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THE SPILLOVER EFFECTS OF WATER SUPPLY INFRASTRUCTURE DEVELOPMENT: A THEORETICAL MODEL

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Abstract

One of the main challenges in low-income Asia and the Pacific countries is users' willingness to pay for water services. In contrast, investors and private operators in the water sector prefer a high rate of return. This has often led to the failure of public-private partnerships for water projects. However, if we look at the overall picture of the development effects of water supply infrastructure, including spillover effects or externalities, the impacts are significant. One of the spillover effects of the development of water supply infrastructure could be the development of the region by inviting new businesses and creating new residential areas. Many people can move to a region where a good water supply is available. These new economic activities will increase tax revenues collected by the government. We develop a theoretical model of the spillover effects of water supply infrastructure developments. Our model shows how the incremental tax revenues that were previously absorbed only by the government could partly be shared with the investors and operators of the water supply infrastructure. Moreover, we propose a pooling system for collecting the incremental tax revenues attributable to the spillover effects in large cities and use them to support the service fee to build and operate systems in rural regions. Such a pooling system can accelerate the expansion of a nationwide network of water supply infrastructure that will quickly reduce the negative externalities and increase positive externalities for the nation.

Keywords: water supply infrastructure, infrastructure financing, spillover effect, Asia

JEL Classification: H20, H54, O18, Q25

Contents

1. INTRODUCTION

Water services are considered to be one of society's basic needs. The United Nations even recognizes access to water as a human right due to the fundamental role it plays in people's health, dignity, and prosperity. However, many are still living without adequate access to clean water. In Asia and the Pacific, around 500 million people do not have access to basic water supplies (WHO/UNICEF 2022). This problem is exacerbated by rapid urbanization, as tens of millions of people each year move into slums and other infrastructure-poor areas. For example, it is estimated that approximately 80% of the seven million residents of Dharavi, Mumbai, India have no running water. Similarly, because of the lack of water infrastructure, low-income households in Penjaringan, Jakarta are forced to purchase water from their neighbors at a 40–60 times higher price than subsidized pipe water.

Water supply infrastructure includes all human-made and natural components required to deliver safe drinking water. The development and operation of infrastructure, including that of water infrastructure, is generally costly. For public goods in particular, it is not rare for investors, often governments, to face budget constraints in financing infrastructure investments. As well as the high initial cost at the construction stage, investors also often face financial difficulties during the operation phase. This is because most infrastructure operators rely on user charges to finance their operation. Yet, people's willingness to pay for public goods is usually low. Moreover, given that public goods must be provided at an affordable price to ensure access for all economic levels of society, keeping user charges low is a challenge given the high maintenance and repair costs.

This high-cost–low-revenue problem of infrastructure development and operation results in the private sector being reluctant to invest in infrastructure, especially for public goods. But, given the limited budgets of governments, especially during the COVID-19 pandemic, the private sector's involvement in infrastructure development is crucial. It is important, therefore, to increase the attractiveness of infrastructure projects for the private sector. One way of doing so is by ensuring enough revenues for the investors while being able to keep users' charges low.

This paper develops a theoretical model to secure adequate revenues for the development and operation of water supply infrastructure, which will encourage the private sector to participate. Specifically, this paper argues that the increased tax revenues that can be attributed to the development of water supply infrastructure should partly be shared with infrastructure developers and operators instead of being fully absorbed by the government.

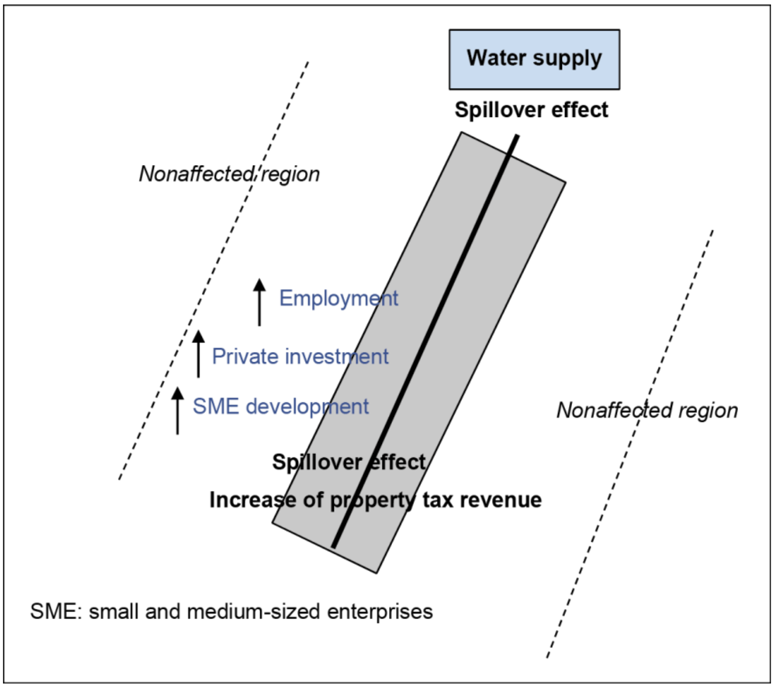
The main argument made in this paper is that the development of water supply infrastructure will increase the amount of taxes, referred to as "spillover" taxes, collected by the government. We identify two ways in which this may occur. First, the improvement of water supply infrastructure is expected to stimulate economic activity such as the construction of new office buildings and new employment. Second, the development of water supply infrastructure will lead to better health outcomes and human capital development. These factors can be measured in economic terms, so the total spillover effects of water supply infrastructure development can be estimated.

