2013-2015 KOTI-EASTS SPECIAL RESEARCH PROJECT REPORT

International Comparison on High-Speed Railway Impacts and Station Area Development : Japan, Taiwan and Korea

KOTI THE KOREA TRANSPORT INSTITUTE

Eastern Asia Society for Transportation Studies 1994 EASTS

2013-2015 KOTI-EASTS Special Research Project Report

International Comparison on High-Speed Railway Impacts and Station Area Development: Japan, Taiwan and Korea

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The Korea Transport Institute (KOTI)

Eastern Asia Society of Transportation Studies (EASTS)

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Preface

The Korea Transport Institute (KOTI) and Eastern Asia Society for Transport Policy Studies (EASTS) started a joint research project "International Comparison on High-Speed Railway Impacts and Station Area Development: Japan, Taiwan and Korea" in 2013 as the first KOTI-EASTS Special Research Project. This project involved transport experts from the three countries, including Japan, Taiwan and Korea. The experts had discussions through a series of meetings: a kickoff meeting in Tokyo in August 2013, a special session at the EASTS conference in Taipei in September 2013, an international seminar in Seoul in November 2013 and at a symposium in Tokyo in July 2014. It was through these discussions that the contents of this joint research project came about.

It is well known that transport infrastructure investment has a close relationship with regional development. High-Speed Railway is likely to bring impacts on regional development as well. A railway station is not only a place for riding trains but is also emerging as a place for people's economic and cultural activities and a hub for regional development.

The year of 2014 is special, as it is the 50th anniversary of Shinkansen and the 10th anniversary of KTX. It would be meaningful to perform a cross-country comparison of the three countries in terms of their high-speed railway networks in order to draw practical lessons and recommendations.

This research project examines the various impacts of High-Speed Railway on transportation and regional development in the three countries including Japan, Taiwan and Korea. And also, it compares high-speed railway station area development of the three countries. The results of this research project present lessons and policy recommendations for high-speed railway's impacts and station area development in the future.

This is the final report of the KOTI-EASTS collaborative research project. We hope this report will be useful for future High-Speed Rail practices and studies.

Jaehak Oh
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Chapter 1

Introduction

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1.1 Background

High-Speed Railway (HSR) in Japan, Taiwan and Korea are expected to play an important role on the intercity transportation system for improving not only intercity transport services but also boosting regional economics, because of its potential of high-speed mobility and industrial growth.

The impact of HSR should not be limited to the improvement of transportation. The HSR may affect various aspects of our life such as economics, communication, employment and innovation.

Recently, the relationship between HSR and regional development has become an important issue. It is regarded that HSR is likely to induce socio-economic benefits. In addition, the HSR station area is emerging as a new hub of economic and cultural activities. Areas along HSR lines, especially near the stations, are expected to have higher land values because of their economic purposes such as offices, factories and residences.

The HSR network in Japan has been operating since 1964 and has had a substantial economic impact on Japan’s rapid economic growth up until 1973. The continuous network development of HSR has enabled the Japanese economy to grow steadily. Korea started its HSR service in 2004 and has continuously extended its network, to this day, about 40 cities are connected by KTX. Taiwan started its HSR service along the west coast corridor in 2007.

While, the networks of these three countries are similar in that each connect the capital city and other major cities, the time frame in which each network was developed and its economic impact in each country is different. Therefore, it is worth discovering both the similarities and differences on the impacts of HSR in the three countries.

1.2 Objectives

HSR has become widespread worldwide and appears to be the major mode for intercity transport. Countries in Europe and East Asia are leading this trend through the expansion of their HSR networks.

Railway stations and its surrounding areas are emerging as hubs for transport as well as spaces for influencing urban development and the regional economy. However, the potential and importance of railway station design and station area development are largely neglected, as there are only a limited number of studies available for assessing HSR impacts and station area development.

The purpose of this project is as follows. First, this project compares and analyzes the socio-economic impacts of HSR. Second, it analyzes the current conditions of station area development, performance and policies for increasing HSR demand and vitalizing the regional economy. And lastly, this project draws policy implications for station area development in Asian countries.

This project compares the progress, policies and performance that are relevant to HSR station area development of three countries: Japan, Taiwan and Korea. It is hopeful that this research would provide lessons and recommendations for HSR station area development practices.

1.3 Research scope and methodology

The scope of this research is as follows.

- Overview of HSR construction and operation
- Major transport and socio-economic changes as a result of HSR
- Case study on the urban and regional development of HSR station areas
- Comparison among three countries: Japan, Taiwan and Korea
- Implications and lessons

This study analyzes HSR impacts and successful factors for HSR station area developments based on the cases of Japan, Taiwan and Korea using the following two approaches.

The first is the country-based approach. In this approach, this study aims to obtain findings on HSR's impacts and successful factors for HSR station area developments from each county's experiences, as described in Chapters 2, 3 and 4.

The second is the comparative approach. From this approach, this study also aims to compare the three countries' cases and to generalize the features of HSR, as discussed in Chapter 5.

This research has collected all of the available data, and has strived to use a standardized format in order to offer a consistent cross-country comparison.

1.4 Structure of the report

According to the objectives, this report consists of the following five chapters.

Chapter 1 serves as an introduction and includes the objectives, scope, methodology and structure of this report.

Then each country's report follows. The case of Japan is discussed in Chapter 2, Taiwan in Chapter 3 and Korea in Chapter 4.

Chapter 5 serves as a conclusion and includes a comparative summary, policy recommendations and future studies in relation to this research.

The structure of this report is shown in Figure 1.4.1.

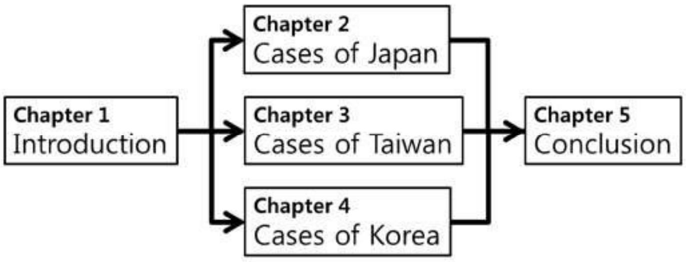

Figure 1.4.1 Structure of the report

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Chapter 2

Case of Japan

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2.1 Present conditions on HSR construction and operation

Japan has a half-century long history of HSR projects that emerged in 1964 as the first HSR in the world. As shown in Figure 2.1.1, Japan has been expanding its HSR network, "Shinkansen", during the past fifty years and is continuing to expand its network.

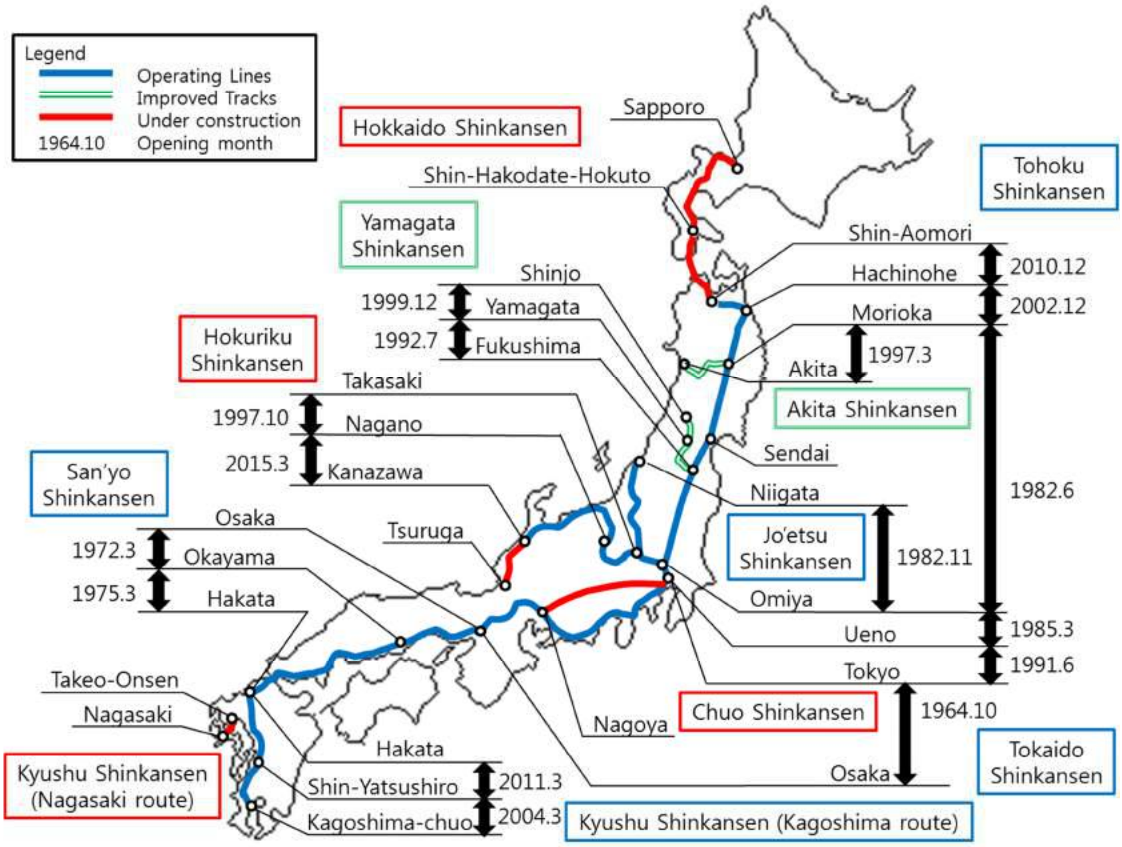


Figure 2.1.1 Shinkansen network (as of August, 2015)

The network reached Shin-aomori in 2010, which is located in the northernmost area in the main island of Japan, Kagoshima-chuo in 2011, which is located in southernmost area in Kyushu island (then an isolated section between Shin-Yatsushiro and Kagoshima-chuo was connected to the main Shinkansen network), and Kanazawa in 2015, as the first extension to Hokuriku district. In addition, three lines are under construction: the Hokuriku Shinkansen extension to Tsuruga, Hokkaido Shinkansen to Sapporo through Shin-Hakodate and Kyushu Shinkansen (Nagasaki route) to Nagasaki.

A new Maglev line called "Linear Chuo Shinkansen" is under construction as a next-generation HSR between Tokyo and Nagoya (286 km) led by the Central Japan Railway Company (JR central). It is planned at a maximum speed of 505 km/h. In addition, a route is also being planned between Nagoya and Osaka (152 km) as the "Chuo Shinkansen".

The network length has been growing as shown in Figure 2.1.2. There was a big jump with each decade since the 1960s. This means that new lines or extensions were constructed almost every ten years and the network's service was consistently being improved in terms of its connectivity.

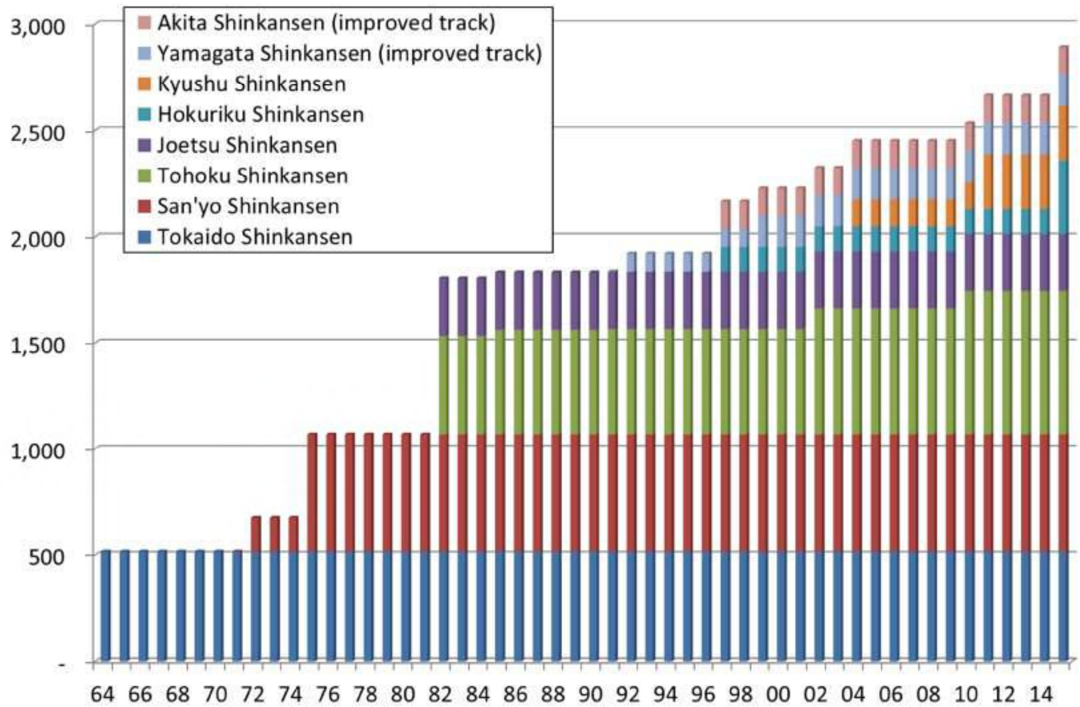


Figure 2.1.2 Shinkansen network length (km)[1]

Japan has a population of around 127 million, of which 47 million live in the Kanto District (Tokyo, Yokohama etc.), 21 million in the Kansai District (Osaka, Kyoto, Kobe etc.) and 11 million in the Chubu District (Nagoya etc.), concentrated along the Tokaido Shinkansen Line.

As of September 2015, the Shinkansen network is 2,892 km in length and made up of eight lines, consisting of two types of tracks: high speed tracks exclusively for Shinkansen (Tokaido, San'yo, Tohoku, Joetsu, Hokuriku and Kyushu Shinkansens) and improved conventional tracks (Yamagata and Akita Shinkansens) (see Table 2.1.1 and Table 2.1.2). That is, the Shinkansen runs not only on exclusive lines but also on improved conventional lines in limited areas.

[1] This Figure was made and updated based on Fig. 2.21 of Yai, et al. (2015)

Table 2.1.1 Present status of Shinkansen

Total length	2,892 km (including 276 km improved tracks)
HSR lines	● Tokaido Shinkansen ● San'yo Shinkansen ● Tohoku Shinkansen ● Jeotsu Shinkansen ● Hokuriku Shinkansen ● Yamagata Shinkansen* ● Akita Shinkansen* * Improved tracks (conventional lines) used for HSR
Opening year	1964
Number of stations	104, of which 12 are shared with conventional lines
Average interval to next stations	28.1 km (103 sections)
Maximum speed	320 km/h
Constructor	Japan National Railways (JNR) (Tokaido, San'yo and Tohoku Shinkansens, -1987) Japan Railway Construction Public Corporation (JRCC) (Joetsu Shinkansen) The Shinkansen Property Corporation (extension of Tohoku Shinkansen, 1987-1991) Japan Railway Construction, Transport and Technology Agency (JRTT) (2003-)
Owner	Japan National Railways (JNR) (-1987) The Shinkansen Property Corporation (1987-1991) East Japan Railway Company (JR East) (partly Tohoku and Joetsu Shinkansens), Central Japan Railway Company (JR Central) (Tokaido Shinkansen), West Japan Railway Company (JR West) (San'yo Shinkansen) (1987-), The Shinkansen Property Corporation/Japan Railway Construction, Transport and Technology Agency (JRTT) (partly Tohoku, Hokuriku, Kyushu Shinkansens, 1987-)
Operator	Japan National Railway (JNR) (-1987) East Japan Railway Company (JR East), Central Japan Railway Company (JR Central), West Japan Railway Company (JR West) (1987-), Kyushu Railway Company (JR Kyushu) (2004-)

Table 2.1.2 Operation status of Shinkansen by line

HSR Line	Number of trains per day*	Number of vehicles per train	Passenger capacity per train**	Average headway (minutes)***
Tohoku Shinkansen	83 (depart from Tokyo)	6, 10, 10+6, 10 + 7 (E5 & E6 connection) etc.	1,067 (731 + 336) (E5) (E6)	12.2 (6:04-22:44)
Joetsu Shinkansen	40 (depart from Tokyo)	10 or 16	1,634 (E4)	25.9 (6:08-23:00)
Hokuriku Shinkansen	41 (depart from Tokyo)	10 or 12	934 (E7)	24.8 (6:16-22:04)
Tokaido Shinkansen	134 (depart from Tokyo)	16	1,323	7.6 (6:00-22:47)
San'yo Shinkansen	98 (depart from Shin-Osaka)	8, 16	1,323 (N700 series)	10.8 (6:00-23:25)
Kyushu Shinkansen	59 (depart from Hakata)	6 or 8	542 (N700)	17.9 (6:10-23:31)
Akita Shinkansen (improved track)	16 (depart from Morioka for Akita)	7	336 (E6)	56.1 (7:58-22:30)
Yamagata Shinkansen (improved track)	16 (depart from Fukushima for Yamagata)	6 or 7	394 (E3)	54.5 (7:47-22:19)

*For weekdays. The numbers are not including specific day's schedule. So each number means at minimum and usually more trains are operated.

**Calculated based on each JR company's web information. Showing a maximum capacity if several cases of capacity.

***Average between the first train and the last train in a day using the number of trains per day.

Shinkansen vehicles have also improved during these fifty years. The first vehicles, which are referred to as type 0, could run at only 210 km/h in 1964. It took four hours between Tokyo and Osaka (550 km). In the next year in 1965, the travel time was soon improved to three hours and ten minutes between the two cities; however, it was in 1992 that the third generation vehicles, type 300, shortened the travel time to less than three hours at the speed of 270 km/h. Presently, the fastest train between Tokyo, Osaka and Fukuoka is type N700, which can run at 270 or 300 km/h, and takes two hours and twenty-five minutes between the two cities. The fastest speed between Tokyo and Aomori is 320 km/h.

Vehicles have not only been improved in terms of speed but also in terms of energy consumption. The current type N700 can run using only half as much electric power as that of the oldest type 0. This improvement was achieved through decreasing the weight of vehicles and improving motor and breaking systems. The type N700 boasts a higher recycle rate, with less weld body and less wear parts, which means that it is considered an environmentally sustainable HSR vehicle.

Figure 2.1.3 shows the trend in the number of passengers of the Shinkansen network. In the figure, Tokaido Shinkansen and San'yo Shinkansen are categorized together as part of the Shinkansen network. Ultimately, the number of passengers is related to the economic situation. The number increased during a comparatively-booming economy, such as from 2002 to 2006, while it decreased just after an economic shock as in 1994 or 2008. The changes are found especially in Tokaido and San'yo Shinkansens, which are used typically for business purposes as discussed in the following paragraph.

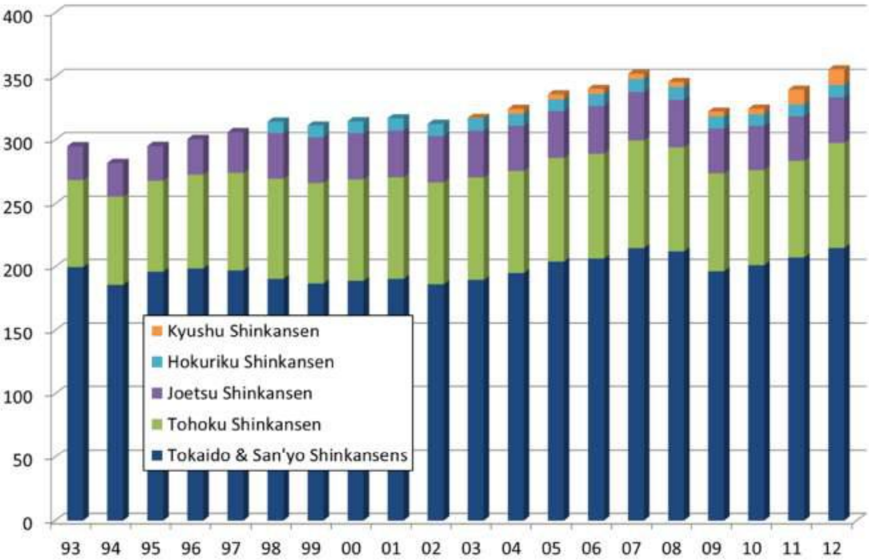


Figure 2.1.3 Trend in number of passengers (million people)[2]

Figure 2.1.4 shows the trip purpose percentages of Shinkansen passengers. One of the typical characteristics of the passengers of the Shinkansen network is trip purpose, of which the most prevalent is business on weekdays. Between Tokyo and Osaka, which are the two largest urban areas, more than 80% of passengers use the Shinkansen network for their business trips. Not only in the section of the network but also in most sections of the Shinkansen network, business is the most frequent purpose (more than half) for all passengers.

On the other hand, passengers' purposes on holidays differ from those on weekdays. Private is generally the most common purpose followed by sightseeing. Nevertheless, business takes up more than 20% of passengers' purposes. It is only between Tokyo and Osaka that business is still the most common purpose.

[2] Data source: Railway Bureau, MLIT (2011), Suujidemiru Tetsudo 2011, Institution for Transport Policy Studies; Railway Bureau, MLIT (2014), Suujidemiru Tetsudo 2014, Institution for Transport Policy Studies.

As a result, the Shinkansen network is used mainly for business on weekdays and for private and sightseeing purposes on holidays. Still, business is present as a major portion on holidays, which presents that business is one of the most significant characteristics of the Shinkansen network.

