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Article

Enhancing private infrastructure financing through capturing spillover effect: Conceptual development and an empirical case study of Vietnam's expressways

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Abstract: While infrastructure provides necessary public services and is vital for the socio-economic development of a nation, public funds alone cannot finance all infrastructure needs in society, especially after the COVID-19 pandemic, where many countries are facing budget deficits. Although private financing schemes, such as public-private partnerships (PPPs) and land value capture, have been considered intensively, they have yet to produce adequate private capital flows to infrastructure projects due to a lack of incentives for private investors. Against the background, this paper proposes a new financing mechanism in which governments might divert some of the increased tax revenue from the spillover effects of newly constructed infrastructures to fund the private sector through grants or subsidies. The empirical work in Vietnam shows a significant increase in tax revenues after completing two expressways, supporting our idea about spillover effects, which includes small- and medium-sized enterprise (SME) development. This study's results suggest that spillover effects can bring new opportunities for governments and multilateral development banks (MDBs) to implement infrastructure projects with greater private sector involvement in the region. It also proposes some financial schemes, such as land capture and financing for business startups, including SMEs, to enhance the spillover effects of infrastructure.

Keywords: infrastructure; private financing; spillover effect; Vietnam
JEL Classification: C82; E22; G32; R00

1. Introduction

Due to the impacts of the COVID-19 pandemic, many countries face growing deficits that bring many challenges to financing government functions, especially infrastructure development (United Nations, 2022). The challenges are even more apparent for developing countries where public funds are limited while infrastructure investment is essential to economic development. In that sense, attracting more private financial resources is a sound policy for these countries. However, many private funding schemes, such as public-private partnerships (PPP), fail in Asia and the Pacific because of low rates of return since increasing tariffs for necessities such as transport, power, water supply and telecommunication is quite tricky (ESCAP, 2019). Low tariffs typically cover only part of all infrastructure construction and operational costs. This raises the question for the governments of how to maintain low user fees while increasing the rates of return to attract more private investments to the infrastructure development projects[1].

This paper proposes that governments maintain low user charges but achieve higher returns to private investors by utilizing spillover tax revenues. Infrastructure such as expressways, roads, water supplies and electricity can generate economic activities and employment that increase tax revenues, which is the infrastructure's spillover effect. Traditionally, all spillover tax revenues go to central and local governments without being diverted to private investors. This paper proposes that part of the tax revenues can be distributed to private investors, including small- and medium-sized enterprises (SMEs) to increase the rates of return as an incentive to encourage more investment in infrastructure development. We offer a conceptual framework for the spillover effects of infrastructure development projects and study the empirical estimation of Vietnam's expressways to income tax and total tax revenues[2].

Challenges in infrastructure investment

Infrastructure development typically requires funds for construction and operation. Capital flows to infrastructure are needed but often face substantial gaps, mainly due to the lack of public funds. In this sense, private capital must be mobilized to fill the gap through developing profitable business models and governance schemes (Indah et al., 2023).

A crucial issue in securing private financing for infrastructure development is to provide stable future revenues or cash flows to privately operated infrastructure projects, for example, through user charges and public subsidies. However, governments face difficulties engaging with private capital for infrastructure development (Leigland, 2018). The private sector often recognizes that infrastructure investment is risky and expensive and difficult to bear (Phalatse, 2022). As shown in **Table 1**, various risks are associated with infrastructure investment, some of which the private sector cannot control alone or fully. Private investors face political and regulatory risks, supply-side risks and demand-side risks. Foreign investors may also face cross-border risks, such as fluctuations in the exchange rate and different business practices. Recently, environmental issues have become additional risks associated with infrastructure.

Table 1. Risks associated with infrastructure investment.

Type of risks	Description
Political and regulatory risks	Heavily regulated with political interventions; unstable and short-time regulations; consumers versus shareholders; price regulations; inconsistent incentives; unfavourable business environment.
Supply-side risks	Cost overruns for constructions and operations; availability and cost of technologies and inputs; difficulty in deciding the timing of investment; lower or higher cost of present and future capital; missing opportunities; change of economic conditions; significant lumpy investments for economies of scale.
User-side risks	Negative- or over-demand; high fluctuations; difficulty in forecasting and pricing; brownfield versus greenfield; loss of customers to competitors or other substitutional services; complex cashflow management.

Table 1. (*Continued*).

Type of risks	Description
Cross-border risks	Exchange rate fluctuations; different legal and regulatory regimes; different national cultures and social norms; difficulty in financial transactions; international trade and logistics costs.
Environmental risks	High costs; disasters; lack of technologies; reputations; community relationships.

Source: The authors.
Note: This table excludes *force majeure* risks such as wars and acts of God.

Those risks are typically attributed to the unique characteristics of infrastructure investment: namely (i) long-term process; (ii) asset-intensiveness; (iii) large capital requirement; (iv) technology requirement; (v) heavy regulation; (vi) illiquidity and irreversibility; and (vii) tricky revenue forecast (Grimsey and Lewis, 2002; Guthrie, 2005). Development and operation of infrastructure are typically characterized by long construction times and long lives for asset-intensive and technology-driven facilities. Authorities heavily regulate infrastructure development to provide public services fairly and reasonably without harming society and the environment. Due to various risks associated with infrastructure investment, total costs of infrastructure construction and operation tend to become high, which may exceed the revenue from infrastructure operations, such as user charges (ESCAP, 2018; Quiggin and Wang, 2019). The private sector is typically willing to take risks for future profits but will try to avoid or minimize such risks as much as possible (Phalatse, 2022). This corporate behaviour usually hampers private financing in infrastructure projects that cannot provide an adequate rate of return or at least an optimistic projection for the future.

