

Public Infrastructure and Foreign Investment in the presence of Monopolistic Competition

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Abstract

In the context of a small open economy where producer services sector operates under conditions of monopolistic competition and the level of foreign investment is endogenously determined, this paper examines the impact of changes in the supply of public infrastructure on various economic variables. The public infrastructure, which also enters consumer utility function in the form of a pure public good, reduces the fixed cost associated with the production of the services sector. It is shown that an increase in the supply of public infrastructure increases wage-rental ratio, decreases foreign investment and decreases the degree of monopoly power in the services sector.

Key Words: Public Infrastructure, Foreign Investment, Monopolistic Competition

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1. Introduction

The end of the cold war and rapid improvement in communication technology during the 1980s has resulted in a significant increase in capital flows across international boundaries. It is well-known that almost 50% of the US foreign investment takes place in Europe and vice versa (See Appleyard and Field, 2003). During the last two decades there has been a significant increase in foreign investment in developing countries. Since the Asian financial crisis of 1997-98, China has become the major recipient of foreign investment. Rapid economic growth experienced by countries such as Malaysia and Thailand before 1997-98 can be attributed to rapid capital inflows. It has been argued that a number of Southeast Asian economies were successful in attracting significant amount of foreign investment because of, among other things, the availability of modern production infrastructure (see Czikota, 2002 and Hill, 2003). Production infrastructure can be viewed as a public input that reduces the cost of production. A number of available studies have attempted to measure the productivity of the public infrastructure. These studies include Aschauer (1989), Otto and Voss (1994), Holtz-Eakin and Lovely (1996) and Lau and Sin (1997).¹

This paper focuses on the link between the supply of the public infrastructure and foreign investment. Din (1996) has considered the impact of development policy on capital inflow in the context of a small open economy but the model does not include a public sector. Holtz-Eakin and Lovely (1996) have developed a theoretical model that is suitable for an examination of the impact of changes in the supply of public infrastructure on various economic variables but their model does not include foreign investment. Markusen and Venables (1999) have considered the role of foreign

¹ For an excellent review of the related literature see Gramlich (1994). It is also worth mentioning that Abe (1990) has shown that changes in the supply of a public input can influence the pattern of trade whereas Casella and Feinstein (2002) have examined the role of public goods in facilitating trade among jurisdictions within the context of economic integration. Recent notable empirical studies involving public infrastructure include Morrison and Schwartz (1996) and Paul (2003).

investment in economic development but their framework does not include a public sector. This paper combines elements of Din (1996), Holtz-Eakin and Lovely (1996) and Markusen and Venables (1999). The model is relevant to a newly industrialised such as Hong Kong and Singapore or a high-income developing country such as Malaysia and Thailand where some sectors operate under condition of monopolistic competition and unemployment is not a serious problem.

This paper develops a framework that allows one to examine the impact of changes in the supply of public infrastructure on various economic variables including foreign investment. Specifically, the paper considers a small open economy that produces one industrial, one agricultural and one public good. The industrial good is produced by means of foreign capital, domestic labour and a large number of varieties of an intermediate good. The intermediate good sector can be considered as the services sector. Varieties of the intermediate good are produced by means of foreign capital and domestic labour. The public and the agricultural goods are produced by means of domestic capital and domestic labour. In other words, foreign investment takes place only in the services and the industrial good sectors. The public good is available to all consumer as well as producers of the intermediate good. In this regard the model resembles Clarida and Findlay (1992). From the point of view of producers, the public good is akin to public infrastructure that reduces the fixed cost associated with the production of the intermediate good. This aspect of the model is borrowed from Holtz-Eakin and Lovely (1996). Because of the presence of fixed costs, the production of each variety of the intermediate good is subject to internal economies of scale which gives rise to monopolistic competition. The presence of internal economies in the services sector gives rise to specialisation-based external economies in the production of the industrial good. Because of the presence of constant returns to scale, the industrial, the agricultural and the public

goods are produced under conditions of perfect competition. The paper shows that an exogenous increase in the supply of public infrastructure can decrease foreign investment and the degree of monopoly power in the services sector.

