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ORIGINAL ARTICLE

Impact of infrastructure on tax revenue: Case study of high-speed train in Japan

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ABSTRACT

This study analyzes the impact of a high-speed rail line on tax revenues and on the economy of affected regions within the country. The economic impact of infrastructure investment can be induced by changes in tax revenues when the infrastructure is in operation. Accurate regional GDP data are not necessarily available in many Asian countries. However, tax data can be collected. Therefore, this study uses tax revenue dates in order to estimate spillover effects of infrastructure investment. The Kyushu high-speed rail line was constructed in 1991 and was completed in 2003. In 2004, the rail line started operating from Kagoshima to Kumamoto. The entire line was opened in 2011. 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 high-speed railway line with other regions that were not affected by the railway line. Our findings show a positive impact on the region's tax revenue following the connection of the Kyushu rapid train with large cities, such as Osaka and Tokyo. 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 finds statistically significant and economically growing impact on tax revenue after it was completed and connected to other large cities, such as Osaka and Tokyo. 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. Public–private partnership (PPP) has been promoted in many Asian countries. However, PPP-infrastructure in India failed in many cases due to the low rate of return from infrastructure investment. This study shows that an increase of tax revenues is significant in the case of the Kyushu rapid train in Japan. If half of the incremental tax revenues were returned to private investors in infrastructure, the rate of return from infrastructure investment would significantly rise for long period of time. It would attract stable and long-term private investors, such as pension funds and insurance funds into infrastructure investment. The last section of the paper will address how incremental tax revenues created by the spillover effects of infrastructure will improve the performance of private investors in infrastructure investment.

Keywords: *infrastructure; tax; growth; regional economy; government spending*

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, 2017). Better infrastructure contributes to the facilitation of international trade through the 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 the 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, and 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 examine the economic impact of infrastructure investment by using, as an example, the Kyushu rapid railway train. Taking into account the importance of fiscal balance and infrastructure provision, we use tax revenues by prefectures, which are available by prefectural level, to compare the economic effects of the high-speed rail line ("*shinkansen*"). GDP is an aggregate indicator of economic activity but fiscal revenue of government is directly linked to tax revenue. Therefore, we focus on total tax revenues of prefectures as well as their decompositions in the forms of personal income taxes and corporate income taxes. Besides these two components, the total tax revenues also include property tax, sales tax, and others.

The estimates 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 (DID) approach to determine the impact of the railway connection to tax revenues of each affected prefecture. Our findings indicate that railways gain increased tax revenues during construction. However, tax revenues during operation without any connections with large cities decline compared to construction periods. This situation

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changed when the newly-built high-speed railway line was connected to large cities. The positive impact on neighboring prefectures indicates a lesser impact on tax revenue in prefectures that are farther away from the high-speed railway line.

We find that DID 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 DID approach. Section 4 presents the empirical results of the differences in total tax revenue, income tax revenue, and corporate income tax revenue. Section 5 addresses how to increase the rate of return for private investors in infrastructure investment. If half of the incremental tax revenues are returned to the infrastructure investors, there will be an increased rate of return from infrastructure and over a long period of time. It will create big incentive for private investors such as pension funds and insurance funds to invest in infrastructure. Section 6 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 industries, the productivity effect of infrastructure is greater in the tertiary industry. In the 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 estimation of the magnitude and statistical significance of the contribution of infrastructure to economic growth, they did not account for the possibility of structural breaks (Pereira and Andraz, 2013). Putting it differently, a general consensus on the economic effects of infrastructure capital is lacking, 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 DID 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 (2017), using regional data for Uzbekistan, found positive effects 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 increases 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 two 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 (2010), 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 the net effect under question.

At the same time, few studies link infrastructure provision to fiscal performance of the regions. A notable example is that of Yoshino and Pontines (2015). Conditioning on the counties' time-invariant individual effects, time-varying covariates, evolving economic characteristics, and the DID 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 (2017), 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, distinguishing the spillover impacts by region, adjacency, and connectivity.

3. Methodology

This section describes our empirical strategy based on the DID 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 use the empirical strategy with a DID 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 divide 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 and Figures 2–19 provide graphic illustration of estimation results. The crucial difference of our study is in the interrogation of generally accepted assumptions about the division into these groups in the framework.