Governments procure the private sector's services like public works to construct, operate and maintain infrastructure to provide public services to society (Akintoye and Kumaraswamy, 2016). Public procurement can be done through various modalities such as construction contracts, management contracts, maintenance services contracts and leasing. Grants and subsidies are the financial incentives of the public sector to encourage the private sector's participation in infrastructure projects through a capital transfer (te Velde and Warner, 2007)[3]. Governments and other public-sector donors provide direct grants to private-sector beneficiaries, often in a capital transfer or fund. Subsidies can also be provided upfront and channelled directly to the private sector (e.g., lower import duties and interest rates) or indirectly by altering investors' perception of risk (e.g., state guarantee, land concession and preferred access to public services). User charges, e.g., fares, tariffs and tolls, are the extent to which users pay in proportion to their use and the costs they impose on public services provided by infrastructure based on the user-pay-and-benefit principle (Cao and Zhao, 2011). One advantage of user charges is that only exclusive users carry a financial burden by paying for public services' benefits while enhancing fairness and acceptance of public services. However, user charges such as subway fees, highway tolls and water and electricity tariffs in developing countries must be reasonable so that they cannot often cover the entire infrastructure investment costs. The rate of return that private investors can expect is often too low to cover various infrastructure development costs such as construction, operation and maintenance. In addition, collecting user charges is a

difficult task for the private sector without support from the government (Cao and Zhao, 2011).

Capturing land for financing infrastructure projects has gained popularity[4]. Highways, railways and water supply create new business opportunities where private investors procure additional lands before constructing the infrastructure. New businesses can be established along with the infrastructures, such as opening apartments, restaurants, retail stores and other commercial facilities. Foreseeable increases in land value with present and future infrastructure development can also finance the current infrastructure projects and facilitate private financing with upfront capital investment. For these reasons, public authorities might favour private infrastructure investors and award them concessions to develop associated businesses around the infrastructure. However, the governments must carefully develop a proper governance structure to offer private investors and operators this opportunity to avoid public accusations of unfair preferential treatment or favouritism due to the lack of transparency and accountability. It may also make land markets volatile, such as a land asset bubble (Peterson, 2009).

One popular solution to deal with risks associated with private infrastructure investment is PPPs, such as build-operate-transfer (BOT) schemes and design-build-operate (DBO) arrangements (ESCAP, 2019). A PPP is an agreement where a public sector body enters into a long-term contractual agreement with a private sector entity to develop and operate public infrastructure (Grimsey and Lewis, 2002). To propagate PPPs, a concrete legal and regulatory architecture is required to guide the public sector, streamline project preparation and implementation and provide the necessary certainty to private investors (ESCAP, 2019). A PPP requires stable revenue streams to develop and operate infrastructures long-term. Those revenues can be divided into: (i) direct revenues, such as public procurement, public grants and subsidies, user charges and financial aid; and (ii) indirect revenues, such as land capture and revenues from the associated businesses. PPPs are not often privately profitable due to: (i) ineffective pricing policies; (ii) inadequate public investment; (iii) inefficient spending; and (iv) lack of technical and managerial innovation. Poor government regulations and a lack of assistance often cause those issues (Henckel and McKibbin, 2017).

Although governments and multilateral development banks (MDBs) have promoted PPPs, the scheme has not been used as expected, particularly in developing countries (Hodge and Greve, 2018; Leigland, 2018). **Figure 1** presents the pre-COVID-19 trends of PPPs in Asia and the Pacific in the past two decades. While private financing through PPPs continuously increased until the five years from 2008 to 2012, it declined from 2013 to 2017. Looking into each subregion, the growth of PPPs has not been consistent, either. While PPPs have been promoted to enhance private investors' involvement in infrastructure development, it has been commonly recognized that additional financing options are necessary to facilitate private financing for infrastructure projects (ESCAP, 2019).

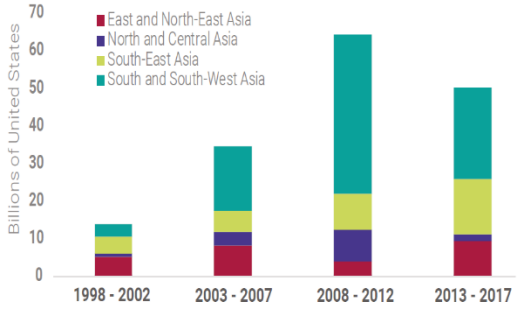

Figure 1. Public-private partnerships in Asia and the Pacific, 1998–2017.
Source: ESCAP (2019).

2. Spillover effects: Theoretical review

If the private investors foresee that the rate of return is significant and reasonably confident, even risky infrastructure assets can be turned into safer investments. One option for enhancing private financing in infrastructure is to capture the positive spillover effects of newly developed infrastructure. Increasing the rate of return for all kinds of infrastructure investment through the partial redemption of spillover tax revenues can encourage private investors, such as more risk-averse pension and insurance funds, to invest in infrastructure projects more. For example, increased tax revenue from newly created businesses, employment and residential areas around constructed roads and railways could be partially shared with private investors, e.g., through grants or subsidies, to encourage private financing for the infrastructure projects.

Spillover effects, also known as externality effects, network effects and indirect effects, are defined as the infrastructure generates socio-economic benefits or drawbacks that accrue outside its target areas and beyond its direct services through establishing the network of physical assets, functions and stakeholders (Cantos, Gumbau-Albert and Maudos, 2005; Hulten, Bennathan and Srinivasan, 2006; Hurlin, 2006; Nakahigashi and Yoshino, 2016). Spillover effects are observed in the infrastructure's external environment and gradually spread through people, entities and services to a broader area.[5] Spillover effects can also be seen as an extension of "land value capture" that is done by the public sector through taxation and sales of assets such as land and property taxes, transport and parking levies, betterment levies[6] and sales of surplus publicly held land or rights of development and use (Chapman, 2017; McIntosh, et al., 2017).[7] Spillover effects created by infrastructure go much further than increases in land value, while the infrastructure raises tax revenues.

Figure 2 illustrates the spillover effects of infrastructure investment. Suppose the centre line is a highway or a new highway to be constructed. Infrastructure construction and operation hire people and use materials. Employment will rise in infrastructure operations such as toll collection, highway maintenance and administration (Pereira, Pereira and Rodrigues, 2021). Then, industries and companies may emerge along the highway corridor, initiating new commercial or manufacturing activities, such as restaurants, retailers, hotels and office buildings, where startups, entrepreneurs and SMEs play a significant role. Houses and apartments can also be built along the highway, and other public and commercial services can start their

businesses. Farmers sell their products to businesses and households along the new expressways and connecting ordinal roads.

