Ph.D. Dissertation
博士論文

Agglomeration and Migration Impacts from High-Speed Rail: Case Study in Japan and Its Implications to Thailand

(高速鉄道整備による集積と人口移動への影響
— 日本の事例分析とタイへの示唆)

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Abstract

This research investigates the impact of agglomeration and migration from high-speed rail (HSR) service. The main objective is to answer the question how productivity benefit from HSR can be maximized through agglomeration and migration. The findings provide a better understanding how agglomeration impact and migration impact from HSR are, which would help planners to coordinate the land use with HSR development in order to best capture the agglomeration benefits.

History of HSR has started in Japan since 1964 when The Tokaido Shinkansen started its service connecting two mega cities, Tokyo and Osaka, together. It was constructed to relieve the over congestion from the conventional line. From the success of HSR service in Japan, Italy implemented the similar engineering concept by providing HSR service in the short section in 1977 and full implementation in Europe has been started in France from 1981. Since then, the ability to link the center of major cities together has been recognized by many countries and the service has been widely implemented in Western Europe and Eastern Asia. Currently, many developing countries consider HSR investment as one of the stimulants to economic activities. Among them, Thailand is also one of the countries which aim to realize the HSR service as one of the means to promote the rail transportation and the means to stimulate the domestics economic activities.

In a discussion regarding benefit from transportation project, direct benefit from time saving would be the main benefit in the discussion along with the project cost in cost-benefit analysis (CBA). However, the importance of indirect benefits has been raised in the discussion in CBA as well since if the only direct benefit is only considered, the naïve assumption that transportation service does not affect the utility change in other markets has to be assumed. In reality, new transportation creates other externalities such as air pollution and transportation accident, which causes a change in other markets and eventually influence the economic productivity.

Among indirect benefit, “agglomeration” is recently one of the most debated indirect benefits from transportation service. Agglomeration benefit could be simply explained as the benefit that comes when firms and people locate near one another as a cluster. If the definition of “near” is defined in a unit of time, better transportation shortens travel time and faster travel also means located near one another too. “Wider Impacts”, a guideline to estimate additional economic impacts from transportation project provided by UK Department of Transport includes the benefit from agglomeration as one of the three additional impacts. Especially in HSR project, agglomeration benefit from HSR is expected to be higher than other types of transportation project because of the characteristics of HSR, which links the city centers together. It was estimated in the HS2 project as ex-ante analysis that agglomeration benefit could be large up to 44% of direct benefit (Kernohan & Rognlien, 2011).

In this research, first, whether there is agglomeration impact from HSR service or not is tested. Next, agglomeration impact in each industry is investigated. The impact of industrial diversity and specialization are further explored in the next step. Finally, this study checks the migration impact from HSR along with other socioeconomic parameters. In these four steps, empirical analyses from the longest history of HSR service in Japan are discussed to give a better understanding about actual agglomeration impact from HSR. It should be noted that currently, there is no ex-post study concerning the relationship between HSR and agglomeration.

Further implementation in the case of Thailand based on the findings from Japan is further discussed for the benefit of HSR development in developing countries.

In the first section, agglomeration impact from HSR service, in general, is investigated along with other HSR service level factors. Empirical analyses with an econometric approach were carried out using panel data for 1981, 1986, 1991, 1996, 2001, and 2006, covering 47 prefectures in Japan. To test the effect of HSR, first, the comparative analysis showed that prefectures with HSR service in Japan tend to be more productive than those without HSR. Next, regression analyses were conducted using ordinary least squared estimation model, fixed-effects model, and instrumental variable model. A number of HSR stations, the share of HSR distance, the share of HSR travel time, and agglomeration from HSR were employed along with other control variables. The results showed that the agglomeration has the significant positive association with the regional productivity while the network externalities also had positive associations although their significances are slightly weaker. They also unveiled the influence of HSR on economic productivity which is higher in the regions with HSR stations, particularly those located within 150-170 km radius from the largest cities rather than those neighboring the largest cities.

In the second section, analyses focus on the agglomeration impact in each industry in order to determine that agglomeration in which industry and under what circumstance such industry should be promoted along with HSR. The analysis assumes two types of agglomeration economies (urbanization agglomeration and localization agglomeration) in 11 industrial sectors and shares a similar dataset with analyses in the first section. Our results show that, on average, the indirect benefit of regional productivity improvement from localization agglomeration tends to be more significant than that from urbanization agglomeration. While the mining sector enjoys significant benefit from urbanization rather than localization agglomeration and the transportation/communication sector enjoys significant benefit from localization rather than urbanization agglomeration, finance/insurance, and real estate can benefit from both agglomeration economies. The results further reveal negative elasticities in the agriculture and service sectors; this could be partly due to the industries' characteristics. Co-agglomeration between different industries is also further investigated to determine which industries should be promoted together. Yet, the results yielded unpromising outcomes due to data limitation.

In the third section, agglomeration in the scope of specialization and diversity is investigated in order to answer two questions: first, to determine whether specialization or diversity promotes economic productivity, and second, to determine whether HSR promotes specialization or diversity. Specialization agglomeration index based on the coefficient of variation of localization agglomeration is proposed to measure city's specialization and diversity. Analyses utilize the data of agglomeration across 17 industrial sectors in Japanese Municipality level. To answer the first question, the result reveals U-curve relationship when productivity is plotted in Y-axis and specialization agglomeration in X-axis. In other words, both specialization and diversity benefit to economic productivity. Yet, a city which is not specialized and not with a high level of industrial diversity will be the loser in the economy. For the second question, based on the assumption of a quadratic function, HSR could affect city's specialization and diversity based on the distance to HSR service. From the results, HSR promotes industrial diversity in the city with HSR service, and the city located around 540 km away from HSR service, while HSR promotes city's specialization in the city located around 270 km away from HSR service.

In the fourth section, migration impact from HSR service is investigated in order to answer the two questions: first, whether the presence of HSR service promotes population growth or not, and second, based on the concern in Thailand, whether HSR service promotes regional growth and prevents centralization Bangkok or not. Regression analysis is formulated assuming the presence of HSR station in the prefecture along with other socioeconomic factors affect migration. The analysis in this section utilizes the origin-destination migration data in Japanese prefecture-level from 1997 to 2009. The results show that the presence of HSR station in the destination prefecture has significant and positive effect while the effect in the origin prefecture is not significant. In other words, more migration towards the region with HSR station can be expected while it is still unclear that region without HSR station faces excess migration or not. To answer the questions, HSR promotes population growth, yet HSR cannot prevent centralization since other socio-economic factors such as level of urbanization, wage level, and unemployment have stronger significance and significance appears in both origin and destination.

Analyses in the case study of Japan from four sections reveal insight information in what condition agglomeration benefits economy, and how HSR promotes agglomeration. Yet, the most important lesson learned from Japan should go back to the fundamental that economic activity can be expanded by agglomeration benefit from HSR. Applying the lesson learned from Japan to Thailand, several implications can be drawn. From the first section, agglomeration benefit to productivity is also found in Thailand although the absence of HSR must be assumed. However, it should be emphasized that generated agglomeration benefit from HSR in Japan could be significantly higher than that in other countries because of the higher population density in Japan. Thus, HSR investment in Thailand should be considered carefully; population density in the service area of HSR should be one of the main considerations in the planning process of HSR in order to maximize the agglomeration benefit. Next, in the second section, as negative agglomeration impact is found in some industries, benefit from policies such as manufacturing and tourism service cluster promotion along with the HSR development might not be as high as expected. In the third section, the findings from Japan reveal that some industries with positive impact from agglomeration might relocate closer to HSR service, thus in Thailand, land use policy should be elaborated together with HSR plan for the preparation of such industrial relocation. The fourth section also suggests that with HSR, more monocentric growth can be expected in Thailand. Therefore, measurements to handle the influx of migrants toward Bangkok and the shrinkage in regional cities should be planned carefully.

Within the scope of this study, two further issues are suggested. First, agglomeration is assumed to be enhanced by HSR. However, other modes of transportation, as well as other telecommunication factors could enhance agglomeration as well. Second, as mentioned that analyses taken in this study are from the case study in Japan, thus some bias toward the result could be expected due to the unique characteristics in Japan. International comparative analysis between different the case studies could be beneficial to the discussion of HSR impact in the future.

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1. Introduction

Achievement of high-speed railways (HSR) in the past few decades draws the attention of many countries. Six out of seven nations in the G7 have HSRs, as well as many other developed countries have HSRs. Even China, the world's largest exporter and second biggest economy, has the largest network of HSR in the world. Successful stories of HSR lure many countries to initiate new HSR projects, especially in developing countries whose leaders believe that HSR will bring prosperity to their nation. But how can a country be sure whether the nation's economy is big enough and their people are ready for HSR investment? Just like the case of Moroccan HSR which received many criticisms for the strain on the budget, should this capital be invested in other more important sector? Uzbekistan, for instance, has considered investing in HSR for a service of only one train per day, is it worth to be invested? In the USA, an auto-oriented nation, how benefits can be gained from HSR in the situation where people are already favored for their best freeway? Even in countries where HSR has been already in service, how can decision makers be sure whether the new proposal will archive a sustainable return like in existing lines? Who can guarantee the success of HSR investment? These questions can be preliminary answered by a proof of impact assessment for HSR. Especially economic impact which has been a point of interest of HSR investment, will be tackled in this study.

Not only HSRs, but also the truth that transportation infrastructure investment will stimulate economic growth is in every individual sense. Level of transportation infrastructure obviously corresponds to the level of economic development. Canning (1998) examined the relationship of infrastructure stocks between 1950-1995 in various countries around the world. Infrastructure stock, including transportation infrastructure (length of road and rail in this report) has a strong positive relationship with other development factors such as population, urbanization level and GDP per capita. Also shown in Fig.1-1, the cross-section data in 1990 shows that the amount of infrastructure stocks per capita which tends to be higher in the country with higher GDP per capita. GDP growth can be perceived along the growth of vehicle distance travel, oil usage and other transportation indicators as shown in Litman (2010). The compilation of various literature on the relationship between transportation infrastructure and productivity was summarized by Deng (2013). It was classified that the level of effect from transportation infrastructure to productivity in each estimation depends on various causes such as time period, scales, regional capability in economic development, affected economic sectors and types and quality of transportation infrastructure.

In an appraisal of economic impact from transportation project, direct benefit from time saving would be the typical benefit in the discussion as an opposing factor to the project cost in cost-benefit analysis (CBA). However, the importance of indirect benefits has been raised in the discussion in CBA as well since if the only direct benefit is only considered, the naïve assumption that transportation service does not affect the utility change in other markets has to be assumed. In reality, new transportation also creates other externalities such as air pollution and transportation accident. These externalities cause a change in other markets and eventually influence the economic productivity.

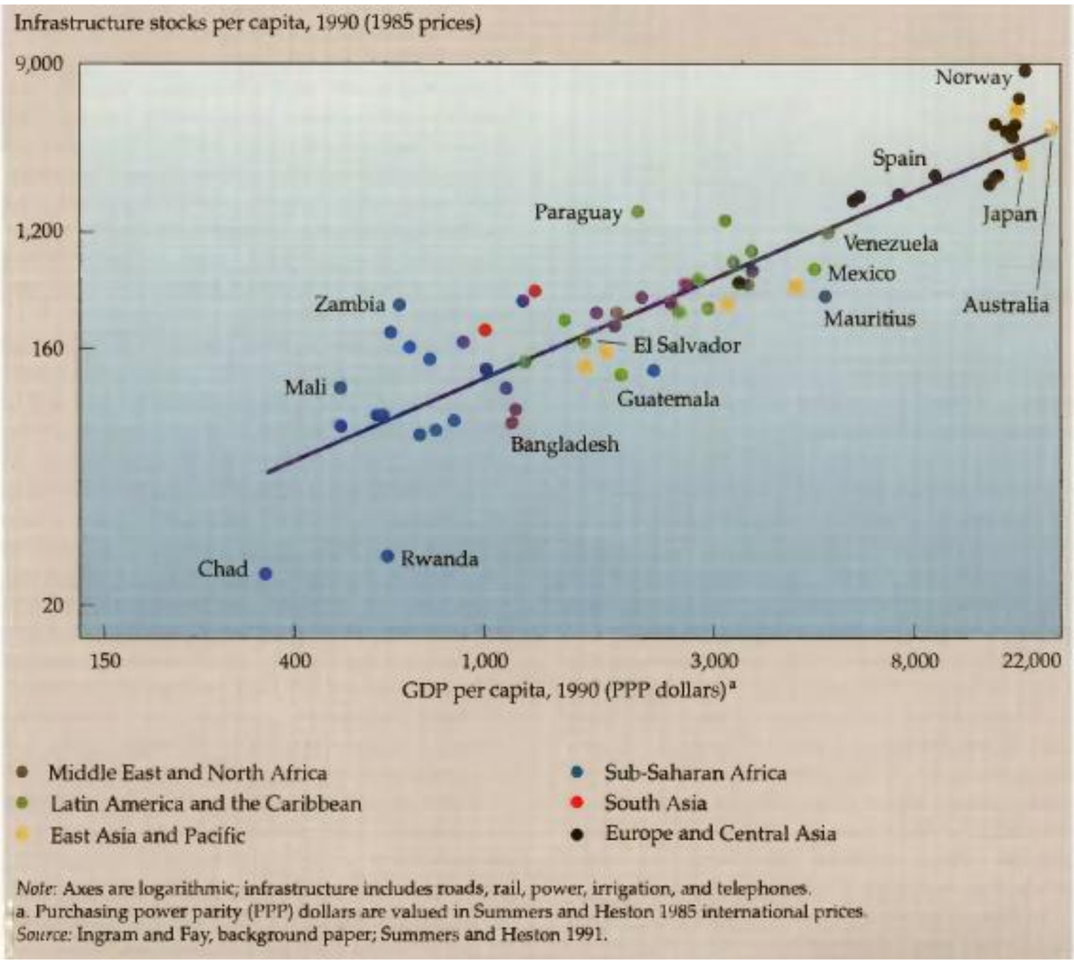

Fig. 1-1. Comparison between GDP and infrastructure stocks per capita in 1990
Source: World Bank (1994)

Among indirect benefit, "agglomeration" has been recently one of the most debated indirect benefits from transportation service. Agglomeration benefit could be simply explained as the benefit that comes when firms and people locate near one another as a cluster. If the definition of "near" is defined in a unit of time, better transportation shortens travel time and faster travel also means located near one another too. "Wider Impacts", a guideline to estimate additional economic impacts from transportation project provided by the Department for Transport of the UK, includes the benefit from agglomeration as one of the three additional impacts. Especially in HSR project, agglomeration benefit from HSR is expected to be higher than other types of transportation project because of the characteristics of HSR, which links the city centers together. It was estimated in the HS2 project in an ex-ante analysis that agglomeration benefit could be large up to 44% of direct benefit (Kernohan & Rognlien, 2011).

From the successful story of HSR service in Japan and in France, the ability to link the centers of major cities together was later recognized by many countries and the service has been widely implemented in the Western Europe and the Eastern Asia. Currently, many developing countries consider HSR investment as one of the stimulants to economic activities. Among them, Thailand is also one of the countries which aim to realize the HSR service as one of the means to promote the rail transportation and the means to stimulate domestic economic activities. The history of the development of Thai High-Speed Railways began in 1994 when government commenced an HSR plan connecting Bangkok with an eastern industrial corridor to Rayong via under-constructed Suvarnabhumi Airport. However, the plan was put on the shelf and later started to be realized again when the Chinese government initiated a discussion with the Laotian government on the investment of railway connection between Kunming and Vientiane in 2008. Since then, HSR investment has been one of the flagship projects in every government until now.

Although the expected agglomeration impact from HSR is not officially recognized by the government, the plan to promote new land use and the special economic zone along with HSR projects are some of the examples which shows that HSR project will be coordinated alongside with other land use scheme in order to maximize the utility of the land use. Thus, it could be said that HSR is expected to strengthen the agglomeration economies in Thailand. In this study, I explore the case study of Japan with the longest history of HSR development in the world since 1964, as an example to investigate the agglomeration effect from HSR. Based on the methods and the results from the case study in Japan, implications to the case study in Thai HSR will be further investigated.

In summary, two main objectives in this research are:

1. To investigate the existing agglomeration and migration impacts from HSR service in Japan and the potential impacts in Thailand, in these following issues
    a. Agglomeration impact from HSR in general
    b. Impact from industrial scale of agglomeration
    c. Impact from diversity of agglomeration
    d. Migration impact
2. To discuss the possible HSR-related policies in Thailand, in order to maximize the economic impact from HSR through agglomeration and migration

This research is structured as follows:

Chapter 1- Introduction: This chapter generally discusses the relationship between agglomeration impact and HSR, and the HSR project in Thailand. Objectives and research structure are described in herein.

Chapter 2- Literature Review: Past discussion regarding economic impact is provided in the first section. The Economic impact is further discussed as direct impact and indirect impact, and how agglomeration is treated as indirect impact in general. Second part provided the past discussion specifically on economic impact and agglomeration impact from HSR project. Expected impact from Thai HSR is further discussed in second part.

Chapter 3- Methodology: Definition of agglomeration is discussed in detail in the first part. The assumption used to explain the agglomeration and the definition of types of agglomeration analyzed in this research are discussed. Second part provided discussion regarding estimation techniques used in this research.

Chapter 4- Analysis 1: Whether the agglomeration impact, in general, does exist as an effect from HSR service or not, is investigated in the case study of Japan along with other direct HSR effects. Temporal and spatial analysis, as well as scenario analysis, are included in addition to the main analysis.

Chapter 5- Analysis 2: Agglomeration impact to each industries is examined. In order to capture the agglomeration benefit, which industry should or should not be agglomerated along with HSR development is investigated in the case study of Japan.

Chapter 6- Analysis 3: Two main issues are explored in this chapter. First, to clarify whether specialization or diversity promotes economic productivity and second, to determine whether HSR promotes specialization or diversity in the case study of Japan.

Chapter 7- Analysis 4: The Thai government expects that HSR could be one of the policy to prevent centralization to Bangkok, but such effect can be expected from HSR or not? The migration effect from HSR service is investigated in the case study of Japan through the assumption of job relocation.

Chapter 8- Implication: Synthesize the results from Japanese case (chapter 4-7) and apply the analyses to the case study in Thailand. Policy discussion regarding Thai HSR is provided based on the findings from Japan and Thailand.

Chapter 9- Conclusion and discussion: summarize the findings of the agglomeration and migration impact from HSR in overall, and give a suggestion for future research.

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2. Literature Review

Economic Impact

Direct Impact

Under perfect competition, theoretically, total benefit from any policy change can be captured through social surplus, the sum of consumer and producer surplus. However, in the real world with full of price distortion[1], at the point where the price cannot be set at marginal social cost to provide maximal social benefit, the estimation of total benefit by consumer surplus approach may yield some inaccuracy. Nevertheless, in order to evaluate the benefit, one of the obvious benefits from transportation to transportation users is direct benefit. A term of "Direct Benefit" can be evaluated using consumer surplus, assuming transportation users as consumer and transportation service as goods. Thus, consumer surplus from a reduction in the cost of transportation can be simply defined as an area α and β in Fig. 2-1. The benefit in the area α corresponds to surplus from existing users where benefit can be gained from a reduction in transportation cost. On the other hand, benefit in triangle area β corresponds to surplus from new users who can afford to pay for transportation cost after a reduction. One of the US guidelines regarding the benefit estimation (Transportation Research Board, 2002) suggested an estimation in two steps: estimation of user cost (vertical axis in Fig. 2-1) and estimation of demand (horizontal axis in Fig. 2-1). In cost estimation, Transportation Research Board (2002) further suggested that the costs perceived by users have two main components: monetary or "out-of-pocket" costs and the value of time spent traveling. Monetary costs such as ticket fare or fuel cost may be easy to be observed. However, the value of time spent on a trip may require a more sophisticated approach to determine a value of time in the monetary unit. For example, in a trip on public transit, people tend to treat time spent on walking, waiting, transferring and in-vehicle time differently. Some people may enjoy walking to closer station, or some may prefer to wait longer for the next service with less crowded. The UK guideline (Department for Transport, 2014c) also suggested a value of reliability[2] of transportation project should be included in direct impact too, as users may value credibility as one of the factors to select the service. Yet, estimation of the cost requires an explicit understanding of cost definition in each type of transportation project. For instance, a highway project requires the use of a car thus cost of fuel and vehicle depreciation are needed apart from public transit project. Some appraiser might include revenue from transportation scheme in direct impact as well since it can be perceived as a benefit to the government (firm), but usually, revenue from the operation will be calculated as a reduction in cost. The latter steps, demand estimation requires bigger resources and information to be estimated. Estimation method may range from the traditional four-step model to more complex model such as activity-based model, land use based model or other variations based on utility function model. In summary, direct benefit is typically defined by impacts shown in the second column of Table 2-1.

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[1] Such as tax, regulations and other externalities

[2] Refers to variation in journey times that individuals are unable to predict. Such variation could come from recurring congestion at the same period each day or from non-recurring events, such as incidents.

Table 2-1. Impact Summary

Category of impact	Impacts that are typically monetised	Impacts that can be monetised but are not reported in the AMCB table	Impacts that it is currently not feasible or practical to monetise
Economy	Business users and private sector providers (including revenues)	Reliability impact on business users Regeneration Wider Impacts	
Environment	Noise Air quality Greenhouse gases	Landscape	Townscape Historic Environment Biodiversity Water environment
Social	Commuting and other users Accidents Physical activity Journey quality	Reliability impact on commuting and other users Option and non-use values	Security Access to services Affordability Severance
Public Accounts	Cost to broad transport budget Indirect tax revenues		

Source: Department for Transport (2014a)

One of the popular methods to assess an impact of any project investment is cost-benefit analysis[3] (CBA) which was introduced in the 19th century. An application to transportation investment was initially regulated in UK, and later to EU, US, Canada, and to other parts around the world. Despite the simplicity of its result – only the ratio between "benefit" and "cost" – it made CBA more popular among other indicators. Yet, a clear interpretation of the definition of "benefit" and "cost" is still currently in the debate until today. In terms of transportation investment, "cost" itself mainly composes of capital such as huge investment cost and service cost plus some negative effect, however, "benefit" assessment may be more complicated to be defined. Usually, transportation benefit includes travel time saving, reliability, comfort and crowding, safety, fitness and health, wider impacts, regeneration, along with other externalities which have no market to be evaluated (sometimes treat as cost) such as noise, local pollution, climate change, environmental capital (Mackie and Worsley, 2013). Although in practice, the term of direct benefit is usually defined in the same manner as mentioned, combinations of other benefits than direct one are determined differently among each appraiser, sector or country, depending on the viewpoint of the evaluator. Moreover, CBA also received many criticisms on its bias. For instance, CBA treats benefit in monetary term equally, which means people value 1 yen equally. However, in reality, millionaire may value 1 yen less than a poorer one. Still, CBA is a powerful tool for policy maker for a solid explanation to any stakeholder regarding the justification of the scheme as quoted in Sunstein (2002), "…(CBA) especially effective in risk evaluation to avoid informational cascades". Suppose a highway project cutting through a large number of residents. CBA or any appraisal could be one of the clear proofs to

[3]Cost-benefit analysis is a general term of a method to compare pros and cons from any project. Comparison of benefit and cost can be present in many variations, such as benefit cost ratio (BCR), or summation of benefits and cost such as net present value (NPV) and internal rate of return (IRR).

the residents that project will be successful. But without a clear proof to the resident, people will have doubt and may resist relocation.

Currently, CBA can be considered as one of the requirements in any project appraisal or any primary feasibility study. As shown in Table 2-2, many OECD countries apply CBA as the main evaluation method. For general transportation project evaluation, World Bank (2005), summarised the benefit term as the sum of change in transportation user benefits (Consumer Surplus) + change in system operating costs and revenues (Producer Surplus and Government impacts) + change in costs of externalities (Environmental costs, accidents, etc.). Cost term is an investment cost including the cost for mitigation measures.

Table 2-2. Evaluation method, period, discount rate and residual capital values used, 1995

Country	Evaluation Method	Evaluation Period (Years)	Discount Rate %	Residual Value of Capital Calculated
Belgium	MCA, NPV[a]	Project's lifetime[b]	4	No
Denmark[c]	First year rate of return	30	6	N/A
Finland	Benefit-cost ratio	30	6	Yes
France	First year rate of return	N/A	8	N/A
Germany	Benefit-cost ratio	30	3	No
Ireland	Benefit-cost ratio	30	Various[d]	N/A
Israel	NPV	15	7	Yes
Italy	Benefit-cost ratio	N/A	N/A	N/A
Netherlands	MCA, NPV	30	4 (1998)[e]	No
Norway	Benefit-cost ratio	25	7	Yes
Portugal	NPV	20	8	No
Spain	Benefit-cost ratio	30	6	No
Sweden	Benefit-cost ratio	40	4	No
UK	Benefit-cost ratio	30	8	No
Australia	Benefit-cost ratio	30	7 (1996)[f]	No
Canada	NPV	30	10	No
New Zealand	Benefit-cost ratio	25	10	Yes
South Africa	Benefit-cost ratio	30	15	No
USA	Benefit-cost ratio	40	7 (1992)[g]	Yes

Source: Banister and Berechman (2000)

Notes:

[a] MCA: Multi-Criteria Analysis; NPV: Net Present Value

[b] The project's benefits are estimated for 30 years and assumed constant thereafter. Benefits and costs are discounted over infinite lifetime.

[c] Future discounted maintenance costs are added to the first year total project's costs

[d] Various trial discount rates are used as a form of sensitivity analysis

[e] This is the official rate of return for risk-free projects. For risky projects a higher discount factor is applied. This level is based on the long-run net interest rate of government bonds.

[f] Austroads (1996)

[g] US Office of Management and Budget (OMB) 1992

Indirect Impact

Apart from the direct benefits, the rest of impacts in the evaluation are generally called "Indirect Impact". Theoretically, while the direct impact directly affects the primary market, indirect impact is referred to the additional impact to the secondary market. Consider a new HSR project, direct impact refers to cost and benefits in the HSR market such as reduction in travel time and transportation cost or even pollution caused by HSR. However, HSR users are transferred from other transportation modes users. Thus, any impact to other modes such as a reduction of congestion in highway which is caused by the induced demand to HSR will be considered as the indirect impact. Indirect impact is often referred to as secondary, second-round, spillover, side, or pecuniary impact as well (Boardman, et al., 2006). However, in practice, the term of indirect impact is still ambiguous, as the effect apart from direct user benefits and cost are usually defined as indirect impact. What impact should be included or not in indirect impact is still under the debate until present. Banister and Berechman (2000) portrayed indirect effects from infrastructure investment as allocative and pecuniary externalities and other multiplier effects. Burgess and Tavasszy (2004) referred the term of indirect effects used in spatial computable general equilibrium (SCGE) model of IASON project as the effects outside transportation market, typically including changes in output, employment and residential population which result from a change in generalized cost by transportation initiative. Weisbrod and Reno (2009) suggested that indirect and induced effects should be treated as an increase of business sales output, value added in GDP, labor income, and tax revenue. Ideally, the existence of the term of direct and indirect should not be separated at all as every cost and benefits should be included in the same appraisal to reflect the real effect caused by transportation scheme. For scheme evaluation, comparison of transportation project appraisal among the UK, France, Japan, the USA and Germany is provided in Hayashi and Morisugi (2000) which showed that the guideline of every country acknowledges the external cost such as environmental impact and safety issue into CBA. Only Germany and UK include economic impact in their appraisal. The Japanese guideline for transportation appraisal also acknowledge economic impact, but economic impact is calculated separately from general CBA (Railway Bureau, MLIT, 2012). However, there are many difficulties regarding the double counting of multiple effects, and researchers claimed that some effects should not be compared or should not be monetized. The task to define indirect impact with precise estimation could be challenging to appraiser as well.

One of the popular methods to define no market indirect impact is contingent valuation method (CVM). CVM is a survey based method which is often referred as a "stated preference." CVM involves directly asking people how much they will value for something. In transportation issue, the survey question may ask to evaluate how much would be a willingness to pay (WTP) for a transportation service. Boardman et al. (2006) provided the general approach of CVM method as follows: first, define the sample of respondents from population; second, ask question to respondents about their evaluation on some goods; third, analyze respondents' WTP for the good from given information; and finally, extrapolate WTP to the entire population. CVM has many advantages, for example, ability to estimate both use and non-use values which can be used on ex-ante evaluation and its flexibility to valuate the variety of different environmental goods. Nevertheless, many problems have been perceived from CVM valuation, for instance, the difference between willingness to pay and willingness to avoid, validity and reliability controlling, hypothetical nature of the survey, behavior in responses and other survey related problem (Holvad, 1999). An example of CVM implication to transportation problem by Ortúzar et al. (2000) showed an evaluation of WTP for transportation accident and pollution reduction costing in Chile. Examples of questions asked are, how much money would you be willing to pay monthly for the next ten years in order to decrease your own possibility of dying by five in one thousand? and how certain that you would pay that amount and not another?

Another interesting type of valuation methods is Hedonic Pricing, a market-value based estimation on land price. In contrast to CVM, hedonic pricing is a revealed preference method where factors affecting land price will be collected on a price basis. The concept of hedonic pricing dated back to a proposal by Rosen (1974) where the price of goods are fixed with a vector of characteristics, thus consumer will try to maximize the individual utility which is a function of such characteristics of goods. Hedonic pricing procedure can be initiated by collecting the data on property sales such as selling price, neighborhood and environmental characteristic which are usually provided in geographic information system (GIS)-based. For application to the transportation problem, accessibility is usually used as a factor that affects the land price. Once data has been collected, the function is estimated with factors that relate to land price in order to test a change on such factor. For example, the impact from transportation project can be evaluated by testing a change in accessibility and see how much change in land price will be affected. Various studies have adopted hedonic pricing for transportation scheme evaluation. One of the initial implementations of Rosen theory of hedonic pricing to land use pricing by Nelson (1978) defined a good as the residential property where its value depends on a characteristic vector of neighborhood characteristic and property accessibility. Neighborhood characteristic used in Nelson`s work was composed of house size, lot size, air pollution along with other unique characteristics test in the additional models such as the percentage of old building, the percentage of colored people, property tax, school expenditure and crime index in the area, etc. Accessibility was defined as auto travel time to the CBD at peak hours. Bowes and Ihlanfeldt (2001) investigated impacts of railway station on residential property values by using hedonic pricing method. In this study, the price of the house is defined by physical and location characteristics of house, neighborhood crime, retail employment and proximity of the house to a rail station which is transportation factor. Armstrong and Rodríguez (2006) used hedonic pricing of linear, semi-log and double-log functions to estimate the accessibility benefits of commuter rail. Property value was defined as a function of property structural attributes (usable area, age, number of bedrooms, number of bathrooms, etc.), community attributes (household income, population density, crime, tax paid, etc.) and accessibility to commuter rail (auto time to station, train headway, average travel time, etc.). One of the applications to HSR by Andersson et al. (2010) also structured in the same pattern. Sales price has been estimated as log-linear, semi-log and Box-Cox functions to structural attributes including, floor area, lot area, age, height, shop use dummy and street frontage dummy. Neighborhood attributes includes road width, commercial/residential zone dummy, mean household income, college-educated district. Accessibility attributes were defined as distance to the CBD, HSR station, freeway interchange and industrial park area. From literature, it can be concluded that hedonic pricing requires a high level of statistical expertise and heavily depends on model specification.

One of the most recognized approaches to identify indirect impacts is the guideline issued by the UK's Department for Transport (DfT) as "Wider Impacts". Wider Impacts guideline from DfT has its root on the study from Standing Advisory Committee on Trunk Road Assessment (SACTRA) on their task "…to consider the effects on the performance of the economy which might be caused by transportation projects and policies, including new infrastructure, changing prices, demand management and measures to reduce traffic."(SACTRA, 1999). According to SACTRA report, it was noted that conventional CBA analysis (which mainly focus on direct user impact) might not cover the whole mechanism in two situations (Department for Transport, 2003). First, when there is a market failure such as imperfect competition and external costs effects. Second, in the geographical term, benefits might not be distributed evenly across the nation as there will be people who gain and loss, such as employment in an area where the project is invested might increase from a reduction in other area. Those questions were initially raised in SACTRA report which was continually developed into a guideline for wider impact. As in the latest issue of the wider impact guideline (Department for Transport, 2014b), additional economic benefits are determined by production-elasticity based which can be categorized in three terms, namely, "agglomeration impact", "output change in imperfectly competitive markets", and "tax revenue arising from labor market impact". Further investigation on DfT guideline will be discussed later in this study. The proposed guideline raised concerns regarding additional economic from transportation investment among appraiser globally. Wangsness et al. (2014) summarized appraisal guidelines in 22 developed countries, finding that five effects originally proposed by DfT guideline have been acknowledged in more than three countries. Another effect which has been acknowledged in more than three countries but has not been included in DfT guideline is excess labor supply effect which focuses on additional jobs created from building and operating transportation infrastructure.

Wider impact proposed by DfT guideline has been in development since past decade. Original proposal in earlier version of DfT guideline incorporated wider impact with four economic benefits and three sub-categories tax benefits (Department for Transport, 2012), namely;

- Agglomeration (WI1)
- Increased competition (WI2)
- Output change in imperfectly competitive markets (WI3)
- Wider impact from labor market change (WI4)
  - o Labor supply change (GP1)
  - o People working longer (GP2)
  - o Move to more or less productive jobs (GP3)

The early proposal also suggested that benefits in WI2 and GP2 should be neglected because of the lack of evidence of their impact (Department for Transport, 2005). Therefore, latest proposal in 2014 completely removed these two impacts and rearranged the new code as follows;

- Agglomeration (WI1)
- Output change in imperfectly competitive markets (WI2)
- Tax revenues arising from labor market impacts (WI3)
  - o Labor supply change (GP1)
  - o Move to more or less productive jobs (GP3)

Noted that later, in order to grasp the overall picture of the term "Wider Impact", in the remaining parts of this chapter, I refer to the 2012 Wider Impact code which will include WB2 and GP2, not 2014 Wider Impact code.

<u>Agglomeration (WI1)</u>

Agglomeration, which will be appreciated in detail in this research, can be roughly explained as benefits from firms staying close together as they can engage in more activities and more effectively than distant firms.

Classical discussion by Marshall (1920) pointed out that the agglomeration economies can be achieved by a reduction in transportation cost by three means. First, agglomeration creates a cluster of firms where producer, supplier, and customer are located together thus the cost of goods and material even service can be reduced. Applying this to transportation means better transportation service creates more opportunities for firms to access to the better and cheaper input material. Not only the goods, but the second discussion also extends to workers as well. Larger pool of labor which can be accessed by firms enables better matching between firms and workers. Better productivity can be expected in an environment that skilled workers have higher chance to match their work according to their skill. Again, better transportation, say shorter travel time inspires workers to work further from their home thus larger agglomeration in labor pooling can be attained by better transportation. Finally, the term of "knowledge spillover" has been raised for agglomeration where technological advance can be sustained through agglomeration. One of the most famous examples of Silicon Valley where the cluster of the information technology (IT) firms are located together where they can learn and assist each other to achieve higher productivity. Again, better transportation, for instance, better accessibility can encourage more meeting, discussion or even workshop. These activities can hasten the learning process, accelerate firm's technology and result in better productivity.

Krugman (1999) gave a description of agglomeration benefits in the denser area as a benefit from better linkage and thicker markets for firms, and spillover between firms. However, he also mentioned that agglomeration may give disbenefits such as rising in land price, wage, and congestion as well. The concept of agglomeration was pioneered by Von Thünen's land use model in the 19th century (von Thünen, 1826) and further developed in geography field. The most famous application of agglomeration model to economic term was proposed by Krugman (1991a) as known under the name of "New Economic Geography". As highlighted in Ascani et al. (2012), new economic geography is composed of four important elements. First, increasing the return to scale escalates where spatial unevenness of economic activity exists. However, such agglomeration should be carefully investigated, as in new economic geography, benefits of clustering may matter less if disbenefits from agglomeration are dominated (Brakman et al., 2004). Second, by implementing Dixit-Stiglitz monopolistic competition model (Dixit and Stiglitz , 1977) to spatial implication, several economic terms can be defined as a function of a change in a number of varieties (firms). Third, transportation cost which was defined as an iceberg transportation cost (Samuelson, 1954) plays a crucial element that influences the location choices. The properties of the iceberg model in new economic geography model imply that transportation cost increase exponentially with the distance shipped which is a contrast to evidence that delivered prices tend to be concave rather than convex with distance (McCann, 2005). Whereas in most traditional economic theory, transportation costs element is equal to zero by assumption. Finally, new economic geography gives pecuniary externalities into account for industrial localization. Externalities emerging from the presence of agglomeration are the benefits from labor market pooling, availability of intermediates and technological spillover effects. Fujita et al. (1999) provided a detailed explanation of new economic geography model and its implementation to an urban economy and international trade. Kanemoto's model (Kanemoto, 2013a; Kanemoto, 2013b), one of the ambitious models which tried to explain Wider Impacts in general equilibrium, was also derived from the concept of new economic geography.

One of the greatest examples to describe the benefit of agglomeration was depicted in Venables (2007). As shown in Fig. 2-1, assuming there is a wage gap between urban and rural area, and a new transportation reduces commuting cost. A shift of commuting cost line creates a direct benefit of cost saving to existing workers (α)

and to new workers (β) who can afford to work in an urban area due to a reduction in commuting cost. However, under the assumption that the productivity in the larger city is higher than the small one, the wage curve creates additional benefit due to an increase in productivity (δ). This additional benefit (δ) is considered as an agglomeration impact.

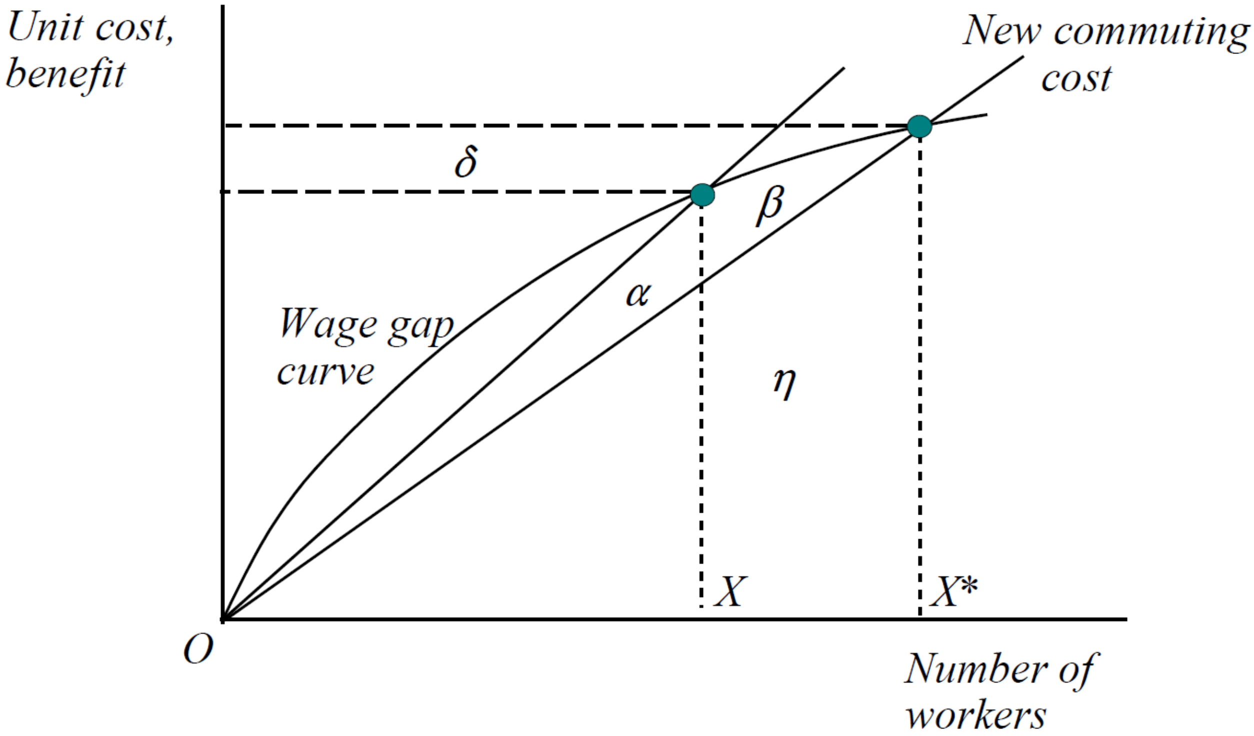

Fig. 2-1. Net gains from transportation improvement with endogenous productivity
Source: Venables (2007)

Recently, agglomeration economy has been in focus by many researchers. Several indexes have been proposed to measure level of agglomeration, for example, agglomeration and co-agglomeration index by Ellison and Glaeser (1997,1999) are defined by Herfindahl Index and the share of employment per industry within region, or Krugman Specialization Index (Krugman, 1991b). Krugman Specialization Index is simply defined as summation of difference between a total share of industry in zone and national level. Nevertheless, a study focusing on a monetary unit of agglomeration impact is still limited. The pioneer to WI1 in DfT guideline came from studies by Graham (2005, 2006) where monetary impact of agglomeration can be determined through elasticity of employment density, transportation cost, and productivity. Further discussion on formula structure is provided in data estimation section.

Increased Competition (WI2)

Under imperfect competition, the price of a goods/service can be set higher than marginal cost by firms. Improvement in transportation can be treated as one of the catalysts to a higher degree of perfect competition which leads to benefits in WI2 and WI3. As pointed out in Jara-Diaz (1986), additional welfare can be gained beyond conventional consumer surplus if there is a difference in level monopoly power between two adjacent markets. According to Department for Transport (2005), benefit in WI2 can be explained as a benefit to firms where transportation development opens new links for firms who can exploit their business in the new market with higher level of monopoly and for consumer in such market. However, guideline argued that such phenomenon would occur only for a new transportation project in the isolated area, for example, a new access bridge to the isolated island. Therefore, the early version of DfT guideline proposed the concept of WI2 but the later versions recommended to ignore its impact because the extensive network of transportation already exists in the UK. Additional transportation infrastructure would not likely to bring more land to be reached, in other words, every area in the UK is already accessible.

<u>Output change in imperfectly competitive markets (WI3)</u>

As mentioned before in WI2, under imperfect competition, firms can set the price with a level of markup. In WI3, along with improvement in transportation, firms receive addition benefit from a reduction in transportation cost which expands their level of benefit. Described in Simmonds (2012), in Fig. 2-2, direct benefit from a reduction in cost can be explained as area A (for existing quantity) and area B (for additional production). However, as mentioned in Department for Transport (2005), the imperfect market creates a markup gap so additional benefit can be further captured in area C, D and E. DfT guideline pointed out that the area of WI3 (C+D+E) is a proportion to direct impact (A+B). Thus, WI3 can be estimated as a proportion to direct impact and such proportion can be estimated by introducing "Uprate Factor" term which DfT guideline suggested a value of 10% to direct benefit. It should be noted that in Kanemoto model (Kanemoto, 2013a; Kanemoto, 2013b) and in the implication by Kidokoro (2015), the cause which makes the market imperfectly competitive is agglomeration benefit. Thus, from the theoretical viewpoint, WI1 and WI3 might share some elements together and should not be considered separately.