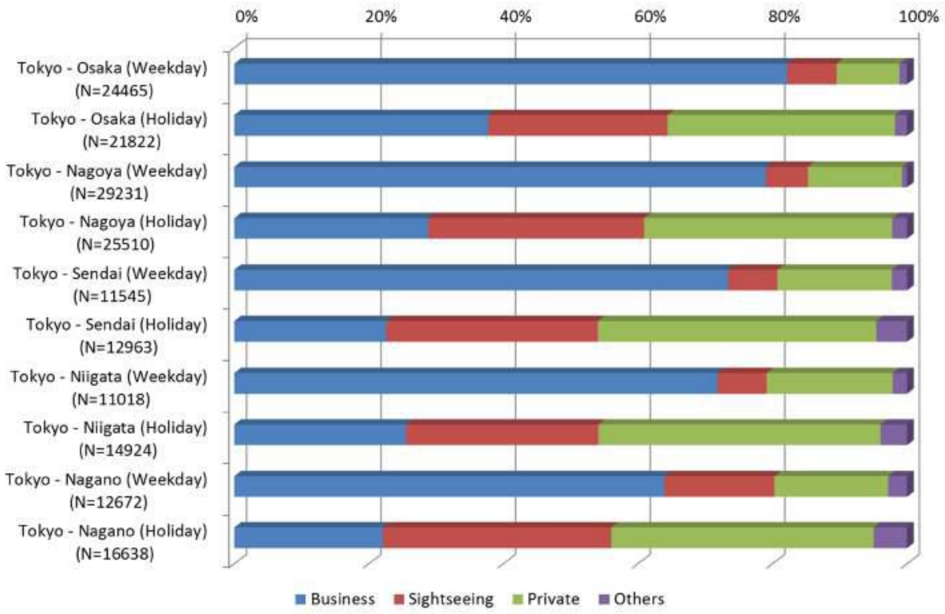


Figure 2.1.4 Trip purpose of Shinkansen passengers[3]

2.2 Qualitative and quantitative impacts of HSR

HSR generates substantial impacts on the regions serviced along the HSR network. For the economy, it affects industry, urban development, tourism, etc. At the same time, people's lifestyles are also affected in terms of employment, education, shopping, etc. It is important to note that regional potentials have to be upgraded to maintain greater impacts of HSR. It certainly shifts modal splits and reduces CO2 emissions; however, the modal share of HSR would decrease against that of air transport under the increase of time value, if technical innovations and service improvements are not made.

[3] Source: 2010 Inter-Regional Travel Survey in Japan. The sections names are by Shinkansen stations but the data are between Prefectures which include the stations. Tokyo means only Tokyo Metropolitan Prefecture.

There are two main kinds of impacts of the provision of a HSR service. One is the improvement of transportation services and the other is the opportunity for regional and urban development. A HSR service affects the growth of economy such as an increase of investment in the region, increase of visitors, expansion of the market of industries and increase of in-migration, e.g. population. It also affects changes in people's behaviors and inter-regional competition, which are important factors in the potential of each region.

Let us think about a principle for reducing disparity between metropolitan areas and peripheral areas. Metropolitan areas usually experience growth before that of peripheral areas. There are two kinds of effects between the two areas; A is the spillover effect of the metropolitan area to the peripheral area and B is the straw effect of the metropolitan area from the peripheral area. If A is larger than B, the disparity between metropolitan areas and peripheral areas will be reduced through the market mechanism. On the other hand, if A is smaller than B, the disparity between the areas will be widened. The latter case needs additional regional policies related to public investment, development financing, progressive taxation, a subsidy system, technical assistance and incentives for self-standing. Without these efforts by the central and local governments, HSR may have a negative effect on the peripheral areas.

Another issue is that the extension of mobility brings regional competition. When a HSR connects several cities, those cities are dropped in the regional competition which is driven by the market mechanism including commerce, culture, education, medicine and tourism. A city with an advantage may increase its population and economy, while a city with a disadvantage may suffer from a straw effect and be regarded as a passed city. In this context, a passed city can be defined as a city that loses its competitiveness, and therefore loses the opportunity for an increase in population and economy; in addition, a passed city refers to one without a HSR station, and is therefore 'passed' because it is not serviced by the HSR. A city with a HSR station has an advantage over the surrounding cities without HSR stations.

The competitiveness of an area is affected by demand for a commercial market, which is not only for business office space and buildings, but also for condominiums. It is also affected by the expansion of commercial market area, potential of a new station area, increasing number of visitors, impact of deregulations and a multiplier effect of investment and developments.

Here, we will discuss about the changes that occur in the level of transportation service as a result of a HSR network. Figure 2.2.1 shows changes in travel time before and after the operation of the Shinkansen service. Here, it shows that it took more than six hours between Tokyo and Osaka on the Tokaido conventional line before the Tokaido Shinkansen operated. The Tokaido Shinkansen dramatically decreased the travel time and has been shortening it further through technological improvements. Currently, the travel time is around two hours and twenty minutes. Therefore, the Tokaido Shinkansen has reduced travel time by more than 60% in the past fifty years. Similar to this situation, intercity travel time by railway has been dramatically decreased by at least 50% through the opening of the Shinkansen service.

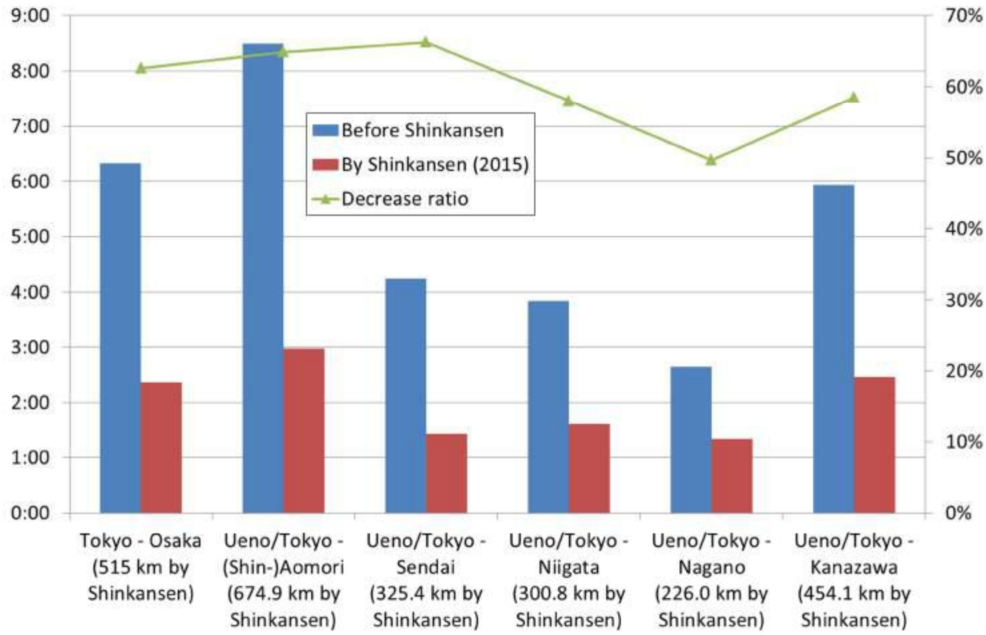


Figure 2.2.1 Comparison of changes in travel time between last conventional express train and Shinkansen

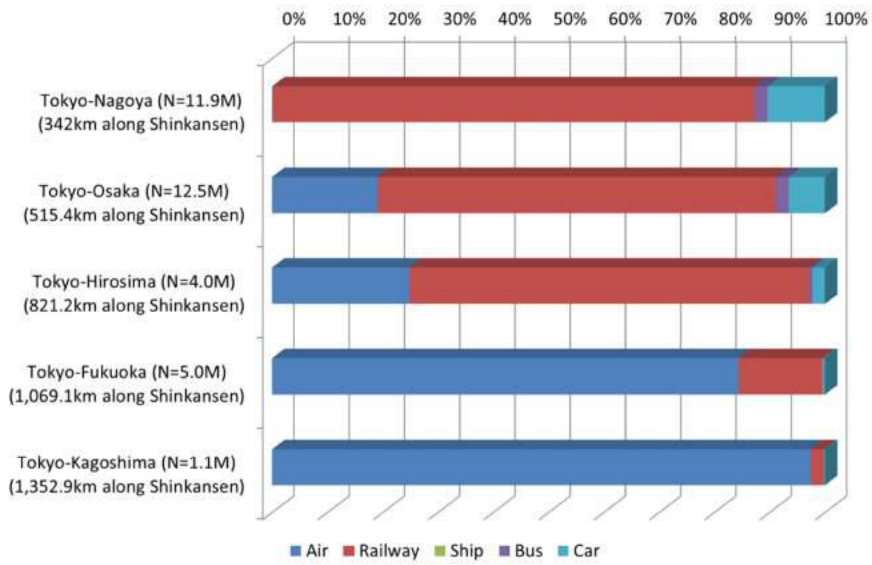


Figure 2.2.2 Modal split by distance from Tokyo[4]

Figure 2.2.2 shows the modal split of intercity transport by distance from Tokyo. To Nagoya,

[4] Source: 2010 Inter-Regional Travel Survey in Japan. The sections names are by Shinkansen stations but the data are between Prefectures which include the stations. Tokyo means only Tokyo Metropolitan Prefecture.

Osaka and Hiroshima, railway has the largest share of all modes. On the other hand, to Fukuoka and Kagoshima, railway loses its significant share and air has the largest. It is depicted that the farther the distance from Tokyo, railway has a decreasing share of modal split while that of air transport increases.

Between Tokyo and Hiroshima, it takes four hours by Shinkansen or a minimum of one hour and twenty minutes by air. But in order to take air transport, it takes an additional forty-five minutes each by bus from the city center to the airport, i.e. the origin and destination. On the other hand, between Tokyo and Fukuoka, it takes five hours by Shinkansen or one hour and forty-five minutes by air, whereby the airport is near the city center and can be easily accessed by subway. Therefore, the modal share of HSR is affected not only by distance or travel time on the HSR, but also by the total travel time including access and egress.

Figure 2.2.3 shows changes in modal split between Tokyo and Nagano Prefectures. The distance is 226 km between Tokyo and Nagano stations using the Shinkansen service.

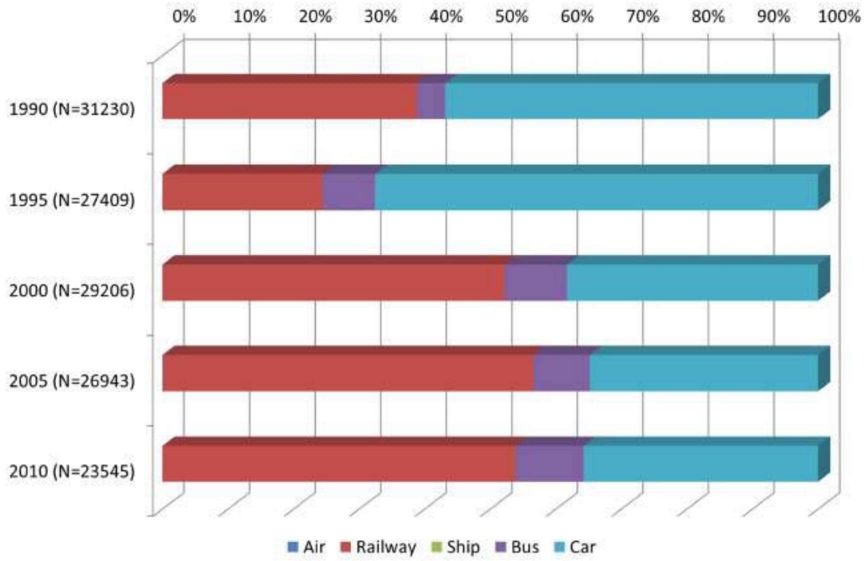


Figure 2.2.3 Change in modal split between Tokyo and Nagano Prefectures (226.0 km along Shinkansen)[5]

Due to the lack of flight or ship routes between Tokyo and Nagano, air and ship transport modes had no share between these two areas. In 1993, the expressway network was extended to Nagano. At that time, it seemed that many people changed their mode of transport from railway to road transport (bus and car). On the other hand, in 1997, the Hokuriku Shinkansen service began between Tokyo and Nagano stations. This dramatically improved the passenger transport

[5] Source: 1990, 1995, 2000, 2005 and 2010 Inter-Regional Travel Survey in Japan. The sections names are by Shinkansen stations but the data are between Prefectures which include the stations. Tokyo means only Tokyo Metropolitan Prefecture.

service, and therefore railway had a higher share after the Hokuriku Shinkansen's open. Throughout the years, it can be seen that the modal split of bus has remained roughly at the same level. That is, we can understand that the modal shift occurred from car to railway. With the opening of the Shinkansen service, railway has had the highest share of modal split at 50% between Tokyo and the Nagano Prefectures.

Now, let us take another example. Figure 2.2.4 shows changes in modal split between Tokyo and the Yamagata Prefectures.

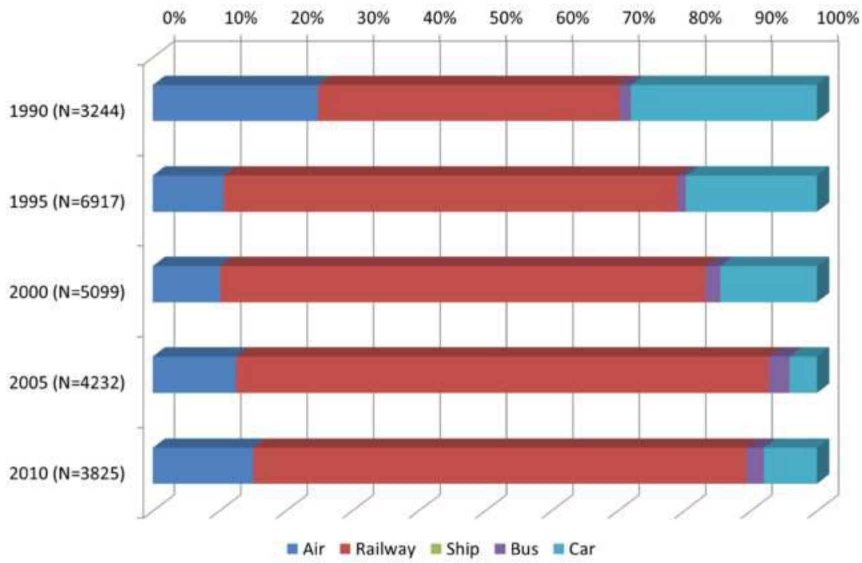


Figure 2.2.4 Change in modal split between Tokyo and Yamagata Prefectures (342.2 km along Shinkansen)[6]

The Yamagata Shinkansen shares its improved tracks with three rails with the conventional trains (this system is called "Mini Shinkansen"). Before HSR was opened in 1992, air and car transport modes also had significant shares of modal split while railway had the highest share of modal split. Yamagata Station has been connected to Sendai by a conventional railway route, where passengers had access to Shinkansen to Tokyo. In addition, the southern area in Yamagata Prefecture (for example, Yonezawa city) has been connected to Fukushima by a conventional railway route, which was improved for Shinkansen later. Therefore, even though passengers needed a connection by a conventional railway, they could have used Shinkansen to access Tokyo via Sendai or Fukushima.

However, after the Yamagata Shinkansen's open in 1992, the shares of modal split were dramatically changed. At first, some air transport users, especially those who used Yamagata

[6] Source: 1990, 1995, 2000, 2005 and 2010 Inter-Regional Travel Survey in Japan. The sections names are by Shinkansen stations but the data are between Prefectures which include the stations. Tokyo means only Tokyo Metropolitan Prefecture.

Airport, changed their modes to railway, using the Shinkansen service. Due to this modal shift, the air route between Tokyo and Yamagata Airport was once abandoned in 2001 (the route was later reopened by another airline company in 2002). On the other hand, there is one more airport (Shonai Airport) in the Shonai area, which is not covered by the Shinkansen service. In the case of the Shonai area, air users were not affected by the Shinkansen's open in terms of their mode of transport to and from Tokyo.

Furthermore, the number of car users dramatically decreased. It was 1991 when the expressway network was extended to Yamagata City from the Tohoku main corridor. This implies that HSR service had an advantage in terms of passenger transport at this level of distance of around 350 km (two hours and thirty minutes by Shinkansen) compared to that of car even if an improved-track HSR operated. This case shows the effect of a direct HSR service.

Figure 2.2.5 shows another case between Tokyo and the Akita Prefectures.

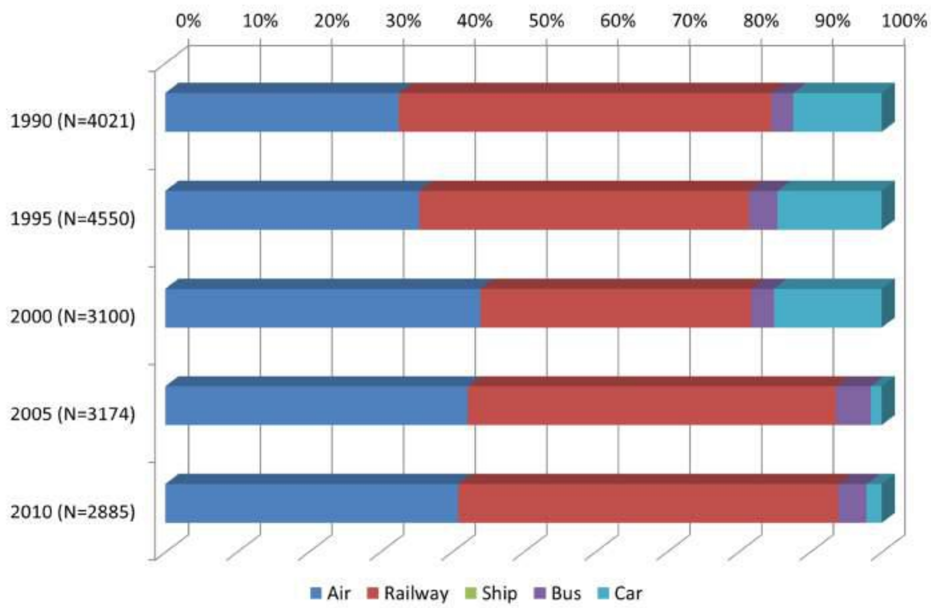


Figure 2.2.5 Change in modal split between Tokyo and Akita Prefectures (662.6 km along Shinkansen)[7]

Akita Shinkansen is also a "Mini Shinkansen" using improved tracks, similar to the Yamagata Shinkansen. The service was opened in 1997 but the modal split of railway seems to have decreased just after the opening. At the same time, a new airport (Odate Noshiro Airport) was opened in 1998 in the Akita Prefecture. Therefore, the figure reflects the modal split including both the new air and railway passengers using the new airport and Akita Shinkansen service in

[7] Source: 1990, 1995, 2000, 2005 and 2010 Inter-Regional Travel Survey in Japan. The sections names are by Shinkansen stations but the data are between Prefectures which include the stations. Tokyo means only Tokyo Metropolitan Prefecture.

2000.

Figure 2.2.6 shows the number of air passengers between Tokyo and Akita. It shows that a decrease in passengers after the Shinkansen's open in 1997. That is, the increase in the modal split of air transport was generated by the new airport, and even though the new airport generated air passengers, the modal split of railway has been increasing in the past ten years.

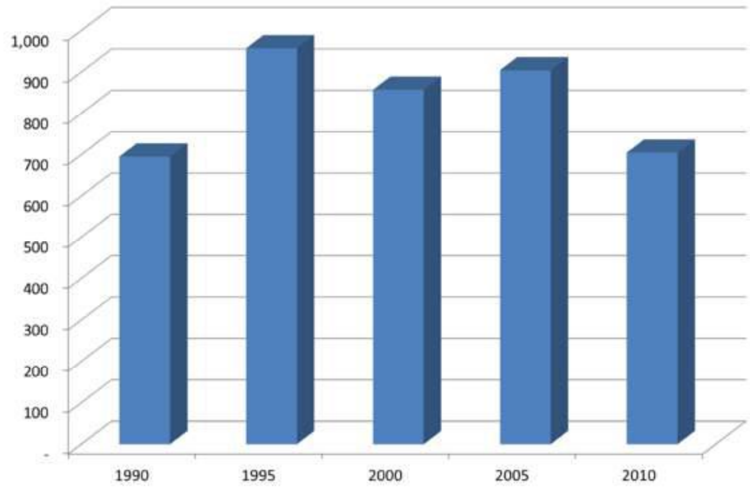


Figure 2.2.6 Number of air passengers between Tokyo (HND) and Akita (AKX)[8] (thousand passengers)

Here, Table 2.2.1 shows changes in several types of economic situations.

The first two cases show the economic impacts of a new HSR station. The first case shows a change in population in the Kohoku District in which the Shin-Yokohama Station is located in. In the district, residential lands were developed rapidly along with the Shin-Yokohama Station's open in 1964, the same time of the Tokaido Shinkansen's open. The district converted agricultural areas into residential areas. This is a typical and positive impact of HSR on the increase in population.

The second case shows a change in the market of the Karuizawa Station area where there exists a large shopping mall complex. The number of shops and sales amount of the shopping mall increased greatly after the Hokuriku Shinkansen's open in 1997. This is an example of HSR's impact on the expansion of a market.

The third case shows the economic impacts of the station redevelopment of Nagoya Station on the Tokaido Shinkansen. In this case, the station's surrounding area was developed with more floor space and a higher amount of sales. On the other hand, there was a smaller impact on the number of employees.

[8] Source: Survey on Air Transport by MLIT at http://www.mlit.go.jp/k-toukei/cgi-bin/search.cgi.

Table 2.2.1 Change in economic situation

Station (Shinkansen)	**Index (unit)**	**Before (Year)**	**After (Year)**	**Increase rate**
Shin-Yokohama (Tokaido)	Population in Kohoku District (thousand people)	147.7 (1960)	235.0 (1965)	59%
Karuizawa (Hokuriku)	Number of shops in outlet mall	30 (1995)	200 (2007)	567%
	Sales amount in outlet mall (100 million yen)	7 (1995)	315 (2007)	4,400%
Nagoya (Tokaido)	Sales amount (100 million yen)	2,694 (1997)	3,254 (2007)	21%
	Floor space (ten thousand m^2)	15.4 (1997)	21.7 (2007)	41%
	Number of employees (ten thousand people)	12.1 (1996)	12.3 (2006)	2%

The cases are further discussed in detail in Section 2.3 as examples of station area development projects.

2.3 Station area development projects and policies

Decision Making Process for Urban Development

There are four steps in the decision making process for urban development.

Step 1 is to decide the strategy for future urban structures. We have to think about regional potential and establish a master plan of the target area. The intentions of local governments cannot be neglected and there exists a need to examine the economic and financial feasibility of each development.

Step 2 is to choose a target zone to be developed. We have to consider desirable and possible land-use patterns and check the feasibility for each time frame. It is also important to see what kind of incentives and regulations are available and/or needed.

Step 3 is to select an institution for development. We have to select an individual institution for each infrastructure development, an institution for land readjustment and an institution for urban renewal. Zoning, land-use and building regulations should be altered in accordance with each development if necessary.

Step 4 is to implement the development projects. We have to decide who will implement each project among various developers and investors. It is necessary to get the agreement of land owners, residents and other stakeholders. The timing of developments is also important because the relationship between the demand of land and its price is critical for success due to the following reason. A land price is expected to be relatively lower soon after HSR is completed, even though it might be higher without the HSR. It means that the cost of development can be less expensive. The land price, however, will be higher in three to five years after the HSR is completed with some investments. The value captured from HSR-related developments has the potential to be huge in the long term.

Location of New Stations

There are three location types of new stations.

