Doctoral Dissertation

Essays on Transportation and Trade Policies

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Summary

This dissertation focuses on two major topics in transportation and international trade fields. The first one is about transportation policy which is the privatization of Japanese National Railway (JNR) in 1987. Due to the heavy deficit, JNR was decided to be privatized and geographically divided into six companies for passenger transport service. This division changed the market condition on the busiest route in Japanese railway industry-Tokyo-Osaka route, namely some regions changed from previous monopoly condition to the duopoly condition after 1987 with some regions stayed in monopoly as it was before. We investigated the impact of market competition after JNR's privatization in 1987 on passengers' time cost by high-speed rail (HSR) and conventional rail (CR) through two different studies separately as showed in Chapter 2 and Chapter 3. These two studies are empirical studies which base on the panel and secondary data taken from published JR timetables in four different years, 1976, 1986, 1996 and 2006. Through HSR study in Chapter 2, we find that the increased market competition by duopoly decreases the HSR time cost by around 4 minutes on average, namely 10% of average time cost for OD pairs, relative to monopoly, while the speed of Shinkansen just increased by 21% in last 50 years. As well, results show that the market competition effect is larger for longer distance trip. However, in the conventional rail study (Chapter 3), analysis results do not show any evidences about the impact of market competition on passengers' time cost by taking conventional rail. Besides, in these two studies, simplified theoretical models about the impact of market competition on passengers' time cost are also constructed for analysis.

The second topic is related to international trade policy, which is the trade liberalization under the globalization background. This topic is discussed as showed in Chapter 4 through theoretical models and assumptions, which investigates the impact of trade liberalization on regional real income inequality in an endogenous growth model. This study is a theoretical study which constructs a footloose capital and endogenous growth model with agriculture, manufacturing and service goods. Results show that effects of globalization may positive, negative, or zero because the service price index and expenditure converge while the manufacturing price index diverges. Differences between interregional knowledge spillover minus intraregional knowledge spillover in the service sector determines the sign of the inequality in regional real income.

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Besides, I would like to express my sincere gratitude to Dr. Katsufumi Fukuda, who was assistant professor in our Development Policy (DP) Course and now work in Toyama University. During the years when he worked in DP course, he provided me good ideas about international trade, as well the impacts of trade liberalization. Special thanks should be given to Dr. Junghwan Hyun who was associate professor in DP Course and now work in Kwangwoon University, Korea. Attending his lessons and the discussion with him after classes brought me knowledge in theoretical study and as well some empirical methods. Also, I would like to thank Professor Shinji Kaneko, Professor Makoto Kakinaka and Associate Professor Ayami Nakaya from Education Development Course for their acceptance as committee members of my PhD thesis and providing those good comments.

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Abbreviations

CR	Conventional Rail
DID	Difference-in-Differences
DP	Development Policy
HSR	High-Speed Rail
IDEC	Graduate School for International Development and Cooperation
JTB	Japan Travel Bureau
JNR	Japanese National Railways
JR East	East Japan Railway Company
JR Central	Central Japan Railway Company
JR West	West Japan Railway Company
OD Pair	Origin-Destination Pair
PhD	Doctor of Philosophy

1. Introduction

This dissertation includes two important and popular research topics in economics field: (1) the impact of market competition on transport service quality; (2) the effect of trade liberalization on regional real income inequality. Both of these two topics are related to transportation economics and international trade. Basically, we are interested in the market competition in transportation field, and the global trade liberalization which take consider of transportation cost. We study the first topic by using the privatization of Japanese National Railway (JNR) in 1987 as an example, and the second topic is analyzed through a theoretical study.

Regard to the first topic, due to heavy deficit in operation, the JNR was decided to be privatized and geographically divided into six different companies for passengers transporting service and one company for goods transporting service. As the busiest route in Japanese railway industry, Tokyo-Osaka route had some changes in the intensity of the market competition. Before 1987, both the high-speed rail (HSR) service and conventional rail (CR) service on this route was provided by JNR, namely no market competition between HSR and CR on this route. However, after the privatization of JNR in 1987, the HSR service on this route is still provided by one company-Central Japan Railway Company (JR Central), with CR service on this route provided by three different railway companies, namely East Japan Railway Company (JR East), Central Japan Railway Company (JR Central) and West Japan Railway Company (JR West). Some segments on this route are still in monopoly as it was before 1987 with some segments on this route changed from monopoly to duopoly after 1987. Therefore, we came with the research question that whether the market competition after 1987 had impact on the services quality that railway companies provided and how big the impact was. Then we investigate the impact of market competition on rail transport services quality measured by passengers' time cost. The impact of market competition on HSR service and CR service are separately discussed in two different studies as showed in the Chapter 2 and Chapter 3. Both of these two studies are empirical researches which use difference-in-differences (DID) approach by analyzing a four years panel data.

Due to the innovations in transportation field, say the development in transportation technology, the business trips and trade communication among different countries have been much more convenient than before since last century which contribute a lot to the trade globalization and trade liberalization. And we came with a research question that whether the trade liberalization benefits the relatively disadvantage countries by reducing the regional income inequality between poor countries and rich countries. Different from the first topic that employs the econometric approach to investigate the impact of market competition, the second topic is discussed in Chapter 4 by using a theoretical approach. Through theoretical models and related assumptions, this study for second topic investigates the effect of trade liberalization on regional real income inequality in an endogenous growth model with manufacturing, agriculture and service goods.

As additional information, Chapter 2 is based on the joint study with associate professor Takahiro Ito and professor Yuichiro Yoshida. Professor Yuichiro Yoshida came with the idea, supervised in the conduction of this study and an early version of the manuscript. Takahiro Ito constructed the econometric models and did the econometric analysis. I collected all the raw data, made econometric analysis and made many revisions to the early draft of manuscript according to our update analysis results and the update version of manuscript is as showed in the Chapter 2. The study in Chapter 3 is a joint study with professor Yuichiro Yoshida. A version of Chapter 3 has been accepted for publication by Journal of International Development and Cooperation, and will be published in the Volume.26, No.1 soon. I conducted most of the work, including the data collection, econometric models constructing and data analysis, result interpretation and I also wrote the first draft of the manuscript. Professor Yuichiro Yoshida supervised me in the data collection and data analysis processes, also provided valuable suggestions. The study in Chapter 4 is a joint study with Dr. Katsufumi Fukuda. A version of Chapter 4 has been accepted for publication by Journal of International Development and Cooperation, and will be published in the Volume.26, No.1 soon. Dr. Katsufumi Fukuda brought the idea and helped a lot in building the models for analysis. The rest of the whole work was conducted by me with strong support from Dr. Katsufumi Fukuda.

2. Does Monopoly Slow Down a Bullet Train?

2.1. Introduction

Japan National Railways (JNR), a state-owned public corporation that founded in 1949 and provided railway services nation-wide was dismantled into six regional railway companies for passenger transport service in 1987. As result for dismantling of JNR, each of the six railway companies is in charge of both the high-speed rail (HSR, which was named as Shinkansen in Japan) and a conventional rail in its respective region. There emerged, however, a limited number of areas with an increased level of market competition, where HSR and conventional rail are operated by two separate companies due to an operational reason. By utilizing this variation in the competitive pressure from a conventional rail, this study measures the impact of market competition on supply behaviors of an oligopolistic HSR transport service provider. Specifically, from the published timetables, we obtain the change in time cost, namely the in-vehicle time and schedule delay (early) of traveling on HSR train before and after the JNR's privatization. This study finds that the passengers' time cost of taking HSR is reduced in the duopoly region, relatively to that in the area that is in monopoly. This study also find that the impact of market competition is larger for relative longer distance trip.

Since the privatization process started in 1987, JNR was geographically divided into six Japan Railway (JR) companies for passenger transport service.[1] In principle, each of them is in charge of both HSR and parallelly running conventional rail in the designated region. Exception to this principle emerged in greater Tokyo and greater Osaka, the first and the second largest metropolitan areas of Japan. This is because the conventional rail service on Tokyo-Osaka route is separately provided by three different JR companies, namely JR East, JR Central and JR West, while the HSR service on whole Tokyo-Osaka route is only provided by JR Central. Therefore, in great Tokyo area, the conventional rail service was provided by JR East with HSR service provided by JR Central; in great Osaka area, the conventional rail service was provided by JR West with HSR service provided by JR Central. However, the conventional

[1]The six JR companies are Hokkaido Railway Company (JR Hokkaido), East Japan Railway Company (JR East), Central Japan Railway Company (JR Central), West Japan Railway Company (JR West), Shikoku Railway Company (JR Shikoku) and Kyushu Railway Company (JR Kyushu).

rail and HSR service in the central part of Japan is owned and only operated by JR Central. This created a difference in the intensity of market competition where HSR and conventional rail services are either monopolized or duopolized after the privatization. This conforms the design of the current research that measures the difference in the impact of duopoly and monopoly before and after the privatization of railway services.

Shinkansen, as known as a “bullet train”, started running in 1964. The zero series, a bullet-shaped train car designed exclusively for Shinkansen ran on the newly developed track of 552.6 km length between Tokyo and Osaka at the maximum operational speed of 210 km/h. It connected these two largest cities of Japan in 3 hours and 10 minutes, which is less than a half of the fastest conventional express trains at that time. As a result, there are two parallel rail tracks that connect major cities between Tokyo and Osaka, namely, HSR (Shinkansen) and the conventional rail. The following Table 2-1 summarizes the differences between these two modes of rail transport along this largest trunk rote in Japan.

Table 2–1 Characteristics of Shinkansen (HSR) and Conventional Rail in 1965

	Shinkansen (HSR)	Conventional Rail
Maximum speed	210 km/h[1]	110 km/h
Average speed[2]	171.8 km/h[1]	86.0 km/h
Minimum travel time[2]	3 hours 10 minutes[1]	6 hours 30 minutes
Gauge	1,435 mm	1,067 mm
Minimum curve radius[2]	2,500 m	400 m
Total length of tunnels[2]	68.0 km	27.0 km
Road crossings	None	About 1,100
Length of a train car	25.0 m	20.5 m
Width of a train car	3.38 m	2.95 m

Notes: [1] These values are just one-year after Shinkansen HSR firstly operated in 1964. [2] These values are between Tokyo and Osaka. Data source: Japan National Railways.

On April 1st, 1987, Japan National Railways (JNR) was divided geographically into six Japan Railway (JR) companies as showed in the following Figure 2-1. In principle, each of the six JR companies provides both the HSR and conventional rail services in the designated region.[2] For example, JR East company is in charge of the area east of Atami city (Shizuoka Ken) including greater Tokyo, and JR West company is covering western part of mainland Japan beyond Maibara city (Shiga Ken) including greater Osaka. While the provision of conventional rail services between Tokyo and Osaka is divided into three different companies at Atami and Maibara as mentioned above, with HSR is operated throughout by one single company, namely JR Central for practicality of operation. This situation is summarized in the Table 2-2 and Figure 2-2.

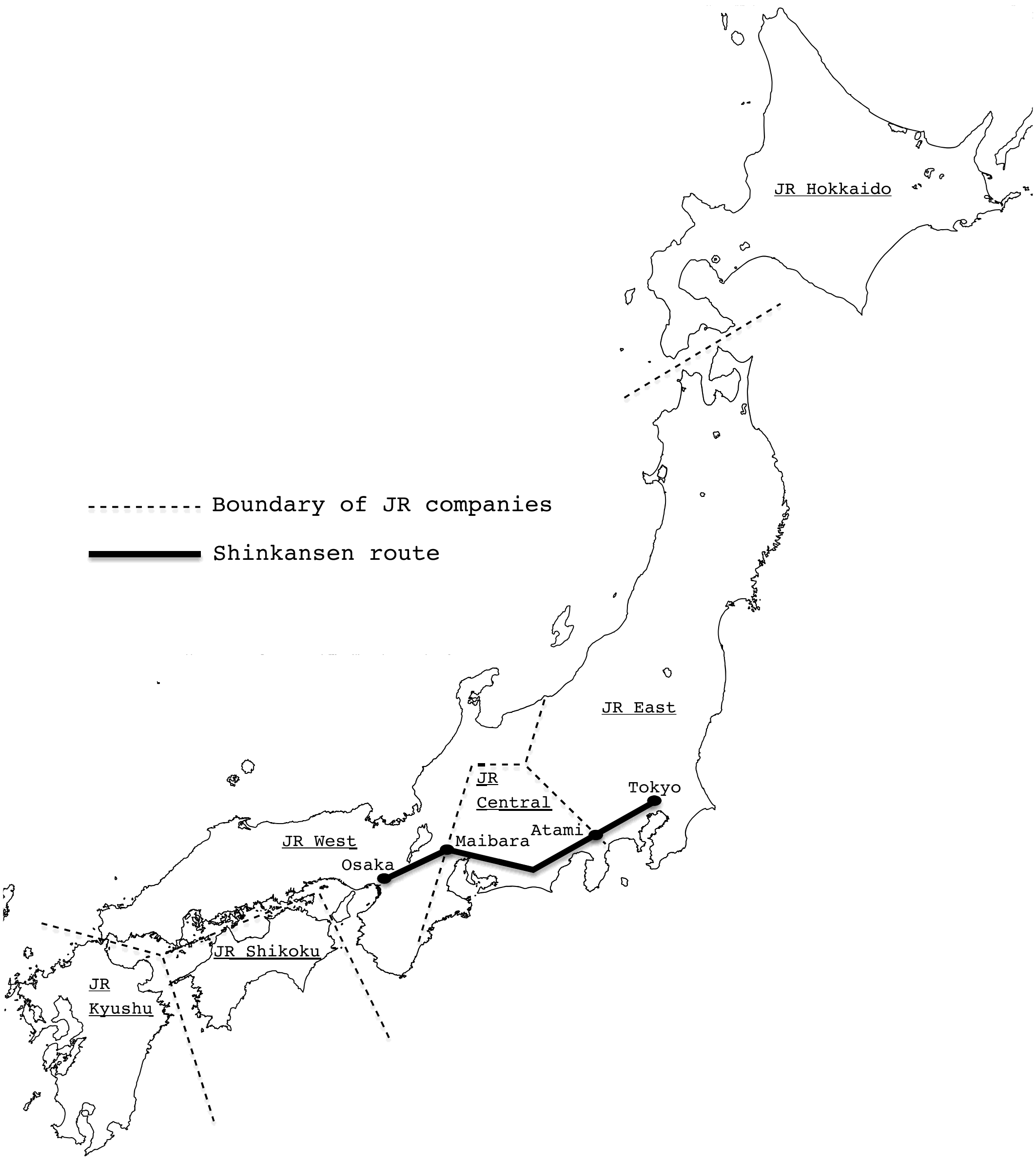

Figure 2-1 Geographical Locations of JR Companies and Shinkansen Route between Tokyo and Osaka

[2] There is no HSR service in the region that Shikoku railway company in charge of.