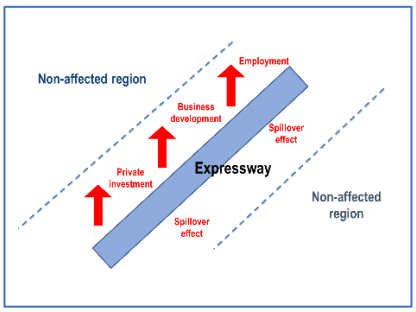

Figure 2. The spillover effect of a highway.

Source: The authors.

This geo-economic development is expected to increase the area's tax revenues through various taxes such as land and property, income, corporate and sales taxes. However, all these incremental tax revenues generated by the newly developed infrastructure went to the local and central governments in the past. They were not directly beneficial to private infrastructure investors and operators. Those players typically rely only on upfront public grants and subsidies for infrastructure construction and user charges for their sources of return on investment.

In macro estimation, Yoshino and Nakahigashi (2004) and Nakahigashi and Yoshino (2016) use a trans-log production function in Japan to estimate the direct effect of infrastructure investment and spillover effects, i.e., indirect effects. The direct effect is created by constructing infrastructure that will increase the output and productivity of the target area through establishing its functions and providing public services. Spillover effects have two channels. One is that public services, such as water supply and electricity, prompt the construction of new office buildings and new housing, increasing the efficient use of land. New roads also invite businesses and manufacturers along the roads. The second channel is to increase employment in the target area by attracting businesses and residents. New companies will create jobs on the site, contributing to consumption and housing development. Consequently, GDP in the area will increase further.

Whether or not infrastructure investment is effective for production activities is verified by estimating the productivity effect of infrastructure. Estimates are made in the following manner using a production function.

$$Y = F(K_P, L, K_G) \tag{1}$$

where K_p is private capital, L stands for labour and K_G is stock of infrastructure investment. The general type of production function is a translog production function.

$$\ln Y = \alpha_0 + \alpha_1 \ln K_P + \alpha_2 \ln E + \alpha_3 \ln K_G + \beta_1 \frac{1}{2}(\ln K_P)^2 + \beta_2 \ln K_P \ln L + \beta_3 \ln K_P \ln K_G + \beta_4 \frac{1}{2}(\ln L)^2 + \beta_5 \ln L \ln K_G + \beta_6 \frac{1}{2}(\ln K_G)^2 \tag{2}$$

In Equation (3), the first term on the right comes under the direct effect, where an increase in marginal productivity is due to new infrastructure investment. The second term is the spillover effect regarding the private capital, and the third represents

the spillover effect related to the labour input. The productivity effect of infrastructure is expressed in marginal productivity.

$$\frac{dY}{dK_G} = \frac{\partial F(K_P, L, K_G)}{\partial K_G} + \frac{\partial F(K_P, L, K_G)}{\partial K_P}\frac{\partial K_P}{\partial K_G} + \frac{\partial F(K_P, L, K_G)}{\partial L}\frac{\partial L}{\partial K_G} \quad (3)$$

Direct effects: $\frac{\partial F(K_P,L,K_G)}{\partial K_G}$, Spillover (or indirect) effects: $\frac{\partial F(K_P,L,K_G)}{\partial K_P}\frac{\partial K_P}{\partial K_G} + \frac{\partial F(K_P,L,K_G)}{\partial L}\frac{\partial L}{\partial K_G}$.

Incremental tax revenues from spillover effects can be written in Equation (4) as follows:

$$dT_{spill} = t \times dY_{spill} = t \times \left(\frac{\partial F(K_P,L,K_G)}{\partial K_P}\frac{\partial K_P}{\partial K_G} + \frac{\partial F(K_P,L,K_G)}{\partial L}\frac{\partial L}{\partial K_G}\right) \times dK_G \quad (4)$$

There are two options in the spillover tax revenues. The first part comes from the contribution of private capital, and the increase in employment creates the second part.

Incremental tax revenues from the direct effect of infrastructure are written in Equation (5) as:

$$dT_{direct} = t \times dY_{direct} = t \times \left(\frac{\partial F(K_P,L,K_G)}{\partial K_G}\right) \times dK_G \quad (5)$$

The total tax increase created by infrastructure is the summation of Equations (4) and (5).

$$dT_{total} = dT_{spill} + dT_{direct} = (4) + (5).$$

The spillover tax revenues are part of the area's increase in total tax revenues, shown in Equation (4). dT_{spill} in Equation (4) is created by private capital and employment, supporting infrastructure investors and construction companies through additional public subsidies. dT_{direct} is the incremental tax revenues generated by the government and the private sector through infrastructure investment.

An empirical economic model estimation using the trans-log production function reports that direct spillover effects are about one-third, and indirect effects are about two-thirds of the total effects (Yoshino, Hesary and Nakahigashi, 2019). Following this finding, the government could retain about 33% of incremental tax revenues while the remaining 67% could be allocated to private infrastructure investors and operators. Theoretically, an econometric analysis should be conducted for each infrastructure project although the public and private sectors can split spillover tax revenues evenly, or 50-50. This will make the allocation process simpler from a policy standpoint of view.

Spillover tax effects can allow private investors and operators to earn additional revenues, enhancing the rates of return gained from infrastructure investments and making infrastructure operations sustainable for the long term. This scenario can solve a classic externality problem in which the benefits of one activity do not accrue to the party that creates them, in this case, the private infrastructure investors and operators (Dahlman, 1979). The solution is to find a way to internalize the externality by capturing incremental tax revenues generated through spillover effects that further support private financing for infrastructure projects (Yoshino, Lakhia and Yap, 2021).

Traditionally in the Asia-Pacific region, private investors for infrastructure rely mainly on user charges such as railway fees, highway tolls and water tariffs, and public grants and subsidies. The governments typically regulate the user charges for accessing infrastructure to keep them as low as possible since public services, such as

water and electricity supplies, are often indispensable for meeting the basic needs of society. In the region's developing countries, the governments typically control infrastructure operators to charge users the fees and tariffs of public services less than the total infrastructure costs (Regan, 2017). Although they could still provide subsidies to compensate for the low return on the private sector's investment in infrastructure, for instance, under a PPP project for constructing and maintaining water supplies,[8] government funds for such subsidies are very limited in the region (ESCAP, 2019). The governments' options to implement incentive regulations such as price and revenue caps are also not feasible in many developing countries due to weak institutional capacities in both public and private sectors.