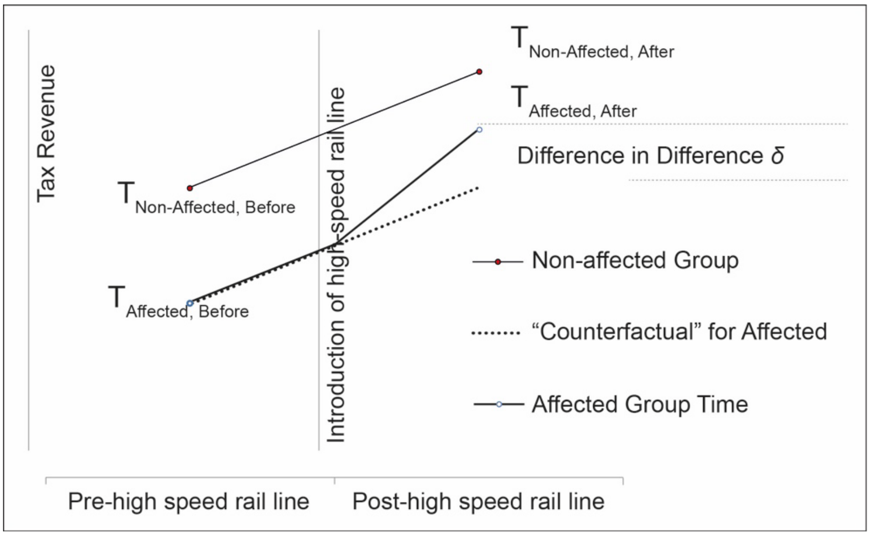


Figure 1. Illustration of the DID Method with the Outcome Variable of Tax Revenue
Source: Authors

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

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 the other of the same regions plus 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, 2017), 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 (2012) and Everaert (2003)—using vector autoregression approach. 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 look at the analysis of spillover effects due to adjacency, which include the above-mentioned three prefectures, and add 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, Glennerster and Kremer, 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 not significant effects of infrastructure provision at the regional level 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 gathered by Pereira and Andraz (2003) using a vector autoregression approach for transport and communication infrastructure, and Pereira and Roca-Sagales (2007) for highways, demonstrates positive spillover effects of infrastructure provision on neighboring regions. Table 1 gives two subsets of the spillover effects analysis.

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

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 allows 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 look 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.

The comparison of time is made based on the following framework. The pre-construction 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	Pre-construction	Construction	Operation phase 1	Operation phase 2
Years	1982–1990	1991–2003	2004–2010	2011–2013

Source: Authors' analysis

The direct calculation of net differences across time and groups of prefectures help 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; 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 the number of taxpayers, accounting for time-invariant region-specific effects and year-specific effects, provide us with the following baseline estimation strategy of the DID specification:

$$\Delta T_{it} = \alpha_i + \phi_t + \beta X_{it} + \delta D_{gt} + \epsilon_{it} \qquad (1)$$

where ΔT is the tax revenue of the prefecture; x denotes time-varying covariates (vector of observed control variables); D is the binary variable indicating whether the observation relates to the affected group after the 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 the number of taxpayers in the prefecture. We include the control variables to account for taxpayers' demographics, which would be inaccurate in the case of choosing just the working-age population from 16 to 64 years old, part of whom may be unemployed or getting education, and not contributing to formation of tax revenues.

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,

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.

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, Duflo and Mullainathan, 2004), we employ heteroscedasticity and autocorrelation consistent (HAC) standard errors, belonging to the class of cluster standard errors. These 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, which are, in our case, prefectures, $i = 1, 2, \ldots, 47$.

3.1 Nearest-neighbor matching procedure

The next step of the analysis consists of the 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 a DID analysis, 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 pre-construction 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 look 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 use 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 empirical 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.

4. Empirical Results Using the Nearest-Neighbor Matching Approach

4.1 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 ¥113 billion and ¥138 billion in increased tax revenue during construction as compared with the counterfactual scenario based on the performance of the non-affected group (Table 4). Treatment Group 1, which includes Kagoshima and Kumamoto prefectures, had a net difference of ¥101 billion in the 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 3. Affected prefectures and their corresponding nearest neighbors by the minimum Euclidian distance between mean value of total tax revenues for the pre-high-speed rail line, 1982–1991 (million Yens)

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

However, the later connection 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.

4.2 Corporate income tax

The dynamics of corporate income tax revenues were similar to those of personal income tax revenue, but with lower levels of magnitude (Table 6).

The construction period is associated with positive and statistically significant DID coefficients in corporate income tax revenues for almost all scales of focus except for spillover effects by connectivity, which is found to be negative and not statistically significant during construction. 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 following the connection of the Kyushu high-speed rail line to the Sanyo high-speed rail line.

Table 4. DID empirical results with outcome variable of total tax revenue using nearest-neighbor matching based on the Euclidian distance between mean tax revenues, 1982–1990 (million Yen)

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]	[9.01]	[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]	[2.71]
	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

Source: Authors

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 and Kumamoto; Group 2: Kagoshima, Kumamoto, and Fukuoka; Group 3: Kagoshima, Kumamoto, Fukuoka, Oita, and Miyazaki; Group 4: Kagoshima, Kumamoto, Fukuoka, Oita, Miyazaki, Saga, and Nagasaki; Group 5: Kagoshima, Kumamoto, Fukuoka, Yamaguchi, Hiroshima, Okayama, Hyogo, and Osaka. T-values are in parentheses. The t-value measures how many standard errors the coefficient is away from zero.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 5. DID empirical 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]	[–1.81]	[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**
		[2.01]	[–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

Source: Authors

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 and Kumamoto; Group 2: Kagoshima, Kumamoto, and Fukuoka; Group 3: Kagoshima, Kumamoto, Fukuoka, Oita, and Miyazaki; Group 4: Kagoshima, Kumamoto, Fukuoka, Oita, Miyazaki, Saga, and Nagasaki; Group 5: Kagoshima, Kumamoto, Fukuoka, Yamaguchi, Hiroshima, Okayama, Hyogo, and Osaka. T-values are in parentheses. The t-value measures how many standard errors the coefficient is away from zero..