Table 2–2 Operators of Railways between Tokyo and Osaka after Dissolution of JNR

	Segments		
Type of Service	Tokyo-Atami	Atami-Maibara	Maibara-Osaka
High Speed Rail	JR Central	JR Central	JR Central
Conventional Rail	JR East	JR Central	JR West
Distance	104.6 km	341.3 km	106.7 km

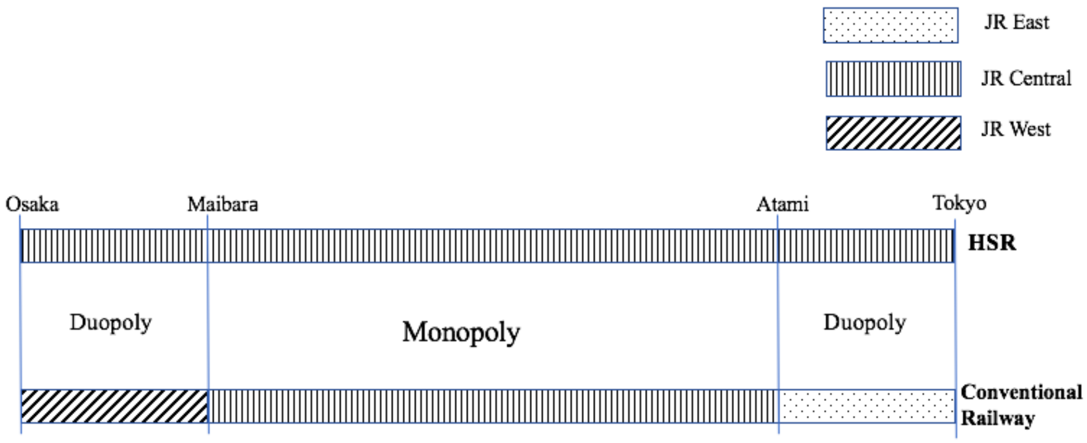

Figure 2-2 Operating Condition of HSR and CR for Tokyo-Osaka Route

When these six JR companies were founded, they were regarded as special corporations because JNR Settlement Corporation-a public entity to settle the huge debt that JNR left-still owned the entire share. JNR was badly in red at that time. Its huge debt was not only due to investment, but also by the cumulated operational losses over the years. JR companies took over about a third of JNR’s debt of 37.1 trillion yen back then, while two third were supposed to be paid by selling their shares in the stock market later on. Though they were publicly owned, the new JR companies were expected to make as much profit as possible and pay back the debt as soon as possible. JR companies who inherited a large, if not excessive, number of employees and unprofitable routes in rural areas, had to improve their operational efficiency greatly in order to be profitable.

Three JR companies in mainland Japan, namely JR East, JR Central and JR West did well by exploiting the market power as regional monopoly. Price back then was set by the government based on their cost with a fixed markup. Their high cost implied high price set by the government. This high price enabled them to cash in their market power as they improved their operational efficiency. JR East was listed on Tokyo Stock Exchange in 1993 and JR West was in 1996, followed by JR Central in 1997. By April 2006, all these three companies' stocks were sold entirely to private shareholders.

Until they were excluded in 2001, these three JR companies were regulated by JR Corporation Law.[3] Under the law, price change required government's approval. Indeed, price has not been changed since 1987 until January 1996, when three JR companies outside of mainland Japan for the first-time requested system-wide price change and were granted approval. However, JR East, JR Central and JR West did not change their price even then, and in fact not ever since the start of JNR's privatization process until now.[4] We therefore measure the treatment effect of the market competition on time cost in this study. For the years after JNR privatization, we focus on two time points when three mainland JR companies started and completed public listing, namely 1996 and 2006. For the years before JNR privatization, we use the year 1976 and year 1986, which use ten years as time gap.

Market competition is the most classic, if not the most important issue in Economics (Chamberlin, 1933;). In fact, there exists a vast theoretical literature on the role and the impact of market competition (Lerner, 1934; Abbott, 1955; Fujita, 1988; Parenti, et al., 2017;). Theory tells that competition increases quality when price is regulated. However, when firms set both price and quality, the impact of competition is ambiguous (Spence, 1975;). Some models predict competition increases quality (Tirole, 1988; Pepall, et al., 2005;).[5] In contrast to the theoretical literature, empirical literature on causal inference of competition impact is limited.[6] Masta (2011) examines the effect of competition in the US supermarket industry by utilizing Walmart store openings as an exogenous shock to local markets. Busso and Galiani (2015), which is the first and sole experimental study in the literature, explores the impact of competition among grocery stores on prices and quality of goods in the Dominican Republic

[3] Other three (JR Hokkaido, JR Shikoku and JR Kyushu) currently are still regulated under the law.

[4] This is mostly due to political pressure that privatization cannot be associated with price increase. However, ever since JR companies are established, Japanese economy has not facing continuous deflation, that effectively increased the relative price. There is common political sentiment or phobia, among formerly state-owned and then privatized regional monopolies, such as highway, electricity and railway companies, regarding discussing prices, especially when they are being profitable.

[5] See appendix for the theoretical illustration in our context.

[6] There exist several papers attempting to identify the impact of market competition. For instance, Domberger and Sherr (1989) is on the market for conveyancing legal services in England and Wales; Hoxby (2000) on school education in the US; Mazzeo (2003) on the US airline industry; Amiti and Khandelwal (2013) on the manufacturing industry. Some of them exploit quasi/natural experiment settings to isolate the impact of competitive environment, such as the timing of a policy implementation and geographical feature. However, none of these studies controls unit-intrinsic heterogeneity mainly because they rely on cross-sectional variations in the degree of competition.

by randomizing the entry of new grocery store in a conditional cash transfer program. Background of this limited empirical literature is a lack of "good" exogenous variation, while experiment is almost impossible. This is largely due to the fact that the intensity of market competition is typically time-invariant, and therefore only cross-sectional data are available. As a result, in many studies, heterogeneity between units in treatment and control is seriously large, which leads to confounding say, by self-selection. Reverse causality is also likely to bias the result if a company with high product quality kicks out others and thus reduces the competition. This study adds to a few empirical studies that measures the impact of competition by using exogenous variation arising from a natural experimental setting along with unit-of-observation fixed effects.

In the section 2.2, we will explain our data and empirical strategy in detail. Section 2.3 presents the results and section 2.4 concludes the study.

2.2. Identification Strategy and Data

2.2.1 Identification Strategy

To estimate the impact of change in the intensity of market competition between the treatment group and control group, in this study, it employs the difference-in-differences (DID) approach as an identification strategy, which with OD pair and year fixed effect by using a panel data in four years (1976, 1986, 1996 and 2006). By using the OD pair and year fixed effects, we could eliminate the bias from potential omitted variables, such as unobserved time-variant variables and time-invariant variables.

The DID approach employed in this study measures the difference between the changes for outcome variable in treatment group and control group among same period, which is the average treatment effect, namely the market competition.

Econometric framework in this study is as follows:

$$Y_{it} = \alpha(Treat_i \times Post_t) + \beta X_{it} + \phi_i + \varphi_t + \varepsilon_{it} \quad (1)$$

Where Y_{it} as outcome variable and it is time cost for directional OD pair *i* in year *t* in this study. Here $Treat_i$ is treatment group dummy that takes a value of one if the OD pair is located on either the Tokyo-Atami route or the Maibara-Osaka route and zero otherwise, $Post_t$ is after treatment year dummy, and it equals to 1 if the year is after 1987, namely 1996 and 2006, and 0 otherwise. ϕ_i and φ_t are OD fixed effect and year fixed effect, respectively, with ε_{it} as error term. α is the coefficient for the interaction term with treatment dummy and post dummy, namely the estimator of treatment effect in this study. Variable X_{it} is a set of control variables which depend on model specification.

2.2.2 Data

As can be seen in the Table 2-2, those segments, Tokyo-Atami and Maibara-Osaka are in duopoly after JNR' privatization in 1987, while Atami-Maibara segment remained as in monopoly. Our unit of analysis is a directional pair of Shinkansen stations, one being the origin and another being the destination, which we refer to as an OD pair. We group OD pairs into two: one with those OD pairs such that the entire journey is contained in the duopolized area, and another with those such that both their origin and destination stations ae in the mopolized area. We refer to the former as the treatment group and the latter as the control group. In this study, we use the HSR stations already existed in 1976 and exist for all the four years. There are two intermediate stations between Tokyo and Atami; six stations between Atami and Maibara and only one station between Maibara and Osaka.[7] Therefore the total number of directional OD pairs is 18 in the treatment area and the number in the control area is 56 for one year.

As the distance for the OD pairs in control area is much longer when comparing with OD pairs in treatment area, the OD pairs in our control area is not well balanced with OD pairs in our treatment area. Then we keep all the OD pairs in the treatment area and pick up the OD pairs in control group which are near the borders (Atami and Maibara). Our treatment area is consisted of two parts, one is greater Tokyo area (Tokyo-Atami route) and the other one is greater Osaka area (Maibara-Osaka route). For greater Tokyo area, route Tokyo-Atami has four stations which located in treatment area and we pick up another fours stations (Atami, Mishima, Shizuoka and Hamamatsu) near the border "Atami" station which located in control area; for greater Osaka area, router Maibara-Osaka has three stations which located in treatment area and we pick up another three stations (Nagoya, Gifu-Hashima and Maibara) near the

[7]The Shinkansen stations used in our study then are, from east to west, Tokyo, Shin-Yokohama, Odawara, Atami, Mishima, Shizuoka, Hamamatsu, Toyohashi, Nagoya, Gifu-Hashima, Maibara, Kyoto and Shin-Osaka.

border "Maibara" station which located in control area.[8] Then, in our study, our treatment group is consisted of OD pairs on "Tokyo-Atami" route and "Maibara-Osaka" route, and our control group is consisted of OD pairs on "Atami-Hamamatsu" route and "Nagoya-Maibara" route. Therefore, there are 18 OD pairs in treatment group and another 18 OD pairs in control group for each year. Then we have 36 OD pairs for each year, which with 144 OD pairs in total for all the four years included in this study.

Our outcome variable is users' time cost. Users' time cost of a trip between an OD pair is a sum of the in-vehicle time and schedule delay. Schedule delay is the time difference between the train actual arrival time and the passengers' target arrival time. Since delay is not allowed in our study for analysis, the schedule delay in this study is namely schedule delay early. In-vehicle time and schedule delay (early) on the four time points before and after the privatization of JNR corporation in 1987 is collected, namely for year 1976, year 1986, year 1996 and year 2006 from the timetables published by Japan Travel Bureau (JTB). Treatment year is as mentioned above, either 1996 or 2006. Duopoly dummy takes the value of one in the treatment years if the OD pair is in the duopolized area, and zero otherwise.

In order to measure user' time cost of an OD pair, we generate 50 hypothetical target arrival times from a uniform distribution between 6:00 AM and 12:00 midnight. This reflects the fact that Shinkansen provides HSR services for inter-city travel that do not exhibit obvious peak hours, and also that by regulation the operation of Shinkansen is restricted from 6:00AM up to midnight. For each of these 50 target arrival time, a train that minimizes the user' time cost is picked, and this kind of time cost is recorded for all the OD pairs. In this study, we assume that late arrivals are not allowed.[9] Then the average of these time values is computed to yield the in-vehicle time and schedule-delay data for each OD pair. We compute the average time cost for all four years (1976, 1986, 1996 and 2006).

The following Table 2-3 presents balance test of baseline characteristics between OD pairs in monopoly and duopoly areas, namely control group and treatment group. Except for population and number of competing private railway companies, there are no significant difference between treatment group and control group in the other related variables. As showed in Panel A of Table 2-3, population in treatment group is significantly higher than the population in control group. This is due to that the cities (such as Tokyo and Osaka) in

[8] Atami and Maibara stations are bordering stations which are considered both in treatment and control areas.

[9] We drop the target arrival time when it is not possible to leave on the same day as the target arrival time is early in the morning.

treatment group are with bigger population than cities in control group. Similarly, as showed in the Panel A of Table 2-3, the number of competing private railway companies in treatment group is significantly more than that in control group. This is due to treatment group with more population which comes with more transport demand, and more demand always with more providers. Fortunately, as showed in the Panel B of Table 2-3, change in population in treatment group is not significantly different from the change in control group. Besides, since the number of competing private railway firms does not change over the years, we do this balance test by taking the number of the competing private railway firms per million capita. The result is showed as in Panel B of Table 2-3, which is that the change in number of competing private railway firms per million capita in treatment is not significant different form that in control group. All these prove that common-trend assumption is satisfied which conforms research design in this study. Besides, robustness checks by considering the influence of population size and number of competing private railway firms will be showed in the following empirical results section.

Table 2–3 Balancing Test of Baseline Characteristics

	Control (monopoly)		Treatment (duopoly)		(2) – (4)
	N. Obs	*Mean (Std. Dev.)*	*N. Obs.*	*Mean (Std. Dev.)*	*Difference [Std.Errors]*
	(1)	(2)	(3)	(4)	(5)
Panel A: Comparison by Level (using 1976 and 1986 data)					
User cost per distance					
Time cost/distance	36	0.704	36	0.746	-0.042
(minutes/km)		(0.322)		(0.238)	[0.067]
Monetary cost/distance	18	25.330	18	25.569	-0.240
(JPY/km)		(15.131)		(299.273)	[4.718]
Other Characteristics					
Population/10,000	36	47.166	36	239.159	-191.993***
		(61.541)		(299.273)	[50.923]
Income per capita	36	1,652.92	36	1,823.86	-170.941
		(759.390)		(853.925)	[190.457]

Distance	18	75.200	18	64.700	10.500
		(43.598)		(30.359)	[12.522]
Number of competing	18	0.111	18	0.556	-0.444**
private railway firms		(0.323)		(0.856)	[0.216]
Number of stops/distance	18	0.026	18	0.027	-0.001
		(0.015)		(0.010)	[0.004]
Imperfectly substitutable	18	0.006	18	0.007	-0.001
with CR		(0.012)		(0.012)	[0.004]
Panel B: Comparison by Change (between 1976 and 1986)					
User cost per distance					
Changes in time cost /	18	-0.026	18	-0.029	0.003
distance		(0.071)		(0.069)	[4.837]
Changes in monetary cost	18	21.547	18	21.505	0.042
/ distance		(5.488)		(4.133)	[1.619]
Other Characteristics					
Changes in population /	18	1.775	18	0.114	1.660
10,000		(1.727)		(20.447)	[4.837]
Changes in income per	18	1,486.380	18	1,586.379	-99.999
capita		(82.964)		(258.153)	[63.912]
Number of private railway	18	0.053	18	0.190	-0.137
firms/(Population/10^6)		(0.154)		(0.433)	[0.108]

Notes: Standard deviations and standard errors are given in parentheses and square brackets, respectively. "Imperfectly substitutable with CR" is the dummy for stations that are imperfectly substitutable with the conventional railway.

The following Table 2-4 summarize the main characteristics of the sample. As showed, the average time cost for all the OD pairs in the sample is 42.14 minutes. The details of other related variables are also showed in the table, respectively.

