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Impact of Infrastructure Investment on Tax: Estimating Spillover Effects of the Kyushu High-Speed Rail Line in Japan on Regional Tax Revenue

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Abstract

This paper analyzes the impact of infrastructure investment on tax revenues and on the economy of the region. In 1991, the Kyushu high-speed rail line was constructed and was completed in 2003. In 2004, the rail line started operating from Kagoshima to Kumamoto. The entire line was opened in 2011. The effect of the Kyushu high-speed rail line (*shinkansen* train) on the economy has often been debated. We estimated its impact in the Kyushu region of Japan by using the difference-in-difference method, and compared the tax revenues of regions along the railway line with other regions that were not affected by the railway line. Our findings showed a positive impact on the region's tax revenue following the connection of the Kyushu rapid train with large cities such as Hiroshima and Osaka. Tax revenue in the region significantly increased during construction in 1991–2003, and dropped after the start of operations in 2004–2010. The rapid train's impact on the neighboring prefectures of Kyushu is positive. However, in 2004–2013, its impact on tax revenue in places farther from the rapid train was observed to be lower. When the Kyushu railway line was connected to the existing high-speed railway line of Sanyo, the situation changed. The study found statistically significant and economically growing impact on tax revenue after it was completed and connected to other large cities such as Hiroshima and Osaka. Tax revenues in the regions close to the high-speed train is higher than in adjacent regions. The difference-in-difference coefficient methods reveal that corporate tax revenue was lower than personal income tax revenue during construction. However, the difference in corporate tax revenues rose after connectivity with large cities was completed. The railway's connectivity to large cities has a significant economic impact not only in the case of Japan but also in other cases such as Uzbekistan.

JEL Classification: H54; O11; O23; R11

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1. INTRODUCTION

Infrastructure is important in the economic development of a country. Economists understand the multiplicative effect of telecommunication and road infrastructure on society and a country's economy. Railways play a significant role in a country's connectivity and interconnectedness (Yoshino and Abidhadjaev 2015). Better infrastructure contributes to facilitation of international trade though decrease in transportation costs (Ando and Kimura 2013). Infrastructure in forms of cellular and landline phones helps to overcome issues of information asymmetry and directly affects the investor's behavior and decision to invest in a particular region.

Japan has made considerable infrastructure investments, based on the development plans adopted in the early 1950s and late 1980s and 1990s. In particular, the Five-Year Economic Independence Plan (1956–1960) aimed to rehabilitate traffic and telecommunication facilities; the New Long-Term Economic Plan (1958–1962) focused on reinforcing transportation capacity by modernizing roads; the National Income Doubling Plan (1961–1970) centered on developing infrastructure to reinforce industrial infrastructure. Similarly, two development plans in the 1980s and the 1990s—Co-Prosperity with the World (1988–1992) and the Five-Year Economic Superpower Plan (1992–1996)—covered the development of highway transportation network, focusing on decentralization of the economy (Yoshino and Nakahigashi 2000).

We would like to examine the economic impact of infrastructure investment by using as an example—the Kyushu bullet train. Since local gross domestic product (GDP) data are not available in Japan, we use tax revenues by region, which are available by prefectural level, to compare the economic effects.

The estimates in this paper focus on three different periods in the Kyushu region of Japan: (i) construction period, (ii) operation period without connectivity, and (iii) operation period after connectivity. We applied the difference-in-difference approach to determine the impact of the railway connection to tax revenues of each affected prefecture. Our findings indicate that railways with no connection to large cities raise tax revenues during construction. However, revenues during operation as an autonomous branch decline after construction ends. This situation changed when the newly built high-speed railway line was connected to large cities. Despite the positive impact on neighboring prefectures, emerging patterns indicate a lesser impact on tax revenue in prefectures that are farther away from the high-speed railway line.

We found that difference-in-difference coefficients for corporate tax revenue were lower than those for personal income tax revenue during construction, but higher during operation after the railway's connectivity to large cities.

This paper is structured as follows: Section 2 briefly describes the available literature on infrastructure investment. Section 3 explains the difference-in-difference approach. Section 4 demonstrates the estimated results of the differences in total tax revenue, income tax revenue, and corporate income tax revenue. Section 5 concludes the paper.

2. LITERATURE REVIEW

Aschauer (1989) carried out empirical work linking the supply of public infrastructure to economic growth in the United States. Aschauer's findings—which were found to be seminal in empirical work—resulted in the explosion of the field, and were followed by both confirmatory (Eisner 1994) and counterfactual (Harmatuck 1996; Hulten and Schwab 1991) arguments with respect to his findings, indicating the statistically significant impact of public infrastructure.

Motivated by increasing debates on infrastructure's impact, corresponding estimations were subsequently carried out using data for other countries (Arslanalp et al. 2010; Yoshino and Nakahigashi 2000). In this aspect, Yoshino and Nakahigashi (2000) conducted one of the earliest empirical studies with regard to the economic effects of infrastructure using data for Asian countries. They employed a translog-type production-function approach to examine the productivity effect of infrastructure for Japan and later for Thailand, distinguishing social capital stock by region, industry, and sector. Their findings revealed that compared with the primary and secondary industry, productivity effect of infrastructure is greater in the tertiary industry. In sectoral analysis, their findings suggest that greater impacts are found in information and telecommunication, as well as in the environment sectors. From the regional perspective, the impact of infrastructure supply appears greater in regions that have a relatively large population and mostly in urban areas.

Though the majority of these frameworks helped address the issues related to the exact estimation of the magnitude and statistical significance of the contribution of infrastructure to economic growth, they do not allow accounting for the possibility of structural breaks (Pereira and Andraz 2013). Putting it differently, a general consensus on the economic effects of infrastructure capital might be absent not only because of the framework chosen, but also because of the sample periods covered or because structural breaks brought about by the provision of such infrastructure were not taken into account.

Quasi-experimental methods, with the assumption of a common time trend and the availability of pre-treatment and post-treatment data on outcome variables of interest provide an alternative framework for estimating the impact of infrastructure investment. One can estimate the degree of departure from the counterfactual scenario, which can be attributed to the provision of treatment, in this case a particular form of infrastructure such as a railway or highway. Estimating the difference-in-difference coefficients might give a better understanding of the net difference brought by introducing an infrastructure facility.

Examples of infrastructure studies, which used the above-mentioned approach, are increasing rapidly. In particular, Yoshino and Abidhadjaev (2015), using regional data for Uzbekistan, found positive effect from the introduction of the Tashguzar–Boysun–Kumkurgan (TBK) railway, in which significant variations in outcome variables of interest as observed by regional GDP and sector valued added were found not only after launching the railway but also during design and construction. Their empirical results in the case of Uzbekistan suggest that the TBK railway induced positive and significant changes in regional GDP growth in the affected regions in the frame of so-called "connectivity effects"—regions located at the far end of the railway system. Decomposing the regional GDP in Uzbekistan, they also found that variations are brought about by increase in industry and services value added, with estimates being approximately equal to 5% and 7%, respectively. Similarly, Gonzalez-Navarro and Quintana-Domeque (2010) gave evidence on the effect of infrastructure investment on poverty reduction: within 2 years after providing infrastructure in the form of paved roads, local households purchased motor vehicles and increased consumption of durable goods.

On the other hand, the results of Faber's (2014) evaluation of the national trunk highway system of the People's Republic of China point out that network connections might have led to a decline in GDP growth among peripheral counties that were non-targeted or lay outside the network system. Similarly, Donaldson (2014), using archival data from colonial India found that though railroads decreased trade costs and inter-regional price gaps, they harmed neighboring regions that had no railroad access, leaving the overall magnitude of net effect under question.