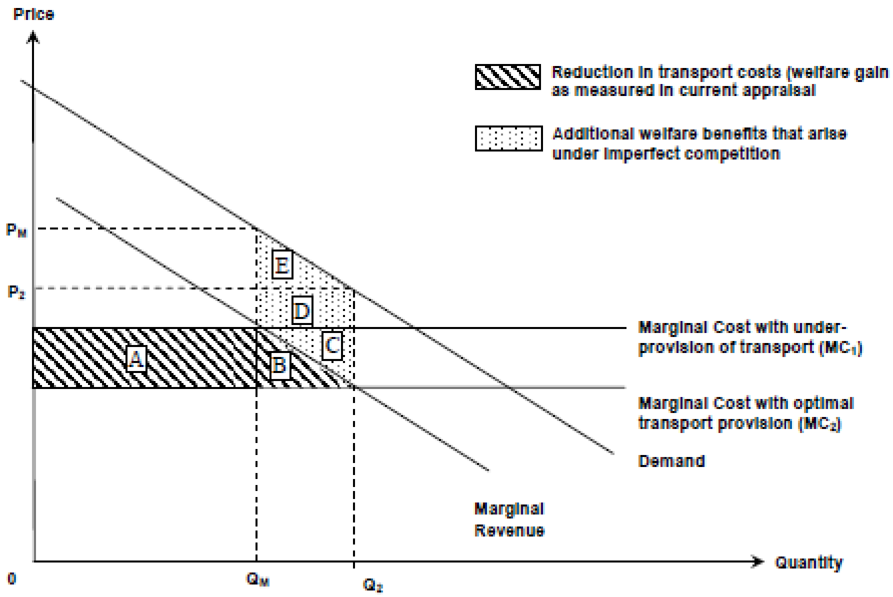

Fig. 2-2. Efficiency gain in imperfectly competitive markets
Source: Department for Transport (2005)

<u>Tax revenues arising from labor market impacts (WI4)</u>

Unlike WI1 and WI3, this benefit will be captured as a tax rate proportion to benefits from individual workers. As depicted in the same model in agglomeration (WI1), Venables (2007) assumed under price distortion of government tax (t), another portion of social benefits would emerge from tax benefit ($\in$) as shown in Fig. 2-3. However, it should be noted that under price distortion, other benefits gained from transportation improvement might be less than in a case of no price distortion, i.e. $\alpha + \beta + \delta$ area in Fig. 2-3 should be less than in Fig. 2-1 because taxation discourages employment growth in the urban area. DfT guideline proposed an estimation of tax benefits from the following three employment change impacts;

Labor supply change (GP1)

DfT defines GP1 as a benefit from an additional worker who chooses to work because of reduction in transportation cost. Additional workers have to be carefully observed, as DfT defined these workers from two groups; people who did not work before (despite living in the study area) and people who came to work from outside study area. Workers who change their workplace within the study area do not include in GP1, thus the origin of the worker should be carefully observed. Apart from the long-term change in employment approach like wider impact proposal, many countries also recognized a short-term employment benefit from transportation infrastructure construction as one of the benefits too. REMI model used in Florida HSR appraisal (Lynch et al., 1997) explained the employment shift effect in two steps: an initial construction surge in HSR related employment activities in the early years of the project and gradual and growing employment recovery through the end of the appraisal period. Furthermore, DfT guideline suggested a tax rate benefit to GP1 at 40% which is higher than GP3 as the guideline claimed that benefit from new worker should be treated at average tax, not marginal tax.

People working longer (GP2)

The idea of GP2 came from an assumption that workers might tend to work longer in their current jobs as they spent less time on commuting because new transportation was provided. This assumption somehow makes sense in the logical term. However, as mentioned in Department for Transport (2005), there is no clear evidence to show that time savings from transportation would affect working hours as workers generally restrict their working hours by regulations. Therefore, the early version of DfT guideline proposed the concept of GP2 but recommended to assumed to be zero.

Move to more or less productive jobs (GP3)

In contrary to GP1, GP3 tends to capture additional benefits from workers who relocate to work in the more productive area. Therefore, regardless of new worker effect in GP1, any workers who change their work to more productive area than average will gain their benefits. However, estimation of GP3 should be carefully observed since those workers who move into more productive zone may come from outside study area or unemployed before. Double counting effect to GP1 might occur. Also, DfT guideline pointed out that if land use model is not available in the study, GP3 can be neglected. This relaxation might create distortion of estimation which may not capture a full benefit in labor supply. For example, wider impact appraisal for the Crossrail project (Crossrail Ltd., 2005, Colin Buchanan and Partners Ltd., 2007) included GP3 in CBA analysis. However, WI3 in HS2 appraisal (High Speed Two Ltd., 2013) was not estimated. Tax rate issue is also recommended to be emphasized as mentioned in GP1.

As mentioned earlier, several implementations on real transportation project appraisal have been conducted in the UK, for instance, Crossrail project in Greater London and High Speed 2 (HS2) project in the middle part of England. However, each appraisal has their own interpretation which might differ from guideline provided by DfT. Original appraisal for Crossrail in 2005 (Crossrail Ltd., 2005) defined appraisal area only in three core main areas, which is different from a suggestion in DfT guideline. Another revised report for Crossrail in 2007 (Colin Buchanan and Partners Ltd., 2007) gave new estimation in employment forecast pattern, resulting in larger estimation in tax benefits from move to more productive jobs. Both Crossrail estimations also yield largest benefits in tax benefits from move to more productive jobs (Table 2-3). However, there was no estimation in move to more productive jobs in the HS2 appraisal (High Speed Two Ltd., 2013) because of no presence of employment model to estimate such benefits[4] (Table 2-4). Apart from GP3 calculation, DfT guideline also allows variation of sensitivity test which includes freight trip[5] in the estimation too. In practice, even in a major project in the UK, variations of definition in wider impact estimation are still found among different transportation project appraisals.

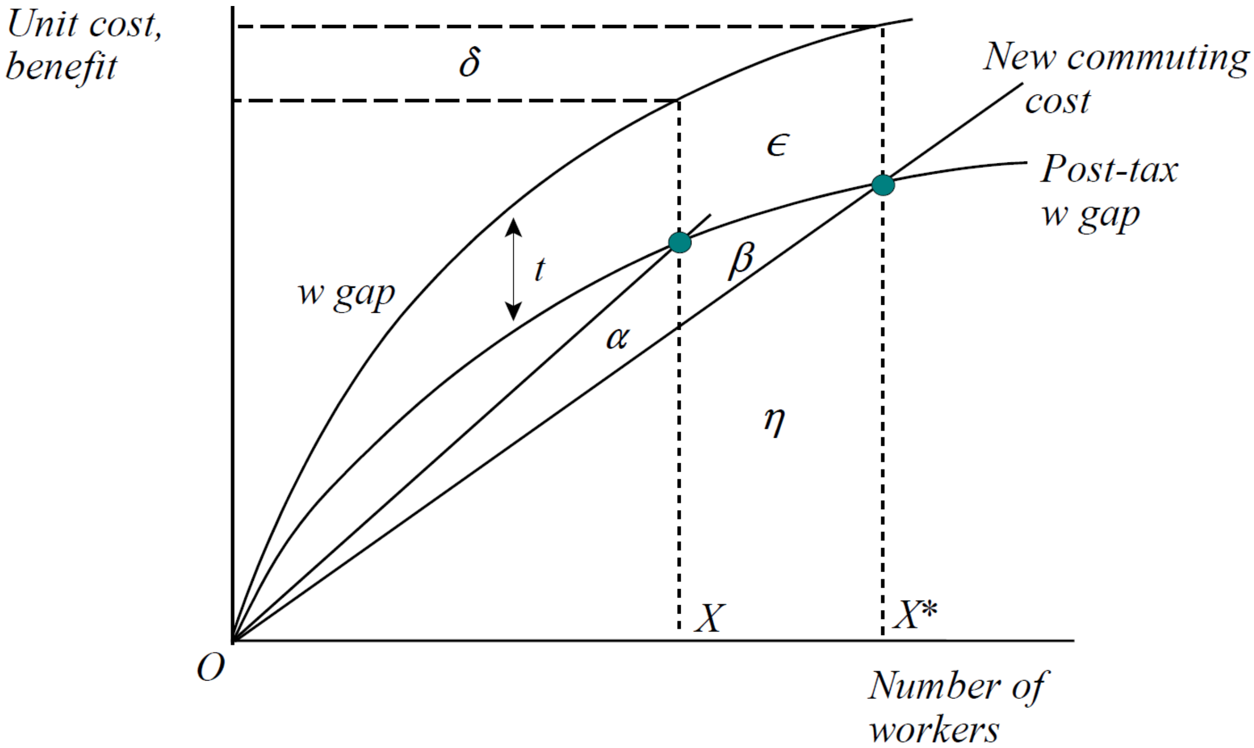

Fig. 2-3. Net gains from transportation improvement with endogenous productivity and tax
Source: Venables (2007)

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[4] In contrary, both Crossrail appraisals reduce difficulties regarding employment and land use pattern model by observing only three core areas.

[5] Where in "Central Estimation", GP3 and benefits from freight mode is not included in calculation

Table 2-3. Crossrail impact assessment

Benefits	High Scenario		Mid Scenario		Low Scenario	
	Welfare (£m)	GDP (£m)	Welfare (£m)	GDP (£m)	Welfare (£m)	GDP (£m)
Business time savings	4,847	4,847	4,847	4,847	4,847	4,847
Commuting time savings	4,152		4,152		4,152	
Leisure time savings	3,833		3,833		3,833	
Conventional User Benefits	**12,832**	**4,847**	**12,832**	**4,847**	**12,832**	**4,847**
Increase in labour force participation		872		872		872
Move to more productive jobs*		46,165		29,919		19,625
Pure agglomeration*	9,322	14,341	8,204	12,622	6,767	10,410
Imperfect competition	485	485	485	485	485	485
Exchequer consequences of increased GDP	19,218		13,742		9,880	
Additional to conventional appraisal (Wider Economic Benefits)	**29,024**	**61,862**	**22,431**	**43,898**	**17,131**	**31,392**
Total (User and WEBs)	**41,856**	**66,709**	**35,263**	**48,745**	**29,963**	**36,239**

Source: Colin Buchanan and Partners Ltd. (2007)

Table 2-4. HS2 estimated benefits for the standard case

		Phase One		Full Network	
Grouped benefit	Disaggregated benefit	Benefit value (£m)	Percentage of total	Benefit value (£m)	Percentage of total
Transport User Benefits	Improved access	£1,094	4%	£1,115	2%
	Reduction in crowding	£4,068	14%	£7,514	11%
	Improvements in interchange	£810	3%	£4,146	6%
	Reductions in waiting	£3,508	12%	£8,081	11%
	Reductions in walking	£404	1%	£1,330	2%
	Reductions in train journey time	£11,518	41%	£31,007	44%
	Greater reliability on the HS2 network	£2,624	9%	£5,496	8%
	Benefits to road users	£568	2%	£1,162	2%
	Total	**£24,594**	**87%**	**£59,852**	**84%**
Wider Economic Impacts	Agglomeration (businesses closer together)	£2,413	9%	£8,706	12%
	Imperfect Competition (increased output due to reduced costs)	£1,692	6%	£4,053	6%
	Increased Labour force participation	£235	1%	£535	1%
	Total	**£4,341**	**15%**	**£13,293**	**19%**
Other Impacts	Reduction of Car Noise	£10	0%	£27	0%
	Carbon	£43	0%	£101	0%
	HS1 Link	£287	1%	£458	1%
	Reduction in Car Accidents	£123	0%	£334	0%
	Noise from HS2 trains	-£55	0%	-£133	0%
	Total	**£407**	**1%**	**£788**	**1%**
	Loss to government of Indirect tax	-£1,208	-4%	-£2,912	-4%
	Total	**£28,134**	**100%**	**£71,020**	**100%**

Source: High Speed Two Ltd. (2013)

Impact from High-Speed Railway

As mentioned in de Rus Mendoza (2012), from the view point of usual economic assumption, benefit from time-saving to increase in productivity can be perceived as a short term effect. While in long term perspective, improvement of accessibility by HSR will attract new activities, resulting in market expansion and increase in firm productivity. For HSR project evaluation, Europian Commission (2008) suggests cost term should be corporate with investment cost such as construction of new lines, stations, purchasing of new rolling stock, along with train operating costs and externalities (land take, visual intrusion, noise, air pollution and global warming effects). Benefits term is composed of time savings, additional capacity, reduced externalities from other modes, increased reliability, generated traffic and wider economic benefits. However, in practice, the definition of cost and benefits are defined differently among various scale of projects, appraisers, and countries. For example, US approach emphasizes benefits from mode shift from highway, aviation and other public transportation to HSR (American Public Transportation Association, 2012).

Sands (1993), Haynes (1997) and Banister and Berechman (2000) provided a summary of empirical evidence of economic impact from Japanese and French HSR. For Japanese HSR (Shinkansen), the obvious effect can be perceived in land use and employment impact. Nakamura and Ueda (1989) found a strong relationship between employment and population growth as the presence of Shinkansen station in three out of six prefectures where Shinkansen is located. Also, development in surrounding area of new Shinkansen stations located in a peripheral area such as New Yokohama Station is likely higher than development in existing stations in the CBD (Amano and Nakagawa, 1990). From the case of French HSR (TGV), several case reports are available in a report by Pieda (1991). For instance, after the introduction of Southeast Line from Paris to Lyon, business trip increased by 56 percent, significant development has begun on a site of the new station, Lyon Part-Dieu. The development was confirmed by a survey of managers who stated TGV is one of the many factors to business relocation decision (Pieda, 1991). In Atlantic Line, a significant development in real estate and large business can be observed in Le Mans, Vendôme (Pieda, 1991) and Nantes (Sands, 1993) as well. Although such development can be physically perceived by a level of urban/regional development, a clear explanation to define a term of economic impact from transportation is still in question. In terms of benefits to the tourism sector, Masson and Petiot (2009) provided evidence to support the effect tourism in French TGV. For instance, evidence from the Southeast Line showed growth in hotel visit as well as a number of congresses, although HSR also penalized the period of stay from an average of 2.3 days in 1980 to 1.7 days in 1992. As well as in Atlantic line, tourism benefit in Le Mans can be perceived in a significant way as a number of attendees from convention and international trade show increased remarkably. De Rus Mendoza (2012) provided a summary of ex-ante forecasted result from IASON project (Tavasszy et al., 2004), showing significant improvement in accessibility and GDP per capita in 2021 upon the completion of the HSR project based on TEN-T network.

One of the recent CBA analyses from California HSR evaluated several benefits such as highway user travel time, fuel, operation and maintenance savings (less congestion because some shift to HSR) and HSR user (who shift from auto) travel time savings, productivity increase and reliability benefits as one of the major benefits from California HSR project (California High-Speed Rail Authority, 2014). Other impacts such as construction emissions, loss of wetlands, agricultural productivity loss and train noise were estimated as disbenefits. The same principle to extended benefit from cost saving in other affected mode of transportation is also followed in Florida HSR study (Lynch et al., 1997) and CBA for Taiwan HSR (Cheng, 2010). In contrary, UK approach seems to focus only on benefits to HSR users. As shown in the HS2 appraisal (High Speed Two Ltd., 2013), main benefits from HSR users are reductions in train journey time, waiting time and crowding. However, one of the interesting points is that the UK approach values wider economic impact which shares around 15% of the benefit in HS2 phase 1, where CBA in other studies gave less attention to such economic impact. Although disbenefit term was considered, only noise from train and loss of indirect tax (e.g., fuel tax) are considered in this project. Tao et al. (2011) used CBA to HSR to other two existing linkages between Mainland China and Hong Kong: HSR, conventional train, and road. Benefits were defined by ticket revenue, travel time, pollution reduction, reliability, and safety improvement where costs were infrastructure, operating and external costs. In the case of the Spanish HSR (AVE) context, de Rus and Inglada (1997) classified costs and benefits as cost, revenue and time saving for HSR and other transportation users; change in the quality of service; reduction in traffic accidents; regional economic development; environmental impact. Ex post study on AVE by Expert Group for Environmental (2012) used a similar definition for benefits as US approach, including time and cost saving for conventional train, car, bus, and air transportation users. However, the AVE's CBA from this ex-post study resulting in deficit net present value. Benefits term in another study on the AVE by Casares and Coto-Millán (2011) also emphasized benefits on users in other modes as well. Apart from benefits and cost definition, distinction in the assumption of demand estimation, namely, "sensitivity analysis" is also one of the factors which results in variation of estimation in the same project. Preston (2009) complied several CBA appraisals on HSR network in the UK, showing variance in CBA estimation under the same project. However, demand estimation issue will not be focused in this study.

In addition to HS2 analysis, many recent appraisals showed a significant interest in an additional economic impact proposed by DfT. Atkins (2012) reported an economic and financial analysis for Norway HSR, recognizing the existence of wider economic impacts. However, it was claimed that full calculations require detailed local and national economic data which is not currently available for Norway. Thus, this study included wider economic impact in sensitivity analysis as 15-30% of conventional user benefits. Another recent empirical analysis on HSR's economic impact was proposed by the World Bank (2014) to capture benefits from high-speed railway project in China. World Bank empirical analysis shares many similarities to DfT guideline in agglomeration and labor impact benefits, but agglomeration was further defined in a hierarchy based on Fujita et al. (1999). Labor impact estimation has been proposed through a probability to relocate due to economic attractiveness, but not estimated in the ex-post case study as claimed that time series data was not large enough to give significant impact. In addition, tourism effect has been proposed as a function of reduction in generalized cost per trip of travel. Tourism effect may play a significant factor to the decision makers to a project implemented in a region with high level of tourism. As mentioned before, the evidence of tourism benefits has been proven in Masson and Petiot (2009). However, estimation of tourism effect might be already captured in one of the agglomeration effect in service sector from DfT guideline. Yet the question is still left on a justification of the mechanism in estimation proposal.

As mentioned in the introduction section, successful projects in HSR development attract various governments to initiate a new plan for HSR. However, as a huge infrastructure investment is required, HSR project creates an extensive concern on budget allocation issue. HSR projects in the USA such as those in California and Texas are struggling to be constructed as Congress cut off financial investment on projects. As well as in UK where HS2 project faces many resistances from The Conservative Party, for not only on a cost of 50 billion pounds but in environmental and land acquisition issue as well. In Japan, an investment of 5.5 trillion yen for benefits from the maglev rail in the first phase is still in question mainly due to population shrinking issue and its competition with an existing HSR line. Even in many developing countries, level of regional economic may not be large enough to create cost effective demand for people who can afford to pay for high service charge for HSR.

In order to ensure the effectiveness of HSR project, credible project evaluation should guarantee the success of the project to some extent. In reality, the government usually claimed that high-speed railway will stimulate economic growth. "(High-Speed Rail) will help accelerate job growth in an economy that is already beginning to grow", once said by Mr. Barack Obama, the Former President of USA. The validity of this statement seems to be justified as many evidence on existing projects have proved a significant growth as a result of HSR investment. However, typical project appraisal such as CBA emphasizes benefits from transportation as a result of a reduction in travel time. Whereas effect to economic development which has been claimed by decision makers has been ignored in the evaluation. Thus, evaluation of economic benefits which can be recorded as an increase in GDP (de Rus Mendoza, 2012) will give a clearer picture to all decision makers how HSR will affect economic development.

Particularly for HSR which presents the unique characteristic of service, exclusive approach to evaluating benefits should be applied. The term of "corridor development" in the same context as conventional rail or highway may not be appropriate for HSR since HSR provides a series of interconnected stations (Vickerman, 1997) with long-distance service. Plassard (1991) referred spatial effect of HSR as "tunnel effect" to reflect effects similar to those in the Channel Tunnel. On the other hand, HSR service is different from air transportation as well since stop through intermediate cities is possible whereas air transportation usually operates within pairs of cities (Ureña et al., 2009). Yet, these unique characteristics of HSR could forge the agglomeration in different ways as compared to other transportation modes; HSR strengthens the agglomeration economies from city centers to city centers. Thus, the different assumption may be needed in order to investigate the effect of HSR. For instance, research done by the same group of Dft wider impact developer (Graham & Melo, 2010) suggested distance decay parameter for HSR appraisal in agglomeration impact (WI1) should be variable subject to distance, not to be fixed as suggest in DfT wider impact guideline. Several assumptions should be customized for HSR in order to secure a feasible estimation of impact.

High-Speed Rail Development in Thailand

History of Thai HSR development began when government commenced the HSR plan connecting Bangkok with an eastern industrial corridor to Rayong via under-constructed Suvarnabhumi Airport in 1994. The 1996 Bangkok-Airport-Rayong HSR study (NESDB, 1996; Fig. 2-4), which was funded by U.S. Trade and Development Agency, has revealed that the financial internal rate of return (FIRR) of 11.02 percent could be expected from HSR operation. However, due to political instability, HSR plan was abandoned and Bangkok-Airport-Rayong HSR has been replaced by a current Airport Rail Link.

HSR plan has started to be realized again when Chinese government initiated a discussion with Laotian government on the investment of railway connection between Kunming and Vientiane. In 2008, Northeast Line has been planned in response to Chinese-Laotian Railway. Since then, railway investment including HSR has been considered as one of the "Mega-Projects" infrastructure investments in Thailand. 2008 plan was later expanded into a 2010 Master Plan (OTP, 2010; Fig. 2-5) where 6 HSR lines have been proposed in this Master

Plan. 2010 Master Plan covers HSR investment in the six main trunk lines and double track upgrade on various existing meter gauge lines.

Although there was a change in political axis after 2010, next government still tried to pursue HSR investment from 2010 Master Plan. In 2013, four sections of HSR proposed in 2010 Master Plan was set to be constructed along with other transportation infrastructure investment in 2-Trillion Baht Investment Loan Bill (NAT, 2013; Fig. 2-6). The government tried to pass the bill of 2-trillion baht loan for infrastructure investment where HSR covers around 43 percent of the loan bill. However, the bill was overruled by the court and the plan was halt due to political unrest in 2014.

The current government is now trying to continue the 2013/2014 plan. The northeastern section from Bangkok to Nakhon Ratchasima is set to be constructed within 2016 and currently under discussion with Chinese Government. North line to Chiang Mai is under a re-study process by MLIT of Japan. The East line to Rayong and Southern section to Hua Hin are under PPP proposal process.

Since around 2009, HSR has been regarded as one of so called "Mega-Projects" investment in Thailand and expected to boost economic activity as a whole. According to The 2-Trillion Baht Investment Loan Bill (NAT, 2013), a 2-trillion investment, where HSR investment accounts for 43%, is expected to boost addition of 1 percent of real GDP growth over the investment period. Other economic impacts are also suggested in the bill, such as job creation of 500,000 positions, 2 percent reduction of logistic cost per GDP, energy cost reduction of 100,000 million baht per year, etc. Direct impact to users such as reduction in passenger car usage and more railway user are also described in this bill, but economic impact is more highlighted and can be considered as the main feature of benefit from this investment bill. The expectation of economic impact is also applied to public perception as well. Amornvivat (2016) mentioned that employment change is likely observed, as new "Mega Projects" would promote a shift of labor from agriculture sector to other sectors, especially service sector that will be emerging along the new infrastructures. Wongfutrakul (2014) conducted a survey study and concluded that HSR will encourage tourism in Chiang Mai and surrounding cities from travel time reduction. Economic benefit from international connectivity was expected in public hearing stage as well (OTP, 2015a; 2015b).

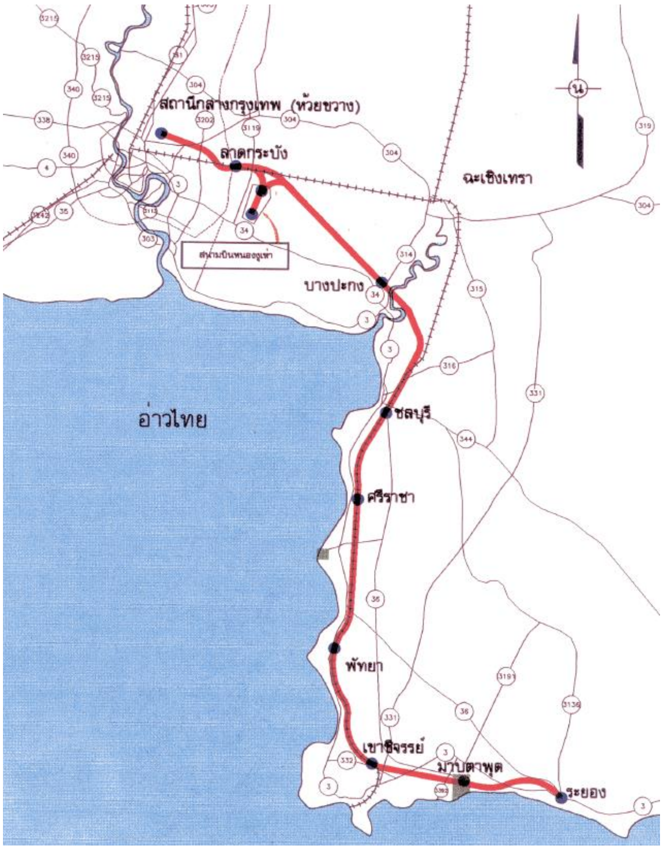

Fig. 2-4. The 1996 Bangkok-Airport-Rayong HSR plan
Source: NESDB (1996)

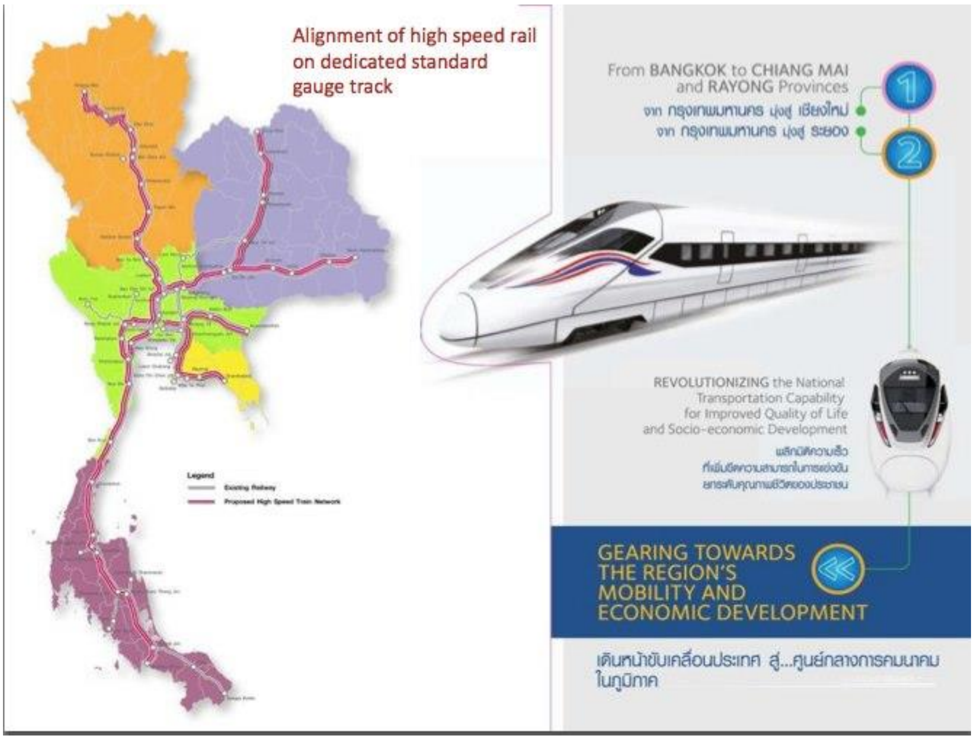

Fig. 2-5. The 2010 Railway Master Plan
Source: OTP (2010)

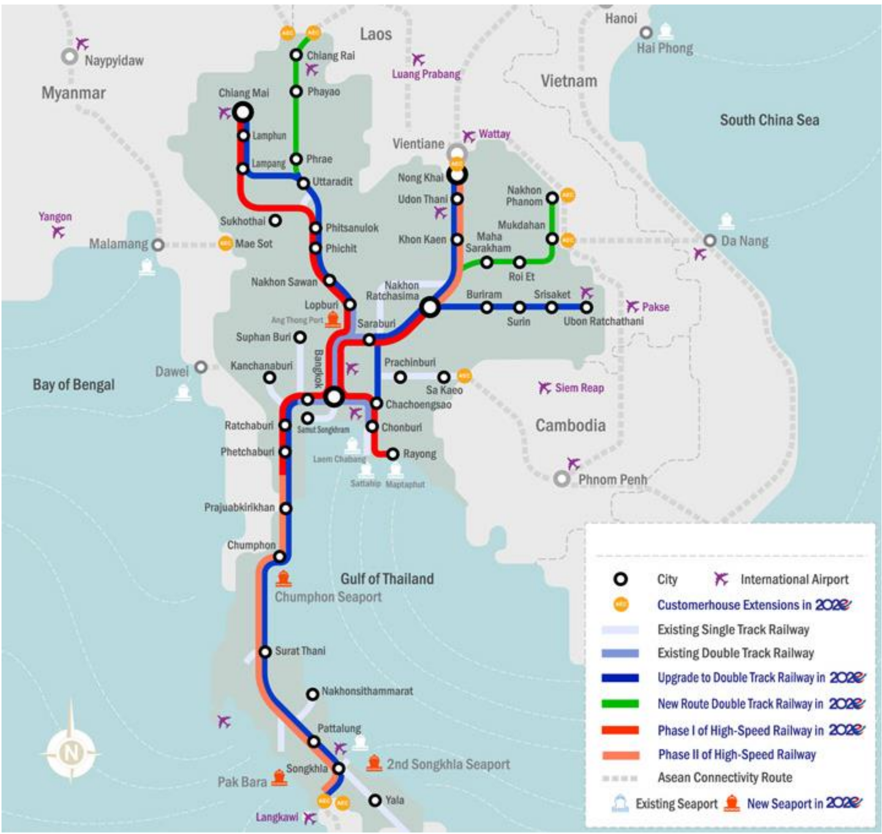

Fig. 2-6. HSR and track upgrade plan in 2013 under The 2-Trillion Baht Transportation Infrastructure Investment Loan Bill
Source: NAT (2013)

Consideration of Indirect Effect in Thai HSR

Currently, there is no official guideline regarding cost-benefit evaluation in Thailand. Consulting company always conducts a feasibility study and project evaluation process for infrastructure investment in Thailand and such result will be later addressed to the government for the decision process. For railway project evaluation, the result is usually shown in financial return and economic return format. As for the financial return, the criterion for Thailand requires project should yield over 5 percent of FIRR. For the economic internal rate of return (EIRR), the criterion is 12 percent. For example, The 1996 Bangkok-Airport-Rayong HSR study (NESDB, 1996), which was funded by U.S. Trade and Development Agency, has revealed FIRR of 11.02 percent. However, EIRR is not shown in this study.

On the contrary, the 2010 Railway Master Plan (OTP, 2010) presented only EIRR results in HSR investment section. The result shows EIRR barely exceed 12 percent in every line except the first phase of the south section to Hua Hin. For EIRR calculation in this study, cost calculation includes several expenditures, namely, design cost, land acquisition cost, construction cost, management cost, environmental measurement cost and rolling stock cost. Benefit calculation includes benefit to road user, time-saving benefit, accident reduction benefit, and pollution reduction benefit. Direct users are highway users, conventional train users, HSR users, and residents in the study area while air and water transportation users are not included in direct user benefits.

Indirect benefit is also presented in this study. However, indirect benefit was separately categorized and not incorporated with direct benefit in EIRR calculation as shown in Table 2-5. Several indirect benefits are presented, such as GDP impact, employment impact, wider impact from accident reduction, wider impact from travel time-saving, wider impact from energy usage and wider impact from logistic cost reduction. Calculation of indirect benefit simply applies a multiplier to investment cost. Thus, there is no mention regarding agglomeration impact. In 2010 Railway Master Plan, GDP impact is calculated from 270 percent of domestic product (local content) which is 70 percent of investment cost. Employment impact is simply shown as 20.7 percent of GDP impact. In The 2-Trillion Baht Transportation Infrastructure Investment Loan Bill, there is no discussion regarding the calculation of cost and benefit. Benefits are presented in general as shown in Table 2-6.

Comparing the evaluation method of HSR to the highway project method, Sihawong (2010) compiled CBA in highway project from nine different cases. Only direct benefit, which composes of vehicle operation, cost saving, travel time saving and accident cost saving is accounted for CBA calculation. However, there is only one case from nine case studies that includes indirect benefit into CBA calculation. In this feasibility study, indirect benefit is productivity change estimated by input-output matrix provided by Office of the National Economics and Social Development Board (NESDB). In summary, difference of methods used implies that benefit estimation in Thailand heavily depends on the assumptions made by consulting company. Providing official guideline could be one of the solutions to correspond each consultant company into the same estimation standard.

Table 2-5. Summary of cost and benefit from the 2010 Railway Master Plan

<table>
<tr><th rowspan="2">Cost</th><th colspan="2">Benefit</th></tr>
<tr><th>Direct</th><th>Indirect</th></tr>
<tr><td>• Design cost
• Land acquisition cost
• Construction cost
• Management cost
• Environmental measurement cost
• Rolling stock acquisition cost
• Operation and Maintenance cost</td><td>• Benefit to road user
• Time-saving benefit
• Accident reduction benefit
• Pollution reduction benefit</td><td>• GDP impact
o = 270% of local content
o Local content = 70% of total cost
• Employment impact
o = 20.7% of GDP impact
• Wider impact from accident reduction
• Wider impact from travel time saving
• Wider impact from energy usage</td></tr>
<tr><td colspan="2">Include in CBA calculation (EIRR, NPV)</td><td>Separate calculation</td></tr>
</table>

Source: OTP (2010)

Table 2-6. Summary of benefits from the 2-Trillion Baht Transportation Infrastructure Investment Loan Bill

Transport Sector Impact	Economic Impact
• 2% reduction of logistic cost per GDP • Inter-city passenger car user reduce from 59% to 40% • Energy cost reduction of 100,000 million baht per year • Railway passenger increase from 54 million to 75 million person-trip/year • Reduce travel time from Bangkok to cities in 300 km radius from more than 3 hours to within 90 minutes by HSR	<u>*Positive Impact*</u> • Increase 1% of real GDP growth per year over investment period • Job creation of 500,000 position <u>*Negative Impact*</u> • Average trade deficit increase of 1% per year from technology import • Average inflation increase of 0.16% per year over investment period

Source: NAT (2013)

Criticism in Thai HSR

Investment of HSR in Thailand has been under intense debate since the 2008 plan. The Economic impact such as production and employment benefit has been highly regarded as the main benefit from HSR as mentioned before. However, concerns such as huge investment cost, overlapping service with meter-gauge double-track project, and low purchasing power of Thai passenger (Bangkok Post Editorial, 2016) as well as concern regarding the plan to let HSR service operates by State Railway of Thailand (Sussangkarn, 2012) are some of the examples of the main discussion since a proposal of HSR plan.

Since consulting company conducts project appraisal and the result is not publicized, this creates an excessive reliance on the unchecked work of the consultancy. Therefore, there is less concern regarding cost-benefit estimation since the report is only distributed within related agencies. Nevertheless, some researchers from Thailand Development Research Institute (TDRI) who have access to such feasibility study report have pointed out some critical points in benefit estimation. For example, Sussangkarn (2012) questioned the poor CBA result of HSR compared to the result of meter-gauge train service in 2010 study (OTP, 2010). Regarding 2010 study, Sussangkarn (2012) pointed out that it is unusual to treat value of time (VOT) in HSR and meter-gauge train service equally for several reasons, such as HSR and conventional rail user are likely to have different VOTs, and shorter travel time on HSR should be more valuable than time spent on conventional train. Furthermore, the possibility of international connection to Laos and Malaysia should be incorporated within the model for economic impact estimation. Also, tourism makes up around 6 percent of Thai economy, thus Sussangkarn (2012) also suggested that HSR demand from foreign tourists could be significant, and should be considered in demand estimation model. However, Sussangkarn (2012) suggested that HSR service will be competitive to air transportation, so the negative impact to aviation sector should be carefully inspected as well.

An article by Ongkittikul (2013) also raised the concerns regarding total benefit from HSR investment which might not be as large as estimated. Ongkittikul (2013) urged for the accountability and transparency in project appraisal process, requested that appraisal process and the result should be all open to the public. Furthermore, methodology and variable used in estimation process should be validated by an independent agency such as NESDB. The criticism concurs with the report from FES-TH and Thai PBS (2013) which suggested that the feasibility study should be conducted by independent agency, not only by consulting company, and another group of independent auditor should be responsible for verifying the content such as assumption used for ticket fare, service frequency, as well as discount rate used in CBA.

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3. Methodology

Agglomeration Economies: Mechanism, Scope, and Empirical Study

An agglomeration economy is typically defined as a benefit of firms staying close together. The concept of industrial scale of economies in Marshall (1890) has been further formulated into three factors leading to agglomeration economies, all closely related to transportation service. First, agglomeration creates clusters of firms wherein producers, suppliers, and customers are located together; this reduces the cost of goods, materials, and even services. Better transportation services can create more opportunities for firms to access better and cheaper input material. Second, this effect is observed in the case of workers as well. A larger pool of workers enables a better matching between firms and workers, and this improves productivity because skilled workers can better match their work with their skills. Since better accessibility inspires workers to work away from home, larger agglomeration can be attained in labor pooling through better transportation. Third, the so-called knowledge spillover can be expected in agglomerated areas. One of the most famous examples is the Silicon Valley; many firms including semiconductor manufacturers and IT firms are located together here, leading to an environment of mutual learning and assistance. Once again, better transportation encourages more meetings, discussions, or even workshops between firms, and this hastens the learning process, accelerates firms' technology, and results in better productivity.

To understand the mechanism of Marshall's economies of scale from an empirical perspective, past studies have categorized agglomeration in different ways. Rosenthal and Strange (2004) provided four types of categorization: industrial scope, temporal scope, geographical scope, and organization scope. As for organization scope, Thabet (2015) provides an investigation between agglomeration and organization-related variables such as competition, firm size, and foreign investment in a case of Tunisia. However, this study would like to focus on agglomeration with regard to the other three scopes. As for temporal scope, the key issue is to investigate whether the effect of agglomeration is static or dynamic. In other words, the agglomeration effect might require an accumulation of knowledge and its effect might develop over a period of years. By using the time lag of a number of plants in the area, Henderson (2003) concluded that high-tech firms also benefitted from the agglomeration level in the past. In a case study of Japan, Fukao et al. (2011) highlight the dynamic change of the manufacturing industry's structure into a technologically oriented one in Japan during the 1990s. As for geographical scope, the key issue is to investigate whether an agglomeration spillover effect exists across the geographical border or not. We provide an index to measure agglomeration by considering the transportation service to capture the spatial lag effects. For industrial scope, which is the main issue in this study, agglomeration is categorized into localization and urbanization agglomeration. In localization agglomeration, we can expect better productivity from agglomeration, if the firms in a similar sector are located close to one another. From Marshall's economy of scale, firms benefit from supplier sharing or even technology transfer through localization. The concept of localized industries was proposed by Marshall (1890) and expanded into a growth model by Arrow (1962) and Romer (1986); the accumulation of knowledge spillover within the same industry is now known as the Marshall–Arrow–Romer externalities. On the other hand, in urbanization agglomeration, the firms' productivity level increases as the total market expands through urbanization, leading to larger labor pooling and cross-industry activities and further to productivity improvement. The benefits of urbanization agglomeration, as described in Jacobs (1969), emerge from different sectors' knowledge spillovers supporting one another. Moreover, innovation growth is believed to be stimulated by a variety of industrialization approaches, because different ideas and information can be synthesized through variety rather than specialization. Glaeser et al. (1992) showed that the economic growth of cities could be developed through the cross-fertilization of ideas in urbanization agglomeration. In other words, firms in large cities benefit from a variety of economies compared to those in small towns.

Empirical studies have reported the robust result of the importance of localization and urbanization agglomeration. For example, Henderson (1986) and Moomaw (1988) highlighted the significance of economies of scales in localization agglomeration in several production industries. Specifically, Henderson (2003) found that the high-tech industry benefits from more localization economies whereas the machinery industry does not, and the machinery industry benefits from more urbanization agglomeration whereas the high-tech industry does not. In contrast, Glaeser et al. (1992) claimed that industrial diversity promotes employment growth in cities, rather than specialization. As regards the study of Japan, where extensive agglomerated areas can be observed because of limited habitable land, Nakamura (1985) estimated the cross section data for 1979. The result showed that localization agglomeration is more important for light industries whereas urbanization agglomeration is more important for heavy industries. However, from these studies, it is still difficult to clarify whether localization agglomeration or urbanization agglomeration is more beneficial to the economies. Nevertheless, there are several insights that we can use from the existing studies. First, previous studies usually considered only the firm scale (number of workers, number of firms) or urban scale (population) to explain the agglomeration level. In this study, we provide an insight on the agglomeration effects from the regional scale. Second, previous studies highlighted only the manufacturing industry, but we would like to expand the scope by covering every industrial sector in the economy for the consideration of agglomeration. Finally, while previous studies discuss the importance of localization agglomeration and urbanization agglomeration, we propose another mechanism between the two agglomerations. Agglomeration does not have to be in a similar industry, as in localization agglomeration, or the absolute size of the agglomeration economies, as in urbanization agglomeration, but we investigate how to best match the different industries to locate together in a precise proportion to maximize the input-output matching process. We provide an index to measure these three types of agglomeration and analyze its impact on production in later sections.

Geographical distribution, as well as transportation services, can shape agglomeration activities. Transportation studies such as Graham (2007), Graham et al. (2009), and Melo et al. (2013, 2016) examined the contribution of transportation to productivity. Graham (2007), Graham et al. (2009), and Melo et al. (2013, 2016) consider transportation as one of the factors for agglomeration economies and showed that improvement in accessibility to transportation in term of "Effective Density" can create a better agglomeration environment. A significant contribution from agglomeration in the context of an urban rail project has been shown in Hensher et al. (2012) in a city scale as well. However, most of these studies investigate the firm- or urban-level effect of agglomeration and ignore the possibility that the spillover effect can spread across the region. Therefore, this study analyzes agglomeration in the regional scale. The case study of Japan can be one of the ideal regional scale case studies for two reasons. First, the firm- or urban-level data could be applied in other countries where the built-up area is distinctly separated and the cross-border effect is unlikely to be expected. However, the built-up area in Japan is highly connected, especially in the coastal area, and so the agglomeration effect can be expected to overflow across the region. Second, since Japan is an island nation, agglomeration across the national border is unlikely to occur. In other words, regional agglomeration can be fully observed without interfering with the agglomeration effect of other countries.