Table 2–4 Summary Statistics of Empirical Variables

Variables	*N. Obs.*	*Mean*	*Std. Dev.*	*Min*	*Max*
User cost					
Time cost (minutes)	144	42.14	15.48	19.04	86.32
Monetary cost (Japanese yen)	144	2,110.00	1,142.54	700.00	4,930.00
Time-variant controls					
Log of population (city/ward level)	144	12.86	1.78	10.58	15.97
Log of total income (prefecture level)	144	7.75	0.54	6.74	8.46
Number of stops	144	1.79	0.99	1.00	5.00
Time-invariant controls					
Treatment group dummy	36	0.50	0.51	0.00	1.00
Distance	36	69.95	37.41	16.10	152.50
Number of competing private railway firms	36	0.33	0.68	0.00	2.00
Imperfectly substitutable with CR	36	0.28	0.45	0.00	1.00

2.3 Empirical Results

2.3.1 Effect of Railway Market Competition on HSR Service

We investigate the effect of market competition on passengers' time cost by HSR, which with results showed in the following Table 2-5. Specifications in Table 2-5 include OD and year fixed effects, as well the time-variant variables[10]. Estimated result in Columns (1) are through basic specifications, and result shows that time cost was significantly lower by 4.167 minutes on average for OD pairs in duopoly area where HSR is competing with conventional rail, relative to OD pairs in monopoly region. This result is robust in terms of additional control by the interaction term between time-invariant variables and $post_{1987}$ dummy as showed in column

10 The time variant control variables include (ln(population in the origin city), ln(population in the destination city), ln(real income in the origin prefecture), and ln(real income in the destination prefecture).

(3). Result in Column (3) shows that market competition significantly reduces the time cost for OD pairs in duopoly region by 3.246 minutes on average, when comparing with OD pairs in monopoly area.

Different from Column (1) and (3), interaction term of duopoly with distance is additionally included in Column (2) and (4). Based on Column (2), Column (4) additionally controls interaction term between time-invariant variables and $post_{1987}$ dummy. Estimate results in Column (2) and (4) show that time cost is significantly lower by 4.084 minutes and 3.487 minutes on average in duopoly area, relative to monopoly region, respectively. Different from the estimate for interaction term of duopoly with distance which seems to be insignificant in Column (2), namely we do not find any evidence; while in Column (4), coefficient for interaction term of duopoly with distance is -0.065 (significant at 1% level) after controlling interaction term of time-invariant variables with $post_{1987}$ dummy. Therefore, all these results consistently show that market competition significantly reduce passengers' time cost by around 4 minutes on average for OD pairs in duopoly region, when comparing with that in the monopoly region.

Table 2–5 Effect of Duopoly on Time Cost

	(1)	(2)	(3)	(4)
Duopoly (Treatment × $Post_{1987}$)	-4.167***	-4.084***	-3.246***	-3.487***
	[1.032]	[1.007]	[0.795]	[0.719]
Duopoly × Distance		-0.026		-0.065***
		[0.025]		[0.012]
OD and year fixed effects	Yes	Yes	Yes	Yes
Time-variant controls	Yes	Yes	Yes	Yes
Time-invariant controls× $Post_{1987}$	No	No	Yes	Yes
Observations	144	144	144	144
R-squared	0.646	0.656	0.693	0.722

Note: (a) This table reports only the coefficient of interest based on equation (1). All standard errors in the square brackets are collected for dyadic correlation. Triple asterisks (***) denote that the coefficient is statistically significant at 1% level. (b) Time-variant controls include ln(population in the origin city), ln(population in the destination city), ln(real income in the origin prefecture), ln(real income in the destination prefecture), the number of stops, and year fixed effects. Time-invariant controls are distance, the number of competing private railway companies, and dummy for stations that are imperfectly substitutable with the conventional railway. For the interaction term between duopoly and distance ("Duopoly × Distance"), we standardize the distance so that the mean of "Duopoly × Distance" is equal to zero for ease of interpretation of the coefficient estimate of "Duopoly", i.e., the coefficient is the average treatment effect of duopoly.

2.3.2 Robustness Checks

2.3.2.1 Robustness Check: Unbalanced Variables' Influences

As showed in Table 2-3, population in duopoly regions is significantly larger than that in monopoly regions. As mentioned, this is reasonable since big cities like Tokyo and Osaka all located in duopoly regions, relative to smaller cities with fewer population in monopoly regions. Besides, as showed in Table 2-3, the number of competing private railway firms in duopoly regions is significantly larger than in monopoly regions. This is due to the duopoly regions are with higher population which create more travelling demand. More demand always comes with more providers, namely, railway firms. Therefore, difference in population and number of competing private railway firms between duopoly and monopoly regions could be confounders in the analysis results.

As a further robustness check, the interaction term between duopoly and population in 1976 in log and the interaction term between duopoly and number of competing private companies are separately taken for analysis in Column (1) and (2). In Column (3), both interaction term between duopoly and population in 1976 in log and interaction term between duopoly and number of competing private companies are used for estimate in column (3). For all the columns in Table 2-6, OD and year fixed effects, time variant variables, the interaction term between time-invariant variables and $post_{1987}$ dummy and interaction term between duopoly with distance are all included. All the estimate results in Table 2-6 consistently show that market competition reduce passengers' time cost by around 3.5 minutes on average for OD pairs in duopoly area, relative to those in monopoly area. In the Columns of Table 2-6, the coefficient for interaction term of duopoly with distance is consistently around -0.067 (significant at 1% level). Besides, as obviously showed in Column (1), (2) and (3) of Table 2-6, no evidences show that population and number of competing private railway firms have influences on passengers' time cost in duopoly region, relative to monopoly region.

Table 2–6 Examining the Influences of Unbalanced Variables

	(1)	(2)	(3)
Duopoly (Treatment × $Post_{1987}$)	-3.461***	-3.634***	-3.655***
	[0.456]	[0.805]	[0.750]
Duopoly × Distance	-0.066***	-0.067***	-0.067***
	[0.015]	[0.012]	[0.018]
Duopoly × Log of pop. In 1976	0.070		0.097
	[0.525]		[0.612]
Duopoly × Number of competing		-0.439	-0.609
private railway firms		[0.703]	[1.353]
OD and year fixed effects	Yes	Yes	Yes
Time-variant controls	Yes	Yes	Yes
Time-invariant controls× $Post_{1987}$	Yes	Yes	Yes
Observations	144	144	144
R-squared	0.723	0.723	0.723

Notes: (1) This table reports only the coefficient of interest based on equation (1). All standard errors in the square brackets are corrected for dyadic correlation. Triple asterisks (***) denote that coefficient is statistically significant at the 1% level. (2) Additional controls are the same as in column 4 of Table 2-5 (see the note in Table 2-5).

2.3.2.2 Robustness check: Heterogeneity between East and JR West

We also conduct robustness check on the heterogeneity between JR East and JR West. In Column (1) and (2) of Table 2-7, the market competition effect is investigated by region with the effect varies according to distance by region. Different from Column (1) which use interaction term between duopoly with distance, Column (2) include triple interaction between duopoly, distance and the company dummies (the company dummy that which JR company provides conventional service against HSR service provided by JR Central). In both Column (1) and (2), OD and year fixed effects, time-variant variables and interaction between time-invariant variables and $post_{1987}$ dummy are all included.

As showed in Column (1) and (2), effect of market competition in the region where JR East competes with JR Central, namely Tokyo region, reduces time cost by 3.562 minutes and 3.448 minutes on average (significant at 1% level), respectively, relative to monopoly region; market competition in the region where JR West competes with JR Central, namely Osaka region, reduces time cost by 3.170 minutes and 2.789 minutes on average (significant at 1% level), respectively, relatively to monopoly region. As showed in Column (1), the coefficient of the interaction term for duopoly with distance is -0.065 (significant at 1% level); in Column (2), the coefficients of triple interaction between duopoly, distance and JR East and triple interaction between duopoly, distance and JR West are -0.057 and -0.090, respectively (both significant at 1% level). Overall, all these estimate results consistently show that impact of market competition in the region where JR East provides conventional rail service and in the region where JR West provides conventional rail service is at same level with significance level at 1%, while the impact of market competition on time cost in the region that JR East competes with JR Central is a bit larger than that in the region where JR West competes with JR Central.

Table 2–7 Checks on the Heterogenous Trends between JR East and JR West

	(1)	(2)
(a) Duopoly (Treatment × $Post_{1987}$) × JR East	-3.562***	-3.448***
	[0.708]	[0.542]
(b) Duopoly × JR West	-3.170***	-2.789***
	[0.821]	[0.705]
Duopoly × Distance	-0.065***	
	[0.011]	
Duopoly × Distance × JR East		-0.057***
		[0.010]
Duopoly × Distance × JR West		-0.090***
		[0.016]
OD and year fixed effects	Yes	Yes
Time-variant controls	Yes	Yes
Time-invariant controls × $Post_{1987}$	Yes	Yes
F test for the null hypothesis that (a) and (b): F(1,13) =	0.63	2.59
Observations	144	144
R-squared	0.723	0.726

Notes: (1) This table reports only the coefficient of interest based on equation (1). All standard errors in the square brackets are corrected for dyadic correlation. Triple asterisks (***) denote that coefficient is statistically significant at the 1% level. (2) Additional controls are the same as in column 4 of Table 5 (see the note in Table 5).

2.3.2.3 Robustness Check: Privatization or Other Trends?

Different from all other tables which focus on changes after JNR privatization in 1987, in Columns of Table 2-8, interaction term between treatment dummy and $post_{1977}$ dummy and interaction term between treatment and $post_{1997}$ dummy are also included to investigate whether there are some other trends instead of the privatization. No clear evidences are found by the interaction term between treatment dummy and $post_{1977}$ dummy and interaction term between treatment dummy and $post_{1997}$ dummy. However, coefficients for interaction between treatment dummy and $post_{1987}$ dummy are -3.226 (significant at 5% level), -3.584 (significant at 1% level) and -3.555 (significant at 1% level) as showed in Column (1), (2) and (3), respectively.

Different from Column (1), Column (2) includes interaction term between duopoly dummy and distance, and the coefficient is -0.058 (significant at 1% level). In Column (3), based on Column (2), triple interaction term between treatment dummy, $post_{1977}$ dummy and distance, and triple interaction term between treatment dummy, $post_{1997}$ dummy and distance are included. No clear evidences are found for effect of triple interaction term between treatment dummy, $post_{1977}$ dummy and distance, and triple interaction term between treatment dummy, $post_{1997}$ dummy and distance. However, coefficient for interaction between duopoly dummy and distance in Column (3) is -0.093 (significant at 1% level), which is larger than that estimate result in Column (2). Overall, all these show the impact of market competition is consistently at same level, as well the coefficient of interaction between duopoly dummy and distance.

Table 2–8 Privatization or Other Trends

	(1)	(2)	(3)
Treatment × $Post_{1977}$	0.592	0.609	0.430
	[0.742]	[0.920]	[1.022]
Duopoly (Treatment × $Post_{1987}$)	-3.226**	-3.584***	-3.555***
	[1.194]	[0.932]	[0.885]
Treatment × $Post_{1997}$	-0.090	0.101	0.062
	[0.966]	[1.010]	[1.456]
Treatment × $Post_{1977}$ × Distance			0.029
			[0.034]
Duopoly (Treatment × $Post_{1987}$) × Distance		-0.058***	-0.093***
		[0.015]	[0.021]
Treatment × $Post_{1997}$ × Distance			0.038
			[0.024]
OD and Year fixed effects	Yes	Yes	Yes
Time-variant controls	Yes	Yes	Yes
Time-variant controls × Post dummies	Yes	Yes	Yes
Observations	144	144	144
R-squared	0.755	0.777	0.787

Note: (a) This table reports only the coefficient of interest based on equation (1). All standard errors in the square brackets are corrected for dyadic correlation. Triple and double asterisks (*** and **) denote that the coefficient is statistically at the 1% and 5% levels, respectively. (b) Additional controls are the same as in column 4 of Table 2-5 (see the notes in Table 2-5).

As an additional evidence, treatment effects by distance are showed in the following Figure 2-3. No clear evidences are showed through the interaction between treatment dummy and $post_{1977}$ dummy and the interaction between treatment dummy and $post_{1997}$ dummy. However, as showed in the (b) of Figure 2-3, the market competition effect after JNR privatization in 1987 significantly reduce time cost for OD pairs in duopoly area, relative to monopoly area. Besides, the market competition effect is larger for longer distance trip, especially for distance larger than 60km (significant at 5% level). In the sample for analysis, there are 20 OD pairs with distance larger than 60 km for each year.

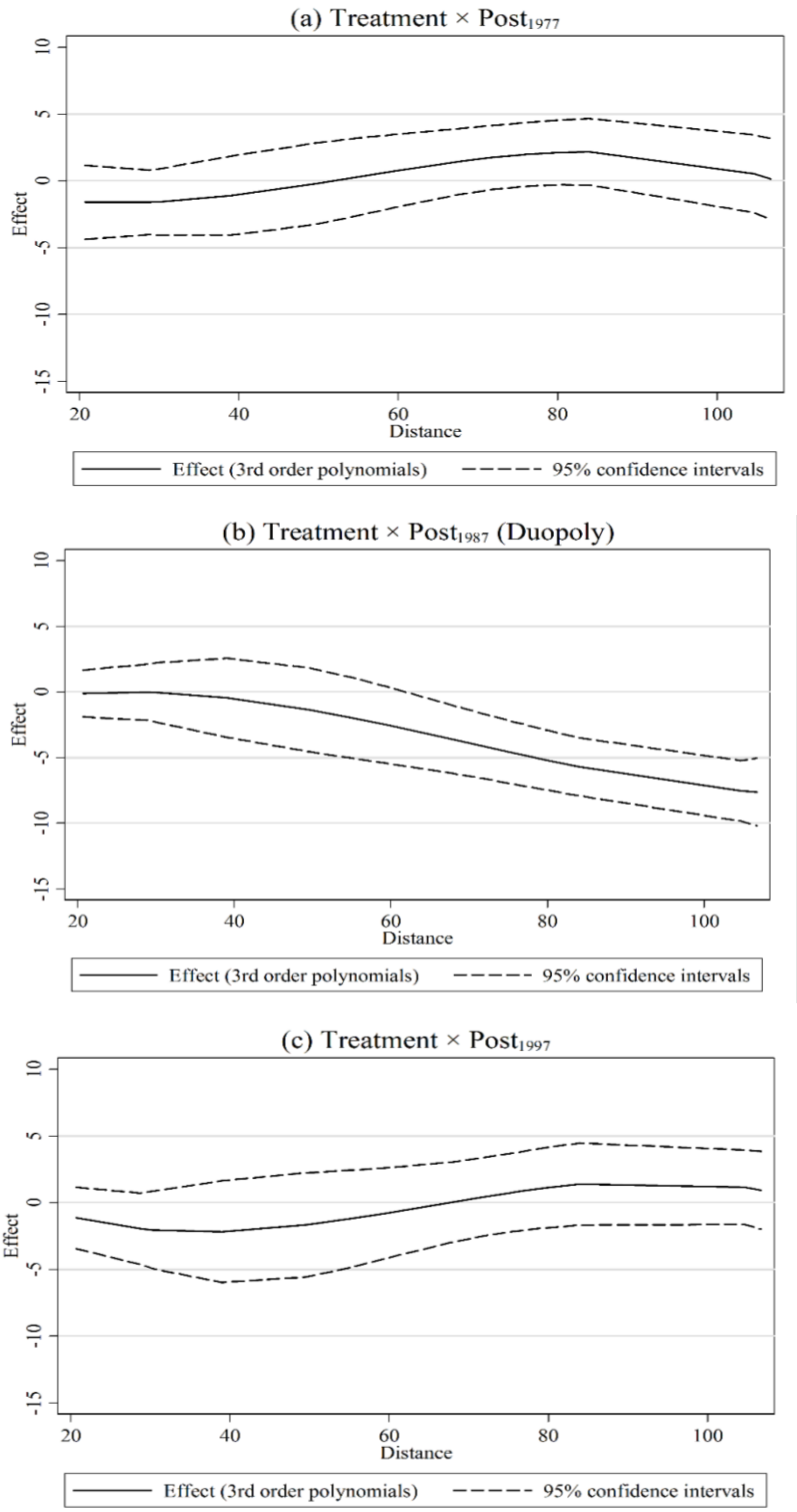

Figure 2-3 Treatment Effect by Distance

2.3.3 Additional Robustness Checks and Theoretical Analysis

2.3.3.1 Examining the Influence of Nozomi Supper Express

Some more additional robustness checks are taken as showed in Appendix A. In the Table A2-1, it examines the influence of Nozomi super express. On the Tokyo-Osaka route, there are three types of HSR trains, Nozomi, Hikari and Kodama. Among them, Nozomi is a supper express HSR that only stop major stations[11] and mainly compete with the air transport. Since large demand exist these major stations, it may confound with our outcome and that is why we conduct the robustness check by considering whether Nozomi stops at the origin station of the OD pair or Nozomi train direct connects both cities of the OD pair.