At the same time, few studies link infrastructure provision to fiscal performance of the regions. A notable example might be that of Yoshino and Pontines (2015). Conditioning on the counties' time-invariant individual effects, time-varying covariates, evolving economic characteristics, and the difference-in-difference estimation strategy linked the changes in tax revenues to the newly built infrastructure project, STAR highway. They found that the STAR highway had a robust, statistically significant, and economically growing impact on business taxes, property taxes, and regulatory fees. Similar to findings of Yoshino and Abidhadjaev (2015), the study also supported the hypothesis of spillover effects across the territory and time, where the positive impact of infrastructure provision extends to neighboring regions and seems to be of anticipating or lagging nature.

Our study also focuses on the fiscal performance of Japanese prefectures and first-order administrative divisions, and links the variations in tax revenues to the newly built Kyushu high-speed rail—*shinkansen*—distinguishing the spillover impacts by region, adjacency, and connectivity.

3. METHODOLOGY

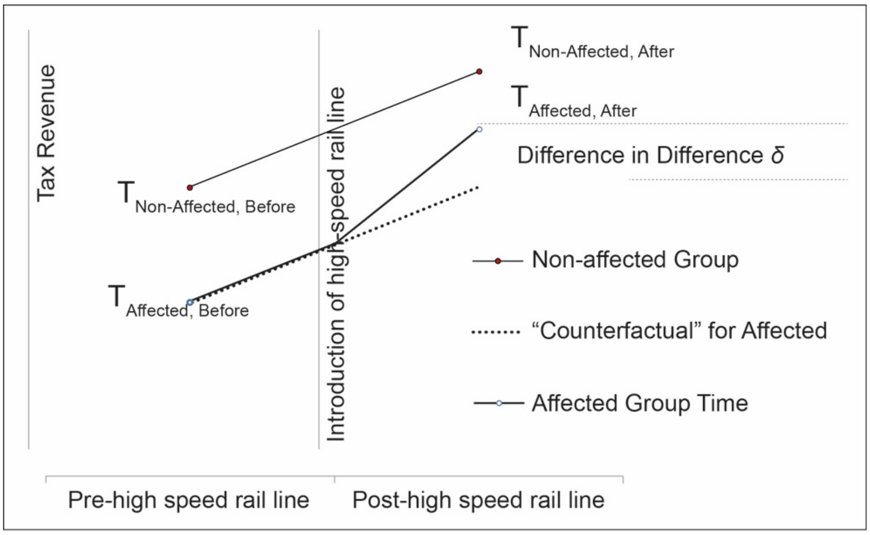
This section describes our empirical strategy based on the difference-in-difference approach. Our analysis aims to capture the economic dimension of infrastructure provision, particularly linking the introduction of the Kyushu rail train to the variations in outcome variables as observed by total tax revenue, personal income tax revenue, corporate income tax revenue, and tax revenue from other sources.

To accomplish this task, we used the empirical strategy with a difference-in-difference approach, distinguishing the degrees of geographic focus that are described as regional effects and spillover effects. This approach allows us to estimate the net difference between the observed "actual" outcome, and an alternative "counterfactual" outcome for a given region of focus and time frame.

To carry out this estimation, we divided the data into a control group and a treated group on a geographic basis and time basis, making the difference between pre-intervention or baseline data and post-intervention data. Figure 1 provides a graphic illustration of the framework. The crucial difference of our study is in the interrogation of generally accepted assumptions about the division into these groups in the framework.

First, we looked at the geographic context and estimated three spillover effects by region, adjacency, and connectivity.

Figure 1: Illustration of the Difference-in-Difference Method with the Outcome Variable of Tax Revenue



Source: Authors.

The estimation of spillover effects by region includes two subsets (Table 1), one with the Kagoshima and Kumamoto regions as those affected by the construction and operation of *shinkansen*, and other of the same regions plus the Fukuoka prefecture, which is located at one end of the Kyushu high-speed rail line. Examples of literature with similar regional-level analysis include (i) Yoshino and Abidhadjaev (2015), Stephan (2003), Seung and Kraybill (2001), and Yoshino and Nakahigashi (2000)—using the production function approach; (ii) Cohen and Paul (2004) and Moreno et al. (2003)—using the behavioral approach; and (iii) Pereira and Andraz (2010) and Everaert (2003)—using vector autoregression approaches. As Pereira and Andraz (2013) demonstrate, literature on infrastructure impact evaluation found negative and positive regional effects. This in turn might be explained by the regions' inability to fully internalize positive externalities from public infrastructure provision.

Consequently, we looked at the analysis of spillover effects due to adjacency, which include the above-mentioned three prefectures and adds the Oita and Miyazaki prefectures and the Saga and Nagasaki prefectures as those that might have been affected because of their adjacent location. In general, quasi-experimental methods for impact evaluation of a particular treatment require clear distinction between treated and non-treated groups (Duflo et al. 2008). The inappropriate distribution of the observational data into treated or control groups might complicate the objective assessment of the treatment. Given the analysis of Pereira and Andraz (2013), who revealed a pattern of negative or insignificant effects of infrastructure provision at the regional level (see also Yoshino and Abidhadjaev [2015]), and positive and significant effects at the aggregate level (Belloc and Vertova 2006, Pereira and Andraz 2005), we considered the case of spillover effects of the *shinkansen* on adjacent or neighboring regions. Earlier empirical evidence, for example, as conducted by Pereira and Andraz (2003) using a vector autoregression approach for transport and communication infrastructure, and Pereira and Roca (2007) for highways demonstrates positive spillover effects of infrastructure provision on neighboring regions. Table 1 gives two subsets of the spillover effects analysis.

Finally, most trains along the Kyushu high-speed rail line provide a quick and easy transfer to the Sanyo high-speed rail line traveling toward Osaka. This allowed us to estimate the spillover effect by connectivity. A similar analysis that Yoshino and Abidhadjaev (2015) conducted for regions in Uzbekistan found economically growing and statistically significant connectivity impact of the introduction of the Tashguzar–Boysun–Kumkurgan railway, meaning that regions located at far ends of the railway system seem to experience larger positive variations in regional GDP growth rate. Taking this aspect into account, we looked at spillover effects by connectivity, including prefectures located along the Kyushu high-speed rail line and the Sanyo high-speed rail line as those being affected. Table 1 lists the prefectures belonging to this group and other above-mentioned groups.

Table 1: Prefectures Assumed to be Affected by the Construction and Operation of the Kyushu High-Speed Rail

Spillover Effects by Region		Spillover Effects by Adjacency		Spillover Effects by Connectivity
Group 1	**Group 2**	**Group 3**	**Group 4**	**Group 5**
1. Kagoshima	1. Kagoshima	1. Kagoshima	1. Kagoshima	1. Osaka
2. Kumamoto	2. Kumamoto	2. Kumamoto	2. Kumamoto	2. Hyogo
	3. Fukuoka	3. Fukuoka	3. Fukuoka	3. Okayama
		4. Oita	4. Oita	4. Hiroshima
		5. Miyazaki	5. Miyazaki	5. Yamaguchi
			6. Saga	6. Fukuoka
			7. Nagasaki	7. Kumamoto
				8. Kagoshima

Source: Authors' analysis.

The comparison of time is made based on the following framework. The preconstruction period covers the years from 1982 to 1990, in the absence of high-speed rail-line construction or operation. The design and construction period until the first phase of the *shinkansen's* operation between Kagoshima and Kumamoto constitutes the period from 1991 to 2003. The first phase of operation covers the period from 2004 to 2010, and the second phase of operation, when the entire Kyushu high-speed rail line was finished and connected to the Fukuoka station includes the time period from 2011 to 2013 (Table 2).

Table 2: Construction and Operation Timeline of the High-Speed Rail Line

Period	Preconstruction	Construction	Operation I	Operation II
Years	1982–1990	1991–2003	2004–2010	2011–2013

Source: Authors' analysis; Ministry of Land, Infrastructure, Transport and Tourism.

The direct calculation of net differences across time and groups of prefectures helped us obtain estimates with an eye on the time-invariant region-specific effects used to proxy the idiosyncratic features of a region proceeding from historical and social development as well as year-specific effects capturing the effect of changes in legislation or overall business climate.