The first type is developing a new HSR station with a new urban development. This type contains only one HSR station in a brand-new location. The second type is developing a new HSR station in an area with existing or conventional railway. This type produces a new conventional railway station and a new HSR station. The third type is an expansion of an existing station in an area with a conventional railway. This contains the development of station buildings, a station plaza and a backyard of a station.

Let us explain the third type in further detail. An expansion of an existing station contains station buildings, a station plaza for feeder transport modes and accessibility and a backyard. When a station building is developed in a major city, we can expect business and commercial uses such as department stores, hotels, shops, etc. If it is constructed in a local city, we can expect services for passengers and public uses such as a town office, a library, day-cares/nurseries, etc. Whereas so called the front side of the station may be used for station buildings as mentioned before, a backyard of the station is usually used as a freight station, agriculture fields, a bright lights area and a residential area. Thus, urban renewal is needed so as to change those areas into office buildings, commercial areas and condominiums.

Japan's Experiences

In order to learn from Japan's experiences, eleven cases are chosen as examples, as shown in Table 2.3.1 and Table 2.3.2.

Table 2.3.1 Summary of the eleven case stations

Name of station	Number of trucks for HSR	Number of trains per day*	Number of passengers (thousand)	Type of stopping trains	Connection	Main city	City pop. (thousand) ******	Main industry *******
Tohoku Shinkansen								
Hachinohe	4	17 (for Tokyo)	3.6**	All types (partly skipped)	Conventional railway, bus	Hachinohe City	231.6	Mining, fishery, transport
Sendai	4	66 (for Tokyo)	26.6**	All trains	Conventional railway, subway, bus	Sendai City	1,055.0	Energy, real estate, education
Hokuriku Shinkansen								
Karuizawa	4	25 (for Tokyo)	3.4**	*Hakutaka, Asama* (partly skipped)	Conventional railway, bus	Karuizawa Town	20.2	Tourism, real estate
Sakudaira	2	24 (for Tokyo)	2.5**	*Hakutaka, Asama* (partly skipped)	Conventional railway, bus	Saku City	99.7	Agriculture, combined services
Tokaido Shinkansen								
Shinagawa	4	135 (for Shin-Osaka)	33***	All trains	Conventional railway, bus	Tokyo Metropolitan Area	13,474.5	Information, real estate, academic research and tech services
Shin-Yokohama	4	136 (for Shin-Osaka)	30.8****	All trains	Conventional railway, bus	Yokohama City	3,719.4	Information, real estate, academic research and tech services
Nagoya	4	133 (for Tokyo)	(199)***	All trains	Conventional railway	Nagoya City	2,282.2	Real estate, energy, wholesale and retail
Gifu-Hashima	6 (of which 2 are only for pass)	31 (for Tokyo)	2.8*****	*Hikari, Kodama* (partly skipped)	Conventional railway, bus	Hashima City	68.7	Manufacturing, construction
Kyoto	4	127 (for Tokyo)	34***	All trains	Conventional railway, bus	Kyoto City	1,468.8	Tourism, education, real estate
Shin-Osaka	8	127 (for Tokyo)	72***	All trains	San'yo Shinkansen, conventional railway, bus	Osaka City	2,697.7	Real estate, tourism, information
Kyushu Shinkansen								
Kagoshima-chuo	4	38 (for Hakata)	(20.4)***	Terminal	Conventional railway, bus	Kagoshima City	605.7	Medical, wholesale and retail, finance

(The annotations are on the next page.)

* For weekdays. The numbers are not including specific day's schedule. So each number means at minimum and usually more trains are operated.
, * People only getting on per day. Source: each JR company. ** as of FY2014. *** as of FY2013. ( ) includes JR's conventional railway passengers.
**** Source: Kanagawa Prefecture Web. FY2013. ***** Source: Hashima City Web. FY2013.
***** Source: each city/town web. For Tokyo Metropolitan area and Saku, Nagoya, Kagoshima cities are as of July 1. For others, as of August 1.
****** Two industries which ratios of the number of workers in each city/town compared to those in the national average are largest. Calculated based on National Population Census 2010.

Table 2.3.2 Classification of the eleven cases for the three location types of new stations

Location type	Case No.	Station name	Shinkansen	Urbanized / agricultural area when the Shinkansen station was built
A new HSR station with a new urban development	1	Gifu-Hashima	Tokaido	Agricultural
A new HSR station at an existing or conventional railway	2	Shin-Yokohama	Tokaido	Agricultural
	3	Shin-Osaka	Tokaido and San'yo	Agricultural
	4	Sakudaira	Hokuriku	Agricultural
An expansion of an existing station on a conventional railway	5	Shinagawa	Tokaido	Urbanized
	6	Nagoya	Tokaido	Urbanized
	7	Kyoto	Tokaido	Urbanized
	8	Sendai	Tohoku	Urbanized
	9	Hachinohe	Tohoku	Urbanized
	10	Karuizawa	Hokuriku	Urbanized (resort)
	11	Kagoshima-chuo	Kyushu	Urbanized

Case 1: Gifu-Hashima Station – A new HSR station with a new urban development

Gifu-Hashima Station was opened in 1964 as a new station on the Tokaido Shinkansen. When Tokaido Shinkansen was being designed, there were some route alternatives between Nagoya and Osaka. Of these, one was to connect Nagoya and Osaka relatively linearly but the presence of big mountains served as an obstacle and a technical difficulty. Another was to stop at Gifu city, which is the most developed urban area in the Gifu Prefecture, but this alternative would create a detour in the route. Finally the route was decided as what is today, that is, avoiding the difficult mountains and also being far from the urban area of Gifu city. Gifu-Hashima Station was built along this route.

Gifu-Hashima Station area was just an agricultural area and where plans for land development were limited. This caused a delay for land development, urban sprawl around the station and also for the construction of a connecting railway. Therefore, the land-use around the Gifu-Hashima Station has not been intensified. In addition, the access to Gifu-Hashima Station had been limited to road transportation until a new private railway (Meitetsu Hashima Line operated by Nagoya Railroad) was opened to connect the station with the urban area of Gifu city in 1982. Public use and service for passengers has been very limited in and around the station.

Based on the discussion above, this is an example of a problematic case.

(1967)

(2006)

Figure 2.3.1 Gifu-Hashima Station area[9]

Case 2: Shin-Yokohama Station – A new HSR station at an existing or conventional railway

Shin-Yokohama Station was opened in 1964 as a new station on the Tokaido Shinkansen at the same time being part of the existing Yokohama Line, which has been a conventional railway. In spite of being located in an agricultural (especially a flood reservoir) area when the station was built, the station area was developed rapidly as a new business district with a new subway line after the Shinkansen service was opened. However, almost 40 years after the opening of the Shinkansen service, the station area needed to be redeveloped taking advantage of the convenience of being a traffic terminal of the Shinkansen service because of the need for a wider area and for the expansion of various functions such as business and commerce.

In 2003, JR Central and Yokohama City Government cooperatively decided on establishing a comprehensive city redevelopment plan. The most notable cooperation was the exchange of land between Yokohama City and JR Central. JR Central rebuilt and expanded the station building, while Yokohama City rebuilt the station plaza, a bus terminal, a passage between stations of JR and the subway, a pedestrian deck and a park. As a result of this redeployment of

[9] Source: Geospatial Information Authority of Japan, aerial photograph MKK672X-C1B-13 taken in 1967 and CCB20062X-C8-12 in 2006.

the station buildings, well-designed station facilities were developed.

Table 2.3.3 Timeline of the development of Shin-Yokohama Station

(Month) Year	Event
1964	Opening of Shin-Yokohama Station
1968	Double lined of Yokohama Line
1985	Connected from Yokohama Station by subway
1993	Connected through suburb areas by subway
2003	Decision of comprehensive city redevelopment plan
July 2005	Start of redevelopment of station building
August 2005	Change of city plan for pedestrian deck
March 2008	Opening of traffic square and walk-through
November 2008	Opening of pedestrian deck
March 2009	Completion of the project

(1966)

(2008)

Figure 2.3.2 Shin-Yokohama Station area[10]

In line with the development, a "twin core" has been formed with Yokohama's city center by promoting a suitable center for the big city that can accommodate its overall functions. In addition, a new subway line is under construction connecting three existing railway lines between Yokohama and Tokyo through the Sin-Yokohama Station.

In this case, the simultaneous land development and the delay of land-use was a significant factor in the successful and sound development of the station area.

[10] Source: Geospatial Information Authority of Japan, aerial photograph MKT668X-C1-8 taken in 1966 and CKT20072-C19-17 in 2008.

Case 3: Shin-Osaka Station – A new HSR station at an existing or conventional railway

Shin-Osaka Station was opened in 1964 as a new station on the Tokaido Shinkansen at the same time existing on the Tokaido Line, which has been a conventional railway. One month prior to the open of the station on the Shinkansen service, the Osaka Subway Line started to operate at the Shin-Osaka Station. In spite of being an agricultural area when the station was built, the station area was developed rapidly with a new business district and a new town (Senri New Town) development almost simultaneously with the start of the Shinkansen operation. In addition, the urban expressway was connected to the Shin-Osaka station area. Furthermore, a new railway line was connected to the existing subway directly at Shin-Osaka, following this the Senri New Town was connected through Shin-Osaka to the central area of Osaka by railway.

As described, the simultaneous development has made the Shin-Osaka Station area well-developed. From this viewpoint, this case is a successful example of the development of a new HSR station at an existing conventional railway.

Case 4: Sakudaira Station – A new HSR station at an existing or conventional railway

Sakudaira Station opened in 1997 as a new station on the Hokuriku Shinkansen service (called “Nagano Shinkansen”) at the same time on the existing Koumi Line, which has been a conventional railway. The Koumi Line was a ground-level railway service around the station but the newly Hokuriku Shinkansen also needed to be built at the ground-level because of slope levels near the station. After, the Koumi Line was elevated over the new Shinkansen service.

Table 2.3.4 Redevelopment Project around Sakudaira Station Area

Enforcement	Saku City
Area	About 60 ha
Period	From 1994 to 2002
Project cost	8.5 billion yen
Number of landowners	217 people
City planning decision	In 1995
Modifications	In 1996, 1997, 1999 and 2002
Public facilities in the area	● Road: 14,660.3 m − City planning road: 4,527.4 m − Compartment road: 7,249.0 m − Special road: 2,883.9 m ● Park: 7 places (18,093 m^2) ● Balancing reservoir: 3 places (6,383.39 m^2)

In conjunction with the Hokuriku Shinkansen’s opening, the area’s local government (Saku City) enforced a redevelopment project around the Sakudaira Station area (see Table 2.3.4). Prior to the project, the area was agricultural, but the project redeveloped the land-use into both commercial areas and condominiums. As a result, more than sixty buildings were built in the

Sakudaira Station area during the ten years after the Shinkansen service was opened. The number of commuters doubled from 1998 to 2001.

Also in this case, the simultaneous land development and the delay of land-use were significant factors in the success of the HSR station area development.

Case 5: Shinagawa Station – An expansion of an existing station on a conventional railway

Shinagawa Station was opened in 1872 as one of the oldest stations in Japan on the conventional Tokaido Line. Tokaido Shinkansen had been built through the Shinagawa Station area when it opened in 1964, but it did not have a station in Shinagawa. However, the Tokaido Shinkansen service needed more convenient access especially from the west side of Tokyo. Finally, a new Shinagawa Station was built on the existing Tokaido Shinkansen in 2003, which was around forty years after the start of the operation of the Shinkansen service.

Before the Shinagawa Station was built on the Tokaido Shinkansen, the station area had already been developed as an urbanized area especially in the west side. However, it had a former freight railway space nearby and an industrial area in its surroundings on the east side. Therefore, the station area had an advantage in utilizing the empty lots.

With the new Shinkansen Station building, the station area was redeveloped. As a result, the station area was renewed as a big business district and green spaces and became one of the most developed business areas in the central Tokyo.

In this case of Shinagawa, the simultaneous development has made the station area well-developed. From this viewpoint, this case is also a successful example.

Case 6: Nagoya Station – An expansion of an existing station on a conventional railway

Nagoya Station was opened in 1886 on conventional lines. When the Tokaido Shinkansen service started operations in 1964, a new station was also opened on the Shinkansen service in an area that was already urbanized.

There were former freight railway spaces near the Nagoya Station, which was an advantage in the development of the station area. Also, the west side ("back area") was a low-density area while the east side of the station ("front area") was already a business district. Both sides were developed as business and commercial areas. However, land adjustment was in fact limited in the development of the station area. In addition, station and station plaza developments were limited.

The station itself was developed greatly. In 2000, twin towers were opened as the station buildings. Afterward, several office buildings were built in the station's surrounding areas.

However, the surrounding area did not welcome the benefits brought by the station area development. Table 2.3.5 shows changes in sales amount and in floor space in the Nagoya Station area and Sakae area, which is the business center of Nagoya and close to Nagoya Station. By the Nagoya Station area development, a sales amount was increased in the Nagoya Station area but decreased in the Sakae area between 1997 and 2007. Also, floor spaces were increased by 40% in the Nagoya Station area but only by 8% in the Sakae area.

Table 2.3.5 Development impacts of Nagoya Station Area

	Nagoya		**Sakae**	
	1997	**2007**	**1997**	**2007**
Sales amount (billion yen)	269.4	325.4 (+20.8%)	537.7	510.9 (-5.0%)
Floor space (thousand km^2)	154	217 (+40.9%)	317	341 (+7.6%)

(1971) (2007)

Figure 2.3.3 Nagoya Station area[11]

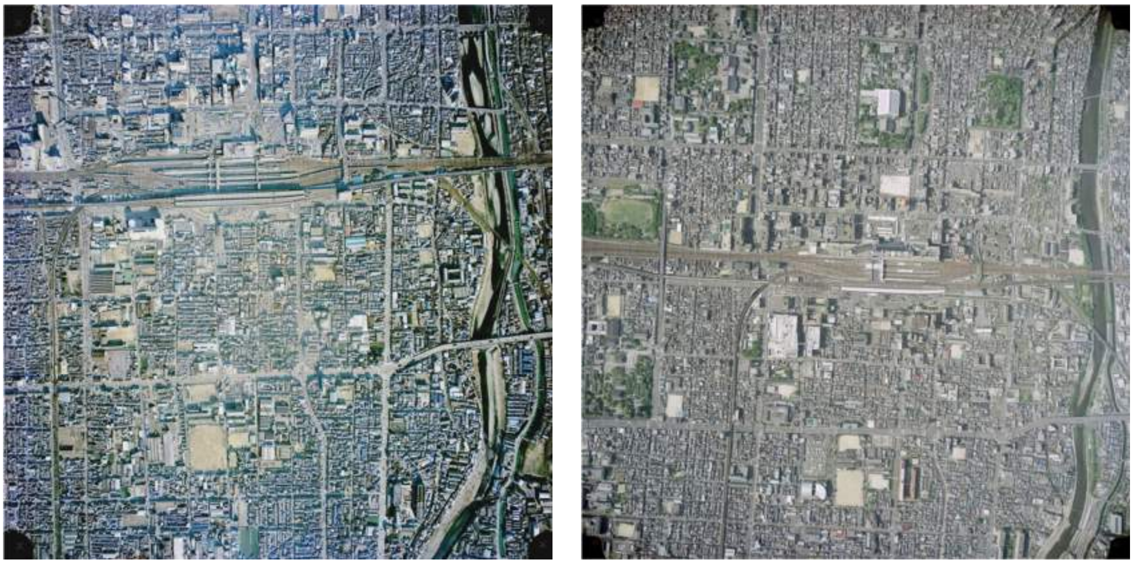
In this case, the station area itself was well-developed but the development did not have spillover effects on the station's surrounding areas. From this viewpoint, the urban renewal was not maximized.

[11] Source: Geospatial Information Authority of Japan, aerial photograph MCB716-C6-10 taken in 1971 and CCB20072-C2-45 in 2007.

Case 7: Kyoto Station – An expansion of an existing station on a conventional railway

Kyoto Station was opened in 1877 on a conventional line connected to Osaka and Kobe. Similar to the case of Nagoya Station, it became one of the Shinkansen stations in an urbanized area when the Tokaido Shinkansen service started its operations in 1964. After the privatization and separation of Japan National Railways in 1987, the Tokaido Shinkansen was owned and operated by JR Central while the JR conventional lines by JR West in and around Kyoto Station.

Kyoto Station was located a short distance away from the city center (old downtown). Therefore, the Kyoto station area was not very well-developed. But in the 1990s, the Kyoto Station building was redeveloped.



(1975) (2008)

Figure 2.3.4 Kyoto Station area[12]

The station redevelopment project was implemented only by JR West. A new station building was opened in 1997 as a terminal and a facility complex with a total surface area of 238,000 m^2 made up of sixteen floors and three basement floors, consisting of a 12,000 m^2 terminal, a 70,000 m^2 hotel, 88,000 m^2 of commercial facilities, 11,000 m^2 of cultural facilities, 37,000 m^2 parking areas and 38,000 m^2 public facilities. The building has a height, width and length of 60 m, 470 m and 80 m, respectively.

As a result of this big-scale project, Kyoto Station has been experiencing an increase in users. However, the redevelopment was not a united redevelopment, that it was not accompanied by a redevelopment of the surrounding areas. Consequently the station cannot play a role as a base for regional development. From this viewpoint, this case is evaluated as same as Nagoya Station.

[12] Source: Geospatial Information Authority of Japan, aerial photograph CKK7415-C9-14 taken in 1975 and CKK20081-C21B-14 in 2008.

Case 8: Sendai Station – An expansion of an existing station on a conventional railway

Sendai Station was opened in 1887 on a conventional line. When the Tohoku Shinkansen service started its operations in 1982, a new station was also opened on the Shinkansen. The station area was already urbanized.

This case is a successful example from the viewpoint of a simultaneous land development and a delay of land-use.

(1984) (2013)

Figure 2.3.5 Sendai Station area[13]

When the new station for the newly opening Shinkansen service was planned, the existing station needed to keep the right-of-way of the Shinkansen service. In order to do this, the existing station was relocated and reconstructed. The site for storage tracks was converted to one for commercial and amusement facilities. After such land developments, both (east and west) sides of the station were renewed with station plazas. Especially the east side of the station, which is still being redeveloped for businesses, commercial uses and a hotel complex. This redevelopment is implemented by JR East on the land owned by the company. Sendai City also implements the station area redevelopment projects for station plazas and walk-through paths between both sides in addition to JR East's project.

With the land developments, one subway line was opened through Sendai Station and another subway line is under construction which is also through Sendai Station. One of the conventional lines was relocated underground. Additionally, an airport access line was opened using one of

[13] Source: Geospatial Information Authority of Japan, aerial photograph CTO842-C6-18 taken in 1984 and CTO201311-C15-14 in 2013.

the existing conventional lines.

As described above, the Sendai Station area was developed with a simultaneous land development, a delay of land-use and through the relocation and reconstruction of the existing station and a railway line, as harmonized and integrated developments.

Case 9: Hachinohe Station – An expansion of an existing station on a conventional railway

Hachinohe Station was opened in 1981 (which was then called Shiriuchi Station) on a conventional line. When Tohoku Shinkansen was extended from Morioka to Hachinohe in 2002, a new station was opened on the Shinkansen service.

Hachinohe Station is located about 5 km away from downtown Hachinohe. For this reason, not many business or hotel facilities were developed in the station area. Land adjustments were limited and it was not necessary to enhance the station and station plaza.

This case is an example of the limited impacts of an urban structure.

Case 10: Karuizawa Station – An expansion of an existing station on a conventional railway

Karuizawa Station was opened in 1888 on a conventional line. When the Hokuriku Shinkansen service started its operation in 1997, a new station was also opened on the Shinkansen network. The station area was already urbanized, especially as a resort area. For example, there have been many cottage areas in the Karuizawa district, where people could enjoy tennis in the summer and skiing in the winter.

This case is an example of a development led by a private company. The south side of the station has large facilities such as outlet malls or the Prince Hotel, etc., attracting customers, while the north side has a shopping street (old Karuizawa). Developments such as shopping malls and ski areas by private companies are one of the important factors for attracting customers through the year.

Before the Shinkansen service's open in 1995, there were only 30 shops in the station area. Recently, however, there are more than 200 shops in the area. In addition, sales amounts of outlet malls have been rapidly increasing as shown in Figure 2.3.6.

In Karuizawa, the local government did not execute any large-scale city planning projects, but private companies have developed the station area well. As a result, private developments have highly contributed to the station area development.

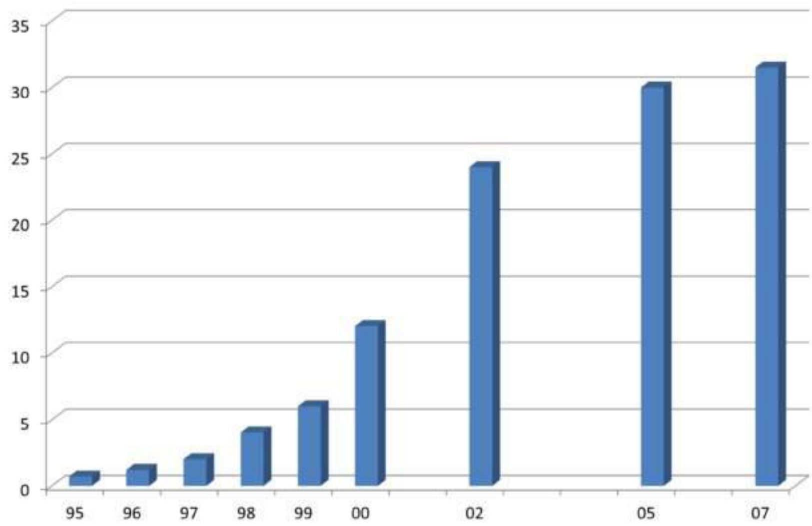


Figure 2.3.6 Sales amount of the outlet mall in Karuizawa (billion yen)

Case 11: Kagoshima-chuo Station – An expansion of an existing station on a conventional railway

Kagoshima-chuo Station opened in 1913 (which was then called Take Station, and later, Nishi-Kagoshima) on a conventional line. When the first phase of Kyushu Shinkansen was opened between Shin-Yatsushiro and Kagoshima-chuo, a new station was opened as Kagoshima-chuo.

Kagoshima-chuo Station is the main terminal in Kagoshima city. In the site of the station, many shops form a big shopping complex. However, the station area has not been well-developed because of limits to land adjustment and the station and station plaza's development.

This case is also an example of the limited impacts of an urban structure.

