table 4A.5. Estimates of the dummy variable indicate that firm relocation from SMA to non-SMA is significantly different between firms in different phases. The estimated size is largest among firms in the initial policy period (phase 2), followed by phase 1, phase 3, and phase 4. This finding indicates the following, all else being equal: 1) the introduction of subsidy policies for firm relocation from SMA to non-SMA positively affects the spatial dispersion of manufacturing firms; 2) the likelihood of firms relocating from SMA to non-SMA hardly increases in response to the expansion of subsidies; and 3) the contraction of subsidies diminishes the propensity of firms to leave the SMA and move into non-SMA.

The results of the above analyses imply that the expansion of subsidy measures did not effectively encourage firm relocation from SMA to non-SMA. In this sense, an increase in firm relocation from SMA to non-SMA during the period 2004 to 2010 (shown in Figure 4A.2) can be explained by increasing the merits of location alternatives in non-SMA (e.g., the improvement in spatial accessibility as a result of massive investment in transportation networks and relative advantage in terms of land prices). Therefore, to attract firms into non-SMA, more attention should be paid to local development in terms of favorable environments for industrial activities and the improvements in accessibility between the SMA and non−SMA, rather than solely providing financial subsidies to relocating firms.

Table 4A.2 Relocation Pattern Observed by Firms during the Period of 1997 to 2014

		Destination		
		SMA	non−SMA	Total
Origin	SMA	3,926 (92.46%)	320 (7.54%)	4,246
	non−SMA	1,388 (21.25%)	5,145 (78.75%)	6,533
	Total	5,314	5,465	10,779

* The percentage in parenthesis is calculated by row.

Table 4A.3 Relocation Pattern Observed by Firms with Eligibility for the Subsidy Recipient during the Period of 1997 to 2014

		Destination		
		SMA	non−SMA	Total
Origin	SMA	461 (89.86%)	52 (10.14%)	513
	non−SMA	235 (35.77%)	422 (64.23%)	657
	Total	699	474	1170

* The percentage in parenthesis is calculated by row.

Table 4A.4 Estimation Results of Firm Relocation Decision by the Composition of Period and Eligibility for the Subsidy Recipient

Stage	Variable	(1) Group 1			(2) Group 2			(3) Group 3			(4) Group 4		
		Coef.		S.E.	Coef.		S.E.	Coef.		S.E.	Coef.		S.E.
Stage 1: Whether to move (1: move, 0: stay)	AGE	−0.017		0.010	−0.039	***	0.003	−0.020	***	0.004	−0.027	***	0.002
	ln(SIZE)	−0.533	***	0.199	−0.146	***	0.043	−0.274	***	0.070	−0.007		0.039
	LGROW	−1.175	***	0.321	0.537	***	0.054	−0.463	***	0.098	0.763	***	0.047
	LVAR	0.000		0.000	0.014	***	0.002	0.000	*	0.000	0.006	***	0.002
	ln(MARKET_O)	−1.759	***	0.542	−1.872	***	0.113	−1.095	***	0.201	−1.131	***	0.094
	ln(POPDEN_O)	1.768	***	0.576	1.718	***	0.116	0.936	**	0.211	0.870	***	0.100
	ln(SPEC_O)	−0.269	***	0.099	−0.284	***	0.021	−0.155	***	0.039	−0.323	***	0.016
	COMP_O	0.423	**	0.182	0.180	***	0.026	0.127	***	0.048	0.068	***	0.019
	ln(DIV_O)	−0.427	**	0.177	0.128	***	0.043	0.056		0.074	0.183	***	0.033
	ln(PROD_O)	−0.267		0.172	0.192	***	0.036	0.092		0.060	0.125	***	0.026
	ln(LWAGE_O)	0.001		0.049	0.015		0.012	−0.043	***	0.014	0.014	**	0.007
	ln(LANDP_O)	0.903	***	0.238	0.253	***	0.052	0.314	***	0.091	0.378	***	0.041

Table 4A.4 Estimation Results of Firm Relocation Decision by the Composition of Period and Eligibility for the Subsidy Recipient (continued)