This paper is organized as follows. Section 2 reviews past studies and literature on spillover effects from infrastructure development. Section 3 discusses how water infrastructure creates spillover effects. This section provides a framework for estimating the impact of infrastructure investment and case studies. Section 4 focuses on the benefits of water supply infrastructure for human capital development and health. Section 5 explains the proposal for a pooling system of the benefits resulting from the creation of water supply infrastructure. It also estimates how much infrastructure investment will increase spillover effects. Section 6 concludes and describes policy implications.

2. LITERATURE REVIEW OF SPILLOVER EFFECTS FROM INFRASTRUCTURE DEVELOPMENT

Traditionally, the sources of revenue for water suppliers came from the user charges for water supply infrastructure. However, users' willingness to pay for public goods such as water is low, while investors and water operators prefer a high rate of return. Hence, the public-private partnership (PPP) projects for water supplies and infrastructure projects in general sometimes fail.

Figure 1: Diagrammatic Spillover Effect of Water Supply Infrastructure Development



Note: The solid black line in the middle represents the water supply; the gray part is the area that enjoys a spillover effect; the dashed lines on the left and right are the borders of the area affected by spillover effects.

Source: Yoshino et al. (2019).

On the other hand, the impacts are massive if we look at the overall picture of the effects, including the spillovers or externalities of the development of water supply infrastructure. Figure 1 illustrates the spillover effects of the development of water supply infrastructure. Suppose a new water supply infrastructure is constructed in the area shaded gray. After completion of the infrastructure, new industries and new companies start their activities in the region along these water supply corridors. Housing, restaurants, and services can be constructed along with new water supplies and start their businesses. The territory with the newly developed water supply infrastructure (dark gray shaded area) benefits from the spillover effects of the new development of water supply infrastructure. This economic development due to spillover effects will raise tax revenues from this territory for government, including government revenues from income tax, sales taxes, and property tax (Yoshino et al. 2019).

Yoshino and Nakahigashi (2004) estimated the direct effects of infrastructure investment and the indirect effects, or spillover effects, by using a translog production function in Japan. The direct effects refer to increments in production by a marginal increase in the production factor (private capital and private labor) due to an increase in infrastructure. The indirect or spillover effects refer to private enterprises' production increases and investing in production elements based on their initial increase in marginal productivity. The infrastructure that will increase the region's output creates the immediate impact of investment. The two channels of the spillover effects on construction and employment will increase regional output and contribute to the increased consumption and housing. The regional gross domestic product (GDP) will increase accordingly.

To investigate the effectiveness of the investment, the production function is utilized to estimate the effect of infrastructure.

$$Y = f\ (K_p, L, K_G), \tag{1}$$

where Y is regional GDP, *Kp* stands for private capital such as factories and business, *L* stands for labor input, and K_G stands for government (or public) capital, which includes water supply infrastructure (water supply infrastructure is a part of government investment).

To identify the productivity effect of infrastructure in greater detail, Yoshino and Nakano (1994) classified the productivity effect according to its direct and spillover effects. The infrastructure effect is explained in marginal productivity:

$$\frac{dY}{dK_G} = \underbrace{\frac{\partial f}{\partial K_p}\frac{\partial K_p}{\partial K_G} + \frac{\partial f}{\partial L}\frac{\partial L}{\partial K_G}}_{\text{Spillover effect}} + \underbrace{\frac{\partial f}{\partial K_G}}_{\text{Direct effect}}. \tag{2}$$

The direct effect of infrastructure investment and its spillover effects is estimated in Table 1, using macroeconomic data for Japan. For example, in the period 1956–1960, the direct effect of infrastructure investments that increased output was 0.696. The spillover effect that emerged from an increase in private capital was 0.452, and the spillover effect induced by an increase in employment was 1.071. This shows the direct effect of infrastructure that increased the output, the spillover effect created by an increase in private capital, and the spillover effect produced by an increase in employment. Finally, the total spillover effect in the period 1956–1960 was 68.6% from the total effect of infrastructure investment.

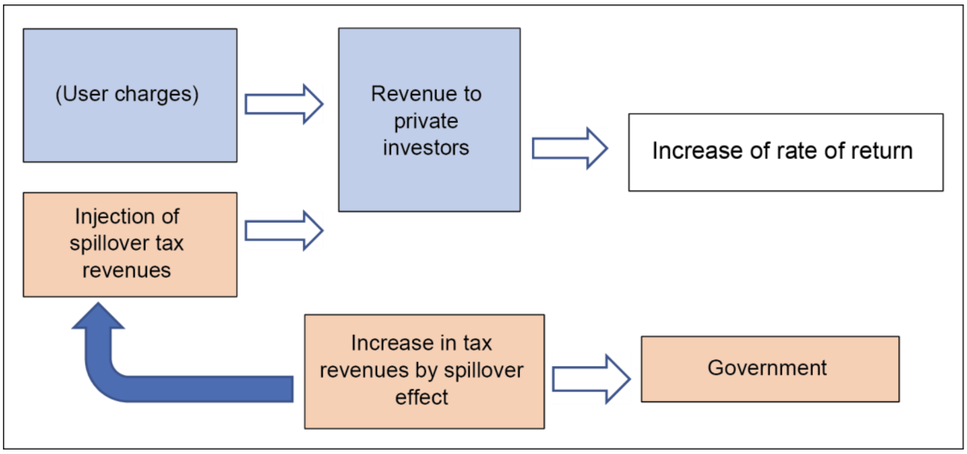
Table 1: Economic Effect of Infrastructure Investment in Japan (Macroeconomic Estimation)