Spillover tax revenues could link with infrastructure projects by providing additional income, such as subsidies to infrastructure operators. This scheme captures property tax revenues and considers accessing part of other tax revenues such as corporate taxes, income taxes and sales taxes. Those tax revenues are expected to increase through the spillover effects of newly developed infrastructure. It also suggests that the fractions of incremental tax revenues through spillover effects link the level of public subsidiaries to the infrastructure investors and operators (Sundaram and Chowdhury, 2019a). Once the expected rate of return was increased, private investors would be more willing to invest in construction and other upfront infrastructure costs since they do not have to worry about cost recovery as long as the infrastructure creates spillover effects. In the United States, property tax revenues have been used to increase the rates of return to infrastructure investors (Chapman, 2017). This scheme could prevent shortages of essential public services such as fresh water and electricity supplies, which require reasonable tariffs on society. For instance, a water supply agency, which can capture user charges and part of spillover tax revenues through subsidies, earns sufficient income for its operations and maintenance.

To maximize the positive impact of infrastructure development and enhance associated spillover tax revenues, the government must collaborate with entrepreneurs and SMEs to increase the number of startup businesses around the newly developed infrastructure. In a nation's business community, more than 95% of enterprises are typically SMEs that face challenges in accessing adequate funds and resources compared with large enterprises (Abe, et al., 2012). Entrepreneurs and SME owners are willing to invest in emerging opportunities created by infrastructure in a new area, starting new businesses, such as hotels, restaurants, retail stores and others. Those new establishments will provide necessary commercial services to households and other businesses around the infrastructure. At the same time, new businesses will create jobs while mitigating income inequality. However, those entrepreneurs and SME owners often find it challenging to raise capital for new businesses and enhance their institutional capacities. Within this context, the government must create an enabling environment for small businesses by providing grants, subsidies, exemptions, incentives and training (Abe, Troilo and Batsaikhan, 2015).

Figure 3 illustrates the relationships between user charges, increased tax revenues generated by infrastructure investment and the rates of return on the investment. The green line at the bottom represents the inflows of user charges, and the blue-dotted line indicates increased tax revenue made by spillover effects. The red line is the total rate of return on the infrastructure investment as the summation of user

charges and incremental tax revenues. Regional GDP will increase tax revenues, as shown by the blue-dotted line. Supposing these incremental tax revenues are used for public subsidies to the infrastructure investors or operators, part of the blue-dotted line becomes the total revenue. The rate of return rises from the user charges (green line) to somewhere near the blue dotted line. Suppose these spillover tax revenues, created by the new infrastructure, were fully linked with public subsidies to the infrastructure investors. In that case, the actual rate of return on investment rises significantly to the red line. This development can encourage private investors to participate more in infrastructure investment.

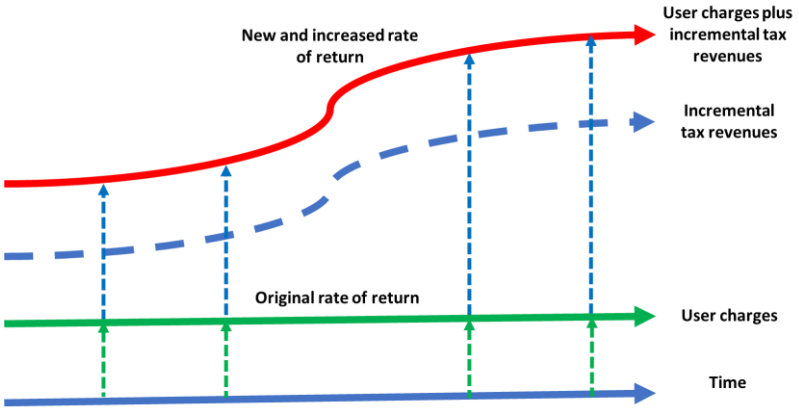

Figure 3. User charges, spillover tax revenues and rate of return.
Source: The authors.

However, policymakers must design and implement a proper mechanism tolink incremental tax revenues to subsidies effectively. Taxpayers could ultimately accuse the governments if such a mechanism were not implemented fairly and transparently. In particular, the incremental tax revenues' injection rate must be carefully determined through a process agreed upon by multi-stakeholders. While the government's fiscal spending is strictly regulated, taxpayers may see such tax-linked subsidies to specific infrastructure operators as an irregular deviation. The governments also face difficulty quantifying the impact of infrastructure on tax revenues, which is influenced by many factors, such as natural and human resources, market access and openness, trade and investment and technological advancement. To minimize abuses and protect the public interest, the governments should ensure the transparency and accountability of the subsidy schemes. Public interest agencies, civil society organizations and the media should help the governments closely monitor the "de-risking" schemes and make the society fully aware of their costs and risks (Sundaram and Chowdhury, 2019b).

It is also essential to make the contract between the public and private sectors clean and transparent. Since the agreement between the government and a private-sector entity in some developing countries is unclear, the cost of infrastructure development may become highly unexpected. Suppose MDBs such as the Asian Development Bank (ADB) and World Bank jointly participate in infrastructure projects with the government and the private sector. In that case, they can monitor the clearness and transparency of the contract so that the costs of infrastructure investment can be kept at a minimum level. Otherwise, the infrastructure will be very costly to the

country, and at the same time, it will affect the governance of infrastructure development and operation.

Finally, linking spillover tax revenues with infrastructure projects can only be supported if the governments collect taxes fairly and effectively. Tax collection is complex, particularly in developing countries (Slemrod and Yitzhaki, 2000). Tax authorities often face trouble tracing the informal sector's revenues and profits, as small businesses do not often pay tax, and even large companies could hide their revenues (Abe, et al., 2012; OECD, 2015). Tax administration in developing countries already has many problems, including poor compliance and unregistered business. Under globalization and fintech evolution, intensifying state-level tax competition, growing mobile assets, and emerging opportunities for tax avoidance have increased rapidly and potentially constrained taxation of corporate and personal incomes (OECD, 2017; Swank, 2016). Critical issues include poor governance and a lack of technology to implement tax policies with reasonable administrative and auditing costs.

