Increased Labour Supply, Foreign Investment and Welfare in the presence of Productive Public Infrastructure

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Abstract

This paper focuses on the impact of an exogenous increase in the supply of labour on foreign investment, public infrastructure and welfare. By making use of a simple general equilibrium model this paper shows that increased supply of labour increases the provision of public infrastructure and hence the domestic wage rate. An increase in the supply of labour leads to an unambiguous increase in foreign investment if public infrastructure is more (or equally) labour intensive as compared to the final good. The size of the increase in wage rate and public infrastructure is affected by the size of the fixed cost associated with infrastructure production. An increase in the supply of labour leads to a larger increase in welfare as long as the public infrastructure is productive and its production involves some fixed cost.

Key Words: Foreign Investment, Provision of Public Infrastructure, Labour Inflow

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1. Introduction

Foreign investment has played a significant role in economic growth in a number of Asian economies such as Hong Kong, Malaysia, Singapore, South Korea, Taiwan and Thailand. A significant increase in foreign investment has occurred over the last few decades. Increased foreign investment may, in part, be attributed to improvements in communication technology and the end of the cold war.\(^1\) The recent expansion of the European Union, moves towards inclusion of India in ASEAN, the signing of a free trade agreement between Australia and the US and continued growth economic growth in China appear likely to create additional opportunities for foreign investment within the Asian economies. The following figure shows the actual and forecasted growth rate of the US real investment in Singapore’s manufacturing sector from 1981 to 2004. A decline in the growth rate of the US investment in Singapore’s manufacturing sector in the recent years can be attributed to a strong competition from China.

![Figure 1: Growth Rate of the US Real Investment in Singapore's Manufacturing Sector (1981-2004)](image)

\(^1\) Despite a world-wide increase in foreign investment, most foreign investment takes place from one developed country to another. For example, almost 50% of the US foreign investment takes place in Europe and vice versa (See Appleyard and Field, 2001).
Figure 1 shows that after a continuous decline in the growth rate of the US investment in Singapore starting from 1999, there has been an increase in 2003. Time series forecasting involving a second order Autoregressive process suggests that the negative trend is likely to continue into the future. On the other hand, time series forecasting, involving an autoregressive process of order eight, suggests that the growth rate of Japanese real investment in Singapore’s manufacturing sector is likely to increase as indicated by Figure 2 below.

Figure 2: Growth Rate of the Japanese Real Investment in Singapore's Manufacturing Sector (1981-2004)

The existing literature in the area of development economics suggests that foreign investment, among other things, is attracted by the provision of appropriate production infrastructure. However, most existing studies involving foreign investment do not explicitly include infrastructure provision. A number of existing studies have considered the impact of exogenous changes in foreign investment on prices, production and welfare. The welfare aspects of foreign investment and several related issues have been discussed by a number of recent studies including Markusen and Venables (1999), Markusen (2002), Fumagalli (2003),

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2 See Wong (1995) and Bhagwati, Panagariya and Srinivassan (1998) for an excellent review of the existing literature on foreign investment and trade.
Asiedu and Lien (2003), De Santis and Stähler (2004) and Desai, Foley and Hines (2004). Din (1996) is one of the few studies where foreign investment is endogenous. Appleyard and Field (2001), Hill (2003) and Lipsey (2003) believe that foreign investment, in addition to facilitating technology transfer, also creates jobs. While all countries welcome capital inflow, restrictions of labour inflow have not eased over time. For obvious reasons, high wage countries accept only a small number of foreign workers. In other words, while the supply of capital due to foreign investment is almost endogenous, the supply of labour due to serve restrictions on labour inflow remains exogenous.

The importance of the role of public infrastructure in all real economies has been long recognised. Rioja (1999) showed that public infrastructure investment could lead to a sizeable increase in GDP. Demetriades and Mamuneas (2000) examined the impact of public infrastructure on production and input demand in 12 OECD countries and showed that increased spending on public infrastructure was associated with higher levels of production. They also found a positive relationship between the demand for inputs and the supply of public infrastructure. Kemmerling and Stephan (2002) argue that public infrastructure makes significant contribution to the private sector production. Hoffmann (2003) empirically examined the link between the supply of public infrastructure and capital inflows. By making use of fairly disaggregated cross-sectional data, Hoffmann concluded that there was a positive relationship between the supply of public infrastructure and capital inflow.³

The following figure shows the actual and forecasted growth rate of the real average productivity of labour in Singapore’s manufacturing sector. Variation in the growth rates of

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the average productivity of labour can be linked to variations in foreign investment and
corporate infrastructure provision. Figure 3 shows that the growth rate is forecasted to decline
in the future. The forecasted growth rate is based on an autoregressive process of order six.

Figure 3: Growth Rate of the Real Average
Productivity of Labour in Singapore's

In real life, provision of public infrastructure involves significant fixed cost. While
the existing empirical studies have established the usefulness of infrastructure provision,
none of the existing studies seem to have considered the role of the fixed cost. This paper
focuses on the impact of exogenous increase in labour supply when foreign investment and
public infrastructure provision is endogenous and the infrastructure provision involves
significant fixed cost.