Economic Effect	1956–60	1961–65	1966–70	1971–75	1976–80	1981–85	1986–90	1991–95	1996–2000	2001–05	2006–10
Direct effect	0.696	0.737	0.638	0.508	0.359	0.275	0.215	0.181	0.135	0.114	0.108
Spillover effect of private capital (Kp)	0.452	0.557	0.493	0.389	0.270	0.203	0.174	0.146	0.110	0.091	0.085
Spillover effect of employment (L)	1.071	0.973	0.814	0.639	0.448	0.350	0.247	0.208	0.154	0.132	0.125
Total effect of infrastructure investment	2.219	2.267	1.944	1.536	1.076	0.828	0.635	0.536	0.399	0.337	0.318
Share of spillover effect, %	68.6%	67.5%	67.2%	66.9%	66.7%	66.8%	66.2%	66.2%	66.1%	66.1%	66.1%

Source: Yoshino, Nakahigashi, and Pontines (2017).

At the project level of estimation, the incremental benefits of transferring the spillover effects to the additional normal project revenues would change the internal rate of return for the project. Figure 2 illustrates a model for returning a share of the spillover tax revenues to investors in water infrastructure projects. User charges are usually below the average cost of maintaining and constructing water supply infrastructures. Therefore, we propose using some of the spillover tax revenues created by the water supply infrastructure for the maintenance or operation of infrastructure. Thus, government should share these increased spillover tax revenues with private investors in infrastructure investment.

Figure 2: Model for Returning Fractional Spillover Tax Revenues to Investors in Water Projects



Source: Yoshino et al. (2019)

3. WATER SUPPLY INFRASTRUCTURE INVESTMENTS AND THE SPILLOVER EFFECTS

Water supply infrastructure comprises the physical and organizational structures and facilities used to deliver safe drinking water and sanitation. The development of water supply infrastructure creates spillover effects and impacts the economy, especially in the region where the infrastructure is developed. New restaurants, hotels, shopping malls, and residential areas will be developed if the water supply infrastructure is well equipped. These activities will contribute to increases in tax revenues, including corporate tax, property tax, income tax, etc. In the same way as water supply infrastructure, various infrastructure projects can be used to demonstrate the spillover effects. The construction of new roads and railways lifts the value of the assigned land. New apartments and new businesses can be established in the region, thanks to the accessibility of the water services.

Figure 3: Illustration of Spillover Effect of Water Supply

Source: Authors.

To provide a framework for estimating the impact of infrastructure investment, Yoshino and Abidhadjaev (2016) estimate the difference-in-difference (DID) coefficients to better understand the net difference brought about by introducing an infrastructure facility. The following two equations can be used to illustrate the difference-in-difference method:

$$Y_1 = F(K_{p1,}L_1\,,K_{g1},X), \tag{3}$$

$$Y_2 = F(K_{p2,}L_2,X). \tag{4}$$

The notations are the same as in Equations 1 and 2, but note that Equations 3 and 4 include X, which represents other variables that affect the economy. Equation 3 shows regional GDP in Region 1 where new infrastructure is constructed, while Equation 4 represents the region where no infrastructure investments are made. The DID method measures the differences in Region 1 and Region 2 due to the impact of infrastructure investment (*Kg*), as shown in Equation 5.

Specifically, Equation 5 measures the difference in the GDP of Region 1 and Region 2, where Region 1 is enjoying the operation of infrastructure and Region 2 has no such infrastructure. Y_1-Y_2 measures an increment of GDP created by infrastructure investments.

$$Y_1 - Y_2 = F(K_{p1,}L_1,K_{g1}X)\text{- } F(K_{p2,}L_2,X). \tag{5}$$

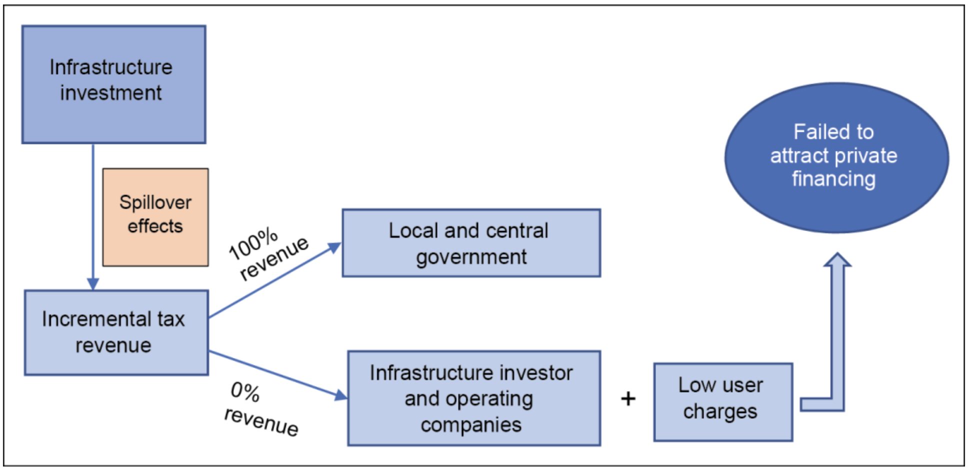
Changes in GDP will contribute much more to the tax revenues that result from the newly constructed infrastructure investments.

$$Tax\ revenue = txY, \tag{6}$$

where *t* is tax rate and *Y* is GDP.