3. Spillover effects: Empirical evidence in Vietnam

Applying the differences-in-differences (DID) method,[9] we analyzed the effects of two expressway projects, the Noi Bai–Lao Cai and Ha Noi–Thai Nguyen routes, on income tax revenue, corporate tax revenue and total domestic tax revenue in the Northern Midland and Mountainous Region of Vietnam.[10] The Noi Bai–Lao Cai expressway is 265 kilometres, starting in Noi Bai, a suburban area of Ha Noi, and ending at a busy gateway to China in Lao Cai. The construction process began in 2008, and the expressway opened to traffic in 2014. The Ha Noi–Thai Nguyen project, which also opened to traffic in 2014, connects Ha Noi to Thai Nguyen, a new production hub in Vietnam. The construction of the Ha Noi–Thai Nguyen expressway began in 2009. **Figure 4** provides an overview of the planned expressed way networks in Vietnam.

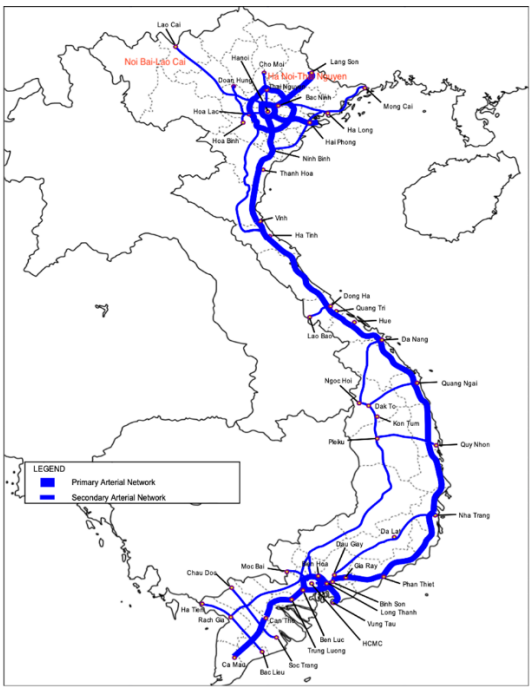

Figure 4. Vietnam's planned expressway networks.
Source: Japan International Cooperation Agency (JICA) and Vietnam Ministry of Transport (2010).

We classified the region's provinces into two groups: the treated group covers provinces where the expressways pass by, and the control group covers other provinces. Four provinces (Phu Tho, Yen Bai, Lao Cai and Thai Nguyen) belong to the treated (affected) group. Another ten provinces (Bac Giang, Bac Kan, Cao Bang, Dien Bien, Ha Giang, Hoa Binh, Lai Chau, Lang Son, Son La and Tuyen Quang) belong to the control (unaffected) group.[11] Although the construction of the expressways finished in 2014, it would take several months for these projects to exert effects on the economic activities in the provinces. As a result, we divided the time into two periods: 2009–2014 (the construction phase) and 2015–2018 (the operation phase). The following analyses used the data from three sources: provincial statistical yearbooks, the General Statistics Office of Vietnam (GSO) and the provincial competitiveness index (PCI), which is compiled jointly by the United States Agency for International Development (USAID) and the Vietnam Chamber of Commerce and Industry (VCCI). **Tables A1** and **A2** in the appendixes present more details of the data used in the analyses.

The econometric model of this study followed the model that Yoshino and Abidhadjaev (2017) used to study the impact of the high-speed train line on government revenue in Japan:

$$Rev_{it} = \beta_1 D_{affected} \times D_{2015-2018} + \beta_3 X_{it} + \varepsilon_{it} + \varphi_t \quad (6)$$

where i stands for province i, and t refers to year t. Rev_{it} represents the government revenue (income tax revenue, tax revenue from business activities and total domestic tax revenue). Besides the total tax revenue, we ran a regression using the revenue per capita as the dependent variable. The main independent variable is $D_{affected} \times D_{2015-2018}$. $D_{affected}$ is a binary dummy variable taking the value one if provinces belong to the regions through which the expressways pass. $D_{2015-2018}$ is also a binary variable, taking the value one if the observation belongs to the operation phase (2015–2018). $D_{affected} \times D_{2015-2018}$ equals one if the observations are those of the affected provinces in the operation phase. Therefore, the estimated coefficients of $D_{affected} \times D_{2015-2018}$ illustrate the changes in revenue from the construction phase to the operation phase that occur in affected provinces but not in other provinces. X_{it} denotes the control variables: the lag variables of GDP and GDP per capita, the agricultural sector's share and the corruption index.

3.1. Effects of expressway projects on income tax revenue

Table 2 summarizes the tax revenues of affected and non-affected provinces. Two periods are compared: 2009–2014 (the construction phase) and 2015–2018 (the operation phase). The table suggests that the affected provinces experienced higher tax increases in all tax categories than non-affected provinces. Noteworthily, a rise in income tax revenues was significantly higher in the affected provinces (176.6%, while business tax revenue showed a relatively moderate increase (86.3%). It may be because it would take businesses some time to benefit from their new investments, or they have not reported accurate revenue rises after the operation of expressways. Companies in the Northern Midland and Mountainous region have also received various tax incentives to encourage business investments, such as lower tax rates and tax exemptions, thus lowering the government's tax revenue (PwC, 2018).

Table 2. Tax revenues of affected and non-affected groups over 2009–2018.

	2009–2018 (whole period)	**2009–2014 (pre-operation)**	**2015–2018 (post-operation)**	**% Increase**
All provinces				
Total tax revenue	1587.79	1114.44	2204.84	97.8
Business tax revenue	828.05	623.46	1091.1	75.0
Income tax revenue	68.71	42.21	103.24	144.6
Affected provinces				
Total tax revenue	2710.19	1828.82	3811.91	108.4
Business tax revenue	1406.97	1009.02	1879.55	86.3
Income tax revenue	145.64	81.59	225.71	176.6
Non-affected provinces				
Total tax revenue	1153.32	884.86	1562.02	76.5
Business tax revenue	610.18	485.24	775.72	59.9
Income tax revenue	38.93	27.36	54.26	98.3

Notes: The data shows provinces' yearly average tax revenues in the region and the affected and non-affected groups. Tax revenues are measured in billion VND.