Stage	Variable	(1) Group 1			(2) Group 2			(3) Group 3			(4) Group 4		
		Coef.		S.E.	Coef.		S.E.	Coef.		S.E.	Coef.		S.E.
Stage 2: Where to move	ln(MARKET_D)	0.623	***	0.176	0.602	***	0.036	0.538	***	0.052	0.653	***	0.025
	ln(POPDEN_D)	−0.517	**	0.225	−0.550	***	0.046	−0.688	***	0.079	−0.874	***	0.034
	ln(SPEC_D)	0.459	***	0.100	0.596	***	0.022	0.485	***	0.033	0.581	***	0.016
	COMP_D	−0.500	**	0.196	0.058	***	0.016	−0.301	***	0.053	−0.028		0.019
	ln(DIV_D)	0.305	*	0.166	0.297	***	0.035	0.198	***	0.056	0.233	***	0.027
	ln(PROD_D)	0.044		0.149	0.061	**	0.028	0.118	**	0.053	0.207	***	0.023
	ln(LWAGE_D)	0.028		0.052	0.013		0.011	0.028	**	0.013	−0.006		0.006
	ln(LANDP_D)	−0.330		0.254	−0.597	***	0.050	−0.275	***	0.065	−0.515	***	0.032
	TIME	−0.038	***	0.005	−0.055	***	0.001	−0.036	***	0.002	−0.051	***	0.001
	FLOW	0.926	**	0.302	0.720	***	0.074	0.573	***	0.100	0.464	***	0.049
Mode fit summary	Inclusive value	0.733	***	0.131	0.770	***	0.023	0.821	***	0.043	0.775	***	0.017
	Sample size	1,222			17,170			6,904			28,359		
	Log likelihood	13,442			−8,332			−2,813			−14,052		
	AIC	865			16,725			5,685			28,164		

* Time fixed effects are controlled by including year dummies

Table 4A.5 Estimation Results of Firm Relocation Decision by the Phases of the Policies on Subsidies for Firm Relocation

Stage	Variable	(1) Phase 1			(2) Phase 2			(3) Phase 3			(4) Phase 4		
		Coef.		S.E.	Coef.		S.E.	Coef.		S.E.	Coef.		S.E.
Stage 1: Whether to move (1: move, 0: stay)	AGE	−0.017		0.010	−0.006		0.011	−0.025	***	0.007	−0.019	***	0.006
	ln(SIZE)	−0.533	***	0.199	0.433	**	0.215	−0.341	***	0.114	−0.467	***	0.106
	LGROW	−1.175	***	0.321	−1.293	**	0.554	−0.378	***	0.131	−0.546	***	0.149
	LVAR	0.000		0.000	0.000		0.001	0.000		0.000	0.004	***	0.001
	ln(MARKET_O)	−1.759	***	0.542	−2.066	***	0.734	−0.761	**	0.351	−1.068	***	0.275
	ln(POPDEN_O)	1.768	***	0.576	1.307	*	0.766	0.684	*	0.387	0.945	***	0.280
	ln(SPEC_O)	−0.269	***	0.099	−0.301	**	0.127	−0.156	**	0.061	−0.135	**	0.056
	COMP_O	0.423	**	0.182	0.365	**	0.186	0.133		0.084	0.019		0.089
	ln(DIV_O)	−0.427	**	0.177	0.080		0.224	0.010		0.113	0.073		0.113
	ln(PROD_O)	−0.267		0.172	0.073		0.192	0.085		0.096	0.096		0.086
	ln(LWAGE_O)	0.001		0.049	−0.028		0.051	−0.032		0.025	−0.051	**	0.020
	ln(LANDP_O)	0.903	***	0.238	0.456		0.304	0.362	**	0.151	0.278	***	0.129

Table 4A.5 Estimation Results of Firm Relocation Decision by Phases of the Policies on Subsidies for Firm Relocation (continued)