Assumption for Agglomeration: Effective Density

In the research related to agglomeration economies, many variables have been applied to explain the agglomeration level. Raw data such as a number of firms or population is also used to determine the agglomeration level in studies such as Nakamura (1985), Beeson (1987), and Henderson (2003). Furthermore, several indices have been proposed to capture the effect of agglomeration as well. The Ellison and Glaeser agglomeration index (Ellison and Glaeser, 1997) can be regarded as the most widely used index to measure agglomeration in view of its simplicity and unbiased estimation. Further to the Ellison and Glaeser agglomeration index, other discrete agglomeration indices have been proposed, such as the weighted agglomeration index by Maurel and Sédillot (1999) or the probability-based index by Mori et al. (2005). However, these indices compare the agglomeration activity in the zone with other activity outside the zone discretely without actual spatial consideration. Based on Ellison and Glaeser index, Duranton and Overman (2005) proposed an agglomeration index incorporating the distance between firms. In a comparison of the proposed index with the Ellison and Glaeser agglomeration index, Duranton and Overman (2005) concluded that the degree of agglomeration could be remarkably different when the spatial distribution is considered. By considering the distance between the sources of activity, the gravity model-based index as applied in Beeson (1987) is also one of the useful indices from its capability to consider the decay parameter along with the size of agglomeration. The agglomeration index in this study will be explained by *effective density*, one of the gravity model-based indices proposed by the Department for Transport (DfT), Wider Impact Guideline (Department for Transport, 2014), for incorporating transportation into agglomeration.

For the selection of a suitable index for our study, two conditions need to be satisfied. First, our main objective is to investigate the impact of agglomeration through localization agglomeration and urbanization agglomeration. Therefore, the index used in this study must be applicable to these two types of agglomeration unbiasedly, while the Ellison and Glaeser agglomeration index and other earlier mentioned ones may satisfy only localization agglomeration. Second, I would like to consider the accessibility effect because Duranton and Overman (2005) pointed out the importance of the geographical distribution of activities. The gravity model-based index can satisfy both our conditions since the mass, which represents an activity, can be applied to both localization and urbanization agglomeration while the distance in this index can be represented by the accessibility factor. Thus, I can apply the *effective density* index to our study. The effective density of zone *i* is defined as the sum of the mass of employment in another zone *j* and the travel time between zone *i* and zone *j*. This formulation depicts agglomeration in two ways: the mass of employment gives a number of activities generated by a particular zone *j*, and travel time represents the attractiveness of zone *j*'s activities from the viewpoint of zone *i*. This study assumes three types of effective densities to represent agglomeration. The first follows the concept of *urbanization agglomeration*. The economic scale in zone *j* will be explained by the total employment in zone *j*. The effective density under urbanization agglomeration can be formulated as

$$ED_{nit} = \sum_j \frac{E_{jt}}{g_{ijt}}, \qquad (3\text{-}1)$$

where ED_{nit} represents the effective density of zone *i* in any industry *n*, E_{jt} represents the total employment in zone *j*, and g_{ijt} represents the travel time between zone *i* and zone *j*, all at time *t*. This formulation is also used to explain the regional agglomeration in general in the next chapter.

The second type of effective density follows the concept of *localization agglomeration*. For regional productivity-level in industry *n*, the economic scale of each zone *j* will be explained only by the employment of industry *n* in zone *j*. Effective density under localization agglomeration can be formulated as

$$ED_{nit} = \sum_j \frac{E_{njt}}{g_{ijt}}, \tag{3-2}$$

where ED_{nit} represents the effective density, and E_{njt}, the employment of zone *i* in industry *n*, at time *t*.

Definitions and Assumptions of Agglomeration Used in This Study

Considering the definition of regional agglomeration given by Effective Density in concerning city *i*, agglomeration is defined by the sum of the ratio between employments from other cities *j* divided by generalized cost from other cities *j* to *i*. Intuitively, transportation improvements lead to less generalized cost and thus lead to more agglomeration. Yet, transportation may cause employment change in each city and this affects the agglomeration pattern as well. Migration may not be the direct effect from transportation as people are likely to move the place with better jobs, not the place with better transportation service. However, transportation might indirectly induce migration through firm relocation as the firm may relocate to the place with better accessibility in order to enjoy the cost reduction as well as agglomeration benefit. In this sense, new transportation cause a change to agglomeration in two ways; first, through a reduction in generalized cost, and second, through employment in terms of spatial distribution change. According to the calculation of WI1 (Department for Transport, 2014) which I mentioned in the previous chapter, Employment (*E*) used in Effective Density is assumed to be fixed between with and without case, if the estimation of employment change from land use model is not present. In case of absence of employment change, agglomeration change or Effective Density change is assumed to be affected only by less generalized cost. However, in case if the land use model is available, both effects from transportation to agglomeration could be incorporated together. In order to avoid confusion, later I would like to define the impact from HSR to agglomeration through a reduction of generalized cost as "Agglomeration" and impact through employment change as "Migration". Fig. 3-2 conceptualize how HSR investment leads to productivity improvement through agglomeration and migration.

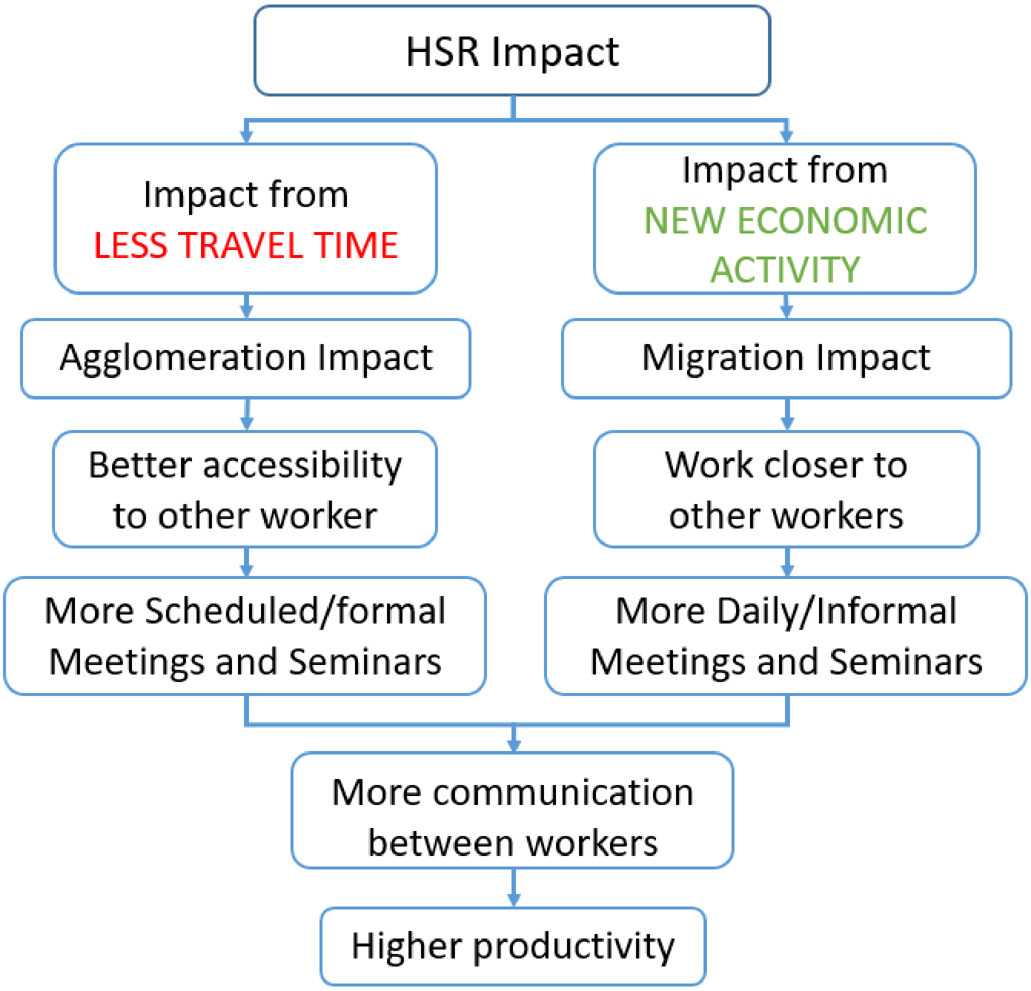

Fig. 3-1. Agglomeration and migration impact from HSR

In this study, I consider the impact from HSR to agglomeration and migration in an ex-post context which is different from the framework given in UK DfT Wider Impacts. In chapter 4, 5 and 6, agglomeration impact from HSR will be highlighted from several perspectives. In chapter 4 and 5, the impact from HSR will be explained through a reduction of travel time used for Effective Density calculation while the distance to HSR station is used to explain the impact from HSR in chapter 6. Although employment variable is also applied in the model in chapter 4, 5 and 6, under the assumption of the regression, it is necessary to assume the employment change in each region/year is independent of HSR effect (travel time in ch.4, 5, distance to HSR station in ch.6). This may cause bias (underestimate) estimation to HSR effect because HSR may affect migration, which causes employment change as well. Indeed, it is possible to incorporate both effects into one model but it requires more theoretical discussion to clearly distinguish agglomeration and migration which beyond the scope of this study. Later in chapter 7, migration impact from HSR will be separately discussed.

In chapter 4, 5 and 6, agglomeration impact from HSR will be discussed from several points of view. As mentioned that in the discussion regarding agglomeration, there are four scopes to be discussed. In chapter 4, I aim to discuss the impact from HSR to agglomeration in general although the result will be highlighted mainly in temporal scope (how agglomeration impact changes through time) and geographical scope (where agglomeration impact from HSR could be significantly observed). In fact, the analysis in chapter 4, 5 and 6 are all over the temporal and spatial scope as panel data is used in chapter 4 and 6, and time-lag model is implemented in chapter 6. Chapter 5 and 6 discuss the industrial scope, yet the sub-scope is separately discussed in different context. In chapter 5, I aim to find whether "urbanization agglomeration" or "localization agglomeration" is more productive to the economy. In chapter 6, I aim to find whether "specialization agglomeration" or "diversity agglomeration" is more productive to the economy. To give a better understanding of the definitions, Fig. 3-2 and Fig. 3-3 depict the situation of that four sub-scopes in chapter 5 and 6 respectively.

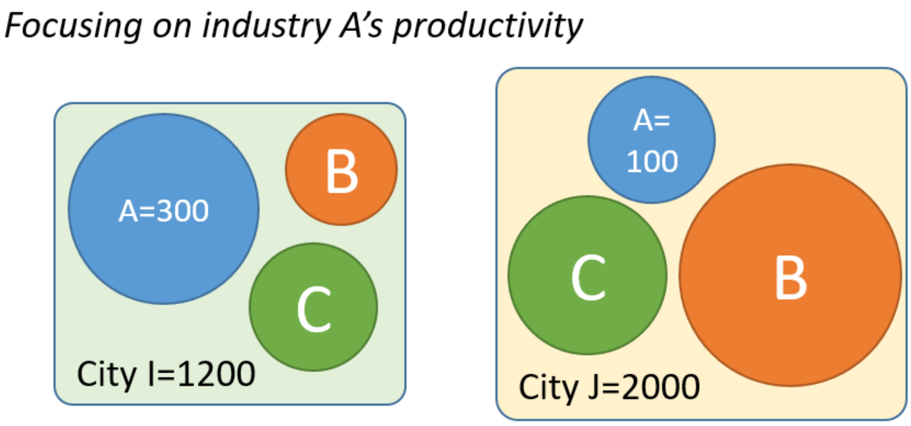

Fig. 3-2. Example of two cities with different industrial scale of agglomeration

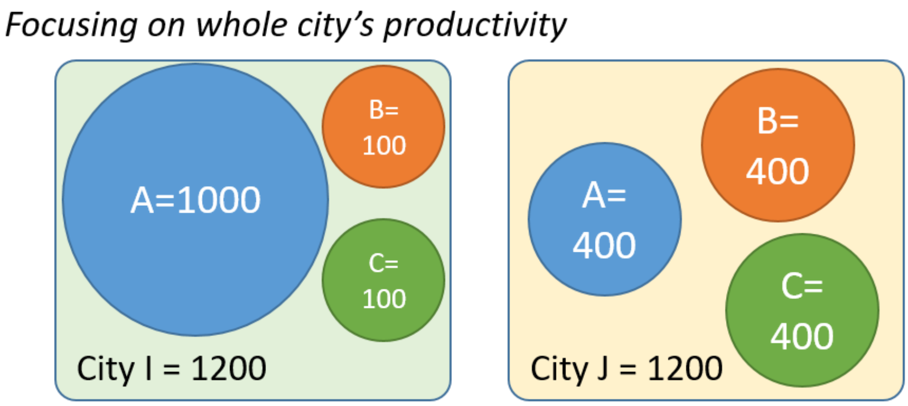

Fig. 3-3. Example of two cities with different industrial diversity

In Fig. 3-2, let us consider two cities *I* and *J*. City *I* has total worker of 1,200 and worker in industry *A* of 300. City *J* is larger than city *I* but a number of worker in industry *A* is only 100. Consider that productivity in industry *A* in which city is higher, the concept of localization agglomeration explains that agglomeration in the same industry is more important thus productivity of *A* in city *I* is higher. On the contrary, the concept of urbanization agglomeration explains that agglomeration of the whole economy is more important, thus productivity of *A* in *J* is higher. However, each industry may have a different effect from localization agglomeration or urbanization agglomeration. For example, manufacturing industry may benefit more from agglomeration in the same industry rather than the size of the total economy while situation could be different in other industries. Thus, the analysis in chapter 5 will give an answer on how localization agglomeration and urbanization agglomeration benefit to what industry.

In Fig. 3-3, let us consider two cities with the same size, yet in city *I*, industry *A* is dominant, while in city *J*, there is no dominant industry. Consider the productivity of the whole city, the concept of specialization agglomeration explains that city with one or few specialize industry is more productive, thus following this concept, productivity in city *I* is higher. On the contrary, the concept of diversity agglomeration explains that city with a more diverse mix of industries is better so following diversity agglomeration productivity in city *J* is higher. However, there is still insufficient evidence to confirm whether specialization or diversity is more productive, especially when incorporating the regional agglomeration into account. Thus, the analysis in chapter 6 will give an answer whether specialization or diversity is more productive.

Production Function in Chapter 5 - Generalization of Olley & Pakes Method

Chapter 5 empirically analyzes the impact of agglomeration on regional production by estimating the regional production function. Since the generalization of the model is based on Olley and Pakes (1996), thus I would like to discuss the theoretical issue separately in this chapter. First, I assume a generalized Cobb–Douglas function for the regional production function as follows:

$$GDP_{nit} = AK_{nit}^{\beta_k} L_{nit}^{\beta_l}, \tag{3-3}$$

where GDP_{nit} represents the GDP of zone *i* in industry *n* at time *t*; A represents the technology used (TFP); K_{nit} and L_{nit} represent respectively the capital and labor input of zone *i* in industry *n* at time *t*; and ρ , β_k , and β_l represent the elasticities of technology, capital, and labor, respectively.

In chapter 5, I assume that technology A is empirically explained by other socioeconomic related variables. However, in chapter 5, applying the estimation method by Olley and Pakes (1996), *A* is represented by the agglomeration index called effective density, *ED*, and the set of other independent variables, ϕ. I define the justification of the usage of effective density in the next subsection.

$$GDP_{nit} = A[ED, \phi] \cdot K_{nit}^{\beta_k} L_{nit}^{\beta_l}. \tag{3-4}$$

The logarithmic transformation of the production function in Eq. (3-4) gives

$$gdp_{nit} = \rho ED_{nit} + \phi_{nit} + \beta_k k_{nit} + \beta_l l_{nit}, \tag{3-5}$$

where the lower case gdp_{nit}, ED_{nit}, ϕ_{nit}, k_{nit}, and l_{nit} represent the logarithmic GDP, logarithmic effective density, the set of other independent variables related to technological shocks, logarithmic capital, and logarithmic labor, respectively. ρ , β_k , and β_l represent the coefficients of effective density, capital input, and labor input, respectively. Effective density in the estimation in chapter 5 refers to the specification of urbanization agglomeration, localization agglomeration, and mixed agglomeration (Eqs. (3-1), (3-2), and (5-1)).

One issue to be addressed in econometric estimation is the endogeneity effect. This could arise with reverse causality and omitted variables. This study assumes that agglomeration affects productivity. On the other hand, reverse causation, which can be reasonably expected when a region with higher productivity attracts more firms and workers, leads to further agglomeration. The most popular technique to deal with the endogeneity problem in regression analysis is the instrumental variable (IV) approach. By applying this approach to our estimation, agglomeration ED_{nit} is estimated by IVs in the first step, and the instrumented agglomeration is applied with other explanatory variables to explain production in the second step. Although we tried various IVs for our empirical analysis, including the generalized method of moments (GMM) technique (Arellano and Bond, 1991), mainly with our agglomeration parameter, ED_{nit}, the IVs and the GMM model yielded unpromising results and we could not find any suitable IV/GMM model to our analysis. Several conditions might restrict the application of IV/GMM estimation to our dataset. For example, our dataset has only six time series observations, which might be too few to incorporate time-series effect. Another possible reason is the rather stagnant growth in several variables such as labor and capital input in some prefectures. Because of these two reasons, the IV/GMM model can result in biased estimations due to inadequate lags and the small first-difference problem, eventually leading to the problem of the weak instrument (Alonso-Borrego and Arellano, 1999; Arellano and Bover, 1995; Blundell and Bond, 1998).

Although we observe a stagnant growth of inputs in some prefectures and industries, constant production growth can be observed to a certain extent. This supports our assumption that besides input shocks, the TFP itself essentially affects the production level in Japan. Therefore, we assume productivity shocks apart from the agglomeration effect, and inputs are explained through a set of other independent variables, ϕ. We then expand the ϕ term using the semi-parametric approach, following the original work of Olley and Pakes (1996), which is one of the popular approaches applied in Graham et al. (2009) and Thabet (2015). With this method, we can assume that capital and investment are the proxy variables of TFP, apart from effective density:

$$gdp_{nit} = \rho ED_{nit} + \phi(k_{nit}, v_{nit}) + \beta_k k_{nit} + \beta_l l_{nit}, \quad (3\text{-}6)$$

where v_{nit} represents the investment of zone *i* in industry *n* at time *t*. In our regression process, $\phi(k_{nit}, v_{nit})$ is assumed to be non-parametric and is specified as a third-order bivariate polynomial expansion of the Cobb–Douglas function. The estimated model can be written as follows:

$$gdp_{nit} = \rho ED_{nit} + \beta_k k_{nit} + \beta_l l_{nit} + \beta_v v_{nit} + \beta_{kk}(k_{nit})^2 + \beta_{vv}(v_{nit})^2 + \beta_{kv} k_{nit} v_{nit} +$$
$$\beta_{kkv}(k_{nit})^2 v_{nit} + \beta_{kvv} k_{nit}(v_{nit})^2 + \beta_{kkk}(k_{nit})^3 + \beta_{vvv}(v_{nit})^3. \quad (3\text{-}7)$$

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4. Agglomeration Impact to Productivity

In this chapter, I aim to investigate the agglomeration effect from HSR in general. In addition, I compare agglomeration effect from HSR with other HSR service level indicator to clarify whether agglomeration or service level benefits more to the economy. Sociodemographic, socioeconomic, and transportation panel data are prepared by prefecture in Japan for 1981, 1986, 1991, 1996, 2001, and 2006. The dataset covers 47 prefectures in Japan, presented in five-year intervals because major surveys in Japan are conducted every five years. The sociodemographic and socioeconomic data in this study including the number of employees, gross regional product (GRP), capital and investment across prefectures and industries are derived from Statistic Bureau of Japan. The industry category "FIRE" is defined as a combination of finance, insurance, and real estate sectors. This study assumes GRP per employee as a measurement of prefectural economic productivity. Note that the GRP and other monetary data are deflated into 2000 price level.

Transportation-related variables consist of total travel time between prefectures, number of HSR stations, average share of HSR distance out of total trip distance, average share of HSR travel time out of total travel time, and number of transfers to the nearest HSR stations in each of the three largest cities: Tokyo, Osaka, and Nagoya. Note that different data for transportation networks and services are prepared for different years based on the service availability by transportation mode in the past. A representative node in each prefecture is assumed to be located at the prefectural office.

The total travel time between prefectures is computed as the multi-modal shortest travel time from an origin to a destination. The transportation modes cover HSR, conventional rail, air, inter-city bus, and private car. First, to estimate the total travel time by public transportation, it is divided into two parts: the multi-modal shortest travel time from a rail station, an airport, or an inter-city bus terminal that is located closest to a representative node in an origin prefecture to another rail station, airport, or inter-city bus terminal that is located closest to a representative node in a destination prefecture; and the last- and first-mile travel time for access/egress to and from the rail station, the airport, or the inter-city bus terminal. For the last- and first-mile trip, the shortest access/egress travel time of single local public transportation service is assumed if such service is available; and if the local public transportation service is not available, a private car is assumed. Next, the total travel time by car is computed using the road network data for each year under the assumption that the car is used directly from the origin to destination. If the road network does not directly connect an island with others, the use of car-ferry services is assumed. Note that intra-zone travel time is assumed to equal to the minimum value of inter-regional travel time (equals to 32 minutes, in this study).

The average share of HSR distance out of total trip distance, represented by d_i, is defined as:

$$d_i = \frac{1}{N} \sum_{j \in N} \left[\frac{DH_{ij}}{D_{ij}} \right] \tag{4-1}$$

where i and j represent prefectures as components in a set of N total number of the prefectures in Japan $(N=47)$, DH_{ij} represents the total HSR-link distance from i to j, and D_{ij} represents the total multi-modal trip distance from i to j. The distances are computed assuming a path with the shortest travel time from i to j and. It is also possible that the usage of HSR is selected multiple times in the shortest travel time route. We also assume no usage of HSR in the intra-zone trip (a case where $i = j$).

The average share of HSR travel time out of total travel time to/from a region, represented by r_i, which is defined as:

$$r_i = \frac{1}{N}\sum_{j\in N}\left[\frac{TH_{ij}}{T_{ij}}\right] \quad (4\text{-}2)$$

where TH_{ij} represents the travel time during which the HSR service is used from i to j, and T_{ij} represents the total travel time from i to j. The travel times are computed again assuming a path with the shortest multi-modal travel time and multiple usages of HSR is also possible. We also assume no usage of HSR in intra-zone trip in this calculation.

The calculation of the shortest multi-modal travel time along with the trip distance was conducted with National Integrated Transport Analysis System (NITAS), which was developed by Ministry of Land, Infrastructure, Transport and Tourism (MLIT) of Japan. The number of transfers to and from HSR stations is collected from past rail timetables published by Japan Tourist Bureau.

Descriptive Statistics

Table 4-1 shows descriptive statistics of the dataset, which contains 282 records compiled from 47 prefectures over six years. First, average economic productivity is 7.01 million JPY per employee, ranging from 4.61 to 11.61 million JPY. Note that one US dollar was on average equal to 110.6 JPY at 2000 price levels. The average economic productivity has been increasing, while its standard deviation has fluctuated. The standard deviation was higher in 1991, probably because the Japanese economy experienced the asset price bubble in late 80's which economic disparities among regions become larger during such period. It was also higher in 2006, possibly because the government introduced deregulation policies following the new approach of liberalism and privatization, which led to higher economic disparities among regions. Transportation related variables such as the number of HSR station, the share of HSR distance out of total trip distance, and the share of HSR travel time out of total travel time show increasing trends over time. Such change from 1981 to 2006 indicates the effect of rapid HSR network development throughout Japan during this period. Agglomeration reached its peak in 1996 and decrease after that; this is mainly influenced by the reduction of the labor force in Japan after 1996 although average travel time decreases over time from 1981 to 2006. The number of transfers to any of the three largest cities is 0.42 on average and generally decreasing. This may imply that the local access/egress public transportation services in the largest cities have been significantly improved in the past decades. This includes the expansion of local public transportation networks in these cities, enabling passengers to travel directly to the nearest HSR station. Other socioeconomic data such as capital per employee, investment per employee and wage also show an increasing trend over time regardless of the reduction in the labor force after 1996. Note that the capital used in this study is the sum of public and private capital.

Table 4-1.
Descriptive Statistics of Dataset.

	Total	1981	1986	1991	1996	2001	2006
Economic Productivity (Million JPY/employee)							
Minimum	4.61	4.61	5.11	5.83	6.10	6.56	6.75
Median	7.06	5.28	5.90	6.89	7.24	7.64	8.42
Maximum	11.61	6.93	8.27	9.37	9.42	10.50	11.61
Mean	7.01	5.43	6.03	6.97	7.32	7.71	8.57
Standard deviation	1.26	0.56	0.64	0.78	0.69	0.67	0.88

Number of HSR station							
Minimum	0	0	0	0	0	0	0
Median	0	0	0	0	0	0	1
Maximum	7	6	6	6	6	6	7
Mean	1.27	0.74	1.30	1.30	1.30	1.40	1.57
Standard deviation	1.81	1.51	1.83	1.83	1.83	1.87	1.95
Average share of HSR distance out of total trip distance (%)							
Minimum	0	0	0	0	0	0	0
Median	68.91	55.17	69.81	71.02	69.90	71.02	76.87
Maximum	87.71	71.35	82.54	84.12	82.54	84.12	87.71
Mean	65.54	51.89	66.22	68.17	66.51	68.17	72.28
Standard deviation	15.43	13.66	13.87	14.28	14.16	14.28	14.63
Average share of HSR travel time out of total travel time (%)							
Minimum	0	0	0	0	0	0	0
Median	16.48	17.79	17.29	14.66	15.01	17.96	18.02
Maximum	49.01	47.63	46.38	45.65	45.65	49.01	46.28
Mean	17.85	18.04	17.60	16.36	16.50	19.36	19.24
Standard deviation	11.35	11.29	11.10	11.07	11.09	12.12	11.65
Agglomeration (Thousand person/minutes)							
Minimum	147.19	147.19	170.71	191.49	198.15	192.47	202.19
Median	263.10	215.73	241.65	269.42	278.96	271.13	265.93
Maximum	631.47	504.17	542.39	609.56	631.47	608.73	604.42
Mean	296.14	254.87	273.72	310.32	322.16	310.65	305.10
Standard deviation	96.55	81.48	86.67	98.93	103.40	98.03	96.21
Capital per employee (Million JPY/employee)							
Minimum	8.63	8.63	11.32	14.74	17.60	20.68	22.76
Median	21.75	12.07	16.02	19.57	23.05	27.60	30.77
Maximum	38.98	16.86	21.15	26.11	30.08	35.45	38.98
Mean	21.83	12.36	16.07	19.97	23.42	28.02	31.12
Standard deviation	7.10	1.78	2.07	2.51	2.80	3.38	4.00
Private investment per employee (Million JPY/employee)							
Minimum	0.06	0.06	0.10	0.14	0.14	0.17	0.27
Median	0.18	0.07	0.12	0.18	0.18	0.20	0.30
Maximum	0.58	0.15	0.25	0.36	0.31	0.38	0.58
Mean	0.18	0.08	0.13	0.19	0.18	0.20	0.31
Standard deviation	0.08	0.01	0.02	0.03	0.03	0.03	0.05
Average annual wage (Million JPY/employee)							
Minimum	2.40	2.40	2.54	2.86	3.27	3.51	3.38
Median	3.74	2.91	3.20	3.69	4.15	4.30	4.42
Maximum	6.30	3.91	4.43	5.07	5.62	5.92	6.30
Mean	3.77	2.93	3.20	3.68	4.12	4.32	4.41
Standard deviation	0.74	0.36	0.42	0.50	0.51	0.52	0.57
Number of transfers to any of three largest cities							

Minimum	0	0	0	0	0	0	0
Median	0	0	0	0	0	0	0
Maximum	4	4	4	2	2	2	2
Mean	0.43	0.60	0.57	0.34	0.34	0.34	0.38
Standard deviation	0.76	1.08	1.06	0.52	0.52	0.52	0.61
Share of FIRE industry GRP per total GRP (%)							
Minimum	8.89	8.89	9.62	9.16	14.17	13.34	13.31
Median	14.65	11.85	12.90	12.18	17.37	16.16	16.55
Maximum	26.52	15.79	21.20	19.66	26.52	23.42	23.06
Mean	14.81	11.93	13.07	12.44	17.79	16.75	16.88
Standard deviation	3.28	1.96	2.21	2.12	2.70	2.27	2.32

HSR related indexes

This study assumes transportation service is one of the factors to improve regional economic productivity. It is expected that the regional economic productivity is stimulated by an interaction between two regions, which can be explained by other regional socioeconomic or sociodemographic factors; and that the inter-regional interaction increase as the accessibility to the region is improved. HSR is considered as the main contributor to the improvement of regional accessibility in Japan during the past half century. Such regional accessibility premium from HSR service has been highlighted in many studies such as in Cao *et al.* (2013) and Levinson (2012). Then, this study investigates the impact from HSR service on regional economic productivity through the following four indexes:

(a) Index 1: The number of HSR station(s) in a region (s_i);

(b) Index 2: The average share of HSR distance out of total trip distance to/from a given region (d_i), as defined in Eq. (4-1);

(c) Index 3: The average share of HSR travel time out of total travel time to/from a region (r_i), as defined in Eq. (4-2); and

(d) Index 4: Regional agglomeration, represented by a_i, which is defined in Eq. (3-1):

As mentioned in previous chapter, this study assumes that regional worker represents the attractiveness of activities in the region, based on the existing research (Department for Transport, 2014; Graham and Melo, 2012; Graham, 2007). Multiple transportation modes are incorporated into the estimation of inter-regional travel time because other inter-urban travel modes apart from HSR are also expected to influence travel time. Nevertheless, HSR could be regarded as the main contributor to saving the inter-regional travel time. As shown in the dataset section, a high share of HSR distance out of total trip distance could be one of the evidence to show the contribution of HSR in Japan.

The Indexes 1, 2, and 3 (s_i, d_i, and r_i) are introduced assuming that HSR directly affects the regional economic productivity through the service level of HSR. This reflects the expectation that HSR reduces the travel time and such saved time could be spent for other productive activities. We also assume that HSR indirectly affects the regional economic productivity through agglomeration, which is represented by the Index 4 (a_i). An agglomeration economy is typically defined as the benefit from firms staying close together. HSR service is assumed to contribute to the so-called "knowledge spillover" across different regions through the agglomeration economy. For instance, HSR may encourage more meetings, discussions, or even workshops between firms, and this hastens learning process, accelerates firms' technology, and results in better productivity.

Comparative Analysis between Prefectures with HSR Stations and Prefectures without HSR Stations

47 Prefectures are classified into two subgroups: those with HSR stations and those without HSR stations in each year. Table 4-2 shows the differences in economic productivity and agglomeration between the two subgroups by year. Agglomeration refers to the specification in Eq. (3-1). First, from the cross-sectional viewpoint, Table 4-2 shows that the means of economic productivity and agglomeration are significantly higher in prefectures with HSR stations than those in prefectures without HSR stations in all years. This may suggest that the presence of HSR stations could have significant positive impacts on regional economic productivity and agglomeration. Furthermore, it also shows that the growths of economic productivity and agglomeration in the prefectures with HSR stations seem slower than those without HSR stations. In other words, the gap between prefectures with and without HSR stations has become smaller gradually. Also, by comparing the prefectures with HSR stations, prefectures with new HSR stations are less productive than those with existing HSR stations before. This may be because the HSR network has been extended to the regions with lower productivity and lower agglomeration under the national government's policy which intends to develop the high-speed transportation network covering all over the nation. Not only the new extension but also the additional new HSR stations in Japan can be also observed in the existing lines as well. These new HSR stations are facing the decreasing marginal impact because the less productive sites were left to be selected for HSR station development in later years.

The expansion of HSR network in Japan and the prefectural productivity in Fig. 4-2 also suggest that early HSR service in Japan before 1981 is available only on the western shoreline which is the most productive corridor in Japan. However, after the major extension to the eastern region in 1982, productivity in the eastern part of Japan gradually improves especially those located close to Tokyo. We observe some time lag between major extension in 1982 and the catching-up process of the eastern region, which could be observed after 1996. Fig. 4-1 also suggests that productivity in many prefectures outside HSR service range remain unproductive, compare to prefectures with better access to HSR service.

Table 4-2.
The difference of Productivity and Agglomeration between Prefectures With and Without HSR Stations.

Year	HSR Availability		Productivity (Mil.JYP/employee)		Agglomeration (1,000 person/minute)		N	HSR Network Length (km)	Annual Passenger (Million person)
			Mean	SD	Mean	SD			
1981	With HSR station	Existing	6.428	0.525	343.482	82.456	13	1,069.1	126
		New	n/a	n/a	n/a	n/a	0		
	Without HSR station		5.698	0.514	220.984	50.057	34		
1986	With HSR station	Existing	7.149	0.738	365.022	89.475	13	1,831.5	183
		New	6.361	0.377	267.480	91.085	7		
	Without HSR station		6.312	0.564	231.382	40.488	27		
1991	With HSR station	Existing	8.057	0.873	375.845	113.370	20	1,835.1	293.6
		New	n/a	n/a	n/a	n/a	0		
	Without HSR station		7.221	0.649	261.781	46.629	27		
1996	With HSR station	Existing	8.228	0.738	390.888	117.820	20	1,835.1	300.1
		New	n/a	n/a	n/a	n/a	0		
	Without HSR station		7.544	0.589	271.255	49.458	27		
2001	With HSR station	Existing	8.591	0.798	375.284	112.520	20	1,952.5	306.8
		New	8.082	n/a	275.323	n/a	1		
	Without HSR station		8.000	0.541	262.286	47.286	26		
2006	With HSR station	Existing	9.614	0.974	364.671	109.289	21	2,175.9	329.5
		New	8.563	0.296	224.081	20.366	3		
	Without HSR station		8.849	0.810	261.282	46.550	23		

Note: n/a represents not available.

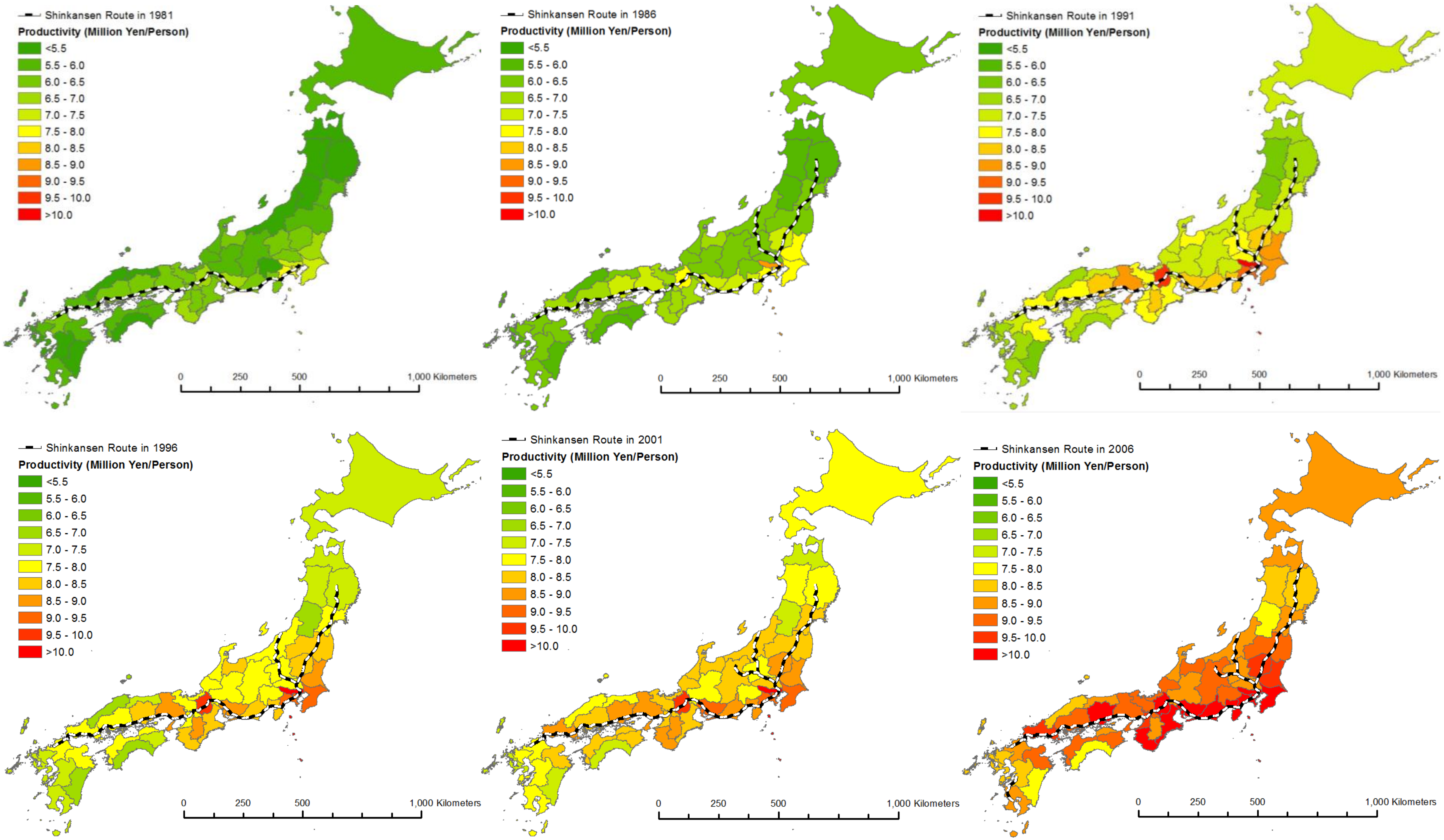

Fig. 4-1. Prefectural Productivity and HSR Network in 1981, 1986, 1991, 1996, 2001, and 2006.

Regression Analysis

This paper empirically analyzes the association of HSR with prefectural economic productivity by assuming a function explained by HSR related variables and other factors as follows:

$$Y_{i,t} = f(H_{i,t}, C_{i,t}) \tag{4-4}$$

where

$Y_{i,t}$: Natural log of GRP per employee in prefecture *i*, at year *t*;
$H_{i,t}$: A set of HSR related variables in prefecture *i*, at year *t*; and
$C_{i,t}$: A set of other control variables in prefecture *i*, at year *t*.

As this study aims to find what is the main contributor from HSR to regional economic productivity, I specify $H_{i,t}$ as the following function:

$$H_{i,t} = g(s_{i,t}, d_{i,t}, r_{i,t}, A_{i,t}) \tag{4-5}$$

where

$s_{i,t}$: Number of HSR station(s) in prefecture *i*, at year *t*;
$d_{i,t}$: The average share of HSR distance out of total trip distance in prefecture *i*, at year *t*;
$r_{i,t}$: The average share of HSR travel time out of total travel time in prefecture *i*, at year *t*; and
$A_{i,t}$: Natural log of agglomeration in prefecture *i*, at year *t* (ln of $a_{i,t}$ from Eq. (3)).

As for $C_{i,t}$, control variables in this study include other transportation-related variables and socioeconomic variables. $C_{i,t}$ is specified as the following function:

$$C_{i,t} = h(K_{i,t}, I_{i,t}, W_{i,t}, tf_{i,t}, fire_{i,t}, \eta_t) \tag{4-6}$$

where

$K_{i,t}$: Natural log of capital per employee in prefecture *i*, at year *t*;
$I_{i,t}$: Natural log of private investment per employee in prefecture *i*, at year *t*;
$W_{i,t}$: Natural log of average annual wage in prefecture *i*, at year *t*;
$tf_{i,t}$: Minimum number of transfers from prefecture *i* to the nearest HSR station in each of the three largest cities: Tokyo, Osaka, and Nagoya at year *t*;
$fire_{i,t}$: The share of production in Finance and Insurance, and Real Estate (FIRE) industries out of total GRP in prefecture *i*, at year *t*; and
η_t : Year fixed effects at year *t*.

We expect positive effects from HSR related variables ($H_{i,t}$) on the economic productivity since individuals working in the prefecture with better access to HSR service could benefit more from transportation service including HSR than other transportation modes. This means that the marginal effects of $s_{i,t}$, $d_{i,t}$, $r_{i,t}$, and $A_{i,t}$ are expected to be positive. As for the other control variables ($C_{i,t}$), it is assumed that the prefecture where more transfers are required to reach the HSR stations in the largest cities has fewer business opportunities, which leads to less economic productivity. FIRE industry is typically regarded as one of the high-productivity sectors, thus higher productivity could be expected in the prefecture with a higher share of FIRE industry. Socioeconomic variables such as capital, investment, and wage have been typically introduced to explain the economic productivity according to similar studies such as Martín and Nombela (2007) and Hernández and Jiménez

(2014). They are expected to positively influence the economic productivity. Additionally, other factors such as the economic crisis in Japan may affect the economic productivity during our time frame; thus the year control variable is also introduced in a fixed effects model. Following model will be estimated for pooling and fixed effects models:

$$Y_{i,t} = \alpha_0 + \alpha_H H_{i,t} + \alpha_1 K_{i,t} + \alpha_2 I_{i,t} + \alpha_3 W_{i,t} + \alpha_4 tf_{i,t} + \alpha_5 fire_{i,t} + \alpha_6 \eta_t + \varepsilon_{i,t} \quad (4\text{-}7)$$

where α_H represents the coefficient of tested HSR related parameter, $\alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5$, and α_6 are intercept and coefficients of other control variables respectively. As for pooling model, the term $\alpha_6 \eta_t$ is omitted in estimation, while the term α_0 is omitted in fixed effect model.