Tax revenues, including those brought about by the development of the new infrastructure, are usually absorbed entirely by the government. Therefore, the infrastructure investors or instruction companies do not receive the direct benefit of increased tax revenues. Figure 4 shows that all these incremental tax revenues went to the local and central government and were not shared with infrastructure investors, who relied mostly on user charges for their sources of revenue. If government would like to attract more private investors, then they need to increase user charges because traditionally, all the revenues came from user charges. In particular, water is a necessary good and the government is reluctant to increase user charges. It is hard to attract private investors into the development of water supply infrastructure because of the low rate of return they can expect to cover operation and management. Low user charges, such as the water tariff, have caused water supply infrastructure and other infrastructure companies that depend on user charges to struggle with revenues.

Figure 4: The Traditional Circle of Spillover Effect Benefits Created by Infrastructure Investment



Source: Authors.

This paper proposes sharing spillover incremental tax revenues with infrastructure investors: for example, 50% of incremental tax revenues with infrastructure investors and infrastructure operating companies, to enable them to have enough revenue and to cover a significant part of their infrastructure maintenance and operations, which will lead to lower user fees.

In order to illustrate the increase in the rate of return (ROR) created by the spillover effect, we use past research on the spillover effect created by the Information and Communication Technology (ICT) infrastructure. We use data from the Global System of Mobile Communication (GSM) subscriber from 2005 to 2016 from India in Table 2.

Table 2 shows the main estimation result for the GSM revenue and total state tax increase. The detailed data and estimation strategy are available in Yoshino et al. (2022). To calculate the increased ROR, the first step is to compute the total revenue obtained from subscriber fees as user charges; next, to define the tax revenue after the infrastructure has started. According to the estimation, a 10 percentage point increase in GSM subscribers per capita is expected to raise the total state tax revenue per capita by ₹134. The estimated average total state tax revenue increase is 172,994. The tax increment of 14.2% is calculated by: $172,994 \ / \ 1,221,318 = 0.142 \ or \ 14.2\%$.

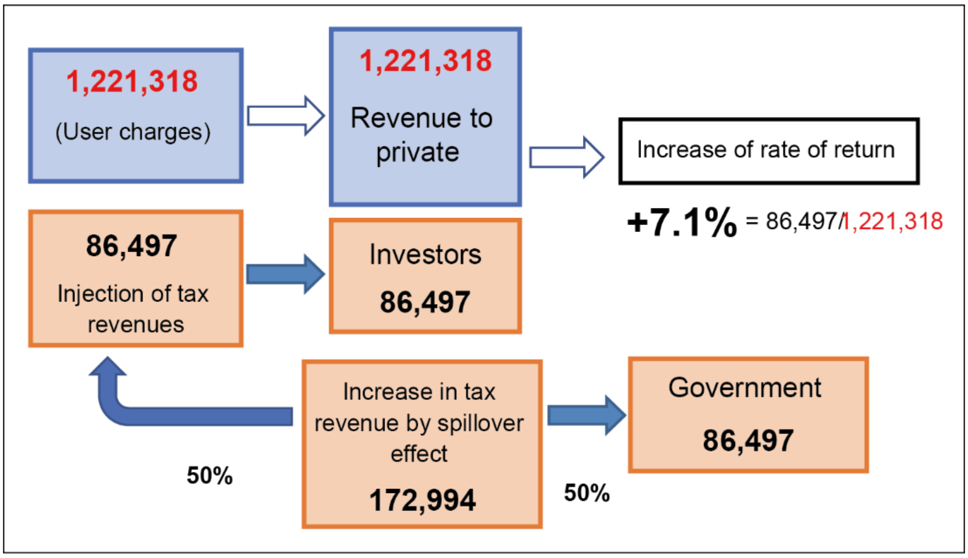
Table 2: Data Illustration to Define the Impact of Spillover Effect on Tax Revenue

Variable	Value
Average total revenue obtained from subscriber fees of mobile operators (2005–2016), million rupee	1,221,318
Estimated average total state tax increase, million rupee	172,994
Tax increment, %	14.2

Source: Authors' calculation using data from Yoshino et al. (2022).

Figure 5 illustrates a proposal to return spillover tax revenues to private investors based on the results shown in Table 2. The bottom part of the figure shows tax revenues created by the spillover effects of the ICT infrastructure (172,994 million rupees). Then, the government will inject a share of the increased tax revenues into private investors as subsidies. Out of the tax revenue increment received by government, 50% can be shared with private investors and 50% will remain with the government. If 50% of incremental tax revenues coming from the spillover effect are shared with the infrastructure investor by the government, the investors will receive an additional revenue from the increment in tax revenue created by the spillover effect equal to $172{,}994 \times 50\% = 86{,}497$. Finally, the return rate increases by 7.1% of the total revenue collected from user charges.

Figure 5: An Example of Shared Fractional Spillover Tax Revenues with Investors Using the Case of ICT Infrastructure Development in India



Source: Authors' calculation based on Yoshino et al. (2022).

Table 3 shows the cost and revenue of the PPP water supply project in Jakarta, Indonesia. The planning and preparation stage took place before 2015. The construction took four years from 2015 to 2019, and the total construction cost was Rp74 billion. Maintenance and operation costs for 11 years, from 2019 to 2030, are estimated to be Rp83 billion. In total, Rp180 billion will be spent, as shown in the cost column. The revenue from user charges (over the same period) is expected to be Rp248 billion. Hence, this case study is expected to earn revenue of Rp248 billion and spend a total of Rp83 billion.