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Figure 2. Net additional total tax increase in affected prefectures of Japan as compared to non-railway case scenario (million Yens)

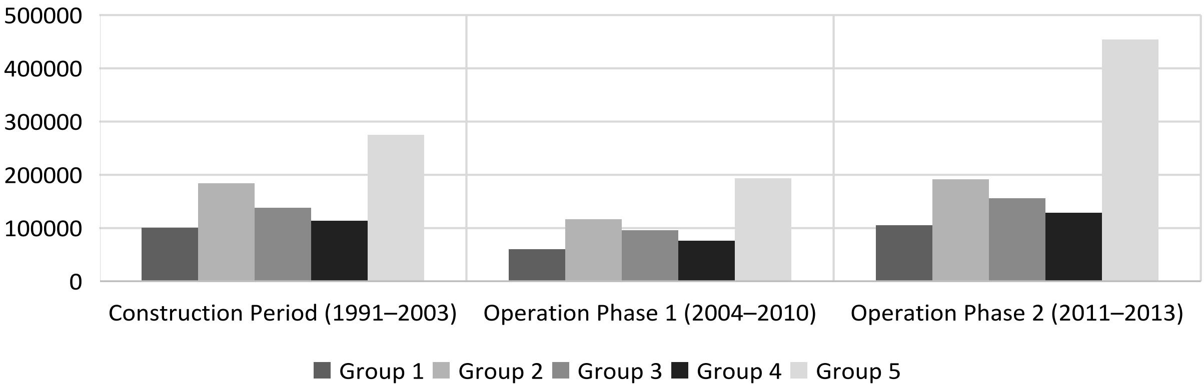


Figure 3

Group 1: Net additional total tax increase in affected prefectures of Japan as compared to non-railway case scenario (million Yens)

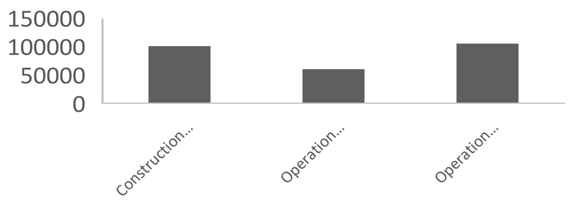


Figure 4

Group 2: Net additional total tax increase in affected prefectures of Japan as compared to non-railway case scenario (million Yens)

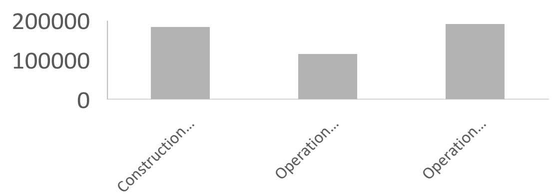


Figure 5

Group 3: Net additional total tax increase in affected prefectures of Japan as compared to non-railway case scenario (million Yens)

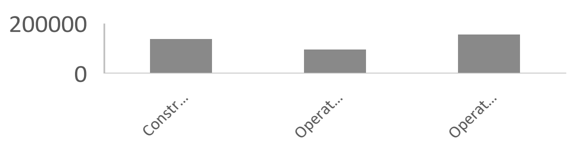


Figure 6

Group 4: Net additional total tax increase in affected prefectures of Japan as compared to non-railway case scenario (million Yens)

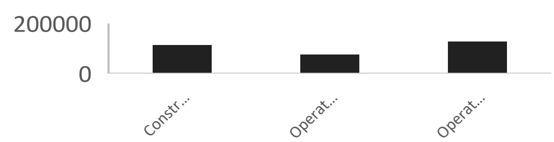
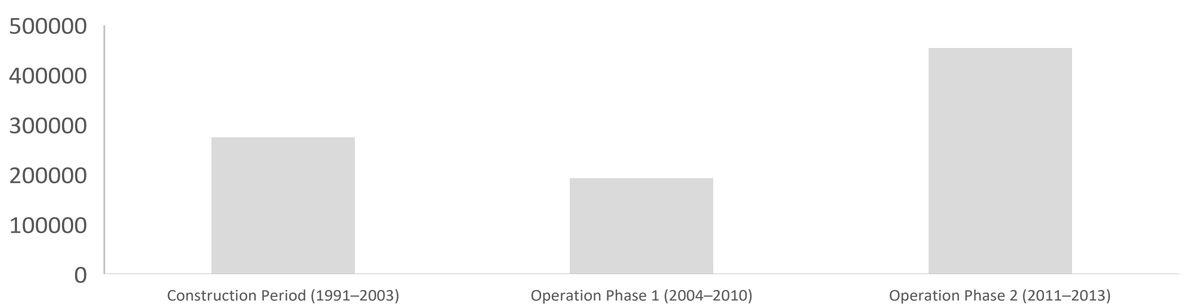


Figure 7

Group 5: Net additional total tax increase in affected prefectures of Japan as compared to non-railway case scenario (million Yens)