The impact of market competition is investigated in all column of Table A2-1, with the market competition effect by distance estimated in column (2) and (4). Different from only take control for Nozomi stop in column (1) and (2), column (3) and (4) additionally take control for Nozomi train direct connects the OD pair. Overall, the estimate results show that after taking consider of Nozomi effect, the impact of market competition is still significant at same level, which is market competition reduces the time cost for OD pairs in duopoly region by around 3 minutes on average (significant at 1% level), relative to monopoly region. Besides, the impact of market competition increases when distance increase, namely the impact is stronger for longer distance trip.

2.3.3.2 Additional Robustness Check by Distribution of Target Times

The following Figure 2-4 shows the distribution of passenger volume over time within a day. Apparently, there exist two typical peak time periods. Therefore, robustness check by taking the weight of passenger distribution at each time period as showed in Table A2 as showed in Appendix A.

[11] In our study, the major stations that Nozomi stops are Tokyo, Shin-Yokohama, Nagoya, Kyoto and Shin-Osaka.

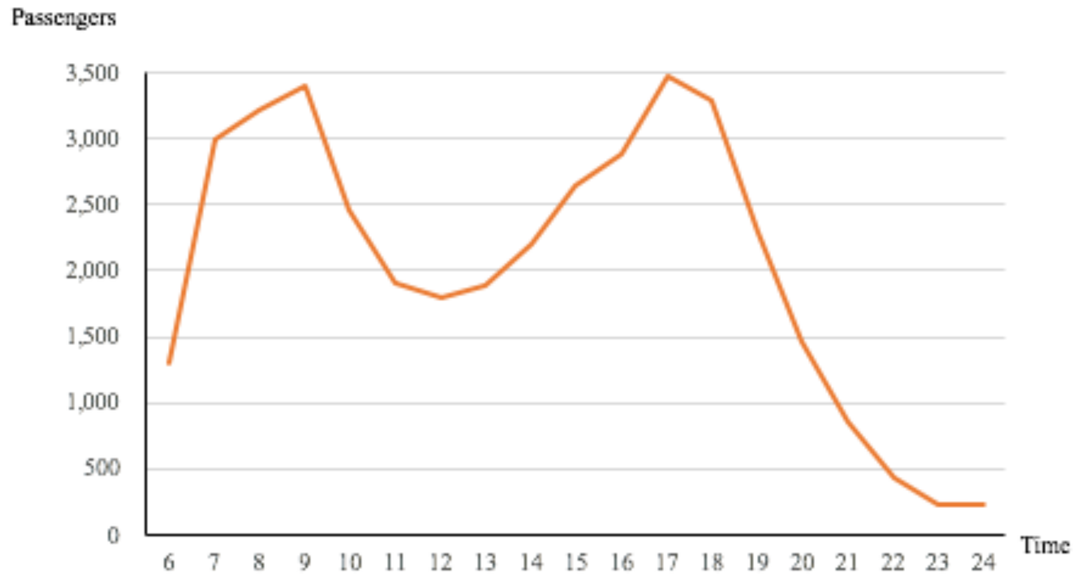

Figure 2-4 Distribution of Passenger Volume over Time within a Day

Notes: Number of passengers on non-reserved-seat cars of a Hikari Super Express between Odawara and Shizuoka in October 1989. 22-24 O'clock values are extrapolated by second-order approximation. Source: Ministry of Transportation, Japan.

Different from other analysis, which simply use the mean of actual time cost for all available target arrival times for each OD pair, the analysis in column (2) in Table A2-2 take the average of actual time cost with the weight by the share of passenger volume. After taken the weight, the coefficient is still almost same value with significance level at 1%. Overall, the distribution of passenger volume is not one of the main factors that influence the time cost.

2.3.3.3 Robustness Checks on Statistical Robustness with Dyadic Correlation

Results for checks on statistical robustness are showed in Table A2-3 in appendix A by using different kinds of cluster variables and different type of clustering method. To check the reliability of our variance estimator and the statistical robustness of our results, we compute standard errors under several different correlation assumptions. As can be seen from the Table A2-3, our standard errors are slightly larger than those based on alternative correlation assumptions except the Leave-one-node-out Jackknife clustering method. The reason for conducting this robustness check is mainly because the number of nodes (stations) is in this study is not large enough and a larger fraction of elements in the error correlation matrix are nonzero.

2.3.3.4 Theoretical Analysis: Market Structure and Travel Time of Parallel Railways

In the appendix B, it constructs a situation with two types of train services in parallel, but in difference conditions, namely duopoly and monopoly. Given the condition that the price regulated, for the same trip, time cost for the passengers' in duopoly condition with market competition is less than that in monopoly condition. Besides, in the case of symmetric parallel railway which with a situation that both price and the speed of railways are endogenous determined, through the analysis in appendix B, we yield that time cost in duopoly is less than in monopoly.

2.4 Conclusions

This study investigated the impact of market competition on passengers' time cost by HSR. When Japan National Railways (JNR) was privatized into six regionally monopolistic railway cooperation in 1987, there emerged exceptional areas where the industrial structure of railway transportation happened to be duopolistic due to separation of high-speed and conventional rails. Leveraging on this nature experimental setting arising from the privatization of JNR, we conducted a difference-in-difference approach to estimate whether the change in speed and scheduling of HSR has made user worse off in the segments where HSR and conventional rail competes with each other, after the privatization and regional separation of JNR in 1987. The results showed that the increased competition by duopoly decreases the HSR time cost by around 4 minutes on average, namely around 10% of average travel time for OD pairs, relative to monopoly, while the speed of Shinkansen only increased by 21% in last 50 years. Besides, the estimate results also show that the market competition effect is larger for the longer distance trip.

Appendix A Additional Robustness Checks

Table A 2-1 Examining the Influence of Nozomi Supper Express

	(1)	(2)	(3)	(4)
Duopoly	-3.182***	-3.453***	-3.267***	-3.364***
(Treatment × $Post_{1987}$)	[0.755]	[0.809]	[0.772]	[0.692]
Duopoly × Distance		-0.065***		-0.072***
		[0.012]		[0.015]
OD and year fixed effects	Yes	Yes	Yes	Yes
Time-variant controls	Yes	Yes	Yes	Yes
Time-invariant controls × $Post_{1987}$	Yes	Yes	Yes	Yes
Nozomi stop station × $Post_{1987}$	Yes	Yes	Yes	Yes
Nozomi direct link OD × $Post_{1987}$	No	No	Yes	Yes
Observations	144	144	144	144
R-squared	0.693	0.723	0.695	0.724

Notes**:** This table reports only the coefficient of interest based on equation (1). Except additional include the interaction term between Nozomi stop station with Post1987 dummy, other specifications in this Column (1) is the same with that in Column (4) of Table 2-5. Additional controls are the same as in Column 4 of Table 2-5 (see the notes in Table 2-5).

Table A 2-2 Additional Robustness Check by Distribution of Target Times

	(1) (Col.4 of Table 2-5)	(2)
Treatment × $Post_{1987}$	-3.487***	-3.456***
(Duopoly)	[0.719]	[0.663]
Duopoly × Distance	-0.065***	-0.055***
	[0.012]	[0.013]
Weight	No	# of passengers
OD and year fixed effects	Yes	Yes
Time-variant controls	Yes	Yes
Time-invariant controls × $Post_{1987}$	Yes	Yes
Observations	144	144
R-squared	0.722	0.710

Notes: This table reports only the coefficient of interest based on equation (1). Additional controls are the same as in Column 4 of Table 2-5 (see the notes in Table 2-5).

Table A 2-3 Checks on Statistical Robustness

	Coefs.	(1) (Col.4 of Table 2-5)	(2)	（3）	（4）
Duopoly (Treatment × $Post_{1987}$)	-3.487	[0.719]***	[1.266]***	[0.661]***	[0.516]***
Duopoly × Distance	-0.065	[0.012]***	[0.031]**	[0.012]***	[0.012]***
Cluster variable(s)		Origin ID & destination	Station ID	Origin ID & Destination ID	Entity (OD pair) ID
Type of clustering		Dyadic	Leave-one-node- out Jacknife	Two-way	One-way
OD and year fixed effects		Yes	Yes	Yes	Yes
Time-variant controls		Yes	Yes	Yes	Yes
Time-invariant controls × $Post_{1987}$		Yes	Yes	Yes	Yes

Notes: (a) This table reports only the coefficient of interest based on equation (1). All standard errors in the square brackets are corrected for dyadic correlation. Triple and double asterisks (*** and **) denote that the coefficient is statistically significant at the 1% and 5% levels, respectively. (b) Additional controls are the same as in Column 4 of Table 5 (see the notes in Table 5)

Appendix B Market Structure and Travel Time of Parallel Railways

We here illustrate a situation where monopoly increases the users' time cost under a plausible setting. Let us suppose there are two types of train services in parallel denoted by i = 1, 2. Demand of type i train service is a function of its own price as well as that of another:

$$Q_i = Q_i(P_i, P_j)$$

for $i \neq j \in \{1,2\}$, where is Q_i the demand and P_i is the price of the type i train. Here, Q_{ii} = $\partial Q_i / \partial P_i$ < 0 and since railways are substitutive Q_{ij} = $\partial Q_i / \partial P_j$ > 0. For simplicity we assume Q_{iij}= 0.

Price is consisted of two parts, namely, ticket price is f_i and user's time cost is t_i, hence:

$$P_i = f_i + t_i \qquad \text{for } i = 1, 2.$$

Time cost t_i of the type i train determines the amount of required investment $K_I(t_i)$. We assume K_i > 0, K_i' < 0 and K_i'' is positive and monotonic. Duopoly owns either type while monopoly owns both types of train services. Then duopolist's problem is to maximize its profit with respect to ticket price f_i and time cost t_i which can be written as:

$$\max_{f_i, t_i} \pi_i = f_i Q_i(P_i, P_j) - K_i(t_i),$$

$$s.t.\ P_i = t_i + f_i$$

Given P_j for $i \neq j \in \{1, 2\}$. The first-order conditions are:

$$Q_i + f_i Q_{ii} = 0$$

$$f_i Q_{ii} - K_i'(t_i) = 0$$

where we define $Q_{ii} = \partial Q_i / \partial P_i < 0$.

Let t_i^D and f_i^D be the solution to the above and let $P_i^D = t_i^D + f_i^D$.

Monopolist's problem in turn becomes:

$$\max_{f_1, f_2, t_1, t_2} \pi_1 + \pi_2$$

and the corresponding first-order conditions are:

$$Q_i + f_i Q_{ii} + f_j Q_{ji} = 0$$

$$f_i Q_{ii} + f_j Q_{ji} - K_i'(t_i) = 0$$

for $i \neq j \in \{1,2\}$. Let t_i^M and f_i^M be the solution to the above and let $P_i^M = t_i^M + f_i^M$. We can rewrite these first-order conditions by using a parameter $\delta \in \{0, 1\}$:

$$Q_i = -K_i'(t_i)$$

$$f_i D_i^i + \delta f_j D_i^j = K_i'(t_i) \qquad (1)$$

as $\delta = 0$ corresponds to duopoly and $\delta = 1$ to monopoly.

Travel time under price regulation

Suppose for now that the fare is effectively restricted as in our context. Then duopolist's profit- maximization problem becomes

$$\max_{t_i} \pi_i = f_i Q_i(P_i, P_j) - K_i(t_i), \quad s.t.\ P_i = t_i + f_i$$

which further yields the first-order condition as:

$$f_i Q_{ii} = K_i'(t_i^D) \text{ for } i = 1, 2.$$

We assume that the second-order condition is globally satisfied implying that $f_i Q_{iii} < K_i''$.[12] In turn, monopolist's problem is now simply:

$$\max_{t_1, t_2} (\pi_1 + \pi_2)$$

[12] Here we denote by $Q_{iii} = \partial Q_{ii} / \partial t_i$

and the corresponding first-order conditions are:

$$f_i Q_{ii} + f_j Q_{ji} = K_i^{'}(t_i^M) \qquad \text{for } i \neq j \in \{1,2\}.$$

The fact that $f_j Q_{ji} > 0$ and $f_j Q_{iii} < K_i^{''}$, along with $K_i^{'} < 0$ yields:

$$t^M > t^D.$$

A case of symmetric parallel railways

Here, we consider a situation where both price and the speed of railways–i.e. the time cost–are endogenously determined. For analytical tractability we specify the demand and investment functions assuming symmetry between the two parallel railways as follows:

$$Q_i = a_0 - a_1 P_i + a_2 P_j$$

$$K_i = k_0 + k_1 t_i + \frac{1}{2} k_2 t_i^2$$

For $i \neq j \in \{1,2\}$, with all parameters being positive, and $a_1 > a_2$. Then the first order conditions (1) imply:

$$a_0 + (a_2 - a_1)(t + f) = k_1 - k_2 t$$

$$(a_1 - \delta a_2) f = k_1 - k_2 t$$

where, by symmetry we let $t = t_i$ and $f = f_i$ for both $i = 1,2$. Solving these gives the time cost t as a continuous function of δ:

$$t\,(\,\delta\,) = \frac{(k_1 - a_0)(a_1 - \delta a_2) + (a_1 - a_2)\,k_1}{(k_2 - a_1 + a_2)(a_1 - \delta a_2) + (a_1 - a_2)\,k_2}$$

This generate $t^M = t\,(1)$ and $t^D = t\,(0)$

Hence:

$$t^M - t^D = t\,(1) - t(0).$$

Using continuity of $t\ (\ \delta\ )$ with respect to δ rewrites the above as:

$$t^M - t^D = \int_0^1 t'\ (\ \delta\ ) d\delta$$

$$t'(\ \delta\ ) = \{a_2(a_1 - a_2)[a_0 k_2 - (a_1 - a_2)\ k_1\ ]\}\ g^{-2}$$

and $g = (k_2 - a_1 + a_2)\ (a_1 - \delta a_2) + (a_1 - a_2)k_2$.