It is well known that the coefficients estimated with the Ordinary Least Squared (OLS) method could be biased if both directions of causal relationship would exist in the model. Thus an additional model is estimated, assuming that HSR related variables are explained endogenously by other explanatory variables through an instrumental variable (IV) approach. This study assumes that the instrumented HSR related variables are expressed as the functions with the following variables:

$$\overline{H_{\iota,t}} = \gamma\left(Y_{i,t-1}, K_{i,t}, I_{i,t}, W_{i,t}, tf_{i,t}, fire_{i,t}, \eta_t\right) \quad (4\text{-}8)$$

where $Y_{i,t-1}$ represents lagged natural log of GRP per employee in prefecture *i*, at year *t-1*. Once instrumented HSR related variable $\overline{H_{\iota,t}}$ is obtained, I estimate the IV model based on Eq. (7) but $H_{i,t}$ is replaced by $\overline{H_{\iota,t}}$ as follows:

$$Y_{i,t} = \alpha_0 + \alpha_H \overline{H_{\iota,t}} + \alpha_1 K_{i,t} + \alpha_2 I_{i,t} + \alpha_3 W_{i,t} + \alpha_4 tf_{i,t} + \alpha_5 fire_{i,t} + \alpha_6 \eta_t + \varepsilon_{i,t} \quad (4\text{-}9)$$

In order to further investigate the temporal dynamics of benefit from HSR which already discussed in general in comparative analysis, I test the effect of HSR related parameter chronologically by introducing year dummies with the HSR related parameters. Natural log of GRP per employee is then estimated using the following model:

$$\begin{aligned} Y_{i,t} = {} & \alpha_0 + \alpha_{H:81} H_{i,t} \cdot D_{81} + \alpha_{H:86} H_{i,t} \cdot D_{86} + \alpha_{H:91} H_{i,t} \cdot D_{91} + \alpha_{H:96} H_{i,t} \cdot D_{96} \\ & + \alpha_{H:01} H_{i,t} \cdot D_{01} + \alpha_{H:06} H_{i,t} \cdot D_{06} + \alpha_1 K_{i,t} + \alpha_2 I_{i,t} + \alpha_3 W_{i,t} + \alpha_4 tf_{i,t} \\ & + \alpha_5 fire_{i,t} + \alpha_6 \eta_t + \varepsilon_{i,t} \end{aligned} \quad (4\text{-}10)$$

where D_{81}, D_{86}, D_{91}, D_{96}, D_{01}, and D_{06} are HSR related parameter year dummies. Dummy equals to 1 if HSR related parameter is observed in year *t*=1981, 1986, 1991, 1996, 2001, and 2006 respectively; and equals to 0 if not.

Not only the temporal dynamics, but the spatial dynamics of HSR effect should be also investigated as well. I further test the spatial effect by separating HSR related effect into each lines of HSR service in Japan. Six lines are tested based on the service availability in 2006. Prefectures such as Tokyo, Osaka, and Fukuoka have HSR service more than one line since they serve as a terminal for multiple lines. Thus, natural log of GRP per employee is then estimated using the following model:

$$\begin{aligned} Y_{i,t} = {} & \alpha_0 + \alpha_{H:Tokaido} H_{i,t} \cdot D_{81} + \alpha_{H:Sanyo} H_{i,t} \cdot D_{86} + \alpha_{H:Tohoku} H_{i,t} \cdot D_{91} \\ & + \alpha_{H:Joetsu} H_{i,t} \cdot D_{96} + \alpha_{H:Hokuriku} H_{i,t} \cdot D_{01} + \alpha_{H:Kyusyu} H_{i,t} \cdot D_{06} \\ & + \alpha_1 K_{i,t} + \alpha_2 I_{i,t} + \alpha_3 W_{i,t} + \alpha_4 tf_{i,t} + \alpha_5 fire_{i,t} + \alpha_6 \eta_t + \varepsilon_{i,t} \end{aligned} \quad (4\text{-}11)$$

Table 4-3 summarizes the estimation results of eight models formulated as Eq. (4-7). Two types of estimation approaches are applied to the regression analysis to correlate Prefectural economic productivity with the explanatory variables using a Cobb-Douglas function: pooling OLS model and fixed effects model. The results of the pooling OLS model are shown in Models (a), (b), (c), and (d) while those of the fixed effects model are shown in Models (e), (f), (g), and (h). In each model, I separately test HSR related variables ($H_{i,t}$) one by one with other control variables ($C_{i,t}$) to avoid correlations among the four HSR related variables: Models (a) and (e) present the estimated effects of number of HSR station ($s_{i,t}$); Models (b) and (f) present those of the share of HSR distance out of total trip distance ($d_{i,t}$); Models (c) and (g) present those of a share of HSR travel time out of total travel time ($r_{i,t}$); and Models (d) and (h) present those of agglomeration ($A_{i,t}$).

First, the estimation results of Models (d) and (h) unveil that the agglomeration ($A_{i,t}$) has a significantly positive association with the regional economic productivity. This is interpreted as a consequence of the process that the improvement of accessibility by introducing HSR service leads to the change in technological level (De Rus, 2012). Note that the change in technology influences the performances in the firm's production function. The change in technology could include the enhancement of knowledge spillover through communication among businesspersons and/or the knowledge production through innovative joint activities among employees. Particularly HSR is expected to improve the accessibility more significantly than other transportation mode, and this may influence the economic productivity.

Second, Models (b), (c), (f), and (g) show that both the share of HSR distance out of total trip distance ($d_{i,t}$) and the share of HSR travel time out of total travel time ($r_{i,t}$) have positive associations with the regional economic productivity, but their statistical significances are slightly weaker than the agglomeration. This may suggest that HSR itself may have solely influences on the economic productivity although other transportation mode could also contribute to it and this may reduce the significance of the HSR-related effect. The positive effect found in HSR-related factor is probably caused by the positive network externality (Katz & Shapiro, 1985) from HSR. Here the HSR-network externality is defined as the effect that a region could benefit depending on the scale of HSR network; the more extended the HSR network is, the better accessibility to activity in the region from other regions is, and the higher economic productivity are expected in each region.

Third, however, the results of Models (a) and (e) show that the number of HSR station ($s_{i,t}$) does not influence the regional economic productivity. This may not mean that the last- and first-mile trips have no effect on economic productivity because the number of HSR station represents merely the average distance to HSR stations and not the overall accessibility to HSR stations including travel time or transfer. Thus if the public transportation service connecting with HSR station would not be well developed, the HSR station may not contribute to the economic activities in the prefecture. The result could suggest the difference of feeder service from HSR station across cities in Japan. For instance, feeder service in small towns might be inadequate compared to the extensive urban rail service in the big cities.

Fourth, the estimation results of all models show the significantly negative association with the number of transfers to any of three largest cities ($tf_{i,t}$). Since half of the Japanese population lives in the metropolitan area of these three cities, thus the accessibility to/from these cities should affect the regional economic performance as well. The result supports our expectation because more transfers to the center of business activity would hinder the opportunity for business trips, resulting in lower productivity.

Fifth, the estimation results of all models also show the significantly positive associations of capital per employee ($K_{i,t}$), private investment per employee ($I_{i,t}$), and annual wage ($W_{i,t}$) with the regional productivity as expected. Based on classical economics, inputs such as labor and capital are typically regarded as factors of production. We then measure the productivity by assuming factors of production per employee determine the level of productivity in a similar manner as factors of production determine level of production.

Sixth, the estimation results with the pooling OLS models (Models (a) to (d)) unexpectedly show that the share of productions in FIRE industries GRP out of total GRP ($fire_{i,t}$) has negative associations with the regional productivity. This may be because FIRE industry was most seriously damaged by the economic recession in Japan during early 1990's. This could be supported by the estimation results with the year fixed-effects models (Models (e) to (h)), which show that the share of FIRE industry has no significant effect on the regional economic productivity. This suggests that FIRE industry does not affect the regional economic productivity in Japan's case, at least during the period in our analysis.

Finally, among the eight models, Model (h) could be a preferable model from a statistical viewpoint since most of the estimated coefficients show significant effects on the regional productivity and adjusted *R*-squared is higher than 0.9. Note that the year control parameters are significant at the 99.9% level in every fixed-effects models (Models (e) to (h)).

Table 4-4 summarizes the estimation results of eight IV models, in which the HSR related variables are instrumented using Eq. (4-9). The instrument is assumed to be the lagged value of dependent variable itself, similarly to an autoregressive order 1 (AR [1]) model, which is one of the most popular methods. The results of IV analysis are similar to those with the OLS models although the significance of HSR related variables is quite weaker. The estimation results from IV analysis could suggest the reverse causal relationship; high productivity in the region could attract more agglomeration and more HSR investment to the region.

In order to make a further investigation of the temporal effect of HSR, Table 4-5 summarizes the estimation results in the case where the HSR related effects are controlled chronologically based on the specification of Eq. (4-10), only in pooling OLS models (Models (a) to (d)). The year-controlled HSR related effects in Model (q), (r), and (s) are not significant in some years, so it is impossible to discuss the dynamic direct effect from HSR from these results. However, in Model (t) where the agglomeration effect is assumed, the result reveals that the agglomeration effect from HSR on the regional productivity is significantly and uniformly decreasing over time. Although I expect that the network effect from a further extension of HSR network would yield positive impact to productivity through time, the result could further support the argument from Table 2 that marginal impacts of HSR network are decreasing through time due to the fact that new HSR extensions in Japan are developed in less productive regions.

Table 4-3.

Estimation Results of Pooling and Fixed Effects Models.

	Coef.	SE	t-stat.	p-value	sig	Coef.	SE	t-stat.	p-value	sig	Coef.	SE	t-stat.	p-value	sig	Coef.	SE	t-stat.	p-value	sig
	Model (a)					Model (b)					Model (c)					Model (d)				
Const.	4.990	0.33	14.9	0.000	***	5.120	0.33	15.4	0.000	***	5.147	0.34	15.1	0.000	***	5.294	0.32	16.6	0.000	***
s	0.001	0.00	0.7	0.485																
d						0.062	0.02	2.8	0.005	**										
r											0.069	0.03	2.1	0.038	*					
A																0.108	0.02	5.8	0.000	***
K	0.097	0.02	5.9	0.000	***	0.095	0.02	6.0	0.000	***	0.099	0.02	6.1	0.000	***	0.148	0.02	8.3	0.000	***
I	0.089	0.01	6.5	0.000	***	0.085	0.01	6.3	0.000	***	0.094	0.01	6.8	0.000	***	0.094	0.01	7.3	0.000	***
W	0.543	0.03	19.0	0.000	***	0.537	0.03	19.1	0.000	***	0.525	0.03	17.6	0.000	***	0.373	0.04	9.3	0.000	***
fire	-0.547	0.16	-3.5	0.001	***	-0.530	0.15	-3.5	0.001	***	-0.458	0.16	-2.8	0.005	**	-0.638	0.15	-4.4	0.000	***
tf	-0.017	0.00	-3.7	0.000	***	-0.016	0.00	-3.5	0.000	***	-0.015	0.00	-3.0	0.003	**	-0.016	0.00	-3.7	0.000	***
Adj.R^2			0.915					0.917					0.916					0.924		
F-stat.			505.5					520.3					513.2					571.3		
N			282					282					282					282		
	Model (e)					Model (f)					Model (g)					Model (h)				
s	0.001	0.00	0.6	0.570																
d						0.063	0.02	3.3	0.001	**										
r											0.076	0.03	2.5	0.011	*					
A																0.085	0.02	4.9	0.000	***
K	0.270	0.03	10.4	0.000	***	0.271	0.03	10.7	0.000	***	0.280	0.03	10.8	0.000	***	0.290	0.03	11.5	0.000	***
I	0.142	0.02	5.9	0.000	***	0.148	0.02	6.3	0.000	***	0.155	0.02	6.4	0.000	***	0.149	0.02	6.5	0.000	***
W	0.602	0.03	21.9	0.000	***	0.586	0.03	21.6	0.000	***	0.577	0.03	20.0	0.000	***	0.454	0.04	11.4	0.000	***
fire	-0.111	0.15	-0.8	0.447		-0.093	0.14	-0.7	0.511		0.002	0.15	0.0	0.990		-0.249	0.14	-1.8	0.077	.
tf	-0.018	0.00	-4.1	0.000	***	-0.017	0.00	-4.1	0.000	***	-0.015	0.00	-3.4	0.001	***	-0.017	0.00	-4.3	0.000	***
Adj.R^2			0.936					0.939					0.938					0.942		
F-stat.			377.3					392.6					386.5					413.0		
N			282					282					282					282		

Note: "***": $p<0.001$; "**": $p<0.01$; "*": $p<0.05$; "." $p<0.1$

Table 4-4.

Estimation Results of Pooling and Fixed Effects Models with IV.

	Coef.	SE	t-stat.	p-value	sig	Coef.	SE	t-stat.	p-value	sig	Coef.	SE	t-stat.	p-value	sig	Coef.	SE	t-stat.	p-value	sig
	Model (i)					Model (j)					Model (k)					Model (l)				
Const.	7.789	3.24	2.4	0.017	*	8.279	3.24	2.6	0.011	*	11.831	3.69	3.2	0.002	**	6.440	0.95	6.8	0.000	***
$\bar{s}$	0.210	0.15	1.4	0.166																
$\bar{d}$						2.455	1.65	1.5	0.139											
$\bar{r}$											2.623	1.26	2.1	0.039	*					
$\bar{A}$																0.865	0.22	4.0	0.000	***
K	0.366	0.23	1.6	0.113		0.110	0.12	0.9	0.351		0.265	0.12	2.3	0.024	*	0.563	0.12	4.5	0.000	***
I	0.025	0.13	0.2	0.855		0.130	0.11	1.2	0.229		0.253	0.10	2.5	0.012	*	0.183	0.04	4.3	0.000	***
W	0.054	0.40	0.1	0.891		0.159	0.32	0.5	0.615		-0.303	0.42	-0.7	0.471		-0.861	0.35	-2.5	0.015	*
fire	2.617	2.55	1.0	0.306		0.148	1.20	0.1	0.902		3.717	2.19	1.7	0.091	.	-1.089	0.44	-2.5	0.014	*
tf	0.172	0.15	1.2	0.239		0.083	0.08	1.0	0.304		0.137	0.08	1.7	0.094	.	-0.003	0.01	-0.2	0.824	
Adj.R^2	0.109					0.158					0.245					0.578				
F-stat.	-31.349					-30.392					-23.121					17.535				
N	235					235					235					235				
	Model (m)					Model (n)					Model (o)					Model (p)				
$\bar{s}$	0.232	0.19	1.2	0.215																
$\bar{d}$						1.700	0.80	2.1	0.034	*										
$\bar{r}$											2.148	0.83	2.6	0.010	*					
$\bar{A}$																0.764	0.17	4.5	0.000	***
K	0.672	0.41	1.7	0.099	.	0.354	0.16	2.3	0.025	*	0.620	0.18	3.4	0.001	***	0.496	0.09	5.7	0.000	***
I	0.043	0.25	0.2	0.863		0.418	0.19	2.3	0.025	*	0.473	0.17	2.8	0.005	**	0.213	0.07	3.2	0.002	**
W	0.065	0.51	0.1	0.898		0.173	0.25	0.7	0.495		-0.194	0.33	-0.6	0.559		-0.712	0.30	-2.4	0.020	*
fire	4.022	3.56	1.1	0.260		0.093	0.85	0.1	0.913		3.822	1.64	2.3	0.021	*	-1.262	0.49	-2.6	0.011	*
tf	0.201	0.18	1.1	0.272		0.035	0.04	1.0	0.338		0.102	0.05	2.0	0.049	*	-0.009	0.01	-0.7	0.465	
Adj.R^2	0.081					0.272					0.349					0.627				
F-stat.	-19.104					-12.713					-8.108					20.022				
N	235					235					235					235				

Note: "***": $p<0.001$; "**": $p<0.01$; "*": $p<0.05$; "." $p<0.1$

Table 4-5.
Estimation Results of Pooling Models with Year-Controlled on HSR Related Variables.

	Coef.	SE	t-stat.	p-value	sig		Coef.	SE	t-stat.	p-value	sig
Model (q)						Model (r)					
Constant	4.645	0.35	13.2	0.000	***	*Constant.*	2.790	0.49	5.7	0.000	***
s:81	0.003	0.00	0.7	0.481		*d:81*	0.183	0.04	4.8	0.000	***
s:86	0.002	0.00	0.4	0.657		*d:86*	0.098	0.02	4.3	0.000	***
s:91	0.007	0.00	1.8	0.073	.	*d:91*	0.083	0.02	3.8	0.000	***
s:96	-0.004	0.00	-1.2	0.239		*d:96*	-0.001	0.02	0.0	0.972	
s:01	-0.007	0.00	-2.1	0.039	*	*d:01*	-0.027	0.02	-1.1	0.269	
s:06	0.008	0.00	2.4	0.016	*	*d:06*	0.033	0.03	1.2	0.222	
K	0.112	0.02	6.6	0.000	***	*K*	0.191	0.02	9.0	0.000	***
I	0.069	0.01	4.7	0.000	***	*I*	0.068	0.02	3.7	0.000	***
W	0.564	0.03	19.4	0.000	***	*W*	0.593	0.03	21.0	0.000	***
fire	-0.436	0.16	-2.8	0.006	**	*fire*	-0.111	0.15	-0.7	0.461	
tf	-0.016	0.00	-3.4	0.001	***	*tf*	-0.013	0.00	-3.1	0.002	**
Adjusted R^2			0.918			Adjusted R^2			0.933		
F-stat.			288.4			F-stat.			353.6		
N			282			N			282		
Model (s)						Model (t)					
Constant.	3.961	0.40	9.8	0.000	***	*Constant.*	1.298	0.62	2.1	0.037	*
r:81	0.167	0.06	2.8	0.006	**	*A:81*	0.097	0.02	5.6	0.000	***
r:86	0.120	0.05	2.5	0.012	*	*A:86*	0.090	0.02	5.2	0.000	***
r:91	0.161	0.05	3.2	0.001	**	*A:91*	0.085	0.02	5.0	0.000	***
r:96	-0.058	0.05	-1.2	0.227		*A:96*	0.081	0.02	4.6	0.000	***
r:01	-0.102	0.05	-2.3	0.025	*	*A:01*	0.078	0.02	4.5	0.000	***
r:06	0.123	0.05	2.6	0.010	*	*A:06*	0.078	0.02	4.5	0.000	***
K	0.146	0.02	8.2	0.000	***	*K*	0.288	0.02	11.6	0.000	***
I	0.058	0.02	3.6	0.000	***	*I*	0.146	0.02	6.4	0.000	***
W	0.577	0.03	19.3	0.000	***	*W*	0.456	0.04	11.4	0.000	***
fire	-0.183	0.16	-1.1	0.260		*fire*	-0.237	0.14	-1.7	0.094	.
tf	-0.010	0.00	-2.3	0.025	*	*tf*	-0.017	0.00	-4.2	0.000	***
Adjusted R^2			0.926			Adjusted R^2			0.944		
F-stat.			321.4			F-stat.			412.9		
N			282			N			282		

Note: "***": p<0.001; "**": p<0.01; "*": p<0.05; "." p<0.1

In Table 4-6, instead of checking chronological effect, the effect of each HSR lines are checked based on the specification of Eq. (4-11), only in pooling OLS models (Models (a) to (d)). The line-controlled HSR related effects in Model (u), (v), (w) and (x) show the significant result only in Tokaido line and a weak significant in Tohoku line in some models. The result suggests that the effect of HSR on productivity is concentrated only in the regions along Tokaido line or the regions between Tokyo and Osaka. HSR effect in other regions of Japan is not significant since utilization of HSR in other regions may be limited compared to prefectures along Tokaido line. The result also implies that benefit from HSR investment in other regions apart from Tokaido line is not significant in terms of productivity effect.

Table 4-6.
Estimation Results of Pooling Models with Line-Controlled on HSR Related Variables.

	Coef.	SE	t-stat.	p-value	sig		Coef.	SE	t-stat.	p-value	sig
Model (u)						Model (v)					
Constant	5.158	0.34	15.1	0.000	***	*Constant*	5.300	0.35	15.1	0.000	***
s:Tokaido	0.013	0.00	4.0	0.000	***	*d:Tokaido*	0.060	0.01	4.1	0.000	***
s:Sanyo	-0.002	0.00	-0.7	0.493		*d:Sanyo*	-0.013	0.01	-1.0	0.331	
s:Tohoku	0.004	0.00	1.5	0.145		*d:Tohoku*	0.034	0.01	2.5	0.011	*
s:Joetsu	0.004	0.00	1.1	0.277		*d:Joetsu*	0.023	0.02	1.3	0.202	
s:Hokuriku	-0.004	0.01	-0.6	0.550		*d:Hokuriku*	-0.017	0.03	-0.6	0.542	
s:Kyushu	0.010	0.01	0.8	0.437		*d:Kyushu*	0.033	0.04	0.9	0.356	
K	0.125	0.02	7.2	0.000	***	*K*	0.138	0.02	7.3	0.000	***
I	0.079	0.01	5.7	0.000	***	*I*	0.075	0.01	5.4	0.000	***
W	0.508	0.03	16.5	0.000	***	*W*	0.487	0.03	14.5	0.000	***
fire	-0.509	0.16	-3.2	0.001	**	*fire*	-0.551	0.15	-3.6	0.000	***
tf	-0.017	0.00	-3.7	0.000	***	*tf*	-0.016	0.00	-3.6	0.000	***
Adjusted R^2	0.920					Adjusted R^2	0.922				
F-stat.	294.6					F-stat.	302.4				
N	282					N	282				
Model (w)						Model (x)					
Constant	5.232	0.35	14.8	0.000	***	*Constant*	5.290	0.35	15.1	0.000	***
r:Tokaido	0.112	0.03	3.3	0.001	***	*A:Tokaido*	0.003	0.00	4.1	0.000	***
r:Sanyo	0.007	0.04	0.2	0.860		*A:Sanyo*	-0.001	0.00	-1.1	0.290	
r:Tohoku	0.066	0.03	1.9	0.058	.	*A:Tohoku*	0.002	0.00	2.6	0.010	*
r:Joetsu	0.070	0.06	1.2	0.245		*A:Joetsu*	0.001	0.00	1.3	0.209	
r:Hokuriku	-0.074	0.07	-1.0	0.307		*A:Hokuriku*	-0.001	0.00	-0.6	0.520	
r:Kyushu	0.114	0.19	0.6	0.538		*A:Kyushu*	0.002	0.00	0.9	0.376	
K	0.120	0.02	6.9	0.000	***	*K*	0.140	0.02	7.3	0.000	***
I	0.084	0.01	6.0	0.000	***	*I*	0.076	0.01	5.5	0.000	***
W	0.504	0.03	15.6	0.000	***	*W*	0.486	0.03	14.4	0.000	***
fire	-0.455	0.16	-2.9	0.004	**	*fire*	-0.551	0.15	-3.6	0.000	***
tf	-0.016	0.00	-3.4	0.001	***	*tf*	-0.016	0.00	-3.6	0.000	***
Adjusted R^2	0.918					Adjusted R^2	0.922				
F-stat.	287.2					F-stat.	302.8				
N	282					N	282				

Scenario Analysis: Estimation of HSR's Impact on Regional Economic Productivity

According to our definition of agglomeration, the travel time saving is not caused only by the improvement and/or an introduction of HSR. Then, to evaluate the impact solely from the HSR, a simple scenario analysis is implemented in which the expected regional productivity in a scenario where HSR exists (with-scenario) is compared with that in another scenario where no HSR exists (without-scenario), using the estimated model. It is assumed that the without-scenario has the same conditions as the with-scenario except for the HSR network in each year. This subsection assumes Model (h) in the year 2006 for estimating the economic productivities in the with-scenario and the without-scenario. The travel time which requires computation of the agglomeration ($A_{i,t}$) is treated differently under with-scenario and without-scenario, in which the travel time in the with-scenario is estimated with the data used in the regression analysis while that in the without-scenario is estimated assuming a path with the shortest travel time between each O-D pair in the existing network without HSR in 2006.

Fig. 4-2 illustrates the estimated economic productivity gain from the HSR network by prefecture. This shows that the impact of the HSR network on regional productivity is larger in prefectures along the HSR lines, and is especially large in the prefectures located within around 150-170 km radius from the largest cities. However, prefectures located near the largest cities, such as those close to Tokyo and Osaka, do not seem affected much by HSR. This is because HSR significantly improves accessibility from peripheral regions to the largest cities, which enables more business communication and/or opportunities in the peripheral regions. On the other hand, HSR contributes less to economic productivity improvements in the vicinity of the largest cities for three reasons: first, because the HSR has fewer advantages against the competitive express urban rail services; second, the HSR usually has few stations in the metropolitan areas; and third, because the marginal benefit of HSR introduction is smaller due to the richer infrastructure stock in metropolitan areas. This could lead to the idea that the economic productivity of peripheral areas may be increased through the introduction of HSR lines, which may justify HSR projects as a means of narrowing the economic inequalities

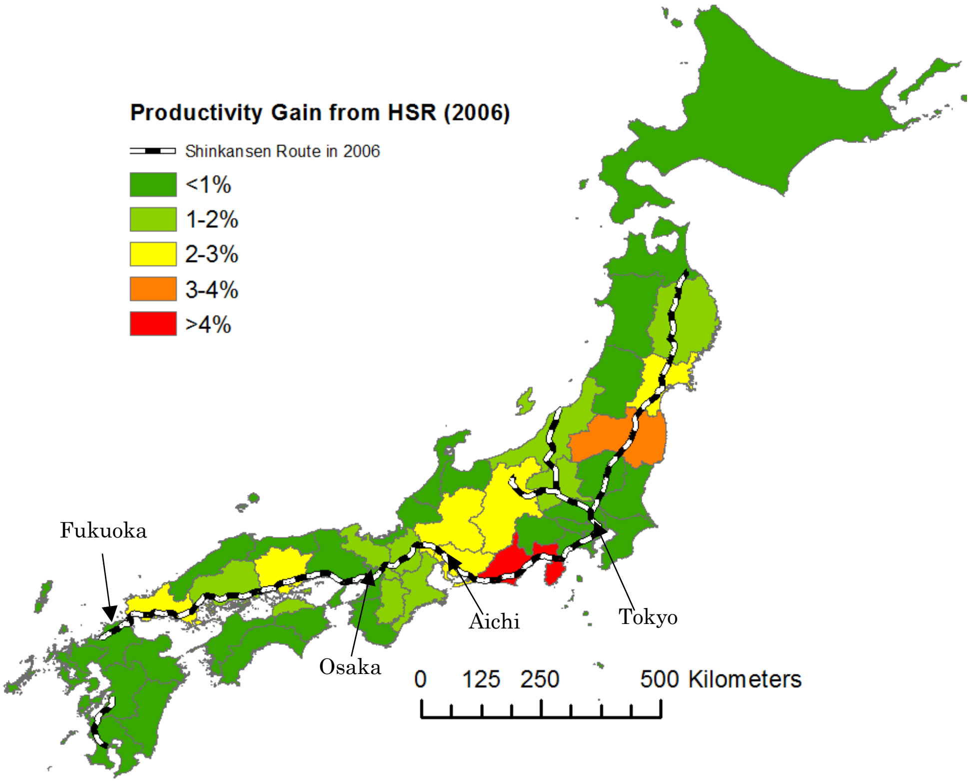

Fig.4-2. Productivity Gains from HSR Network by Prefecture in 2006.

among regions. This is supported by past studies; for instance, Sasaki *et al.* (1997) concluded that the HSR network does not contribute to regional dispersion between developed regions and remote regions, while the ESPON (2015) showed that HSR contributes only marginal benefits in regions where transportation infrastructure has been highly developed.

Conclusion

This study empirically analyzed the impact of the Japanese HSR system on the regional productivity. The main findings are:

- Regions with HSR stations have higher economic productivity than those without HSR stations;
- The regional gap of economic productivity between with-HSR and without-HSR regions has been gradually decreasing;
- Agglomeration through the introduction of HSR could positively affect regional economic productivity;
    - The agglomeration impact from HSR to productivity is reducing through time
    - The agglomeration impact from HSR to productivity is significant only in the main economic corridor of Japan
- HSR network externalities are positively associated with regional economic productivity; and
- The benefit of HSR is larger in the regions along the HSR network, especially those located few hundred kilometers away from the largest cities in Japan.

One of the uniqueness in this study was that the above results were derived from the empirical case study in Japan with panel data covering a long period of past 25 years during which the HSR network has been extended gradually. The positive association of HSR services on economic productivity is quite robust even if the reverse causal effect is also incorporated into the model estimation.

Several implications could be obtained from the case study of HSR in Japan. The first implication is drawn from the positive impacts of agglomeration effect and network externality. They could emphasize the role of HSR which serves as trunk lines connecting the main cities of Japan and which provides the agglomeration benefit by connecting major economic activities together. Despite its benefit, recently, large-scale transportation infrastructure investment has been criticized because the expected benefit could be insufficient due to the expected population decline in Japan. The results of this study may support the further extension of HSR network linking the major cities with HSR in Japan, such as the Chuo Shinkansen Maglev project, which connects Tokyo with the third largest metropolitan area, Nagoya.

The second implication may be derived from the dynamic changes in HSR's effect. As shown in the empirical analysis, the marginal impact of HSR could be decreasing over time. This may mean, as more HSR network expands, a decreasing effect of extending HSR network on the HSR's marginal contribution to economic productivity is more dominant than an increasing effect. The increasing effect is caused by the agglomeration and/or network externality since the expansion of HSR network is expected to increase the regional economic productivity through the increasing return from the agglomeration economy and/or from the economy of network scale. Meanwhile, the negative effect could be explained by the decreasing return of HSR service or the transportation development strategies of extending the HSR network to less productive regions. They suggest that the economic impacts of HSR investment should be discussed from a long-term viewpoint. At some point where the negative effect is exceptionally large and the positive effect is not feasible, the expansion of HSR network should be ceased.

The third implication is the potential contribution of HSR to mitigation of regional inequality in terms of economic productivity. Our empirical analysis suggested that the economic productivity of peripheral areas might be increased through the introduction of HSR lines. Particularly the less agglomerated areas located between major cities could be benefited by connecting the areas with major cities by HSR. HSR network investment could be regarded as one of the policy tools for narrowing down the economic inequalities across regions.

The case study of HSR in Japan is one of the best examples to show the contribution of HSR to the economy. However, the agglomeration benefit from HSR in Japan could be significantly higher than other countries owing to the higher population density in Japan. Implications of HSR investment from the case study of Japan should be considered carefully for other countries, especially countries where population density and level of urbanization are still lower. This study has pointed out that the indirect effect from agglomeration to the productivity could be more important than the direct effect from HSR service level. Thus, population density in the service area of HSR should be one of the main considerations in the planning process of HSR in order to maximize the agglomeration benefit.

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5. Industrial Agglomeration

In this chapter, the goal is to investigate the industrial agglomeration. The questions of what industry should be agglomerated together with HSR and under what circumstance it should be agglomerate will be clarified in this chapter. We use the inter-regional transportation data of Japan for our empirical analysis. Since inter-regional transportation connects one region with another, its impact on region-wide economic productivity can be felt across regions rather than within a region. Thus, we obtain data at the prefectural level (first-level administrative division in Japan[6], approximately equivalent to NUTS2[7] in the European Union) for our dataset, although, in reality, urbanization in the prefectural context might vary across prefectures. For instance, the built-up areas in megacities such as Tokyo and Osaka can cover multiple prefectures whereas the built-up areas in less urbanized prefectures might cover only small towns in a single prefecture. Thus, agglomeration in our data may be regarded as a macroscopic approximation at the regional level. Our dataset covers 11 industries (agriculture; mining; manufacturing; construction; electricity, gas and water; retail; finance/insurance; real estate; transportation/communication; service; and government service) based on the classification of the Japanese Ministry of Economy, Trade, and Industry (METI). This classification reasonably distinguishes each industry so that localization agglomeration within the industry could be analyzed properly. The dataset covers 47 Japanese prefectures for six time frames at five-year intervals: 1981, 1986, 1991, 1996, 2001, and 2006. Socio-demographic and socio-economic data, such as prefectural population, GDP, employees, wage, capital, and investment stock data by industry, were derived from the Statistic Bureau and Cabinet office of Japan. Note that all economic data were adjusted to the year 2000. As for transportation data, the travel time between each prefecture pair was estimated as the shortest travel time for the six travel modes of high-speed rail, conventional rail, air, ferry, intercity bus, and private car. We used the National Integrated Transport Analysis System (NITAS) software developed by the Japanese Ministry of Land, Infrastructure, Transport, and Tourism (MLIT) to search for the shortest path. Also, note that the transportation network has over six variations across six time periods since the transportation infrastructure was developed gradually over time. Table 4-1 summarizes the statistics of the dataset used in this study. Note that the minimum value is usually obtained from the mining industry, where the geographical distribution is uneven, while the maximum value is distributed between the manufacturing industry during the early years and service industry during the later years.

In addition to urbanization and localization agglomeration, the third type of effective density follows *mixed agglomeration*, a format of agglomeration indicator in which we try to include the effect of both urbanization and localization. Under Marshall's proposal, more interaction between industries can lead to better returns for both parties. However, localization considers only the interaction between the same types of industry and ignores the interaction between different types of industries. On the contrary, urbanization considers the whole economy and ignores the economic structure. A city with the same worker level but different in structure

[6] The administrative divisions of Japan can be divided into two levels. The upper tier is called "Prefecture"; this consists of 47 prefecture in Japan. The lower tier is called "Municipality"; there are several municipalities in one prefecture. Presently (2017), there are 1,742 municipalities in Japan; this could be decreased due to depopulation in Japan. However, each prefecture and municipality may have different levels of autonomy based on its sub-classification. For example, Tokyo Prefecture, Osaka Prefecture, and Hokkaido Prefecture may have higher levels of autonomy than other prefectures. At the municipality level, a large municipality specified as "Designated City" has a higher level of autonomy than the other municipality sub-classifications.

[7] NUTS, or Nomenclature of Territorial Units for Statistics, is a subdivision code used in EU. The NUTS2 level indicates a population range of 800,000–3,000,000. The prefecture-level population of Japan has a range of 600,000–12,000,000.

would be considered to have the same effective density in the urbanization format. Zones with different industry types and industrial share can have different effects from agglomeration as well. For a better understanding of the whole agglomeration economy, we define the *weighted effective density* under mixed agglomeration by assuming a weight parameter of γ_{nmt} for each pair of industry as

$$ED_{nit} = \sum_{j} \sum_{m} \frac{\gamma_{nmt} E_{mjt}}{g_{ijt}}, \tag{5-1}$$

where γ_{nmt} is the effective density's weight parameter to explain the degree of industrial interaction between industry *n* and industry *m* at time *t*. From this formulation, we can explain agglomeration at a point between localization and urbanization through the weight γ_{nmt}, which roughly represents the productivity of joint activities and/or interactions between industries *n* and *m;* weight γ_{nmt} is the formulation modifying the co-agglomeration index proposed by Ellison and Glaeser (1997) as

$$\gamma_{nmt} = \exp\left[\frac{\sum_{i} (s_{nit} - x_{it})(s_{mit} - x_{it})}{1 - \sum_{i} x_{it}^{2}}\right], \tag{5-2}$$

where s_{nit} and s_{mit} are the respective shares of employment in industries *n* and *m* out of the total employment in zone *i* at time *t*, and x_{it} is the mean share of employment in zone *i* out of the national employment across all industries at time *t*. Note that Ellison and Glaeser's co-agglomeration index ignores the real spatial interaction agglomeration in terms of distance between firms (Duranton and Overman, 2005). Thus, the co-agglomeration index in a spacious zone becomes the same as that in a smaller zone if both zones have the same number of firms, although, in reality, the smaller zone can attain better agglomeration benefits from the shorter distance between firms. Despite such methodological disadvantages, our analysis uses this index for analytical simplicity.

Fig. 4-1 illustrates the relationship between three types of prefectural effective density and the prefectural GDP. For the localization and mixed agglomeration cases, we present the prefectural GDP for the manufacturing industry as an example. Although the later years indicate less production, a comparison of the data for the same time period shows the prefectures with more effective density to have higher GDP, implying that agglomeration leads to higher overall production. This may be rather reasonable because effective density includes a number of workers and hence has a positive influence on the prefectural GDP. Plots in Fig. 1 clearly suggests a relationship between agglomeration and prefectural production. However, to find the return to productivity that can be expected from agglomeration, we present a controlled analysis in the next section.

Table 5-1. Descriptive Statistics of Dataset

	Total	1981	1986	1991	1996	2001	2006
Production (Million JPY/industry/prefecture/year)							
Minimum	230	230	414	719	502	638	479
Median	378,414	273,240	323,247	396,046	456,916	449,022	446,210
Maximum	22,070,600	9,823,798	14,766,990	16,315,540	19,606,770	22,070,600	21,338,830
Mean	820,429	553,442	667,168	848,140	924,442	938,668	990,715
Standard deviation	1,605,935	948,974	1,271,036	1,617,179	1,728,182	1,864,892	1,937,460
Capital (Million JPY/industry/prefecture/year)							
Minimum	1,815	1,936	1,815	2,226	2,550	2,845	3,045
Median	854,233	364,181	595,462	862,513	1,092,411	1,277,283	1,349,462
Maximum	48,220,493	22,162,743	24,359,178	27,276,188	31,974,930	37,173,812	48,220,493
Mean	2,305,760	1,288,976	1,664,959	2,140,179	2,583,399	2,955,790	3,201,257
Standard deviation	4,145,113	2,503,369	3,004,524	3,630,910	4,305,946	4,908,843	5,418,859
Number of employee (Person/industry/prefecture/year)							
Minimum	49	228	99	162	96	65	49
Median	41,587	39,882	41,593	42,934	44,193	42,333	38,430
Maximum	3,248,648	2,386,409	2,608,705	2,671,269	2,841,936	2,654,384	3,248,648
Mean	112,900	99,700	105,165	116,091	126,669	116,360	113,413
Standard deviation	234,242	202,944	216,547	237,327	258,192	241,460	244,809
Investment (Million JPY/industry/prefecture/year)							
Minimum	115	115	141	225	127	133	208
Median	61,074	41,143	54,715	79,218	73,845	64,918	55,603
Maximum	11,917,150	4,989,108	7,560,264	10,917,420	8,846,604	8,958,830	11,917,150
Mean	248,229	152,166	197,865	315,386	262,008	247,909	314,037
Standard deviation	667,031	377,376	522,269	817,661	657,969	639,079	853,210
Urbanization agglomeration (Person/minute/industry/prefecture/year)							
Minimum	147,188	147,188	170,714	191,491	198,151	192,470	202,194
Median	263,100	215,733	241,652	269,420	278,960	271,131	265,933
Maximum	631,467	504,171	542,392	609,558	631,467	608,729	604,423
Mean	296,137	254,866	273,723	310,319	322,163	310,647	305,103
Standard deviation	96,393	80,686	85,822	97,968	102,390	97,077	95,270
Localization agglomeration (Person/minute/industry/prefecture/year)							
Minimum	118	411	335	262	222	163	118
Median	16,289	14,803	15,217	16,738	17,257	16,854	17,058
Maximum	216,685	149,714	163,562	175,887	189,490	181,887	216,685
Mean	27,121	23,171	24,881	28,208	30,497	28,237	27,735
Standard deviation	32,613	27,128	29,302	32,942	36,325	33,852	34,809
Mixed agglomeration (Person/minute/industry/prefecture/year)							
Minimum	130,080	130,080	149,481	167,164	179,060	166,125	172,166
Median	429,163	384,356	402,143	442,870	468,439	448,376	436,988
Maximum	39,101,417	6,970,554	7,311,297	7,452,168	7,771,859	9,471,800	39,101,417
Mean	1,261,707	868,319	939,701	1,027,291	1,148,991	1,121,471	2,464,468
Standard deviation	2,675,939	1,134,532	1,203,867	1,250,391	1,397,458	1,487,553	5,724,662

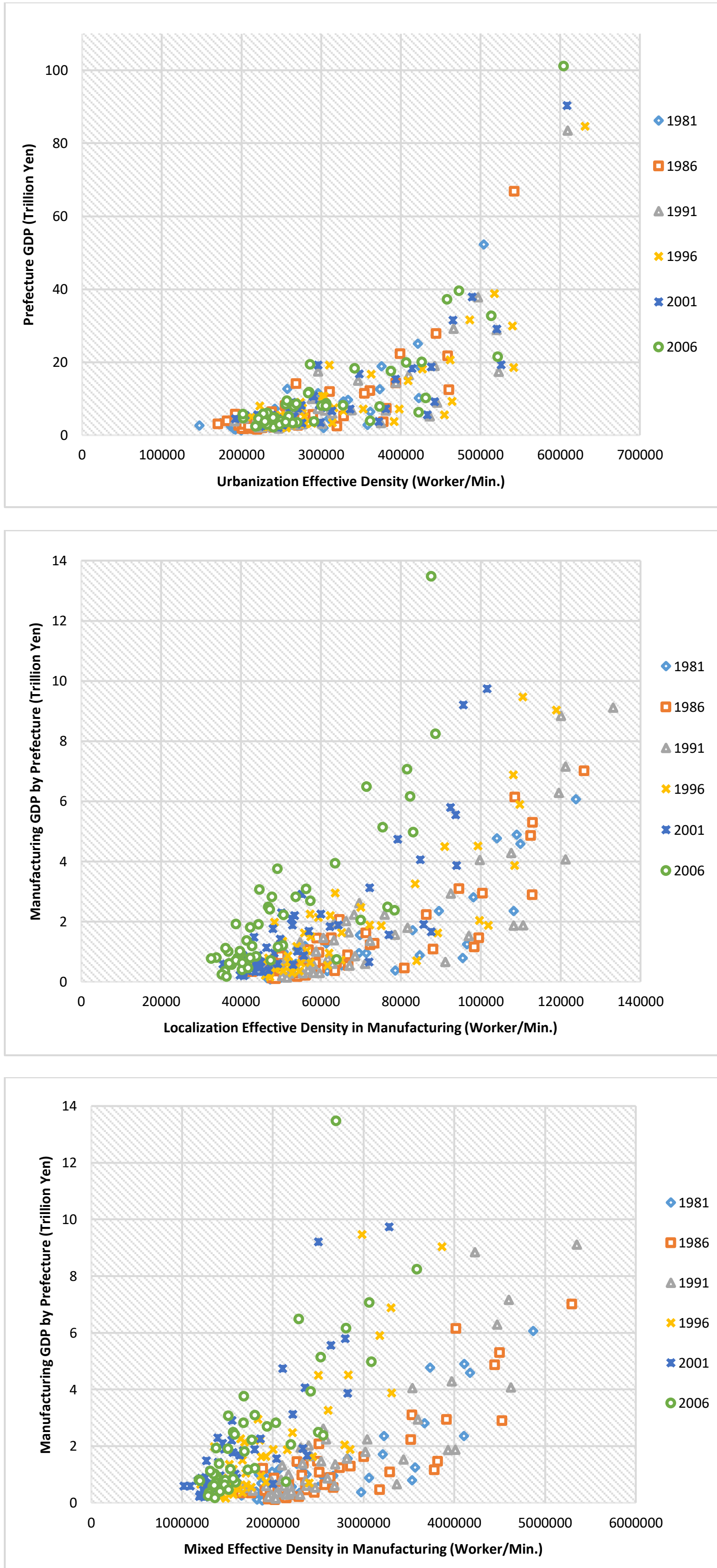

Fig. 5-1. Urbanization, Localization, and Mixed Agglomerations versus Prefectural GDP

Regression Analysis

We estimate three models in regression processes, the prefectural fixed-effect model ("prefecture controlled"), the time period fixed-effect model ("time controlled"), and the prefectural and time period fixed-effect model ("two-way controlled"). The panel data are estimated for each type of agglomeration assumption across the industrial categorization based on Eq. (3-7). Tables 5-2, 5-3, and 5-4 give the estimation results, highlighting the elasticities of effective density for each model.