Source: Authors

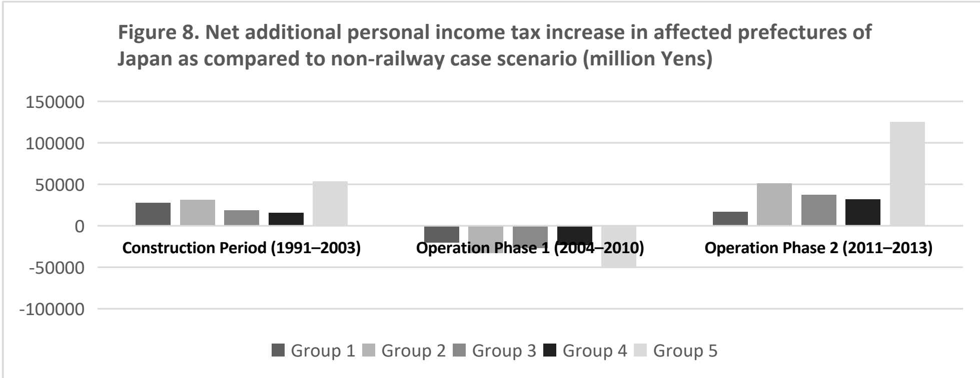


Figure 8. Net additional personal income tax increase in affected prefectures of Japan as compared to non-railway case scenario (million Yens)

Source: Authors

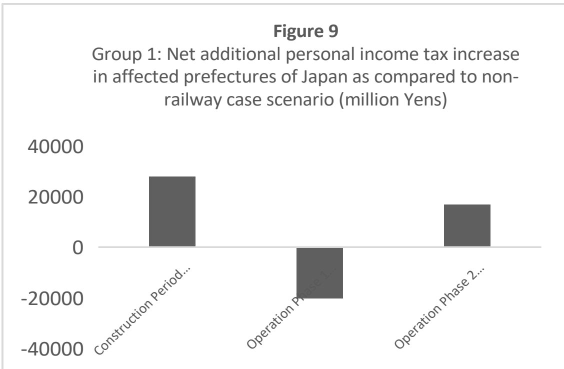


Figure 9
Group 1: Net additional personal income tax increase in affected prefectures of Japan as compared to non-railway case scenario (million Yens)

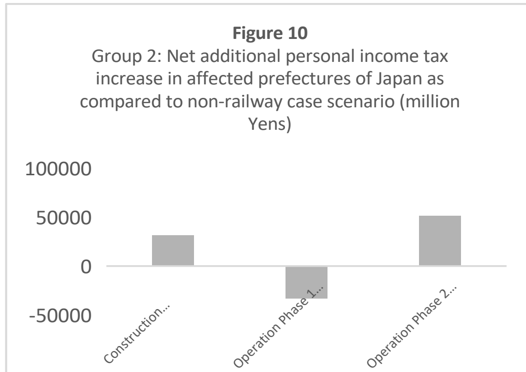


Figure 10
Group 2: Net additional personal income tax increase in affected prefectures of Japan as compared to non-railway case scenario (million Yens)

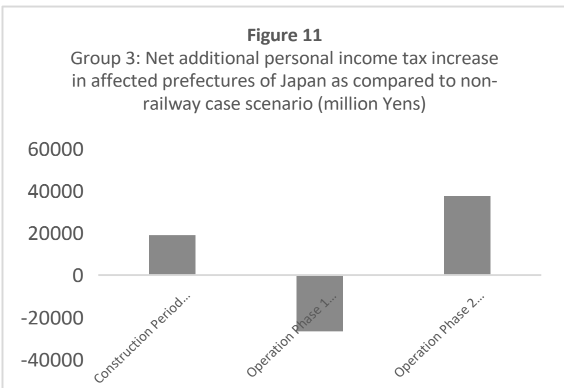


Figure 11
Group 3: Net additional personal income tax increase in affected prefectures of Japan as compared to non-railway case scenario (million Yens)

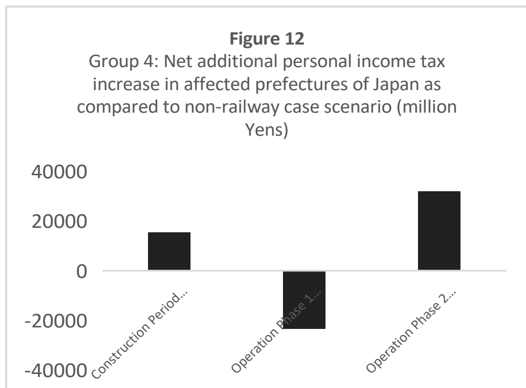


Figure 12
Group 4: Net additional personal income tax increase in affected prefectures of Japan as compared to non-railway case scenario (million Yens)