The rest of the paper is organised as follows. A simple model of a small open-economy is developed in section two. The impact of changes in the supply of public infrastructure on foreign investment, production, prices and the degree of monopoly power is examined in section three whereas the last section offers some concluding remarks.

2. A Simple Model

Consider a small open-economy that produces two traded goods (Y and Z) and one non-traded public good (G). Y is an industrial good whereas Z is an agricultural good. The industrial good is produced by means of foreign capital, domestic labour and a large number of varieties producer services. Each variety of the non-traded intermediate good (i.e., producer services) is produced by means of foreign capital and domestic labour. The agricultural and the public goods are produced by means of domestic capital and domestic labour. In other words, capital is sector specific - domestic capital is utilised in the production of the public and the agricultural goods whereas the foreign capital is utilised in the production of the industrial and the intermediate goods.² This paper assumes that foreign investment takes place in industrial sector only. This is not an unrealistic assumption since the industrial sectors attract most of the foreign investment. The production functions for Y , Z and G are as follows:

² For mathematical simplicity this paper assumes that the domestic supply of capital utilised in production of the industrial and the intermediate goods is zero. It can be easily confirmed that the results presented in this paper would be unaffected if the domestic supply of the relevant capital was not zero, see Din (1996).

$$Y = (L_y^{1-b} K_y^b)^{1-a} \left(\sum_{i=1}^n x_i^d \right)^{\frac{a}{d}}$$

$$Z = L_z^{1-g} K_z^g$$

$$G = L_g^{1-f} K_g^f$$

Where α , β , γ , ϕ and δ are parameters in the range $[0,1]$; x_i is the output of the i -th variety produced by industry X ; n is the number of varieties produced; L_y , L_z and L_g respectively are labour used in the production of Y , Z and G ; K_y , K_z and K_g respectively are capital used in the production of Y , Z and G .

Because of the presence of constant returns to scale, the average cost of production of each of the public, the agricultural and the industrial goods is fixed. On the other hand, due to the presence of fixed cost, the production of each variety of the intermediate good is subject to internal economies of scale. Because of the presence of internal economies of scale, monopolistic competition prevails in the non-traded intermediate good sector whereas all other goods are produced under conditions of perfect competition. The public good is primarily utilised by the consumers. However, from the point of view of the producers of the services sector, the public good is akin to public infrastructure that serves to reduce the fixed cost associated with the production of each variety.

There are many firms in producer services sector, each a little monopolist producing a distinct product with a technology that exhibits internal economies of scale. Examples of producer services consulting, auditing, engineering, architectural, legal services, etc. These services are primarily utilised by the industrial good producers and therefore they do not enter as input in the

production of other goods. The total production cost of each variety of the non-traded producer services consists of fixed and variable cost as follows:

$$c(w, r, x_i) = \left[\frac{m}{G^s} + I x_i \right] w^{1-q} \bar{r}^q$$

Where \bar{r} and w respectively are the price of foreign capital and the wage rate; q and s are parameters in the range (0, 1); and λ and m are positive constants. \bar{r} is determined in the international market and the industrial good is the numéraire. The first expression on the right hand side of the above equation is the fixed cost whereas the second expression is the variable cost. It is clear that an increase in the supply of public infrastructure decreases the fixed cost. An increase in the supply of production infrastructure is likely to attract foreign capital. It is obvious that the public infrastructure can be incorporated in the present model in a number of ways. For example one can argue that the public infrastructure also affects the variable cost in X -industry and it can be beneficial to the producers of Z . It is possible to incorporate these considerations in this model but the net effect would be that the mathematics would become too complicated with little additional insight. This paper attempts to examine the implications of changes in the supply of public infrastructure in a most simple setting.