At the same time, changes in tax revenue dynamics might be caused by a wide range of other factors besides the aforementioned effects and provision of the high-speed rail-line. If we do not account for the possibility of positive effects resulting from other evolving factors, our estimates might be downward or upward biased by negative or positive effects induced by other factors. This challenge in estimation is also mentioned in program evaluation literature as an external validity problem (Banerjee and Duflo 2009, Ravallion 2009, and Rodrik 2008).

To address this issue, we need to acknowledge the factor inputs, which might affect the performance of tax revenue in the prefecture and control for time-varying covariates. Incorporating the number of taxpayers in the estimation framework and obtaining a linear projection of the tax revenues onto number of taxpayers, accounting for time-invariant region-specific effects and year-specific effects provide us with the following definitions of affected groups and non-affected groups of prefectures:

Affected group, $T_{g=A}$

t=0 (before shinkansen): $\Delta T_{A0} = \alpha_{A0} + \gamma_{A0} + X_{A0}\beta' + \varepsilon_{A0}$ (1)

t=1 (after shinkansen): $\Delta T_{A1} = \alpha_{A1} + \gamma_{A1} + X_{A1}\beta' + \varphi_{A1} + \delta + \varepsilon_{A1}$ (2)

Non-affected group, $T_{g=N}$

t=0 (before shinkansen): $\Delta T_{N0} = \alpha_{N0} + \gamma_{N0} + X_{N0}\beta + \varepsilon_{N0}$ (3)

t=1 (after shinkansen): $\Delta T_{N1} = \alpha_{N1} + \gamma_{N1} + X_{N1}\beta + \varphi_{N1} + \varepsilon_{N1}$ (4)

This regression framework makes it possible to control for the above-mentioned covariates and get a less biased estimate of the difference-in-difference coefficient of interest. Equations (1) to (4) provide us with the baseline estimation strategy of the difference-in-difference specification:

$$\Delta T_{it} = \alpha_i + \phi_t + X'_{it} * \beta + \delta * D_{gt} + \epsilon_{it} \quad (5)$$

where ΔT is the tax revenue of the prefecture, X denotes time-varying covariates (vector of observed controls), D is the binary variable indicating whether the observation relates to the affected group after provision of the *shinkansen*, i indexes prefectures, g indexes groups of prefectures (1 = affected group, 0 = non-affected group), t indexes treatment before and after (t=0 before the *shinkansen*, t=1 after the *shinkansen*), α_i is the sum of autonomous (α) and time-invariant unobserved region-specific (γ_i) rates of growth,[1] φ_t is the year-specific growth effect, and ϵ_{it} is the error term, assumed to be independent over time.

The vector of observed controls, X, constitutes number of taxpayers given in the prefecture.

The assumption of zero effect of such factors would imply that the number of taxpayers in the region is not determined by location or favorable changes in business climate. This aspect of ignoring important information on how the variables change over time when region-specific characteristics are correlated with time-varying covariates makes it difficult to choose a random effects estimator. To ensure the accounting of both time-invariant unobserved characteristics, such as the advantageous location of a region and year-specific growth effects similar to favorable changes in the business climate, we employed a fixed-effects estimator.

With regard to possible autocorrelation within a prefecture (Bertrand et al. 2004), we employed heteroscedasticity and autocorrelation consistent (HAC) standard errors, belonging to the class of cluster standard errors. HAC standard errors treat the errors as uncorrelated across regions, but allow for heteroscedasticity and arbitrary autocorrelation within a region, which is consistent with the assumption of the fixed-effects regression in regard to independent and identical distribution across entities, in our case, prefectures i = 1,…47.

Nearest-Neighbor Matching Procedure

The next step of analysis consists of the exact matching of treated and control groups. In other words we can choose the closest counterpart of the treated prefecture from those in the control group and carry out an analysis of difference-in-difference, which can be done in two ways: (i) account for specific characteristics of the regions such as location or number of enterprises, matching the prefectures with the closest number of enterprises in the preconstruction period in this aspect; and (ii) actually focus on the dependent variable and find the closest match from the pre-high-speed rail-line period by observing the average performance of prefectures in affected groups and non-affected groups.

In the next stage, we looked at the minimum distance in unit measurement from which we chose an instrument. In this aspect, there are three options: the Mahalanobis distance, the inverse variance, or the Euclidian distance. In the scope of this study, we used Euclidian distance as the distance metric to find the closest match or nearest neighbor for our affected prefectures in the pre-high-speed rail-line period.

By finding the minimum distance between the mean tax revenue amount and standard deviation during the pre-high-speed rail line of 1982–1990, we can determine the closest counterpart of the affected prefecture, or in other words, we can find the “nearest neighbor” of the affected prefecture. These groups of nearest neighbors provide a unique dataset for constructing the counterfactual scenario in the absence of treatment in the form of the Kyushu high-speed rail line. In the scope of this study, we present estimation results for the case of nearest neighbors calculated by minimum distance between the mean value of tax revenues in the pre-*shinkansen* period of 1982–1990. Table 3 lists the nearest neighbors for the groups of affected prefectures based on the minimum distance on mean value.

[1] This approach requires an assumption of a common time path or parallel trends, accepting the autonomous rate of growth α to be equal in both affected and non-affected groups.

Table 3: Affected Prefectures and their Corresponding Nearest Neighbors by Minimum Euclidian Distance between Mean Value of Total Tax Revenues for the Pre-High-Speed Rail Line, 1982–1991
(¥ million)

	Prefecture	Mean Tax Revenue	Standard Deviation		Prefecture	Mean Tax Revenue	Standard Deviation
1.	Kagoshima	204,108	13,756	1.	Wakayama	239,582	22,349
2.	Kumamoto	245,181	17,704	2.	Shiga	240,466	15,817
3.	Fukuoka	1,104,007	77,674	3.	Hokkaido	1,109,382	73,606
4.	Oita	197,082	12,781	4.	Nara	192,948	19,900
5.	Miyazaki	138,677	9,054	5.	Tokushima	120,935	13,249
6.	Saga	120,374	9,258	6.	Kochi	113,679	7,138
7.	Nagasaki	185,051	12,494	7.	Aomori	184,093	11,142
8.	Osaka	4,945,666	409,167	8.	Aichi	3,054,083	212,024
9.	Hyogo	1,561,176	126,463	9.	Saitama	1,175,458	120,307
10.	Okayama	474,501	34,628	10.	Gunma	468,592	31,106
11.	Hiroshima	781,393	51,698	11.	Kyoto	921,084	67,185
12.	Yamaguchi	339,400	29,622	12.	Fukushima	311,416	32,678

Source: National Tax Agency Japan.

4. ESTIMATION RESULTS

4.1 Estimations with Limited Set of Observations

To avoid bias caused by outliers at the first stage, we excluded the observations for the prefectures of Tokyo, Aichi, Kanagawa, and Osaka, which demonstrated superb performance in tax revenue during the pre-high-speed rail line period due to the concentration of industrial and commercial conglomerates. The general pattern observed is the occurrence of u-shaped dynamics of net difference in tax revenue performance for all spillover effects. There is diminishing net difference in tax revenues during the construction period and operation phase 1 of the Kyushu high-speed rail line, while the coefficients bounce back during operation phase 2.

Total Tax Revenue

In the matter of spillover effects by adjacency, Treatment Group 4 and Treatment Group 3 had on average a net difference of ¥110 billion and ¥134 billion in total tax revenues during construction as compared with the counterfactual scenario based on the non-affected group, which includes observations for all other prefectures except Tokyo, Aichi, Kanagawa, and Osaka (Table 4a). These impacts diminished, though staying positive, after construction, constituting ¥76 billion and ¥97 billion during operation phase 1 for Treatment Group 4 and Treatment Group 3, respectively. The subsequent connection of the Kyushu high-speed rail line to the Sanyo high-speed rail line in 2011 pushed the net difference almost twice as high as during construction, being equal to ¥201 billion and ¥229 billion during operation phase 2 for Treatment Group 4 and Treatment Group 3, respectively. Overall, it appears that the connection of the previously autonomous Kyushu high-speed rail line to the greater system of high-speed rail network had a statistically significant and economically growing impact on total tax revenue performance of the Kyushu region as a whole.