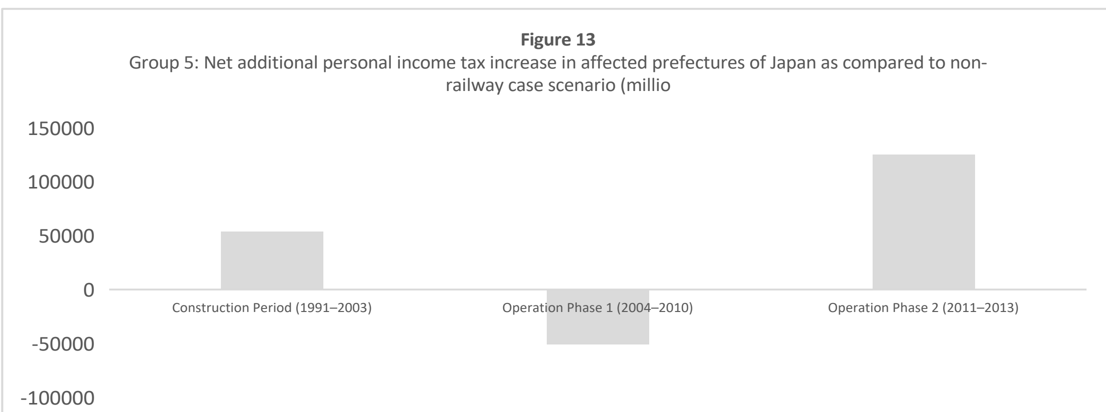
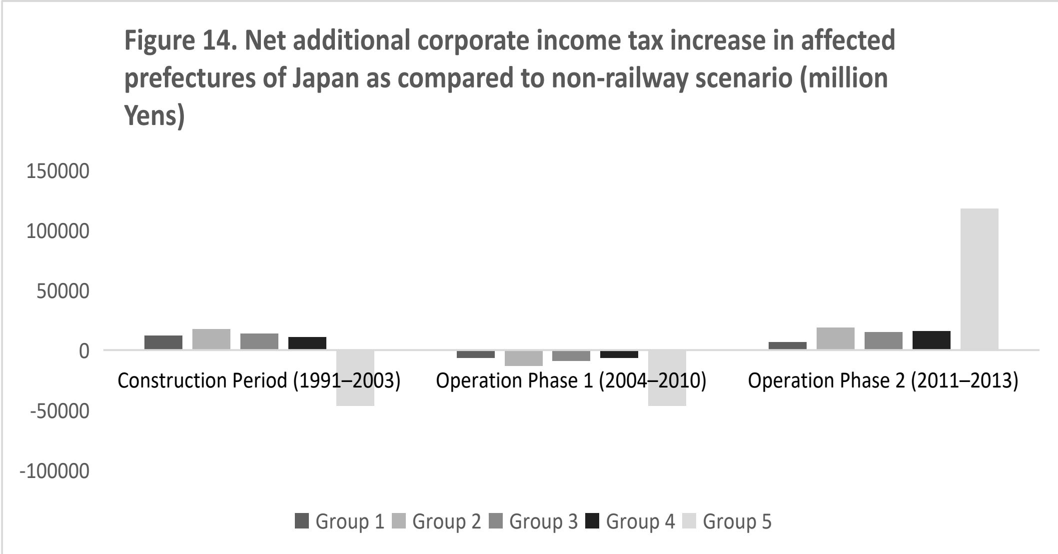


Figure 13
Group 5: Net additional personal income tax increase in affected prefectures of Japan as compared to non-railway case scenario (millio

Source: Authors

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 and Kumamoto; Group 2: Kagoshima, Kumamoto, and Fukuoka; Group 3: Kagoshima, Kumamoto, Fukuoka, Oita, and Miyazaki; Group 4: Kagoshima, Kumamoto, Fukuoka, Oita, Miyazaki, Saga, and Nagasaki; Group 5: Kagoshima, Kumamoto, Fukuoka, Yamaguchi, Hiroshima, Okayama, Hyogo, and Osaka.



Source: Authors

Table 6. DID empirical 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

Source: Authors.

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 and Kumamoto; Group 2: Kagoshima, Kumamoto, and Fukuoka; Group 3: Kagoshima, Kumamoto, Fukuoka, Oita, and Miyazaki; Group 4: Kagoshima, Kumamoto, Fukuoka, Oita, Miyazaki, Saga, and Nagasaki; Group 5: Kagoshima, Kumamoto, Fukuoka, Yamaguchi, Hiroshima, Okayama, Hyogo, and Osaka. T-values are in parentheses. The t-value measures how many standard errors the coefficient is away from zero.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

5. Attracting private investors into infrastructure investment by returning spillover tax revenues

The previous chapters estimated the increase in tax revenues created by infrastructure investment. If part of these tax revenues were returned to private investors in infrastructure, it will increase their rate of return over a long period of time, which will attract many private investors. India, for example, is not so eager to use public–private partnerships (PPP) since many have failed due to lack of returns from infrastructure investment.