Now, $K_i'(t_i) < 0$ implies $t < k_1/k_2$ which further implies that:

$$a_0 k_2 - (a_1 - a_2)k_1 > 0$$

This, together with $a_1 > a_2 > 0$, yields:

$$t^M > t^D.$$

3. Market competition Effect on Passengers by Conventional Rail

3.1. Introduction

As already mentioned in the introduction part of Chapter 2, a number of studies investigated either the correlated relationship or casual inference between market competition and service/product quality. Many studies find that competition improves service/product quality (Mazzeo, 2003; Greenfield, 2014; Pan, 2015; Bergman, 2016;). Some papers show the negative effect of competition on service quality. Propper et al. (2004) estimated the relationship between competition and quality of care in UK health care market through least squares regressions and found the relationship was to be negative, while the estimated effect was quite small. Forder and Allan (2014) found that higher competition pushed down quality in English care homes market through instrumental variable (IV) estimations, while the lower quality was due to decrease in price instead of competition. Lahiri and Ono (1988) found that by eliminating or impairing minor firms, a government can actually increase welfare.

This study investigates the impact of market competition between CR and HSR transport service on passengers' time cost by using CR. Same with the estimation method used in Chapter 2, this study also use difference-in-differences (DID) approach by comparing passengers' time cost on certain origin-destination (OD) pair before and after 1987. The data was also collected from timetables published in four different years under by same company-Japan Travel Bureau (JTB) Foundation. The two years before 1987 are year 1976 and 1986, and the other two years after 1987 are year 1996 and 2006. In this research, only local & rapid trains that just need base fare are included. Table 3-1 shows the different types of CR services on the Tokyo-Osaka route that are provided by JR companies.

Table 3–1 Different Types of Conventional Rail Services

Train type	Base fare	Express fee	Stops
Local	Need	No need	Every station
Rapid	Need	No need	Less than local, but more than express
Express	Need	Express fee	Less than rapid, more than limited express
Limited Express	Need	Limited Express fee	Only stop at main stations

Note: For reserved seats, extra reservation fee is necessary.

As already mentioned in Chapter 2, due to heavy deficits, JNR, a state-owned public corporation, was divided into six railway companies for transporting passengers after April 1, 1987. Each of them is in charge of CR and parallelly-running HSR services in certain region except Shinkoku region with HSR service. For the busy Tokyo-Osaka route, CR service is provided by three different companies. CR service between Tokyo and Atami is provided by JR East; between Atami and Maibara, it is provided by JR Central; and between Maibara and Osaka, it is provided by JR West. However, HSR service on the Tokyo-Osaka route is provided only by JR Central. Therefore, CR and HSR on the Tokyo-Atami route and the Maibara-Osaka route compete with each other, since they belong to different companies. As both CR and HSR services are provided by JR Central on the Atami-Maibara route, rail transport service is in monopoly. These conform the research design of this study, for measuring the difference in the impact of duopoly and monopoly, before and after JNR's privatization.

CR service on the Tokyo-Osaka route existed for many years, before HSR service first parallelly operated in 1964. CR provides low-cost transport services that compete with HSR in some regions. Even though no CR provides direct transport service for the Tokyo-Osaka route, the trip can be easily completed through transfers. When comparing with HSR, CR has some disadvantages, such as more time cost and unavoidable transfers. As CR's speed is just half of HSR's and it needs transfer time, time cost of travelling through CR is more than twice of HSR (shown in Table 3-2). Fortunately, the selection of transfer stations is flexible, and transfer is convenient, without the need to get out of the stations. Therefore, CR has its advantages with disadvantages, when compared to HSR.

Table 3–2 CR V.S HSR (Between Tokyo Station and Shin-Osaka Station, Year 1982)

Type	Distance	Time cost (shortest)	Least Transfer	Ticket Price (JPY)	Frequency
CR	552.6km	More than 9h	3	6,600	Less than HSR
HSR	552.6km	3h10min	0	11,000	80

Note: Here CR just considers the non-reserved seat service which only cost base fare.

Ticket price for HSR here is price of non-reserved seat which is the base fare.

Data source: JR Timetable, published by Japan Travel Bureau Foundation, year 1982.

3.2. Literature Review

As competition is important in a market system, many economists are interested in analyzing the effect of market competition. Previous studies have discussed about the impact of market competition, especially theoretical works (Gabszewicz and Thisse, 1979; Perry and Porter, 1985; Suzumura and Kiyono, 1987; Maskin and Tirole, 1988; Hsu, et al., 2010; Matsa, 2011; Xia and Zhang, 2016; Tsunoda, 2018;) and empirical studies which investigate the relationship between market competition and service or product quality (Propper, et al., 2004; Greenfield, 2014; Pan, et al., 2015;). However, only a few empirical studies discuss the causal inference of market competition on service quality.

Among the limited empirical studies that estimate causal inference of market competition, most of them investigate the effect of competition on health care services (Forder and Allan, 2014; Bergman, et al., 2016;) and the impact of competition between HSR and airlines (Albalate, 2015; Wan, et al., 2016; Zhang, et al., 2017). Empirical literatures exist for other industries, such as education industry (Hoxby, 2000;), manufacturing industry (Tang and Wang, 2005;), supermarket industry (Bonanno and Lopez, 2009;) and while their number is less. Besides, many of them are not perfect in research design since they analyze the problem without observation fixed effect, existing reverse causality or confounders. As panel data in this study is analyzed with year and OD fixed effects and taken consideration for heterogeneity, it can be a better way for examining the impact of competition in transportation field, where randomized experiment is almost impossible.

Almost all the studies that discuss about competition between HSR and CR use theoretic approach for analysis. Hsu et al. (2010) analyzed competition and cooperation between HSR and CR by studying two roughly-parallel rail systems in Taiwan, although they just used game theoretical approach and the data used to test their models was only one year. Raturi and Verma (2013) used game theoretical approach to analyze the impact of HSR introduction and used passengers' time cost and monetary cost data to analyze the sensitivity of equilibrium state, although only simulation data was used. Different from these theoretical studies, this study randomly generates different target arrival time (TAT), collects time cost data for them from published JR timetables, and then takes average as time cost for each origin-destination (OD) pair. This study proceeds by using panel data and difference-in-differences approach to analyze causal inference in railway industry. As rail transportation accounts for a high percentage in transportation industry and is closely related to quality of daily lives, it is necessary to carry out this research.

3.3. Identification strategy

As described in introduction part, rail transport services for Tokyo-Atami and Maibara-Osaka routes changed from monopoly to duopoly after 1987, and all the OD pairs on these two routes are included in the treatment group; rail services for Atami-Maibara route is in monopoly for all the years, and all the OD pairs on this route are included in control group. To estimate the effect of changes in market competition between the treatment and control groups, this study uses difference-in-differences (DID) approach as identification strategy which is the same with the method used in the study in Chapter 2.

This study estimates the impact of market competition along with year and OD pair fixed effects by using four years data (1976, 1986, 1996, 2006). By using year and OD pair fixed effects, it can eliminate omitted variable bias. DID approach measure the average treatment effect as a difference between the changes in the outcome variable of treatment and control groups over the same period.

Basic DID model in this study is as follows:

$$Y_{it} = \beta(Treat_i \times Post_t) + \gamma X_{it} + \phi_i + \varphi_t + u_{it} \quad (2)$$

Where Y_{it} as outcome variable and it is time cost for directional OD pair *i* in year *t* in this study, $Treat_i$ is a treated-group dummy that takes a value of one if OD pair is located on the Tokyo-Atami route and the Maibara-Osaka route and zero otherwise, $Post_t$ is a after treatment year (1987) dummy, and it equals to 1 if the year is 1996 and 2006, and 0 otherwise. ϕ_i and φ_t are OD and year fixed effects, respectively. β is the estimator of treatment effect in this study. Variable X_{it} is a set of control variables which depend on model specification. Finally, u_{it} is the error term.

3.4. Data

3.4.1. Data Sources

Time cost data used in this research for all the four years are collected from JR timetables published by Japan Travel Bureau (JTB) Foundation. Other variables include: (1) Population data collected from Japanese national survey (Kokusei Chosa, every five years one time). For year 1976, this study uses year 1975 survey data; for year 1986, this study uses year 1985 survey data; for year 1996, this study uses year 1995 survey data; and for year 2006, this study uses year 2005 survey data; (2) Per capita income data from Japanese central government website (Cabinet Office, Government of Japan); (3) GDP deflator from World Bank national accounts data and OECD National Accounts data files; (4) Number of stops means the number of conventional rail stations between origin and destination stations for each OD pair and is collected from the JR timetables published by JTB Foundation; (5) The number of private railway firms that compete with JR company for same OD pair (from JR companies).

3.4.2. Details about the data

In this research, unit of analysis is directional origin-destination (OD) station pair within each region (three regions in total). Therefore, two kinds of OD pairs exist in this research: one kind is where both origin and destination stations are on either Tokyo-Atami route or Maibara-Osaka route which makes up the treatment group; the other kind is where both origin and destination stations are on Atami-Maibara route which is set as our control group.

Stations that included in this study are the stations which provide both HSR and CR services for all the four years (details are shown in the following Table 3-3). Therefore, the stations without HSR service or established after year 1976 are not included in our analysis. As shown in Table 3-3, the maximum distance for OD pairs in the control group (341.3 km) is nearly three times that of the maximum distance for OD pairs in treatment group (110.5 km). To keep the balance, in this study, we pick up the OD pairs in control group which near the borders (Atami and Nagoya) and within the maximum distance of OD pairs in the treatment group (110.5km). As shown in Table 3-3, 12 OD pairs in the control group with 18 OD pairs in the treatment group for each year (four years in total), making a total of 120 OD pairs for all four years.

Table 3–3 OD Pairs in the Analysis for One Year

Group	Number of OD Pairs	Maximum Distance	Number of OD Pairs Near Borders and Within 110.5km
1.Treatment Group			
Tokyo-Atami	12	104.6	12
Maibara-Osaka	6	110.5	6
Total	18	110.5	18
2.Control Group			
Atami-Maibara	56	341.3	12
All	74	341.3	30

Note: Stations between Tokyo and Osaka included in this research are: Tokyo, Yokohama (Shin-Yokohama for HSR), Odawara and Atami, Mishima, Shizuoka, Hamamatsu, Toyohashi, Gifu (Gifu-hashima for HSR), Maibara, Kyoto and Osaka (Shin-Osaka for HSR). As Atami and Maibara station are boundary stations, they are considered in charged by JR companies on both sides.

In this study, time cost consists of in-vehicle time and schedule delay. In-vehicle time is the time difference between train's actual arrival time and actual departure time (both available in published timetables); schedule delay is the time gap between target arrival time and actual arrival time. Target arrival time are 50 randomly generated time points between 6:00 and 24:00 pm in this study and actual arrival time is available in published timetables. For each target arrival time, the train that minimizes time cost is selected and recorded for all OD pairs. Average of the time cost for all target arrival time is generated as final time cost for each OD pair in each year. As delay in arrival is supposed to be not allowed in this study, schedule delay in this research is schedule delay early (not schedule delay late). Besides, CR services included in this study are non-reserved seats and without express fee. Seasonal trains that run for short periods or trains that run on weekends are not included as well.

3.5 Results and Interpretations

3.5.1 Summary Statistics

In Table 3-4, it shows that the average time cost for all the OD pairs used in this study is 74.68 minutes. Besides, other information for time-variant and time-invariant control variables are shown there as well.

Table 3–4 Summary Statistics of Empirical Variables

Variables	Observations	Mean	Standard Deviations	Min	Max
Time cost (minutes)	120	74.68	32.56	24.03	140.67
Time-variant Controls					
Log of Population (City/Ward Level)	120	12.92	1.89	10.58	15.97
Log of Income per Capita (Prefecture Level)	120	7.76	0.54	6.74	8.46
Number of Stops	120	11	6.37	1	26
Time-invariant Controls					
Treatment Group Dummy	30	0.60	0.50	0	1
Number of Competing Private Railway Companies	30	0.40	0.72	0	2

***Note**:* Treatment group dummy is 1, if OD pair is located in treatment group (OD pairs on Tokyo-Atami and Maibara-Osaka route), otherwise it is 0. Number of competing private railway companies is the number of private railways that do not belong to JR but provide transport service for the OD pairs.

3.5.2 Balance Check

To verify the validity of common trend assumption, balancing test of baseline characteristics was executed as showed in the following Table 3-5. Table 3-5 presents the balance checks of baseline characteristics between OD pairs in monopoly and duopoly areas for the years before JNR's privatization (1976 and 1986).

Table 3–5 Balancing Test of Baseline Characteristics

	Control Group		Treatment Group		(2) - (4)
	Observations	Mean (*Std. Dev.*)	Observations	Mean (*Std. Dev.*)	Differences [*Std. Errors*]
	(1)	(2)	(3)	(4)	(5)
Panel A: Comparison by Level (using 1976 and 1986 data)					
Time Cost/Distance	24	1.641	36	1.327	0.314
(minutes/km)		(0.324)		(0.262)	[0.076]***
Other characteristics					
Population/10,000	24	52.504	36	239.159	-186.655
		(73.89)		(299.273)	[62.479]***
Income per Capita	24	1,658.734	36	1,823.859	-165.125
		(773.155)		(853.925)	[216.839]
Number of Stops /	12	0.153	18	0.171	-0.018
Distance		(0.047)		(0.042)	[0.016]
Number of Competing	12	0.167	18	0.556	-0.389
Private Rail Firms		(0.389)		(0.856)	[0.265]*
Panel B: Comparison by Change (Between 1976 and 1986)					
Changes in	12	-0.153	18	-0.106	-0.048
Time Cost/Distance		(0.089)		(0.104)	[0.037]
Other characteristics					
Changes	12	1.164	18	0.114	1.050
in Population/10,000		(1.420)		(20.447)	[5.947]
Changes in Income	12	1,497.425	18	1,586.379	-88.954
per Capita		(101.183)		(258.153)	[78.602]
Change in Number of	12	-0.002	18	-0.025	0.023
Competing Private Rail		(0.006)		(0.093)	[0.027]
Firms/Capita in Million					

Note: Standard deviations are given in parentheses and standard errors are given in square bracket. Significant differences are indicated as: * means p value<0.1, **means p value<0.05, *** means p value <0.01.