Focusing on spillover effects by region, we can observe a similar pattern of high net difference in total tax revenue during construction of the high-speed rail line—relatively low but positive coefficients at operation phase 1 and bouncing back during operation phase 2 with coefficients of a magnitude of ¥282 billion and ¥169 billion with a corresponding t-value of 2.56 for Treatment Group 2 and 4.18 for Treatment Group 1.

Finally, estimates for spillover effects by connectivity, focusing on prefectures located alongside the Kyushu high-speed rail line provide further evidence on the nature of core-periphery links. We can observe that if the coefficient for Treatment Group 5 is slightly higher than that of Treatment Group 2 during construction and during operation phase 1—constituting of a magnitude of ¥194 billion for the former and ¥181 billion for the latter, and demonstrating corresponding coefficients of ¥118 billion and ¥100 billion during 2004–2011—the net difference in total tax revenue during operation phase 2 rose to ¥353 billion and ¥282 billion, respectively. These estimates for 2011–2013 are not only the highest compared with the results for other treatment groups, but also constitute the peak of net difference in total tax revenue as compared with others, given the time frames in the scope of this analysis.

Tables 4b and 4c present estimation results for the structural components of total tax revenue by decomposing it into personal income tax and corporate income tax revenues. This gives an opportunity to observe how the above-mentioned types of tax revenues reacted to the construction and operation of the new high-speed rail line in the Kyushu region.

Personal and Corporate Income Tax Revenue

Evidence provided in Tables 4b and 4c reveals a similar pattern: positive net difference in personal income tax and corporate income tax revenue throughout construction in 1990–2003, followed by a decline in operation phase 1, in contrast to that of total tax revenue being negative during 2004–2011, giving positive difference-in-difference coefficients at operation phase 2 during 2011–2013 for almost all treatment groups.

In magnitude, personal income tax seems to have a higher net difference as compared with corporate income tax during construction, while vice versa is true during operation phase 2, where coefficients for corporate tax revenue turn out higher than that of personal income tax: for the case of spillover effects by adjacency, the net difference in personal income tax revenue for Treatment Group 4 and Treatment Group 3 is equal to ¥15 billion and ¥18 billion, respectively, while the corresponding figures for corporate tax revenue are ¥10 billion and ¥13 billion. However, observing the estimates during operation phase 2, we can see that the net differences for corporate income tax in the frame of adjacency effects are equal to ¥86 billion and ¥88 billion, while the corresponding indicators for Treatment Group 4 and Treatment Group 3 in personal income tax revenue are ¥51 billion and ¥54 billion, respectively. A similar pattern is observed in the frame of spillover effects by region, though point estimates for personal income tax seem to be statistically more significant than those for corporate income tax. Turning to spillover effects by connectivity, corporate income tax does not seem to be affected during construction—with the coefficient of net difference being close to 0 during construction, negative and statistically insignificant during operation phase 1, and constituting ¥182 billion with a t-value of 1.7 during operation phase 2.

Table 4a: Difference-in-Difference Estimation Results with Outcome Variable of Total Tax Revenue
(excluding observations for Tokyo, Aichi, Kanagawa, and Osaka prefectures from the control group)

Scale of Focus	Affected Group of Prefectures	Construction Period (1991–2003)	Operation Phase 1 (2004–2010)	Operation Phase 2 (2011–2013)
Spillover Effect by Region	Treatment Group 1	99,949***	60,884***	168,586***
		[6.8]	[5.46]	[4.18]
	Treatment Group 2	181,098**	117,907**	281,933**
		[2.67]	[2.47]	[2.56]
Spillover Effect by Adjacency	Treatment Group 3	134,498***	97,210***	229,224***
		[2.73]	[2.91]	[2.93]
	Treatment Group 4	109,557***	76,310***	200,704***
		[2.86]	[2.8]	[3.11]
Spillover Effect by Connectivity	Treatment Group 5	193,639***	99,830**	352,718***
		[5.22]	[2.25]	[3.49]
Number of Observations		946	731	559

Table 4b: Difference-in-Difference Estimation Results with Outcome Variable of Personal Income Tax Revenue

Scale of Focus	Affected Group of Prefectures	Construction Period (1991–2003)	Operation Phase 1 (2004–2010)	Operation Phase 2 (2011–2013)
Spillover Effect by Region	Treatment Group 1	27,371**	–20,204**	43,806**
		[2.17]	[–2.33]	[2.12]
	Treatment Group 2	31,216***	–32,422***	69,743**
		[3.47]	[–2.78]	[2.17]
Spillover Effect by Adjacency	Treatment Group 3	18,346*	–26,311***	54,135**
		[2]	[–3.36]	[2.31]
	Treatment Group 4	14,648**	–23,410***	51,064**
		[2.11]	[–3.6]	[2.59]
Spillover Effect by Connectivity	Treatment Group 5	33,660***	–54,830***	100,684**
		[3.45]	[–2.99]	[2.65]
Number of Observations		946	731	559

Table 4c: Difference-in-Difference Estimation Results with Outcome Variable of Corporate Income Tax Revenue

Scale of Focus	Affected Group of Prefectures	Construction Period (1991–2003)	Operation Phase 1 (2004–2010)	Operation Phase 2 (2011–2013)
Spillover Effect by Region	Treatment Group 1	11,946***	–6,228**	76,216
		[7.7]	[–2.14]	[1.65]
	Treatment Group 2	17,300***	–12,716**	111,579
		[3.81]	[–2.21]	[1.5]
Spillover Effect by Adjacency	Treatment Group 3	13,311***	–8,629*	87,983
		[3.26]	[–1.89]	[1.56]
	Treatment Group 4	10,407***	–6,344*	86,054*
		[3.01]	[–1.73]	[1.69]
Spillover Effect by Connectivity	Treatment Group 5	–57	–14,430	182,127*
		[–0.01]	[–1.63]	[1.7]
Number of Observations		946	731	559

Notes: The tax revenue amount is adjusted for Consumer Price Index with 1982 as the base year. Pre-high-speed rail line construction period covers the years from 1982 to 1990. Non-affected groups include the rest of the prefectures. Treated groups: Group 1: Kagoshima, Kumamoto; Group 2: Kagoshima, Kumamoto, Fukuoka; Group 3: Kagoshima, Kumamoto, Fukuoka, Oita, Miyazaki; Group 4: Kagoshima, Kumamoto, Fukuoka, Oita, Miyazaki, Saga, Nagasaki; Group 5: Kagoshima, Kumamoto, Fukuoka, Yamaguchi, Hiroshima, Okayama, Hyogo, Osaka. T-values are in parentheses. T-value measures how many standard errors the coefficient is away from zero.

* p<.1, ** p<.05, *** p<.01.

Source: Authors.

4.2 Estimation with Full Set of Observations

The next stage of analysis presupposes the inclusion of observations for the Tokyo, Aichi, Kanagawa, and Osaka prefectures in a control group. In doing so, we observed estimation results that were both similar and different.

Overall comparison of Table 5a and Table 4a reveals that the pattern is the same but the coefficients are lower, resulting in a lower net difference due to the introduction of the Kyushu high-speed rail line. Thus, the estimate for Treatment Group 4 is ¥95 billion and for Treatment Group 3 is ¥119 billion in full set, while that for the limited set is ¥110 billion and ¥134 billion respectively, which is significant statistically in both cases. Other combinations of affected groups with the outcome variable of total tax revenue demonstrate a similar response (Table 5a).