Figure 15
Group 1: Net additional corporate income tax increase in affected prefectures of Japan as compared to non-railway scenario (million Yens)

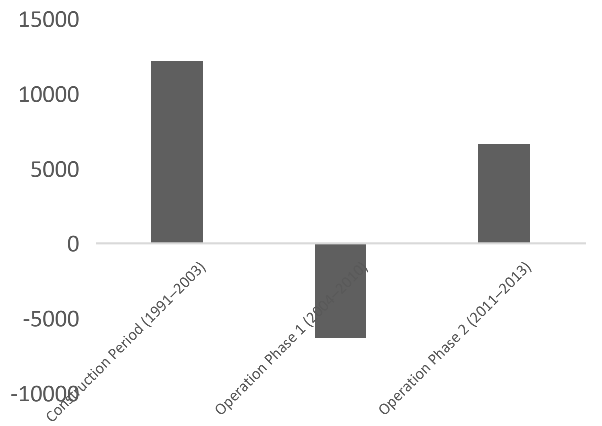


Figure 16
Group 2: Net additional corporate income tax increase in affected prefectures of Japan as compared to non-railway scenario (million Yens)

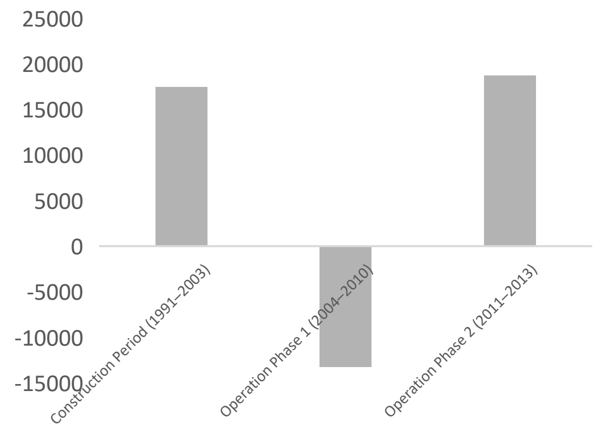


Figure 17
Group 3: Net additional corporate income tax increase in affected prefectures of Japan as compared to non-railway scenario (million Yens)

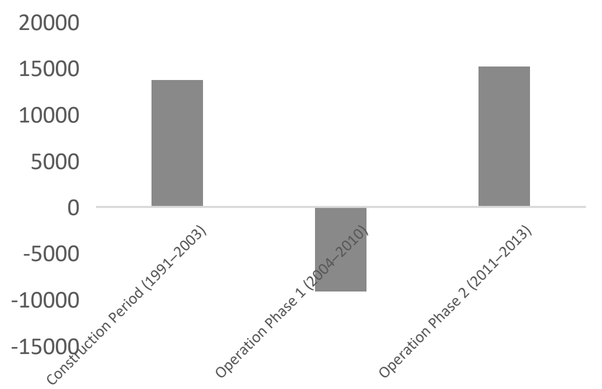


Figure 18
Group 4: Net additional corporate income tax increase in affected prefectures of Japan as compared to non-railway scenario (million Yens)

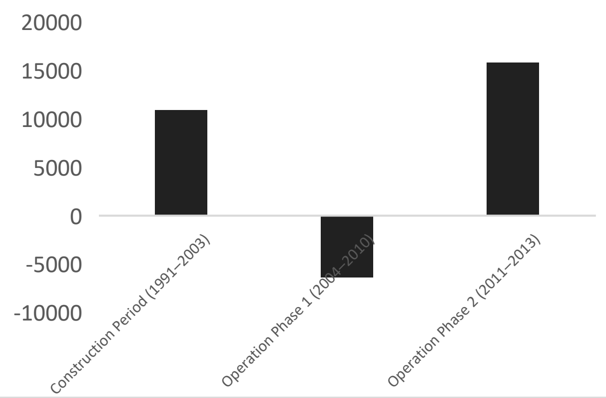


Figure 19
Group 5: Net additional corporate income tax increase in affected prefectures of Japan as compared to non-railway scenario (million Yens)

Source: Authors

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 and Kumamoto; Group 2: Kagoshima, Kumamoto, and Fukuoka; Group 3: Kagoshima, Kumamoto, Fukuoka, Oita, and Miyazaki; Group 4: Kagoshima, Kumamoto, Fukuoka, Oita, Miyazaki, Saga, and Nagasaki; Group 5: Kagoshima, Kumamoto, Fukuoka, Yamaguchi, Hiroshima, Okayama, Hyogo, and Osaka.

It is well known that good infrastructure creates huge spillover effects in the region around a project. Railways will bring manufacturing factories into the region by making the shipping of products faster and safer. Railways can connect manufacturers to markets and to ports. New industry creates jobs in the region. Eventually, service sector businesses, such as restaurants and hotels will be constructed to meet the increased demand in the region. Farmers and small businesses can sell their products at the train stations. A study by Yoshino and Abidhadjaev (2016) shows that good educational opportunities together with infrastructure investment create qualified workers who enhance regional productivity.

The spillover effects of infrastructure investment will increase revenues from corporate, income, and property taxes. In the past, all these tax revenues were collected by the government and not returned to the investors in infrastructure. The difference-in-difference method (Yoshino and Abidhadjaev, 2017; Yoshino and Pontines, 2015 can be used to compute the effect of spillovers on tax revenues in places where infrastructure investment occurred compared to ones where no infrastructure investment took place.

In recent years, PPPs, including the use of private funds, are being emphasized. Utilizing private funds to develop infrastructure has the advantage of increasing pressure to: (1) shorten the period of construction and complete the project as quickly as possible, (2) complete the project at minimal construction cost, and (3) operate the project profitably at low cost after completion. Despite these advantages, there have not been many PPP projects in Japan.