Summary

In order to achieve an effective HSR development for regional society, different strategies should be taken in consideration of the location of railway station. There are three kinds of stations: the expansion of existing railway stations, new stations on the existing railway and new stations.

There should be some developments along with HSR such as new station buildings, station plazas and access roads; master plan for land adjustment and land-use; and urban renewal projects.

We should analyze the feasibility, consensus of stakeholders and the strength of leadership.

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Chapter 3

Case of Taiwan

3.1 Present conditions on HSR construction and operation

The rapid economic development in Taiwan during 1980 and 1990 placed a heavy burden on its regional transport infrastructure, particularly along the western Taiwan corridor. While the western Taiwan corridor only has an area of about 25,600 km^2, 95% of Taiwan's population of 23 million is concentrated there. The high average population density of 750 persons/km^2 along the corridor and the increasing car ownership due to the growing per capita income has caused serious traffic congestion along intercity highways. The existing narrow gauge railway has a maximum design speed of 120 km/h and has continuously lost its competitiveness due to the entrance of other modes. The short intercity distances in Taiwan and limited capacity of its domestic airport have constrained the development of the domestic air transportation market.

Figure 3.1.1 Taiwan HSR network

The Ministry of Transportation and Communications (MOTC) in Taiwan commissioned a HSR feasibility study in 1989, which suggested Taiwan needs a HSR through the approach of central government ownership and management. The Cabinet approved the plan in 1992. However, it was rejected by the legislators because they feared the cost be overrun by the government. In 1994, Taiwan's government decided to build the HSR using the build-operate-transfer (BOT) scheme. Without profound legal support, a BOT project cannot be smoothly implemented. With this realization, the MOTC proposed a special law "Statute for Encouragement of Private Participation in Transportation Infrastructure" for HSR and it was approved by Legislative Yuan and promulgated by the president in December 1994.

Based on the law, a two-stage process was conducted to select bidders. The first stage was to determine whether bidders were qualified to carry out the project based on their qualifications and the second stage was to decide the optimal bidder through negotiations and selection processes. There were two private investors, Taiwan High Speed Rail Consortium (THSRC) and China Development Corporation that participated in the bidding process. Both of them were qualified in the first stage but THSRC won the bidding. The conclusion was that THSRC will pay for the total construction cost of 15.6 billion USD including minimum scope and optional scope, while the government be responsible for 3.2 billion USD of defined government works such as land acquisition and co-constructed section. Part of the agreement is that the government gives the THSRC a thirty-five-year concession period to build and operate the HSR network and fifty years to develop and operate station enterprise development land. After the expiration of concession periods, THSRC will transfer the operation assets back to the government.

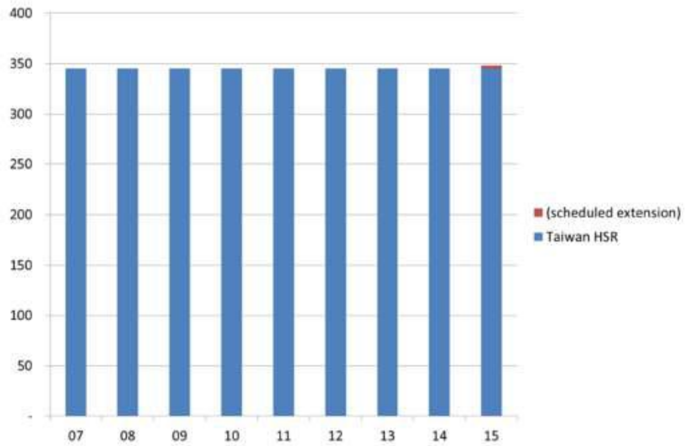


Figure 3.1.2 Taiwan HSR network length (km)

Table 3.1.1 Present status of Taiwan HSR

Total length	345 km
HSR lines	● Taiwan HSR
Opening year	2007
Number of stations	8, of which all are independent from conventional lines
Average interval to next stations	49.3 km (7 sections)
Maximum speed	300 km/h
Constructor	Taiwan High Speed Rail Corporation (THSRC) (BOT)
Owner	Taiwan High Speed Rail Corporation (THSRC) (BOT)
Operator	Taiwan High Speed Rail Corporation (THSRC) (BOT)

Table 3.1.2 List of stations on Taiwan HSR (as of 2015)

Name of station*	Number of tracks for HSR	Number of trains per day	Number of passengers (million)[14]	Type of stopping trains	Connection	Main city	Main city's population (thousand)	Main industry
(Nangang)	---	---	---	---	Rail, metro, bus, road	Taipei City	2,704.1 (2015.1)	Commerce, services
Taipei	4	126	27.2	All				
Banqiao	4	125	6.3	Almost all		New Taipei City	3,967.6 (2015.1)	
Taoyuan	4 (of which 2 are only for pass)	78	8.7	Local (and one rapid)	Bus, metro (2016), bus, road	Taoyuan City	2,061.5 (2015.1)	Manufacture, international business
Hsinchu	4 (of which 2 are only for pass)	77	8.9	Local	Rail, bus, road	Hsinchu City	432.2 (2015.1)	High-tech industries
(Miaoli)	4 (of which 2 are only for pass)	---	---	---	---	Miaoli City	90.9 (2015.1)	Agriculture, tourism
Taichung	6 (of which 2 are only for pass)	128	18.0	All	Rail, bus, road	Taichung City	2,721.7 (2015.1)	High-tech industries, commerce, services
(Changhua)	4 (of which 2 are only for pass)	---	---	---	---	Tianzhong Town	42.7 (2015.1)	Agriculture, tourism
(Yunlin)	4 (of which 2 are only for pass)	---	---	---	---	Douliou City	108.1 (2015.1)	Agriculture, tourism
Chiayi	4 (of which 2 are only for pass)	71	4.7	Local and some of rapid	Bus, road	Chiayi City	270.9 (2015.1)	Agriculture, tourism
Tainan	4 (of which 2 are only for pass)	71	6.7	Local and some of rapid	Rail, bus, road	Tainan City	1,884.6 (2015.1)	High-tech industries, agriculture
Zuoying	6	117	15.6	All	Rail, metro, bus, road	Kaohsiung City	2,779.4 (2015.1)	Manufacture, commerce, services

*The stations in parentheses will be in operation after 2015 and are not discussed in this study.

THSRC was renamed as the Taiwan High Speed Rail Corporation (THSRC) after it won the BOT competition and signed the BOT agreement with the Bureau of High Speed Rail (BOHSR) in 1998. THSRC won the BOT contract with its partners of the Euro-Train consortium. However, THSRC adopted the Japanese system later due to technical reasons such as safety record of zero accidents and for political reasons. The Taiwan HSR commenced operations in January 2007. It opens a new chapter in the story of Asian HSR development after Japan and Korea. Figure 3.1.1 presents the route, stations and profile of Taiwan's HSR. As shown in

[14] The sum of inbound and outbound. Data of 2014. Source: Ministry Of Transportation and Communication R.O.C., Passenger Counts for Taiwan High Speed Rail, http://stat.motc.gov.tw/mocdb/stmain.jsp?sys=220&ym=9600&ymt=11000&kind=21&type=1&funid=b220102&cycle=4&outmode=0&compmode=0&outkind=1&fldlst=11&codspc0=0,9,&rdm=Vo6fijY9

Figure 3.1.2, the total length of HSR is 345 km, of which viaducts and bridges are 251 km, tunnels are 52 km and cut and fill are 42 km in length. The reason to have this high proportion of viaduct is mainly because Taiwan's HSR aims to ensure the exclusive right-of-way in the suburban area and partially because it wants to avoid the building tear down and dislocation in the existing built-up area. It will take about ninety minutes from Taipei to Zuoying (Kaohsiung) with a maximum operation speed of 300 km/h. The HSR is currently serving eight stations (Taipei, Banciao, Taoyuan, Hsinchu, Taichung, Chiayi, Tainan and Zuoying) and will serve further four stations (Nangang, Miaoli, Changhua and Yunlin) successively after 2015 (see Table 3.1.1 and Table 3.1.2).

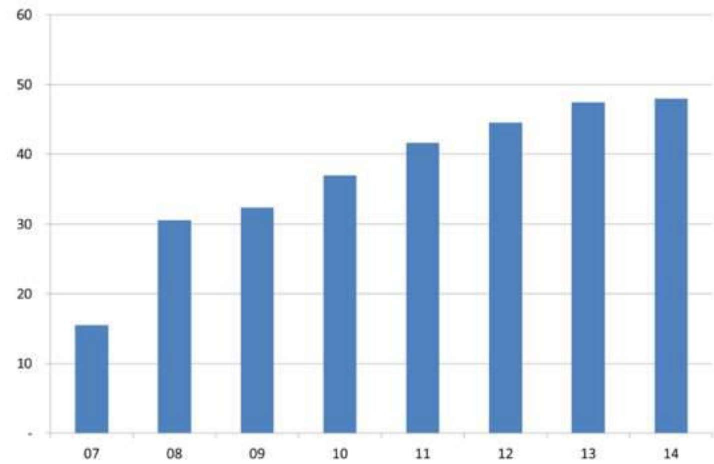


Figure 3.1.3 Trend in number of passengers of Taiwan HSR (million people)[15]

THSRC has carried about 300 million passengers from the start of operations on 2007 to 2014 (see Figure 3.1.3). Also the Taiwan HSR has recently covered 74% in population at the same time 36% in area of the country in 2014. Table 3.1.3 shows the HSR's operating status. The HSR stably provided 131 trains per day in average while carried increasing passengers in the past eight years. The present average daily ridership is the triple of that in the year of HSR opening. Because of the increasing passengers, THSRC has received a book surplus since 2011, when the system had been in service for five years. Furthermore, in order to improve passenger service quality, THSRC has instituted services including automatic voice reservations, online reservations, free seating and pre-check-in for China Airlines/EVA passengers at Taoyuan station, and in 2010 introduced new service measures including ticket purchase and pick-up at convenience stores, periodic tickets and multi-ride tickets. The reliability of Taiwan HSR has been well since the opening date with the performances of high train punctuality rates (>99%) and zero passenger death/injury.

[15] The figure was made based on the data of Taiwan HSR at http://www.thsrc.com.tw/tw/Article/ArticleContent/1e07f685-045e-403c-bf92-88c2d86bf826.

Table 3.1.3 Operation status of Taiwan HSR (as of May, 2015)

HSR Line	**Number of trains per day**	**Number of vehicles per train**	**Passenger Capacity per train**	**Average headway**
Taiwan HSR	63 (departs from Taipei, Wednesday)	12	989	16.0 minutes

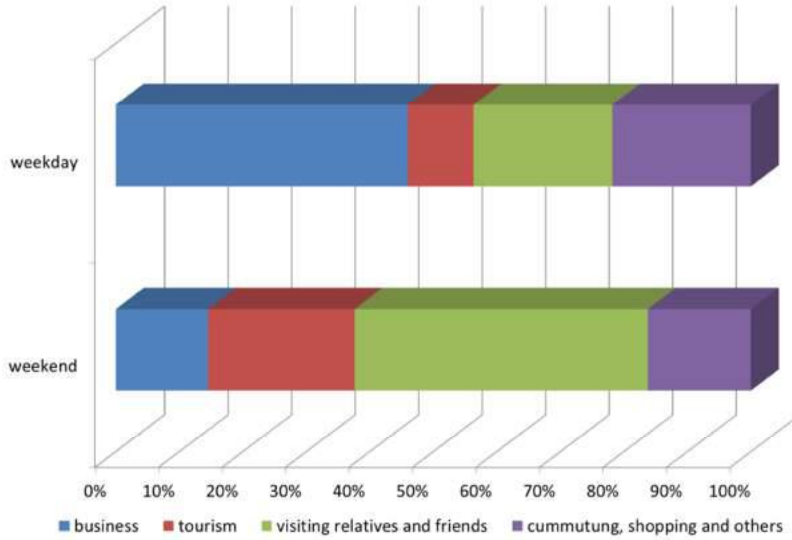


Figure 3.1.4 Trip purpose of Taiwan HSR passengers[16]

As shown in Figure 3.1.4, the Taiwan HSR is used mainly for business (46%) and visiting relatives and friends (22%) on weekdays and for visiting relatives and friends (46%) and tourism (23%) on weekends.

3.2 Qualitative and quantitative impacts of HSR

Taiwan HSR has made a dramatic change in a level of transport service, especially in terms of travel time. As shown in Figure 3.2.1, the conventional trains took around five hours between the two largest cities: Taipei and Kaohsiung in 2006 but the HSR service has made the same trip in around one hour and thirty minutes. The decrease ratio is 69%. Such a dramatic change seems to have huge impacts on the intercity transport situation in Taiwan.

[16] Source: Institute of Transportation (2012)

To identify the possible impacts of HSR on socio-economic developments in Taiwan, this study reviewed previous research on Taiwan HSR's impacts as listed in Table 3.2.1. The research is divided into two approaches. First, with-and-without comparison studies before HSR opening, and second, before-and-after comparison studies after HSR's opening. Four development issues have been explored in the past twenty years including demography, industry, modal split and property price.

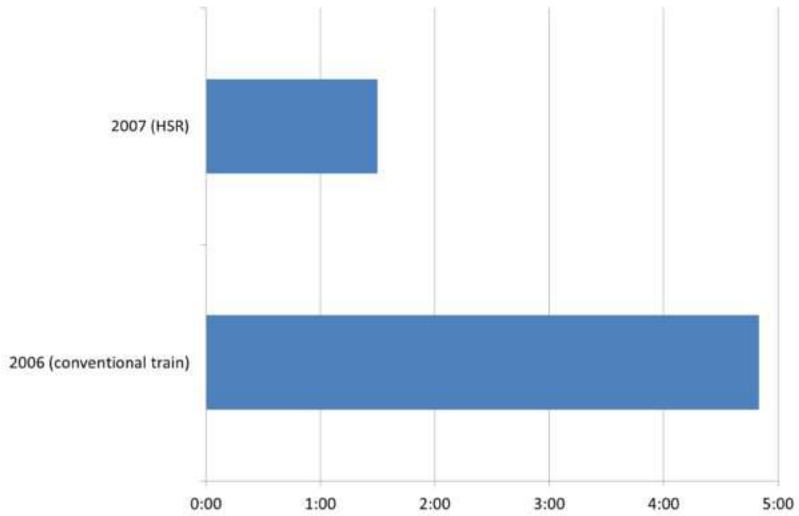


Figure 3.2.1 Comparison of changes in travel time between last conventional express train and Taiwan HSR between Taipei and Kaohsiung

Table 3.2.1 Review of impact studies of Taiwan HSR

Development	With/without studies before 2007	Before/after studies after 2007
Demography	Lin et al. (2005); Lian (2006)	Yang (2012)
Industry	Chen (1990); Yu (1997); Li (2000); Lin et al. (2005); Lian (2006)	Tzeng (2007); Yen (2008); Li and Tzeng (2008); Wu et al. (2008)
Modal split	Chiu (1994)	Cheng (2010); Institute of Transportation (2012)
Property price	—	Yen (2008); Li (2009); Hu (2010); Anderson et al. (2010); Yang (2011)

Lin et al. (2005), Lian (2006) and Yang (2012) concluded that HSR encourages population migration to regions served by HSR because of the increased accessibility and the establishment of station area development plans.

This chapter compares the population splits of HSR regions in Taiwan before and after the opening of its HSR and argues that the population reallocation effect of HSR is still insignificant in Taiwan. The HSR regions denote the countries and cities served by HSR stations within one hour accessing time (i.e., Taipei City, New Taipei City, Taoyuan County, Hsinchu City, Hsinchu County, Taichung City, Chiayi City, Chiayi County, Tainan City and Kaohsiung City). As shown in Figure 3.2.2, the annual rate of change in population splits of HSR regions and the other regions were insignificantly different before and after the opening of HSR. There are two possible reasons for explaining this insignificant change. One reason is that demographical migrations commonly take time to be implemented; and, the other is that the accessibility difference between HSR regions and the other regions is not significant enough to re-shape population distribution.

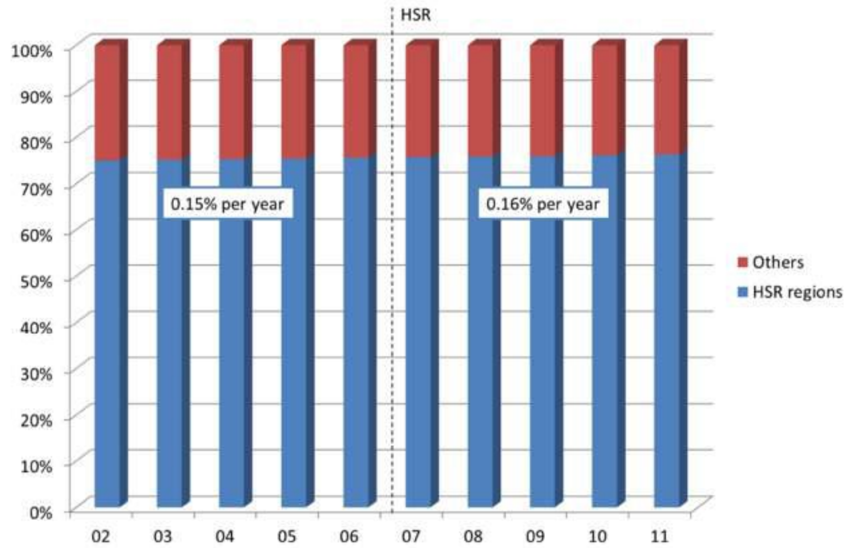


Figure 3.2.2 Population splits in Taiwan (2002-2011)

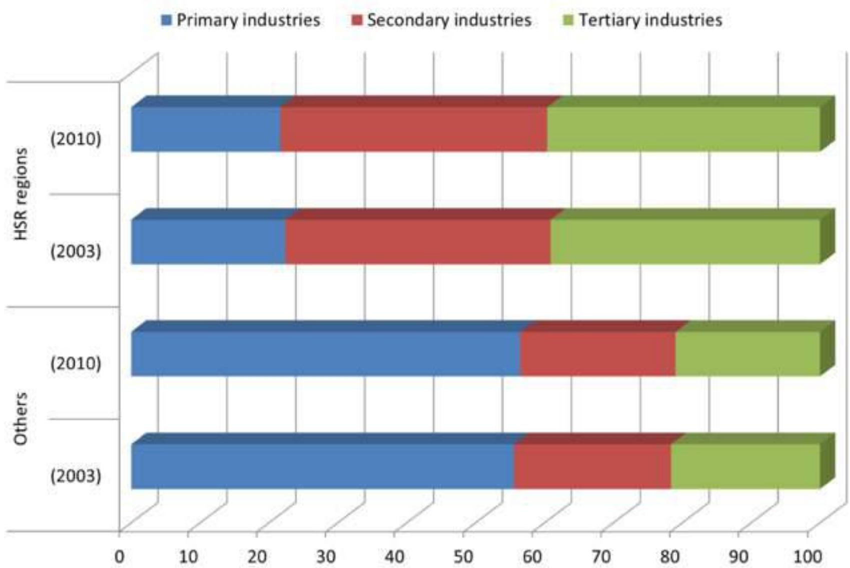


Figure 3.2.3 Changes of industrial splits

For industrial developments, Li and Tzeng (2008) and Wu et al. (2008) both argued that HSR results in a spatially balanced development along the western Taiwan corridor. Li (2000) concluded a major impact of HSR construction on Taiwan's macro economy. Chen (1990), Yu (1997), Lin et al. (2005), Lian (2006), Tzeng (2007) and Yen (2008) concluded that HSR is positively related to the locations of secondary and tertiary industries. This study argues that the positive associations between HSR and secondary and tertiary industries could still be doubtful in Taiwan's experiences. Figure 3.2.3 demonstrates the changes of industrial splits of HSR regions and the other regions between 2003 and 2011 and presents insignificant increases of secondary and tertiary industry splits after HSR's opening. The possible reasons for explaining this insignificant change should be similar to the demographical changes, i.e., industrial relocations take time to be implemented and the accessibility difference between HSR regions and the other regions is not significant enough to reshape industrial distribution.

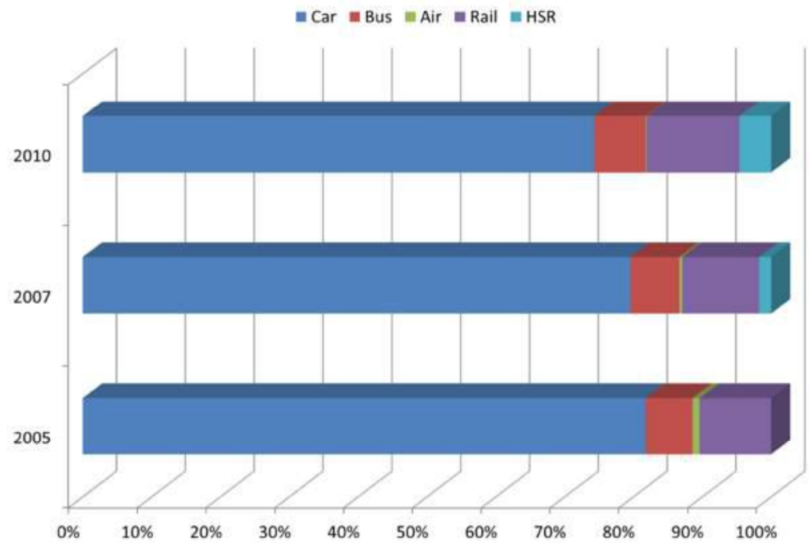


Figure 3.2.4 Modal split of intercity travel in Taiwan (weekday)

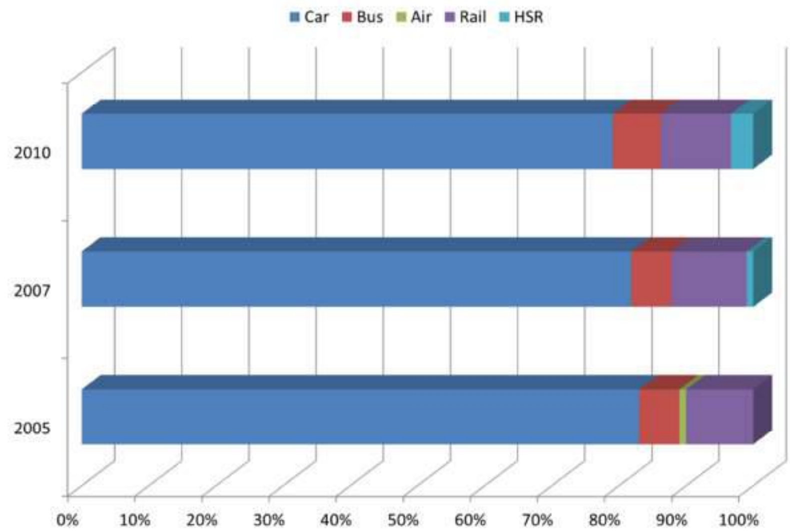


Figure 3.2.5 Modal split of intercity travel in Taiwan (weekend)

Twenty years ago, Chiu (1994) predicted that HSR will be a mass rapid transit system connecting major cities in western Taiwan. Since HSR is a new transportation system in Taiwan, it affects mode choices of intercity travels. The question is what travel modes will be affected and how significant will the effects be? Cheng (2010) analyzed the data of the first year after HSR's opening and concluded that domestic aviation significantly suffered from HSR while intercity bus and traditional railways were not significantly affected. The investigation of the Institute of Transportation (2012) provides newly detailed evidence on modal split changes. Figure 3.2.4 and Figure 3.2.5 show the modal splits of intercity travel in 2005 (before HSR opening), 2007 (first year after HSR opening) and 2010 (four years after HSR opening).