As shown in Panel A in Table 3-5, the mean of time cost per distance in control group is significantly higher than that in treatment group (duopoly) at 1% level. This might be due to speed difference that affects in-vehicle time or frequency difference that affects schedule delay early. Besides, population in treatment group is significantly higher than population in control group at 1% significance level. This is because Tokyo, Yokohama and Osaka stations (in treatment group) all located in big cities. Population of these cities are much higher when compared with population of cities that OD pairs in control group (Atami-Maibara) are located. As for per capita income and number of stops per distance, there is no significant difference among the treatment and control group. As shown in Table 3-5, the number of competing private firms in treatment group is higher than that in control group at 10% significant level. This is reasonable as OD pairs in treatment group are located in Tokyo and Osaka regions and have relatively higher passengers' volume along with more private rail firms that compete with JR companies.

Panel B of Table 3-5 shows the changes between year 1976 and 1986 in treatment and control group. It is necessary to check whether the changes between treatment group and control group is balanced before treatment, which is a common trend assumption in this study. The results show that there are no significant differences in the change of time cost per distance, population, per capita income and the number of competing private rail firms per million capita among treatment and control group between year 1976 and 1986. Since the number of competing private rail firms in this study does not change over the years, the number of competing private rail firms per million capita is used as an alternative. All these prove that the commend trend assumption is satisfied which conform research design in this study.

3.5.3 Effect of Market Competition on Conventional Rail

Table 3–6 Reduced Form Regressions of Time Cost (Duopoly Effect)

	(1)	(2)	(3)
Treatment × Post1987 (Duopoly)	5.573	3.790	2.968
	[3.439]	[2.600]	[2.833]
OD and Year Fixed Effects	Yes	Yes	Yes
Time-variant Controls	No	Yes	Yes
Time-invariant Controls × Post Dummies	No	No	Yes
Observations	120	120	120
R-squared	0.804	0.849	0.868

Note: Clustered robust standard errors for undirectional OD pairs are showed in brackets, *** p<0.01, ** p<0.05, * p<0.1. Time-variant controls include ln(population in the origin city), ln(population in the destination city), ln(real income per capita in the origin prefecture), ln(real income per capita in the destination prefecture) and number of stops between each OD pair. Time-invariant controls include the number of competing private railway companies.

The result of the OD and year fixed effects analysis in row (1) of Table 3-6 shows that market competition leads to an increment in time cost for the treatment group by 5.573 minutes when comparing with the change of time cost in control group, but it is not statistically significant. The row (2) shows the regression result after additional including time-variant controls. The reduced form regressions result in row (2) show that coefficient of duopoly is 3.790, which means market competition leads to an increment of time cost in treatment group by 3.790 minutes on an average when comparing with the change of time cost in control group, but it is still not statistically significant. The row (3) shows regression result after additionally including Time-invariant controls × Post dummies. Reduced form regressions result shows that the coefficient of duopoly is 2.968, which means market competition leads to an increment of time cost in treatment group by 2.968 minutes on an average when comparing with the change of time cost in control group, but it is not statistically significant as well.

Base on the model used in row (3) of Table 3-6, another specification by using cross term between Treatment dummy and Year is used for additional analysis. Therefore, Treatment × Year 1986, Treatment × Year 1996, Treatment × Year 2006 are used instead of Treatment ×

Post 1987, and analysis result is shown in Table 3-7. As shown in Table 3-7, coefficients of treatment effect in 1986, 1996 and 2006 are 2.413, 3.559 and -3.119, respectively. But all of them are not statistically significant. Therefore, no statistically significant treatment effect is found on passengers' time cost in treatment group.

Table 3–7 Reduced Form Regressions of Time Cost (Duopoly Effect)

	(4)
Treatment × Year 1986	2.413
	[3.211]
Treatment × Year 1996	3.559
	[3.217]
Treatment × Year 2006	-3.119
	[1.879]
OD and year fixed effects	Yes
Time-variant controls	Yes
Time-invariant controls × Post dummies	Yes
Observations	120
R-squared	0.877

Note: Clustered robust standard errors for undirectional OD pairs are showed in brackets, *** p<0.01, ** p<0.05, * p<0.1. Time-variant controls include ln(population in the origin city), ln(population in the destination city), ln(real income per capita in the origin prefecture), ln(real income per capita in the destination prefecture) and number of stops between each OD pair. Time-invariant controls include the number of competing private railway companies. Treatment × Year 1986 is the cross term between treatment dummy and year 1986. Treatment × Year 1996 is the cross term between treatment dummy and year 1996. Treatment × Year 2006 is the cross term between treatment dummy and year 2006.

3.5.4 Discussion

Regression results in Table 3-6 show that market competition after JR privatization in 1987 led to an increment of time cost in the treatment group when comparing with change of time cost in control group, but it is not statistically significant. After using the Treatment × Year specification used in the analysis of Table 3-7, we still could not find any statistically significant treatment effect in treatment group when comparing with control group. Different from this empirical analysis, theoretical analysis of market competition on passengers' time cost by CR is shown in the Appendix C. There exist following three possible reasons for why above empirical analysis results are different from the theoretical analysis results showed in the Appendix C.

First of all, after privatization of JNR in 1987, JR Central improved its CR transport service (by either speed or frequency) on the entire route they were in charge of, rather than only improving services around Nagoya station. After the privatization in 1987, JR Central replaced the trains it inherited from JNR by new type of trains on whole route (not just around Nagoya) and until 2006, 80% percentage of its local trains was replaced by the new types of trains. The new type of trains has characteristics like larger maximum speed, acceleration and deceleration. Since JR Central used new type of trains, its conventional rail transport service could get much improvement in its service like speed and then have potential to increase frequency (link showed in References). Besides, JR Central actually reduced the trains frequency for some low demand route and increased the frequency for the busy lines it in charged to obtain more profit (link showed in References).

Second, CR services in the regions which were going to be in charged by JR East company and JR West companies probably already got improved before 1987, as they probably could receive the detailed information on JNR's privatization before it was publicly announced. Those regions could have the chance and incentive to do so, since in July 1982, the central government had approved the suggestion of JNR's privatization and had started taking appropriate actions in 1983. And finally, the public announcement was made in 1987. After isochronous operation policy was operated, timetable for some regions changed on March 14th, 1985, such as in Sendai (belong to JR East after 1987), Nagano (belong to JR East after 1987) and Keihanshin regions (Kyoto, Osaka and Kobe regions, which belong to JR West after 1987). Along with the change of timetable, the number of local trains operated those regions (belong to JR East and JR West after 1987) got huge increasement.

Third, but not the least, different from HSR service which is only provided by JR Central company for the Tokyo-Osaka route after 1987, three different JR companies are in charge of CR transport services between Tokyo and Osaka. As these three JR companies are so different in population density and operating net income, their behavior might be different and that probably led to the estimated market competition results shown in this study. For conventional rail service, the population density somehow can reflect the demand which could be the incentive for the JR companies to improve their services. The population density on Tokyo-Atami route (JR East) is much higher than Maibara-Osaka (JR West), and the population density on Maibara-Osaka (JR West) is much higher than that on Atami-Maibara (JR Tokai). For JR companies, their operating net income somehow can show their ability and their budget to invest on infrastructure and their machines to improve their transport services. Take 2000-2001 fiscal year as an example, the operating net income for JR East, JR Tokai and JR West was 69.2 billion JPY, 53.0 billion JPY and 31.0 billion JPY respectively, which is much different in amount (link in References).

3.6 Conclusion

Due to the privatization of Japanese National Railways (JNR) in 1987, it was geographically divided into six different railway companies for passenger transport service. This study investigated the impact of market competition on passengers' time cost by conventional rail by using difference-in-difference approach. Results of the analysis which includes OD and year fixed effects (time-variant controls and time-invariant control), shows that market competition leads to an increment in passengers' time cost by CR in duopoly regions when comparing with the change of time cost in monopoly region, but it is not statistically significant. After including the treatment by year analysis, statistically significant treatment effect is still not found in the treatment group (duopoly region). As a conclusion, market competition leads to an increment in passengers' time cost by CR in duopoly regions when comparing with the change of time cost by CR in monopoly region, but it is not statistically significant.

Appendix C Market Structure and Travel Time of Parallel Railway

Let us suppose there are two types of train services in parallel denoted by $i = 1, 2$. Demand of type i train service is a function of its own price as well as that of another are shown below:

$$Q_i = Q_i(P_{i,} P_j),$$

which we specify as:

$$Q_i = a_{i0} - a_{i1}P_i + a_{i2}P_j \text{ , for } i \neq j \in \{1,2\}$$

and a_{i0}, a_{i1}, a_{i2} being positive parameters, where Q_i is the demand and P_i is the price of the type i train.

Price consists of two parts: ticket price f_i and passengers' time cost t_i, then $P_i = f_i + t_i$ for $i = 1, 2$. Time cost t_i of type i train determines the amount of required investment $K_i(t_i)$. Here assume $K_i > 0, K_i' < 0$, and

$$K_i = k_{i0} - k_{i1}t_i + \frac{1}{2}k_{i2}t_i^2$$

In duopoly condition, two types of train services are provided by two different companies; while in monopoly condition, two types of train services are provided by one company. In duopoly case, each company tries to maximize its profit with respect to ticket price f_i and time cost t_i which can be written as:

$$\max_{t_i} \pi_i = f_i Q_i\left(P_i, P_j\right) - K_i\left(t_i\right)$$

$$= f_i\left(a_{i0} - a_{i1}P_i + a_{i2}P_j\right) - \left(k_{i0} - k_{i1}t_i + \frac{1}{2}k_{i2}t_i^2\right)$$

$$= f_i\left[a_{i0} - a_{i1}\left(t_i + f_i\right) + a_{i2}\left(t_j + f_j\right)\right] - \left(k_{i0} - k_{i1}t_i + \frac{1}{2}k_{i2}t_i^2\right)$$

First order condition (FOC) is:

$$f_i(-a_{i1}) - (-k_{i1} + k_{i2}t_i^D) = 0$$

Then

$$a_{i1}f_i = k_{i1} - k_{i2}t_i^D$$

$$\frac{a_{i1}f_i - k_{i1}}{-k_{i2}} = t_i^D$$

Then

$$t_i^D = \frac{-a_{i1}f_i + k_{i1}}{k_{i2}}$$

For the monopoly condition, one company provides both kinds of train service:

$$\max_{t_1,t_2} \pi_1 + \pi_2 = \sum_{i=1}^{2} [f_i\left(a_{i0} - a_{i1}P_i + a_{i2}P_j\right) - \left(k_{i0} - k_{i1}t_i + \frac{1}{2}k_{i2}t_i^2\right)]$$

$$\max_{t_1,t_2} \pi = \pi_1 + \pi_2 = \sum_{i=1}^{2}\{f_i\,[a_{i0} - a_{i1}\left(t_i + f_i\right) + a_{i2}\left(t_j + f_j\right)] - \left(k_{i0} - k_{i1}t_i + \frac{1}{2}k_{i2}t_i^2\right)\}$$

FOC is : $\frac{\partial\pi}{\partial t_i} = f_i(-a_{i1}) - (-k_{i1} + k_{i2}t_i^M) + f_j a_{j2} = 0$

$$\frac{-a_{i1}f_i + a_{j2}f_j + k_{i1}}{k_{i2}} = t_i^M$$

Then $t_i^M = \frac{-a_{i1}f_i + a_{j2}f_j + k_{i1}}{k_{i2}}$

$$t_i^D = \frac{-a_{i1}f_i + k_{i1}}{k_{i2}}$$

So $t_i^M > t_i^D$

4. Effect of Trade Liberalization on Regional Income Inequality

4.1 Introduction

Trade liberalization and its impact have been a popular topic in international trade filed for decades (Edwards, 1993; Krishna and Mitra, 1998; Ferreira and Rossi, 2003; Wacziarg and Welch, 2008;). Many theoretical and empirical papers in the economic geography have been examining the effect of globalization on inequality in regional income. In terms of empirical work, Jian et al. (1996) shows that convergence occurs from 1978 to 1990 and divergence occurs after then. Moreover, Bouvet (2010) shows that globalization does not change regional income inequality. Ezcurra and Rodriguez-Pose (2013) and Lessmann and Seidel (2017) show that globalization leads to divergence.

In terms of theoretical work, Dupont (2007) examines this topic using a variety expansion endogenous growth and the footloose capital model with agriculture and manufacturing goods. He shows that regional income inequality unambiguously shrinks because real income depends on expenditure relative to price index, and inequality in expenditure decrease and price index increases. Moreover, Minniti and Parello (2011) extends Dupont (2007) into a semi endogenous growth model. They show that globalization does not change regional income inequality at all because inequalities in expenditure and price index do not change at all. Cerina and Mureddu (2014) examines effects of agglomeration on inequality in regional income by introducing service sector, which is the main industry in advanced countries, but they did not examine effects of globalization on inequality in regional income. Fukuda (2019) shows that globalization increases or does not change inequality in regional income in a semi endogenous growth model with service sector because interregional spillover minus intraregional spillover in the service sector affect inequality in service price index.

These theoretical results seem not to be consistent with empirical evidence as above explained. As well, all these studies not include the scale effect (lager population lead to higher growth rate in steady state) which actually effects in long period as mentioned in Kremer (1993) and Temple (2003). Motivated by these, we reexamine the effect of globalization on inequality in regional real income in an endogenous growth model with agriculture, manufacturing, and service goods. Results show that globalization increases, decreases, or does not change inequality in regional real income. This is because inequalities in expenditure and service price decrease, but inequality in manufacturing price index increases. Moreover, inequality in service price index depends on the size of intraregional knowledge spillover minus interregional knowledge spillover from manufacturing sector. Effects on inequality in regional income depends on this effect. This result seems to be consistent with empirical evidence explained above because this model shows all of empirical results.

4.2 The Model

4.2.1 Basic Model Structure

This study examines a two countries footloose capital model. Each consumer supplies one unit of labor inelastically in each period. Labor is the only production factor and serves as the numeraire. There are tradable manufacturing goods in the monopolistically competitive sector, tradable and numeraire agriculture goods in the perfectly competitive sector, and non-tradable service goods in the perfectly competitive sector. Each manufacturing firm chooses the location of production comparing profit levels. In the service sector, there are knowledge spillover from manufacturing goods sector. In the R&D sector, each firm chooses the location of R&D activity comparing the R&D costs. Due to intertemporal knowledge spillover, the number of varieties keep increasing. Consumer can invest in R&D activities in own country or the foreign country.