Infrastructure projects pose a variety of risks arising from: (1) regime change, for example, when a change in local administration causes stoppages before project completion; (2) cost increases, for example, when extensions in construction period or delays in land acquisition create additional interest expense; (3) unexpected decreases in revenue due to fee setting and decreased traffic; (4) unanticipated expenses, for example, when compensation is required for noise occurring after the completion of an infrastructure project; and (5) delays in land acquisition due to complicated ownership structure.

Private investors apply various ideas in order to avoid possible risks and earn benefits. Some investors, however, may force the transfer of risks onto the public sector. In these cases, it will be essential to clarify the risk-sharing between public and private sectors in advance. In particular, Viability Gap Funding (VGF), which is a certain rate of return in the form of a capital grant that the public sector guarantees private investors, would be appropriate for infrastructure projects that are indispensable for the public, but are high-risk and low-earning. Even in projects in which private funds are not involved because of low expected revenue, it will be possible to introduce private funds. However, in this case, if the ratio of the injection by the public sector is too high, it creates a moral hazard problem. The public sector secures a rate of return for private investors which exceeds the revenues from the infrastructure project, which leads to the accumulation of debt by the public sector. On the other hand, when this ratio is too low, there is a possibility that the private sector would not invest in the project at all.

However, it does not follow that the injection of VGF can improve the efficiency of the infrastructure project. For projects whose only return comes from user charges (Figure 20), the gap between the government guaranteed return and the actual return could be very wide. Private investors can secure a high rate of return, but the government sector will accumulate debt every year over the life of the project.

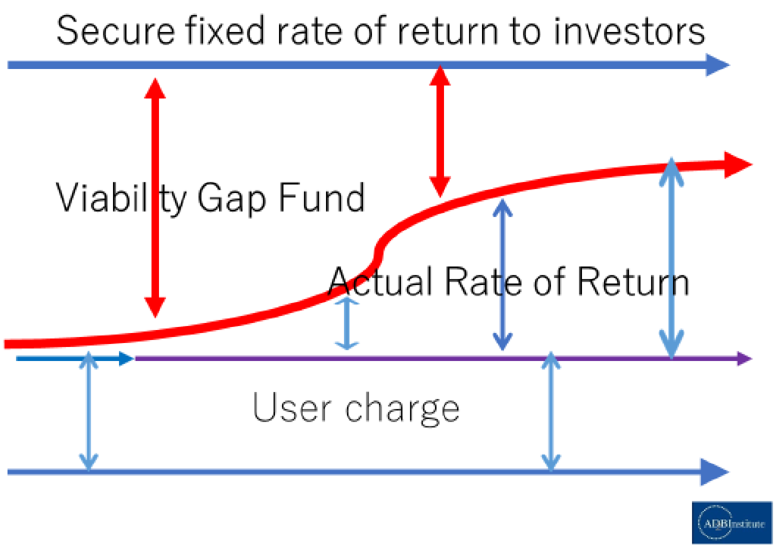


Figure 20. Viability Gap Funding
Source: Authors

Infrastructure projects generate benefits in addition to operating revenues, such as tolls. While construction companies may be mainly interested in making railways and highways, this study shows that the spillover effects from the development of such infrastructure are also very significant for the local economy. Infrastructure development can stimulate business activity in an area and create employment. Additionally, small and middle-sized enterprises (SMEs) in the area can open stores along new roadways and at new railway stations, increasing sales. If it is possible to confirm that the increase in tax revenue is due to the spillover effects of infrastructure, it might be possible to return the increase in tax revenue to private investors and the public sector (Figure 21). By doing so, the rate of return to private investors is increased and, as a result, it will become possible to attract private funds to various infrastructure projects.

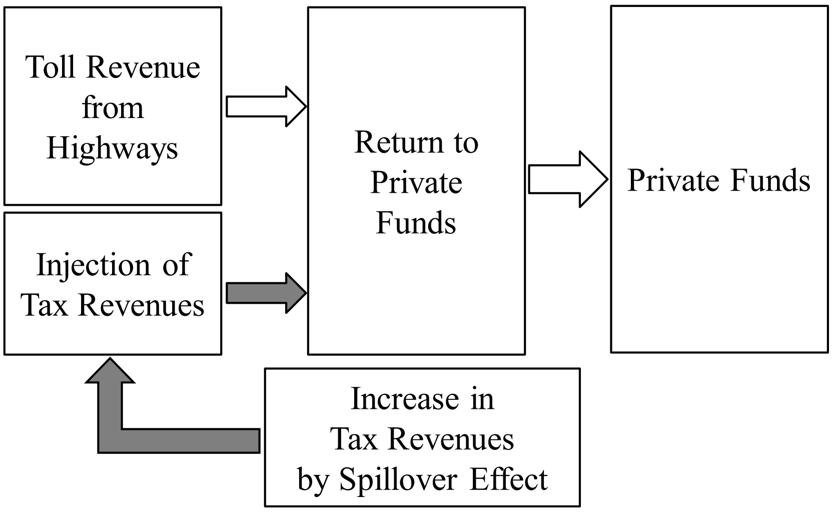
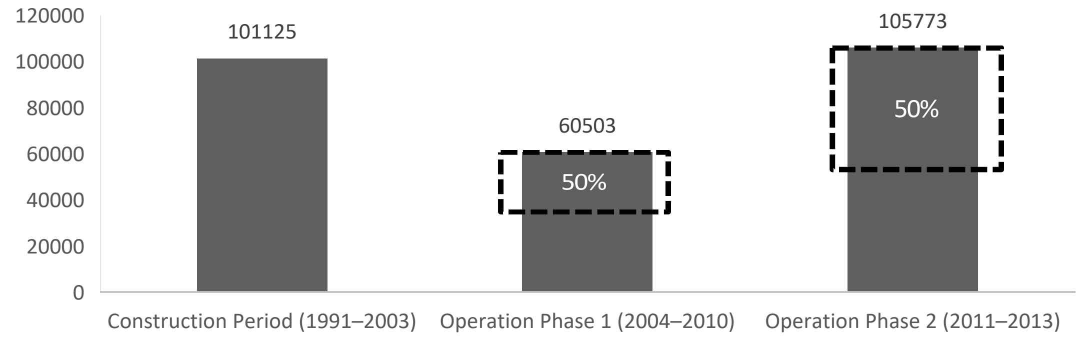