Due to identical production functions and an equalisation of factor prices between sectors, all varieties produced are equally priced. Additionally, no two firms produce the same variety. Free entry and exit of firms derives the profit of firms down to zero. This paper considers a symmetric equilibrium where aggregate output of the services sector equals $X = nx$. Accordingly, the production function for the industrial good can be written as

$$Y = K_y^{b(1-a)} L_y^{(1-a)(1-b)} X^a n^{\frac{a(1-d)}{d}}$$

From the point of view of each firm in Y - industry, the number of varieties supplied is given. Accordingly, there are constant returns at the firm level (i.e., the exponents of K_y , L_y and X add up to unity) but for the industry as a whole there are economies of scale because $\alpha(1-\delta)/\delta$ is positive. For technical reasons $\alpha(1-\delta)/\delta$ is assumed to be less than unity (see Wong, 1995). In other words, the presence of internal economies of scale in the intermediate good industry leads to external economies of scale in the final good industry. The external economies of scale in the industrial good sector are compatible with perfect competition. The producer services sector produces a large number of differentiated goods. The price elasticity of demand for each differentiated good is $\left(\frac{1}{1-d}\right)$.³ The agricultural and the public good/infrastructure is also produced under conditions of perfect competition. Varieties of producer services are produced under conditions of monopolistic competition.

The following condition determines the equilibrium output of the industrial good industry where p_x is the price of x .

$$1 = \Theta \left[\frac{w}{\bar{r}} \right]^{-b+ab} \left[\frac{w}{p_x} \right]^{-a} w n^{\frac{-a(1-d)}{d}} \quad (1)$$

Where $\Theta = \frac{\mathbf{a}^{-a} \mathbf{b}^{-b(1-a)}}{(1-\mathbf{a})^{1-a} (1-\mathbf{b})^{(1-a)(1-b)}} > 0$

The right-hand side of equation (1) is the unit cost of production whereas the left-hand side is the unit price, which has been set equal to unity. The productivity of the industrial good industry is

³ A large number of existing studies are based on this and similar assumptions. For example see Dixit (1984), Helpman and Krugman (1985), Rivera-Batiz and Rivera-Batiz (1991), Ethier and Horn (1991), Holtz-Eakin and Lovely (1996), Rodrik (1996) and Venables (1996).

affected by the number of varieties produced by the services sector. An increase in the number of available varieties decreases the unit cost of production in the industrial good sector.

The presence of economies of scale in the services sector implies that a single firm under monopolistic competition will produce each variety. If the services sector is active in equilibrium then the following first order condition must hold

$$dp_x = l w^{1-q} \bar{r}^q \quad (2)$$

Equation (2) is the usual profit maximisation condition which shows that marginal revenue equals marginal cost. Because of free entry and exit, the price of each variety of the intermediate good in the long-run equilibrium will just cover average cost. By making use of the above equation, the zero profit condition which determines the number of firms in X -industry can be written as follows:

$$(1 - d)p_x x = \left[\frac{m}{G^s} \right] w^{1-q} \bar{r}^q \quad (3)$$

The equilibrium output of the agricultural industry is determined by the following condition where p_z is the price of the agricultural good which is determined in the international market.

$$p_z = \left[g^g + (1 - g)^{1-g} \right] w^{1-g} r^g \quad (4)$$

The small open economy under consideration is a price taker and therefore, the price of the agricultural good is exogenous.

The market clearing condition for labour, which is assumed to be in fixed supply, is as follows:

$$\begin{aligned} & \left[\frac{g}{1-g} \right]^{-g} \left[\frac{w}{r} \right]^{-g} Z + \left[\frac{f}{1-f} \right]^{-f} \left[\frac{w}{r} \right]^{-f} G + n \left[\frac{m}{G^s} + l x \right] (1 - q) \left[\frac{w}{\bar{r}} \right]^{-q} \\ & + \Theta(1 - a)(1 - b) \left[\frac{w}{\bar{r}} \right]^{-b(1-a)} \left[\frac{w}{p_x} \right]^{-a} n^{\frac{-a(1-d)}{d}} Y = L \end{aligned} \quad (5)$$

The first, the second, the third term and the fourth terms on the left-hand side of equation (5), respectively, are the demand for labour in industry Z , G , X and Y .