Divergence emerges when total tax revenue is broken down into personal and corporate income tax revenue. As shown in Table 5b, in contrast to the results in Table 4b, almost all the coefficients of net difference—except for those in spillover effects by region for Treatment Group 2 and by connectivity in Treatment Group 5—became statistically insignificant during construction. This suggests that the prefectures located along the Kyushu high-speed rail line and the Sanyo high-speed rail line seem to be the main beneficiary in terms of increase in personal income tax revenue. Similar dynamics is observed during 2004–2010 except for the case of spillover effects by adjacency, which includes all seven prefectures in Kyushu island.

When excluding the observations for Tokyo, Aichi, Kanagawa, and Osaka prefectures from the control groups, the following commonality between revenues for personal and corporate income taxes is observed: estimates of difference in difference for the period of 2011–2013 remain both positive and statistically significant, though being of lower magnitude with respect to estimates with baseline set of observations.

Table 5a: Periodic Difference-in-Difference Estimation Results with Outcome Variable of Total Tax Revenue
(with observations for Tokyo, Aichi, Kanagawa, and Osaka prefectures included in the control group)

Scale of Focus	Affected Group of Prefectures	Construction Period (1991–2003)	Operation Phase 1 (2004–2010)	Operation Phase 2 (2011–2013)
Spillover Effect by Region	Treatment Group 1	96,603***	64,067	164,542***
		[3.39]	[1.14]	[5.66]
	Treatment Group 2	170,051**	110,832**	273,935***
		[2.65]	[2.04]	[2.77]
Spillover Effect by Adjacency	Treatment Group 3	119,371**	87,089**	223,107***
		[2.36]	[2.13]	[3.22]
	Treatment Group 4	94,896**	75,132**	194,791***
		[2.39]	[2.48]	[3.51]
Spillover Effect by Connectivity	Treatment Group 5	298,403***	271,385	481,536***
		[2.94]	[1.59]	[2.99]
Number of Observations		1,034	799	611

Table 5b: Difference-in-Difference Estimation Results with Outcome Variable of Personal Income Tax Revenue

Scale of Focus	Affected Group of Prefectures	Construction Period (1991–2003)	Operation Phase 1 (2004–2010)	Operation Phase 2 (2011–2013)
Spillover Effect by Region	Treatment Group 1	25,724	–19,033	42,035**
		[1.32]	[–0.75]	[2.34]
	Treatment Group 2	25,783*	–35,023	66,498**
		[1.93]	[–1.63]	[2.41]
Spillover Effect by Adjacency	Treatment Group 3	10,915	–30,029**	51,675**
		[0.85]	[–2.18]	[2.59]
	Treatment Group 4	7,448	–23,844**	48,690***
		[0.74]	[–2.13]	[3.01]
Spillover Effect by Connectivity	Treatment Group 5	65,186**	–23761	151,360**
		[2.02]	[–0.55]	[2.59]
Number of observations		1,034	799	611

Table 5c: Difference-in-Difference Estimation Results with Outcome Variable of Corporate Income Tax Revenue

Scale of Focus	Affected Group of Prefectures	Construction Period (1991–2003)	Operation Phase 1 (2004–2010)	Operation Phase 2 (2011–2013)
Spillover Effect by Region	Treatment Group 1	10,350	–4,773	72,330**
		[1.26]	[–0.2]	[2.2]
	Treatment Group 2	12,040*	–15,948	104,664*
		[1.88]	[–0.87]	[2]
Spillover Effect by Adjacency	Treatment Group 3	6,116	–13,250	82,730**
		[0.81]	[–1.06]	[2.1]
	Treatment Group 4	3,436	–6,883	80,998**
		[0.52]	[–0.7]	[2.34]
Spillover Effect by Connectivity	Treatment Group 5	–39,703	–28,031	179,632
		[–0.92]	[–0.65]	[1.58]
Number of observations		1,034	799	611

Notes: The amount for tax revenue is adjusted for Consumer Price Index with 1982 as base year. Pre-high-speed rail line construction period covers the years from 1982 to 1990. Non-affected groups include rest of the prefectures. Treated groups: Group 1: Kagoshima, Kumamoto; Group 2: Kagoshima, Kumamoto, Fukuoka; Group 3: Kagoshima, Kumamoto, Fukuoka, Oita, Miyazaki; Group 4: Kagoshima, Kumamoto, Fukuoka, Oita, Miyazaki, Saga, Nagasaki; Group 5: Kagoshima, Kumamoto, Fukuoka, Yamaguchi, Hiroshima, Okayama, Hyogo, Osaka. T-values are in parentheses. T-value measures how many standard errors the coefficient is away from zero.

* p<.1, ** p<.05, *** p<.01

Source: Authors.

Regarding impact on corporate income tax revenue, we observed that in the differences of baseline estimation results, almost all the coefficients of net difference are statistically insignificant during construction and operation phase 1 (Table 4c). The only exception is for spillover effects by region, which has an estimate of ¥12 billion for Treatment Group 2, which includes the observation for Kagoshima, Kumamoto, and Fukuoka prefectures for the period 1991–2003. It appears that the construction of the Kyushu high-speed rail line induced a growing impact on businesses located mostly in the above-mentioned three prefectures.

The coefficients of difference in difference for corporate income tax during operation phase 2, covering the period from 2011 to 2013, follow the pattern of personal income tax. We obtained statistically significant and positive coefficients though of lower magnitudes compared with those obtained in the frame of baseline estimation.

4.3 Heterogeneity of Responses in Amounts of Income and Income Tax

This section builds upon the two previous estimation results regarding the negative net difference of income taxes. The following questions need to be addressed: does the resulting negative net difference in personal and corporate income tax during operation phase 1 mean that income of households and firms decreased after the introduction of the high-speed rail line? If not, what are the possible causes for the decrease in tax revenue amount in comparison with the counterfactual scenario without the introduction of the Kyushu high-speed rail line?

Despite the negative coefficients of the difference-in-difference for personal income tax and corporate income tax, they are not enough to make logical deductions about the states of personal and corporate income amount. We need to take into account the existence of thresholds for progressive taxation or substantial changes in tax revenue (Table 6). In other words, there is a possibility that personal income and corporate income were not hurt in the region because of the introduction of a new mode of transportation. On the contrary, income might have even increased, however, just not enough to translate into a positive net difference in tax revenue. To address this issue, we turn to the estimation of difference-in-difference coefficients for personal income amount and corporate income amount in the Kyushu region as well as in the regions adjacent to the Sanyo high-speed rail line, which are included in Treatment Group 5.

Table 6: Individual Income Tax Rates

Taxable Income Brackets		**Tax Rates** (%)
–	Or under ¥1,950,000	5
Over ¥1,950,000	Or under ¥3,300,000	10
Over ¥3,300,000	Or under ¥6,950,000	20
Over ¥6,950,000	Or under ¥9,000,000	23
Over ¥9,000,000	Or under ¥18,000,000	33
Over ¥18,000,000	Or under ¥40,000,000	40
Over ¥40,000,000	–	45

– = not applicable.

Source: Japan External Trade Organization.

With regard to personal income tax, Japan's tax filing system has two modes of collection: (i) a self-assessed income tax payment, in which individual taxpayers calculate annual income and the corresponding tax amount and file their tax returns, and (ii) a tax withholding system where companies on behalf of its employees collect income tax on the date of salary payment. Although the above-mentioned mode of payment is determined depending on the type of income and the category of the income recipient, taxation is progressive for both modes. For example, if annual personal income is under approximately ¥2 million, a tax rate equal to 5% is applied. However, if annual personal income exceeds this amount, personal income tax is 10% of total income provided it is less than ¥3.3 million.

On the other hand, income deductions are regressive in order. Provided that employment income is equal to or less than approximately ¥1.6 million, an individual is eligible for ¥650,000 income deduction. For subsequent thresholds of employment income, the percentage of income deduction is relatively lesser (Table 7).