Table 3: Cost and Revenue of Water Supply Project in Jakarta, Indonesia

Project Phase	**Period**	**Duration**	**Cost** (Rp billion)	**Revenue** (Rp billion)
Planning and Preparation	Before 2015	N/A	23	N/A
Construction and Transaction	2015–2019	4 years	74	N/A
Operation	2019–2030	11 years	83	248* (user charges)
Total		15 years	180	

*Authors' estimate.

Source: Authors' calculation using data from Limbong (2019).

Next, we analyze the impact of spillover tax revenues on the cost-benefit structure. Table 4 shows an original scenario (Column 2) and a scenario with spillover tax revenues (Column 3). The original scenario describes the cost-benefit structure of the project without the return of spillover tax revenue. Another scenario includes the return of spillover tax revenue in the calculation. The introduction of the return of spillover tax revenues increases the total revenue from 248 to 270 billion rupiah, and therefore changes the NPV of total revenue from 244 billion rupiah to 266 billion rupiah. By subtracting the NPV cost from the NPV revenue, the total revenue resulting in 131 billion rupiah, which is significantly higher than that of the original scenario of only 101 billion rupiah.

As for the internal rate of return (IRR), introducing the return of spillover tax revenues increases the IRR from 47% to 52%. The infrastructure project can attract much more private investment than the original scenario.

Table 4: Two Scenarios of Rate of Return of Water Supply Project in Jakarta, Indonesia

Variable	**Without Spillover Tax Revenue**	**With Spillover Tax Revenue**
(1)	*(2)*	*(3)*
Total Cost, Rp Billion	–180	–170
Net Present Value Cost (NPV) Cost, Rp Billion	127	120
Total Revenue, Rp Billion	248	270
NPV Revenue, Rp Billion	244	266
Net NPV, Rp Billion	101	131
Internal Rate of Return, %	47%	52%

4. THEORETICAL MODEL OF SPILLOVER EFFECTS OF WATER SUPPLY INFRASTRUCTURE ON HUMAN CAPITAL DEVELOPMENT AND HEALTH

In addition to increasing land and property values, which in turn will increase tax revenues collected by the government, the development of water supply infrastructure will also directly affect residents by improving their health and other environmental aspects. If all these benefits had been considered, the impact on water supply infrastructure would have been much more significant than what is reflected by the user charges. Therefore, this section will develop a theoretical model on the effects of the development of water infrastructure on human capital development and health by analyzing the behavior of households, the behavior of producers, and the water prices.

4.1 Behavior of Households

Equation 7 stands for the utility function of workers. C is positive consumption, L is labor supply as a negative utility, and β shows the relative magnitude of the labor supply in comparison to consumption.

Equation 8 is a budget constraint. Entire income is a wage revenue and then *PC* stands for consumption. In this model, we assume income comes from work and all the money will be consumed for simplicity.

Equation 13 and Figure 6 show the labor supply curve. In Equation 13, β diminishes as clean water supply infrastructure increases. β represents the disutility of labor supply by households. If clean water supply infrastructure becomes available, it will enhance health and reduce the disutility of labor supply. As real wages rise, the supply of labor increases. Thus, the labor supply curve is upward sloping, as shown in Figure 6. An increase in clean water will shift the labor supply curve to the right due to the reduction in the disutility of labor supply by households.

Households maximize their utility function:

$$\text{MAX } U(C,L) = C - \beta L^2, \tag{7}$$

$$\text{subject to } PC = wL, \tag{8}$$

where L = labor, C = consumption, and w = wage revenue.

Equations 7 and 8 can be converted to a Lagrange function:

$$\mathcal{L} = U(C,L) - \lambda(PC - wL). \tag{9}$$

From Equation 9 the first-order conditions are as follows:

$$\frac{\delta\mathcal{L}}{\delta C} = 1 - \lambda P = 0, \tag{10}$$

$$\frac{\delta\mathcal{L}}{\delta L} = -2\beta L + \lambda w = 0, \tag{11}$$

From Equation 10 we derive the Lagrange multiplier: $\lambda = \frac{1}{P}$. (12)

From Equation (11): $L^S = \frac{\lambda w}{2\beta} = \frac{1}{2\beta}\frac{w}{P}$. (13)

From Equations 8 and 13: $C = (w/p)(1/2\beta)(w/p)$. (14)

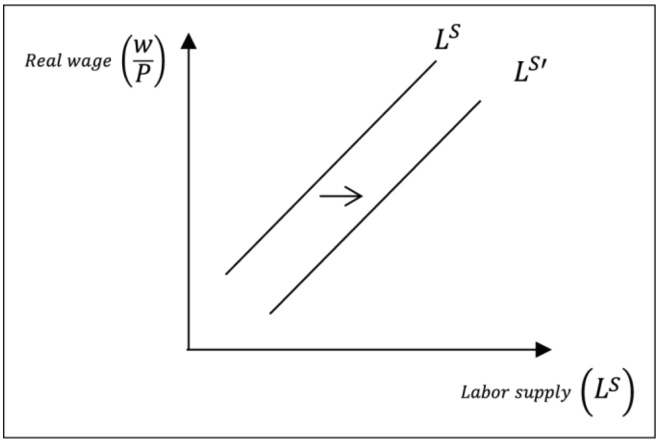
4.2 Behavior of Producers

The production function of producers is shown by Equation 15 as follows:

$$Y = F(K_P, AL, K_G) = K_P^{\alpha}(AL)^{\beta}K_G^{\gamma} + \theta_1[(AL)K_G] + \theta_2[KpK_G], \tag{15}$$

where K_P is private capital, A is quality of labor (if health conditions are improved by water supply, "A" increases), L is labor, and K_G is public capital.