Tables 3–5 below present the empirical results of the regressions on income tax revenue, business tax revenue and total tax revenue, respectively. The within R squared value is quite high, from around 0.71 to 0.94, suggesting that the econometric models perform quite well in capturing the real data. The estimated coefficients of the main explanatory variable, $D_{affected} * D_{2015-2018}$, are significantly positive in most cases, suggesting positive impacts of infrastructure projects on all three types of government revenues. The GDP and GDP per capita appear to enhance government revenues. At the same time, the results of agriculture's share differ between income and business tax revenues.

Table 3 shows the outcomes of the regressions on income tax revenue. Its second column contains the regression results on the total income tax when including all the control variables where the estimated coefficient of the main variable, $D_{affected} * D_{2015-2018}$, stands at around 35.59. This number indicates that the operation of the expressway projects adds VND 35.59 billion to the income tax revenue of the affected provinces compared with the non-affected provinces. Considering that the mean income tax revenue of the affected provinces is around VND 146 billion (see **Table 1** again), the increase makes up a substantial ratio of approximately 24 per cent of the average revenue. The fourth column also suggests that the income tax per capita of the affected provinces increased by about VND 0.0372 million after completing the infrastructure projects. These figures imply that the Noi Bai–Lao Cai and Ha Noi–Thai Nguyen expressways help create economic opportunities and new jobs in the provinces they traverse, raising peoples' incomes and increasing the income tax revenue.

Table 3. Effects on income tax revenue.

Dependent variable **Independent variable**	**Income tax**	**Income tax**	**Income tax per capita**	**Income tax per capita**
$D_{affected}{*}D_{2015-2018}$	29.71**	35.59***	0.0365**	0.0372***
	(0.038)	(0.006)	(0.029)	(0.006)
$GDP_{i,t}$	0.0102***	0.0123***		
	(0.000)	(0.000)		
GDP per $capita_{i,t}$			0.00884***	0.0115***
			(0.000)	(0.000)
Agriculture $share_{i,t}$		659.1**		0.595*
		(0.030)		(0.099)
Corruption $restriction_{i,t}$		2.772		0.00388
		(0.233)		(0.157)
Constant	−106.5***	−313.7***	−0.106***	−0.320**
	(0.000)	(0.004)	(0.000)	(0.110)
Within *R* squared	0.771	0.796	0.705	0.735
Observations	115	115	115	115
Number of groups	14	14	14	14

Note: *p*-value in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 4. Effects on revenue from business activities.

Dependent variable **Independent variable**	**Business tax revenue**	**Business tax revenue**	**Business tax revenue per capita**	**Business tax revenue per capita**
$D_{affected}{*}D_{2015-2018}$	264.7**	232.5*	0.107	0.0977
	(0.035)	(0.081)	(0.149)	(0.368)
$GDP_{i,t}$	0.0512***	0.0440***	-	-
	(0.000)	(0.000)	-	-
GDP per $capita_{i,t}$	-	-	0.0615***	0.0402***
	-	-	(0.000)	(0.000)
Agriculture $share_{i,t}$	-	−2,171**	-	−4.399***
	-	(0.039)	-	(0.003)
Corruption $restriction_{i,t}$	-	−37.12**	-	-0.0588**
	-	(0.032)	-	(0.014)
Constant	−44.74	795.0***	−0.235***	1.538***
	(0.338)	(0.004)	(0.001)	(0.001)
Within *R* squared	0.797	0.815	0.724	0.781
Observations	114	114	114	114
Number of groups	14	14	14	14

Note: *p*-value in parentheses.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 5. Effects on total tax revenue.

Dependent variable **Independent variable**	**Total tax revenue**	**Total tax revenue**	**Total tax revenue per capita**	**Total tax revenue per capita**
$D_{affected}{*}D_{2015-2018}$	490.1***	479.7**	0.452***	0.442**
	(0.007)	(0.012)	(0.008)	(0.021)
$GDP_{i,t}$	0.128***	0.124***		
	(0.000)	(0.000)		
GDP per $capita_{i,t}$			0.133***	0.118***
			(0.000)	(0.000)
Agriculture $share_{i,t}$		−1,203		−3.248*
		(0.335)		(0.086)
Corruption $restriction_{i,t}$		−4.466		−0.0394*
		(0.764)		(0.086)
Constant	−606.4***	−231.7	−0.824***	0.461
	(0.000)	(0.508)	(0.000)	(0.341)
Within *R* squared	0.936	0.937	0.895	0.902
Observations	115	115	115	115
Number of groups	14	14	14	14

Note: *p*-value in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

3.2. Effects of expressway projects on tax revenue from business activities

Table 4 presents the regression results on government revenue from business activities. The estimated coefficients of the DID variable are significantly positive for total business tax revenue. The results presented in the table's second column indicate that, on average, the operation of infrastructure projects adds approximately VND 232.5 billion to the affected provinces. The mean business tax revenue for the provinces is about VND 828 billion annually, and the equivalent figures in the affected and non-affected provinces are approximately VND 1406 billion and VND 610 billion, respectively. This finding provides evidence that, once the expressways are open, they bring more economic opportunities to businesses in the area. In return, local governments benefit from collecting more taxes. The coefficients for the DID variable are also positive but insignificant for business tax revenue per capita. The insignificant results in business tax might be because it is probably better to measure revenue per business tax entity rather than per capita revenue. However, due to the unavailability of the data, we do not cover business tax per business entity in the analysis.

3.3. Effects on total tax revenue

Finally, we ran the tests to estimate the effects on the total tax revenue (**Table 5**). The results of the $D_{affected}{*}D_{2015-2018}$ variable are positive and significant at the one per cent level in all. More specifically, the table shows in the second column that, after controlling for the lag of GDP, the agriculture share and corruption restriction index, the total revenue rises by about VND 479.7 billion compared with the

unaffected provinces. Given that the mean total tax revenue of all the provinces is approximately VND 1588 billion, the operation of new expressways exerts substantial effects on the economic activities and tax collection of the local governments of the affected provinces. In addition, the domestic revenue per capita also increases considerably by around VND 0.442 million.