Table 7: Employment Income Deductions

Employment Income	**Employment Income Deductions**
Up to ¥1,625,000	¥650,000
Over ¥1,625,000 and up to ¥1,800,000	(employment income) x 40%
Over ¥1,800,000 and up to ¥3,600,000	(employment income) x 30% + ¥180,000
Over ¥3,600,000 and up to ¥6,600,000	(employment income) x 20% + ¥540,000
Over ¥6,600,000 and up to ¥10,000,000	(employment income) x 10% + ¥1,200,000
Over ¥10,000,000 and up to ¥15,000,000	(employment income) x 5% + ¥1,700,000
Over ¥15,000,000	¥2,450,000

Source: Japan External Trade Organization.

Under the corporate taxation system of Japan, tax revenue is based on corporate tax, local corporate tax, corporate inhabitant tax, enterprise tax, and special local corporate tax. Similar to personal income taxation, the corporate tax rate applied is progressive in nature (Table 8). This implies that if the construction and operation of Kyushu's high-speed rail line positively affects companies with relatively lower income levels more than companies with higher income levels, the total corporate tax revenue might decrease while corporate income has a positive net growth.

Table 8: Tax Burden on Corporate Income

Taxable Income Brackets	**Up to ¥4 million** (%)	**¥4 million to ¥8 million** (%)	**Over ¥8 million** (%)
Corporate tax	15.00	15.00	25.50
Local corporate tax	0.66	0.66	1.12
Corporate inhabitant taxes			
1. Prefectural	0.48	0.48	0.81
2. Municipal	1.45	1.45	2.47
Enterprise tax	3.40	5.10	6.70
Special local corporate tax	1.46	2.20	2.89
Total tax rate	22.45	24.89	39.49
Effective tax rate	21.42	23.20	36.05

Note: Corporate income tax rate applies for 3 business years from the business year beginning between 1 October 2014 and 31 March 2015. The rates for local taxes may vary somewhat depending on the scale of the business and the local government under whose jurisdiction it is located. Applicable tax rates will vary according to the timing.

Source: Japan External Trade Organization.

Table 9a and Table 9b contain the estimation amounts for personal income and corporate income, supporting the above-mentioned hypothesis. Compared with Table 5b and Table 5c, the difference-in-difference coefficients for 2004–2010 for personal income and corporate income are positive. Thus, even though Treatment Group 4 representing all seven prefectures of the Kyushu region experienced during 2004–2010 a decline in personal income tax revenue expressed as negative and a statistically significant coefficient of difference-in-difference approximately equal to ¥24 billion, the net difference in actual personal income amount was positive with a point estimate of about ¥36 billion and a corresponding t-value of 1.98.

Table 9: Periodic and Yearly Difference-in-Difference Estimation Results for Income Tax Revenue and Income Amount
(with observations for Tokyo, Aichi, Kanagawa, and Osaka prefectures included in the control group)

Table 9a: Difference-in-Difference Estimation Results with Outcome Variable of Personal Income

Scale of Focus	**Affected Group of Prefectures**	**Construction Period (1991–2003)**	**Operation Phase 1 (2004–2010)**	**Operation Phase 2 (2011–2013)**
Spillover Effect by Region	Treatment Group 1	71,896***	36,139	146,328***
		[3.84]	[0.77]	[4.05]
	Treatment Group 2	105,264***	56,258	257,728**
		[3.44]	[1.59]	[2.53]
Spillover Effect by Adjacency	Treatment Group 3	73,302***	35,527	192,325**
		[2.73]	[1.41]	[2.61]
	Treatment Group 4	63,214***	36,289*	173,304***
		[3.08]	[1.98]	[3.03]
Spillover Effect by Connectivity	Treatment Group 5	175,670***	159,268*	502,215***
		[3.33]	[1.73]	[3.31]
Number of Observations		1,034	799	611

Table 9b: Difference-in-Difference Estimation Results with Outcome Variable of Corporate Income

Scale of Focus	Affected Group of Prefectures	Construction Period (1991–2003)	Operation Phase 1 (2004–2010)	Operation Phase 2 (2011–2013)
Spillover Effect by Region	Treatment Group 1	44,006*	22,435	170,451***
		[2.01]	[0.30]	[3.11]
	Treatment Group 2	80,506**	64,950	291,338**
		[2.31]	[1.05]	[2.37]
Spillover Effect by Adjacency	Treatment Group 3	51,345	37,220	222,365**
		[1.65]	[0.83]	[2.49]
	Treatment Group 4	38,021	42,439	208,093***
		[1.49]	[1.32]	[2.89]
Spillover Effect by Connectivity	Treatment Group 5	9,911	149,853	481,490**
		[0.16]	[1.09]	[2.38]
Number of Observations		1,034	799	611

Table 9c: Difference-in-Difference Estimation Results with Outcome Variable of Personal Income

Scale of Focus	Affected Group of Prefectures	Operation Phase 2 (2011)	Operation Phase 2 (2012)	Operation Phase 2 (2013)
Spillover Effect by Region	Treatment Group 1	205,742***	222,838***	210,253***
		[3.54]	[3.92]	[3.85]
	Treatment Group 2	357,639**	380,186**	362,152**
		[2.52]	[2.63]	[2.62]
Spillover Effect by Adjacency	Treatment Group 3	268,582**	283,948***	272,865***
		[2.63]	[2.69]	[2.74]
	Treatment Group 4	244,461***	258,087***	249,291***
		[3.09]	[3.16]	[3.24]
Spillover Effect by Connectivity	Treatment Group 5	725,690***	750,253***	759,822***
		[2.95]	[3.04]	[3.06]
Number of Observations		517	517	517

Table 9d: Difference-in-Difference Estimation Results with Outcome Variable of Corporate Income

Scale of Focus	Affected Group of Prefectures	Operation Phase 2 (2011)	Operation Phase 2 (2012)	Operation Phase 2 (2013)
Spillover Effect by Region	Treatment Group 1	285,100**	252,629**	234,657**
		[2.28]	[2.47]	[2.36]
	Treatment Group 2	454,240*	421,456**	427,170**
		[1.98]	[2.10]	[2.05]
Spillover Effect by Adjacency	Treatment Group 3	349,486**	322,383**	320,794**
		[2.05]	[2.18]	[2.11]
	Treatment Group 4	328,484**	299,017**	300,348**
		[2.24]	[2.40]	[2.38]
Spillover Effect by Connectivity	Treatment Group 5	809,657*	779,620*	838,416**
		[1.75]	[1.97]	[2.02]
Number of Observations		517	517	517

Notes: The tax revenue amount is adjusted for Consumer Price Index with 1982 as the base year. Pre-high-speed rail line construction period covers the years from 1982 to 1990. Non-affected groups include rest of the prefectures. Treated groups: Group 1: Kagoshima, Kumamoto; Group 2: Kagoshima, Kumamoto, Fukuoka; Group 3: Kagoshima, Kumamoto, Fukuoka, Oita, Miyazaki; Group 4: Kagoshima, Kumamoto, Fukuoka, Oita, Miyazaki, Saga, Nagasaki; Group 5: Kagoshima, Kumamoto, Fukuoka, Yamaguchi, Hiroshima, Okayama, Hyogo, Osaka. T-values are in parentheses. The t-value measures how many standard errors the coefficient is away from zero.

* p<.1, ** p<.05, *** p<.01

Source: Authors.

Yearly Estimations

Similar to the previous section, this part of the analysis is derived from the results of the estimation, which shows at least two distinguishing aspects for operation phase 2: (i) it disrupts the trend of net difference in tax revenue as compared with the previous period, where tax returns diminished after the end of construction during operation phase 1; the overall tax revenue bounced back during operation phase 2; and (ii) it has exceptionally high estimates in comparison with all the time frames analyzed in this study.

Tables 10a to 10c show the results of estimation for operation phase 2 only. It breaks down operation phase 2 into three distinct periods, providing exact estimates of difference-in-difference in tax revenue for the years 2011, 2012, and 2013.