The evidence shows that HSR had replaced most of domestic aviation and a slight part of car use in either weekdays or weekend. The market share of intercity bus seems unrelated to HSR and it means that the target passengers between intercity bus (low cost and long/unstable travel time) and HSR (high cost and short/predictable travel time) are significantly different. An interesting change happened to traditional railways. The HSR did not negatively affect traditional railway's market share. Surprisingly, traditional railway received a growth in modal split on weekdays after HSR opening. This could be because of the connections between these two railway systems. Six of the eight HSR stations are connected by traditional railways and such connections encouraged travelers to use traditional railway for accessing the HSR service.

The previous studies of HSR impacts on property prices reach diverse conclusions among the HSR stations. The stations in northern Taiwan including Taipei, Taoyuan, Hsinchu and Taichung were positively related to the property prices of neighboring areas (Hu, 2010; Yang, 2011; Yen 2008) while the stations in southern Taiwan including Chiayi and Tainan were unrelated to property prices (Anderson et al., 2010; Li, 2009; Yen, 2008). There are two possible reasons for explaining this difference. One reason is that the real estate market in the south has been less active than that in the north for many years; and, the other is that Chiayi and Tainan Stations are both located far away from existing urban areas. Further discussions on this issue are in Section 3.3 regarding the comparisons between Hsinchu and Tainan Station areas.

From the statistics, land prices show similar trends of that of property prices. Figure 3.2.6 shows changes in the land price index of station areas by station using prices in 2006 with a baseline of 100. The northern stations have been positively related to the land prices of their areas especially in Taipei and New Taipei cities while the southern stations are not shown to be related.

On the other hand, total values of production show different trends from both of the property and land prices. As shown in Figure 3.2.7, the cities with southern stations have experienced a higher increase in the total value of production between 2006 and 2011 rather than those with the northern stations, in contrast to property and land prices.

As discussed above, HSR's impacts on station areas are diverse and depend on the situation of each station. The station area development cases in Taiwan are discussed in the following section.

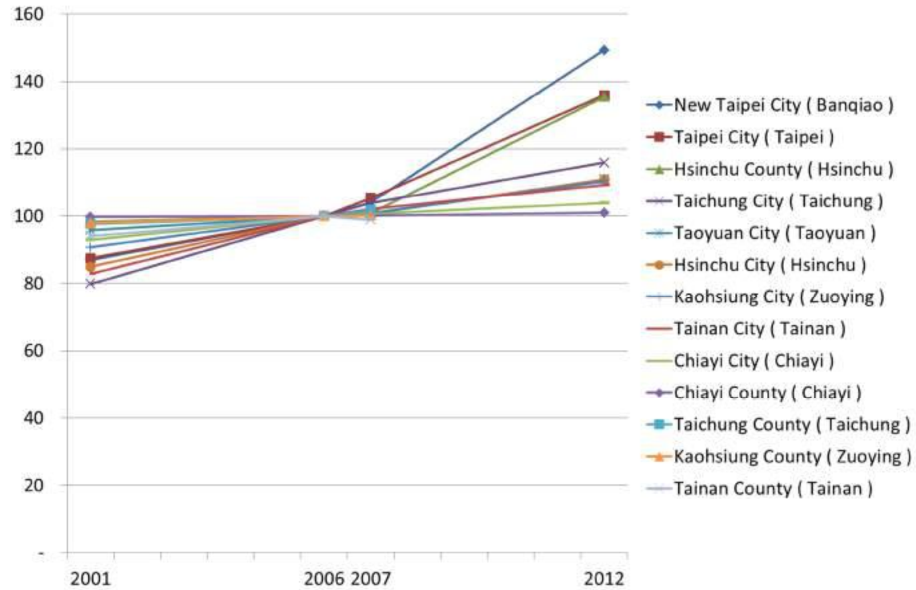


Figure 3.2.6 Change in land price index (2006=100)[17][18]

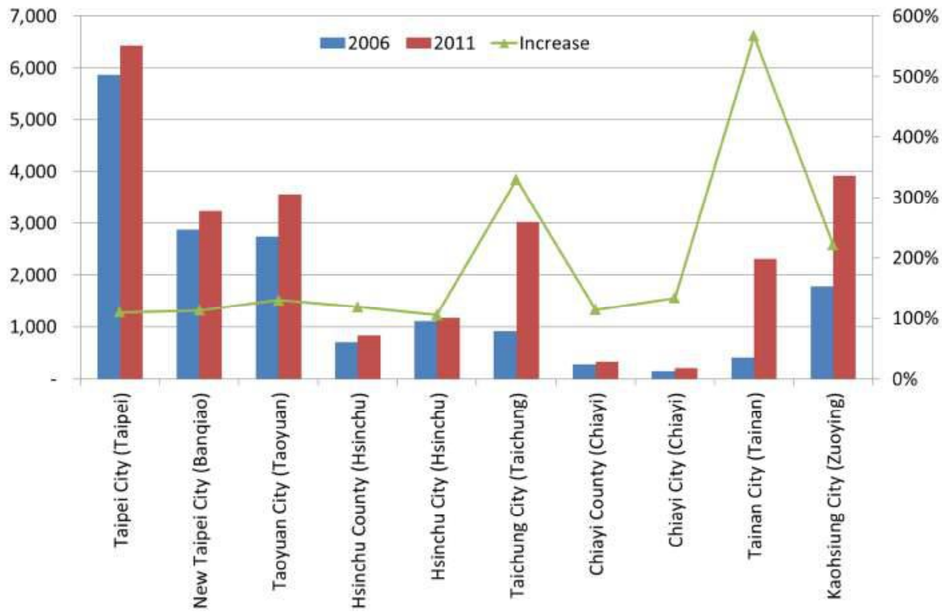


Figure 3.2.7 Change in total value of production year-round (billion NT)[19]

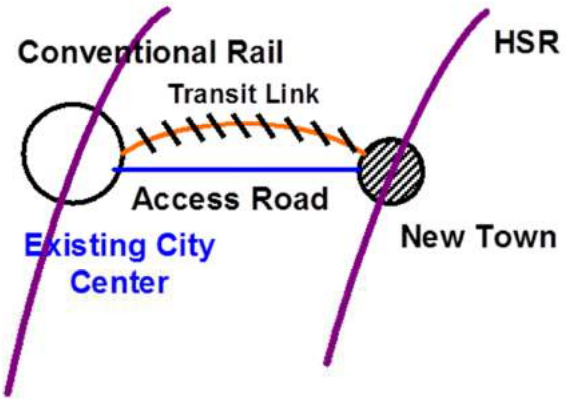
[17] Data source: Department of Land Administration, Ministry of Interior, 2004, Land Price Index Report No. 21, Taipei: Department of Land Administration, Ministry of Interior. Department of Land Administration, Ministry of Interior, 2013, Land Price Index Report No. 39, Taipei: Department of Land Administration, Ministry of Interior

[18] Taichung, Kaohsiung and Tainan Counties don't have data in 2012 because they were reformed.

3.3 Station area development projects and policies

Development plan

Apart from Taipei, Banqiao and Zuoying stations, which are located at conventional railway stations within city centers, the other HSR stations are located at sub/exurban areas. These sub/exurban station areas are developed through a new town approach as shown in Figure 3.3.1. The approach includes two major methods: one is deploying Station District Plans via urban planning process; and, the other is improving connections between a new town and existing city center by public transit systems (railway, rapid transit or feeder bus).



New Town Approach

- Station District Plan
- Connections between new town and existing city center

Figure 3.3.1 New town approach for sub-exurban HSR stations areas

There are eight Station District Plans (SDPs) as listed in Table 3.3.1 and only five SDPs, whose HSR stations are in operation and are discussed in this study. They include Taoyuan, Hsinchu, Taichung, Chiayi and Tainan stations. The five SDPs have been given different functions tailored to the local development characteristics. Since Taoyuan Station is located nearby the Taoyuan International Airport, the Taoyuan SDP has taken this advantage to be positioned as an international business park. Considering the major science parks and research institutes located at the nearby region, Hsinchu and Tainan SDPs are planned as a biomedical science park and a green energy and eco-science park, respectively. Taichung SDP is planned as an entertainment

[19] Data source: Directorate-General of Budget, Accounting and Statistics, Executive Yuan (2008), Industry, Commerce and Service Census Report in 2006, Taipei: Directorate-General of Budget, Accounting and Statistics, Executive Yuan. Directorate-General of Budget, Accounting and Statistics, Executive Yuan (2013), Industry, Commerce and Service Census Report in 2011, Taipei: Directorate-General of Budget, Accounting and Statistics, Executive Yuan.

and shopping park because of its central location along the western Taiwan corridor. According to the tourism and agricultural resources, Chiayi SDP is planned as a tourism and exquisite agriculture park.

Table 3.3.1 Station District Plans along Taiwan HSR

Name of station*	District area (ha)	Planned population (cap)	Station (ha)	Business zone (ha)	C/M park (ha)	Developmental theme
Taoyuan	490	60,000	19.68	8.55	22.00	International business park
Hsinchu	309	45,000	14.76	4.87	38.30	Biomedical science park
(Miaoli)	(440)	(21,000)	(7.08)	(4.90)	(10.02)	Culture creativity park
Taichung	273	23,000	29.43	11.3	15.61	Entertainment & shopping park
(Changhua)	(963)	(5,000)	(7.81)	-	-	Floriculture biotech park
(Yunlin)	(422)	(47,000)	(8.36)	(6.15)	(9.66)	New lakeside city
Chiayi	135	20,000	12.51	3.14	9.87	Tourism & exquisite agriculture park
Tainan	299	32,000	16.73	4.02	47.17	Green energy & eco-science park
Total	1,506 (1,825)	180,000 (73,000)	93.11 (23.25)	31.88 (11.05)	132.95 (19.68)	-
In charge agency	Local government		THSRC		BOHSR	-

*The stations in parentheses will be in operation after 2015 and are not discussed in this study.

The planned population ranges from 20,000to 60,000 and the planned areas range from 135 to 490 ha. In each of the SDP, a commercial/manufacture park (C/M park) is planned nearby the HSR station. The land use regulation for C/M parks is flexible, ranging from company headquarters, R&D and design centers, to convention centers, financial districts, or entertainment and shopping centers. There are 132 ha of C/M parks, out of a total of SDP's area of 1,506 ha. The government is responsible for the development of C/M parks.

Legal and institutional system

The land used for the HSR project is 345 km in length and 18 m in width, passing 14 counties and cities. The land acquisition process began in 1995 by means of expropriation, purchase, leasehold and agree-to-use. This land acquisition has been completed and these lands have been handed over to THSRC. On the other hand, to deploy SDPs, the government takes the approach of zone expropriation based on the following laws: "Statute for Encouragement of Private Participation in Transportation Infrastructure Projects" and "Statute of Implementation of Zone Expropriation". The zone expropriation of the five SDPs was publicly announced on March 29, 1999 and the urban plans were publicly announced on October 20, 1999.

Zone expropriation is a means of land readjustment and a self-financing land administrative measure. Through zone expropriation, a group of separate land parcels are assembled within the framework of a comprehensive plan into a unified site which can then be subdivided for the development purposes as shown in Figure 3.3.2. To process zone expropriation, the finance to implement it has to be proven as feasible, that is, self-financing. To assure self-financing, the area of zone expropriation should be larger than the area of the station area. It includes the land of station area, the land to be returned to landowners and the land for recovering the zone expropriation cost as shown in Figure 3.3.3. This cost recovery land is temporarily owned by the government and will be sold on the open market to recover the costs of public facilities such as roads, parks and schools in the area of zone expropriation. Through this zone expropriation method, the government can effectively acquire the station area land and promote developments of SDPs, and the landowners can redeem 40% to 50% of their expropriated area in principle without loss of their rights. Although the land redeemed is reduced as compared with the original area, however the land value will greatly increase due to up-zoning of land use. Nevertheless, the living environment can be improved because the government has a comprehensive plan and is responsible for the construction of public facilities in the area of zone expropriation.

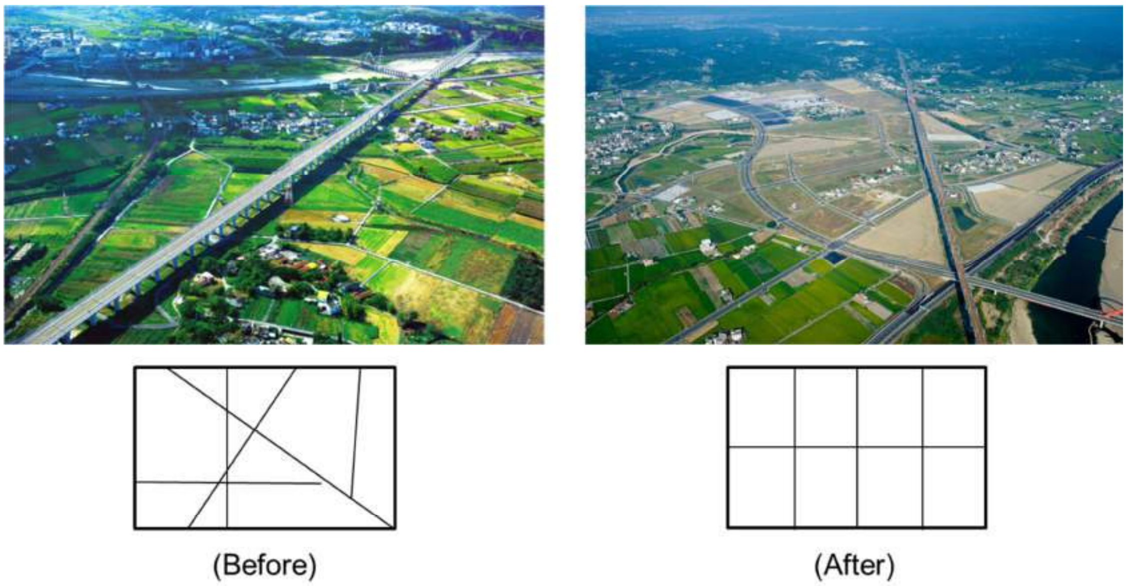


Figure 3.3.2 Demonstration of zone expropriation[20]

Three governmental agencies (BOHSR, Ministry of Interior and local governments) are involved in zone expropriation. Each agency plays its own role to complete the expropriation process and share a certain percentage of the profit generated from the land disposal after the tendering. In terms of the tasks, the BOHSR mainly takes charge of drafting master plans and expropriation plans. The Ministry of Interior is the public agency of chief executives of zone

[20] Source: BOHSR, MOTC

expropriation. It is responsible to complete the work in a timely manner and provide necessary assistance and coordination in the scope of urban planning. Furthermore, local governments primarily act as developers of the land expropriation.

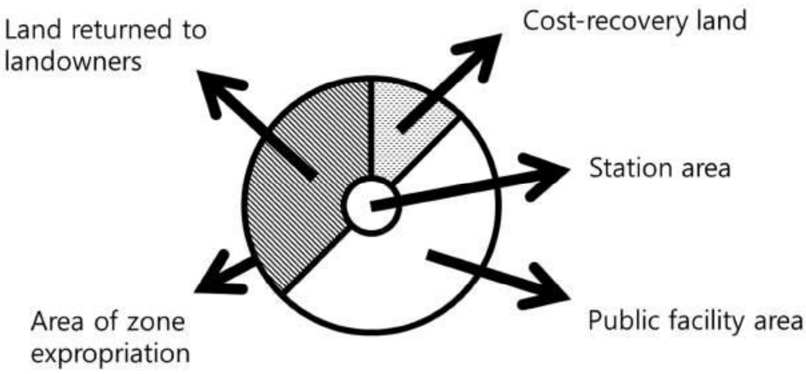


Figure 3.3.3 Land area of zone expropriation

Performance

Table 3.3.2 demonstrates a general overview for the development situation of SDPs. In June 2013, the developed lands in Taoyuan, Hsinchu and Taichung SDPs had been nearly or over 50% of the planned areas while that in Chiayi and Tainan SDPs were both less than 10%. It is obvious that the two SDPs in southern Taiwan are developed in a quite slow speed. To clearly identify how each SDP's development performance is, an index named *pending ration* (PR) is deveined as follows:

$$PR = 1 - (\text{area of sold, rented or developed land} / \text{area of total available land}) \quad (3.3.1)$$

The land area measured in Eq. (3.3.1) includes only the lands obtained by the government after completing zone expropriation. A higher PR means a worse development performance. Based on the data from BOHSR, in June 2013, the five SDPs' PRs were 29% for Taoyuan, 13% for Hsinchu, 55% for Taichung, 65% for Chiayi and 88% for Tainan as listed in Table 3.3.2. It can be concluded that Hsinchu SDP is the most successful case and Tainan SDP is the most unsuccessful case in terms of the speed of land development.

Table 3.3.2 Development situation of SDPs[21]

Station (PR)	Bird's eye view (Sep. 2012)	Land development situation (June 2013)
Taoyuan (29%)		
Hsinchu (13%)		
Taichung (55%)		

[21] Source: The photos and maps are all from BOHSR, MOTC

Chiayi (65%)

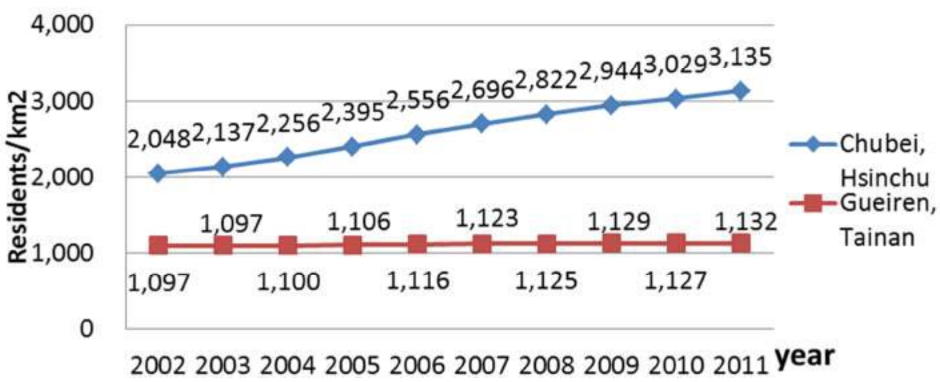
Tainan (88%)

*The stations in parentheses will be in operation after 2015 and are not discussed in this study.

Case analysis

What matters to HSR station area development speed? To answer this question, this study compares numerous conditions, which could be related to station area development, comparing the Hsinchu (successful case) and Tainan (unsuccessful case) SDPs as listed in Table 3.3.3.

Table 3.3.3 Comparisons between Hsinchu and Tainan SDPs

<table>
<tr><th>SDP</th><th>Hsinchu</th><th>Tainan</th></tr>
<tr><td>1. Location</td><td></td><td></td></tr>
<tr><td>1.1. Distance to the most nearby urban planning area</td><td>0 km</td><td>2.5 km</td></tr>
<tr><td>1.2. Distance to the major city center</td><td>6.7 km</td><td>10 km</td></tr>
<tr><td>1.3. Population density of the township where the station is located</td><td colspan="2">
</td></tr>
<tr><td>2. Investment</td><td></td><td></td></tr>
<tr><td>2.1. Major projects around HSR station</td><td>■ Completed
- Railway (major city center – HSR station)
- Hsinchu County Oval-shaped stadium (Jhubei Dome)
■ In progress (target year)
- Hsinchu Biomedical Park (2016)
- Taiwan Knowledge Economy Park (2021)</td><td>■ Completed
- Railway (major city center – HSR)
- Tainan campus, NCTU
■ In progress (target year)
- Metropolitan park (2014)</td></tr>
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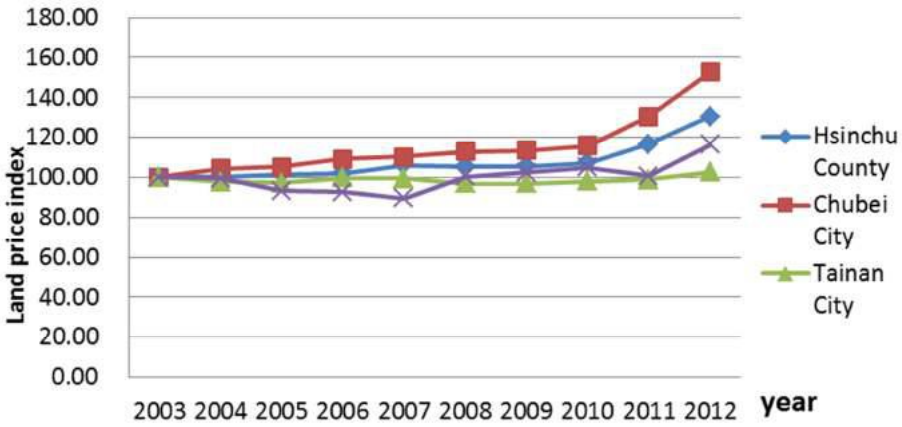
3. Real-estate market

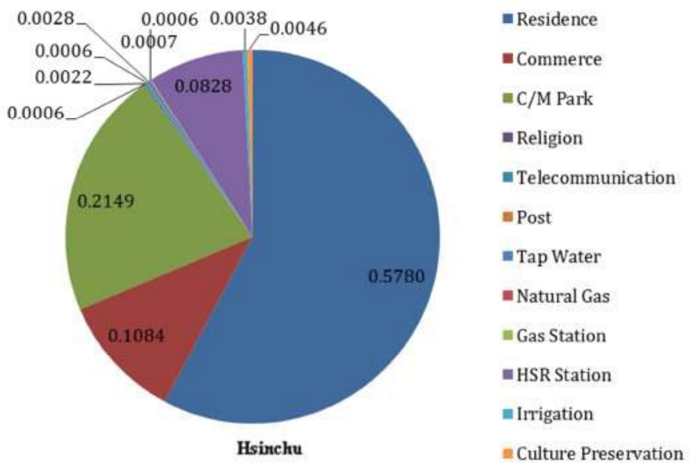
3.1. Land price index

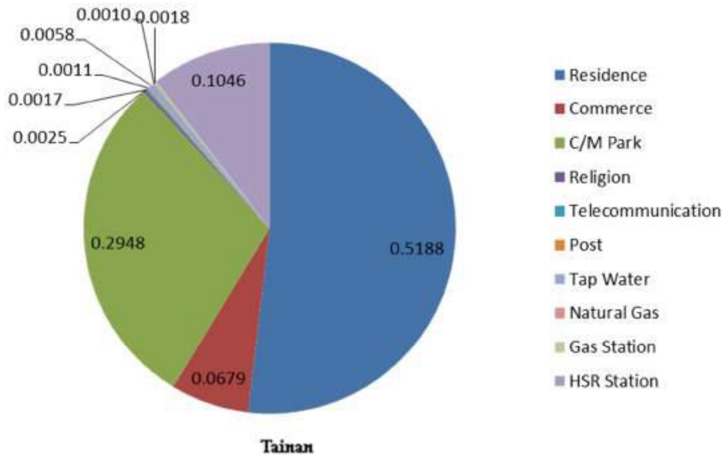


4. Access		
4.1. Railway	1	1
4.2. Bus line	9	4
4.3. Expressway	2	2

5. Plan

5.1. Land use zoning





The locations of these two stations are significantly different from each other. Hsinchu's SDP is not far from the major city center and is connected with existing urban areas, of which is located near the Hsinchu County Government. The population density around Hsinchu station is over 3,000 residents per km^2 now and was remarkably increasing in the past decade. However, Tainan's SDP is relatively far from the major city center and existing urban areas. Furthermore, it is surrounded by rural areas with low population density. The administrative area where the Tainan SDP is located, Gueiren District, did not have any population growth in the past decade. Based on the above differences, a location that is close to or connected with existing and growing urban areas should be a positive condition for a well-developed HSR station area.