Stage	Variable	(1) Phase 1			(2) Phase 2			(3) Phase 3			(4) Phase 4		
		Coef.		S.E.	Coef.		S.E.	Coef.		S.E.	Coef.		S.E.
Stage 2: Where to move	ln(MARKET_D)	0.623	***	0.176	0.526	***	0.139	0.512	***	0.086	0.559	***	0.076
	ln(POPDEN_D)	−0.517	**	0.225	−0.526	***	0.200	−0.838	***	0.141	−0.602	***	0.112
	ln(SPEC_D)	0.459	***	0.100	0.496	***	0.091	0.560	***	0.057	0.440	***	0.047
	COMP_D	−0.500	**	0.196	−0.258	*	0.141	−0.357	***	0.095	−0.284	***	0.074
	ln(DIV_D)	0.305	*	0.166	0.351	**	0.164	0.239	***	0.093	0.145	*	0.081
	ln(PROD_D)	0.044		0.149	0.483	***	0.144	0.218	**	0.089	−0.028		0.077
	ln(LWAGE_D)	0.028		0.052	0.030		0.039	0.014		0.022	0.036	**	0.019
	ln(LANDP_D)	−0.330		0.254	−0.732	***	0.199	−0.346	***	0.114	−0.179	**	0.092
	TIME	−0.038	***	0.005	−0.025	***	0.003	−0.035	***	0.003	−0.040	***	0.002
	FLOW	0.926	***	0.302	1.329	***	0.287	0.730	***	0.167	0.269	*	0.150
Mode fit summary	Inclusive value	0.733	***	0.131	0.910	***	0.158	0.766	***	0.065	0.801	***	0.059
	Sample size	1,222			1,239			2,568			3,097		
	Log likelihood	13,442			13,629			28,248			34,067		
	AIC	865			678			2,260			2,738		

* Time fixed effects are controlled by including year dummies

Chapter 5. Conclusions

5.1. Summary

Economic efficiency and equity are two major issues in transportation investment and regional development. Focusing on economic efficiency, Chapter 2 analyzes the spatial economic impacts of road and railway accessibility levels on manufacturing output, with the focus on substitution and complementarity of the intra− and the inter−modal relationship. In a Translog production function framework, *ceteris paribus*, railroad accessibility has positive effects on the marginal value added of local manufacturing industries with respect to both of road and railroad variables, enjoying increasing returns to scale. However, road accessibility could positively influence only on the marginal value added with respect to the railroad variables, holding decreasing returns to scale. This implies that there is not a competing but a complementary relationship between the two transportation modes in terms of increasing manufacturing production.

Chapter 3 develops a framework for economic analysis of high−speed railroad of Korea (KTX) in order to estimate the dynamic economic effects of transportation project on the economic growth and the regional disparity in Korea. The framework is composed of a Spatial Computable General Equilibrium (SCGE) model and a microsimulation module or transportation model of highway and railroad networks. The latter module measures a change in interregional accessibility by highway and railroad line, while the SCGE model estimates the spatial economic effects of the transportation projects on the GDP and the regional distribution of wages. The results indicate that while the development of Honam KTX increase national economic output, regional disparity in terms of GRDP increases, and economic growth effect concentrate to Seoul Metropolitan Area (SMA). However, the increase in factor mobility by time reduces the regional disparity and alleviates the divergence of regional economies. The increase in factor mobility is desirable in terms of the growth of national economic output as well, indicating the enhancement of factor mobility leads to better allocation of resources, and contribute to economic performance (Begg, 1995).

The conclusion in Chapter 3 implies that factor mobility contributes to the alleviation of regional economic disparity caused by transportation investment. Given that firm relocation is an important instrument to reallocate factor inputs, particularly capital inputs, across regions, Chapter 4 aims to analyze the determinants of firm relocation decisions. Using a panel dataset of manufacturing establishments in South Korea, a two-step decision making process of relocation (whether to relocate and where to relocate) is analyzed. Results indicate that in general, both intra- and inter-industry agglomerations attract relocating firms, but local competition discourages their entry. Firms in relatively early stage in their life cycle tend to relocate to municipalities with high degree of specialization of the own industry, but those in later stage in their life cycle are more likely to avoid locations with intra-industry agglomeration. This indicates that firms benefit from localized economies as they pass nursery phase in their life cycle, consistent with product life cycle theory. However, the benefit does not persist over time because industrial specialization could generate negative externalities such as lock-in.