As expected, the GDP and GDP per capita lags are positive and significant at the one per cent level. These outcomes confirm that the size of the economy and income level are important factors determining governments' tax collection and revenue. The estimated coefficients of the agricultural share are also significantly negative on business tax revenue because it is more difficult to tax businesses in the agriculture sector than those in manufacturing or services (Gupta, 2007). The significantly negative coefficients of the corruption restriction variable suggest that governments that perform better in restricting corruption collect less revenue from business activities. This finding may support the "grease of the wheels" hypothesis about the effects of corruption on business activities in the region (Maruichi and Abe, 2019). In economies with administrative inefficiency, enterprises might benefit from bribery that overcomes administrative delays and reduces transaction costs (Méon and Weill, 2010).

The empirical result supports that infrastructure development brings more economic opportunities and hence increase tax revenue collected by provincial governments. Poor infrastructure has remained one of the biggest obstacles to economic development in Vietnam, and the government has prioritized infrastructure development as a key policy area and increased investment in infrastructure development, encouraging the private sector's participation in PPP (Giang and Pheng, 2015). However, these actions often either resulted in low investment return, which has further discouraged private investment, or forced high user charges, which have caused resistance of the public (Le, et al., 2020). In this context, it would be more beneficial if the Vietnam could reinvest spillover tax revenues into future infrastructure projects, subsidize private investors or reduce user charges. Unfortunately, the current legal framework in Vietnam does not allow such a mechanism that its budget law strictly classifies tax revenues according to its original sources and dictates how they can be allocated. Among those, land related tax revenues, including rights sales or rent, are distributed completely to the locals for future infrastructure development (Nguyen-Hoang and Schroeder, 2010). Despite the present empirical evidence, Vietnam has yet to have neither legal nor policy framework to utilize spillover tax revenues for infrastructure development.

4. Policy implications and conclusions

This paper estimated the spillover effects created by expressways in Vietnam. Applying the DID method, this paper shows that the operation of expressways projects added a substantial amount to both the income and corporate tax revenues of the affected area. These results reinforce the argument that infrastructure investment such as roads, expressways and trains can bring businesses and economic activities to the regions and hence generate higher government tax revenues. If spillover tax revenues are even partially shared with private investors, their rates of return will rise. In this

way, the governments might achieve the goals of keeping the tariffs low and attracting more private investors to important infrastructure development projects. For this purpose, the governments must establish proper governance and institutional frameworks while cooperating with private investors and operators. Key policy implications in this regard are presented in turn.

First, the governments design and provide proper incentive schemes such as subsidies to private infrastructure investors and operators while encouraging them to make their efforts to maximize profits. Such incentives link with the growth of tax revenues and others in the adjacent areas to the infrastructure. By so doing, the private sector can foresee an adequate rate of return on their investment in infrastructure and is encouraged higher investment in infrastructure projects. In the past, private investors were only interested in constructing infrastructure without paying attention to economic development and job creation in the region. Yet, coherent regulatory policies and associated institutional and governance frameworks are necessary to boost private financing for infrastructure.

Second, the land capture of private infrastructure investors and operators could provide additional incentives to encourage private financing in infrastructure. Businesses operating in the adjacent area of the infrastructure can significantly contribute to spillover effects and increase tax revenues to the public authorities. However, the direct involvement of the private infrastructure investors and operators in land and business development around the infrastructure can promote more private financing for infrastructure development as they can foresee additional cash flows from newly developed businesses surrounding the infrastructure. Yet, the governments must carefully create a proper governance structure to offer this opportunity to the private investors fairly and transparently to avoid accusations and protect the public interests.

Third, in addition to direct incentives to private investors and infrastructure operators such as price-cap regulations and revenue-cap regulations (Yoshino, Azhgaliyeva and Mishra, 2021), one but indirect incentive scheme for infrastructure development is the financing of business startups and SMEs that operate around infrastructure (Abe, Troilo and Batsaikhan, 2015). If infrastructure such as railways and roads are developed in a new area, entrepreneurs and SME owners will be interested in starting new businesses such as hotels, restaurants and retail shops because new residents who use such transport infrastructure will be available as their new customers. However, the entrepreneurs and the SME owners often find it difficult to raise money, and banks often deny loans to startups and smaller businesses without a credit history (Abe, et al., 2012; Yoshino and Kaji, 2013). In this case, providing financing for startups and SMEs, for example, through geographically-concentrated or sector-dedicated public infrastructure funds such as subnational development funds and highway trust funds would enhance spillover effects, such as increased tax revenue around the area where more businesses are newly developed (Inderst and Croce, 2013).

Fourth, to successfully capture the spillover effects of infrastructure, the governments must collect the incremental taxes effectively and fairly through appropriate tax payment systems. Without proper taxation to avoid evasion, the governments are unlikely to capture the activities of businesses and households to collect taxes fully. A proper tax payment system for spillover effects can make the

taxation process transparent and efficient with affordable tariffs for citizens and businesses while simultaneously ensuring the financial viability of the infrastructure projects. Besides, suppose there is some discrimination in taxation among the different groups of the society. In that case, people may not support the governments using incremental tax revenues to help private infrastructure investors, although they use indirect incentives such as subsidies. In this regard, the government may wish to adopt advanced technology such as satellite data to capture incremental taxes efficiently and comprehensively.

Fifth, the governments must reduce informality in their economies. With high informality, they cannot capture spillover effects effectively, missing many commercial and private activities in the target area around newly developed infrastructure. They may need to overhaul their governance structure for the private sector to encourage businesses to make themselves formal. The governments can provide an enabling business environment with effective trade and investment policies and proper incentives to support private sector development. They can also implement easy registration schemes, e.g., a one-stop service centre, to increase formality in business.

Sixth, spillover tax revenues could create moral hazard among private infrastructure investors and operators as the private sector could receive more subsidies than the actual value of spillover effects (as spillover tax return from the government). To determine an appropriate distribution between the government and the private sector, each infrastructure project must conduct a precious econometric analysis (Yoshino, et al., 2019). However, as a rule of thumb, a 50-50 share between the public and private sectors is recommended to avoid debate and complex procedures.

Finally, the governments can ask for technical assistance from international development agencies and MDBs, such as the United Nations, ADB and the World Bank, to help build their institutional capacity to fully capture the spillover effects of infrastructure. Especially international development agencies and MDBs can contribute to implementing and monitoring the proper transfer of spillover tax return from the government to private investors and operators by fostering long-term commitments among the stakeholders. Spillover tax return to the private investors and operators will allow them to pay for the maintenance and repair of the infrastructures. In addition, the governments can facilitate the exchange of experiences and knowledge with neighbouring countries in the region.