The governmental investments around these two stations are slightly different between each other. Major projects around Hsinchu station include railway, stadium and technology-based or knowledge-based industrial parks while that around Tainan station include railway, university campus and recreational park. It is able to be expected that major projects around Hsinchu station will provide more jobs than that around Tainan station. Thus major projects creating job opportunity near to HSR station should be another positive condition for a well-developed HSR station area.

The real estate markets around these two stations are significantly different between each other. Using 2003 as the base year, the land price indexes (base year = 100) in Table 3.3.3 show that Hsinchu County and Chubei City, where the Hsinchu HSR station is located at, performed a stable and remarkable growth in the past decade. However, Tainan City and Gueiren District, where the Tainan HSR station is located at, experienced stagnations, declines and relatively low growth in the past decade on land price. It is obvious that real estate market is related to station area development. An active real estate market speeds HSR station area development. This should be also a positive condition for a well-developed HSR station area.

There is no significant difference between these two SDPs on their access transportation systems and land use plans. They are both served by railways, buses and expressways. Hsinchu HSR station is served by more bus lines than Tainan station because the region around the station is densely developed and the travel demand supports bus services. It is not able to argue that increasing bus lines speeds SDP development. The frameworks of land use zoning between these two SDPs are quite similar. It could be concluded that the conditions related to SDPs themselves, either in transportation or in land use, did not matter HSR station area development in Taiwan.

Based on the above analysis, this study argues that external conditions, rather than internal conditions, of SDP mattered HSR station area development in Taiwan. Specifically, positive conditions for successful station area development are: 1) a station location where is close to or connected with existing and growing urban areas; 2) providing major projects that create job opportunity near to HSR station; and, 3) an active real estate market around HSR stations.

Improvement agendas and future policies

The BOHSR raises the following agendas for promoting SDP developments:

- Actively embed emerging industries into the stations in southern Taiwan and balance developments among regions.
- Apply successful experience of Hsinchu station to other stations and continuously allocate major projects to station districts.
- Review financial plans and land disposal strategies to attract major investment to station districts by innovative mechanisms.
- Play a role of land reserve bank to satisfy the demands of strategic industries and maintain urban development functions.
- Boost district development and speed up self-liquidation financing by investment promotion.

Chapter 4

Case of Korea

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4.1 Present conditions on HSR construction and operation

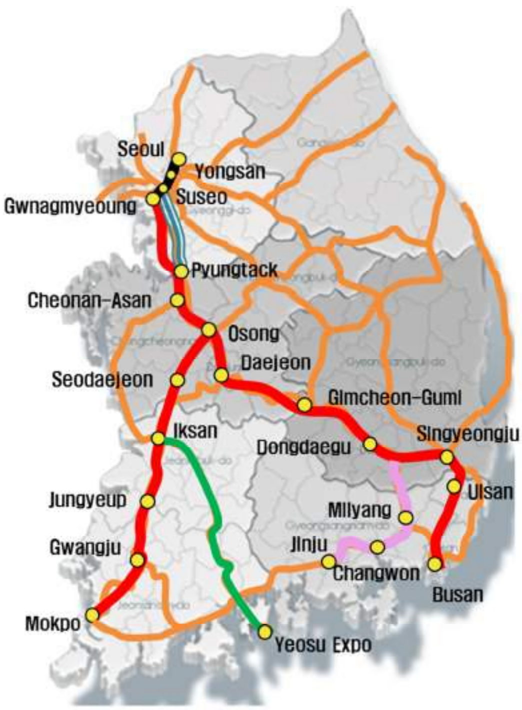
The Republic of Korea (Korea) has been expanding its HSR network, “KTX” (Korea Train eXpress), as shown in Figure 4.1.1 in the past ten years since its first KTX line that started operations in 2004. The KTX network continues to extend new lines and tracks and upgrade existing rail to accommodate for high speed operations (see Figure 4.1.2). If the plan for 2020 is implemented, the KTX network length will reach around 2,300 km with more than 700 km of new tracks and 1,600 km of improved tracks all over Korea.

Early back to the 1970s, a rough vision was contemplated to introduce HSR connecting the capital, Seoul and the second biggest city, Busan as one of the alternative measures to resolve the problem of forecasted overcapacity demand of the Gyeongbu Line which had been a conventional railway between the two cities. At that time, reducing the freight cost on the Gyeongbu corridor between Seoul and Busan was one of the most critical issues in Korea. However, the vision did not become a reality until the 1980s. In 1983, the Korean Government started a feasibility study on Gyeongbu HSR Line’s construction. The Government decided on a policy for the construction of Gyeongbu HSR Line in 1989 and approved a construction master plan for the HSR in 1990. The master plan was to construct 409 km of HSR between Seoul and Busan with Daejeon and Dongdaegu as intermediate stops and a design speed of 350 km/h at the cost of 5.8 billion USD. The construction period was set from 1991 to 1998. However, the master plan was revised in 1993 and 1997 due to frequent changes in the master plan, mistaken prediction of construction cost, etc. Finally, the construction budget was changed to 17.6 billion USD and the period was extended to 2001. Furthermore, Daejeon and Dongdaegu stations which had been planned as underground were revised to the ground-level.

The HSR construction was divided into two phases because of the difficult economic situation. But the basic framework was maintained. In the first phase, new tracks were constructed for the HSR only between Seoul and Dongdaegu (located in Daegu city) stations, while existing tracks were enhanced for the segments of Seoul, Daejeon and Daegu downtown areas. Also a conventional line, the Honam Line was improved to run at a high speed. The first phase was started in 1992 and ended 2004. In the second phase, new tracks were constructed between Daegu and Busan, while Daejeon and Daegu stations were revised to underground level in 2010. Also, new tracks were constructed between Osong and Gwangju on the Honam Line in 2015.

Corridor	Track	Length
Gyeongbu	New Track	401.8km
	Improved Track	22km
	Improved Track	115.4km
Honam	New Track	182.4Km
	Improved Track	244.6Km
Gyeongjeon	Improved Track	157.6km
Jeolla	Improved Track	180.4km
Seoul~Incheon Airport	Improved Track	56.9km
Pohang	Improved Track	38.7km
Total		1399.8km

Figure 4.1.1 KTX network (as of September, 2015)[22]



	Length
New Track (Design Speed 300km/h)	701km
Improved Track (Design Speed 230km/h)	1,661km
Total	2,361km

- Benefit range by KTX
  : 84% of population,
  82% of national territory
- Link between major cities within 90 minutes
- Access time to KTX stations within 30 minutes

Figure 4.1.2 KTX network plan for 2020[23]

[22] Date sources: Korail, http://info.korail.com.

Currently, Korea has a population of around 51 million, of which 25 million live in Seoul city and its surrounding areas (Incheon city and Gyeonggi-do)[24]. The next largest cities are Busan (around 3.5 million), Daegu (2.4 million), Daejeon (1.5 million), Gwangju (1.5 million), and Ulsan (1.2 million) except Incheon (2.9 million). These cities lie along the KTX lines, therefore the KTX network connects Seoul to the large cities in Korea.

As of September 2015, the KTX network has a length of 1,400 km made up of eight lines that consist of three types of tracks: high speed tracks only for KTX ("New Track" in Figures 4.1.1 and Figure 4.1.2), updated conventional tracks and non-updated conventional tracks (see Table 4.1.1 and Table 4.1.2). That is, the KTX service runs not only on exclusive lines but also onto conventional lines.

Table 4.1.1 Present status of KTX

Total length	1,399.8 km
HSR lines	● Gyeongbu High Speed Railway Line (include Gyeonggi line*) ● Gyeongbu Line*** ● Gyeongjeon Line*** ● Honam High Speed Railway Line ● Honam Line** ● Jeolla Line* ● Pohang Line* ● Incheon International Airport Direct Line* * Upgraded conventional lines used for HSR ** Partly upgraded conventional lines used for HSR *** Not-upgraded conventional lines used for HSR
Opening year	2004
Number of stations	36, of which 10 are shared with conventional lines
Average interval to next stations	40.8 km (35 sections)
Maximum speed	305 km/h
Constructor	Korean High Speed Rail Construction Authority (KHSRCA) (-2004) Korea Rail Network Authority (KRNA) (2004-)
Owner	Korean National Railroad (KNR) (-2004) Korea Rail Network Authority (KRNA) (2004-)
Operator	Korean National Railroad (KNR) (-2004) Korea Railroad Corporation (KORAIL) (2004-)

[23] Source: Ministry of Land, Infrastructure and Transport, http://www.molit.go.kr.

[24] As of 2014. Source: KOSIS, Registered population (city and province), http://kosis.kr/statHtml/statHtml.do?orgId=101&tblId=DT_1YL4301&vw_cd=&list_id=&scrId=&seqNo=&lang_mode=ko&obj_var_id=&itm_id=&conn_path=E1.

Table 4.1.2 Operation status of KTX by line (as of May, 2015)[25]

HSR Line	Type of train*	Number of trains per day	Number of vehicles per train	Passenger capacity per train	Average headway
Gyeongbu High Speed Railway Line	K	61	18	935	16.9 (05:10-23:30)
	S	6	8	363	
Gyeongbu Line	K	9	18	935	112.5 (05:40-20:40)
Gyeongjeon Line	K	3	18	935	92.3 (05:15-22:10)
	S	9	8	363	
Honam High Speed Railway Line	K	6	18	935	44.6 (05:20-22:15)
	S	18	8	363	
Honam Line	K	9	18	935	100 (06:20-19:40)
Jeolla Line	K	3	18	935	108.9 (05:20-21:40)
	S	7	8	363	
Pohang Line	K	1	18	935	112.8 (05:15-22:10)
	S	9	8	363	
Incheon International Airport Railroad	K	7	18	935	104.4 (06:55-20:35)
	S	2	8	363	

* K is KTX, S is KTX-Sancheon (new-type vehicles)

Over time, the KTX network has expanded to cover more areas and serve more of the population, especially across the southern half of the country (see Figure 4.1.3). In 2004 when the KTX service started its operations, the KTX service's coverage area was 39.7% of the whole country which was equivalent to 84.1% of the population (accessible to KTX within sixty minutes). In 2012, the service's coverage area expanded to 55.5% of the country and serviced 90.6% of the population.

The KTX network has been growing as shown in Figure 4.1.4. The network length has grown rapidly as it has doubled in the ten years since it started its operation for the main corridors. On the other hand, in terms of the HSR Lines, the network growth is not rapid. After the first Gyeongbu HSR Line was opened in 2004, it took ten years to open the next Honam HSR Line in 2015 even though the Gyeongbu HSR Line was extended in 2010. This 10-year interval to the next new tracks is almost same with Japan's Shinkansen history as described in Chapter 2.

[25] Data source: Korail, http://letskorail.com.

However, Korea's case is different from Japan's Shinkansen case, in that the improved tracks network of conventional lines complements the lack of HSR Lines in Korea.

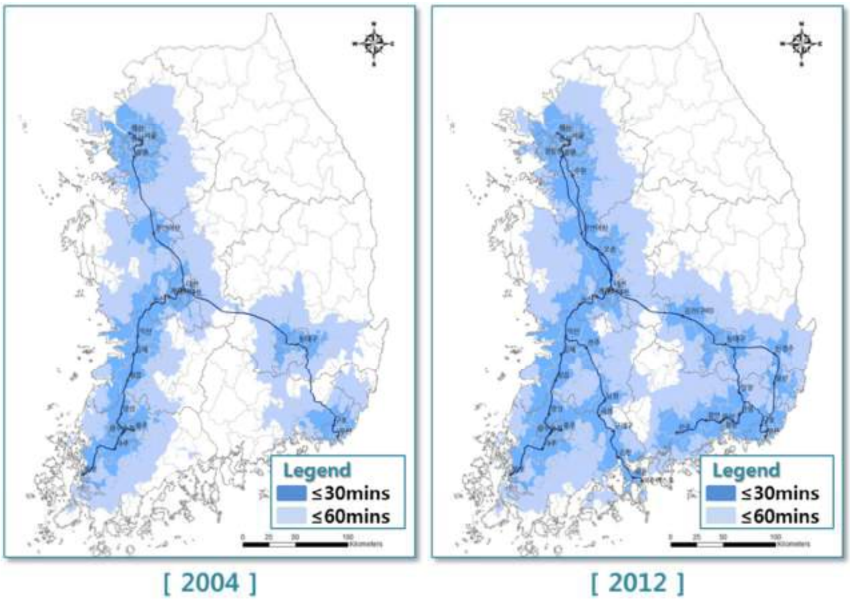


Figure 4.1.3 Area-based coverage of KTX network[26]

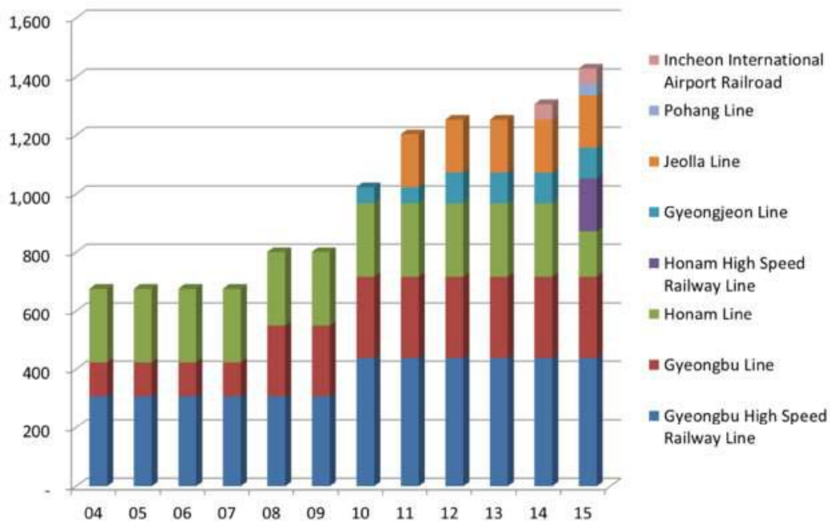


Figure 4.1.4 KTX network length (including operating conventional lines, km)[27]

Figure 4.1.5 shows a trend in number of passengers of the KTX. Ultimately, the number of passengers is constantly increasing. It reached more than 140 thousand people per day in 2013,

[26] Source: Oh, J. et al. (2013), KTX Economic Development Research, The Korea Transport Institute.

[27] Data source: Korail, http://info.korail.com/mbs/www/subview.jsp?id=www_020110010000.

which is twice as much as it was in 2004 when the KTX service began. Individually, the Gyeongbu corridor passengers account for more than 80% of the total KTX passengers. Therefore, the trend in the number of the KTX passengers is similar with that of the number of Gyeongbu Corridor passengers, which is used most frequently for visiting purposes as discussed in the following paragraph.

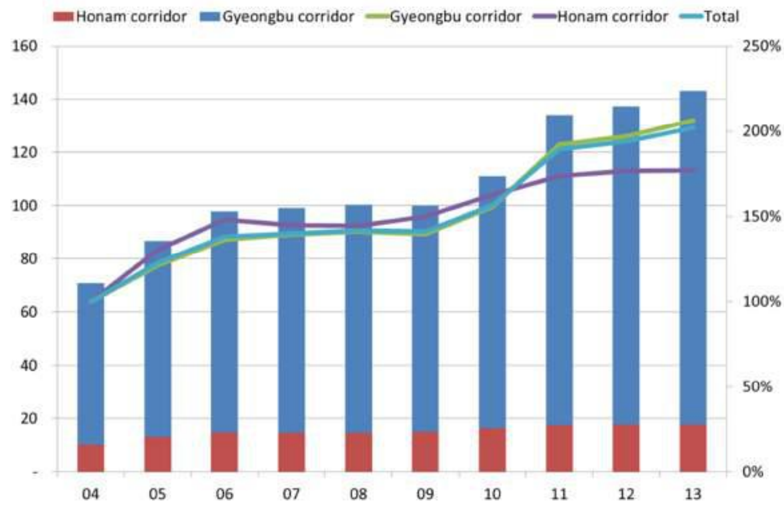


Figure 4.1.5 Trend in number of passengers per day (thousand people)[28]

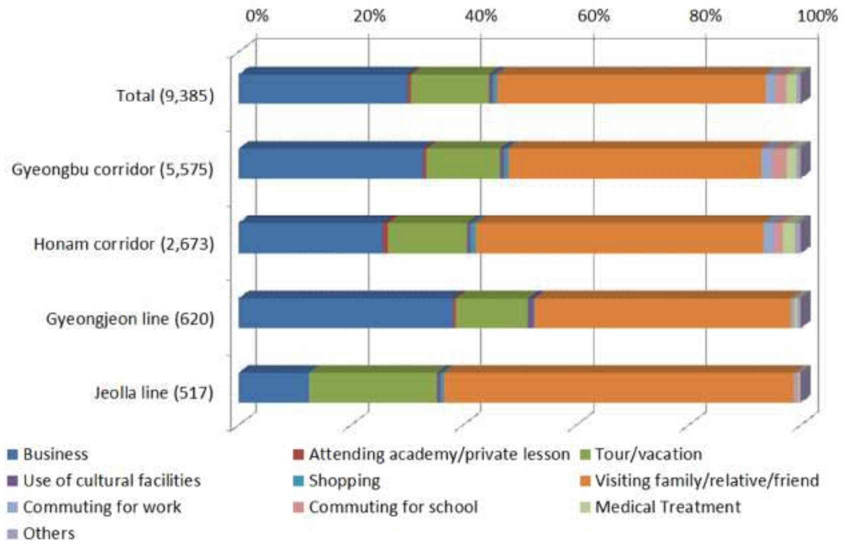


Figure 4.1.6 Trip purpose of KTX passengers[29]

28 As of 2014. Data source: Korail (2010 - 2014), Statistics annual report of railway, Korail.

29 Source: Oh, J. et al. (2014), KTX Economic Development Research, The Korea Transport Institute.

Figure 4.1.6 shows trip purposes of the KTX passengers. The KTX service is used most commonly for private uses such as visiting (family, relatives and friend) and leisure. In case of the two biggest corridors of Gyeongbu and Honam, visiting and leisure purposes occupy more than 60% of the total purposes of the passengers while business purposes occupy around 25%.

On the other hand, we can find each line's characteristics as well. Gyeongjeon Line is used for business purposes in comparison to the other lines, while the Jeolla Line is mainly for tour or visiting purposes.

As described above, the KTX service is used most commonly for private purposes while trip purposes vary according to lines.

4.2 Qualitative and quantitative impacts of HSR

KTX has had strong impacts on levels of transportation services. First of all, travel time has dramatically changed. Figure 4.2.1 shows changes in travel time from Seoul to major local cities before and after the implementation of the KTX along the Gyeongbu HSR Line.

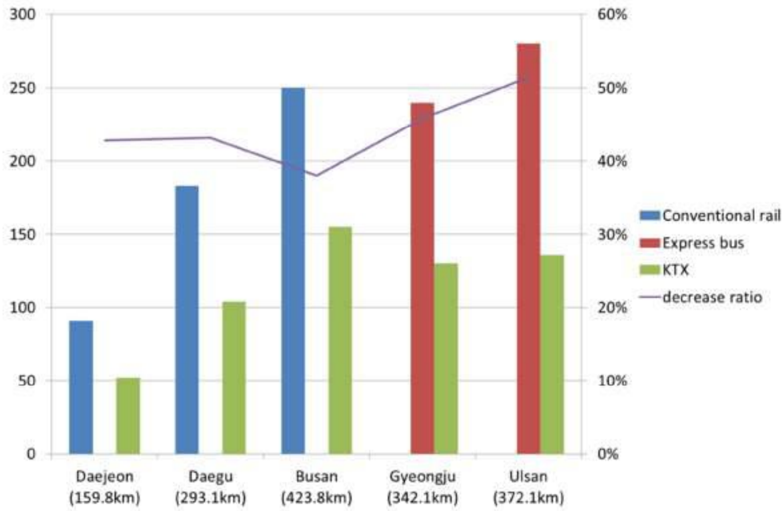


Figure 4.2.1 Change in travel time from Seoul (minutes)[30]

The figure shows a comparison of the travel time of conventional rail and that of KTX in the cases of Daejeon, Daegu and Busan, and a comparison of the travel time of express bus and that

[30] The distance is in case of KTX. Source: The Korea Transport Institute (2014), 10 Years of KTX Operation, Changes in Life and Economy, The Korea Transport Institute.

of KTX in the cases of Gyeongju and Ulsan. The KTX made almost a 40% to 50% reduction in travel times from Seoul to the cities. The routes in which express bus was used most commonly made a higher reduction in travel time by KTX than that in which conventional rail was used. On the other hand, in comparing Daejeon, Daegu and Busan, longer distance does not always result in a decrease in travel time, assumed to be due to the shape of the KTX route between Daegu and Busan, which is a detour compared to that of the original conventional railway.