The influence of industrial agglomeration and competition, local average wage level and land prices has different effect on relocation decision of firms depending on firm level attributes such as the type (single or multi−plant firm), size of employment, and technology intensiveness, because each variables could serve as both cost and benefit for the firms.

In order for balanced development across regions, policy measures to deconcentrate industrial activities to non−SMA have been continued for decades. Focusing on the subsidies offered for relocating firms, the effect of the policies on firm's likelihood of relocation from SMA to non−SMA is investigated. The results indicate that despite the increase in the proportion of firms moving toward non−SMA after 2004, the introduction of the subsidies, the effect of the subsidies on firm's relocation to non−SMA seems to be not successful once the influence of other factors are controlled. This implies that not only subsidies or regulative policies to redistribute industrial activities may not effective as itself without local level attributes satisfying the firm's location demand

5.2. Further Research

This paper is composed of three essays on transportation and regional development focusing on economic efficiency and equity. From the first essay, future research agenda could entail quantifying of the road accessibility index with congestion effects considered. In this paper, the population of the destination is utilized to represent the mass of attraction, and planning speed is applied to calculate road travel time based on the assumption that the road infrastructure is under-saturated without traffic delay. As shown in Graham (2007), road traffic congestion negatively influences agglomeration benefits; thus, it would be meaningful to compare the productivity effect of transportation accessibility with/without consideration of the road traffic congestion. In addition, improvements in road and railroad accessibility affect the spatial mobility of labor and capital as well as population; therefore, it would be useful to analyze the spatial economic impact of transportation accessibility under an equilibrium state by developing a simultaneous system in which the production function and the functions of factor mobility and migration are interacted.

In the second essay, there are two further research issues regarding the SCGE modeling. One is that the recursive integrated transport-SCGE model can be transformed into a long-term optimization model based on the notions of rational expectations. The dynamic optimization model requires a large numbers of variables, and some of the parameters are likely to be statistically insignificant or to be guesstimates. It also has practical problems such as the limits of computation and the regional data for forecasting the control variables. This simulation contributes to the identification of the optimal allocation of railroad investments over time and space and measures their contribution to a reduction in regional disparities under constant economic growth. Another extension is to develop a framework to estimate economic effects of railroad linkages between North and South Korea on national economies. The possible access to the high-speed railroad of China may change the economic benefits of railroad projects and affect the priorities for construction. The network effects in this case are likely to be much larger than any other domestic link projects.

In the third essay, it could be worthwhile to analyze the difference in firm’s location choice depending on the motivation of relocation. Since a firm relocation can be either an adaptive behavior for changes in internal or external conditions that firms are facing (Pellenbarg 2005) or a strategy to exploit spatial advantages provided by a specific site (Figueiredo *et al.*, 2002), generalized interpretation on firm relocation behavior without enough consideration of the drivers of relocation could be often misleading. In addition, we could extend the view on recursive relocations. Aside from being the identification as firm maturity in its own product life cycle, it can also be an outcome of dissatisfaction of previous relocation. For example, if a firm fails to acquire expected benefit from relocation or face an adverse effect, it could try relocation again to retrieve the failure. Furthermore, there could be systematic differences between firms with recursive relocations and the others (e.g. financial instability, ownership of premises, and real estate arbitrage). So, an inclusive approach taking into account the motivations and potential heterogeneity of recursive firm relocations would be needed.