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Notes

1. While "infrastructure investment" could cover the functions of an infrastructure project broadly, including financing, construction, operation and ownership of infrastructure facilities, "infrastructure financing" may narrowly focus on funding issues related to an infrastructure project (Grimsey and Lewis, 2002). Although some confusion exists between infrastructure investment and financing, this paper uses those terms more or less as equivalent.
2. In this vein, land value capture has been used in infrastructure investment, where landowners receive an explicit return through increased land prices. However, the land value capture can only cover part of the spillover effects discussed in this paper. To share spillover tax revenues properly with private investors, a watchdog such as an international development agency or an MDB must regularly monitor the transfer of the spillover tax revenues.
3. While governments provide grants to initiate a third party's predefined activities, they use subsides to share the costs of the predefined activities.
4. The private sector's "land capture" is different from the public sector's "land value capture." The land value capture refers to "the process of using various fiscal instruments to capture a portion of land value increments to support the financing of public investments and services" (ESCAP, 2018, p. 9). Land values, as well as property values and rental premiums, are strongly and positively associated with the level of infrastructure investment, such as road construction, mass transit development and water supply (Peterson, 2009). The governments can increase their tax revenues with incremental land value through various tax schemes, such as land and property tax, toll fees and parking levies, and finance new infrastructure projects directly (McIntosh, et al., 2017).
5. However, empirical support for significant spillover effects shows mixed results (cf., Cantos, Gumbau-Albert and Maudos, 2005).
6. "A betterment levy captures part of the land-value gain attributable to infrastructure investment by imposing a one-time tax or charge on the land-value gain" (Peterson, 2009, p. 6).
7. The private sector's "land capture" differs from the public sector's "land value capture." Land value capture is "using various fiscal instruments to capture a portion of land value increments to support the financing of public investments and services" (ESCAP, 2018, p. 9). Land values, as well as property values and rental premiums, are strongly and positively associated with the level of infrastructure investment, such as road construction, mass transit development and water supply (Peterson, 2009). The governments can increase their tax revenues with incremental land value through various tax schemes, such as land and property tax, toll fees and parking levies, and finance new infrastructure projects directly (McIntosh, et al., 2017).
8. For example, public subsidies to operators can increase dividends to investors.
9. The basic idea of the DID method is that when a policy change is introduced, two groups, affected and unaffected groups, will emerge. We assume that two groups are subjected to the same time trend, so by comparing the affected group between pre- and post-changes and the unaffected group between the two periods, we can capture the impact of policy change (Lechner, Rodriguez-Planas and Kranz, 2016).
10. The Northern Midland and Mountainous has been the poorest region of Vietnam. One reason for this is the insufficiency of access to economic opportunities due to the flawed infrastructure system in the region (ADB, 2014).
11. We do not include Ha Noi and Vinh Phuc, two other provinces where the expressways pass because they belong to the Red Delta Region of Vietnam and thus are not part of the region of interest.

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Appendix

Table A1. Descriptive statistics of variables used in regression analyses.

Details	Unit	Obs	Mean	SD	Min	Max
All provinces						
Total domestic revenue	billion VNDs	129	1587.79	1407.80	253.50	8633.49
Revenue from business activities	billion VNDs	128	828.05	710.63	109.37	4481.70
Income tax revenue	billion VNDs	129	68.71	118.38	0.32	877.32
Domestic revenue per capita	million VNDs	129	1.77	1.11	0.62	6.81
Revenue from business activities per capita	million VNDs	128	0.94	0.61	0.29	3.53
Income tax revenue per capita	million VNDs	129	0.07	0.09	0.00	0.69
GDP	billion VNDs	130	18228.62	13305.03	3908.63	72064.21
GDP per capita	million VNDs	130	20.50	8.27	9.79	56.82
Share of agriculture		130	0.24	0.05	0.10	0.38
Corruption restriction index		140	5.38	0.96	2.81	8.05
Treatment group						
Total domestic revenue	billion VNDs	36	2710.19	1808.76	719.56	8633.49
Revenue from business activities	billion VNDs	35	1406.97	915.84	379.84	4481.70
Income tax revenue	billion VNDs	36	145.64	192.51	20.85	877.32
Domestic revenue per capita	million VNDs	36	2.67	1.51	0.96	6.81
Revenue from business activities per capita	million VNDs	35	1.39	0.74	0.51	3.53
Income tax revenue per capita	million VNDs	36	0.13	0.15	0.03	0.69
Control group						
Total domestic revenue	billion VNDs	93	1153.32	910.50	253.50	5759.94
Revenue from business activities	billion VNDs	93	610.18	460.06	109.37	2005.87
Income tax revenue	billion VNDs	93	38.93	46.76	0.32	322.39
Domestic revenue per capita	million VNDs	93	1.42	0.63	0.62	3.40
Revenue from business activities per capita	million VNDs	93	0.77	0.45	0.29	2.51
Income tax revenue per capita	million VNDs	93	0.04	0.03	0.00	0.19

Table A2. Correlation matrix of variables used in regression analyses.

	Total tax revenue	**Business tax revenue**	**Income tax revenue**	**Total tax revenue per capita**	**Business tax revenue per capita**	**Income tax revenue per capita**	**GDP**	**GDP per capita**	**Agriculture share**	**Corruption restriction**
Total tax revenue	1									
Business tax revenue	0.93	1								
Income tax revenue	0.89	0.82	1							
Total tax revenue per capita	0.87	0.83	0.73	1						
Business tax revenue per capita	0.74	0.86	0.61	0.91	1					
Income tax revenue per capita	0.86	0.82	0.98	0.78	0.67	1				
GDP	0.95	0.86	0.85	0.72	0.59	0.78	1			
GDP per capita	0.89	0.84	0.79	0.93	0.81	0.82	0.84	1		
Agriculture share	−0.68	−0.64	−0.55	−0.81	−0.74	−0.59	−0.60	−0.78	1	
Corruption restriction	0.17	0.14	0.17	0.05	0.02	0.14	0.20	0.08	−0.11	1