KTX also has brought changes in people's behaviors. Since the opening of the KTX service, visits to other regions have increased. When asked if trips to other regions are increasing after the launch of KTX, 48% of the respondents answered "yes." In the case of the Cheonan-Asan Station, the affirmative response reached 76.9%, proving the assertion that the Seoul Capital Area is expanding into these regions. The increased travel volume consisted mostly of visiting families and relatives as well as work and business-related purposes (Oh, 2011).

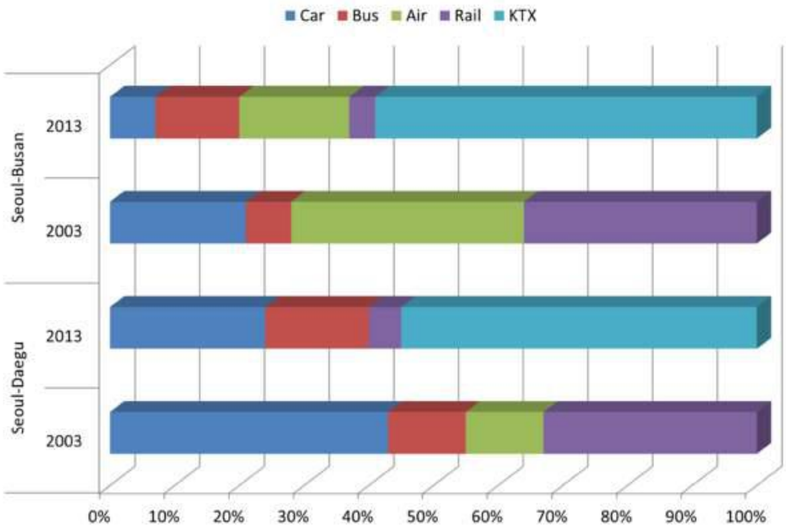


Figure 4.2.2 Change in modal split in intercity transport[31]

Following the opening of the Gyeongbu HSR, Dongdaegu Station has emerged as an interregional transport hub. The Seoul-Dongdaegu traffic volume sharply increased from 7.66 million in 2003 to 11.90 million in 2008. This increase was due to the substantial amount of direct traffic volume between Seoul and Pohang and Seoul and Gyeongsan, passing through Dongdaegu Station. These results showed that passengers used the KTX service, even if it meant passing through another city, due to the fast mobility of the service offered. This exemplifies that KTX stations are emerging as interregional transport hubs (Oh, 2011).

After the opening of the KTX service, a large shift appeared in the modal split for interregional

[31] Data source: Car: Korea Expressway Corporation, http://www.ex.co.kr. Bus: Expressbus Lines Association, http://www.kobus.co.kr. Air: Korea Airports Corporation, http://www.airport.co.kr. Rail and KTX: Korail, http://info.korail.com,

travel. Figure 4.2.2 shows the shift in modal split from 2003 to 2013 between Seoul and Daegu and between Seoul and Busan. In both cases, the modal share of air transport and conventional rail modes dramatically decreased. KTX and bus transport became more competitive in comparison to air transport and conventional rail modes. Car also lost its competitiveness in the corridor between Seoul and Busan, while it is still competitive between Seoul and Daejeon.

It is important to note that the KTX has more than half of the modal share in both cases. That is, the KTX, which provides a shorter travel time with lower cost (see Table 4.2.1), had a dramatic impact on modal split. On the other hand, the situation generated a competitor that could provide a longer-time travel with cheaper fare. In the case of Korea, the competitor was the express bus mode.

Table 4.2.1 Travel time and fare in intercity transport[32]

Section		Car	Bus	Air	Rail	KTX
Seoul - Daegu	Travel time*	3:40	3:40	-	3:03	1:44
	Fare**	60,000	17,000	-		39,500
Seoul - Busan	Travel time*	4:40	4:40	0:55	4:10	2:35
	Fare**	89,500	23,000	85,000		58,600

* h:mm, **KRW

There was an emphasis on socio-economic impacts in Korea, rather than on transportation impacts. At the time of the opening of the KTX, small and medium regional cities worried that the KTX-induced straw effect would further concentrate the population in the Seoul Capital Area. Although the KTX received much attention as a high-speed "green" mode of transport, the voice of concern was widespread. It was also predicted that these cities would become passing tourist spots rather than destinations for overnight trips due to the reduction in transit time (Oh, 2011).

However, the straw effect did not occur. Rather, local populations increased since the opening of the KTX service. As the 1st time in the past forty years, almost more than 8,000 persons moved out of the Seoul Capital Area in 2011.

Based on the fast mobility of KTX, a new form of the national economy was born. The hosting of international conferences that had been mostly concentrated in Seoul increased greatly in regional cities such as Busan, Daejeon and Daegu following the opening of KTX. Due to the provision of the HSR service the burden of holding and attending an event in a regional city had been reduced. Figure 4.2.3 shows a change in international conference venues. The number of international conferences held in cities along the KTX dramatically increased. It is evident that the venue choices were more evenly distributed among the cities with the implementation of KTX, as Busan and Daegu got more shares. This change is attributed to KTX development.

32 Data source: Car: Korea Expressway Corporation, http://www.ex.co.kr, Bus: Expressbus Lines Association, http://www.kobus.co.kr, Air: Korea Airports Corporation, http://www.airport.co.kr, Rail and KTX: Korail, http://info.korail.com,

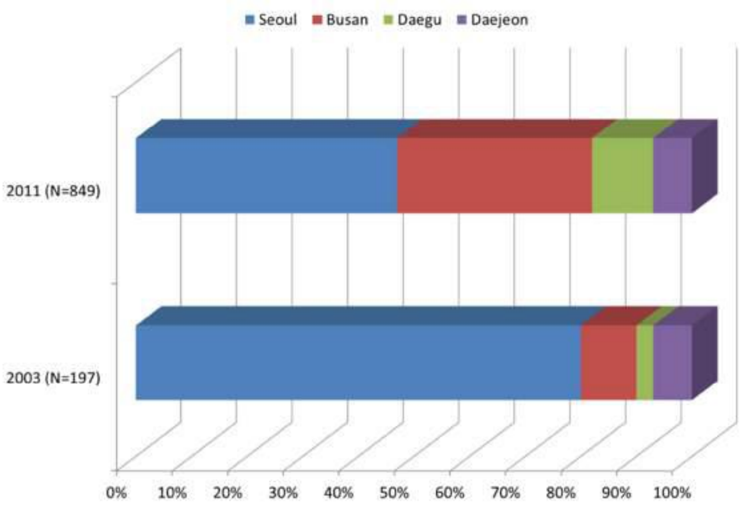


Figure 4.2.3 Change in number of international conferences held in cities with KTX stations[33]

Table 4.2.2 New economic activities at KTX stations[34]

	2005	2011
Number of conferences held within KTX station	153 cases	11,447 cases
Number of conference room users	4,012 people	341,543 people
Sales from rent on conference room	17 million KRW	2,098 million KRW

Not only international conferences but other economic activities are also generated within KTX stations as shown in Table 4.2.2. For example, both the number of conferences held within KTX stations and the number of conference room users have been sharply increasing. Also, the sales from rent on conference rooms have been increasing accordingly.

Figure 4.2.4 shows the change in the number of employed persons during 2011 and 2006 by access time to a KTX station in the industrial sectors, including the health and welfare service industry, education service industry and the art, sports and leisure service industry. These service industries' employment has a strong relationship with access to a KTX station. Table 4.2.3 shows the correlations, which are negative and statistically significant. This means that the number of employed persons decreases as access time increases. In addition, the correlation is strongest in the case of health and welfare services. As such, it can be inferred that tertiary industries thrive around KTX stations. As a result, the KTX contributes to regional economic development.

[33] The distance is in case of KTX. Source: The Korea Transport Institute (2014), 10 Years of KTX Operation, Changes in Life and Economy, The Korea Transport Institute.

[34] The distance is in case of KTX. Source: The Korea Transport Institute (2014), 10 Years of KTX Operation, Changes in Life and Economy, The Korea Transport Institute.

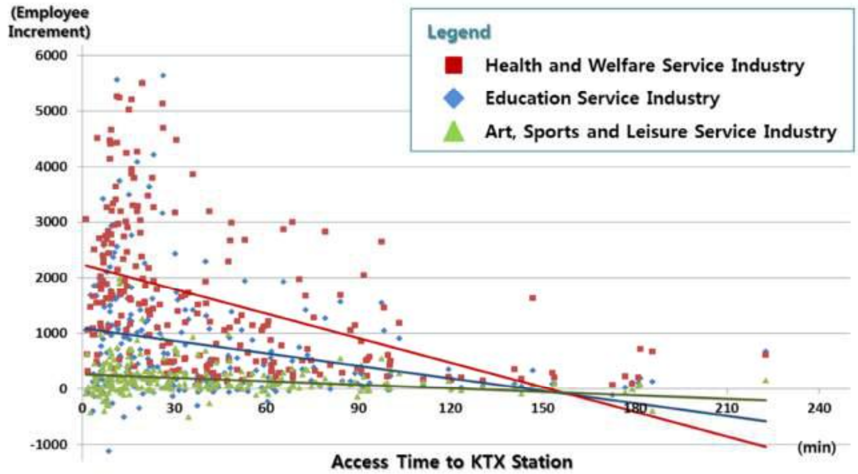


Figure 4.2.4 Change in number of employed persons by access time to KTX station[35]

Table 4.2.3 Correlation between employment and access time to KTX station[36]

Industry	Pearson correlation	P value
Health and welfare service	-0.44	***
Education service	-0.30	***
Art, sports and leisure service	-0.26	***

*** <0.001

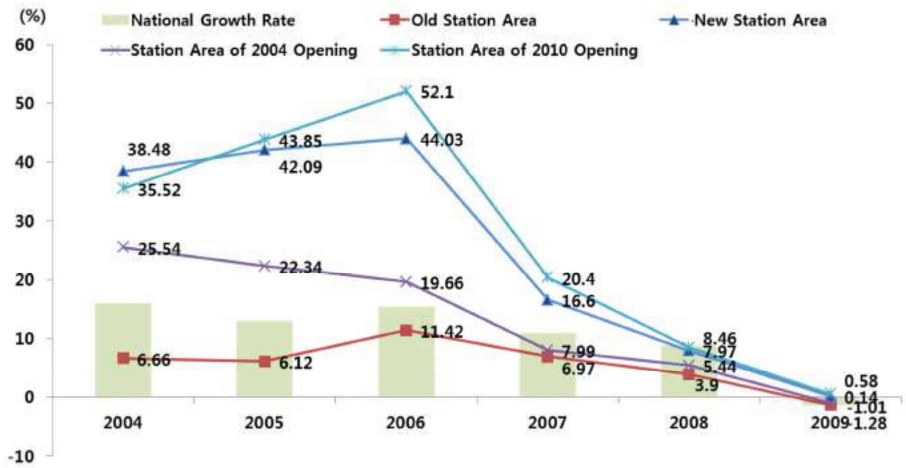


Figure 4.2.5 Change in land price (2004-2009)[37]

[35] Source: The Korea Transport Institute (2014), 10 Years of KTX Operation, Changes in Life and Economy, The Korea Transport Institute.

[36] Source: Oh, J. et al. (2013), KTX Economic Development Research, The Korea Transport Institute.

Figure 4.2.5 shows changes in land price around KTX station areas. While, land prices stopped growing in 2009 because of a worldwide recession, new station areas experienced much higher growths greater than the national growth rate before the recession in comparison to the existing KTX station areas.

4.3 Station area development projects and policies

Development Plans

With KTX station areas emerging as core hubs for regional development, station area development plans were prepared for many KTX stations. In order to foster station area development, several KTX stations are in the process of constructing intermodal transport center complexes (ITCC) which combine both an intermodal transfer function and various business and commercial functions.

KTX has nine stations on the Gyeongbu HSR Line other than Seoul station (see Table 4.3.1). Of the nine stations, Gwangmyeong, Cheonan-Asan, Osong, Gimcheon-Gumi, Dongdaegu, Singyeongju and Ulsan are new stations while Daejeon, Dongdaegu and Busan are existing stations plans (see Table 4.3.2). The station areas have been developed based on their development.

[37] Source: Korea Real Estate Research Institute (2009) and Oh, J. and Lee, J, (2013), HSR Impacts and Station Area Development: The Korean Case, KOTI-EASTS International Seminar, The Korea Transport Institute.

Table 4.3.1 List of KTX stations on Gyeongbu High Speed Railway Line (not including Haengsin and Seoul)[38]

Name of station	No. of trucks for HSR	No. of trains per day	No. of passengers (thousand) (2014)	Type of stopping trains	Connection	Main city(ies)	Area pop (2014) [39]	Main industry (2012)
Gwangmyeong	6 (of which only 2 are for pass)	60	7,250	Local	Seoul Metro	Gwangmyeong, Anyang, Gumpo, Seoul	348,560 (Gwangmyeong)	Art, sports Leisure service
Cheonan-Asan	6 (of which only 2 are for pass)	34	6,004	Local	Conventional line (Asan Station)	Cheonan, Asan	293,954 (Asan)	Manufacturing
Osong	10 (of which only 4 are for pass)	51	2,728	Loal	Conventional line, BRT	Cheongju, Sejong	831,521 (Cheongju)	Construction
Daejeon	6	89	10,420	All trains	Conventional lines, Daejeon Metro	Daejeon	1,531,809	Scientific and technical service
Gimcheon-Gumi	4 (of which only 2 are for pass)	26	1,118	Local	---	Gimcheon, Gumi	135,456 (Gimcheon)	Agriculture
Dongdaegu	6	94	13,157	All trains	Conventional lines, Daegu Metro	Daegu	2,493,264	Healthcare and Social welfare service
Singyeongju	4 (of which only 2 are for pass)	32	2,390	Local	---	Gyeongju	261,535	Electricity, gas steam and water service, Art, sports and leisure service
Ulsan	5 (of which 2 are only for pass, 1 is not used)	43	5,411	Local	Limousine bus	Ulsan	1,166,377	Manufacturing
Busan	6	76	14,897	All trains	Conventional line, Busan subway	Busan	3,519,401	Fishing, Transport

[38] Data source: Korail, http://www.letskorail.com/ebizcom/cs/guide/guide/guide11.do.

[39] As of 2014. Data source: KOSIS, http://kosis.kr/statHtml/statHtml.do?orgId=101&tblId=DT_1B04005N_2014&vw_cd=MT_ZTITLE&list_id=A6&seqNo=&lang_mode=ko&language=kor&obj_var_id=&itm_id=&conn_path=E1.

Table 4.3.2 Type of KTX stations by location on Gyeongbu HSR line including Yongsan

Location	Old stations	New stations
CBD	Yongsan, Daejeon, Dongdaegu, Busan	-
Outside CBD	-	Kwangmyoung, Chenan-Asan, Osong, Gimcheon-Gumi, Shingyeongju, Ulsan,

Yongsan Station, which is located in the center of Seoul and is on the Honam HSR Line, established a massive development project (see Figure 4.3.1). This station area is an international business district. The project budget was worth around 40 million USD.

Figure 4.3.1 Development Plans of Yongsan and Daejeon stations[40]

In the case of Daejeon Station, a key aspect of the development has been urban regeneration (see Figure 4.3.1). However, the station area is located an old neighborhood, which made the project difficult.

Dongdaegu Station was designed as an intermodal transport center in its development plan. This project is under construction and is almost completed (see Figure 4.3.2).

In the case of Busan Station, the development plan was intended to develop the station area in conjunction with a port as a rail-port regeneration project (see Figure 4.3.2).

[40] Source: Oh, J. and Lee, J. (2013), HSR Impacts and Station Area Development: The Korean Case, KOTI-EASTS International Seminar, The Korea Transport Institute.

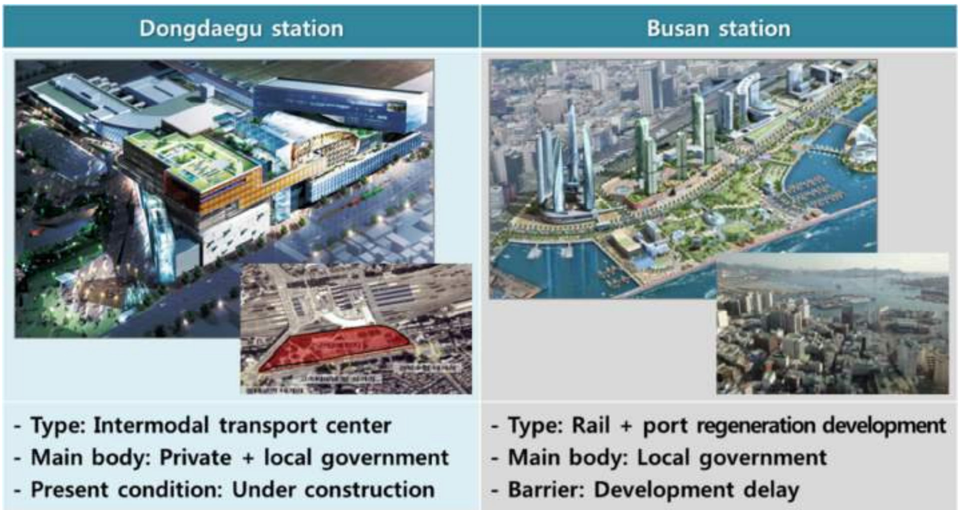


Figure 4.3.2 Development Plans of Dongdaegu and Busan stations[41]

Figure 4.3.3 Development Plans of Gwangmyeong and Cheonan-Asan stations[42]

Gwangmyeong Station (see Figure 4.3.3) was designed as a residential and commercial district in an area of about two million square meters with 9.7 thousand houses and a population of 27 thousand in the development plan. The budget was 1.65 USD. The housing development was announced before the KTX's open in 2004. However, the development plan itself was approved after the KTX's open. In line with the area's land-use, a feeder transport system was planned.

[41] Source: Oh, J. and Lee, J. (2013), HSR Impacts and Station Area Development: The Korean Case, KOTI-EASTS International Seminar, The Korea Transport Institute.

[42] Source: Oh, J. and Lee, J. (2013), HSR Impacts and Station Area Development: The Korean Case, KOTI-EASTS International Seminar, The Korea Transport Institute.

But the construction of the system has not been progressing and therefore most of the system is not yet available.

Cheonan-Asan Station has been designed as a new town in its development plan (see Figure 4.3.3). The project was completed and residents have already moved in. The station area has been filled with tall apartments.

Osong Station has a development plan showing a new town development under the local government (see Figure 4.3.4). However, the plan has been facing a financial problem. Then the plan has become difficult to be implemented.

Figure 4.3.4 Development Plans of Osong and Gimcheon-Gumi stations[43]

Gimcheon-Gumi station, which is another representative case, has been designed as an innovative city with ten thousand houses and a population of 26 thousand in an area of 3.8 million m^2 (see Figure 4.3.4). The budget was 870 million USD. This station was opened in 2010 at the second stage of the Gyeongbu HSR Line project. But the station area development started earlier than that of the station’s open. The development plan was approved in 2007; in the same year, the construction began. The construction was completed in 2013. At that time, 90% of the land had already been sold.

[43] Source: Oh, J. and Lee, J. (2013), HSR Impacts and Station Area Development: The Korean Case, KOTI-EASTS International Seminar, The Korea Transport Institute.

Figure 4.3.5 Development Plans of Singyeongju and Ulsan stations[44]

Finally, Figure 4.3.5 shows the cases of Singyeongju and Ulsan stations. Both cases have been designed as new towns (and as an intermodal transport center in the case of Ulsan). However, both developments have been delayed.

As shown in the above, every KTX station has its own KTX station area development plans. As the KTX station area is becoming a new growth pole for regional development, the station area development plan should be made in accordance with adjacent urban and regional development strategy (see Table 4.3.3).

Table 4.3.3 Overview of KTX station areas development on Gyeongbu High Speed Railway Line (with Yongsan, not including Haengsin and Seoul)

Station	Year of Approval	Execution Body	Development Plan	Investment & Execution
Yongsan (Honam HSR Line)	2006	Private sector	Yes	No
Gwangmyeong	2004	LH	Yes	Not without
Cheonan-Asan	2005	LH	Yes	Yes
Osong	2005	Local government	Yes	No
Daejeon	2006	Local government and KORAIL	Not without	No
Gimcheon-Gumi	2007	Central government and LH	Yes	Yes
Dongdaegu	2005	Private sector	Yes	Yes
Singyeongju	2013	Private sector	Yes	Not without
Ulsan	2009	Local government	Yes	Not without
Busan	2005	Local government	Yes	No

44 Source: Oh, J. and Lee, J. (2013), HSR Impacts and Station Area Development: The Korean Case, KOTI-EASTS International Seminar, The Korea Transport Institute.

Legal and Institutional Systems

The station area development has had three-type developments, which are based on different acts. For example, the station development is under the Act of Railway Construction. The railway service area is under the Act of Railway Business or the Act of National Integrated Transport System Efficiency. The station area is under the Act of Housing Development Promotion or The Act of Station Area Development Promotion. Among these acts, the Act of National Integrated Transport System Efficiency and the Act of Station Area Development Promotion were recently introduced for efficient development. The former was adopted in 2009 and the latter was adopted in 2010.The Act of Railway Construction was enacted to construct railway network and to boost station area development. For these purposes, this act includes the code for planning a railway network, railway construction and station area development. The main purpose of the act is to boost railway network construction and to enhance public interests.

The Act of National Integrated Transport System Efficiency was enacted to coordinate various transport facilities and modes of transport including surface, marine, and air as a way of integrating transport systems. For these purposes, the act includes the code for the efficient development and management of national transport systems. It also includes the code for the development and management of intermodal transport center complex (ITCC). The main purpose of the act is to improve people's movement and to boost national economic development.

The Act of Housing Development Promotion was enacted to solve the urgent housing shortage problem. For the purpose, the act includes the code for special exception on the acquisition, development and provision of land for housing. The main purpose of the act is to stabilize people's housing and to enhance people's welfare.

The Act of Urban Development was enacted to pursue planned and systematic urban development. For these purposes, the act includes the code for planning and construction of urban areas. The main purpose of the act is to create better urban circumstances and to enhance public interest.