4.2.2 Consumer

The utility function is given by

$$u(D_t) = \int_0^\infty e^{-\rho t} \log C_Y^\alpha C_S^\gamma C_M^\beta \mathrm{d}t,\ \alpha + \beta + \gamma = 1, \tag{1}$$

where ρ is the individual's subjective discount rate, C_Y is consumption of agricultural goods, C_S is consumption of non-traded service goods, and C_M is consumption of manufactured goods which depends on the consumption of a continuum of varieties given by

$$C_M = \left(\int_0^n c_i(t)^{\frac{\sigma-1}{\sigma}} \mathrm{d}i + \int_0^{n^*} c_j(t)^{\frac{\sigma-1}{\sigma}} \mathrm{d}i \right)^{\frac{\sigma}{\sigma-1}}, \sigma > 1, \tag{2}$$

where n is the Northern varieties, n^* is the Southern varieties, $c_i(t)$ is the demand of domestically-produced i-th variety, $c_j(t)$ is the demand of imported j-th variety and $\sigma > 1$ is the elasticity of substitution between varieties.

Instantaneous budget constraint is as follows:

$$C_Y + P_M C_M + P_s C_s = E \tag{3}$$

where P_M is price index of C_M, P_s is the price of service goods, and E is aggregate expenditure.

Following Dupont (2007), Minniti and Parello (2011), and Fukuda (2019), price of agricultural goods is unity. Consumer's maximization problem is consisting of third stages. The first stage derives the demands for domestically produced and exported manufacturing goods, and it is

$$c_i(t) = \frac{p_i^{-\sigma} E_M(t)}{P_M^{1-\sigma}} \text{ and } c_j(t) = \frac{(\tau p_j)^{-\sigma} E_M(t)}{P_M^{1-\sigma}}, \tag{4}$$

Where $P_M = (\int_0^n p_i^{1-\sigma} di + \int_0^{n^*} \tau^{1-\sigma} p_j^{1-\sigma} dj)^{\frac{1}{1-\sigma}}$ is the price index of manufacturing goods in the North and $E_M(t)$ is the northern expenditure for manufacturing goods.

The second stage yields expenditure share for each good, and it is given by

$$Y = \alpha E, E_M(t) \equiv P_M C_M = \beta E, \text{and } P_s C_s = \gamma E. \tag{5}$$

Third stage is the dynamic utility maximization problem. The flow budget constraint is

$$\dot{A}(t) = r(t)A(t) + L(t) - E(t), \tag{6}$$

where $r(t)$ is the rate of return on riskless bond and $A(t)$ is stock of financial asset. The Euler equation is given by

$$\frac{\dot{E}(t)}{E(t)} = r(t) - \rho. \tag{7}$$

4.2.3 Production

The agriculture good is produced in the perfectly competitive sector, and the production factor is the labor. One unit of labor produces one unit of agriculture goods. We assume that both countries produce this good, and wage in both countries are unity due to numeraire. Following Cerina and Mureddu (2014), the service good is non-traded goods, produced in the perfectly competitive sector, and the production factor is the labor. The production function is

$$C_s = \frac{L_s}{a_s};\ C_s^* = \frac{L_s^*}{a_s^*}, \tag{8}$$

where a_s is unit labor requirement for service goods in the home country and a_s^* is unit labor requirement for service goods in the foreign country. Profit maximization yields:

$$P_s = a_s(n, n^*) \text{ and } P_s^* = a_s^*(n, n^*), \tag{9}$$

where n is the number of northern manufacturing firms and n^* is the number of southern manufacturing firms.

Following Cerina and Mureddu (2014), unit labor requirement for service good depends negatively on agglomeration of manufacturing firms in the Home and Foreign countries as follows:

$$\frac{\partial a_s(n,n^*)}{\partial n}, \frac{\partial a_s(n,n^*)}{\partial n^*},\ \frac{\partial a_s^*(n,n^*)}{\partial n}, \text{and } \frac{\partial a_s^*(n,n^*)}{\partial n^*} < 0. \tag{10}$$

Moreover, we assume local knowledge spillover is equal to or strictly greater than international spillover, and it is

$$|\theta_n(n,n^*)| \geq |\theta_{n^*}(n,n^*)|, \forall(n,n^*); |\theta_{n^*}^*(n,n^*)| \geq |\theta_n^*(n,n^*)|, \forall(n,n^*), \tag{11}$$

Where

$$\begin{bmatrix} \frac{\partial a_s(n,n^*)}{\partial n}\frac{n}{a_s(n,n^*)} & \frac{\partial a_s(n,n^*)}{\partial n^*}\frac{n^*}{a_s(n,n^*)} \\ \frac{\partial a_s^*(n,n^*)}{\partial n}\frac{n}{a_s^*(n,n^*)} & \frac{\partial a_s^*(n,n^*)}{\partial n^*}\frac{n^*}{a_s^*(n,n^*)} \end{bmatrix} \equiv \begin{bmatrix} \theta_n(n,n^*) & \theta_{n^*}(n,n^*) \\ \theta_n^*(n,n^*) & \theta_{n^*}^*(n,n^*) \end{bmatrix}, \tag{12}$$

is the knowledge spillover matrix. Finally, we assume a symmetric spillover matrix as follows:

$$\theta_n(n,n^*) = \theta^*_{n^*}(n,n^*) < 0 \text{ and } \theta_{n^*}(n,n^*) = \theta^*_n(n,n^*) < 0. \qquad (13)$$

4.2.4 Manufacturing Firms

Manufacturing goods are produced in the monopolistically competitive sector. Each firm need produce one unit of capital in the R&D sector and the number of world-wide manufacturing firms is the same with the amount of world-wide capital stock (see, i.e. Dupont, 2007; Minniti and Parello, 2011; Martin and Ottaviano, 1999;). β units of labor can produce one unit of differentiate goods. Each firm chooses the location of the manufacturing comparing the profits in both countries. Moreover, serving the foreign market needs iceberg costs measured by τ. The amount of world-wide capital is the same with the number of world-wide manufacturing firms:

$$K^w(t) = K(t) + K^*(t) = n(t) + n^*(t) = N(t). \qquad (14)$$

Using demand function (5), profit maximizing derives the profit maximizing prices are given by

$$p = p^* = \frac{\sigma\beta}{\sigma - 1}. \qquad (15)$$

Using (5) and (16), we derive profit functions in each country as follows:

$$\pi = \frac{\sigma\beta}{\sigma - 1}x \text{ and } \pi^* = \frac{\sigma\beta}{\sigma - 1}x^*, \qquad (16)$$

where

$$x = \frac{\alpha(\sigma-1)}{\beta\sigma}\left[\frac{E}{n+\delta n^*} + \frac{\delta E^*}{\delta n+n^*}\right] \text{ and } x^* = \frac{\alpha(\sigma-1)}{\beta\sigma}\left[\frac{\delta E}{n+\delta n^*} + \frac{E^*}{\delta n+n^*}\right], \qquad (17)$$

are sizes of firms in the North and South. In the equilibrium where manufacturing firms locate in both countries, Northern and Southern profits are equalized. Thus, the fraction of northern manufacturing firms is

$$s_n \equiv \frac{n}{N} = \frac{1}{2} + \left(\frac{1+\delta}{1-\delta}\right)(s_E - \frac{1}{2}), \qquad (18)$$

where $s_E \equiv \frac{E}{E^w}$ is the fraction of northern expenditure share. Substituting this back into the size of manufacturing firms yields

$$x = x^* = \frac{\alpha(\sigma-1)E^w}{\beta\sigma N}. \quad (19)$$

4.2.5 R&D

The production function for varieties (capital) is given by

$$\dot{N}(t) = \frac{L_I(t)}{b_I(t)}, \quad (20)$$

where

$$b_I(t) = \frac{1}{N(t)[s_n + \lambda(1-s_n)]}, \quad (21)$$

is the intertemporal knowledge spillover, $L_I(t)$ is the R&D labor, and $1 > \lambda > 0$ is international spillover.

The R&D sector is the perfectly competitive. In the equilibrium with R&D activity, the value of capital denoted by $V(t)$ must be equalized with the R&D cost. Thus, following condition holds:

$$V(t) = \frac{1}{N(t)[s_n + \lambda(1-s_n)]}. \quad (22)$$

Consumer saves in two ways. The first way is riskless bond. The second is firms' share whose rate of return is given by capital gain and dividend. So, the no-arbitrage condition is given by

$$\frac{\dot{V}(t)}{V(t)} + \frac{\pi(t)}{V(t)} = r(t). \quad (23)$$

The world-wide labor demand is composed of service goods, agriculture goods, manufacturing goods, and R&D. The world-wide labor supply is given by $2L$. The world-wide labor constraint is given by

$$\begin{aligned} 2L &= L_M + L_S + L_Y + L_I \\ &= \frac{\alpha(\sigma-1)E^w}{\sigma} + (1-\alpha)E^w + \frac{g}{s_n + \lambda(1-s_n)} \end{aligned} \quad (24)$$

From now, we pay attention to the steady state equilibrium. Rewritten the no-arbitrage condition yields following relationship between growth rate, the world-wide expenditure, and the fraction of northern firms as follows:

$$-g + \alpha E^{w}[s_n + \lambda(1 - s_n)] = \rho. \qquad (25)$$

We finally derive the northern and southern expenditures using budget constraint. Rewritten budget constraints lead to

$$E = \frac{s_K \rho}{s_n + \lambda(1 - s_n)} + L \text{ and } E^* = \frac{(1 - s_k)\rho}{s_n + \lambda(1 - s_n)} + L. \qquad (26)$$

The world-wide expenditure and the northern expenditure share are given by

$$E^{w} = \frac{\rho}{s_n + \lambda(1 - s_n)} + 2L \text{ and } s_E = \frac{\frac{\rho s_k}{s_n + \lambda(1 - s_n)} + L}{\frac{\rho}{s_n + \lambda(1 - s_n)} + 2L} = \frac{1}{2} + \frac{\frac{\rho}{s_n + \lambda(1 - s_n)}(s_k - \frac{1}{2})}{\frac{\rho}{s_n + \lambda(1 - s_n)} + 2L(t)}, \qquad (27)$$

where $s_k \equiv \frac{K}{K + K^*}$ is the northern share of physical capital.

Combining (18) and (27), we derive the northern share of manufacturing firms, and it is given by

$$s_n = \frac{1}{2} + \left(\frac{1 + \delta}{1 - \delta}\right) \frac{\rho(s_k - \frac{1}{2})}{\rho + 2L(t)[s_n + \lambda(1 - s_n)]}. \qquad (28)$$

The left-hand side of (28) is 45-degree line through the origin while the right-hand side of (28) is decreasing function of the northern share of manufacturing firms and lower limit of the right-hand side of (28) is 1/2, as shown in Figure 4-1. Large population size ensures unique and existence of the northern share of manufacturing firms from (28). Moreover, (26) and (27) determine the northern expenditure, the northern expenditure share, and the world-wide expenditure. The no-arbitrage condition determines the growth rate in (25).

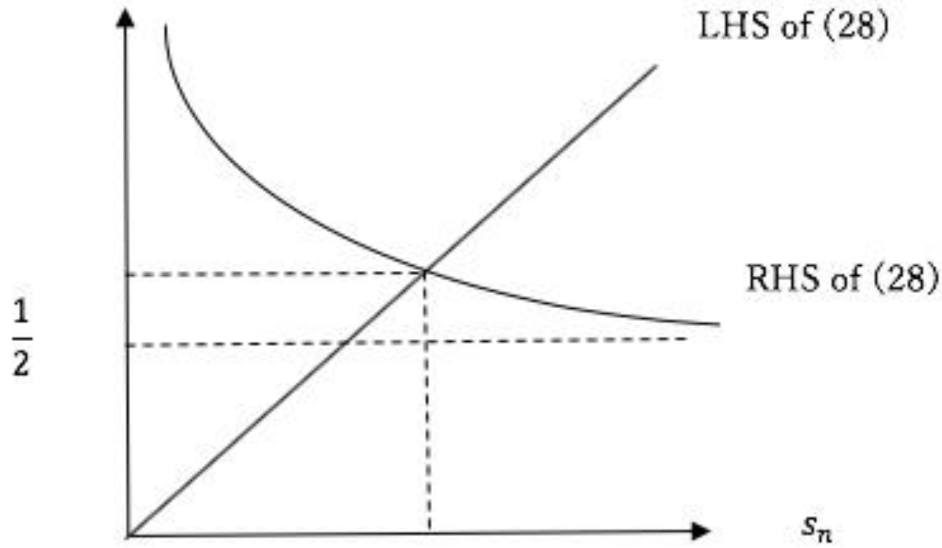

Figure 4-1 Determination of the Northern Share of Manufacturing Firms

4.3 Effects of globalization on regional income inequality

In this study, it examine the effects of globalization on regional real income inequality in the steady state. The real income is defined as nominal expenditure divided by price index of manufacturing and price of service goods. We derive the effect of globalization on expenditure as follows:

$$\frac{\partial E}{\partial \delta}\frac{1}{E} - \frac{\partial E^*}{\partial \delta}\frac{1}{E^*} = \frac{1}{s_E(1-s_E)}\frac{\partial s_E}{\partial \delta} = \frac{\rho L(1-\lambda)(1-2s_k)\frac{\partial s_n}{\partial \delta}}{s_E(1-s_E)\{\rho + 2L[s_n + \lambda(1-s_n)]\}^2} < 0. \tag{29}$$

As Dupont (2007) derived, the effect of globalization on the nominal expenditure inequality is negative because the north has a larger capital, and value of capital decreases due to globalization and knowledge spillover in the R&D sector. Northern expenditure decreases more, and the nominal expenditure inequality decreases as in Dupont (2007).

We turn to derive the effect of globalization on inequality in manufacturing price index as follows:

$$\frac{\partial P}{\partial \delta}\frac{1}{P}-\frac{\partial P^*}{\partial \delta}\frac{1}{P^*}=\frac{-[\delta(1+\delta)\frac{\partial s_n}{\partial \delta}+1-2s_n]}{(\sigma-1)[s_n+\delta(1-s_n)][1-(1-\delta)s_n]}$$
$$=\frac{-(1+\delta)^2\frac{\partial s_E}{\partial \delta}}{(\sigma-1)[s_n+\delta(1-s_n)][1-(1-\delta)s_n]}>0. \quad (30)$$

As Dupont (2007) pointed out, the effect of globalization on inequality in the manufacturing price index is composed of a direct openness effect, an indirect static effect, and an indirect dynamic effect. An indirect dynamic effect is common and does not affect inequality as in Dupont (2007). A direct openness effect is positive for both countries, but its effect is stronger for the South because $\frac{2s_n-1}{(\sigma-1)[s_n+\delta(1-s_n)][1-(1-\delta)s_n]}>0$ measures differences between direct openness effect in the North and South. An indirect static effect is positive for the north but negative for the south, and $\frac{-\delta(1+\delta)\frac{\partial s_n}{\partial \delta}}{(\sigma-1)[s_n+\delta(1-s_n)][1-(1-\delta)s_n]}<0$ measures differences between indirect static openness effect in the North and South. A direct openness effect dominates an indirect static effect. So, the southern manufacturing price index decreases more, and inequality in manufacturing price index increases as in Dupont (2007).