Table 5-2 summarizes the estimation results of the three regression models using urbanization agglomeration in 11 industries, assuming Eq. (3-1) for effective density. For all industries, model fitness is the highest in the time-controlled model, followed by the prefecture-controlled model and the two-way-controlled model. First, the prefecture-controlled model shows that effective density has significantly positive impacts on mining and finance/insurance and negative impacts on real estate and government service industries. Next, the time-controlled model shows that effective density has a significantly positive impact on real estate and negative impact on the agriculture industry. Finally, the two-way-controlled model shows that effective density has no impact on any industry.

Table 5-3 summarizes the estimation results of the three regression models using localization agglomeration in 11 industries, assuming Eq. (3-2) for effective density. First, the prefecture-controlled model shows that effective density has significant positive impacts on construction, retailing, finance/insurance, and transportation/communication industries and negative impacts on manufacturing, electricity/gas/water, and service industries. Next, the time-controlled model shows that effective density has a significantly positive impact on real estate and negative impact on the agriculture industry. Finally, the two-way-controlled model shows that effective density has a significantly positive impact on the mining industry.

Table 5-4 summarizes the estimation results of the three regression models using mixed agglomeration in 11 industries, assuming Eq. (5-1) for effective density. Models assuming mixed effective density tend to perform better than those assuming urbanization agglomeration, although the results are generally the same as for earlier models. First, the prefecture-controlled model shows that effective density has significant positive impacts on mining, finance/insurance, and transportation/communication and negative impacts on the service industry. Next, the time-controlled model shows that effective density has a significantly positive impact on real estate and negative impact on the agriculture industry. Finally, the two-way-controlled model shows that effective density has a significantly positive impact on government service.

From Table 5-2, 5-3 and 5-4, the best goodness of fit, as described by the adjusted R^2, is in the time-controlled model, followed by the prefecture-controlled and two-way-controlled models. Furthermore, we observed poor significance for the two-way-controlled model. This could be due to misspecification in the two-way-controlled model because the prefecture-controlled and year-controlled parameters are correlated. For example, in early 1980's when Japanese economy is still growing, we observed higher growth in the big prefecture. However, during 1990's where economic crisis occurred, such major prefectures may have lower growth than other small prefecture as the negative shock from the economic crisis is expected to be larger in major prefectures. In another word, prefecture control in the major prefecture and year control could be correlated while negative correlation is expected in the small prefecture and year control.

Therefore, we would like to refrain our interpretation of results from the two-way-controlled model. Our major findings based on the prefecture- and year-controlled model results can be summarized as follows:

The prefecture-controlled model shows that

[1] both urbanization and localization agglomerations have a positive influence on regional productivity in the finance/insurance industry;

[2] urbanization agglomeration tends to have a positive influence on regional productivity in the mining industry;

[3] localization agglomeration tends to have a positive influence on regional productivity in the transportation/communication industry; and

[4] localization agglomeration tends to have a negative influence on regional productivity in the services industry.

The time-controlled model shows that

[5] both urbanization and localization agglomerations have a positive influence on regional productivity in the real estate industry; and

[6] both urbanization and localization agglomerations have a negative influence on regional productivity in the agriculture industry.

From the above findings, a significant result from both the urbanization and mixed agglomeration models implies influence from urbanization agglomeration, whereas a significant result from both the localization and mixed agglomeration models implies influence from localization agglomeration. Further, note that the prefecture-controlled model excludes the impacts of the unique prefecture-related factor by introducing constants to each prefecture whereas the time-controlled model excludes the impacts of the unique time-related factor by introducing constants to each time period. Findings [1] to [4] are based on observations of the prefecture-controlled model only, meaning that the results could hold true across prefectures but can be affected by the time factor. Findings [5] and [6] are based on observations of the time-controlled model only, meaning that the results could hold true across time but can be affected by the prefectural factor.

Discussion

From the results, the fitness of the estimated models assuming localization agglomeration tends to be higher than that for the other two models in any industries. The number of industries with significant estimates for agglomeration is also largest in the localization models. This could imply that localization agglomeration has a higher influence on economic production than urbanization agglomeration. However, the results also show that agglomeration has different effects for each industry.

First, the positive impacts of both urbanization and localization agglomeration on regional productivity in the finance/insurance and real estate industries, or the so-called FIRE industry, may be explained reasonably using Marshall's theory. Since the FIRE industry should have customers from many other industries, a higher density of potential customers from various industries can give more business opportunities to them; this may be one of the sources of external benefit from urbanization agglomeration. Because the FIRE industry particularly needs the latest information about local/regional/global markets, the social network of workers in the same industry can effectively contribute by sharing knowledge through meetings. Communication opportunities such as seminars and informal meetings attract business people from across regions, and so a higher density of colleagues in the FIRE industry can provide more knowledge spillover through communication; this is one of the sources of external benefit from localization agglomeration. Localization agglomeration also affects the labor pool as well as the procurement of high-standard service, because the FIRE industry requires skillful labor and efficient business environment for attaining higher productivity. A significant impact can be found in the finance/insurance industry only with the prefecture-controlled model, probably because its impact considerably varies across prefectures. Similarly, a significant impact can be found in the real estate industry with the time-controlled model, probably because the real estate market in Japan was influenced by conditions in the national economic market rather than by each prefecture's unique condition, although the significance in the prefecture-controlled model is relatively strong as well. Note that the estimated elasticities in the finance/insurance industry with respect to urbanization, localization, and mixed agglomerations are 0.935, 0.750, and 1.214, respectively, and those in the real estate industry are 0.292, 0.244, and 0.294 respectively. This could mean that urbanization agglomeration may have a greater influence on productivity than localization agglomeration in those industries.

Second, the positive impact of urbanization agglomeration on regional productivity in mining may be explained from the market perspective. Although the intuition is, localization should be more vital in mining sector since mining products usually come directly from natural resources, which are typically located in limited areas based on geographical conditions of resource availability. By controlling the natural resources effect by the prefecture-fixed effect, we observed the significant effect in urbanization agglomeration effect. This could be mainly due to the fact that the mining company is not only in the mine ore area, but our data reveals that company also established its office in the urban area in order to sell its product. Especially in Japan where there is higher share in rare metal and precious ore market and the demand in this market is usually higher in the more urbanized area.

Third, the positive impact of localization agglomeration on regional productivity in transportation/communication may reflect regional market characteristics. For instance, when transportation firms are located closely, trucks/vans or drivers can be easily shared among them, thus reducing their potential business risk due to demand fluctuation in the transportation market. The network economy may also work in transportation/communication businesses that particularly use the physical network. In the case of Japan, multiple public transit operators working closely together can form a wider transportation network covering vast areas and thus enhance accessibility and the mobility of passengers; this could improve the productivity of public transit operators from the complementarity of services. A significant impact of agglomeration was found in the transportation/communication industry only with the prefecture-controlled model because its impact considerably varies over prefectures from the geographically uneven availability of natural resources.

Fourth, localization agglomeration negatively influences regional productivity in the service industry. Generally, negative elasticities of agglomeration to productivity are found when the centrifugal forces stemming from agglomeration are stronger than the centripetal forces (Fujita et al., 2001). The centrifugal force, or diseconomies from agglomeration, may arise from higher land rent, increased living expenses, or more congestion from a denser population. One possible reason for negative elasticity in the service industry is that agglomeration of the same service firms can cause serious market competition among them and lose the additional benefit of the imperfect competitive market. Agglomeration can even lead to over-competition, generating negative external effects such as weaker position in business contracts with their clients or customers, while less agglomerated firms can enjoy higher market power. The negative impact on some industries is supported by Combes et al. (2012), where the firm selection process[8] has no impact on spatial productivity difference.

Fifth, both urbanization and localization agglomerations have a negative influence on regional productivity in the agriculture industry. One possible explanation is that the economy of geographical scale works well in agricultural business because it typically requires larger land for better production. A larger area of land decreases the average cost of production, resulting in better productivity, and leads to less agglomeration. Another possible reason, particularly for the poor impact of localization agglomeration, is the negative external effect of agglomeration. For example, densely agglomerated agricultural businesses consume excessive natural resources such as water, wood, and fish and thus reduce the performance of the agricultural production.

Finally, industries other than FIRE, transportation/communication, service, and agriculture may not have notable impacts from agglomeration. In particular, the poor significance of agglomeration in electricity/gas/water, retail, and government service industries could be explained by the characteristics of such services and/or goods. Because these are essential goods/services for people's daily life, the industries producing such commodities are required to be distributed evenly. Government service is a typical case, and retail and electricity/gas/water industries have to run their businesses even if their profit is near zero. More positively, these industries themselves distribute evenly based on the distribution of population, and so regional agglomeration may make less sense in these industries.

[8] The firm selection approach explains the better productivity from agglomeration resulting from the intensive competition in larger markets. Only the best firms can survive competition, resulting in better overall productivity in a large market compared to a smaller market.

Table 5-2. Estimated elasticities of regional productivity with respect to effective density based on urbanization agglomeration

			Prefecture control			
	Agriculture	Mining	Manufacturing	Construction	Elec, Gas & Water	Retail
ED	0.090	1.267 ***	-0.032	-0.011	0.175	-0.055
	(0.155)	(0.178)	(0.155)	(0.184)	(0.148)	(0.113)
l	0.195 ***	0.286 ***	0.411 ***	0.574 ***	-0.123	0.269 ***
	(0.041)	(0.033)	(0.123)	(0.050)	(0.076)	(0.025)
Adj. R^2	0.429	0.510	0.727	0.642	0.706	0.745
	Finance & Insur	Real Estate	Transport & Comm	Service	Gov. Service	
ED	0.935 ***	-0.417 **	-0.051	0.066	-0.195 ***	
	(0.198)	(0.138)	(0.155)	(0.083)	(0.054)	
l	0.548 ***	0.636 ***	0.220 ***	0.080 *	0.549 ***	
	(0.063)	(0.075)	(0.064)	(0.036)	(0.056)	
Adj. R^2	0.699	0.730	0.721	0.771	0.747	
			Time control			
	Agriculture	Mining	Manufacturing	Construction	Elec, Gas & Water	Retail
ED	-0.296 ***	0.011	0.095 *	-0.101 *	0.002	0.033
	(0.059)	(0.053)	(0.047)	(0.045)	(0.030)	(0.037)
l	0.331 ***	0.053	0.574 ***	0.253 ***	0.111 ***	0.212 ***
	(0.038)	(0.038)	(0.027)	(0.060)	(0.027)	(0.043)
Adj. R^2	0.777	0.885	0.928	0.915	0.927	0.930
	Finance & Insur	Real Estate	Transport & Comm	Service	Gov. Service	
ED	0.062	0.292 ***	0.016	0.021	0.001	
	(0.041)	(0.072)	(0.031)	(0.019)	(0.027)	
l	0.194 ***	0.090	0.009	0.159 ***	0.963 ***	
	(0.058)	(0.181)	(0.046)	(0.032)	(0.040)	
Adj. R^2	0.926	0.893	0.930	0.936	0.929	
			Two-way control			
	Agriculture	Mining	Manufacturing	Construction	Elec, Gas & Water	Retail
ED	-0.199	0.460	0.097	-0.298	0.062	0.057
	(0.230)	(0.286)	(0.201)	(0.191)	(0.149)	(0.115)
l	0.206 ***	0.158 ***	0.376 ***	0.172 *	0.073	0.064
	(0.037)	(0.046)	(0.112)	(0.074)	(0.047)	(0.038)
Adj. R^2	0.185	0.611	0.330	0.295	0.617	0.557
	Finance & Insur	Real Estate	Transport & Comm	Service	Gov. Service	
ED	0.064	0.164	0.222	0.005	0.095	
	(0.116)	(0.188)	(0.118)	(0.076)	(0.068)	
l	0.062	0.585 ***	0.098 *	0.060 *	0.710 ***	
	(0.044)	(0.119)	(0.043)	(0.029)	(0.063)	
Adj. R^2	0.537	0.284	0.490	0.630	0.372	

Note: The estimates in parenthesis represent standard errors; *** significance at the 0.1% level, ** significance at the 1% level, and * significance at the 5% level; for every model, number of observation = 282.

Table 5-3. Estimated elasticities of regional productivity with respect to effective density based on localization agglomeration

					Prefecture control						
	Agriculture		Mining		Manufacturing		Construction		Elec, Gas & Water		Retail
ED	-0.121		0.060		-0.274	***	0.532	***	-1.324	***	0.203 ***
	(0.212)		(0.091)		(0.067)		(0.107)		(0.151)		(0.058)
l	0.209	***	0.180	*	0.570	***	0.321	***	0.117		0.131 **
	(0.050)		(0.078)		(0.112)		(0.069)		(0.072)		(0.043)
Adj. R^2	0.429		0.447		0.732		0.657		0.728		0.747
	Finance & Insur		Real Estate		Transport & Comm		Service		Gov. Service		
ED	0.750	***	0.153		0.520	***	-0.478	***	-0.207	**	
	(0.106)		(0.121)		(0.055)		(0.057)		(0.073)		
l	0.256	**	0.647	***	0.141	*	0.152	***	0.563	***	
	(0.082)		(0.076)		(0.055)		(0.031)		(0.063)		
Adj. R^2	0.709		0.728		0.742		0.776		0.745		
					Time control						
	Agriculture		Mining		Manufacturing		Construction		Elec, Gas & Water		Retail
ED	-0.470	***	0.142		0.109	*	-0.106	*	0.008		0.024
	(0.108)		(0.090)		(0.044)		(0.053)		(0.032)		(0.036)
l	0.401	***	0.045		0.567	***	0.262	***	0.111	***	0.217 ***
	(0.036)		(0.038)		(0.027)		(0.059)		(0.027)		(0.043)
Adj. R^2	0.773		0.886		0.928		0.915		0.927		0.930
	Finance & Insur		Real Estate		Transport & Comm		Service		Gov. Service		
ED	0.061		0.244	***	0.013		0.018		-0.007		
	(0.040)		(0.066)		(0.031)		(0.020)		(0.029)		
l	0.190	**	0.083		0.007		0.161	***	0.964	***	
	(0.057)		(0.182)		(0.046)		(0.032)		(0.040)		
Adj. R^2	0.926		0.892		0.930		0.936		0.929		
					Two-way control						
	Agriculture		Mining		Manufacturing		Construction		Elec, Gas & Water		Retail
ED	-0.575	*	1.073	***	0.274		-0.254		0.155		0.029
	(0.253)		(0.209)		(0.195)		(0.207)		(0.155)		(0.111)
l	0.267	***	0.014		0.364	**	0.177	*	0.057		0.066
	(0.045)		(0.052)		(0.112)		(0.074)		(0.050)		(0.038)
Adj. R^2	0.197		0.627		0.333		0.293		0.618		0.557
	Finance & Insur		Real Estate		Transport & Comm		Service		Gov. Service		
ED	0.060		0.292		0.221	*	0.026		0.054		
	(0.104)		(0.187)		(0.097)		(0.075)		(0.074)		
l	0.060		0.570	***	0.071		0.060	*	0.711	***	
	(0.044)		(0.118)		(0.045)		(0.029)		(0.063)		
Adj. R^2	0.537		0.287		0.492		0.630		0.370		

Note: The estimates in parenthesis represent standard errors; *** significance at the 0.1% level, ** significance at the 1% level, and * significance at the 5% level; for every model, number of observation = 282.

Table 5-4. Estimated elasticities of regional productivity with respect to effective density based on mixed agglomeration

	Prefecture control					
	Agriculture	Mining	Manufacturing	Construction	Elec, Gas & Water	Retail
ED	0.218	1.076 ***	-0.037	0.447 **	-0.038	0.127 **
	(0.134)	(0.164)	(0.057)	(0.135)	(0.137)	(0.039)
l	0.197 ***	0.244 ***	0.402 ***	0.444 ***	-0.126	0.169 ***
	(0.041)	(0.032)	(0.108)	(0.063)	(0.077)	(0.036)
Adj. R^2	0.433	0.502	0.728	0.649	0.706	0.747
	Finance & Insur	Real Estate	Transport & Comm	Service	Gov. Service	
ED	1.214 ***	-0.362 **	0.664 ***	-0.042 ***	-0.052	
	(0.150)	(0.119)	(0.132)	(0.008)	(0.075)	
l	0.355 ***	0.627 ***	0.198 **	0.050	0.464 ***	
	(0.065)	(0.075)	(0.061)	(0.033)	(0.053)	
Adj. R^2	0.713	0.730	0.729	0.773	0.744	
	Time control					
	Agriculture	Mining	Manufacturing	Construction	Elec, Gas & Water	Retail
ED	-0.297 ***	0.011	0.100 *	-0.102 *	0.002	0.031
	(0.059)	(0.053)	(0.046)	(0.044)	(0.030)	(0.036)
l	0.331 ***	0.053	0.572 ***	0.253 ***	0.111 ***	0.213 ***
	(0.038)	(0.038)	(0.027)	(0.060)	(0.027)	(0.043)
Adj. R^2	0.777	0.885	0.928	0.915	0.927	0.930
	Finance & Insur	Real Estate	Transport & Comm	Service	Gov. Service	
ED	0.062	0.294 ***	0.016	0.021	0.000	
	(0.041)	(0.072)	(0.031)	(0.019)	(0.026)	
l	0.194 ***	0.089	0.009	0.159 ***	0.963 ***	
	(0.058)	(0.181)	(0.046)	(0.032)	(0.040)	
Adj. R^2	0.926	0.893	0.930	0.936	0.929	
	Two-way control					
	Agriculture	Mining	Manufacturing	Construction	Elec, Gas & Water	Retail
ED	0.000 *	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
l	0.181	0.040	0.151	0.173	0.262	-0.167
	(0.094)	(0.092)	(0.130)	(0.121)	(0.380)	(0.490)
Adj. R^2	0.005	0.485	0.253	0.125	0.114	0.017
	Finance & Insur	Real Estate	Transport & Comm	Service	Gov. Service	
ED	0.000	0.000 *	0.000	0.000	0.000 ***	
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	
l	-0.029	0.372	-0.209	0.029	0.311 *	
	(0.075)	(0.303)	(0.300)	(0.049)	(0.124)	
Adj. R^2	0.372	0.070	0.163	0.426	0.191	

Note: The estimates in parenthesis represent standard errors; ***significant at the 0.1% level, ** significance at the 1% level, and * significance at the 5% level; for every model, number of observation = 282.

Conclusion

This study provided empirical evidence of the impacts of agglomeration on regional development using Japanese historical data. Although our study shares similar settings with Nakamura (1985), several contrasts can be found. Urbanization agglomeration is explained in Nakamura (1985) by the population in a densely inhabited district (DID). However, our study considers urbanization agglomeration with the total number of workers in the prefecture. In Japan, many towns near big cities serve as a residential area for workers in big cities. From the 2000 data, the daytime to nighttime population ratio for Tokyo Prefecture is around 1.2, whereas that for the neighboring prefectures such as Saitama, Chiba, and Kanagawa is less than 0.9. We believe that the number of workers is more reasonable for urbanization agglomeration because the worker is one of the contributors to firm productivity. Another difference is that the transportation factor is included in the agglomeration model. Agglomeration economies cannot be realized without communication between firms, and transportation can be considered as one of the barriers to communication level. Ideally, for panel-data analysis, other communication variables such as level of Internet penetration or mobile phone usage should be included in the agglomeration model; this also depicts the accessibility level between firms across region and time. However, we would like to restrict our scope to transportation in this study.

Our results showed that on average, the indirect benefit from regional productivity improvement through localization agglomeration tends to be more significant than that through urbanization agglomeration although their robustness indicates that every industry utilizes agglomeration in different ways. From our results for Japanese industries, mining enjoys significant benefit from urbanization rather than localization, transportation/communication enjoys significant benefit from localization rather than urbanization, and FIRE benefits from both types of agglomeration economies. Negative elasticities were found for agriculture and service industries, but this could be partly due to the industries' characteristics. Furthermore, this study also discussed the factors that could lead to agglomeration. As in our discussions on the mining industry, the geographical distribution of natural resources is one of the factors considered. Although we tried to analyze the potential reverse causality and explain agglomeration with other factors, our attempts failed because of our limited dataset. This could be partly because of the unique policy implemented earlier in Japan by the national government in the 1980s and 1990s. Although the early stages following World War II saw a series of expressways and high-speed railways successfully introduced to expand the transportation network and meet the challenges of rapid economic growth, the government gradually shifted its policy goal from national economic development to regional economic development under the concept of "regionally balanced national development policy" in the 1980s and 1990s. During that period in Japan, the investment of inter-regional transportation infrastructure or development of regional industries may have been determined through political debates rather than a consistent decision-making process, thus making it difficult for us to interpret the mechanism of regional agglomeration in Japan. Note that the formal cost-benefit analysis guideline for transportation investment was introduced in Japan around 2000.

Although this study contributed to validating the assumption that improved regional accessibility promoted economic development through agglomeration, several further issues remain to be addressed. First, from a technical perspective, one of the issues is the rationale for using "effective density" to explain agglomeration. Kanemoto (2013) and Kidokoro (2015) explained the difference between an agglomeration economy and transportation investment through general equilibrium, mentioning that the concept of effective density might not be justified in some cases. For example, the effective density in Eq. (3) follows urbanization agglomeration, neglecting the industrial structure. Thus, a problem could arise. For example, a zone with 90% employment in industry *n* and 10% employment in industry *m* has the same effective density as another zone with 10% employment in industry *n* and 90% in industry *m*, although, obviously, the productivity between them should be different. This is the main reason we introduced the weighted effective density in our analysis to consider the whole economy within the zone, although the result could imply that the Ellison and Glaeser co-agglomeration index is not promising, at least with our specification and dataset. Further examination would be required for the definition of agglomeration. Yet, our finding can help the regional planner with regard to agglomeration to a certain extent. Nevertheless, we draw the first conclusion from our analysis: the relationship between transportation investment and the economy through agglomeration can be positive, negative, or not related, depending on the type and distribution of industrial activities. Many agglomeration-related studies focus only on the manufacturing sector, but we argue that the effect of inter-industrial agglomeration should be further investigated to reveal the real mechanism behind the cross-fertilization process proposed in urbanization agglomeration.

Finally, we emphasize the interest gain from the coordination between land use and transportation service. Many practices can be explained using the results obtained in the case study of Japan. For example, the results show that the agglomeration productivity premium found in the real estate industry and in the transportation and communication industry are positively significant in several models. These results concur with the real situation in Japan, where transit-oriented development has been effectively established in large urban areas from the late 20th century. The situation in Japan can explain the negative results in agriculture as well; the limited land available for cultivation in Japan is against the nature of the agricultural sector, where a larger land area decreases the average cost of production, implying that less agglomeration leads to higher productivity. However, we emphasize that these results can be unique for Japan, where limited habitable land is the main issue, forcing economic activities to agglomerate together. Nevertheless, another conclusion can be drawn from our findings: transportation improvement significantly promotes the economy through agglomeration from better accessibility in many industries.

One policy implication drawn from the first conclusion is that the agglomeration effect should be treated industry by industry. For example, our result shows a negative impact of localization agglomeration in the service industry. While we continuously observed an increasing trend of employment in the service industry in Japan, we believe that the service industry in Japan should be expanded to the regions where an agglomeration of the service sector is still lagging behind in order to reduce the over-competition effect. As for the second conclusion, we believe that to maximize regional productivity from agglomeration, the land-use and transportation planning should consider whether, which, and where each sector should be allocated and transportation infrastructure invested. In Japan, huge infrastructure investment is criticized because the expected benefit might not be sufficient due to the declining population in Japan. However, we agree with the transportation project linking the major cities, such as the Chuo Shinkansen Maglev project. Despite its huge investment cost, we believe that this project will be able to generate sufficient indirect benefit through agglomeration along the most populated corridor in Japan.

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6. Specialization/Diversity Agglomeration

Literature regarding agglomeration on specialization and diversity remains ambiguous whether which is best contributed to the local productivity. Local specialization could favor the original idea of Marshall (1920) where better productivity from agglomeration can be expected in the area where firms in a similar sector located close to each other. On the other hand, industrial diversity could fulfill the idea proposed by Jacobs (1969) where innovation growth is believed to be stimulated by a variety of industrialization since different ideas and information can be synthesized through variety rather than specialization. Although empirical analysis from the past literature might suggest the importance of diversity rather than specialization, the concept of specialization is still intriguing and could not be ignored. It is also interesting to understand why the effects of industrial diversity benefit the local productivity where industrial specialization was rarely suggested in the past empirical study.

Specialization/diversity agglomeration is usually discussed on the basis of the spatial interaction between activities (such as firms, or workers). By taking spatial consideration into account, it is certain that transportation improvement could enhance the performance of spatial interaction between activities. Better transportation reduces the cost of travel, encourages more meetings, discussions, or even workshops between firms, and this hastens the learning process, accelerates firms' technology, and results in better productivity. Transportation literatures such as (Graham, 2007; Graham et al., 2009; Melo et al., 2013; 2016) considered transportation as one of the factors for agglomeration economies and showed that improvement in accessibility from transportation in term of "Effective Density" could create a better agglomeration environment. However, only the size of agglomeration has been considered by transportation effect. Considering specialization/diversity effect from transportation from the viewpoint of theory, one of the facts could be extracted from New Economic Geography (NEG); less trade cost, which could be the result of better transportation, leads to more goods variety in the economy (Krugman, 1991). Yet, there is a lack of empirical study to support the idea given by NEG. Especially in the case of HSR where the effect could be different from what has been proposed in NEG since HSR mainly serve passenger transport rather than freight transport assumed in NEG. This chapter will be divided into two sections, where the relationship between industrial specialization/diversity and productivity will be discussed in the first section, and how HSR affects local industrial specialization/diversity will be empirically analyzed in the latter section.

Literature Review

Past literature provides the discussion regarding agglomeration economies from many perspectives. Rosenthal and Strange (2004) provided a categorization of such agglomeration perspectives into four scopes; industrial scope, temporal scope, geographical scope, and organization scope. In this thesis, I would like to focus on the industrial scope, which is the most widely discussed topic in the literature regarding agglomeration economies. Within industrial scope, Rosenthal and Strange (2004) further provides two sub-scopes which are usually discussed in many studies. The first scope discusses the issue regarding the size of the industrial agglomeration whether the size of the agglomeration within the same industry (localization agglomeration), or whether the size of total agglomeration in the economy (urbanization agglomeration) is more beneficial to productivity in the agglomerated area. The discussion regarding localization/urbanization has been conducted in the previous chapter. In this chapter, I would like to scope the discussion on the second sub-scope, which is the discussion whether an agglomerated area with more specialization or diversity, is more beneficial to productivity. In general, the localization/urbanization agglomeration scope, and specialization/diversity agglomeration scope may seem similar at glance since the concept of Marshall's economy could be applied to both localization agglomeration and specialization agglomeration, while the concept of Jacob's economy could be also applied to both urbanization agglomeration and diversity agglomeration. Table 6-1 provides the further explanation to distinguish the characteristic of the sub-scope within the industrial scope.

As mentioned in the previous chapter, past empirical literature may favor the benefit from localization agglomeration rather than the urbanization agglomeration. However, in the specialization/diversity scope, surprisingly, the positive significance of diversity agglomeration to the economy has been highlighted more than specialization. Several studies highlight the benefit of specialization agglomeration in conceptual perspective. Helsley and Strange (1990) provided the model highlighting the job-matching process, and concluded that more specialization means a larger pool of workers in the similar skill which allows better matching and eventually leads to more productivity. General equilibrium model proposed in Duranton and Puga (2001) can suggest the importance of both specialized and diversified environment whereas the diversified city could be suitable for the firms in an early stage while the matured firms have larger benefit in the specialized city. However, by comparing the effect of specialization and diversity, empirical studies may found the diversity agglomeration to be more beneficial to the economy. Glaeser et al. (1992) analyzed the growth of the top 6 industries in 1956, concluded that specialization does not encourage growth. Similar interpretation also can be found in Henderson et al. (1995) which concluded that specialization has no positive contribution to growth in high-technology industries in between 1970-1987. Henderson et al. (1995) further suggested that employment growth is higher in the area with more employment diversity, which is measured by Herfindahl-Hirschman Index (HHI) of employment. Thus, result from empirical studies tends to favor the importance of diversity agglomeration to the economy rather than specialization one.

Nevertheless, from past literature, several issues regarding specialization/diversity agglomeration remains inconclusive. Although intuitively, the mechanism of diversity agglomeration shares several similarities to urbanization agglomeration, however, the reason why the larger benefit is usually found in localization agglomeration effect rather than urbanization one should be discussed along with the specialization/diversity scope. Another issue is regarding indexes used to measure specialization/diversity. Usually, two types of indexes are utilized to measure the degree of specialization or diversity; first, the index which consider the industrial distribution only in its own area which HHI is usually applied in the first type, and the second which the distribution of each industry across every area is considered along with the distribution across industry in its own area. In the latter type, the indexes which applied from Ellison and Glaeser agglomeration index (Ellison & Glaeser, 1997) are usually introduced in the analysis. The question is that which type of index can best explain the condition of industrial synthesis mentioned in Jacob's economy. Furthermore, indexes used in the past literature often neglect the neighboring effect especially the index in the first type which activity distribution in its own area only is considered. As mentioned that agglomeration should be discussed with the spatial consideration, thus by considering the neighboring effect, the degree of specialization/diversity could vary across spatial unevenness too.

Table 6-1. Relationship between localization/urbanization agglomeration and specialization/diversity agglomeration

	Measurement	Concept
Localization (Urbanization) Agglomeration	Size of agglomeration	Marshall's economy (Jacob's economy)
Specialization (Diversity) Agglomeration	Distribution of agglomeration	Marshall's economy (Jacob's economy)

Until now, there is no literature that investigates the effect of specialization/diversity from transportation, especially from HSR. Past literature usually assumes that industrial promotion usually depends on specific policy and is not affected by infrastructure investment such as HSR. Therefore, in this study, we thus propose new causal effect assuming new transportation such as HSR service induces the change in industrial structure.

Specialization/Diversity Agglomeration Index

Although past literature favors the effect from diversity agglomeration rather than specialization agglomeration, one of the important issues is how the indexes are selected to explain the characteristics of diversity/specialization. As we mentioned that, the ideal index should be the index that can best capture the characteristics of Marshall's economy or Jacob's economy. Since Marshall's concept of the industrial scale of economies does not mention about the interaction of the scale of economies between industries and vice versa, Jacob's concept does not restrict any industrial specialization Thus, it is also possible that diversity and specialization could be considered in the separate framework. For instance, Batisse (2002) and Thabet (2015) consider specialization as a ratio between a share of the industry within the zone and a share of the industry from the whole country, while diversity is separately defined as an inverse of normalized HHI of industrial concentration. Paci and Usai (1999) and Van Der Panne (2004) measure industrial diversity by an index based on reciprocal of Gini index. Although past studies usually consider specialization/diversity in separate variables, yet, both could be intuitively considered together with the same index as they can be considered as an opposing factor to each other. As shown in the index used in Batisse (2002) and Thabet (2015), diversity is defined as an index of industrial concentration, and this concentration can be also considered as specialization.

I have pointed out another issue regarding how to incorporate of the neighboring effect in order to express the actual "agglomeration". In general, number of employment is the most common indicator used to measure specialization/diversity agglomeration (Glaeser et al., 1992; Henderson et al., 1995; Paci and Usai, 1999; Van Der Panne, 2004) although other indicator such as value added is also applied in studies such as Batisse (2002) and Thabet (2015) yet these indexes still failed to capture the neighboring effect. In order to capture neighboring effect, following indicator is applied to measure the regional agglomeration in this study.

$$A_{i,k} = \sum_j \frac{E_{j,k}}{g_{j\rightarrow i}} \tag{6-1}$$

where $A_{i,k}$ represents the agglomeration of industry k in zone i, $E_{j,k}$ represents the activity of industry k in zone j, and $g_{i\rightarrow j}$ represents the generalized cost of transport between zone i and zone j. In this study, I simplify the activity $E_{j,k}$ by employment of industry k in zone j and generalized cost $g_{i\rightarrow j}$ is simplified by Euclidian distance between zone i and zone j. The calculation of activity in zone j includes intra-zone activity where $j = i$ as well. This indicator is an application of gravity model used in the past studies such as in Stewart (1947) as index called "Population Potential" or later in Graham (2007) and other transportation related studies as index called "Effective Density"

Another issue regarding index selection is the industrial distribution whether agglomeration only in its own zone or the whole study area should be considered. For example, specialization index used in Glaeser et al. (1992), Paci and Usai (1999), and Batisse (2002) considers agglomeration of the whole study area as a ratio of regional specialization and the ratio of global specialization. On the other hand, index applied from HHI and Gini index can be considered as an index, which considered an agglomeration only in its zone since the share of industry is considered only within its own region. From these two concepts, I propose two indexed based on the coefficient of variation. The first case where only agglomeration in its own zone is considered:

$$CV_{A_i} = \frac{\sigma_{A_i}}{\mu_{A_i}} = \frac{\sqrt{\frac{1}{n}\sum_{k=1}^{n}\left(A_{i,k}-\mu_{A_i}\right)^2}}{\frac{1}{n}\sum_{k=1}^{n} A_{i,k}} \tag{6-2}$$

where CV_{A_i} represents the specialization/diversity agglomeration index of zone i in the first case, σ_{A_i} represents the standard deviation of agglomeration across every n industries in zone i, and μ_{A_i} represents the mean of agglomeration across every n industries in zone i. This index ranges the case of perfect diversified zone and perfect specialized zone from 0 to ∞, where the perfect diversified zone is the case where agglomeration level of every industry is uniformly distributed equally and the perfect specialized zone is the case where there is only one industry agglomerated in the zone.

As for the second case where an agglomeration of the whole study area is considered, the coefficient of variation will be determined by the local agglomeration concentration instead of agglomeration directly like the first case. The local agglomeration concentration is determined by:

$$s_{i,k} = \frac{A_{i,k}}{\frac{1}{n}\sum_{k=1}^{n} A_{i,k}} \tag{6-3}$$

where $s_{i,k}$ represents local agglomeration concentration of industry k in zone i, which is determined by the ratio of agglomeration of industry k in zone i to average agglomeration in zone i. Specialization/diversity agglomeration index in the second case is later formulated as:

$$CV_{s_i} = \frac{\sigma_{s_i}}{\mu_{s_i}} = \frac{\sqrt{\frac{1}{n}\sum_{k=1}^{n}\left(s_{i,k}-\mu_{s_i}\right)^2}}{\frac{1}{n}\sum_{k=1}^{n} s_{i,k}} \tag{6-4}$$

where CV_{s_i} represents the specialization/diversity agglomeration index of zone *i* in the second case, σ_{s_i} represents the standard deviation of local share of agglomeration across every *n* industries in zone *i*, and μ_{s_i} represents the mean of local share of agglomeration across every *n* industries in zone *i*. This index ranges the case of perfect diversified zone and perfect specialized zone from 0 to ∞. However, in the second case, the perfect diversified zone is achieved if the distribution of industry in such zone is equal to the global industrial distribution. The perfect specialized zone is the case where there is only one industry agglomerated in the zone as same as in the first case. Fig. 6-1 shows the example of industrial distribution of five industries in the first and second case where the zone is perfectly diversified.

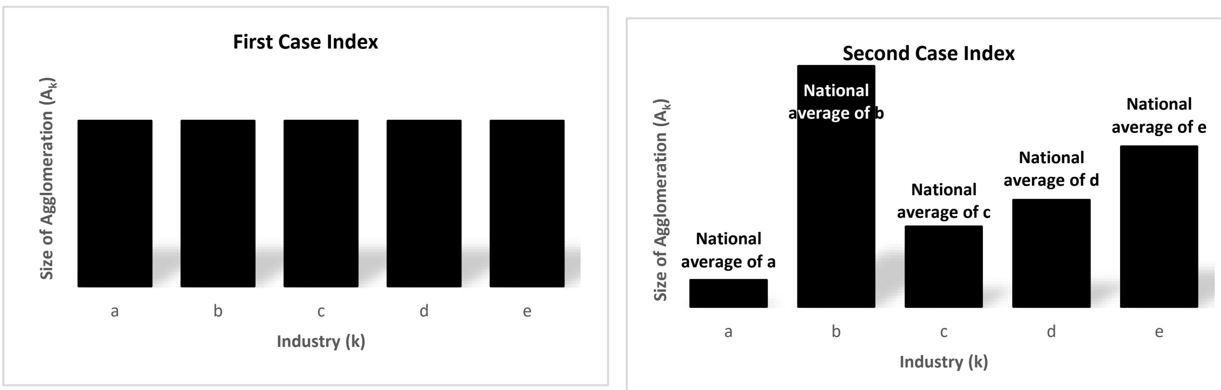

Fig. 6-1. Industrial distribution of perfect diversified zone from the first and second case agglomeration index

Specialization/Diversity Agglomeration and Local Productivity

As mentioned earlier that the past studies tend to consider specialization and diversity in separate context. The separate framework could be logical from the perspective of agglomeration of small industry (e.g., in terms of employment). For example, if a region has a high concentration of IT industry, such region could be considered as highly specialized in IT industry, while the regional still maintain a high level of diversity because the share of IT employment is relatively low compared to other industry such as manufacturing and other general services. However, from the perspective of large industry, the separate framework is not advised since a high concentration of large industry always leads to lower diversity. A marginal increase of specialization of any industry might lead to increase or decrease in marginal diversity, depends on the original size of agglomeration. Thus, it depends on how specialization and diversity are defined to best match the concept of Marshall's and Jacob's economy. In this study, I define "specialization" as city's specialization, not industrial concentration as defined in other studies. In other words, if the city has a high concentration in any industry regardless of which industry, such city will be defined as a specialized city. With this definition, it is possible for us to investigate specialization agglomeration and diversified agglomeration as an opposing factor within the same index.

I investigate the effect of specialization/diversity agglomeration to local productivity in the case study in Japanese municipality (city) level. I measure the agglomeration level from the number of employees across 17 industrial categorizations from 1,907 Japanese municipalities and the distance between each municipality. Local productivity is measured by municipality corporate tax income per number of the taxpayer. The cross-sectional data is based on 2014 Economic Census for Business Frame from Japanese Ministry of Economy, Trade, and Industry (METI). Figure 6-2 shows the relationship between specialization/diversity agglomeration index and local productivity in the first case where only agglomeration of in its own zone is considered.

Considering the relationship between the index and the productivity from agglomeration index, I found the u-shape relationship in the first case index (Fig. 6-2). By assuming a uniform distribution of the agglomeration size across industry is the perfect diversity case, we could explain the u-shape relationship through both Marshall's economy and Jacob's economy in the same time. Plots on the half left could follow the explanation of Jacob's economy where cities with more diversity (although not perfectly diversified or $CV_{Ai} = 0$) have more opportunity to obtain the spillover effect from different businesses. While Marshall's economy could explain the situation of cities in the plot on the half right, where benefit from specialization agglomeration within the few industries become significance. However, cities situated along the middle of the plot will be the loser; the diversity of industry is not large enough nor the specialization of any dominant industry is also not strong enough to enjoy agglomeration benefit. Therefore, according to this plot, the temporal shift of level of specialization (CV_{Ai}) should be planned carefully. As for example for the city on the right half plot, if the city wishes to increase its productivity in the next 10 years, changing its industrial distribution to be more specialized (at least more than the global average trend in the next 10 years) should guarantee better productivity. Otherwise, it should direct a huge change to promote more diversity in the city in order to shift the position from the half right to half left plot.

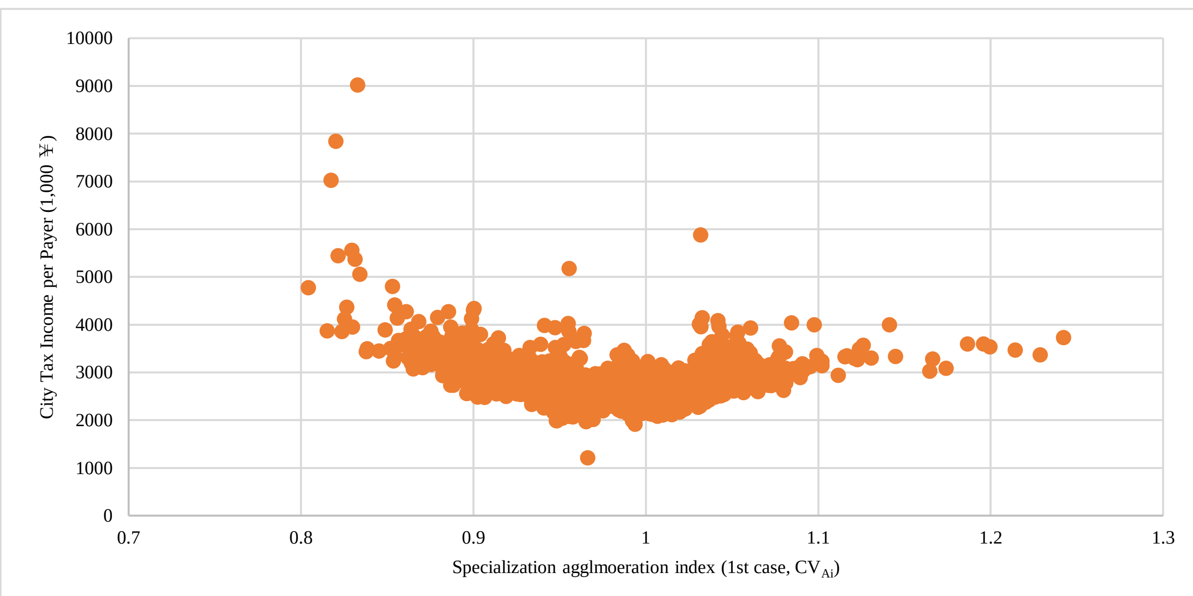

Fig.6-2. City productivity and its specialization agglomeration index (first case)

As for the second case where an agglomeration of the whole study area is considered, the relationship between specialization/diversity agglomeration index and local productivity is portrayed in Fig. 6-3.