The Act of Station Area Development Promotion was enacted to pursue efficient and systematic development for station areas. For these purposes, the act integrated codes on station area development scattered in several laws. The act includes the code for the specific process and financial support for station area development.

Performance

Due to the worldwide recession around 2008 the station area development projects had been put on hiatus. In addition, changes in economic situation made financing for projects difficult. In addition, there have been three problems in station area development cases. The first problem is the slow construction of the feeder transport system. The second is the lack of capability of the executing agency, which delayed the development. The last problem is the law system. Even if there are laws for station area development, they are not enacted efficiently for the development. Furthermore, integrated coordination is complicated and difficult to be adjusted.

Some of the old and new town projects have had some difficulties with financial problems which is presented in the cases of Busan and Gwangmyeong stations. What is the problem behind the slow progress? There is not always one specified reason. For example, conflicts between stakeholders or interested agencies and also high land price have prevented the developments from their progresses in the cases of old stations.

On the other hand, a major problem is the lack of infrastructure, especially transport system for accessibility in the cases of new stations. Local governments usually do not have enough budget to build such infrastructure without full support by the Central Government. Also, institutional cooperation has sometimes become problematic. Additionally, the governments are sometimes so passive to allow for business in the developments in spite of their investments. It is most important to progress station area developments with the related agencies' understanding of the importance of the developments.

Table 4.3.4 Problems and obstacles of KTX station area development

Area	Problems and obstacles
Development plan	Lack of integrating transport, urban and industrial plan
Access transport	Slow progress for feeder transport system
Financing	Sensitive to economic growth and recession
Institutional collaboration	Conflicts among interest groups
Legal system	Inefficient legal system for incentive, numerous regulation for approval, etc.

Based on the discussions just above, key factors for successful developments are listed:

- Leading development plans: integration of transport, urban and industrial plans to avoid uncoordinated developments
- Simultaneous development with accessibility to transport: to avoid inefficient developments
- Financial strategies: business feasibility, provision of incentives and establishment of finance system for projects to avoid sensitivities to economic recession
- Efficient legal system: to avoid inefficiency for incentives and numerous approval procedures by different regulations
- Leadership of executing organization, clear role of each agency and institutional collaboration: coordination and support for incentives by the central government, steady implementation of developments by the private sector in charge and cooperation

by the public to avoid the stopping of progress due to conflicts between interested agencies

Future Strategy: Creation of a KTX Economic Zone

With the opening of the high-speed railway, the national transport system is being rapidly reorganized around the KTX network. It seems to have an advantage in connecting the whole country as one economic area through the HSR network. From a different viewpoint, the Korean Peninsula also has possibilities to enjoy the various benefits of becoming one economic area through a HSR network if it is unified in the future. The concept of a KTX economic zone consists of integrating the whole country into a single city by compressing the time and space of the national territory through the high-speed railway (Oh, 2011).

Before discussing a linkage between KTX and regional development, we must think about how to develop KTX station areas as hubs for regional transport and economies. What are successful developments of KTX station areas?

We propose three significant strategies for HSR station area developments. To develop the KTX economic zone, three interconnected strategies of transport hub formation, regional specialization and urban development are proposed (Oh, 2011).

Table 4.3.5 Regional specialization

Function	Facilities
Transport	Intermodal transport center, subway station, express bus terminal, intercity bus terminal, bus and taxi stops, parking and ride
Information	Conference center, convention center, tourist information center, exhibition center
Business	Office building, hotel, shopping mall, department store, retail store, discount store, restaurant, hospital
Residential	Complex building, apartment
Amenity	Station plaza, pedestrian deck, park

Firstly, we have to build transport hubs around HSR stations in order to establish hub-and-spoke structures with a high-level of transport connectivity for transfers. It is expected to increase station area development potentials through the building of intermodal transport centers in KTX stations. This concept could realize Transit-Oriented Development, which combines business, commercial and residential functions with intermodal transport centers.

Secondly, we have to find economic and regional specializations, which are significant items to create locally-based service industries, as shown in Table 4.3.5. It is important to link station area developments to local industries for the brand-making of KTX station areas.

Finally, we have to harmonize station area developments with existing urban areas. In other words, integrated urban developments are needed. Integrated development plans are required to realize the integration projects. It is important to foster differentiated urban functions from the existing central business district (CBD) and to make station areas perform a role as regional growth hubs in accordance with local and long-term comprehensive urban strategies. Then a concept of station area zoning is helpful, which is differentiated development densities and land uses between a primary station area for higher density development and a secondary station area for lower density development (see Figure 4.3.6).

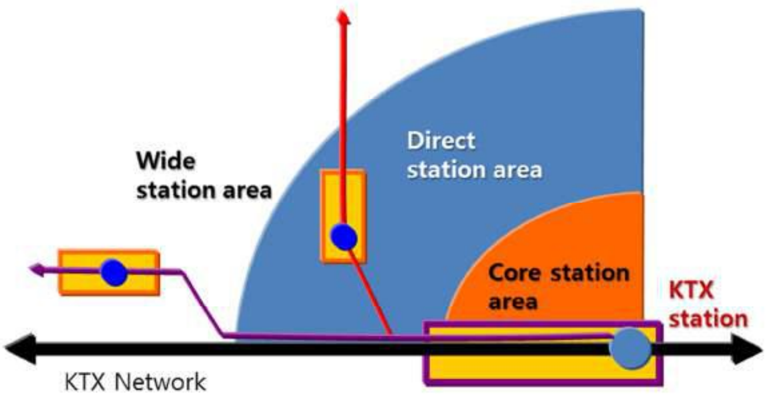


Figure 4.3.6 Transit-oriented development[45]

Additionally, we have to prepare effective systems for an intelligible and steady implementation of HSR projects from the viewpoints of finance and regulations. Therefore, it is needed to improve project financial capability and incentives and to establish a comprehensive legal framework for HSR economic development.

[45] Source: Oh, J. and Lee, J. (2013), HSR Impacts and Station Area Development: The Korean Case, KOTI-EASTS International Seminar, The Korea Transport Institute.

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Chapter 5

Conclusion

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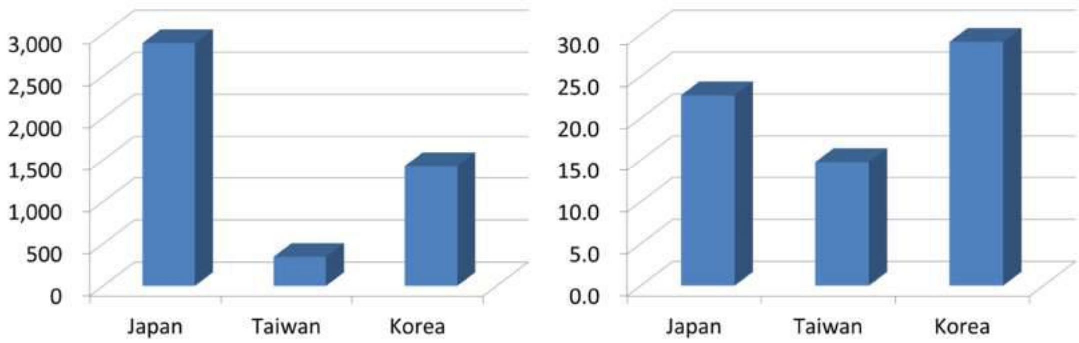
5.1 Summary and comparison of the three cases

In the previous chapters of this research, we discussed HSR's impacts and station area developments based on the cases of Japan, Taiwan and Korea individually. In this section, the comparison of the cases of the three countries is to be made.

5.1.1. HSR impacts

We understood that each HSR has had various economic and social impacts. At the same time, the impacts have been closely related to the basic characteristics of HSR.

Figure 5.1.1 shows the extension of the HSR network and the length per capita.



(a) Length (km) (b) Length per population (km/million people)

Figure 5.1.1 Lengths of the HSR networks

In the three cases, Korea has the longest HSR network length in terms of per population while Japan has the longest HSR network in length. However, the number of passengers is the lowest in terms of per population in Korea as shown in Figure 5.1.2. This implies a difference in usage or trip purpose among the cases. Therefore, we need to analyze more basic characteristics of the HSRs. Other characteristics are arranged in Table 5.1.1.

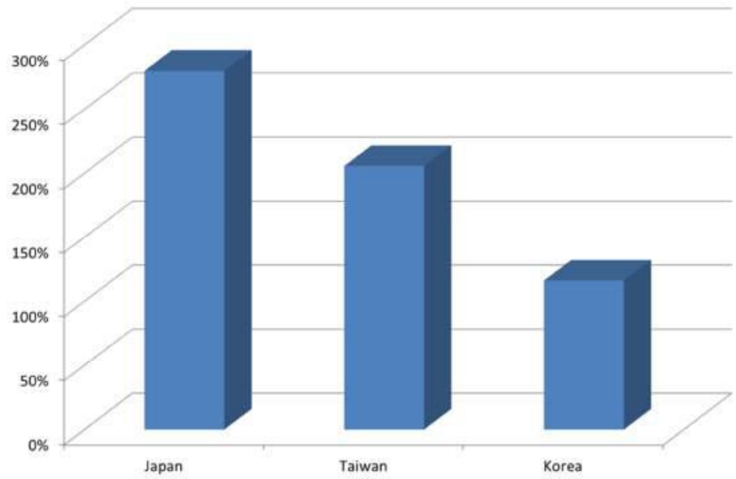


Figure 5.1.2 Ratio of number of annual passengers per capita

Table 5.1.1 Summary of characteristics of each HSR network

	Shinkansen (Japan)	Taiwan HSR	KTX (Korea)
Maximum speed	320 km/h	300 km/h	305 km/h
Number of trains per day	134*	63	67*
Number of vehicles per train	16*	12	18/8**
Passenger capacity per train	1,323*	989	935/363**
Average headway	7.6 minutes*	16.0 minutes	16.9 minutes**
Main trip purpose	Business* (weekday) Business and private* (holiday)	Business (weekdays) Visiting (weekend)	Visiting**

Note: the definitions of the terms and data in this table are subject to each of the previous chapters.
* In case of Tokaido Shinkansen. ** In case of Gyeongbu HSR Line

In addition, Figure 5.1.3 shows modal shares of Tokyo-Nagoya, Tokyo-Osaka and Seoul-Busan, where distances range from 300 km to 500 km. As discussed before, modal split has been dramatically changed by HSR operation in intercity transport. However, bus transport still has a larger share between Seoul and Busan than between Tokyo and Nagoya or Osaka. Of course a difference in road networks or bus services affects the modal splits; however, the difference of the service levels of HSRs is regarded as one of the major factors of modal split.

As described in Section 2.2, there are two kinds of HSR impacts: one is the improvement of intercity transport services and the other is the opportunity for regional and urban development.

In terms of improvement of intercity transport services, for example, travel time has been dramatically reduced in each HSR line (see Figure 2.2.1, Figure 3.2.1 and Figure 4.2.1). And as discussed above, the reductions in travel time have affected modal splits of intercity transport in each country. At the same time, HSR has also affected other modes. In Japan, air transport has become more competitive; in Taiwan, conventional railway has resulted in larger shares; in Korea, express bus still maintains competitive in terms of travel fare

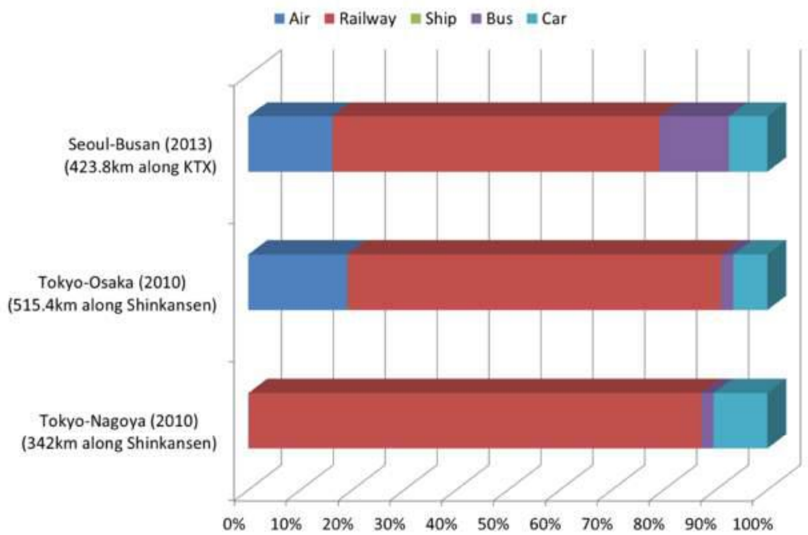


Figure 5.1.3 Modal split of Tokyo-Nagoya, Tokyo-Osaka and Seoul-Busan

In terms of opportunity for regional and urban development, changes in economic situations were analyzed in the previous chapters. From the Taiwan case, which is the newest HSR among the three cases, it was found that HSR impacts are not reflected significantly on the population or industries. Population or industrial splits have stayed about the same in HSR and other regions (Figure 3.2.2 and Figure 3.2.3) while economic activities in Korea have dramatically changed in the KTX service regions.

Table 5.1.2 Analysis of HSR impacts

	Shinkansen (Japan)	Taiwan HSR	KTX (Korea)
Significant impacts on	· *Modal split* · population in nearby residence area · sales amount	· *Modal split* · property prices and land prices in northern Taiwan · total value of production in southern Taiwan	· *Modal split* · international conferences in KTX areas · conferences within KTX stations · employment situation · land price in new station areas
Insignificant impacts on	· *Straw effects* · *population split*	· *Population split* · industrial split · property prices and land prices in southern Taiwan · total value of production in northern Taiwan	· *Straw effects (centralization)* · *population split* · widening disparity

Note: *Italics* indicate common items. This table excludes the impacts of only station area development

Table 5.1.2 shows HSR impacts which were analyzed in the previous chapters. In Table 5.1.2, the impacts are related to opportunity for regional and urban development. Although economic situations or HSR development circumstances are different, there have been significant impacts of the introduction of HSR common to the three countries. A new HSR line or an extension of an existing HSR line clearly has significant and widespread impacts even if the impacts take longer to be reflected. A successful growth, specifically whether a region experiences HSR positive impacts, is dependent on the efforts and the willingness of the region rather than the introduction of HSR itself.

Table 5.1.3 Key factors of station area development

	Shinkansen (Japan)	Taiwan HSR	KTX (Korea)
Basic concepts	· Strategy for future urban structure · targeting zone · selection of the institution for development · implementation of development projects	· Development plan (station district plan) · improvement of connections between new town and city center	· Integrating station area development with regional and urban development · considering HSR networks and stations as the key elements of national economic and territory development strategy
Factors that influence the decision making process	· Regional potential · master plan of the area; intentions of local governments · economical and financial feasibility · incentive and regulation · change of zoning, land use and building regulation · agreement of land owners, residents and stakeholders · timing of development	· Zone expropriation (land readjustment, self-financing)	· Cooperation between related institutions such as central government, local government public corporations and local people · high willingness of local governments
Factors of successful cases	· Simultaneous land development and delay of land use · land readjustment, exchange lands · development of business district, commercial area or condominium · railway or subway connection · investment by private sector	· Proximity to city center · high population density · creation of employment · active real estate market	· Earlier construction of feeder transport · making earlier land use plan of HSR station areas
Factors of unsuccessful cases	· Limited land development plan · failure in united redevelopment of surroundings · delay of land development · limited land adjustment · sprawl	· Farness from city center; low population density;	· Economic recession · financial difficulty · poor local cooperation · delay of feeder transport · lack of execution body's capability · law system inefficiency · conflicts between stakeholders · high land price

Note: this table excludes impacts only of station area development

5.1.2. HSR station area development

The country reports discussed the basic concepts and many cases of HSR station area development. Key factors are identified both for successful and unsuccessful cases of HSR station area development (see Table 5.1.3).

First, a plan or strategy for the regional development structure is necessary the development of the area. In the cases of Taiwan and Korea, the development plans for station area development are incorporated in the planning systems. In the case of Japan, a strategy is developed for each station area with a goal towards the future urban structure. Based on these cases, there have been a number of basic concepts and factors that influence the decision making process that have been identified. In terms of development methods, one of the factors is land readjustment for maximizing the intensity of land-use or urban renewal. Another is the simultaneous influence of land development and delay in land use (i.e. timing of development). This is important to avoid high land prices. Financial feasibility is a necessity to avoid financial problems, which was a difficulty for the unsuccessful cases in Korea. In addition to the lack of financial feasibility, the unsuccessful cases in Korea also lacked an efficient legal system. Moreover, proper incentives are needed to attract private sector investment, which has led to successful developments in Japan. A good level of access to HSR stations is also a key factor for successful station area developments in three countries. A strong willingness of local governments or of leading bodies of development and cooperation between related agencies are also critical in some of the cases.

Based on the key factors in Table 5.1.3 and following the decision making process of urban development discussed in the previous chapters, we can summarize the significant factors of successful station area development:

Plan or strategy of regional and urban development

It is necessary to develop a plan or a strategy of regional structure as a basic concept in order to share a clear direction and to integrate related developments. It is important to consider intentions of local government.

Financial feasibility

Obviously, projects need to be economically feasible. Economic and financial feasibility should be checked with business feasibility or financing system in order to avoid difficulties from negative economic impacts such as economic recessions or uncertainty.

Efficient legal system and incentives

A station area development consists of many kinds of development, for example, that of the railway itself, station building, local transport facilities, station plaza, land use, business or commercial district, condominiums, etc. The development is related to many kinds of regulations. It is important to develop an efficient legal system in order to make it easier to find available or needed regulations or related incentives and also to avoid complicated procedures.

Land adjustment

This is not required but it is important to adjust or exchange lands in accordance with each development if needed in order to maximize intensity of land-use or urban renewal, which sometimes changes the zoning of or makes replacement of land. This sometimes establishes reserved areas for securing financial resources for the construction of infrastructure.

Simultaneous land development and delay in land use

In order to avoid a high land prices, it is important to implement a simultaneous land development in conjunction with a delay in land-use, if necessary. A lower land price can generate a significant capture of value.

Connection to local transport and also to city center

It is important for a station to be connected to the main local transport network and also the city center. Furthermore, it is more important to have the connections in an early stage of station area development in order to create a high level of demand.

Strong leadership of leading body

In order to progress developments promptly, strong leadership is expected for a leading agency with a set direction or a committee with decision making or coordination power is a requirement for success.

Consensus of related agencies

Without cooperation by related agencies such as stakeholders or interested bodies, it is hard to implement developments especially in urban areas. Building their consensus is a significant factor of a successful development.

5.2 Policy recommendations

The Shinkansen, Taiwan HSR and KTX networks have been developed for a long period of time, but still continue to develop future plans for the expansion and extension of their networks. For the provision of HSR services, it is important to consider the factors that influence the station area, as well as to develop the station area as much as possible for the efficient development of

HSR, regional societies and the economy. As discussed in the previous sections, the case studies have shown that a certain amount of time is needed to reflect the impacts of new HSR services. Therefore, mid- or long-term, regional and comprehensive plans or strategies should be developed for the success of future cases based on the key factors of successful development identified in the report.

This section identifies key policy recommendations for future HSR networks based on the analysis of successful cases of HSR impacts and station area developments.

Defining and sharing clear goals of introducing or extending HSR

HSR impacts were identified in this research; however, a region can take advantage of HSR's positive impacts not merely from the introduction of HSR but only if the HSR contributes to the region's future plans. Therefore it is needed to define clear goals of introducing or extending the HSR and also to develop the HSR ensuring HSR's positive impacts. Of course the goals should be shared with the region.

Developing planning systems

In order to make roles of related organizations clear and to share planning process including consensus building, it is needed to develop planning systems especially for station area development. This would also contribute to an effective legal system.

Involving the region and private sectors for a self-sustained and competitive station area development

We learned that investment by private sector is one of the successful factors of station area development. It also can contribute to a self-sustainability and competitiveness of station area and its development. At the same time, the understandings and cooperation of the region and the private sectors are necessary for the development, and therefore it is necessary to involve all related bodies.

Creation of business chances

This has two meanings. One is more passengers for business use. The other is creation of employment in station area. More passengers for business use will generate higher demands of the service level of HSR. This affects the higher service level of HSR, which can generate more passengers. On the other hand, creation of employment was identified as a significant factor of successful station area development. It is highly important to create business opportunities around HSR.

Capturing land value by controlling timing of land development

One of the successful factors of station area development was identified as delay in land-use. As a result, lower land prices can generate a significant capture of value for station area development. It is necessary to control the timing of development and also the capture of value.

Improving connectivity to local transport at HSR stations

Finally, connectivity to local transport is one of the successful factors of station area development with no later than the development itself. It is necessary to improve connectivity and accessibility without delay.

5.3 Future studies

As discussed in the previous sections, this study has attempted to achieve its objectives, which are to compare and analyze the socio-economic impacts of HSR, to analyze the current conditions of station area development through reviewing the performance and policies for increasing HSR demand and vitalizing the regional economy and to financially draw policy implications for HSR station area development. Through the discussion, this study identified key factors for successful HSR station area developments based on the cases of Japan, Taiwan and Korea.

At the same time, this study highlights challenges for future studies on the analysis of HSR impacts and station area development, from the following three viewpoints.

First, survey or collect related time-series data on HSR impacts and analyze the long-term and short-term changes constantly based on time-series trend data. In order to understand HSR impacts more precisely, more analyses are needed with more detailed data in other countries. In this study, socio-economic impacts were analyzed for each HSR case. However, analyzed items were not always common for the all cases because of the limited data in each case. It is necessary to compare the cases based on a standardized criteria for a more consistent and precise comparison. For example, significant or insignificant HSR impacts were identified in this study but the meanings of the impacts are not always the same. Similarly, the factors for successful and unsuccessful station area developments may have different impacts depending on location or other variables. It is important to understand the more specific and individual influences of the impacts as well as to generalize these influences for future practices.

Second, we need to study the role of policies for successful HSR station area development. Especially, it is necessary to find out the impacts of key policy factors on station area development such as the timing of the provision of an access transport system, the institution coordination system and project financing method.

Finally, for further studies it would be beneficial to extend the research scope and methodology to HSR networks in other countries, for example, France, Germany, China and those countries which have already started or will develop new HSR operations. The discussion on successful and unsuccessful station area development of other HSR cases will be useful to understand more general information, as well as to create new ideas in the context of East Asia. Knowledge exchange and knowledge sharing on policies and experiences on HSR impacts and station area development among countries will be expected to improve HSR's functions and benefits.

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