The net increase in total tax revenue of the Kyushu region that was attributed to the Kyushu high-speed rail line in 2011 was equal to about ¥320 billion as compared with the counterfactual scenario in the absence of the high-speed rail line (Table 10a). This statistically significant result with a t-value of 2.7 is obtained from the estimation with a full set of observations. The corresponding coefficients for 2012 and 2013 are equal to 308 with a t-value of ¥2.83 billion and ¥303 billion respectively, and a t-value of 2.82. Thus, the effect of the railway is diminishing in nature. This finding is in line with earlier evidence found by Yoshino and Abidhadjaev (2015), which estimated the impact of the railway connection in Uzbekistan upon regional economic performance, and demonstrating diminishing rates of infrastructure impact as time passed. This finding is in line with earlier evidence found by Yoshino and Abidhadjaev (2015), estimating the impact of the railway connection in Uzbekistan within the countries' regional economic performance, which demonstrated the diminishing rates of infrastructure impact as time goes by.

The same pattern of diminishing impact was shown when total tax revenue was broken down into personal income tax revenue, corporate income tax revenue, and estimated yearly impact of the Kyushu high-speed rail line during operation phase 2—expressed by the coefficients on Treatment Group 4 and Treatment Group 3 in spillover effects by adjacency, and Treatment Group 2 in spillover effects by region.

Table 10a: Yearly Difference-in-Difference Estimation Results with Outcome Variable of Total Tax Revenue
(with observations for Tokyo, Aichi, Kanagawa, and Osaka prefectures included in the control group)

Scale of Focus	Affected Group of Prefectures	Operation Phase 2 (2011)	Operation Phase 2 (2012)	Operation Phase 2 (2013)
Spillover Effect by Region	Treatment Group 1	268,644***	270,263***	253,343***
		[3.05]	[3.37]	[3.15]
	Treatment Group 2	450,497**	438,096**	422,721**
		[2.29]	[2.45]	[2.37]
Spillover Effect by Adjacency	Treatment Group 3	358,183**	346,698**	336,284**
		[2.53]	[2.66]	[2.61]
	Treatment Group 4	319,956***	308,103***	303,789***
		[2.7]	[2.83]	[2.82]
Spillover Effect by Connectivity	Treatment Group 5	869,153**	840,176**	873,185**
		[2.24]	[2.32]	[2.29]
Number of Observations		517	517	517

Table 10b: Difference-in-Difference Estimation Results with Outcome Variable of Personal Income Tax Revenue

Scale of Focus	Affected Group of Prefectures	Operation Phase 2 (2011)	Operation Phase 2 (2012)	Operation Phase 2 (2013)
Spillover Effect by Region	Treatment Group 1	75,583**	80,473**	69,235**
		[2.04]	[2.30]	[2.10]
	Treatment Group 2	127,651*	123,897**	110,807**
		[1.98]	[2.18]	[2.11]
Spillover Effect by Adjacency	Treatment Group 3	97,430**	95,393**	85,923**
		[2.07]	[2.26]	[2.22]
	Treatment Group 4	90,734**	88,516**	82,342**
		[2.29]	[2.47]	[2.49]
Spillover Effect by Connectivity	Treatment Group 5	280,001**	274,942**	277,902**
		[2.03]	[2.15]	[2.15]
Number of Observations		517	517	517

Table 10c: Difference-in-Difference Estimation Results with Outcome Variable of Corporate Income Tax Revenue

Scale of Focus	Affected Group of Prefectures	Operation Phase 2 (2011)	Operation Phase 2 (2012)	Operation Phase 2 (2013)
Spillover Effect by Region	Treatment Group 1	92,720**	89,083**	76,303*
		[2.05]	[2.09]	[1.82]
	Treatment Group 2	134,314*	133,086*	113,555*
		[1.81]	[1.89]	[1.75]
Spillover Effect by Adjacency	Treatment Group 3	105,830*	104,332*	88,877*
		[1.90]	[1.96]	[1.81]
	Treatment Group 4	102,111**	99,558**	88,615*
		[2.08]	[2.14]	[2.01]
Spillover Effect by Connectivity	Treatment Group 5	234,839	226,902	214,220
		[1.47]	[1.53]	[1.44]
Number of Observations		517	517	517

Notes: The tax revenue amount is adjusted for Consumer Price Index with 1982 as base year. Pre-high-speed rail line construction period covers the years from 1982 to 1990. Non-affected groups include the rest of the prefectures. Treated groups: Group 1: Kagoshima, Kumamoto; Group 2: Kagoshima, Kumamoto, Fukuoka; Group 3: Kagoshima, Kumamoto, Fukuoka, Oita, Miyazaki; Group 4: Kagoshima, Kumamoto, Fukuoka, Oita, Miyazaki, Saga, Nagasaki; Group 5: Kagoshima, Kumamoto, Fukuoka, Yamaguchi, Hiroshima, Okayama, Hyogo, Osaka. T-values are in parentheses. The t-value measures how many standard errors the coefficient is away from zero.

* p<.1, ** p<.05, *** p<.01

Source: Authors.

4.4 Estimation Results Using the Nearest-Neighbor Matching Approach

Total Tax Revenue

Using the nearest-neighbor matching approach, we found positive and statistically significant results during construction for all spillover effects. The prefectures in Treatment Group 4 and Treatment Group 3 demonstrated ¥11 billion and ¥13 billion higher tax revenue during construction as compared with the counterfactual scenario based on the performance of the non-affected group (Table 11). Treatment Group 1, which includes Kagoshima and Kumamoto prefectures, had a net difference of ¥10 billion in analogous period with regard to total tax revenue. Finally, the highest magnitude of difference during construction is observed in the frames of spillover effects by region for Treatment Group 2 and spillover effects by connectivity from Treatment Group 5. The higher magnitude of positive net difference during construction was followed by lower though positive and statistically significant coefficients during operation phase 1, which bounced back during operation phase 2.

Table 11: Difference-in-Difference Estimation Results with Outcome Variable of Total Tax Revenue Using Nearest-Neighbor Matching Based on the Euclidian Distance between Mean Tax Revenues, 1982–1990

Scale of Focus	Affected Group of Prefectures	Construction Period (1991–2003)	Operation Phase 1 (2004–2010)	Operation Phase 2 (2011–2013)
Spillover Effect by Region	Treatment Group 1	101,125***	60,503***	105,773***
		[9.11]	[9]	[12.71]
	Number of Observations	88	68	52
	Treatment Group 2	183,783*	116,203*	191,940
		[2.47]	[2.25]	[1.9]
	Number of Observations	132	102	78
Spillover Effect by Adjacency	Treatment Group 3	138,420**	95,595**	156,133**
		[2.75]	[2.73]	[2.54]
	Number of Observations	220	170	130
	Treatment Group 4	113,430**	76,182**	128,318**
		[2.95]	[2.74]	[2.7]
	Number of Observations	308	238	182
Spillover Effect by Connectivity	Treatment Group 5	275,121***	193,207*	454621**
		[3.08]	[1.78]	[2.85]
	Number of Observations	330	255	195

Notes: The tax revenue amount is adjusted for Consumer Price Index with 1982 as the base year. Pre-high-speed rail line construction period covers the years from 1982 to 1990. Non-affected groups include rest of the prefectures. Treated groups: Group 1: Kagoshima, Kumamoto; Group 2: Kagoshima, Kumamoto, Fukuoka; Group 3: Kagoshima, Kumamoto, Fukuoka, Oita, Miyazaki; Group 4: Kagoshima, Kumamoto, Fukuoka, Oita, Miyazaki, Saga, Nagasaki; Group 5: Kagoshima, Kumamoto, Fukuoka, Yamaguchi, Hiroshima, Okayama, Hyogo, Osaka. T-values are in parentheses. The t-value measures how many standard errors the coefficient is away from zero.

* p<.1, ** p<.05, *** p<.01

Source: Authors.