Figure 6: The Impact of Increased Water Supply on Labor Supply Curve



Source: Authors.

The producer's profit function is obtained by subtracting the costs of labor and capital from the revenues (Equation 16):

$$\pi = PY - r_P K_P - wL - r_G K_G. \quad (16)$$

Producers maximize their profits, which are as follows:

$$\frac{\delta\pi}{\delta L} = \beta\frac{PY}{L} + \theta A K_G - w = 0, \quad (17)$$

$$\frac{\delta\pi}{\delta Kp} = \propto\frac{PY}{Kp} + \theta_2 K_G - r_p = 0. \quad (19)$$

From Equation 17 we get labor demand. Equation 18 is the demand for labor by companies, which depends on the real wage rate and also the magnitude of public infrastructure (shown by K_G, which includes water supply infrastructure). As the improvement of health created by water supply infrastructure increases, that will increase the demand for labor. As is shown in Equation 18, an increase in A (improvement of health conditions of workers caused by water supply) will increase the demand for labor.

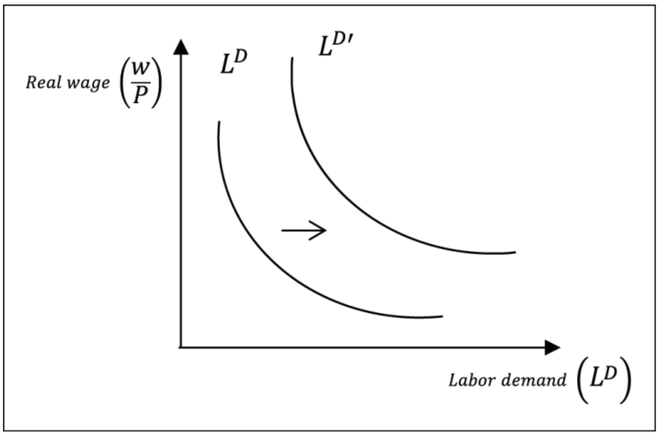
$$L^d = \frac{\beta Y}{\left(\frac{w}{P} - \frac{\theta A K_G}{P}\right)}. \quad (18)$$

And from Equation 19 we get capital demand. Equation 20 explains that a lower interest rate (r_p) will increase the demand for capital:

$$K_P = \frac{\propto PY}{(r_p - \theta K_p)}. \quad (20)$$

Referring to Equation 18, Figure 7 illustrates that an increased supply of clean water will increase labor demand (shift the labor demand curve to the right) because of increases in government capital (K_G) and the quality of labor/productivity (A).

Figure 7: Labor Demand Curve and the Increase in Water Supply

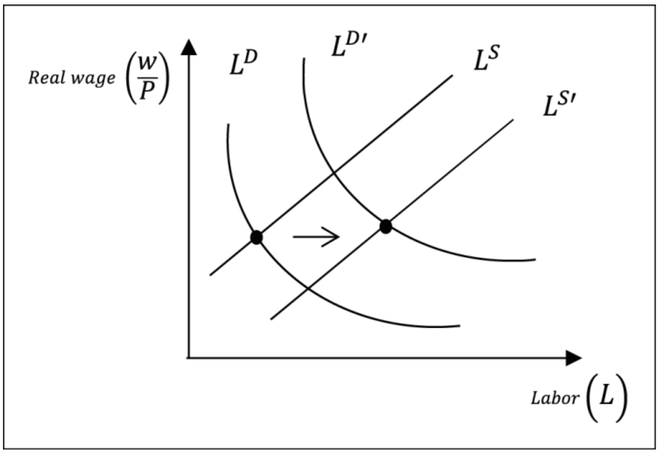


Source: Authors.

4.3 The Total Effects of an Increase in Water Supply Due to the Shift in Labor Supply and Labor Demand

Figure 8 shows the labor market equilibrium where labor supply is obtained from the utility maximization of workers, and labor demand is received from the company's profit maximization. The labor market equilibrium is at the intercept of the wage rate and supply and demand for labor as shown by point E. Improving water supply will increase labor supply because health quality will be enhanced, leading to an increased labor supply (a shift of the labor supply curve from L^S to $L^{S'}$). As for the demand, labor quality or productivity will rise and increase labor demand (a shift of the labor supply curve from L^D to $L^{D'}$). As a result, the new labor market equilibrium, shown by E', is determined at the new intercept of new labor supply and new labor demand. Most importantly, we can find a significant increase in labor demand and labor supply simultaneously owing to the rise in the supply of clean water.

Figure 8: The Impact of Increased Water Supply on Labor Market Equilibrium



Source: Authors.

4.4 Spillover Effects of Water Infrastructure Investment on the Price Level of Water

This section discusses the impact of the spillover effects of water supply infrastructure investment on the price level of water.

Traditionally, the price of water supply was determined by the costs of maintaining water supply infrastructure based on user charges. However, according to this paper, water supply infrastructure companies can receive a part of the spillover tax revenues, in addition to the user charges. That means the price of water by users can be diminished, and the extra payment created by spillover tax revenue can become additional income for the water supply infrastructure operating company.