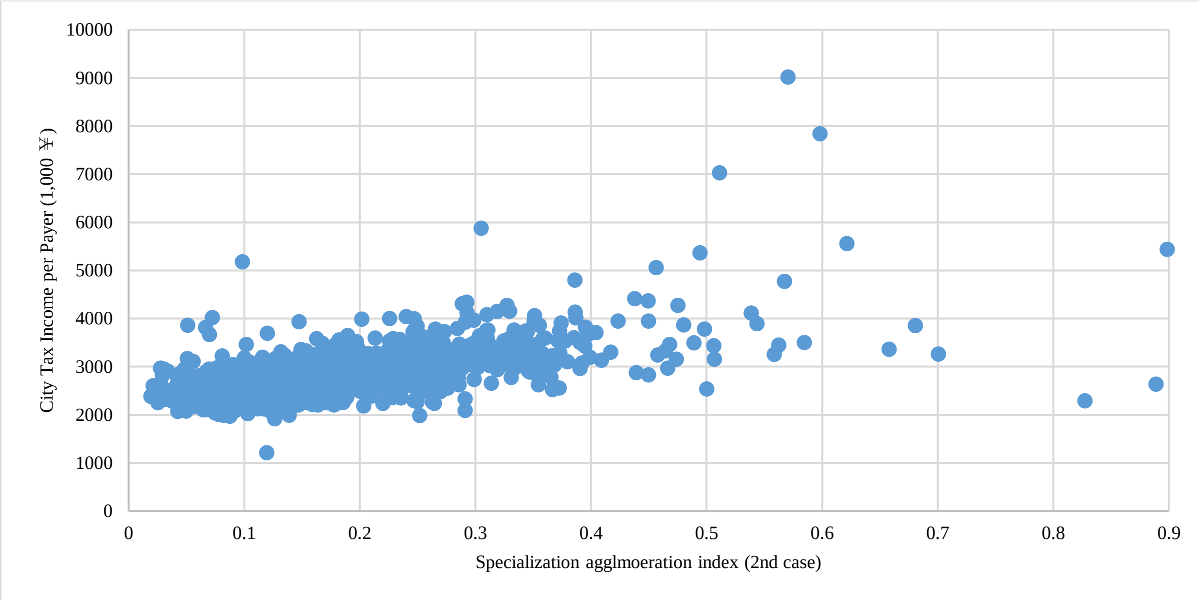

Fig. 6-3. City productivity and its specialization agglomeration index (second case)

Considering the relationship between the index and the productivity from agglomeration index, I found a linear relationship in the second case index (Fig. 6-3). By assuming the average national distribution of agglomeration size across industry is the perfect diversity case, it could be interpreted that the national average distribution is not the productive distribution. This could further explain why the unevenness of spatial concentration can be observed across the country because firms might avoid locating their industries where the industrial agglomeration distribution is closed to average national distribution. With this index, as the city develops into more specialized one, it can enjoy more clustering benefit through the concept of Marshall's economy. However, the concept of Jacob's economy may not be explained through this index as average national distribution is not the ideal industrial distribution portrayed by Jacob's economy. Therefore, if the city wishes to improve its productivity, the city should try to avoid their industrial composition from national average as much as possible. Since the index in the second case (CV_{Si}) presents a one-way relationship, I would like to focus on the first index (CV_{Ai}) from this point onwards so the dynamics of productivity with the respected to specialization can be also discussed.

HSR and Specialization/Diversity Agglomeration

In this section, I would like to investigate the relationship between HSR and the level of specialization agglomeration in order to link the effect of HSR to productivity through specialization/diversity agglomeration. In the first part, I present the situation of specialization/diversity agglomeration in Japan. In the latter part, I further analyze the effect of HSR and specialization/diversity agglomeration through regression analysis. CV_{Ai} used in both parts are based on the data presented in the earlier section.

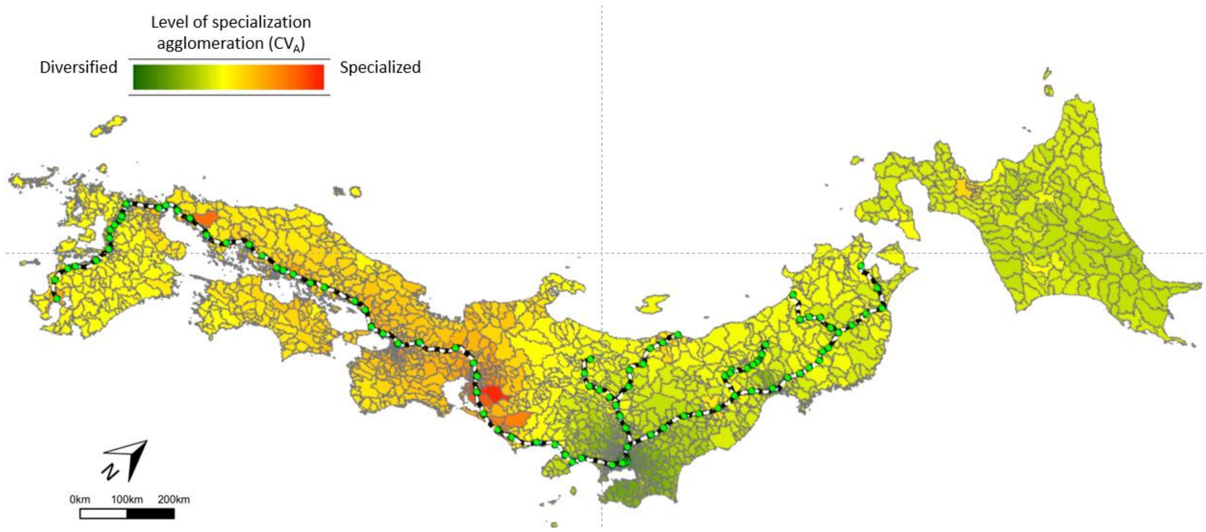

Fig. 6-4. Situation of specialization (first case) agglomeration in Japan (2014)
Lines and dots represent HSR routes and stations

Fig. 6-4 shows the plot of CV_{Ai} in the first case in municipality level of Japan. Several findings can be drawn from this figure. Comparing the east and the west region, the west side tends to be more specialized than the east side. The main reason behind this development is because of the high industrial diversity in Tokyo Metropolitan area. To be precise, specialized industrial with a lower share of workers such as finance and IT sectors are concentrated in Tokyo. This makes our index to be more diversified because the share of small industry became larger in Tokyo than other regions. It is also possible to say that Tokyo area is a highly specialized area for such industries. However, the index used in this study defines the term of specialization as for the whole economy, not on any specific industry. Another reason is that this index considers the neighboring effect, so regions close to Tokyo are highly affected by the agglomeration in Tokyo especially when the agglomeration level in their own region is significantly smaller than Tokyo. Not only the distinction between the west and the east but also the difference between the regions along HSR and those located further away can be observed as well. The regions along HSR lines tend to be more specialized although there might be some exceptions. Nevertheless, additional analysis is needed to explain the relationship between HSR and level of specialization agglomeration.

In order to make a better understanding of the impact from HSR to the level of specialization agglomeration, CV_{Ai} is applied as the dependent variable for regression analysis. Independent variables are consist of HSR related variable and other socio-economic variables. The general model specification can be defined as follows:

$$CV_{A_i} = f(\alpha(HSR), \gamma(\phi)) \quad (6\text{-}5)$$

Where:

CV_{Ai}	: Specialization/diversity index (first case)
$\alpha(HSR)$	: Function of HSR related variables
$\gamma(\phi)$	: Function of other socio-economics related variables

Here, the effect of HSR is determined by the distance from such city *i* to the nearest HSR station. Furthermore, I assume the effect of HSR to specialization in a quadratic function. This assumption is based on the three cases of trade cost proposed in Ottaviano et al. (2002). Also, I apply the technique of spatial lag and time lag to this estimation. Spatial lag term incorporates the effect of specialization agglomeration level in neighboring cities weighted by distance. Time lag includes the level of specialization agglomeration in the year 2012 into consideration. In summary, to be estimated function is structured as follows:

$$CV_{A_i} = \beta_0 + \beta_1 HSR_i + \beta_2 HSR_i^2 + \beta_3 \mathbf{WCV_A} + \beta_4 CV_{A_{i,2012}} + \beta_5 U_i + \beta_6 U_i^2 + \beta_7 DID_i + \beta_8 DID_i^2 + \beta_9 PD_i^2 + \beta_{10} OH_i + \beta_{11} TW_i + \beta_{12} DC_i + \beta_{13} MF_i \quad (6\text{-}6)$$

Where:

HSR_i : Distance from city *i* to the nearest HSR station (km)
$\mathbf{WCV_A}$: A matrix of product between reciprocal of distance between city *i* to other cities and specialization index of other cities
$CV_{A_{i,2012}}$: Specialization agglomeration of city *i* in year 2012
U_i : Unemployment rate in city *i*
DID_i : Percentage of Densely Inhabited District of prefecture which city *i* is located
PD_i : Population density of city *i* (person/km^2)
OH_i : Rate of owned house in city *i*
TW_i : Percentage of worker in tertiary industry in city *i*
DC_i : Designated city dummy; equals to 1 if city *i* is designated city, 0 if not
MF_i : Male to female population ratio in city *i*

Table 6-2 shows the estimation result based on Eq. 6-6. The estimates of HSR parameter show positive value in β_1 and negative value in β_2. In other words, the inverse u-shape parabolic curve is found if distance to HSR station is plotted in X-axis and specialization index is plotted in Y-axis. From this relationship, the result could be interpreted into three cases. First, cities along HSR lines receive agglomeration benefit which is strengthen by HSR. This agglomeration benefit attracts firms in the industry with positive agglomeration impact from other region to relocate in order to enjoy the agglomeration benefit. Thus, cities along HSR lines tend to be more diversified because various types of business relocate to the city. However, cities located further away from HSR lines (those on the apex of the inverse u-shape parabolic, according to the estimation, those located around 270 km away from HSR lines) tend to be more specialized because many business relocated to cities along HSR lines. Only business, which is not affected by positive agglomeration impact, remains in the city. This industry eventually becomes dominant industry which affects the index to be more specialized. In the case where cities located very far from HSR (according to the estimation, those located around 540 km away from HSR lines), firms may decide not to relocate because agglomeration benefit could be less than the trade cost. If firms relocate, premium from agglomeration could be less than the cost to transport their products from city along HSR lines to city very far from HSR line. In other words, by not relocate to HSR area, it is more productive to produce and sell in the same area. This situation makes cities very far from HSR remain diversified because no relocation, although in our dataset level of diversity in these regions are still smaller compare to regions along HSR lines.

Table 6-2. Estimation result of HSR distance and specialization agglomeration index

	Estimates	SE	t-stat	p-value
Constant	-0.9747	0.0028	-343.735	0.000
HSR	2.16E-05	4.48E-06	4.814	0.000
HSR^2	-3.94E-08	7.59E-09	-5.194	0.000
$\mathbf{WCV_A}$	0.9979	0.0015	673.697	0.000
$CV_{A_{2012}}$	0.9894	0.0033	300.525	0.000
U	0.0155	0.0023	6.621	0.000
U^2	-0.0017	0.0003	-5.113	0.000
DID	4.11E-04	8.08E-05	5.085	0.000
DID^2	-4.26E-06	6.53E-07	-6.523	0.000
PD^2	-73.9864	6.8397	-10.817	0.000
OH	-1.76E-06	1.64E-07	-10.740	0.000
TW	-7.73E-05	2.12E-05	-3.649	0.000
DC	0.0060	0.0009	6.435	0.000
MF	-2.87E-04	3.02E-05	-9.519	0.000
$\mathbf{R^2}$	0.9913			

Conclusion

The analyses in this chapter aim to answer two questions related to specialization/diversity agglomeration; how does industrial specialization agglomeration affect city's productivity and how does HSR affect industrial specialization agglomeration. The answers to questions can be drawn from the analyses in this study as follows:

- Specialization agglomeration benefits productivity, but diversity agglomeration also benefits productivity as well. However, the city that neither diversification of industry is not large enough nor the specialization of any dominant industry is also not strong enough to enjoy agglomeration benefit will be the loser in this productivity competition.
- Introduction of HSR could shape the spatial distribution of specialization agglomeration into the case where the city is diversified, specialized and diversified, depends on the distance to HSR service ranging from 0, 270 and 540 km respectively.

This empirical result from Japan could be one of the evidence how HSR shape the new spatial distribution of industrial agglomeration. For countries who wish to introduce the HSR service, one of the possible policy implications is that the city should be prepared for the change of industrial distribution into the diversified city or specialized city according to the new HSR service. A case study of Japan could be one of the cases where there is very little intervention from the government policy since the change of industrial distribution is supervised mainly by the private sector.

However, the central/local government could signalize the change of industrial distribution in order to capture the best agglomeration benefit along with HSR investment. Thus, this result could be one of the possible references for the public sector to guide private sector to the best direction.

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7. Migration

History of human migration could trace back around 100,000 years ago when Homo sapiens migrated out of Africa. Migration in prehistoric human was take placed simply to increase the survivability rate. Migration in a modern human, as well, is also the means to increase the survivability rate, yet the factor to increase the survivability rate of modern human changes from "sufficient food" in prehistoric age to "sufficient income" in the modern era.

Theories related to migration were initially conceptualized by demographers, which mainly aims to answer what are the factors which affect the volume of migrants, especially international migration. The most classical theory, "Laws of Migration" by Ravenstein (1885) depicted the situation of rural-urban migration, where the volume of migrants primarily depends on the distance of movement, level of urbanization and gender of migrants. A Theory of Migration by Lee (1966) provided the further discussion related to migration issue. In this literature, the decision to migrate depends on four main factors: factors related to the origin, and destination, intervening obstacles and personal factors, although the detail regarding these four factors was only conceptualized without any proof in detail. In late 20th century, the issue regarding migration has been started to catch an attention by the economist. One of the pioneer works which try to explain migration through economic model is the Harris-Todaro Model (Harris and Todaro, 1970). This model explained that the expected urban income and the availability of urban jobs are the main factors affecting rural-urban migration.

This chapter highlights the effect of HSR to migration. A migration trend could be one of the indicators to predict agglomeration change which leads to productivity change in the future as shown in earlier chapters. The concepts from early demographic researchers mentioned the effect of urbanization and the city-specific factors affect migration. Later these ideas were interpreted through economic model into the wage differences. However, the effect from infrastructure investment to migration was rarely mentioned in the past literature although it could be considered as one of the city-specific factors too. This could be due to the fact that direct causal relationship between infrastructure investment and migration is still ambiguous. Todaro (1980) mentioned the possibility of the relationship between urban service and migration, but it was also mentioned that more evidence is needed since there was no literature which empirically analyzes the migrant's utilization on urban service. Thus, the discussions to explain and to prove the effect of HSR on migration will be further challenged in this chapter.

Literature Review

Early discussion regarding migration dates back to late 19th century in "Laws of Migration" by Ravenstein (1885). Ravenstein (1885) depicted the situation of migration in the United Kingdom and concluded several findings based on the observed situation of migration. Several factors had been discussed, such as gender where female tends to migrate more than male or rural population tends to migrate more than urban dwellers. Some of these assumptions are still debatable such as gender, for example, Lucas (1997) found out that more migration found in female could be true in American population but the observed migration is found higher among male population in Asia and Africa

However, the most relevant factor to this research which was discussed in Ravenstein (1885) is the importance of distance and city size factors. Ravenstein (1885) discussed that higher volume has been observed in shorter distance migration and those who migrate tend to move from rural area to urban area rather than those in urban to rural. Appling to this research, distance discussed in past literature, in general, could be interpreted as travel cost between origin and destination of migration and HSR could be one of the means to decrease the travel cost if the value of time is sufficiently high. Although the actual context in terms of regional connectivity might be totally different between late 19th century and current situation. Difficulty to migrate could be an important factor in migration decision in the past but the importance of this factor could be diminished because of better transportation service in the 21st century.

The next classical discussion regarding migration, "A Theory of Migration" by Lee (1966) also provided the discussion based on the work of Ravenstein. Four factors are discussed in Lee's study: Origin factors, Destination factors, Intervening factors and Personal factors. From the viewpoint of the classical discussion, transportation service could be considered as the intervening factor because of the poor mobility between regions. However, as transportation service keeps better, the effect of transportation service could be shifted to origin and destination factors. Contemporary discussion by Lucas (1997) also mentioned the possibility that transportation service, as one of the urban service, could positively affect migration although more evidence is needed.

Ravenstein's work has enlightened many other works regarding migration, including the works by Stouffer. One of the notable concept called "Intervening Opportunity" has been initially proposed in Stouffer (1940) but the concept was later implemented to migration issue in Stouffer (1960). This concept explains the migration condition between two zones by:

$$M_{ij} = K \frac{X_M^a}{X_B^b X_C^c}$$

Where: M_{ij} = Migration between i and j

X_M = Size effect, measured by total other in migrant to j (not from i) * total other out migrant from i (not to j)

X_B = Intervening Opportunities, measured by sum of in-migrant of every city that situated between i and j

X_C = Competing Migrants, measured by sum of out-migrant of every city that have the same distance (or less) between i and j

A similar concept is also applied empirically by Galle and Taeuber (1966). However, migration explained in these studies is still based on the empirical framework. Migration issue has been started to received attention by the economist since the Harris-Todaro Model (Harris & Todaro, 1970) has been proposed. This model conceptualized the situation of movement between the rural-urban area which governed by the wage difference between rural and urban area and the job availability in the urban area. Thus from the viewpoint of the economist, the wage rate is the main factor to migration decision. Urban amenity such as transportation service seems to be the indirect factor to migration although direct effect to wage rate could be possible. This model explains the movement between rural and urban area by:

$$W_u^e = \frac{\overline{W}_M N_M}{N_u}, \qquad \frac{N_M}{N_u} \leq 1$$

Where: W_u^e = wage in agriculture sector in rural area
$\overline{W}_M$ = wage in manufacturing sector in urban area
N_u = total number of job seekers in urban area from both urban and rural
N_M = total number of job available in urban area

In this equilibrium, the ratio between wage in the rural and urban area, or the ratio between N_u and N_M describes the probability that people from the rural area will migrate to the urban area. As mentioned, this model does not explain any effect from urban service to migration.

Recently, the effect of infrastructure on migration has been in attention by researchers. Lucas (1997) described the situation where infrastructure may indirectly or directly affect migration decision. It is also mentioned that among types of infrastructure, the effect from local transportation seems to have the most obvious result, while the effect from inter-city transportation, such as HSR in our case, is still ambiguous. By reviewing the labor migration situation in the case study of China and Indonesia, Xiang and Lindquist (2014) stated that "Migration can be more clearly conceptualized through a focus on infrastructure rather than on state policies, the labor market, or migrant social networks alone". Barry (2002) proposed the less-restricted model based on the Harris-Todaro Model which incorporates the effect of investment and infrastructure. One of the conclusions drawn from this model is infrastructure stock level could be one of the factors to migration decision. Although possible effect from infrastructure to migration has been described and modeled in these studies, however, they do not provide any empirical analysis to clearly prove the effect between infrastructure and migration.

Hypothesis

The effect from wage difference seems to be the main factor in migration decision and this relationship has been proved by many past studies. However, the question in this study is whether there is a relationship between HSR and migration or not and if there is, HSR positively or negatively affects migration. Some past studies provided evidences to show that infrastructure, in overall, could affect migration decision. However, there is still no study which explicitly shows the clear evidence to prove that transportation service affects migration, or precisely in our case, there is no evidence to prove the effect from HSR to inter-regional migration.

Although Lucas (1997) argued that infrastructure may indirectly or directly affect and the example of local transportation service was raised as the direct factor to migration. Based on the framework by Chen and Silva (2013), HSR could directly affect migration through better living condition and indirectly affect migration through increasing of new business and firms. However, it is unusual to conclude that HSR directly affects migration, as migrants may not relocate just because they want live near HSR station. On the other hand, HSR could indirectly affect migration through relocation of the firms because premium in inter-regional transport cost as shown in the framework by Chen and Silva (2013). Thus, I would like to propose the hypothesis to link the relationship between HSR and migration in Fig.7-2.

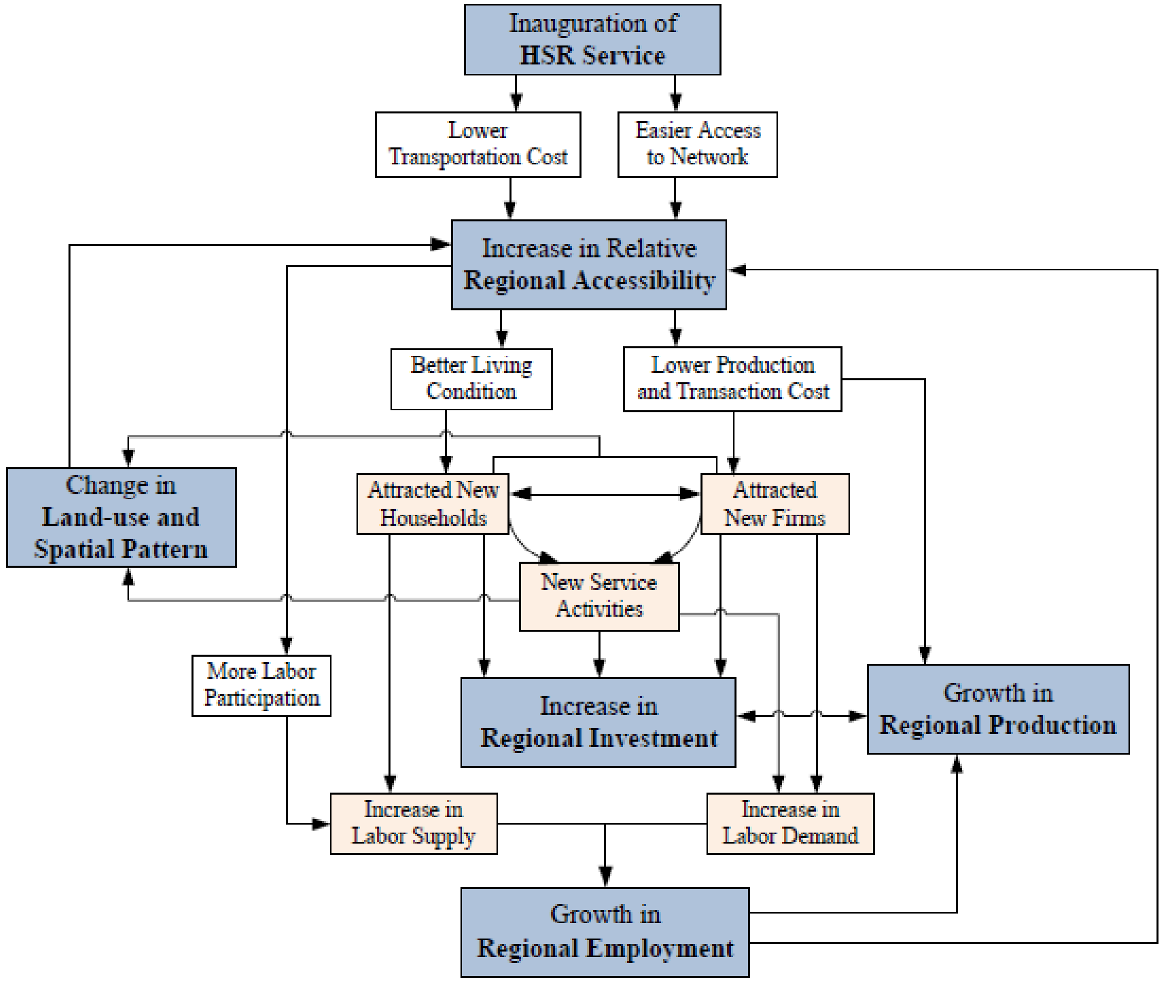

Fig. 7-1. Causal between HSR and regional growth (Chen & Silva, 2013)

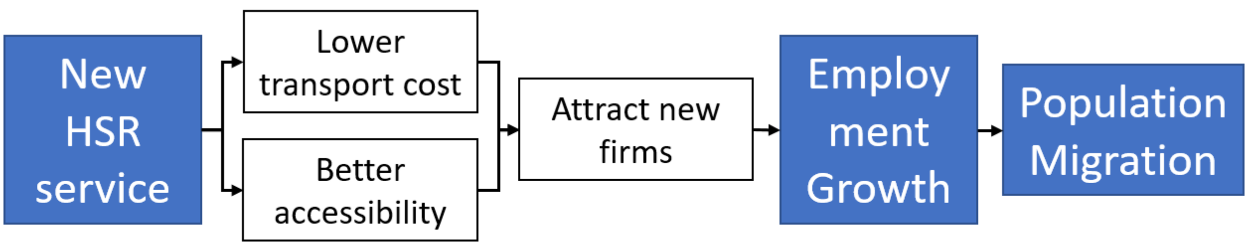

Fig. 7-2. Propose causal between HSR, employment growth and population migration

HSR and Employment Growth

Based on the proposed hypothesis, two regression analyses will be conducted in this chapter follows the proposed causal diagram shown in Fig.7.2. The first analysis tests the relationship between HSR service and employment growth. Next, the correlation between employment growth and population migration will be shown to confirm the correlation between these two factors. The second analysis further tests the relationship between HSR service and migration.

In the first analysis, regression analysis will be applied. The percentage of employment growth will be tested as a dependent variable along with other socioeconomic related independent variable. HSR effect will be explained through the average-passenger travel time to each prefecture. This average-passenger travel time is one of the representatives of the HSR effect in Japan as the share HSR of usage in inter-regional trip in Japan is considerably high compared to other modes such as intercity bus or aviation. This fact can be proved by the data shown in Table 4-1 as in average, the share of HSR distance out of total trip distance is 65.54% in the dataset of chapter 4 which covers travel time between 1981 to 2006. Model specification empirically test in this analysis is structured as follows:

$$\%\Delta E_{i,t} = \beta_0 + \beta_1\left(\frac{GRP}{E}\right)_{i,t} + \beta_2 DID_{i,t} + \beta_3 U_{i,t} + \beta_4 tt_{i,t} + \beta_5 Tokyo_{i,t} \tag{7-1}$$

Where: $\%\Delta E_{i,t}$ = percentage of employment growth in prefecture *i*, at time *t*

$\left(\frac{GRP}{E}\right)_{i,t}$ = GRP (Gross Regional Product) per employment (mil. yen per person)

$DID_{i,t}$ = percentage of DID (Densely Inhabited District) to total inhabited land

$U_{i,t}$ = unemployment rate (%)

$tt_{i,t}$ = average-passenger travel time to prefecture *i* (minutes)

$Tokyo_{i,t}$ = Tokyo prefecture dummy

The dataset covers data from 1997-2010 in 47 prefectures in Japan. Data of GRP, total employment, DID, and unemployment rate are acquired from Statistics Bureau, Ministry of Internal Affairs and Communications of Japan. Employment data is from The Establishment and Enterprise Census which conducts every five years. Thus, the worker data between census years is the interpolated data between available data. Average-passenger travel time (*tt*) data is the same data used in chapter 4 and 5 which is calculated from NITAS. However, travel time data is only available in 1996, 2001, 2006, 2008 and 2010. Thus, the travel time used in the year without available data will be based on the latest available year, for example, data in the year 1997-2000 used in this analysis will be based on available data in 1996. The result based on the regression analysis of Eq. (7-1) is shown in Table 7-1 below:

Table 7-1.

Estimation result of employment growth analysis

	Coef.	**Std.Error**	**t-value**	**Pr(>|t|)**	
Const.	2.688	0.554	4.855	0.000	***
GRP/E	-0.243	0.036	-6.803	0.000	***
DID	0.006	0.002	2.853	0.004	**
U	-0.098	0.026	-3.779	0.000	***
tt	-0.006	0.001	-5.553	0.000	***
Tokyo	0.740	0.201	3.676	0.000	***
N			658		
Adj. R^2			0.166		

Note: "***": p<0.001; "**": p<0.01

From the result, every explanatory variables used in this model are all significant although model's goodness of fit is quite low. Coefficient of each variable show the expected sign as discussed in past migration theory except $\frac{GRP}{E}$. Positive sign found in *DID* and negative found in *U* match the discussion in previous studies as firms tends to relocate to more urbanized area and lower unemployment intuitively increase employment growth. However, by control employment growth with Tokyo dummy along with other variables, I found the negative sign in $\frac{GRP}{E}$ which is against the logic that workers tend to move to more productive area. However, this result could be explained through the unique economic situation in Japan during the time-frame used in the dataset. After the Japanese asset price bubble's collapsed in early 90's, laid-off workers might move back to their origin to find more basic jobs. This explanation can be supported by data shown in Table 7-2 where the migration difference between large and small prefectures is significantly smaller in late 90's. The result of average-passenger travel time (*tt*) is negative which is the expected result; region which is easier to be accessed or with less access travel time could be the main choice for firms as they will face less travel cost to other regions. Firms' choice affects workers choice and this makes regions with higher accessibility have higher employment growth.

HSR and Migration

Next, I would like to link the effect of employment growth to migration. Although job-related factors are mentioned as the main factor to migration decision in the past literature, other factor such as education might affect migration in young people. However, as Japanese society becomes more senior society, the share of education factor to total migration becomes smaller through time. Another possible scenario can occur when retired workers migrate back to their hometown or the place where their family resides. However, the share of migrants from this scenario to total migration may not be so high due to the fact that the scenario where the whole family moves together with the head of the family seems to be more likely to occur. Therefore, the effect of employment growth to migration seems to be the most significant factor and it is expected that regions with higher employment growth will have higher migration. Fig. 7-3 shows the plot of the ratio between migration and population in the vertical axis and percentage of employment growth in horizontal axis within the same time-frame and regions analyzed in the earlier analysis. This plot could support the fact that there is a strong correlation between employment growth and migration.

Table 7-2.

Ratio between total migrant and population in each prefecture, 1975-2010

%M/P	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
11.北海道	-0.10	-0.02	-0.08	-0.08	-0.03	-0.08	-0.19	-0.21	-0.24	-0.35	-0.48	-0.56	-0.61	-0.42	-0.39	-0.29	-0.19	-0.10	-0.05	-0.02	0.02	-0.03	-0.06	-0.17	-0.13	-0.16	-0.19	-0.15	-0.17	-0.21	-0.25	-0.33	-0.36	-0.38	-0.22	-0.16
12.青森県	-0.17	-0.03	-0.16	-0.10	-0.29	-0.34	-0.53	-0.55	-0.60	-0.71	-0.69	-0.84	-0.79	-0.86	-0.80	-0.74	-0.65	-0.49	-0.21	-0.07	-0.05	-0.11	-0.17	-0.20	-0.17	-0.16	-0.20	-0.30	-0.36	-0.46	-0.50	-0.66	-0.73	-0.66	-0.48	-0.37
13.岩手県	-0.37	-0.28	-0.41	-0.32	-0.33	-0.33	-0.37	-0.45	-0.48	-0.48	-0.56	-0.63	-0.70	-0.51	-0.58	-0.35	-0.32	-0.22	-0.07	-0.07	-0.03	-0.04	-0.08	-0.15	-0.13	-0.16	-0.25	-0.33	-0.29	-0.32	-0.42	-0.43	-0.51	-0.51	-0.41	-0.32
14.宮城県	0.37	0.31	0.20	0.21	0.33	0.20	0.17	0.18	0.02	-0.01	0.01	0.01	0.13	0.20	0.18	0.22	0.32	0.27	0.29	0.26	0.31	0.21	0.17	0.06	0.00	-0.03	-0.10	-0.15	-0.07	-0.14	-0.16	-0.21	-0.23	-0.21	-0.08	-0.02
15.秋田県	-0.31	-0.21	-0.28	-0.33	-0.29	-0.41	-0.48	-0.62	-0.57	-0.57	-0.55	-0.66	-0.63	-0.62	-0.56	-0.41	-0.39	-0.29	-0.18	-0.08	-0.14	-0.18	-0.21	-0.20	-0.22	-0.26	-0.27	-0.34	-0.38	-0.32	-0.42	-0.51	-0.61	-0.56	-0.41	-0.34
16.山形県	-0.36	-0.17	-0.20	-0.20	-0.25	-0.24	-0.32	-0.43	-0.44	-0.33	-0.34	-0.37	-0.34	-0.31	-0.37	-0.31	-0.25	-0.19	-0.12	-0.09	-0.05	-0.16	-0.14	-0.14	-0.18	-0.14	-0.28	-0.29	-0.33	-0.30	-0.35	-0.39	-0.43	-0.44	-0.34	-0.31
17.福島県	-0.38	-0.26	-0.20	-0.25	-0.25	-0.22	-0.31	-0.28	-0.24	-0.20	-0.24	-0.30	-0.22	-0.23	-0.18	-0.11	-0.11	0.02	0.07	0.03	0.01	-0.08	-0.13	-0.17	-0.15	-0.16	-0.27	-0.29	-0.30	-0.29	-0.30	-0.37	-0.43	-0.40	-0.39	-0.28
18.茨城県	0.66	0.54	0.63	1.00	1.09	0.94	0.68	0.75	0.50	0.31	0.30	0.22	0.37	0.53	0.56	0.49	0.58	0.47	0.40	0.36	0.23	0.09	0.09	0.02	-0.02	-0.12	-0.16	-0.15	-0.14	-0.12	-0.12	-0.07	-0.08	-0.08	0.06	0.03
19.栃木県	0.01	0.04	0.07	0.08	0.27	0.10	0.03	0.02	-0.01	0.09	0.18	0.14	0.18	0.18	0.22	0.35	0.25	0.20	0.26	0.13	0.12	0.15	0.09	0.04	0.01	0.01	-0.09	-0.11	-0.02	0.07	-0.02	-0.06	-0.01	-0.07	-0.13	-0.08
20.群馬県	-0.05	0.22	0.21	0.11	0.05	0.10	0.14	0.10	0.08	0.12	0.08	0.02	0.00	0.04	0.11	0.07	0.10	0.07	0.06	0.08	0.03	0.00	0.02	0.00	0.04	0.00	-0.05	-0.07	-0.04	-0.10	-0.08	-0.12	-0.14	-0.12	-0.09	-0.06
21.埼玉県	1.74	1.45	1.20	1.07	1.03	0.95	0.86	0.79	0.70	0.65	0.68	0.88	1.38	1.33	1.19	0.93	0.72	0.69	0.58	0.43	0.33	0.23	0.12	0.09	0.06	0.06	0.10	0.05	0.09	0.05	0.00	0.11	0.12	0.21	0.25	0.21
22.千葉県	1.87	1.53	1.53	1.76	1.59	1.40	1.13	0.91	0.79	0.66	0.62	0.73	1.08	1.15	0.97	0.73	0.64	0.58	0.43	0.23	0.14	0.08	0.10	0.12	0.20	0.16	0.23	0.23	0.18	0.03	0.10	0.20	0.32	0.39	0.35	0.23
23.東京都	-1.10	-1.05	-0.91	-0.91	-0.92	-0.82	-0.55	-0.34	-0.10	-0.02	0.01	-0.03	-0.48	-0.62	-0.52	-0.43	-0.31	-0.43	-0.57	-0.52	-0.28	-0.05	0.15	0.26	0.31	0.46	0.56	0.60	0.54	0.58	0.69	0.71	0.74	0.64	0.43	0.37
24.神奈川県	0.51	0.46	0.53	0.60	0.47	0.41	0.52	0.56	0.58	0.59	0.66	0.92	1.03	0.75	0.65	0.57	0.38	0.21	0.07	0.02	-0.03	0.04	0.10	0.21	0.15	0.23	0.33	0.34	0.28	0.26	0.25	0.25	0.37	0.33	0.24	0.16
25.新潟県	-0.33	-0.28	-0.36	-0.27	-0.26	-0.17	-0.35	-0.33	-0.36	-0.32	-0.34	-0.41	-0.37	-0.28	-0.27	-0.21	-0.17	-0.10	0.00	0.07	0.04	-0.01	-0.03	-0.13	-0.18	-0.19	-0.21	-0.22	-0.19	-0.20	-0.23	-0.29	-0.28	-0.26	-0.19	-0.17
26.富山県	-0.14	-0.14	-0.11	-0.11	-0.09	-0.14	-0.18	-0.16	-0.17	-0.15	-0.15	-0.19	-0.20	-0.19	-0.17	-0.15	-0.10	-0.16	0.01	0.02	0.03	0.04	-0.05	-0.10	-0.09	-0.10	-0.21	-0.16	-0.12	-0.10	-0.10	-0.12	-0.16	-0.20	-0.18	-0.06
27.石川県	0.04	0.11	-0.04	-0.07	0.05	0.03	-0.03	0.01	-0.10	-0.16	-0.14	-0.23	-0.24	-0.13	-0.12	-0.12	-0.08	-0.01	-0.02	-0.04	0.08	-0.03	-0.14	-0.12	-0.10	-0.10	-0.18	-0.11	-0.18	-0.20	-0.24	-0.19	-0.18	-0.15	-0.07	-0.04
28.福井県	-0.17	-0.05	-0.28	-0.22	-0.22	-0.17	-0.20	-0.07	-0.07	-0.17	-0.12	-0.32	-0.22	-0.22	-0.22	-0.21	-0.28	-0.21	-0.04	0.00	0.00	-0.10	-0.13	-0.08	-0.12	-0.14	-0.21	-0.19	-0.22	-0.25	-0.25	-0.24	-0.31	-0.29	-0.28	-0.17
29.山梨県	-0.34	-0.25	-0.18	-0.22	-0.13	-0.03	-0.03	0.00	0.15	0.13	0.24	0.18	0.03	0.17	0.18	0.39	0.29	0.13	0.28	0.27	0.16	0.13	0.03	0.04	0.04	0.02	-0.15	-0.15	-0.24	-0.12	-0.18	-0.28	-0.29	-0.40	-0.14	-0.16
30.長野県	-0.20	0.00	0.02	-0.03	-0.06	-0.09	-0.10	-0.10	-0.03	0.15	0.07	-0.02	-0.15	-0.09	-0.05	-0.01	0.02	0.07	0.08	0.16	0.15	0.08	0.05	-0.03	0.03	0.01	-0.05	-0.10	-0.12	-0.11	-0.20	-0.18	-0.22	-0.20	-0.21	-0.10
31.岐阜県	0.00	0.12	0.20	0.07	0.10	0.10	0.10	0.11	0.01	0.00	-0.04	-0.05	-0.02	0.04	0.03	0.15	0.04	0.00	-0.01	0.01	0.01	-0.07	-0.08	-0.13	-0.10	-0.15	-0.19	-0.17	-0.15	-0.17	-0.17	-0.18	-0.18	-0.22	-0.25	-0.16
32.静岡県	-0.09	-0.14	-0.14	-0.15	-0.14	-0.09	-0.07	-0.02	-0.11	-0.04	0.07	0.04	0.05	0.07	0.03	0.03	0.02	-0.01	0.01	0.05	-0.06	-0.05	-0.09	-0.08	-0.05	-0.04	-0.06	-0.08	-0.06	-0.07	-0.04	-0.05	-0.05	-0.02	-0.08	-0.10
33.愛知県	-0.17	-0.22	-0.11	-0.07	-0.14	-0.16	-0.15	-0.13	-0.08	-0.03	0.08	0.15	0.09	0.03	0.06	0.05	0.06	0.02	0.00	-0.05	-0.03	-0.03	0.03	0.08	0.06	0.02	0.05	0.08	0.10	0.16	0.27	0.29	0.28	0.25	0.06	-0.02
34.三重県	0.03	-0.06	0.00	-0.01	0.03	0.33	0.35	0.22	0.06	-0.01	0.13	0.14	0.16	0.18	0.38	0.35	0.29	0.22	0.22	0.29	0.25	0.12	0.02	0.03	-0.04	-0.03	-0.11	-0.15	-0.08	0.02	-0.03	0.03	0.04	-0.01	-0.18	-0.09
35.滋賀県	0.95	1.03	0.94	0.64	0.85	0.87	0.66	0.64	0.45	0.44	0.51	0.35	0.43	0.68	0.85	0.85	0.41	0.40	0.57	0.57	0.57	0.41	0.44	0.45	0.35	0.36	0.18	0.16	0.13	0.13	0.12	0.21	0.22	0.21	0.08	0.16
36.京都府	0.02	0.02	-0.08	-0.05	-0.16	-0.10	-0.05	0.03	0.00	-0.09	-0.17	-0.08	-0.18	-0.12	-0.25	-0.32	-0.19	-0.17	-0.21	-0.15	0.04	-0.05	-0.09	-0.08	-0.13	-0.19	-0.14	-0.16	-0.11	-0.07	-0.08	-0.11	-0.16	-0.12	-0.14	-0.07
37.大阪府	-0.44	-0.53	-0.57	-0.51	-0.49	-0.48	-0.39	-0.32	-0.19	-0.16	-0.23	-0.14	-0.21	-0.41	-0.51	-0.59	-0.46	-0.44	-0.45	-0.42	0.13	-0.26	-0.32	-0.32	-0.33	-0.30	-0.23	-0.23	-0.16	-0.15	-0.10	-0.07	-0.06	-0.04	-0.03	-0.04
38.兵庫県	-0.20	-0.23	-0.28	-0.30	-0.31	-0.22	-0.15	-0.12	-0.11	-0.09	-0.05	-0.04	-0.03	0.13	0.26	0.30	0.21	0.21	0.22	0.19	-1.10	0.09	0.18	0.21	0.20	0.04	0.07	0.01	-0.02	-0.02	0.02	0.00	-0.03	0.00	0.00	-0.05
39.奈良県	0.98	1.12	1.65	1.66	1.75	1.66	1.21	0.91	0.77	0.74	0.63	0.63	0.83	0.81	0.92	0.66	0.45	0.58	0.55	0.38	0.55	0.30	0.11	-0.08	0.00	-0.16	-0.36	-0.31	-0.32	-0.34	-0.34	-0.33	-0.35	-0.30	-0.21	-0.16
40.和歌山県	-0.31	-0.18	-0.32	-0.26	-0.29	-0.31	-0.25	-0.25	-0.43	-0.47	-0.44	-0.49	-0.47	-0.29	-0.08	0.05	-0.04	0.12	0.13	0.24	0.13	-0.06	-0.17	-0.17	-0.18	-0.24	-0.27	-0.31	-0.37	-0.32	-0.35	-0.39	-0.46	-0.37	-0.25	-0.22
41.鳥取県	-0.22	0.08	0.08	-0.01	0.16	0.05	-0.07	-0.15	-0.24	-0.21	-0.22	-0.27	-0.30	-0.20	-0.25	-0.16	-0.20	-0.25	-0.08	0.05	0.13	-0.02	-0.05	-0.06	0.00	-0.04	-0.08	-0.06	-0.13	-0.15	-0.29	-0.31	-0.41	-0.48	-0.31	-0.19
42.島根県	-0.29	-0.07	-0.05	-0.01	-0.08	-0.10	-0.18	-0.18	-0.37	-0.14	-0.26	-0.35	-0.40	-0.43	-0.47	-0.44	-0.44	-0.42	-0.27	-0.03	-0.01	-0.17	-0.13	-0.20	-0.08	-0.03	-0.16	-0.23	-0.25	-0.31	-0.33	-0.40	-0.40	-0.36	-0.26	-0.22
43.岡山県	0.07	-0.05	-0.15	-0.10	-0.05	-0.09	-0.07	-0.12	-0.11	-0.13	-0.12	-0.11	-0.21	-0.16	-0.15	-0.07	-0.05	-0.04	0.04	0.07	0.12	-0.01	0.00	-0.04	-0.07	-0.07	-0.09	-0.09	-0.04	-0.05	-0.08	-0.14	-0.09	-0.14	-0.14	-0.11
44.広島県	-0.06	-0.22	-0.17	-0.49	-0.22	0.12	0.10	-0.13	-0.11	-0.13	-0.12	-0.15	-0.22	-0.17	-0.16	-0.03	-0.09	-0.03	-0.07	-0.10	-0.02	-0.13	-0.15	-0.15	-0.19	-0.20	-0.24	-0.17	-0.13	-0.06	-0.07	-0.09	-0.13	-0.16	-0.11	-0.07
45.山口県	-0.15	-0.05	-0.13	-0.18	-0.33	-0.22	-0.15	-0.12	-0.31	-0.36	-0.35	-0.49	-0.48	-0.41	-0.46	-0.47	-0.29	-0.22	-0.16	-0.10	-0.08	-0.19	-0.14	-0.15	-0.20	-0.24	-0.23	-0.22	-0.22	-0.21	-0.25	-0.30	-0.29	-0.26	-0.19	-0.20
46.徳島県	-0.38	-0.09	-0.08	-0.06	-0.05	-0.17	-0.25	-0.26	-0.26	-0.23	-0.30	-0.28	-0.23	-0.26	-0.28	-0.25	-0.20	-0.13	-0.07	-0.03	0.11	0.02	-0.07	0.00	-0.14	-0.16	-0.15	-0.14	-0.21	-0.22	-0.28	-0.26	-0.36	-0.36	-0.26	-0.20
47.香川県	0.03	0.16	0.20	0.01	0.10	0.06	0.02	-0.03	-0.06	-0.05	-0.04	-0.14	-0.19	-0.14	-0.12	-0.08	-0.09	-0.04	0.00	0.06	0.13	0.03	0.00	-0.01	-0.02	-0.14	-0.18	-0.14	-0.11	-0.08	-0.16	-0.13	-0.18	-0.14	-0.08	-0.14
48.愛媛県	-0.18	-0.07	-0.05	-0.26	-0.22	-0.21	-0.20	-0.28	-0.25	-0.25	-0.27	-0.39	-0.45	-0.34	-0.31	-0.30	-0.30	-0.21	-0.18	-0.13	-0.09	-0.12	-0.12	-0.20	-0.23	-0.18	-0.18	-0.19	-0.15	-0.19	-0.22	-0.29	-0.31	-0.25	-0.18	-0.18
49.高知県	0.04	0.18	0.06	0.14	0.05	-0.05	-0.11	-0.12	-0.16	-0.24	-0.28	-0.34	-0.31	-0.29	-0.36	-0.44	-0.36	-0.33	-0.12	0.01	0.06	-0.08	-0.03	-0.03	0.03	0.01	-0.08	-0.07	-0.14	-0.18	-0.31	-0.44	-0.58	-0.56	-0.28	-0.10
50.福岡県	0.52	0.43	0.33	0.16	0.20	0.10	0.16	0.08	0.05	-0.03	-0.11	-0.16	-0.16	-0.05	0.04	0.06	0.10	0.22	0.23	0.21	0.24	0.23	0.20	0.15	0.09	0.09	0.07	0.08	0.05	0.05	0.03	0.06	-0.04	-0.06	0.01	0.05
51.佐賀県	-0.34	-0.24	-0.17	-0.16	-0.06	-0.15	-0.23	-0.30	-0.25	-0.44	-0.47	-0.44	-0.42	-0.42	-0.40	-0.33	-0.27	-0.16	-0.07	0.02	0.04	-0.08	-0.16	-0.18	-0.19	-0.16	-0.27	-0.26	-0.16	-0.27	-0.24	-0.30	-0.32	-0.24	-0.22	-0.19
52.長崎県	-0.50	-0.51	-0.40	-0.47	-0.66	-0.42	-0.43	-0.55	-0.57	-0.64	-0.56	-0.71	-0.75	-0.62	-0.74	-0.66	-0.65	-0.52	-0.31	-0.29	-0.31	-0.35	-0.41	-0.45	-0.34	-0.30	-0.32	-0.33	-0.35	-0.39	-0.56	-0.65	-0.69	-0.61	-0.41	-0.34
53.熊本県	-0.10	0.17	0.14	0.10	0.05	0.07	-0.05	-0.09	-0.14	-0.07	-0.20	-0.23	-0.25	-0.28	-0.29	-0.20	-0.16	-0.04	0.02	0.03	0.05	-0.01	-0.02	-0.04	-0.07	-0.03	-0.08	-0.14	-0.17	-0.12	-0.21	-0.23	-0.28	-0.22	-0.23	-0.13
54.大分県	-0.01	0.01	-0.12	-0.01	0.03	-0.16	-0.08	-0.19	-0.17	-0.19	-0.26	-0.38	-0.48	-0.38	-0.38	-0.29	-0.23	-0.24	-0.16	-0.03	-0.08	-0.12	-0.12	-0.17	-0.11	-0.15	-0.18	-0.14	-0.13	-0.03	-0.17	-0.12	-0.07	-0.15	-0.19	-0.17
55.宮崎県	0.09	0.34	0.34	0.24	0.23	0.12	-0.08	-0.19	-0.34	-0.34	-0.42	-0.58	-0.41	-0.35	-0.42	-0.42	-0.42	-0.17	0.05	0.02	-0.04	-0.07	-0.21	-0.22	-0.10	-0.20	-0.26	-0.25	-0.18	-0.23	-0.32	-0.32	-0.41	-0.37	-0.20	-0.19
56.鹿児島県	-0.26	0.03	0.05	0.07	0.09	0.00	-0.07	-0.17	-0.26	-0.18	-0.21	-0.38	-0.37	-0.50	-0.53	-0.53	-0.45	-0.35	-0.13	0.06	0.11	-0.01	-0.06	-0.12	-0.05	-0.02	-0.15	-0.15	-0.16	-0.15	-0.26	-0.37	-0.41	-0.43	-0.22	-0.17
57.沖縄県	0.38	-0.21	-0.31	-0.47	-0.27	-0.32	-0.24	-0.23	-0.04	0.06	0.06	-0.16	-0.23	-0.31	-0.35	-0.36	-0.43	-0.20	0.04	0.10	0.08	0.00	-0.03	0.06	0.18	0.16	0.05	0.11	0.16	0.21	0.15	-0.04	-0.16	-0.23	0.06	0.03