The market clearing condition for domestic capital (\bar{K}_d), which is assumed to be in fixed supply, is as follows where the first and the second terms on the left-hand side of equation (6), respectively, are the demand for capital in industry Z and G

$$\left[\frac{\mathbf{g}}{1-\mathbf{g}} \right]^{1-b} \left[\frac{w}{r} \right]^{1-g} Z + \left[\frac{\mathbf{f}}{1-\mathbf{f}} \right]^{1-f} \left[\frac{w}{r} \right]^{1-f} G = \bar{K}_d \quad (6)$$

As indicated earlier, the price of the foreign capital (\bar{r}) is determined in the international market. Accordingly the demand for foreign capital determines its supply (K_f). The equilibrium condition is as follows:

$$n\mathbf{q} \left[\frac{\mathbf{m}}{G^s} + l_x \right] \left[\frac{w}{\bar{r}} \right]^{1-q} + \Theta [\mathbf{b}(1-\mathbf{a})] \left[\frac{w}{\bar{r}} \right]^{1-b(1-\mathbf{a})} \left[\frac{w}{P_x} \right]^{-a} n^{\frac{-a(1-d)}{d}} Y = K_f \quad (7)$$

The first and the second terms on the left-hand side of equation (7), respectively, are the demand for capital in industry X and Y . The market clearing condition for the intermediate good is as follows where the left-hand side of the above equation is the demand for the intermediate good in X -industry and the right hand side is the supply.

$$(\Theta \mathbf{a}) \left[\frac{w}{\bar{r}} \right]^{-b(1-\mathbf{a})} \left[\frac{w}{P_x} \right]^{1-\mathbf{a}} n^{\frac{-a(1-d)}{d}} Y = nx \quad (8)$$

On the demand side all consumers are economically indistinguishable. The utility function of a representative consumer is as follows, where ξ and λ are constants and C_y^x and C_z^x respectively are the consumption of the industrial and the agricultural goods.

$$U = G^{\lambda} \left[C_y^x + C_z^x \right]^{\frac{1-\lambda}{\lambda}}$$

The above utility function indicates that the entire amount of the public good is available to each consumer. In other words, G is a pure public good from the view point of the consumers. The optimal supply of the public good which is viewed as the public infrastructure by the producers of the intermediate good can be determined by utility maximisation subject to appropriate resource constraints. However, for the purposes of this paper, the initial supply of the public good/infrastructure does not have to be optimal and therefore no attempt has been made to derive the relevant optimality condition. The cost of the public good/infrastructure is financed by non-distortionary taxes. The government in the present study can be considered as a Stackelberg leader. In other words, the government determines the supply of the public good/infrastructure and the private sector makes its decisions by taking the supply of G as given. This completes the description of the model where equations (1) to (8) are eight equilibrium conditions in eight endogenous variables; Y, Z, K_f, x, n, w, r and p_x . $G, \bar{r}, p_z, \bar{K}_d$ and L are exogenous variables.

3. Changes in the Supply of Public Infrastructure and the Private Sector

The existing literature in the area of foreign investment argues that massive capital inflow into countries like Singapore and Hong Kong can also be attributed to the provision of public infrastructure. Within the context of the present study the impact of exogenous changes in the supply of public infrastructure on prices, production, the degree of monopoly power in producer services sector and foreign investment can be examined by differentiating equilibrium conditions (1) to (8)

with respect to G . The impact of a change in the supply of public infrastructure on wage-rental ratio and the price of the intermediate good (i.e., producer services) is as follows:

$$\hat{w} - \hat{r} = \mathbf{a} \left(\frac{1-d}{d} \right) \left(\frac{\{K_z L_g - K_g L_z - \mathbf{s}K_z (nL_x)\}K_f}{\Delta} \right) \hat{G} \quad (9)$$

$$\hat{p}_x = \mathbf{g}(1-\mathbf{q})\mathbf{a} \left(\frac{1-d}{d} \right) \left(\frac{\{K_z L_g - K_g L_z - \mathbf{s}K_z (nL_x)\}K_f}{\Delta} \right) \hat{G} \quad (10)$$

$$\Delta = K_f \left[\mathbf{a} \left(\frac{1-d}{d} \right) \left\{ (1-\mathbf{g})K_z L_z + (1-\mathbf{f})K_g L_z + \mathbf{g}\mathbf{q}K_z (nL_x + L_y) \right\} \right. \\ \left. - \mathbf{g}\{1-\mathbf{b}(1-\mathbf{a})-\mathbf{a}\mathbf{q}\}(L_y + nL_x)K_z \right]$$