Figure 21. Injection of a fraction of tax revenues gained from spillover effects
Source: Nakahigashi and Yoshino (2016)

In order to enhance efficiency and increase the rate of return on infrastructure development, it is necessary to vary the dividend payment for private investors based on the project's revenues, including both user fees and spillover tax revenues. For example, 50% of additional tax revenues can be returned to private investors based on infrastructure's impact (Figure 22). It is also necessary for infrastructure-operating entities to make efforts to increase income.

Figure 22. Group 1: Net additional total tax increase in affected prefectures of Japan as compared to non-railway case scenario (million Yens)



Source: Authors

Table 7 shows the payoff matrix depending on the presence or absence of efforts by investors and the infrastructure-operating entity. If neither the operating entity nor investors make any effort, the operator gains 50 in revenue and investors receive dividend income r. It is assumed that the operator could increase operating income to 100 by improving the salary system, such as by paying staff bonuses based on the entity's revenue. Furthermore, investors could raise their dividend income to αr ($\alpha > 1$) as a result of efforts to reduce costs and increase infrastructure revenues, such as by increasing the number of highway turnoffs or the number of available cars. The lower right cell of the payoff table represents the revenue when both the operating entity and infrastructure investors make maximum effort to increase revenue and improve service. In this case, income of both the entity and the investors is higher than in the normal case. (The income of the entity increases from 50 to 100 and the income of investors from r to αr.) This illustrates the importance of designing the dividend policy for investors and the salary system of the infrastructure-operating entity to incentivize the entity and investors to improve revenues. To reiterate, in PPPs, as described above, it is necessary to improve the efficiency of infrastructure projects through private funds and to introduce mechanisms to benefit the staff of an infrastructure-operating entity, for example by paying staff bonuses tied to the increase in profit.

Table 7. Payoff table for infrastructure operating entity and investors

	Normal Case	Effort Case
Normal Case	(50 , r) Operating Entity Investors	(50 , αr) Operating Entity Investors
Effort Case	(100 , r) Operating Entity Investors	(100 , αr) Operating Entity Investors

Source: Nakahigashi and Yoshino (2016)

6. Conclusion

This study focuses on estimating infrastructure impact on regional tax revenue in Japan. We employed the DID 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 empirical results suggest that, on average, 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. Empirical 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 type, we found that DID 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. This might suggest that the railway affected the marginal productivity of labor in the short run, and those of capital in the long run, which provide important implications for planning and evaluation policies.

Our work highlights the idea that the impact of infrastructure must be examined from different angles, and conditional on geography, timing, and types of outcome variables. Based on these inferences, infrastructure financing can be modified to take into account all externalities and variations of the impact of infrastructure over time.

Infrastructure investments are being promoted not only in Asia but also in the United States under President Trump. However, the U.S. government does not want to increase government debt. Private funds have to be injected to cover huge needs for infrastructure investment. Bringing increased tax revenues from the spillover effects of infrastructure development, such as increased revenues from corporate, income, sales, and property taxes, will raise the rate of return above what can be gained from user charges alone. Long-term investors, such as pension funds and insurance companies, are growing in Asian countries. Infrastructure investment projects require long-term and patient investors. If the rate of return on infrastructure is increased by injecting spillover tax revenues generated in areas surrounding infrastructure investments, much more long-term private capital could be forthcoming for infrastructure investment. Incentives to improve infrastructure, which will increase regional economic activity, will be created. Greater spillover effects will raise the rate of return for private investors. The higher the expected rate of return, the more private funds would be attracted.

Furthermore, fewer public sector funds would be needed for infrastructure investment which means the government could increase the total amount of infrastructure investment by attracting private finance when incremental tax revenues from spillover effects are used to raise their rate of return.

The method of paying back increased tax revenues obtained from infrastructure investment will attract private long-term investors and require less government funds. Additionally, it will enhance the efficiency and the governance of infrastructure investment.

Future analysis of a similar approach focusing on different case studies will help to create a body of literature that enables us to understand comprehensively the direction and nature of infrastructure impacts.

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