Note: Sharply decrease rate in Hyogo Prefecture in 1995 is caused by the effect from Kobe earthquake in January 17, 1995.

Fig. 7-3. Correlation between employment growth and migration

Following the proposed causal flow shown in Fig.7-2, it is possible to conclude that HSR affects more migration as the positive effect from HSR to employment growth has been proved in previous analysis and the positive correlation between employment growth and migration is shown. To ensure the effect from HSR to migration, I further conduct the test to check this effect directly since the result from the previous analysis could be biased due to the five-year gap of employment database. Similarly to previous analysis, migration will be explained through the ratio between the net migrant between two regions and the total population in the origin. This variable will be tested as a dependent variable along with other socioeconomic related independent variables of origin and destination. In this analysis, HSR effect will be explained directly by potential HSR user where a number of population is used as a proxy. Model specification empirically test in this analysis is structured as follow:

$$\frac{|M_{ij,t}|}{P_{i,t}} = \alpha + \beta_1\left(\frac{GRP}{P}\right)_{i,t} + \gamma_1\left(\frac{GRP}{P}\right)_{j,t} + \beta_2\, DID_{i,t} + \gamma_2 DID_{j,t} + \beta_3 U_{i,t} + \gamma_3 U_{j,t} + \beta_4 HSR_{i,t} + \gamma_4 HSR_{i,t} + \delta d_{ij,t} \quad (7\text{-}2)$$

Where: i = concerning prefecture; j = pair prefecture

$|M_{ij}|$ = excess migration from prefecture i to j (person)

P = prefectural population (person)

d_{ij} = distance from prefecture i to j (km)

HSR = potential HSR user (person)

As same as previous analysis, I apply the dataset which covers data from 1997-2010 in 47 prefectures in Japan. The excess migration ($|M_{ij}|$) is calculated from how much *i* loss population in the pairwise comparison with *j*. For example, if the number of migrant from *i* to *j* is 250 and from *j* to *i* is 200, $|M_{ij}|$ is equal to 250-200=50 and $|M_{ji}|$=200-250=-50. Noted that migration data is available annually so it is expected that this analysis will give more precise result compared to employment growth analysis. Potential HSR user parameter (HSR_i) is calculated from the number of population in *i* multiply by HSR availability in *i*, in other words, it equals to number of population in *i* if there is at least one HSR station in prefecture *i*, 0 if no HSR station. Distance (d_{ij}) is the Euclidian distance between prefecture *i* and *j*. The result based on the regression analysis of Eq. (7-2) is shown in Table 7-3 below:

Table 7-3.
Estimation result of migration analysis

	Coef.	***Std.Error***	***t Stat***	***P-value***	
Const	2.71E-04	7.89E-06	34.324	0.000	***
GRP/P_i	1.67E-05	1.31E-06	12.694	0.000	***
GRP/P_j	-7.93E-05	1.30E-06	-60.957	0.000	***
U_i	-7.25E-06	9.51E-07	-7.618	0.000	***
U_j	4.11E-06	9.48E-07	4.332	0.000	***
DID_i	1.14E-06	6.30E-08	18.120	0.000	***
DID_j	-2.06E-06	6.11E-08	-33.646	0.000	***
HSR_i	-1.43E-13	4.42E-13	-0.323	0.746	
HSR_j	-2.47E-12	4.39E-13	-5.628	0.000	***
d_{ij}	-1.23E-08	2.36E-09	-5.229	0.000	***
$Adj.R^2$		0.261			
N		30,268			

Note: "***": $p<0.001$

From this result, the estimates from other socioeconomic parameters show quite consistent estimation to migration theory. Positive estimates found in $\frac{GRP}{P}$ and *DID*, and negative estimate found in *U* in concerning region *i* imply that more migrant is expected to a region with higher GDP per capita, more urbanization, and less unemployment rate. Opposite sign is observed in other pair region *j* which also implies that if there is lower GDP per capita, less urbanization or more unemployment rate in other region *j*, more migration can be expected in concerning region *i*. Distance factor (d_{ij}) is found to be negative which explain that distance is one of the obstacle factors to migration between region *i* and *j*. Our concerning parameter, HSR, is found significance only in pair region *j* and the sign is negative. It implies that if there is a HSR service in pair region *j* and the user is significantly higher, those people in *j* will be less likely to migrate to *i*. However, it is still unclear that region with HSR service will have more people to move in or not.

Discussion: Gain in One Place is a Loss of Others?

From the result, the migration seems to be a zero-sum game in terms of productivity if I assume that migrants have the same level of productivity regardless of the workplace. Logically, if a person has a fixed level of skill, regardless of where such person is working, he will produce the same production since his skill level does not change. However, if his skill level changes because of the new environment, this migration will be not the zero-sum game since his production level will change too. Agglomeration could be one of the possible environmental effects which affect the labor efficiency through sharing, matching, or learning process as I discussed earlier. Although the loss in the place where migrants move from could not be avoided, the gain at the destination could be larger due to agglomeration effect which could result in a positive impact in overall. By assuming agglomeration in the specification of Effective Density, simple model below can prove that migration towards a place with lower generalized cost is productive.

Assuming economy of two cities *i* and *j*, following the specification in Eq. 3-1, agglomeration of *i* and *j* can be defined as:

$$A_i = \frac{E_i}{g_i} + \frac{E_j}{g_{ij}}; A_j = \frac{E_i}{g_{ij}} + \frac{E_j}{g_j};\ E_i > E_j$$

Where A_i and A_j are regional agglomeration of city *i* and *j*, E_i and E_j are employment in city *i* and *j*, and g_i, g_j, g_{ij} are intra-zone generalized cost of travel within city *i*, intra-zone generalized cost of travel within city *j*, and inter-zone generalized cost of travel between city *i* and *j*, respectively. I further assume that economy in *i* is bigger than *j* from larger employment in city *i*.

Assuming new HSR service connects city *i* and *j*. Following the assumption is shown in Fig. 3-1 that HSR reduce generalized cost through the reduction of travel time between two cities and induce migration toward larger economy as proved in our analyses in this chapter. Thus, agglomeration of *i* and *j* after HSR service can be defined as:

$$\widehat{A_i} = \frac{E_i + E_H}{g_i} + \frac{E_j - E_H}{g_{ij} - g_H}; \widehat{A_j} = \frac{E_i + E_H}{g_{ij} - g_H} + \frac{E_j - E_H}{g_j}$$

Where $\widehat{A_i}$ and $\widehat{A_j}$ are regional agglomeration of city *i* and *j* after HSR service, E_H is migration of employment from *j* to *i* from HSR effect. Employment move from *j* to *i* satisfy the assumption that economy in *i* is bigger than *j* so migration goes from small to big economy as proved in earlier migration analysis. g_H is generalized cost reduction from HSR service in a trip between *i* to *j*.

In chapter 4, I showed that agglomeration is one of the factors affecting productivity change. The production level of any city z is defined as:

$$P_z = \alpha A_z; z = \{i, j\}$$

Where, α is the elasticity of agglomeration to productivity.

Thus, the change of productivity in city *i* and *j* due to HSR is defined by:

$$\alpha[\widehat{A_\iota} - A_i] = \alpha\left\{\left[\frac{E_H}{g_i} - \frac{E_H}{g_{ij} - g_H}\right] + \left[\frac{E_j}{g_{ij} - g_H} - \frac{E_j}{g_{ij}}\right]\right\}$$

$$\alpha[\widehat{A_J} - A_j] = \alpha\left\{\left[-\frac{E_H}{g_j} + \frac{E_H}{g_{ij} - g_H}\right] + \left[\frac{E_i}{g_{ij} - g_H} - \frac{E_i}{g_{ij}}\right]\right\}$$

By aggregate all of the productivity change from HSR in both city *i* and *j*, this model shows that the migration from one city to another does not create zero-sum in productivity under the following condition:

$$\alpha[\widehat{A_\iota} - A_i] + \alpha[\widehat{A_J} - A_j] = \alpha\left\{\left[\frac{E_H}{g_i} - \frac{E_H}{g_j}\right] + \left[\frac{E_i + E_j}{g_{ij} - g_H} - \frac{E_i + E_j}{g_{ij}}\right]\right\}$$

The second term $\alpha\left[\frac{E_i+E_j}{g_{ij}-g_H} - \frac{E_i+E_j}{g_{ij}}\right]$ refers to agglomeration effect as defined in Chapter 3: Methodology. HSR reduces generalized cost g_H thus as g_H is higher, the benefit to productivity is higher. However, my concern in this section is that HSR also creates migration E_H from *j* to *i*. Thus in the first term $\alpha\left[\frac{E_H}{g_i} - \frac{E_H}{g_j}\right]$, if intra-zone generalized cost of travel within city *i* and *j* is equal, this migration create zero-sum productivity change. However, if intra-zone generalized cost is not equal, productivity change could be positive or negative.

From this proof, the definition of intra-zone generalized cost should be carefully discussed. In the big city, it is rational to interpret that the cost of travel the larger city is higher due to several facts such as more distance to CBD and traffic congestion. Following this rationale, migration could result in a negative benefit to productivity since $g_i > g_j$. However, it is also possible to interpret that the cost of travel in the larger city could be lower due to better public transportation service while in small city, people may need to rely on personal car to travel. Furthermore, earnings in the big city are usually higher thus when compare the travel cost increase as a proportion to more salary, more travel cost in the big city could be less burden. Following this rational, migration could result in a positive benefit to productivity since $g_i < g_j$.

This section shows one of the possible outcomes from migration to productivity. As discussed earlier that our assumption of agglomeration depends only on employment and travel cost. Instead of employment, capital level or a number of firms could also determine the production level. Decay parameter, instead of travel cost, could be also determined by other parameters such as telecommunication technology. In order to correctly measure the migration impact, a more sophisticated model with a larger set of variables should be applied.

Conclusion

In this chapter, I try to explain the effect of HSR service to migration on the assumption that HSR indirectly affects migration through the expansion of economic activity and the employment in HSR service area. Employment growth analysis proves that, from the benefit of faster travel time, HSR positively affects employment growth in the region with faster travel time. Next, I connect the relationship between employment growth and migration by showing that both parameters are correlated. Finally, migration analysis explains the factor affecting migration decision. From the result of migration analysis, between regions *i* and *j*, more migration to *i* can be observed if one of the following conditions is satisfied.

- Higher GDP per capita in *i*, or lower in *j*
- Lower unemployment rate in *i*, or higher in *j*
- *i* is more urbanized, or *j* is less urbanized
- Less distance between *i* and *j*
- **Fewer HSR users only in *j***

Although it is unclear that HSR will attract more population or not from this analysis, this analysis confirms that people in the region with HSR will be less likely to move out and the region without can expect more out-migration. In addition, the region in Japan with higher GDP per capita, lower unemployment and more urbanized tends to have HSR service thus it is rather difficult to conclude that which effect is the real factor to migration decision. It should be noted that analyses in this chapter cover dataset from 1997-2010 because of the limitation of unemployment data in prefecture level. Only the first phase of Kyushu Shinkansen and the extension of Tohoku Shinkansen were opened during this period so there are only three prefectures (Kumamoto, Kagoshima, and Aomori), which additionally receive new HSR service. This might affect the result from an analysis in the difference-in-difference framework, which is included in the panel data analysis in this chapter because of limited change during the analysis period.

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8. Implications to Thailand

In Chapter 2, I have reviewed the history of HSR development plan in Thailand as well as the criticisms of HSR project and the HSR impact which is considered in several official documents from the government. However, it should be noted that the expected impacts such as an increase in GDP and employment growth are just an overall summary from the government to present the impact from HSR from the broader scope to the public. In detail, there are several expected impacts from both government and the public side which cannot be accounted in the economic impact analysis. For example, many public investors expected that HSR will boost the agglomeration of manufacturing industry between regions or government expected that HSR will be the new mean to distribute the economic growth to other region and will reduce the degree of centralizing development in Thailand. However, based on the result I found in Japanese case study, HSR is not a panacea which can cure every problem. Expectations of HSR impacts in Thailand are sometimes misled and this could cause several negative problems such as land speculation. In this chapter, I would like to show the general comparison regarding socio-economic condition between Thailand and Japan to show the potential outcomes from Thai HSR. Later, I list some expected impacts from HSR in Thailand and try to verify whether such expected impact will likely to occur in Thailand or not based on analyses in Chapter 4 to 7. A similar test in the case study of Thailand will be conducted if data is available. Based on the results found, I later propose some policy implementations regarding HSR development in Thailand at the end of this chapter.

General Comparison between Japan and Thailand

First, I would like to show the economic condition in Japan and Thailand. From Fig. 8-1, as for economic situation in Japan at the opening year of HSR in 1964, the GDP growth rate in Japan is 11.67% and GDP is about 82 billion US dollar. Comparing to the economic situation of Thailand in 2016, GDP is about 5 trillion US dollar which is quite larger than Japan in 1964 although the growth is rather smaller which is only 3.23%. From this fact, it could be said that the size of the economy in Thailand should be big enough to afford the HSR investment

From the broader point of view, in Fig. 8-2 and 8-3, I present the international comparison of economic condition between every country at the time of HSR introduction. An international comparison shows that Japanese economy in 1964 is quite small compared to the other countries in Europe at the introduction stage of HSR. When calculating the economic level in average, it shows that economy in Thailand projected in 2020 (although the commencement of Thai HSR is expected to be later in the early 2020's) might be too small and it could be too early for HSR investment. Noted that figures shown in Fig. 8-2 and 8-3 are nominal value without considering deflation.

Next, Fig. 8-4 shows the transportation modal share from Tokyo to other regional cities in Japan. The fact from Japan shows that trips less than 1,000 km are dominated by rail transportation. This could be due to the fact that on a trip less than 1,000 km, rail transportation could be more attractive than air transportation because of the margin in door-to-door travel time. Travel to an airport which usually located outside the city requires more access time. In contrary, HSR station usually located in the central business district (CBD) so accessibility to HSR is better, especially the business-related trip which normally ends within CBD. On the other hand, 4 lines which had been proposed in Thai HSR are all shorter than 1,000 km (the longest proposed line, Bangkok-Southern Border is around 970 km). Therefore, in terms of modal share, service distance of HSRs in Thailand is very competitive.

Next, I would like to compare the regional agglomeration from HSR between Japan and Thailand. Refer to the agglomeration defined by Effective Density in Chapter 3, agglomeration is determined by employment and generalized cost. For this general comparison, I simplify employment as HSR users because some workers may not use HSR. Therefore, the actual HSR user could be a better indicator to measure the potential activity created by HSR. Generalized cost is simplified as the level of service (LOS) of HSR because lower LOS increase generalized cost. Then, I make a comparison of HSR users in Japan and Thailand by comparing the total potential users from every means of transportation and purchasing power of those potential users to use HSR service. Total potential users are compared by population density in HSR corridor. Fig. 8-5 and 8-6 show the population density in Japan and Thailand respectively. As shown in figures, population density in Thailand is less than Japan, especially in HSR corridor. One of the main reasons to high density in Japan, apart from total area and the total population, is because the geography of Japan where habitable land is limited along shorelines. While in Thailand, the geography of Thailand mostly consists of plains and plateaus so the population in other regions apart from Bangkok is sparsely distributed. The distribution in Thailand has some similarity to population distribution in the Northeastern part of Japan (Tohoku region), so agglomeration pattern could be similar to those in Joetsu Shinkansen and Tohoku Shinkansen although the potential user could be much lower in Thailand because of the difference in absolute value of population density.

In terms of purchasing power for HSR service, I compare the price per distance between Japanese and Thai HSR. Price of Japanese HSR is based on the current (2017) reserved-seat price for Tohoku Shinkansen and Thai HSR is based on fare calculation system for Northeast Line, which was announced in July 2017. Table 8-1 shows the price per distance comparison. In general, by comparing the destination with similar distance, I found that Japanese HSR is around 5-5.5 times more expensive than Thai HSR. However, I compare the average monthly wage in 2014 and found out that earnings for Thai people are less than Japanese around 5.5 times as shown in Table 8-2. By considering the HSR fare and earnings, thus, affordability for HSR service of Thai and Japanese could be same. By considering both comparisons to determine the potential HSR users, HSR users in Thailand could be significantly less than in Japan.

Considering the LOS between HSR in Japan and Thailand, I would like to compare LOS from two aspects. First, the maximum speed in Shinkansen is range from 260-320 km/h, while Thai HSR is limited at 250 km/h. Second, by comparing service frequency, I select Tohoku Shinkansen as a representative[9] for Japanese HSR and compare with Northeast Line in Thai HSR. I select the OD with similar distance and found out that current (2017) Shinkansen service from Tokyo to Fukushima have around 86 trains per day (both direction) in average while HSR from Bangkok to Nakhon Ratchasima is scheduled to have 20 trains per day service. From this LOS comparison, LOS in Thai HSR is substantially lower than Japanese HSR. Therefore, because of less potential

[9] As mentioned that population distribution pattern in Tohoku region, compared with other regions in Japan, is quite similar to pattern in Thailand

HSR users and lower LOS in Thai HSR, I conclude that regional agglomeration from HSR in Thailand could be significantly less than in Japan. Summary of the comparison of the regional agglomeration from HSR in Japan and Thailand is shown in Fig. 8-7.

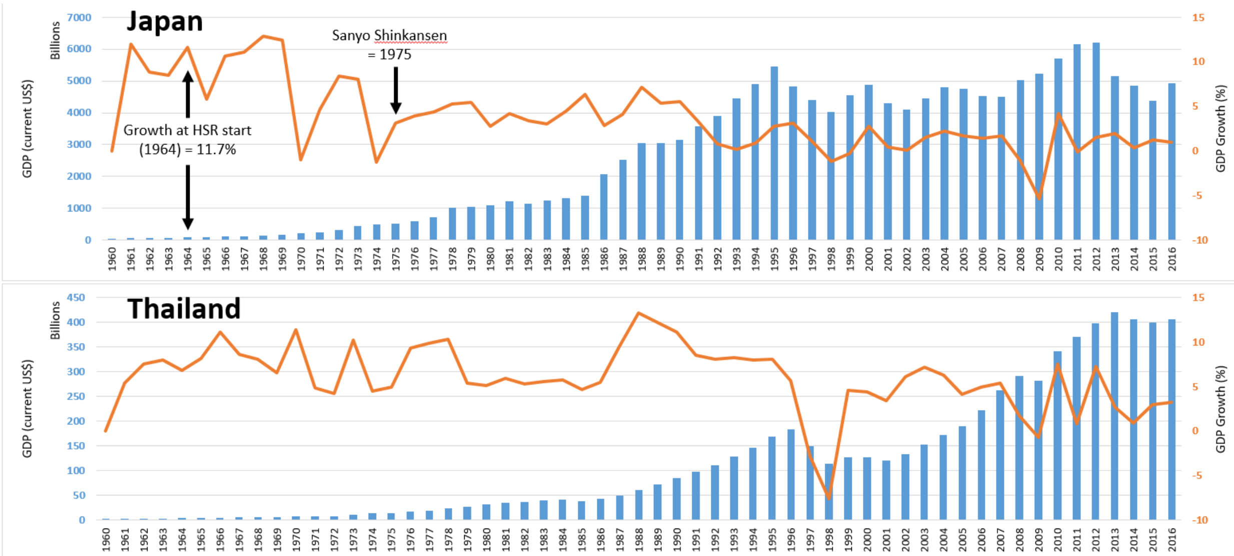

Fig. 8-1. Economic condition in Japan and Thailand from 1960 to 2016

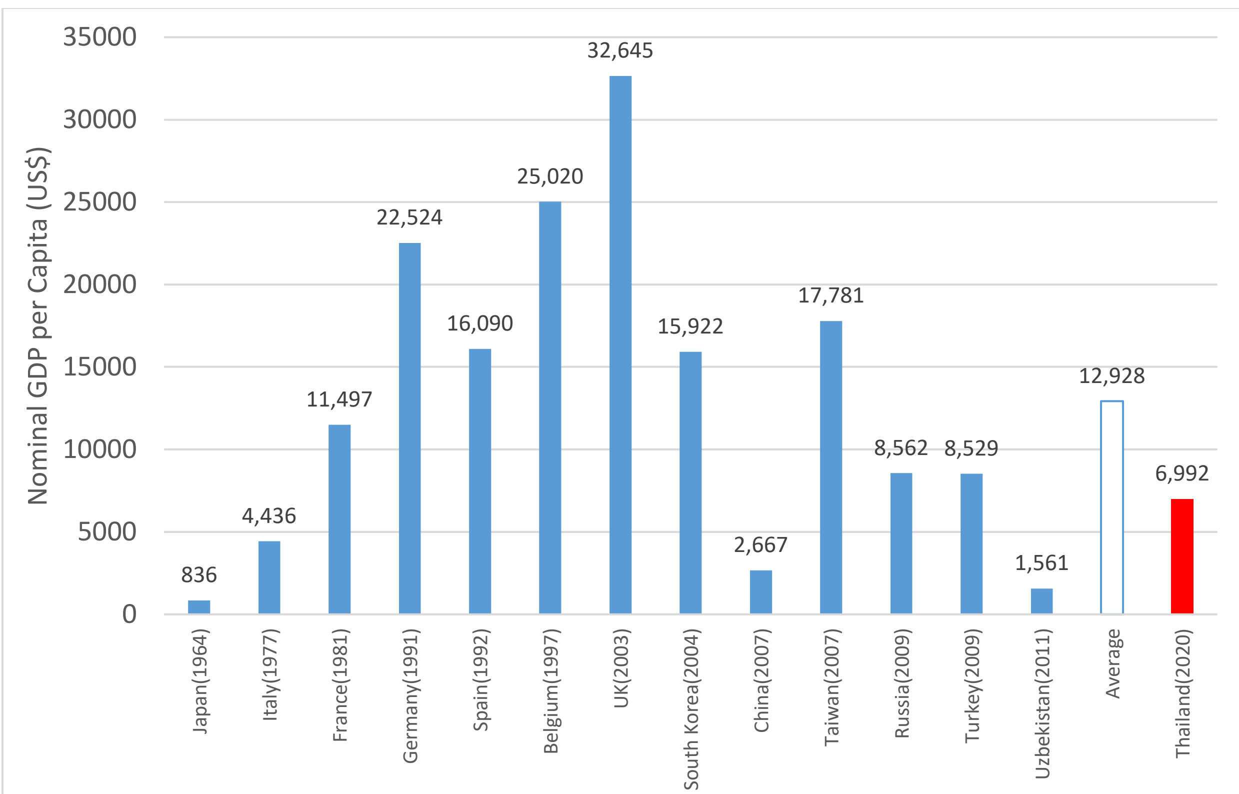

Fig. 8-2. International comparison of GDP per Capita at Introduction of HSR

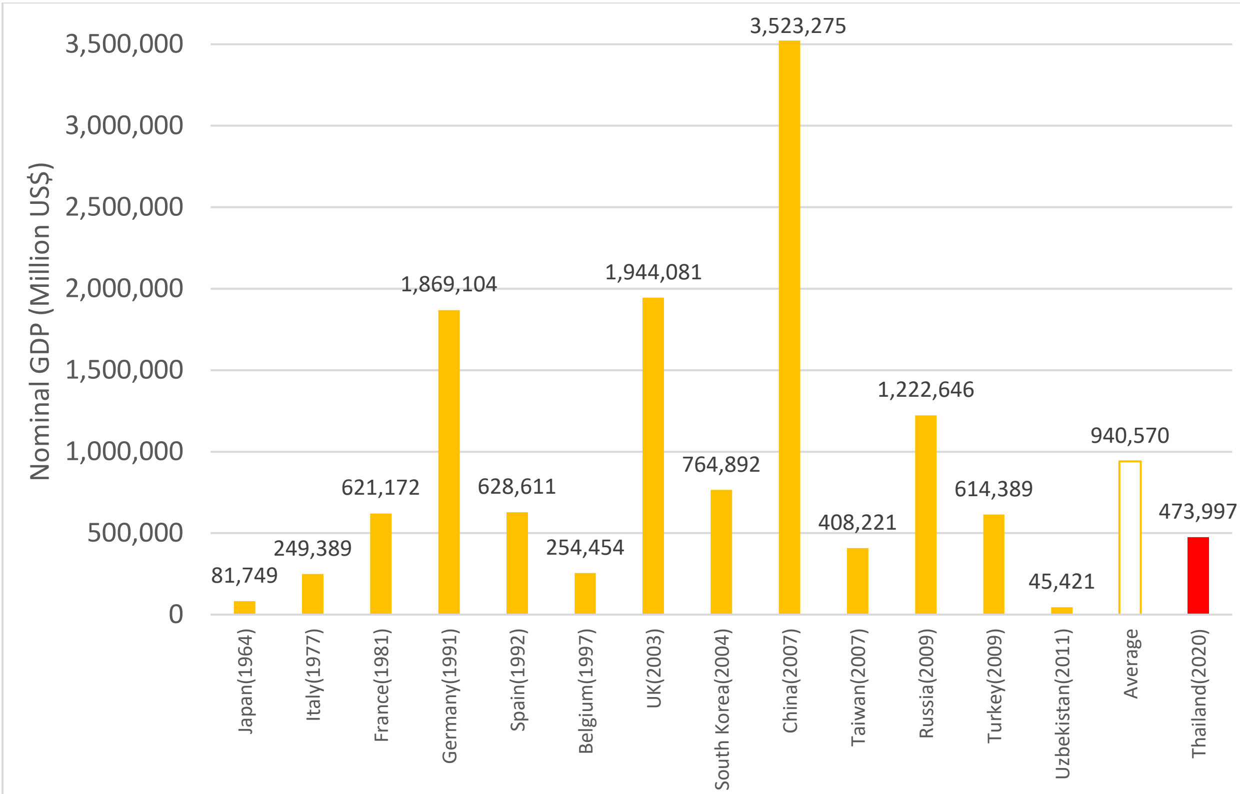

Fig. 8-3. International comparison of GDP at Introduction of HSR

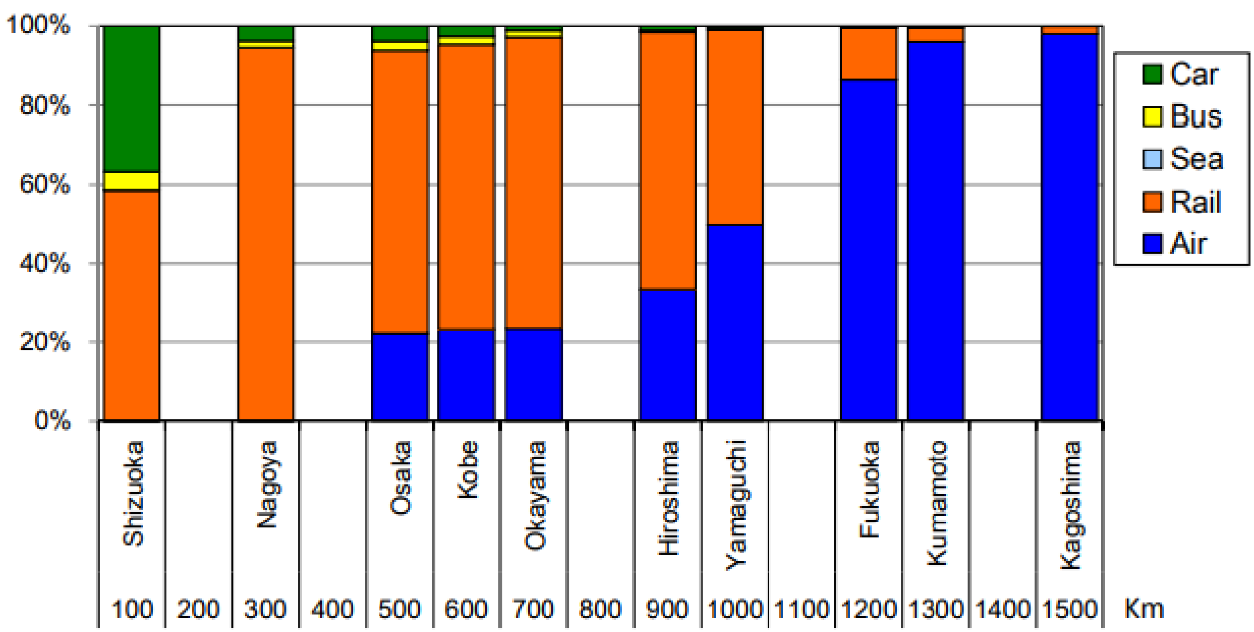

Fig. 8-4. Modal share from trip between Tokyo metropolitan and other prefectures

Source: 2010 inter-regional travel survey in Japan, MLIT, Japan

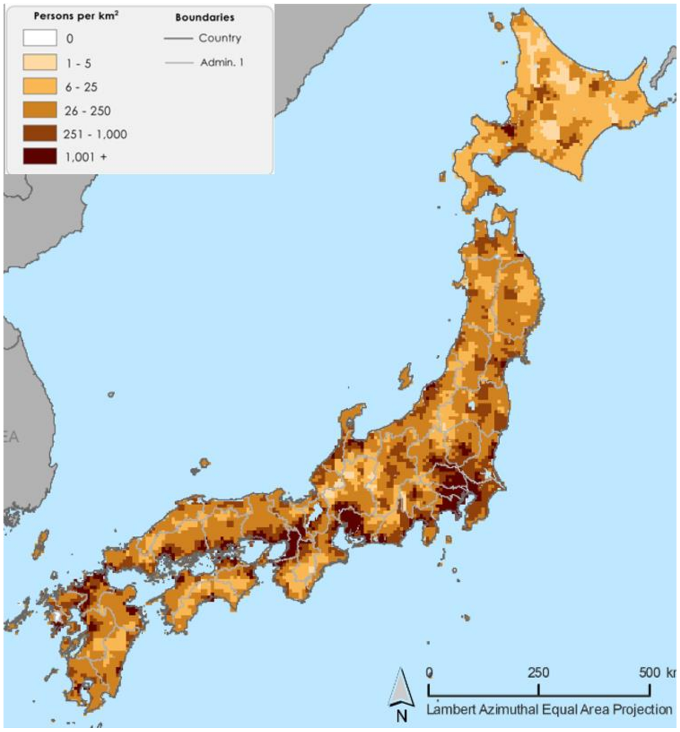

Fig. 8-5. Population distribution in Japan (2000)

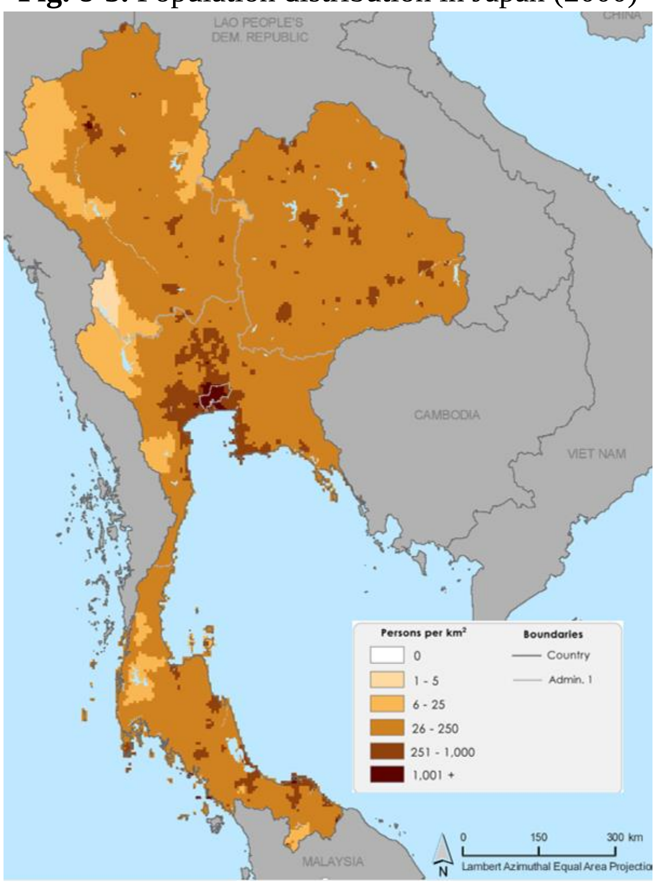

Fig. 8-6. Population distribution in Thailand (2000)

Source of Fig. 8-5, 8-6: Global Rural-Urban Mapping Project (GRUMP)

Table 8-1. Price per distance comparison

	km	Baht	Yen	Yen/km
	From Tokyo			
Oyama	80.6		4260	52.85
Utsunomiya	109		5130	47.06
Nasu-Shiobara	152.4		6610	43.37
Koriyama	213.9		8400	39.27
Fukushima	255.1		9150	35.87
	From Bangkok			
Ayutthaya	63.9	195	650	10.17
Saraburi	110.0	278	927	8.43
Pak Chong	173.9	393	1310	7.53
Nakhon Ratchasima	252.8	535	1783	7.05

Noted: Thai HSR fare calculation formula is, Price (baht) = 80+distance*1.8; Shinkansen fare is based on reserved-seat price; 100 Yen = 30 Baht

Table 8-2. Earnings Comparison

Average monthly wage in 2014 (Yen)		
Japan	Thailand	**JP/TH**
299,600	54,443	**≈5.5**

Noted: 100 Yen = 30 Baht

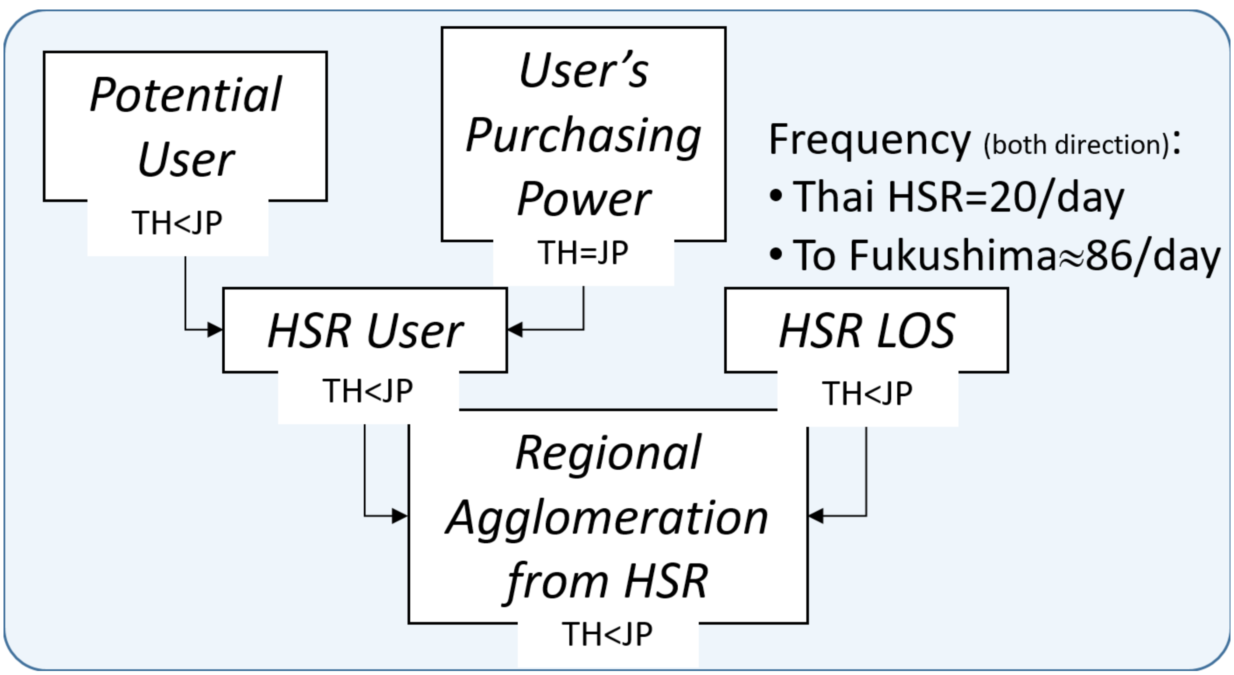

Fig. 8-7. Summary of the expected regional agglomeration from HSR in Thailand

Agglomeration Impact to Productivity Test in Thailand

From the fact that HSR service in Thailand will produce an insufficient direct economic benefit to meet the feasibility criteria, there is a high expectation from the government that agglomeration impact will generate additional benefit and make HSR investment feasible. Although the government mentioned this impact in general as *"the impact when HSR induces more economic activity to service area"*. Yet, as explained earlier in Fig. 2-2, the impact from such "additional impact" could generate two benefits at the same time; first, directly from more workforce, and second, from better productivity because more worker agglomerated together. I will leave the former impact to the migration impact test and test the latter impact in this section whether **HSR increases productivity in the service area through agglomeration or not?**

The case study in Japan shows that HSR positively affects productivity in the region through agglomeration and the effect is decreasing through time. When comparing the productivity difference (GDP per worker) between the with HSR scenario and without HSR scenario, I found the impact could be high up to around 4% although the most affected regions are usually located beyond the edge of the metropolitan area of Tokyo and Osaka. For the rigid comparison, the similar model to Japan (Chapter 4) is applied in the case study in Thailand. However, because capital and investment data are not available at the province level in Thailand, I assume that capital effect and investment effect can be captured through the expansion of CBD area in each province. First, I analyze the impact of HSR on productivity by applying regression analysis to following empirical model:

$$Y_{i,t} = \alpha_0 + \alpha_1 A_{i,t} + \alpha_2 W_{i,t} + \alpha_3 CBD_{i,t} + \alpha_4 fire_{i,t} + \alpha_5 manu_{i,t} \qquad (8\text{-}1)$$

Where: $Y_{i,t}$ = natural log of GPP (Gross Provincial Product) per worker (ln million baht/person) in province i, year t

$A_{i,t}$ = natural log of agglomeration, defines as $ED_{i,t}$ in Eq.(3-1)

$W_{i,t}$ = natural log of annual average income (ln million baht/person)

$CBD_{i,t}$ = natural log of area of CBD (central business district) per worker (ln Rai/person or ln 1,600sq.m/person)

$fire_{i,t}$ = share of GPP from finance, insurance and real estate sector to total GPP

$manu_{i,t}$ = share of GPP from manufacturing sector to total GPP

The panel dataset covers data from 2007-2014 in 76 [10] provinces in Thailand annually. Socioeconomic related data is acquired from National Statistics Office, Ministry of Digital Economy and Society of Thailand. Land use data is collected from the land use database provided by Land Development Department, Ministry of Agriculture and Cooperatives of Thailand. Noted that the database of multi-modal minimum travel time used to calculate effective density in the case study of Japan is not available in Thailand, thus I simplified the measurement of decay

[10] Currently (2017), there are 77 provinces in Thailand. Bueng Kan was established by a partition from Nong Khai in 2011. However, for consistency in analysis, I sum the data of Bueng Kan back into Nong Khai for the data after 2011 which make 76 provinces in my dataset.

parameter by using road distance between each province *i* and *j*. The result of regression analysis is shown in Table 8-3 below:

Table 8-3

Estimation result of agglomeration impact analysis: case study in Thailand

	Coef.	***Std.Error***	***t-value***	***Pr(>|t|)***	
Const.	-0.870	0.385	-2.260	0.024	*
A	0.079	0.034	2.327	0.020	*
W	1.022	0.020	51.453	0.000	***
CBD	0.038	0.008	4.574	0.000	***
fire	-0.898	0.352	-2.551	0.011	*
manu	0.393	0.096	4.083	0.000	***
Adj. R^2			0.927		
F-stat			1540.54		
N			608		

Note: "***": p<0.001; "**": p<0.01; "*": p<0.05

In this analysis, I tried to follow the analysis in Chapter 4 where provincial productivity is explained by labor and capital input per worker. However, there is no capital database in Thailand thus I use area of CBD per worker as a proxy as CBD area is the main area which capital is invested. The significance of both *W* and *CBD* positively affect productivity as expected. Furthermore, I test the share of production in FIRE sector as same as in Chapter 4. In addition, I further test the share of production in the manufacturing sector as manufacturing shares the largest production to total production in Thailand. The result shows positive sign in *manu* as expected, but in *fire*, the result is negative same as found in Japan case study. However, the explanation could be different; in Thailand, *fire* includes the share of real estate sector which could be less productive because the main part of the share comes from real estate for a residential area, not for a commercial development. Finally, the estimate of agglomeration (*A*) is shown positive and the significance is still within acceptable range. By considering HSR project in the first phase where a traveler might change the mode of transportation from the bus or personal car to HSR, it implies that HSR might increase productivity through agglomeration by improvement in inter-regional travel time, similar to the result found in Japan.