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국문초록

교통투자와 지역성장 및 기업이동에 관한 에세이

이 유 진
농경제사회학부 지역정보전공
서울대학교 대학원

본 논문은 교통투자와 지역성장 및 기업이동에 관한 세 가지 에세이를 제시하였다. 2장은 교통 인프라 간 대체-보완 관계를 고려해 도로 및 철도접근성이 제조업의 산출에 미치는 영향을 분석하였다. 접근성 등 지역 변인 간 상호작용을 포함하는 트랜스로그 생산함수의 추정 결과, 다른 조건이 동일할 때 철도접근성의 증가는 철도접근성의 제조업 한계 생산효과를 둘 다 증가시켜 네트워크의 확장에 따른 한계수확 체증효과가 발생하는 것으로 나타났다. 반면 도로접근성의 증가는 도로접근성의 제조업 한계 생산효과를 감소시켜 도로 인프라의 구축에 있어서는 한계수확 체감현상이 발생함을 보였다. 또한 도로접근성 및 철도접근성 간에는 보완관계가 존재해 지역 내 제조업의 산출 증가에 있어서는 두 수단의 복합 개발이 유리하게 작용함을 시사하였다.

3장은 고속철도의 개통이 경제 성장 및 지역 균형에 미치는 영향을 분석하였다. 교통네트워크 시뮬레이션 모듈을 결합한 공간연산일반균형모형을 적용해 호남고속철도 개통의 경제적 효과를 분석한 결과 고속철도의 개통에 따른 시도 단위 지역 별 총생산 증가 효과는 수도권에 집중되며 개통 이전에 비해 지역 간 총생산의 격차가 심화되는 것으로 나타났다. 한편 시간 경과에 따라 생산요소의 지역 간 산업 간 이동성이 증가한다는 가정 하에서는 생산요소의 이동을 전제하지 않은 경우에 비해

고속철도의 개통으로 인한 지역 간 총 생산의 격차가 완화되며 총 생산의 증가 폭도 큰 것으로 나타났다. 이는 교통 인프라, 특히 고속철도의 개통은 지역 간 균형개발에 부정적으로 작용할 수 있으나 생산요소의 이동 제약이 완화됨에 따라 인프라 투자에 따른 지역 간 격차가 완화될 뿐 아니라 요소의 효율적 배분에 따른 경제적 효율성이 증가함을 시사한다.

4장은 제조업체의 입지 이동 결정을 분석하고, 이를 통해 기업의 연령 증가에 따른 입지 선호의 변화를 살펴보았다. 네스티드 로짓 모형을 적용해 입지 이전 여부 및 재입지 지역의 선택의 상호 연관된 의사결정 요인을 분석한 결과 다른 조건이 동일한 경우 산업다양성이 높은 곳에서 해당 산업이 집적한 곳으로 이동하는 것으로 나타나나, 기업의 성숙도가 높을수록(재 이동인 경우) 오히려 해당 산업의 집적 지역에 입지하는 것을 피하는 것으로 분석되었다. 생애주기의 초기 단계에 있는 기업의 경우 산업의 다양성을 통한 학습효과 및 공정혁신의 편익을 누리다가 표준화된 공정을 개발한 후에는 동종 산업이 집적한 곳에 입지함으로써 비용을 절감하고자 하나 그 중 일부 기업은 국지화 경제와 관련해 발생할 수 있는 고착화 등의 부정적 영향을 줄이고자 동종 산업의 집적지역을 이탈해 입지를 이동하는 경향이 나타나는 것으로 해석된다.

동종 산업 간 경쟁은 이동기업의 유입을 제약하지만, 이동기업이 속한 산업의 기술의존도가 높을수록 입지 선택에 있어 동종산업의 경쟁의 영향을 덜 받으며, 이는 기술의존도가 높은 제조업의 경우 동종 산업의 경쟁에 따른 혁신 등 긍정적 효과가 경쟁 자체로 인한 부정적 영향을 상쇄할 수 있음을 시사한다. 기업의 종사자 규모가 증가할수록 입지선택에 있어 이동거리 및 지가에 대한 저항이 감소하며, 이는 소규모 기업에 비해 상대적으로 적절한 부지확보가 어렵기 때문인 것으로 해석된다. 또한 이와 관련해 지역 노동시장에 파급효과가 큰 대규모 기업의 유치의 경우, 특히 적절한 부지의 공급이 중요한 요인으로 작용함을 시사한다.

주요어: 교통 인프라 투자, 교통 접근성, 교통 네트워크, 경제적 영향 평가, 공간연산일반균형모형, 경제 성장 및 지역 균형, 기업 입지 이동, 기업의 입지선호도

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