Personal Income Tax

Construction of the Kyushu high-speed rail line had a positive impact on personal tax revenue. The difference-in-difference coefficients for 1991–2003 for the case of spillover effects by adjacency are equal to ¥15 billion and ¥19 billion with corresponding t-values of 2.26 and 2 for Treatment Group 4 and Treatment Group 3, respectively (Table 12). The spillover effects by region on personal income tax revenue, being higher than those by adjacency, are equal to a net difference of ¥31 billion and ¥25 billion as compared with the counterfactual scenario for Treatment Group 2 and Treatment Group 1, respectively. Turning to spillover effects by connectivity, it appears that construction of the Kyushu *shinkansen* generated ¥54 billion of net difference, the coefficient of interest being statistically significant at 95% confidence level. Once the operation of the high-speed rail line between Kagoshima and Kumamoto started, the impact on personal income tax diminished. This can be observed in the negative net difference as compared with the alternative scenario based on the new non-affected group. This supports the general pattern revealed in the earlier estimations comparing different sets of observations.

Table 12: Difference-in-Difference Estimation Results with Outcome Variable of Personal Income Tax Revenue Using Nearest-Neighbor Matching Based on the Euclidian Distance between Mean Tax Revenues, 1982–1990

Scale of Focus	Affected Group of Prefectures	Construction Period (1991–2003)	Operation Phase 1 (2004–2010)	Operation Phase 2 (2011–2013)
Spillover Effect by Region	Treatment Group 1	27,822.92	–20,139.51	16,721.9
		[2.24]	[–1.8]	[1.42]
	Number of Observations	88	68	52
	Treatment Group 2	31,432.08**	–32,786.25*	51,056.62*
		[3.25]	[–2.32]	[2.42]
	Number of Observations	132	102	78
Spillover Effect by Adjacency	Treatment Group 3	18,821*	–26,698.04**	37,429.24**
		[2]	[–3.03]	[2.88]
	Number of Observations	220	170	130
	Treatment Group 4	15,472.3**	–23,431.25***	31,903.97***
		[2.26]	[–3.39]	[3.07]
	Number of Observations	308	238	182
Spillover Effect by Connectivity	Treatment Group 5	53,576.87**	–50,607.41**	125,253.54**
		[2.29]	[–2.52]	[2.63]
	Number of Observations	330	255	195

Notes: The tax revenue amount is adjusted for Consumer Price Index with 1982 as base year. Pre-high-speed rail line construction period covers the years from 1982 to 1990. Non-affected groups include the rest of the prefectures. Treated groups: Group 1: Kagoshima, Kumamoto; Group 2: Kagoshima, Kumamoto, Fukuoka; Group 3: Kagoshima, Kumamoto, Fukuoka, Oita, Miyazaki; Group 4: Kagoshima, Kumamoto, Fukuoka, Oita, Miyazaki, Saga, Nagasaki; Group 5: Kagoshima, Kumamoto, Fukuoka, Yamaguchi, Hiroshima, Okayama, Hyogo, Osaka. T-values are in parentheses. The t-value measures how many standard errors the coefficient is away from zero.

* p<.1, ** p<.05, *** p<.01

Source: Authors.

However, the connection later of the Kyushu high-speed rail line to the Sanyo high-speed rail line in 2011 resulted in a positive net difference in personal income tax revenue. Thus, in the case of spillover effects by adjacency, net difference constituted ¥32 billion and ¥37 billion for Treatment Group 4 and Treatment Group 3, respectively. In the form of spillover effects by region, the net difference was equal to ¥51 billion and ¥17 billion, though the t-value for the latter was only around 1.42. Finally, regions along the Kyushu high-speed rail line and the Sanyo high-speed rail line appear to have gained about ¥125 billion with a t-value of 2.63 during the operation phase in 2011–2013.

Corporate Income Tax

The dynamics of corporate income tax revenue was similar to that of personal income tax revenue, but with lower levels of magnitude (Table 13).

Table 13: Difference-in-Difference Estimation Results with Outcome Variable of Corporate Income Tax Revenue Using Nearest-Neighbor Matching Based on the Euclidian Distance between Mean Tax Revenues, 1982–1990

Scale of Focus	Affected Group of Prefectures	Construction Period (1991–2003)	Operation Phase 1 (2004–2010)	Operation Phase 2 (2011–2013)
Spillover Effect by Region	Treatment Group 1	12,132.33***	–6,292.71*	6,629.05
		[14.06]	[–2.71]	[2.04]
	Number of Observations	88	68	52
	Treatment Group 2	17,473.79**	–13,261.77	18,730.36**
		[3.56]	[–1.61]	[2.72]
	Number of Observations	132	102	78
Spillover Effect by Adjacency	Treatment Group 3	13,695.24***	–9,138.27	15,128.06**
		[3.37]	[–1.61]	[2.93]
	Number of Observations	220	170	130
	Treatment Group 4	10,902.40***	–6,382.728	15,794.54***
		[3.28]	[–1.54]	[3.84]
	Number of Observations	308	238	182
Spillover Effect by Connectivity	Treatment Group 5	–46,276.71	–46,440.24*	117,806.95**
		[–1.09]	[–1.79]	[2.28]
	Number of Observations	330	255	195

Notes: The tax revenue amount is adjusted for Consumer Price Index with 1982 as base year. Pre-high-speed rail line construction period covers the years from 1982 to 1990. Non-affected groups include rest of the prefectures. Treated groups: Group 1: Kagoshima, Kumamoto; Group 2: Kagoshima, Kumamoto, Fukuoka; Group 3: Kagoshima, Kumamoto, Fukuoka, Oita, Miyazaki; Group 4: Kagoshima, Kumamoto, Fukuoka, Oita, Miyazaki, Saga, Nagasaki; Group 5: Kagoshima, Kumamoto, Fukuoka, Yamaguchi, Hiroshima, Okayama, Hyogo, Osaka. T-values are in parentheses. The t-value measures how many standard errors the coefficient is away from zero.

* p<.1, ** p<.05, *** p<.01

Source: Authors.

The construction period is associated with positive and statistically significant coefficients of difference-in-difference in corporate income tax revenue for almost all scales of focus except for spillover effects by connectivity, which is found to be negative and statistically insignificant both during construction and the subsequent operation phase 1. Similarly, the net difference turned negative for spillover effects by adjacency and region during the operation of the Kyushu high-speed rail line for 2004–2010, before bouncing back after the connection of the Kyushu high-speed rail line to the Sanyo high-speed rail line.

5. CONCLUSION

This study focused on estimating infrastructure impact on regional tax revenue in Japan. We employed the difference-in-difference approach to examine the effect of the Kyushu high-speed rail line on prefectural level tax revenues during the construction period and two periods of subsequent operation.

The estimation results suggest on average that total tax revenues of prefectures affected by the Kyushu high-speed railway line increased during construction and decreased after construction ended while it was operating as an autonomous branch. However, once the rail line was connected to a greater system of rail lines through the linkage with the Sanyo line, the tax revenue bounced back with a positive difference.

In spillover effects, our analysis reveals positive effects of the Kyushu rail line in the region where the rail line was located, and in adjacent prefectures as well as prefectures along the Sanyo high-speed railway line. Estimation results show that the positive change in tax revenue in the actual region of the new Kyushu high-speed rail line was higher than that of adjacent prefectures but lower compared with that of prefectures along the Sanyo high-speed rail line.

Differentiating tax revenue by types, we found that difference-in-difference coefficients for corporate tax revenue were lower than those for personal income tax revenue during construction, but higher during the second phase of operation when the Kyushu high-speed rail line was connected to a greater system of rail lines.

We hope our work highlights the idea that the impact of infrastructure must be examined from a multitude of angles, conditioning on geography, timing, and types of outcome variables. Future analysis of a similar approach focusing on different case studies might help to create a body of literature that helps us understand comprehensively the direction and nature of infrastructure impacts.

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[*] The Asian Development Bank refers to China by the name People's Republic of China.

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