It is clear that the sign of the above derivatives depends on the sign of Δ . The sign of Δ depends on the size of the externality, i.e., $\mathbf{a} \left(\frac{1-d}{d} \right)$, arising from internal economies in the intermediate good sector. Δ is unambiguously negative as the size of this externality approaches zero. The rest of this paper assumes that the size of the externality is sufficiently small so that Δ is negative. This assumption ensures that the price-output responses (e.g., the relationship between p_z and Z) are normal. Also note that $\{1-\mathbf{b}(1-\mathbf{a})-\mathbf{a}\mathbf{q}\}$ is positive.

Equation (9) shows that an increase in the supply of public infrastructure unambiguously increases the wage-rental ratio as long as the infrastructure is equally (or more) capital intensive as compared to the agricultural good. At first this result appears counter intuitive because an increase in the supply of public infrastructure creates a shortage of capital relative to labour which decreases the wage-rental ratio in the context of traditional 2x2 models. However, in the present case, an increase in the supply of public infrastructure affects wage-rental ratio through the externality to the producers of the industrial good. An increase in the supply of public infrastructure increases the

wage-rental ratio because of its positive effect on the production of the industrial good. If varieties of producer services were perfect substitute for each other then the size of externality would be zero and hence the wage-rental ratio would not respond to changes in the supply of public infrastructure. An increase in the supply of public infrastructure, because of its positive effect on the production of the industrial good, increases the equilibrium price of varieties of producer services as indicated by equation (10).

The impact of an increase in the supply of public infrastructure on equilibrium number of varieties produced is as follows:

$$\hat{n} = [1 - \mathbf{b}(1 - \mathbf{a}) - \mathbf{a}\mathbf{q}] [K_z L_g - K_g L_z - \mathbf{s}(nL_x K_z)] \left(\frac{gK_f}{\Delta} \right) \hat{G} \quad (11)$$

Equation (11) shows that relationship between the supply of public infrastructure and the number of varieties produced is positive if the infrastructure is equally (or more) capital intensive as compared to the agricultural good. As noted earlier, an increase in the supply of public infrastructure increases the equilibrium price of each variety. By making use of equations (2) and (3), it can be easily confirmed that there is a negative relationship between the supply of public infrastructure and the production of each variety. This follows from the fact that an increase in the supply of public infrastructure decreases the fixed cost associated with the production of each variety thereby reducing the extent of the economies of scale. An increase in the number of varieties produced is a logical outcome. It can also be easily confirmed that an increase in the supply of public infrastructure increases the overall output of the services industry (i.e., nx). Equation (11) also shows that an increase in the supply of public infrastructure increases the degree of specialisation and hence decreases the monopoly power in producer services sector.

An increase in the degree of specialisation increases the externality enjoyed by the producers of the industrial good. Accordingly, an increase in the supply of public infrastructure leads to a larger increase in the production of the industrial good as shown by equation (12) as follows:

$$\hat{Y} = - \left[\{1 - b(1 - a) - aq\} + a \left(\frac{1-d}{d} \right) (1-q) \right] \left[K_g L_z - K_z L_g + s(nL_x K_z) \left(\frac{gK_f}{\Delta} \right) \right] \hat{G} \quad (12)$$

The impact of an exogenous change in the supply of public infrastructure on production of the agricultural good is as follows:

$$\hat{Z} = \left[\begin{array}{l} g\{1 - b(1 - a) - aq\}(nL_x + L_y) \\ + a \left(\frac{1-d}{d} \right) \left\{ s(nL_x) [(1-g)K_z + (1-f)K_g] \right. \\ \left. - (1-g)K_z L_g - gq(nL_x + L_y)K_g - K_g L_g \right\} \end{array} \right] \left(\frac{K_f}{\Delta} \right) \hat{G} \quad (13)$$

It is clear from equation (13) that the impact of any change in the supply of public infrastructure on the production of the agricultural good does not depend on relative factor intensities. In fact the relationship between the supply of public infrastructure and the production of the agricultural good is likely to be negative if the size of externality to the industrial good producers is sufficiently small.