By using the estimation of *A*, I compare the productivity gain from HSR in each region by assuming the completion of HSR first phase in Thailand. Since the database of inter-model transportation is not available, I simply change the travel time from road travel time[11] to HSR travel time in the O-D pair which HSR is available. The result of scenario analysis shown in Fig. 8-1 depicts the similar result as found in the case study in Japan. The impact to productivity could be high up to around 4% and the most affected regions are located around Bangkok metropolitan area although the distance between affected regions to Bangkok CBD (around 100 km) is less than

[11] I calculate road travel time based on the road distance used agglomeration calculation in Eq.8-1 by assuming average road speed of 77.5 km/hr (based on the survey by Department of Highway in 2014)

the case study in Japan (around 150-170 km). The same explanation can be also applied to Thailand; travel demand to Bangkok CBD is still high in from those most affected regions, but there is no sub-urban transportation service to support the trip to CBD so users are indirectly forced utilize the HSR service.

Industrial Agglomeration Test in Thailand

Based on the expectation that HSR will increase the economic activity in the service area, many investors plan to infuse more investment to their business from the hopes that HSR will make their business better. Investors in many sectors such as real estate, service, and manufacturing sector are now trying to acquire more land although the current owners have set the land price unbelievably high. This speculation might cause the problem later if HSR does not benefit the business in this newly acquired land. Based on the result of the case study in Japan, in general, I found a positive effect from HSR through agglomeration in finance sector and real estate sector. Thus, speculation in real estate business in Thailand could be acceptable. However, based on the result found in the case study in Japan, the agglomeration effect from HSR to service and manufacturing sector is not significant. Intuitively, it is still difficult to argue the effect from HSR to service sector as many types of service are grouped together in Japanese database. However, it is logically justified that HSR does not affect production in manufacturing sector, as agglomeration in manufacturing should be explained through highway[12], not HSR. Since there is no HSR service in Thailand, it is impossible to apply the same analysis to check the effect from HSR to production. However, it is also worth to check the effect of industrial agglomeration from the road in Thailand. Thus, I simplify the regression analysis from the case study in Japan (Chapter 5) as follows:

$$GPP_{n,i,t} = \rho A_{i,t} + \beta_k k_{n,i,t} + \beta_l l_{i,t} + \eta_t \quad (8\text{-}2)$$

Where: $GPP_{n,i,t}$ = natural log of GPP (ln million) in industrial n, province i, year t
$k_{n,i,t}$ = natural log of capital input, use area of related business as a proxy (ln Rai)
$l_{i,t}$ = natural log of the product between annual average income and number of workers (ln million baht)
η_t = year fixed effects dummy

[12] Agglomeration in manufacturing sector is highly affected by freight transportation as tested in Chapter 5. Also, freight transportation in Thailand is very similar to Japan where it is heavily relied on highway.

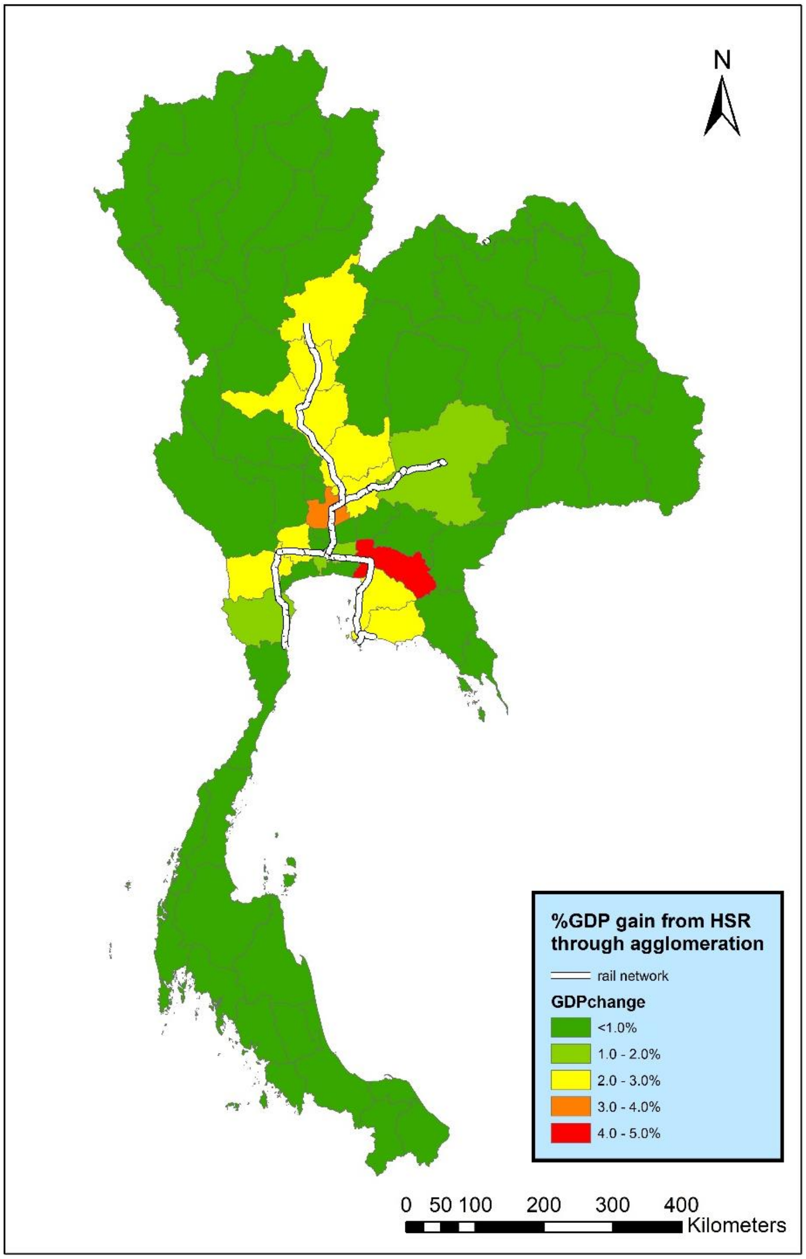

Fig. 8-8. Productivity gains from the first phase of HSR network by province

Similarly to the previous test, for the direct comparison with Japanese case study, I follow the analysis in Chapter 5 where provincial production is explained by labor, capital, and technology input. Since the same dataset is utilized so the capital data is not available, thus I use area of related business to each industry as a proxy to measure capital invested. Furthermore, employment database in each industry is not available in province level so I assume the same level of labor input as total labor input to every industry. The result shown Table 8-4 explains the effect of industrial agglomeration by road to industrial production. Finance sector and real estate sector are found positively affected by agglomeration. Manufacturing is also found positive as expected that this sector benefits from agglomeration through highway transportation. This result also reveals negative result in agriculture and tourism (hotel and restaurant) industry. A negative result in agriculture could be explained by the same argument in the case study in Japan. However, the negative impact found in tourism could due to the fact that tourist attractions in Thailand usually located in the less populated area thus agglomeration may seem to negatively affect this industry. From this result, it is worth to discuss the impact of motorway projects, which will be invested almost parallel to HSR in Thailand. By investing both transportation service, agglomeration benefit could be expanded in various industries.

Table 8-4.
Estimation result of industrial agglomeration analysis: case study in Thailand

Industry	Estimates		Land use for K proxy
Agriculture	*-0.761*	***	Agriculture
Mining	*insignificance*		Mining
Manufacturing	*0.835*	***	Factory+Ind.Estate
Elec,Gas&Water	*0.295*	***	Urban
Construction	*insignificance*		Urban
Wholesale&Retail	*0.193*	***	Commercial
Hotel&Restaurant	*-0.971*	***	Hotel+Attraction
Trans&Comm	*insignificance*		Urban
Finance	*0.422*	***	Commercial
Real Estate	*0.291*	***	Residential
Government	*insignificance*		Government
Education	*0.172*	***	Government
Health	*0.303*	***	Government
Other Service	*0.362*	***	Urban

Specialization/Diversity Agglomeration Test in Thailand

One of the policies which government plans to implement along with HSR investment in Thailand is the promotion of local industry in the city along HSR service area. Several cities are assigned to one local industry and the specialization in such industry is expected to benefit from HSR. Different industries are assigned to different cities as shown in Fig.8-9.

From this plan, the question is whether HSR can promote specialization or not. Since the data of the number of workers in each industry is not available in Thailand, I could not apply similar analysis from Chapter 6 to the case study of Japan. However, according to the result found in the case study in Japan, I found that HSR could cause the city to be more specialize or to be more diverse depending on the distance to HSR service. With the combination of the result found in the previous test and from Chapter 5, it could be further concluded that type of industry should be considered along with the distance to HSR service in order to determine the effect on specialization/diversity. Thus by focusing on the region with HSR service, a possible answer to the question is, HSR may promote, or discourage industrial specialization, or no effect from HSR at all, depending on the types of industry.

Fig. 8-9. Industrial specialization plan

Applying these findings to the case study in Thailand, one of the promotions which conflict with our findings is the promotion of the agriculture business in the city with HSR service. The agglomeration effect to agriculture industry is found to be negative in this study, thus it is not advisable to promote agriculture specialization in the region with HSR service. Based on the result of the case study in Japan combined with the result from the previous test, it is possible to predict that the movement in finance and real estate industry toward the region with HSR service will be observed because positive impact to these industries is expected. The region without HSR service will be more specialized in the agriculture industry as agriculture is the main sector in less developed regions in Thailand. Fig. 8-10 conceptualizes the possible outcome from the effect of HSR to specialization agglomeration in Thailand.

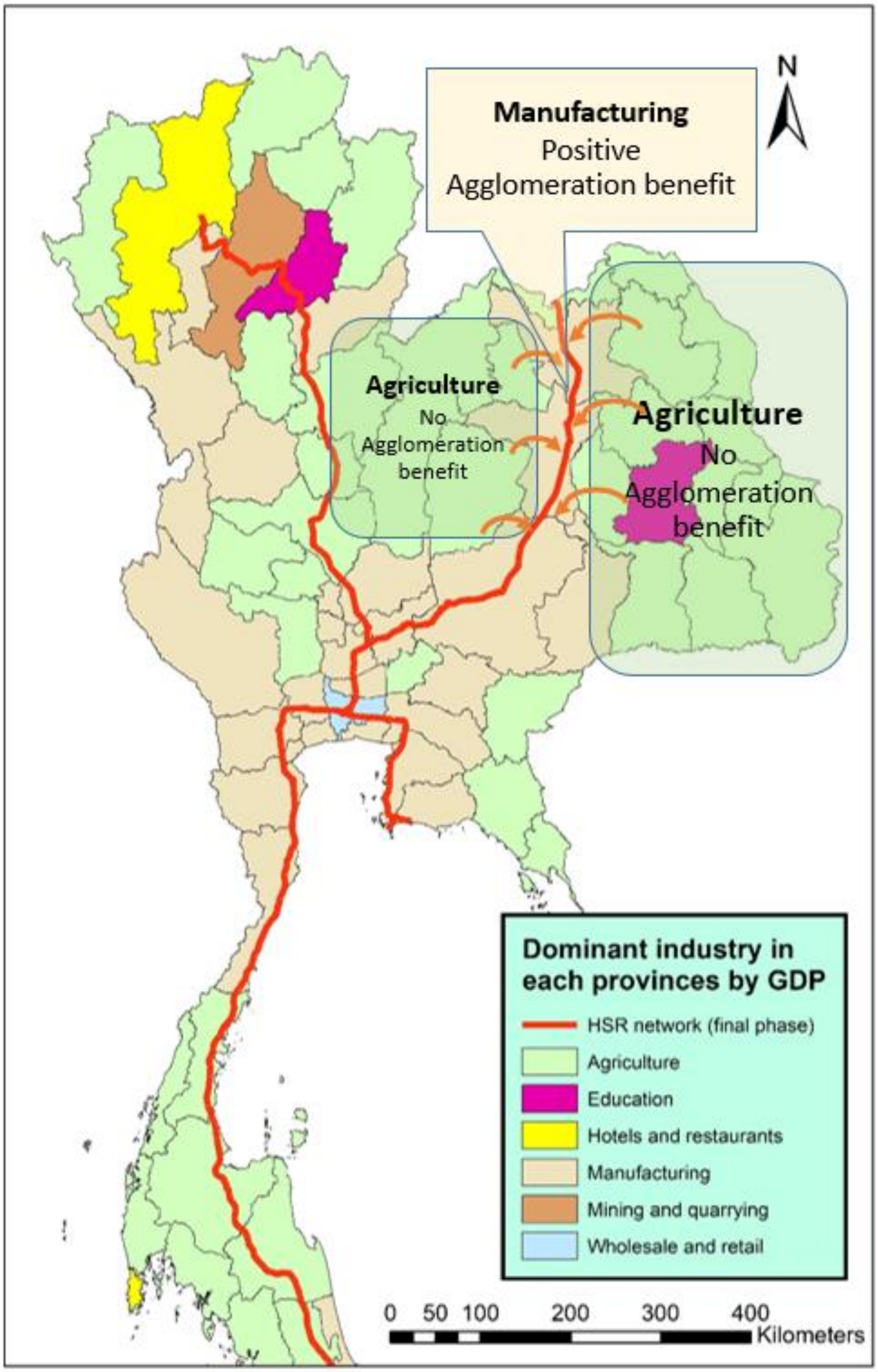

Fig. 8-10. Possible outcome from the effect of HSR to specialization agglomeration

Monocentric Growth Test in Thailand

Another major expected impact from HSR is the ability to create more regional growth and reduce the monocentric growth in Bangkok. HSR is expected to induce more investment in other regional big cities which HSR service is available. However, based on the case study in Japan, migration decision depends heavily on wage rate, level of urbanization and unemployment rate. Intuitively, Bangkok has higher wage rate and higher level of urbanization which attract migrant from other region to move in. Furthermore, HSR is also planned in Bangkok and with the result from the case study in Japan, it implies that people in Bangkok are unlikely to move out from Bangkok. By combining these two effects, I can conclude that monocentric growth is expected to continue. Nevertheless, I apply a similar test to the employment growth analysis from Chapter 7 in this section to check the possible situation of monocentric growth in Bangkok. Unfortunately, I cannot conduct the migration test from the Chapter 7 since the O-D migration data is not available in Thailand. Also, the effect of HSR cannot be directly measured since there is no HSR in Thailand. The model specification to test employment growth in the case study in Thailand is:

$$\%\Delta E_{i,t} = \alpha_0 + \alpha_1 W_{i,t} + \alpha_2 CBD_{i,t} + \alpha_3 A_{i,t} + \beta_1 DB_{i,08} + \beta_1 DB_{i,09}$$
$$+ \beta_1 DB_{i,10} + \beta_1 DB_{i,11} + \beta_1 DB_{i,12} + \beta_1 DB_{i,13} + \beta_1 DB_{i,14} \quad (8\text{-}3)$$

Where: $\%\Delta E_{i,t}$ = percentage of employment growth in prefecture *i*, at year *t*
$DB_{i,t}$ = Road distance from prefecture *i* to Bangkok, at year *t*
Other notations are same as shown in Eq.(8-1)

I apply the same dataset which was used in previous tests in this Chapter, although the analyze period is reduced to 2008-2014 since the data in 2007 is used to calculate the growth in 2008. One of the variations from the case study in Japan is the distance (*DB*) variable which I separately test each year. Table 8-5 shows the result of this test. The result shows that income rate (*W*) and agglomeration (*A*) positively affect worker growth although the area of CBD (*CBD*) may not be the good proxy for the level of capital because the result shows negative estimate. The concerning variable in this test, *DB*, is found to be larger in early year and reduce through time. This result could be interpreted that higher employment growth in the region located further away from Bangkok could be expected in earlier years. However, the situation is switching conversely where higher employment growth in the region closer to Bangkok is expected in later years. Logically, higher employment growth in Bangkok and vicinity in a later year could be the result from more migration to Bangkok or more natural birth rate in Bangkok. However, since the difference of natural birth across the region may not be so high, it is reasonable to conclude that the situation of monocentric growth to Bangkok will be further escalated even after the introduction of HSR in Thailand.

Table 8-5.
Estimation result of worker growth analysis: case study in Thailand

	Coef.	***Std.Error***	***t-value***	***Pr(>|t|)***	
Const.	-1.30E+01	3.40E+00	-5.259	1.37E-07	***
W	1.84E-05	3.67E-06	4.998	1.14E-04	***
CBD	-2.33E+01	8.37E+00	-2.777	4.22E-03	**
A	6.40E-05	1.20E-05	5.136	4.57E-08	***
DB08	1.57E-02	3.90E-03	4.561	4.30E-06	***
DB09	1.51E-02	3.87E-03	4.435	6.97E-06	***
DB10	1.30E-02	3.85E-03	3.873	2.97E-05	***
DB11	1.29E-02	3.82E-03	3.87	2.90E-05	***
DB12	1.23E-02	3.80E-03	3.721	4.52E-05	***
DB13	9.92E-03	3.80E-03	3.01	3.47E-04	**
DB14	-7.07E-03	3.77E-03	-2.104	1.46E-01	*
Adj. R^2			0.1362		
N			532		

Policy Suggestion

Before the discussion about policy suggestion in Thailand, first, I would like to summarize the findings and implementations based on the lesson learned from the case study in Japan and Thailand from chapter 4 to 8 in Table 8-6 and 8-7. For the benefits of policy discussion, I would like to show the concerns raised regarding HSR in Thailand and the answers to those concerns based on the findings from Japan and Thailand, which are presented in Table 8-8.

Table 8-6.
Summary of findings in Japan and Thailand, and general implementations

	Findings - Japanese Case Study	Findings - Thai Case Study (Ch.8)	General Implementation
Chapter 4 Agglomeration to productivity	Regression Analysis • Agglomeration from HSR positively affects productivity. • Increase of agglomeration by 1% will increase productivity by 0.085%. • Agglomeration impact is decreasing through time. • Agglomeration impact is significant only in Tokaido line. Scenario Analysis • Agglomeration impact from HSR could be high up to 5% of productivity. • Especially area at the edge of Tokyo.	Regression Analysis • Agglomeration from HSR positively affects productivity. • Increase of agglomeration by 1% will increase productivity by 0.079%. Scenario Analysis • Agglomeration impact from HSR could be high up to 5% of productivity. • Especially area at the edge of Bangkok.	• HSR Investment in the later stage will be less productive than the earlier because only areas with lower feasibility are left to be chosen. • The agglomeration impact to productivity is significantly higher in the areas at the edge of metropolitan
Chapter 5 Industrial Agglomeration	Urbanization Agglomeration • Positive: Finance; Real estate • Negative: Agriculture Localization Agglomeration • Positive: Finance; Real estate; Retail; Transportation&IT • Negative: Agriculture	Urbanization Agglomeration (assume freight agglomeration) • Positive: Manufacturing; Elec,Gas&Water; Retail; Finance; Real Estate; Government; Education; Health; Other Services • Negative: Agriculture; Hotel&Restaurant	• For HSR development in city center, sectors with positive impact from urbanization agglomeration are advised • For HSR development in new development area, sectors with positive impact in localization agglomeration are advised

Table 8-7.
Summary of findings in Japan and Thailand, and general implementations (continued)

	Findings - Japanese Case Study	Findings - Thai Case Study (Ch.8)	General Implementation

Chapter 6 Specialization Agglomeration	• Specialization and diversity both benefit city's productivity.
	• Effect to specialization or diversity depends on distance to HSR station.
	  ○ Near HSR = diversity
	  ○ 270 km away from HSR = specialized
	  ○ 540 km away from HSR = diversity
		No data in Thailand	• A city which is not specialized and not diversified, is not a productive city.
			• Business with positive agglomeration impact from HSR will relocate closer to HSR, creates more diversity.
			• Business without positive agglomeration impact will remain in the area, creates more specialization.

Chapter 7 Migration	• HSR encourages employment growth. • Employment growth correlates with migration. • More migration can be expected toward the city with higher GDP per capita, more urbanized, and lower unemployment rate. • The presence of HSR discourages people to migrate out	• More monocentric growth is expected in Thailand (without HSR assumption)	• HSR is one of the catalyst to higher population growth in the larger cities.

Table 8-8.
Summary of problems regarding HSR in Thailand and answers to problems

	Problems Regarding HSR in Thailand	Answers based on Findings from Ch. 4-8
Agglomeration to productivity	• Additional (indirect) benefits from HSR are expected from the Government. • Agglomeration is expected as one of additional benefits • *Does HSR create agglomeration impact to productivity?*	• HSR creates a positive agglomeration impact to productivity. • From the scenario analysis, the benefit could be high up to 5% of productivity, depends on the reduction of travel time. • The impact is especially higher in the areas at the edge of Bangkok.
Industrial Agglomeration	• Investors from many sectors plan to make investments in HSR service area because the expectation of positive benefits to their business. • Not every industry benefits from HSR. • *In order to maximize the agglomeration impact, what industry should be promoted along with HSR?*	• In general, finance and insurance sector, and real estate sector, should be promoted along with HSR. • If the land is in the new development area, retail sector, and transportation and communication sector are also suggested. • Agriculture sector should be avoided.
Specialization Agglomeration	• The Government plans to promote specialization of local industry along with HSR. • *Can HSR promote more specialization to local industry?*	• Depends on the types of industry and the distance to HSR service, HSR could promote city’s specialization or diversity. • For example, promotion of agriculture sector in central region along the HSR North Line may not work well.
Migration	• The Government wants to prevent monocentric growth by promoting regional growth along with HSR project. • *Does HSR discourage monocentric growth?*	• HSR is one of the factors among many other which will **encourage** more monocentric growth in Thailand.

Based on the summaries shown in Table 8-6, 8-7 and 8-8, I would like to suggest some policies to the government of Thailand, in order to maximize HSR economic impact through agglomeration and migration as follows:

1. Government should acknowledge regional agglomeration/migration impact from HSR

According to analyses in Chapter 4-7, the result shows the significant agglomeration/migration impact from HSR. While in Thailand, although government acknowledges that the impact from HSR is not only limited to HSR users but HSR can create a wider impact to the local economy. Several plans to promote land use near HSR station have been issued along with HSR investment. However, agglomeration and migration impacts caused by inter-regional accessibility improvements are still not recognized. Regional agglomeration and inter-regional migration too, should be considered in the development plan, as agglomeration economy is not limited only in close-proximity agglomeration.

2. Government should make more intervention into land use planning depending on HSR availability

Based on the result from Chapter 5, HSR positively affects production through agglomeration in several industrial sectors. Thus, promoting agglomeration economy could be one of the means to improve the national economy. In a region with HSR service, industries with positive agglomeration impact (from HSR) such as real estate or finance sector should be promoted. While in the region without HSR, an industry with negative agglomeration impact such as agriculture should be promoted as lower agglomeration might increase production in these industries.

3. Government should encourage more HSR users to maximize agglomeration impact

One of the main assumptions in this study is agglomeration is explained by Effective Density and it is proved in Chapter 4 and 5 that effective density significantly increases productivity and production. Effective Density is one of the parameters to explain to possible interaction from one area to other area. However, in order to capture the agglomeration impact from HSR, the demand in HSR could be used to explain the real interactions from one area to other area by HSR as well. Thus, more HSR user is not only increased impact from time savings, but it also increases agglomeration impact from more activity too. Noted at as shown in Fig. 8-4, the size of agglomeration in Thailand is expected to further decrease because of the decreasing trend of total employment after 2014. Therefore, in order to increase HSR users, fare subsidy could be advised under the strict economic impact analysis. In Japan, some local trains stopped their services after the introduction of HSRs within the same route. Restriction of other competitive modes could be suggested to increase the utilization of HSR.

4. Government should prepare for more monocentric growth

The conclusion from the monocentric growth test in Chapter 7 is that HSR could be one of the factors to increase monocentric growth in Thailand. Therefore, City of Bangkok should prepare any countermeasure to deal with the negative impact from population growth such as congestion, pollution, crime or other social needs. Monocentric growth could be reduced by increasing the investment in other social services and infrastructures in other regions to share the growth from Bangkok. Providing HSR without any local investment in other region is equal to giving an easier way for people to move to Bangkok.

5. Government should provide more education/information about HSR

The most important task for the government is how to give a better understanding about HSR service to Thai people. It is possible to say that Thai people are still lack understanding of the role and the impact from HSR because the development of railway in Thailand suddenly evolves from single-track diesel train to HSR. According to the result from Chapter 5, the effect could be positive, negative, or no effect at all, especially in the manufacturing sector where no impact from agglomeration caused by HSR is found. However, many Thai people have an impression that HSR is just a new type of train, which runs faster. Many investors expected that HSR would create a positive impact to manufacturing industry just because they understand that HSR is used for freight as well. Even one of the ex-prime minister once said that "*farmers can send their vegetables to Bangkok through HSR*". These misunderstandings could lead to inefficient investment; therefore, it is the duty of the government to provide more education and information about HSR to the public.

Discussion Regarding Robustness of the Result from Japanese Case Study

Although I suggested some policies based on findings from Japanese case study, the robustness of agglomeration and migration impact from HSR in this study should be also discussed along with the facts in other countries. This study presents the result based on the case study in Japan thus unique characteristics in Japan could strongly affect the result. For instance, high population density in the coastal area of Japan is one of the supporting factors to increase agglomeration impact from HSR in Japan. Similar population distribution could be found in Taiwan, thus, agglomeration pattern in Taiwan could be similar in Japan. However, this pattern is unlikely to be found in Thailand as population density in Thailand is considerably smaller and there is no large corridor such as those found in Japan. Although the term of regional agglomeration is rarely discussed especially in the context of HSR development, by judging from the population density and distribution pattern, regional agglomeration impact from HSR in Thailand could be similar to the pattern found in France or Spain.

Another issue regarding the robustness of this result is that, although this study highlights the impact from HSR, yet impact from other infrastructure investments and policies could affect regional agglomeration and migration as well. For example, we observed a high migration towards Chiba prefecture while there is no HSR service in Chiba (see Table 7-2 for further details). In this case, urban transportation service connecting Chiba to Tokyo CBD could be one of the vital factors which promote population growth in Chiba. In contrary, in Iwate prefecture where there are 7 HSR stations, negative migration found in Iwate is one of the highest numbers among prefectures in Japan. Some HSR stations in Iwate are located further from city CBD and without public transportation connecting those stations and CBD, the effect of HSR could be significantly diminished. A similar situation could be observed in many HSR stations in Taiwan where unsuccessful development around HSR stations is found. Although I incorporate the impact from other infrastructures into the model as investment and urbanization parameters, it should be emphasized that regional agglomeration and migration impact from HSR could be strengthened by local infrastructure investment as well. In Thailand, some HSR stations are planned to be constructed outside the city center in order to promote the new CBD. However, based on the fact found in Japan, availability of a connection between HSR station and city center should be carefully planned along with HSR plan as well. Especially in the small city where people constantly migrate out to the metropolitan area, only using HSR station as a pivot point may not be sufficient to promote new CBD.

9. Conclusion

Travel time reduction from new transportation infrastructure is approved to be the common impact to the economy as travelers can utilize this time for other productive activity. However, the effect from new transportation to economy is not limited to the utilization of additional time. New transportation can encourage more activities between people with faster travel time or with cheaper travel, and such activities could increase the productivity in overall. With increasing productivity, new people may move into new transportation service area to enjoy the better productive job as well. Thus, it is also possible to say the effect from new transportation to the economy could be observed through agglomeration impact (more activity from better accessibility) and migration impact (more activity from more people moving in).

Although these concepts are usually discussed in the context of urban transportation, the effect in regional scale may also be observed through inter-regional transportation such as HSR too. HSR has been acknowledged by many countries as one of the stimulants to economic activities. Among them, Thailand is also one of the countries which aim to realize the HSR service as one of the means to promote the rail transportation and the mean to stimulate the domestics economic activities. Therefore, this research investigates the impact of agglomeration and migration from HSR service. The main objective is to answer the question how productivity benefit from HSR can be maximized through agglomeration and migration. The findings provide a better understanding regarding the impacts of agglomeration and migration effect from HSR. They can help planners to coordinate other policies with HSR development in order to maximize the economic benefit in overall.

In this research, first, whether there is agglomeration impact from HSR service or not is tested. Next, agglomeration impact in each industry is investigated. The impact of industrial diversity and specialization are further explored in the next step. Finally, this study checks the migration impact from HSR along with other socioeconomic parameters. In these four steps, empirical analyses from the longest history of HSR service in Japan are discussed to give a better understanding about actual agglomeration impact from HSR. It should be noted that currently, there is no ex-post study concerning the relationship between HSR and agglomeration. Implementation in the case of Thailand based on the findings from Japan is further discussed for the benefit of HSR development in developing countries.

In the first section, agglomeration impact from HSR service, in general, is investigated along with other HSR service level factors. Empirical analyses with an econometric approach were carried out using panel data for 1981, 1986, 1991, 1996, 2001, and 2006, covering 47 prefectures in Japan. To test the effect of HSR, first, the comparative analysis showed that prefectures with HSR service in Japan tend to be more productive than those without HSR. Next, regression analyses were conducted using ordinary least squared estimation model, fixed-effects model, and instrumental variable model. A number of HSR stations, the share of HSR distance, the share of HSR travel time, and agglomeration from HSR were employed along with other control variables. The results showed that the agglomeration has the significant positive association with the regional productivity while the network externalities also had positive associations although their significances are slightly weaker. They also unveiled the influence of HSR on economic productivity which is higher in the regions with HSR stations, particularly those located within 150-170 km radius from the largest cities rather than those neighboring the largest cities.

In the second section, analyses focus on the agglomeration impact in each industry in order to determine which industries display higher prospects for gains in case they are offered incentives along with the construction of HSR. The analysis assumes two types of agglomeration economies (urbanization agglomeration and localization agglomeration) in 11 industrial sectors and shares a similar dataset with analyses in the first section. Our results show that, on average, the indirect benefit of regional productivity improvement from localization agglomeration tends to be more significant than that from urbanization agglomeration. While the mining sector enjoys significant benefit from urbanization rather than localization agglomeration and the transportation/communication sector enjoys significant benefit from localization rather than urbanization agglomeration, finance/insurance, and real estate can benefit from both agglomeration economies. The results further reveal negative elasticities in the agriculture and service sectors; this could be partly due to the industries' characteristics. Co-agglomeration between different industries is also further investigated to determine which industries should be promoted together. Yet, the results yielded unpromising conclusions due to data limitation.

In the third section, agglomeration in the scope of specialization and diversity is investigated in order to answer two questions: first, to determine whether specialization or diversity promote economic productivity, and second, to determine whether HSR promotes specialization or diversity. Specialization agglomeration index based on the coefficient of variation of localization agglomeration is proposed to measure city's specialization and diversity. Analyses utilize the data of agglomeration across 17 industrial sectors in Japanese Municipality level. To answer the first question, the result reveals U-curve relationship when productivity is plotted in Y-axis and specialization agglomeration in X-axis. In other words, both specialization and diversity benefit to economic productivity. Yet, a city which is not specialized and not with a high level of industrial diversity will be the loser in the economy. For the second question, based on the assumption of a quadratic function, HSR could affect city's specialization and diversity based on the distance to HSR service. From the results, HSR promotes industrial diversity in the city with HSR service, and the city located around 540 km away from HSR service, while HSR promotes city's specialization in the city located around 270 km away from HSR service.

In the fourth section, migration impact from HSR service is investigated in order to answer the two questions: first, whether the presence of HSR service promotes population growth or not, and second, based on the concern in Thailand, whether HSR service promotes regional growth and prevents centralization Bangkok or not. Regression analysis is formulated assuming the presence of HSR station in the prefecture along with other socioeconomic factors affect migration. The analysis in this section utilizes the origin-destination migration data in Japanese prefecture-level from 1997 to 2009. The results show that the presence of HSR station in the destination prefecture has significant and positive effect while the effect in the origin prefecture is not significant. In other words, more migration towards the region with HSR station can be expected while it is still unclear that region without HSR station faces excess migration or not. To answer the questions, HSR promotes population growth, yet HSR cannot prevent centralization since other socio-economic factors such as level of urbanization, wage level, and unemployment have stronger significance and significance appears in both origin and destination.

Analyses in the case study of Japan from four sections reveal insight information in what condition agglomeration benefits economy, and how HSR promotes agglomeration. Yet, the most important lesson learned from Japan should go back to the fundamental that economic activity can be expanded by agglomeration benefit from HSR. Applying the lesson learned from Japan to Thailand, several implications can be drawn. From the first section, agglomeration benefit to productivity is also found in Thailand although the absence of HSR must be assumed. However, it should be emphasized that generated agglomeration benefit from HSR in Japan could be significantly higher than that in other countries because of the higher population density in Japan. Thus, HSR investment in Thailand should be considered carefully; population density in the service area of HSR should be one of the main considerations in the planning process of HSR in order to maximize the agglomeration benefit. Next, in the second section, as negative agglomeration impact is found in some industries, benefit from policies such as manufacturing and tourism service cluster promotion along with the HSR development might not be as high as expected. In the third section, the findings from Japan reveal that some industries with positive impact from agglomeration might relocate closer to HSR service, thus in Thailand, land use policy should be elaborated together with HSR plan for the preparation of such industrial relocation. The fourth section also suggests that with HSR, more monocentric growth can be expected in Thailand. Therefore, measurements to handle the influx of migrants toward Bangkok and the shrinkage in regional cities should be planned carefully.

Discussion for Further Issues

One of the strong assumptions in this study is that agglomeration is assumed to be explained by the sum of the ratio of employment in other zone and generalized cost of travel from such other zone to the zone in consideration (Eq.3-1). This assumption of "Effective Density" although proposed in some literature, yet it gives the unique definition of agglomeration as spatial unevenness is possible to be considered with agglomeration in this assumption. Considering how "Effective Density" can explain agglomeration, the numerator should be able to explain the total possible activity generated from other zone and the denominator should be the variable which describes the difficulty to prevent such activity to occur. Certainly, it is logical to assume the number of employees as the numerator and the generalized cost of travel as the denominator as both variables are all reflecting the concept given for Effective Density. However, in order to explain the productivity effect from agglomeration through effective density, it would be interesting to explain other types of agglomeration with different variables rather than employment and generalized cost of travel. For example, it would be sensible to explain productivity of manufacturing by agglomeration in the form of employment as manufacturing industry is one of the most labor-intensive industries. In contrast, employment may not be suitable to explain the agglomeration in finance industry as it is one of the most capital-intensive industries. Other variables such as the number of firms, the number of contracts or the value of capital stock could be applied as the numerator in Effective Density as well. Similarly, variable such as the internet penetration level could be used as the denominator instead of the generalized cost of travel to explain productivity in IT industry. Here, I want to state that the set of variable used in this study is just one of the possible assumptions. Other specifications should be further tested to uncover the effect of agglomeration in deeper details.

Another strong assumption assumed in this study is that Effective Density is assumed as a linear relationship between employment and generalized cost of travel. The assumption used in this study is the same specification as Intervening Opportunity (Stouffer, 1960; Galle & Taeuber, 1966) although agglomeration was not explicitly mentioned in the concept of Intervening Opportunity. Studies by Graham (Graham, 2007; Graham et al., 2009; Melo et al., 2013; 2016) directly utilized this specification to explain agglomeration. However, the difference to the assumption in this study is that Effective Density used by Graham and later in Wider Impact guideline allows the effect of the generalized cost of travel to be varied across industries. In other words, the effect of the denominator could be higher in some industry which has high elasticity to transportation cost and lower in some industry which location is not the main factor to its productivity. If the variation of the effect of the generalized cost of travel among industries actually exists, this study may give some bias estimation since the assumption has been relaxed in this study. Not only the denominator but the assumption of the numerator (employment), as well, could be different. The relationship between agglomeration and employment does not have to be linear; quadratic function or other variations could be assumed. If we consider Effective Density as a variation of Newton's law of universal gravitation, numerator could be assumed as a product of employment between concerning zone and other zones as well. Ultimately, other specifications apart from Effective Density could be applied to explain regional agglomeration. Further investigation is needed in order to find the best model to explain the agglomeration economy, especially in the context of the analysis across different industries.

Considering analyses from chapter 4 to 7, each chapter still have further interesting issues to be explored. In chapter 4, it is assumed that HSR related variables affect local productivity. However, extensive investment in expressway and airport across Japan can be observed during the analysis period simultaneously. Due to time limitation, I ignored the possible correlation between HSR and other transportation infrastructure effect. Further investigation is needed to clarify the effect between different transportation services especially whether they are supporting or competing with each other. Similarly in chapter 5, although I presented the agglomeration effect from both HSR and highway, yet more elaborate modeling is needed to separate the effect of passenger agglomeration and freight transportation since the correlation between those two parameters are highly suggested. Furthermore, the concept of co-agglomeration between industries is tested although the result is not promising. I believe that some industries when agglomerated together, they could support each other, or they could suppress each other, or they could be independent to each other. Therefore, in order to fully capture the concept of urbanization agglomeration given in Jacobs (1969), not only co-agglomeration between two industries but the effect of cross-industries agglomeration between every industry in the economy should be further investigated.

In chapter 6, I analyzed the effect of HSR on specialization/diversity agglomeration with cross-sectional data so only the spatial effect is included in this analysis. Indeed, the temporal effect should be also checked alongside with the spatial effect if the data is available. However, my dataset contains the data only from 2012-2014. Two years change may be too short to capture the temporal effect from HSR to specialization/diversity agglomeration. If the time-series data is available, it should be worth to investigate specialization/diversity agglomeration impact from HSR since HSR service could be one of the factors affecting firms' migration in long term. The migration impact is thus further investigated in chapter 7. Migration from the small town towards the larger city is confirmed. However, based on the expectation from Thai government that HSR will be one of the engines to distribute the growth from Bangkok to other regional big cities, HSR effect to migration based on the size of the city should be further investigated. From the result of this study, it can be interpreted that HSR is one of the factors that discourages people to migrate out regardless of the size of the city where HSR is located. However, migration effect from HSR could be varied across the size of the city, i.e., HSR in the small town might encourage more out-migration because HSR provides easier service for those people in the small town to move to the big city. Also, it is confirmed that the big city gains and the small town loses from migration, yet the result for the mid-sized city should be further explored, at least in order to check whether the expectation of the growth in regional big cities from Thai government is correct or not.

Although this study utilized the rich data of HSR from the case study in Japan, it should be noted that some unique characteristics of Japan might affect the result significantly. Especially agglomeration economy in Japan could be significantly higher than other countries mainly because of high population density along HSR corridor in Japan. The robustness of the result from the case study in Japan is addressed in the previous chapter, but it would be interesting to compare the result with similar analysis from other countries with HSR to compare the agglomeration and migration impact from HSR. Introduction of HSR requires a huge investment thus careful consideration regarding HSR impact is needed. Comparative analysis of HSR impact from various countries can be one of the supporting information for decision makers not only in HSR project but in other related infrastructure investments and policy implementations as well.

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