Before, only a few people could afford the price of clean water. However, as income grows and the cost of water remains constant, the demand for clean water increases. More people can afford to pay for clean water, which will contribute to regional development including improved health conditions.

Equation 21 shows that aggregate demand (Y^d) consists of consumption (C), investment (I_p), and government spending (G). In this context, the increase in private capital (ΔK_p) is considered an investment. For example, if there is a new investment of government capital (ΔK_G), it will be a part of the aggregate demand. If a new water supply infrastructure company comes along the road, it will belong to private investment (ΔK_p).

$$Y^d = C + \Delta K_p + \Delta K_G = C + Ip + G. \quad (21)$$

Equation 22 shows the production function, i.e., output is a function of private capital, quality labor, and government capital. Note that both consumption and labor supply are functions of the price level (P), as shown by Equations 23 and 24.

$$Y^s = F\,(K_p, AL, K_G), \quad (22)$$

where:

$$C = \frac{1}{2\beta}\left(\frac{W}{P}\right)^2, \qquad L = \frac{\beta P \gamma}{W - \theta_1 A K_G}, \quad (23)$$

$$\Delta K_p = \Delta\left(\frac{\propto P\gamma}{r_p - \theta K_G}\right), \qquad K_p = \frac{\propto P\gamma}{r_p - \theta K_G}. \quad (24)$$

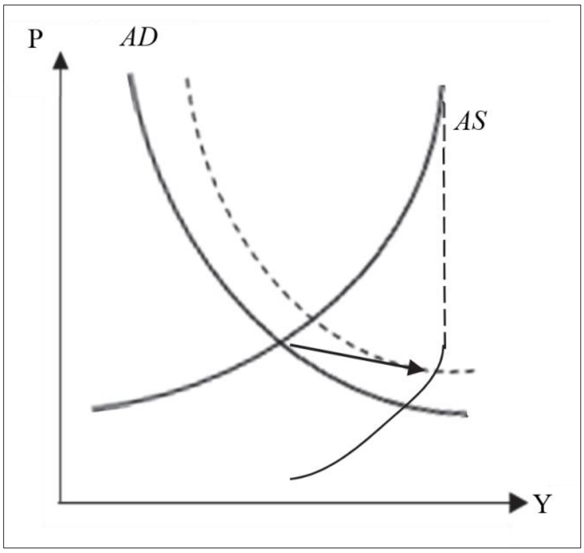
Thus, plugging Equation 23 and Equation 24 into Equation 22, we obtain:

$$Y^s = F\,(K_p(P), AL(P), K_G). \quad (25)$$

Figure 9 displays the aggregate supply (*AS*) curve and aggregate demand (*AD*) curve. If there is an increase in aggregate demand (Y^d), the AD curve moves to the right. If the AS curve shifts more than the AD curve, meaning that aggregate supply increases more than aggregate demand, the price level goes down. Conversely, if the shift of the *AD* curve is greater than that of the *AS* curve, the price level will go up.

In this figure, the shift of the *AS* curve partly comes from the spillover effects of water infrastructure development. New water infrastructure investments will bring new employment in the region as new companies start their business. That will increase K_p as well as *L*, which will further increase aggregate supply. When spillover effects are very large, *AS* will shift more than *AD*, which will reduce the price level.

Figure 9: The Shifts of Aggregate Demand and Aggregate Supply Curve



Source: Authors.

4.5 The Interest Rate Impact on Spillover Effect

This part explains how the interest rate will affect the spillover effects of water supply infrastructure.

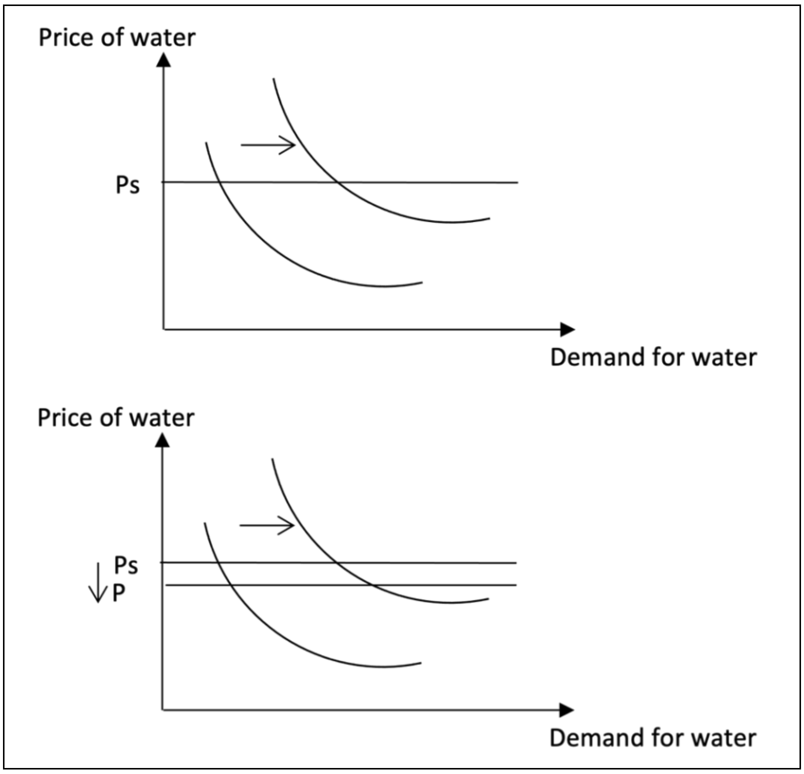
$$Y = \mathrm{F}[K_p(r_p), AL, K_{G})]. \quad (26)$$