The level of foreign investment in the present study is endogenous. The impact of a change in the supply of public infrastructure on capital inflow (i.e., foreign investment) is as follows:

$$\hat{K}_f = \left[\begin{array}{l} g\{1 - b(1 - a) - aq\} \left\{ \bar{K}_d (K_g L_z - K_z L_g) + s(nL_x K_y - nK_x L_y) \right\} \\ + a \left(\frac{1-d}{d} \right) \left\{ \begin{array}{l} g(1-q)(K_g L_z - K_z L_g) \bar{K}_d \\ + s \left[\begin{array}{l} nK_x K_z \{L_z + fL_g + g(nL_x)\} \\ + (1-f)(nK_x)K_g L_z + g(1-q)(nL_x) \end{array} \right] \end{array} \right\} \end{array} \right] \left(\frac{\hat{G}}{\Delta} \right) \quad (14)$$

Equation (14) shows that an increase in the supply of public infrastructure leads to capital outflow (i.e., a decrease in foreign investment) if the infrastructure is equally (or more) capital intensive as compared to the agricultural good and the industrial good is equally (or more) capital intensive as compared to the services sector. It has been argued that provision of public infrastructure leads to capital inflow. However, in the present case an increase in the supply of public infrastructure can lead to capital inflow only if either the infrastructure, or the industrial good, or both are relatively labour intensive. This is likely to be the case in developing countries such as China and India. It is also worth mentioning that in their early stages of economic growth (i.e., during the 1970s and 1980s), the manufacturing sectors of Hong Kong and Singapore were largely labour intensive.

The framework of this paper can also be used to examine the impact of changes in the supply of public infrastructure on welfare. In the context of this paper, welfare can be measured by the disposable income which consists of total income of domestic capital and labour less the total cost of public infrastructure. An increase in the supply of public infrastructure tends to decrease welfare because the cost of infrastructure is funded by taxation. However, an increase in the supply of infrastructure also increases wage-rental ratio. An increase in the supply of public infrastructure can increase welfare only if the increase in wage-rental ratio more than offsets the negative impact of tax burden.

4. Concluding Remarks

Massive foreign investment in Southeast Asian economies such as Hong Kong and Singapore has been attributed to, among other things, provision of modern production infrastructure.

This paper examines the impact of changes in the supply of public infrastructure which also enters consumer utility functions in the form of a pure public good. The results presented in this paper are based on a simple model of a small open economy that produces one industrial, one agricultural and public infrastructure. The industrial good is produced by means of foreign capital, domestic labour and a large number of varieties of producer services. Varieties of producer services are produced by means of foreign capital and domestic labour. The public infrastructure and the agricultural goods are produced by means of domestic capital and domestic labour. The infrastructure can be viewed as a composite good which is available to all consumers and it also serves to reduce the fixed cost associated with the production of varieties of producer services. The public infrastructure and the varieties of producer services are non-traded. All goods except the varieties of producer services are produced under conditions of perfect competition. Due to the presence of internal economies, varieties of producer services are produced under Chamberlinian monopolistic competition. The presence of internal economies in the services sector gives rise to specialisation-based external economies in the industrial good sector.

The paper shows that an exogenous increase in the supply of public infrastructure increases the wage rental-rental ratio and the equilibrium price of varieties of producer services if the infrastructure is equally (or more) capital intensive as compared to the agricultural good. An increase in the supply of public infrastructure increases the number of varieties of producer services which reflects a decrease in the degree of monopoly power in the services sector. An increase in the supply of public infrastructure increases the production of the industrial good but its impact on the production of the agricultural good cannot be unambiguously determined. Finally, an increase in the supply of public infrastructure leads to a decrease in foreign investment if the industrial good is

equally (or more) capital intensive as compared to varieties of producer services and the public infrastructure is equally (or more) capital intensive as compared to the agricultural good. In other words, an exogenous increase in the provision of public infrastructure is likely to increase foreign investment only if (a) the infrastructure is labour intensive as compared to the agricultural good, or (b) the industrial good is labour intensive as compared to varieties of producer services, or (c) both the public infrastructure and the industrial goods are relatively labour intensive.

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