We turn to effect of globalization on inequality in the service price index, and it is derived as follows:

$$\frac{\partial P_s}{\partial \delta}\frac{1}{P_s}-\frac{\partial {P_s}^*}{\partial \delta}\frac{1}{{P_s}^*}=\frac{\partial s_n}{\partial \delta}\left[\frac{\theta_n-\theta_n^*}{s_n(1-s_n)}\right]\leq 0. \quad (31)$$

As in Fukuda (2019), intraregional knowledge spillover is stronger or equal to interregional knowledge spillover in the service sector. Thus, the price of northern service price index may decrease relative to southern service price index, and the inequality in the service price index decreases or remain constant as in Fukuda (2019).

From (29)−(31), globalization leads to increases in inequality in the regional real income if the intraregional knowledge spillover in the service goods sector is larger than the interregional knowledge spillover, and its size is large. Moreover, globalization leads to decrease in inequality in the regional real income if the intraregional knowledge spillover in the service goods sector is equal to the interregional knowledge. This result does not hold without footloose capital in this paper because southern manufacturing price index decreases relative to northern price index while the northern service price index does not change relative to southern price index due to globalization.

This result is different from existing theoretical results of footloose capital model because Dupont (2007) shows that inequality in the regional income decreases in an endogenous growth model with manufacturing and agriculture goods, Minniti and Parello (2011) shows that inequality in the regional income does not change in a semi endogenous growth model with manufacturing and agriculture goods, and Fukuda (2019) shows that the inequality in regional income increases or does not change in a semi endogenous growth model with manufacturing, agriculture, and service goods.[13]

Because empirical paper shows that globalization may not affect or affect positively or negatively, the theoretical result seems to be consistent with empirical evidence.

4.4 Conclusion

This study examines effects of globalization on inequality in regional income in an endogenous growth model with the agriculture, manufacturing, and service goods. Results show that effects of globalization may positive, negative, or zero because the service price index and expenditure converge while the manufacturing price index diverges. Differences between interregional knowledge spillover minus intraregional knowledge spillover in the service sector determines the sign of the inequality in regional income.

[13] As Martin and Ottaviano (1999) shows, growth rate measured by growth rate of number of varieties is common in both countries in steady state, and there is positive effects of globalization on growth rate through northern manufacturing agglomeration.

5. Conclusion

For the topic about the impact of market competition on service quality, this dissertation contributes to related literatures by providing empirical evidences about the causal inference between market competition and service quality in railway industry, taking the privatization of JNR in 1987 as example. Passengers' time cost was set as the outcome variable and a measurement for service quality in the two studies. As mentioned in Chapter 2 and Chapter 3, even though there exist many literatures which investigate the relationship between market competition and service quality or even casual effect between market competition and service quality, quite few of them are in railway industry. Among the only remaining literatures about impact of market competition on service quality in railway industry, almost all of them are using theoretical approaches. Studies in Chapter 2 and Chapter 3 about this topic were conducted by difference-in-differences (DID) approach through using a four-year panel data with OD pair and year fixed effects, which is a relatively good analysis approach and can eliminate the impact from potentially omitted variables. Therefore, either of these two studies could be one of the few empirical researches which analysis the causal effect by using relatively good econometric approach.

In Chapter 2, it discussed the casual effect between market competition and the service quality of HSR service in Japan by using passengers' time cost as the outcome variable. The empirical analysis results are consistent with the analysis results from those theoretical models. Results shows that market competition could increase the service quality, namely the market competition reduces passengers' time cost in duopoly region where HSR competes with conventional rail, relative to that in monopoly region. The consistence in the results of market competition through several rounds of robustness checks provided the evidence for the reliability of the analysis results. Besides, the results in this study about market competition on HSR service quality showed that the impact of market competition was larger for a longer distance trip.

Chapter 3 investigated the impact of market competition on the service quality of conventional rail after JNR's privatization in 1987. With the passengers' time cost as outcome variable and measurement for quality of CR service, the study in chapter 3 also employed the difference-in-differences (DID) method for analysis. However, the results in the analysis for the impact of market competition on CR service were quite different from HSR case and also the analysis from the theoretical models. No statistically significant evidences were found for the impact of market competition on CR service quality and potential reasons were listed in the discussion part of Chapter 3. Both of the studies in Chapter 2 and Chapter 3 contribute much in providing evidences about the market competition impact on service quality in railway industry, where with quite few empirical studies about impact of market competition, especially using reliable econometric approach.

The study in Chapter 4 contributes to literatures that related to the effect of globalization on regional inequality in regional real income. In Chapter 4, it reexamined the effect of trade globalization on inequality in regional real income in an endogenous growth model with agriculture, manufacturing and services goods. Results showed that globalization increases, decreases, or does not change inequality in regional real income. This is because inequalities in nominal expenditure and service price index decrease, but inequality in manufacturing price index increases. Moreover, inequality in service price index depends on the size of intraregional knowledge spillover minus interregional knowledge spillover from manufacturing sector. Different from those theoretical results which seemed not to be consistent with empirical evidence as showed in existed literatures, the results of study in chapter 4 as listed above seemed to be consistent with empirical evidences explained in those literatures because this model shows all of empirical results.

Additionally, as a member of Taoyaka program, I would like to point out how the three studies in this dissertation contribute to the development of disadvantaged areas which is one important goal of Taoyaka program. Transportation is an important necessity in daily lives, especially for the people live in rural and disadvantaged areas in Japan, under the aging and depopulation background. The inconvenience and relative higher transportation cost in disadvantage areas is due to lack of competition. Studies in Chapter 2 and Chapter 3 somehow provide evidences for a way to solve the rural transportation problem which is create market competition, such as provide policy convenience and financial subsidy for private transportation service providers. The third study provides suggestions for the economic development in disadvantage countries which is increase the international knowledge spillover from the developed countries, such as employing engineers from developed countries which can help developing countries to learn more about the advanced technology. Therefore, the three studies contribute to TAOAYAKA goals in some sense.

Besides, as a Taoyaka student, I and my team members carried out onsite team project in Nijo district (Musuda shi, Shimane prefecture) with the goal to achieve rural revitalization under the aging and depopulation background. Since we proposed to achieve the rural revitalization through sixth industry by using its wild animal resources, we took three rounds of surveys among different kinds of respondents about their experience of tasting smoked wild boar meat and their willingness to pay (WTP) for smoked wild boar meat. Results show that: a. Most people have no experience for tasting smoked wild boar meat, but they hear that it is with good taste and rich nutrition; b. Most people are satisfied with its taste after tasting the sample and have strong WTP for the smoked wild boar meat product; c. WTP for 30 grams are 567 JPY for respondents in Hiroshima, 347 JPY for respondents in Masuda and 125 JPY among international students respectively. These survey results suggest that local people should increase the scale of the business if under environment sustainability and sell the products to relatively bigger cities where have more customers with higher WTP. The potential more income from smoked wild boar business could bring more job opportunities and create incentives to bring new bloods to Nijo. Besides, tourism could be one of other choices for local people to increase income and attract new residents. As well, tourism can also be a good advertisement and promotion for local products.

Finally, in the future, when the passenger volume data of OD pairs in railway industry is easily to access as the passenger volume data of OD pairs in airline industry, we could have a more interesting and more direct investigation about the impact of market competition on whole railway industry, or HSR and CR services separately.

References

Abbott, L., 1955. *Quality and Competition: An Essay in Economic Theory,* New York: Columbia University Press.

Albalate, D., Germà, B., and Xavier, F, 2015. Competition and cooperation between high-speed rail and air transportation services in Europe. *Journal of Transport Geography*, 42, 166-174.

Amiti, M., and Khandelwal, A., 2013. Import Competition and Quality Upgrading. *The Review of Economics and Statistics*, 95(2), 476-490.

Bergman, M.A., et al., 2016. Privatization and quality: Evidence from elderly care in Sweden. *Journal of Health Economics*, 49, 109-119.

Bonanno, A., and Lopez, R.A., 2009. Competition Effects of Supermarket Services. *American Journal of Agricultural Economic*s, 91(3), 555-568.

Bouvet, F., 2010. EMU and the dynamics of regional per capita income inequality in Europe. *Journal of Economic Inequality*, 8(3), 323–44.

Busso, M., and Galiani, S., 2015. The Causal Effect of Competition on Prices and Quality: Evidence from a Field Experiment. *NBER.*

Cerina, F., and Francesco M., 2014. Is agglomeration really good for growth? Global efficiency, interregional equity and uneven growth. *Journal of Urban Economics*, 84, 9–22.

Chamberlin, E. H.,1933. *The Theory of Monopolistic Competition*, Cambridge, MA: Harvard University Press.

Domberger, S., and Avrom S., 1989. The impact of competition on pricing and quality of legal services. *International Review of Law and Economics*, 9, 41– 56.

Dupont, V., 2007. Do geographical agglomeration, growth and equity conflict? *Papers in Regional Science*, 86(2), 193–213.

Edwards, S., 1993. Openness, Trade Liberalization, and Growth in Developing Countries. *Journal of Economic Literature*, 31(3), 1358-1393.

Ezcurra, R., and Andrés R. P., 2013. Does Economic Globalization affect Regional Inequality? A Cross-country Analysis. *World Development* 52, 92–103.

Ferreira, P.C., and Rossi, J.L., 2003. New evidence from Brazil on Trade Liberalization and Productivity Growth. *International Economic Review*, 44(4), 1383-1405.

Forder, J., and Allan, S., 2014. The impact of competition on quality and prices in the English care homes market. *Journal of Health Economics*, 34, 73-83.

Fujita, M., 1988. A monopolistic competition model of spatial agglomeration: Differentiated product approach. *Regional Science and Urban Economics*, 18 (1), 87-124.

Fukuda, K., 2019. Trade integration and regional income disparities in a growth model with the service sector and footloose capital. *Applied Economics Letter*, 26(9), 722–725.

Gabszewicz, J.J., and Thisse, J.F., 1979. Price competition, quality and income disparities. *Journal of Economic Theory*, 20(3), 340-359.

Greenfield, D., 2014. Competition and service quality: New evidence from the airline industry. *Economics of Transportation*, 3(1), 80-89.

Hoxby, C., 2000. Does Competition among Public School Benefit Students and Taxpayers? *American Economic Review*, 90(5), 1209–1238.

Hsu, C.W., Lee, Y.S., and Liao, C.H., 2010. Competition between high-speed and conventional rail systems: A game theoretical approach. *Expert Systems with Applications,* 37(4), 3162-3170.

Jian, T.L., Jeffrey, D. S., and Andrew, M.W., 1996. Trends in regional inequality in China. *China Economic Review*, 7(1), 1–21.

Kremer, M., 1993. Population Growth and Technological Change: One Million B.C. to 1990. *The Quarterly Journal of Economics*, 108(3), 681-716.

Krishna, P., and Mitra, D., 1998. Trade liberalization, market discipline and productivity growth: new evidence from India. *Journal of Development Economics*, 56(2), 447-462.

Lahiri, S., and Ono, Y., 1988. Helping Minor Firms Reduces Welfare. *The Economic Journal*, 98(393), 1199-1202.

Lerner, A.P., 1934. The Concept of Monopoly and the Measurement of Monopoly Power. *The Review of Economic Studies*, 1(3), 157-175.

Lessmann, C., and André, S., 2017. Regional inequality, convergence, and its determinants–A view from outer space. *European Economic Review*, 92, 110–132.

Martin, P., and Gianmarco, O., 1999. Growing locations: industry location in a model of endogenous growth. *European Economic Review*, 43(2), 281–302.

Maskin, E., and Tirole, J., 1988. A Theory of Dynamic Oligopoly, I: Overview and Quantity Competition with Large Fixed Costs. *Econometrica*, 56(3), 549-569.

Matsa, D. A., 2011. Competition and Product Quality in the Supermarket Industry. *Quarterly Journal of Economics*, 126(3), 1539-1591.

Mazzeo, M.J., 2003. Competition and Service Quality in the U.S. Airline Industry. *Review of Industrial Organization*, 22, 275–296.

Minniti, A., and Carmelo, P., P., 2011. Trade integration and regional disparity in a model of scale-invariant growth. *Regional Science and Urban Economics*, 41(1), 20–31.

Pan, J., et al., 2015. Does hospital competition improve health care delivery in China? *China Economic Review*, 33, 179-199.

Parenti, M., Ushchev, P., and Thisse, J.F., 2017. Toward a theory of monopolistic competition. *Journal of Economic Theory*, 167, 86-115.

Pepall, L., Richards, D. J., and Norman, G., 2005. *Industrial Organization: Contemporary Theory and Practice*. South-Western, Mason, OH.

Perry, M.K., and Porter, R.H., 1985. Oligopoly and the Incentive for Horizontal Merger. *The American Economic Review*, 75(1), 219-227.

Propper, C., Burgess, S., and Green, K., 2004. Does competition between hospitals improve the quality of care? Hospital death rates and the NHS internal market. *Journal of Public Economics*, 88, 1247-1272.

Raturi, V., et al., 2013. Analyzing Inter-modal Competition between High Speed Rail and Conventional Transport Systems: A Game Theoretic Approach. *Procedia-Social and Behavioral Science*, 104, 904-913.

Spence, A. M., 1975. Monopoly, quality and regulation. *Bell Journal of Economics*, 6(2), 417–429.

Suzumura, K., and Kiyono, K., 1987. Entry Barriers and Economic Welfare. *Review of Economic Studies*, 54(1), 157-167.

Tang, J. M., and Wang, W.M., 2005. Product Market Competition, Skill Shortages and Productivity: Evidence from Canadian Manufacturing Firms. *Journal of Productivity Analysis,* 23 (3), 317-339.

Temple, J., 2003. The Long-Run implication of Growth Theories. *Journal of Economic Surveys*, 17(3), 497-510.

Tirole, J., 1988. *The Theory of Industrial Organization.* MIT Press, Cambridge, MA.

Tsunoda, Y., 2018. Transportation policy for high-speed rail competing with airlines. *Transportation Research Part A: Policy and Practice*, 116, 350-360.

Wacziarg, R., and Welch, K.H, 2008. Trade Liberalization and Growth: New Evidence. *The World Bank Economic Review*, 22(2), 187-231.

Wan, Y.L., et al., 2016. Airlines' reaction to high-speed rail entries: Empirical study of the Northeast Asian Market. *Transportation Research Part A: Policy and Practice*, 94, 532-557.

Xia, W.Y., and Zhang, A.M, 2016. High-speed rail and air transport competition and cooperation: A vertical differentiation approach. *Transportation Research Part B: Methodological*, 94, 456-481.

Zhang, Q., Yang, H.J., and Wang, Q., 2017. Impact of high-speed rail on China's Big Three airlines. *Transportation Research Part A: Policy and Practice*, 98, 77-85.

https://company.jr-central.co.jp/company/achievement/eco-report/_pdf/P12-P16.pdf

https://saiyo.jr-central.co.jp/company/business/conventional.html

https://www.jreast.co.jp/investor/ar/2001/pdf/p76_j.pdf