Equation 27 shows the magnitude of the relation between the spillover and the interest rate (r_p). If the interest rate goes down, it will be relatively less costly for companies to take out loans. Lower interest rates will likely lead to larger spillover effects from infrastructure investments as businesses are more likely to develop. The explanation behind this is dY and dr_p is negative, which means that if the interest rate r_p is lower, the increase of *Y* will be bigger.

$$\frac{dY}{dr_p} = \frac{\partial F}{\partial K_p}\frac{\partial K_p}{\partial r_p} < 0. \quad (27)$$

Finally, the relation between interest rate and spillover effects and real output shows that if the interest rates are lower than the spillover effects of water supply infrastructure development, the new private businesses will become much easier to operate due to the low costs of borrowing.

Figure 10: The Shifts in Demand for Water and Price of Water



Source: Authors.

If a portion of the spillover tax revenues collected by the government is returned to water suppliers, the price for water can be pushed down. In Figure 10, this is shown by the shift of the horizontal line, depicting the price of water, from Ps to P. The lower price of water will further increase water demand, as it has become more affordable for more people. The rise in the demand for water is shown by the shift in the demand curve to the right.

It is important to note that there are variations in population density among regions, which may result in the attractiveness of infrastructure projects for the operators and investors of such projects, including water infrastructure projects, due to the difference in expected profitability. These are two ways to explain this phenomenon:

a) Output and tax revenue

$$Y = F(K_p, L, K_G) \quad (28)$$

$$Tax\ revenue\ =\ t.Y \quad (29)$$

Equation 28 shows that output is a function that depends on private capita, government/public capital, and labor. If water supplies are started in the region, many people can use water. The total production will increase more in the densely populated area than in the less densely populated region. A larger increase in regional GDP in a more populated region will achieve higher tax revenues. Equation 29 explains that tax revenues are dependent on the GDP of the region. If part of increased tax revenues were returned to infrastructure operators, their rate of return would rise much more.

b) Demand, consumption, and investment

$$Y = C + I + G \quad (30)$$

If the population density is higher, more people can increase their productivity when water supply infrastructure builds. The well-established water infrastructure is expected to increase consumption and investment, with the demand for consumption rising much more in the populated region. Likewise, companies' investment will rise more in the densely populated region.

Some regions in Japan have decreasing populations due to the aging population and urbanization of the younger cohorts. Similarly, there are areas, mainly rural ones, in developing countries that are less densely populated than urban areas. This has led to an extensive gap in water and sanitation infrastructure between urban and rural areas. According to ADB (2020), in 2020, rural areas in Asia and the Pacific had 50% or less access to water and sanitation compared to urban areas.

Focusing solely on single projects and the cost and benefits to those directly impacted might lead to an underestimation of their true effects. For example, in calculating the benefits of infrastructure development, the analysis often fails to include its spillover effects, such as the better health outcomes of the residents who now have access to clean water or the increased employment due to the raised labor demand as a result of the growth in businesses.

Similarly, as discussed earlier, such spillover effects may vary among regions. Regions with larger populations may have higher spillover effects, for example on tax revenues, than regions with smaller populations. Therefore, it is crucial to take a comprehensive look at their impact on an entire region or nation. The positive spillover effects in large cities can be pooled together and used to subsidize the water supply infrastructure in rural regions.

5. PROPOSAL OF SPILLOVER EFFECTS POOLING SYSTEM

Large cities can provide enhanced water supplies because the spillover benefits are huge compared to rural regions. However, the negative externality effects would be considerable if we looked at the negative aspects of nonexisting water supply infrastructure. Hence, these industries should focus on nationwide, rather than segmented, policies. We came up with a proposal to shape a pooling system of their profits made by externality effects in large cities so that they can be transferred as a service fee to rural regions. These pooling systems will create a nationwide network of water supplies to reduce negative externalities and create positive externalities for the nation. To apply this idea, setting up a committee consisting of infrastructure developers' private investors and government (central and local government) is necessary from the beginning of the construction of the water supply infrastructure. The ratio of the initial setting is 50:50 incremental tax revenue to government and infrastructure operators' investors. This arrangement shall be reviewed every year by the committee.

6. CONCLUSION AND POLICY IMPLICATIONS

With increasing operation and maintenance costs, maintaining the low price of water is not an easy task. In this paper, we argue that the price of the water supply can be kept very low by sharing the spillover tax revenues collected by the government with private investors and water infrastructure operators. Furthermore, this will bring private sector financing into water supply infrastructure development.

The spillover effect is actual and significant, as illustrated by some estimations in the literature review at the macro and project levels. Additionally, the theoretical model describes another potential spillover effect created by water supply infrastructure, human capital development, and health. By modeling the behavior of households, producers, and the price of water, it is easier to describe to policymakers the importance of water supply for the quality of health, which leads to the increase in labor supply. Through the same mechanism, workers' labor quality or productivity will increase labor demand.

A pooling system for the spillover benefits is crucial as there are variations in population density among regions, which may result in a difference in the attractiveness of water infrastructure projects for the operators and investors of such tasks. The industries should focus on national policy rather than segmented policies. When relevant pooling systems exist, we hope they will create a nationwide network of water supplies to reduce negative externalities and create positive externalities for the nation.

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