The paper shows that an exogenous increase in labour supply increases the provision of
public infrastructure, which in turn, enhances the productivity of the private sector and hence the
domestic wage rate increases. An increase in the supply of labour increases the production of the
private sector and its effect on foreign investment is unambiguously positive as long as the
infrastructure is more (or equally) labour intensive as compared to the private sector. An
increase in the supply of labour leads to a larger increase in welfare if the infrastructure is
productive and its production involves some fixed cost.
Three further sections complete this paper. A simple general equilibrium model is developed in section two. The model describes an economy where foreign investment and public infrastructure are endogenous. Section three uses the model to examine the impact of increased supply of labour on foreign investment, provision of public infrastructure and welfare. The fourth section contains some concluding remarks.

2. A Simple General Equilibrium Model

In order to focus on the impact of increased labour supply on foreign investment, provision of public infrastructure and welfare, this paper utilises a simple model of an economy that produces one final good. The final good can be considered as a composite good. An increase in the supply of labour can be attributed to an increase in immigration or the intake of guest workers. The final good \( Y \) is produced by means of capital, labour and public infrastructure. The public infrastructure \( G \) is akin to a pure public input, which enters production functions. The production functions for \( Y \) is as follows:

\[
Y = G^{\delta} f(K_y, L_y)
\]

where \( \delta \) is a parameter in the range \([0, 1]\); \( L_y \) and \( K_y \) respectively are labour and capital used in the production of \( Y \); \( f(.) \) is linearly homogeneous with respect to capital and labour.

The producers of the final good take the supply of public infrastructure as given. This implies that there are constant returns to scale at the firm level, but there are external economies for the industry as a whole.\(^4\) It is well known that such external economies are consistent with a competitive market structure.

\(^4\) Markusen (1990) provides microeconomic foundations of external economies. For a recent review of literature on external effects, see Choi and Yu (2003).
In the initial equilibrium, the supply of domestic labour is assumed to be fixed and there is no mobility of labour across international boundaries. The wage rate \((w)\) is determined by the interaction of domestic supply and demand. The supply of domestic capital is fixed, but due to free capital mobility, unlimited amount of capital can be acquired from the international market. The domestic producers take the rate of return on capital \((\bar{r})\) determined in the international market as given. This also equals the rate of return on capital in the domestic market. Public infrastructure is produced by means of capital and labour. The cost of infrastructure production involves fixed as well as variable cost as follows:

\[
c(w, r, G; \alpha, \beta) = [\alpha + \beta G]c^G(w, r)
\]

where \(\alpha\) and \(\beta\) are positive parameters and \(c^G(.)\) is homogenous of degree one in its arguments.

\(\alpha = 0\) implies that there is no fixed cost and hence the average cost equals the marginal cost. The above cost function is consistent with real life situations where provision of infrastructure involves significant fixed cost. Because of the presence of the fixed cost, the public infrastructure industry is characterised by internal economies of scale. This paper views public infrastructure as being produced by a public firm that is not focussing on profit maximisation.

The optimal supply of public infrastructure is determined by average cost pricing. In other words, the average cost of public infrastructure production is compared with the marginal benefits to the producers of the final good as follows:

\[
\frac{\delta Y}{G} = \left[\frac{(\alpha + \beta G)c^G(w, r)}{G}\right]
\]

The right hand side of equation (3) is the average cost of public infrastructure provision, whereas the left hand side is the marginal benefits to the producers of the final good. Equation
(3) suggests that the public firm producing infrastructure earns zero profit. The cost of public infrastructure is financed by means of non-distortionary income taxation.\textsuperscript{5}

The profit maximising output of the final good is determined by the following first order condition where $c^y(\cdot)$ is the relevant unit cost function which is homogenous of degree one in its arguments.

$$1 = \frac{c^y(w, \bar{r})}{G^\delta} \quad (4)$$

The right-hand side of equation (4) is the marginal cost and the left hand side is the price, which has been set equal to unity. The supply of infrastructure directly impinges on the marginal cost (which equals the average cost) of the final good as long as $\delta$ is non-zero. This implies that the provision of public infrastructure leads to a positive externality for the producers of the final good. Equation (4) suggests that the presence of public infrastructure reduces the cost of final good production. Empirical analysis conducted by Chandra and Thompson (2000) supports the view that the provision of public infrastructure reduces private sector’s cost of production. In addition, Salinas-Jimenez (2004) suggests that the provision of public infrastructure can increase productivity of the private sector.\textsuperscript{6}

The labour market clearing condition is as follows where $\bar{L}$ is the supply of domestic labour.

$$\left[ \frac{Y}{G^\delta} \right] c^y_u(w, \bar{r}) + (\alpha + \beta G)c^w(u, \bar{r}) = \bar{L} \quad (5)$$

\textsuperscript{5} Feehan (1998) has derived first and second best optimality rules that could be applied to the provision of public infrastructure. In addition, while focusing on the case of factor augmenting public infrastructure, Feehan and Matsumoto (2000) have examined the properties of the optimal tax rates when the cost of public infrastructure is financed according to benefit-taxation principle.

\textsuperscript{6} Other studies such as Conrad and Seitz (1994) have also shown that the provision of public infrastructure can reduce the cost of production. Some of the recent notable studies include Kim (1998), Feltenstein and Ha (1999), Delorme, Thompson and Warren (1999), Paul (2003), Cohen and Paul (2004) and Paul, Sahni and Biswal (2004).
Equation (5) determines the domestic wage rate. The first and the second terms on the left-hand side of equation (5) respectively are the demand for labour in industry $Y$ and $G$; whereas the right hand side is the supply.

Due to free mobility of capital, the rate of return on domestic capital equals the rate of return in the international market. As indicated earlier, the small open economy under consideration cannot influence the international rate of return. The equilibrium foreign investment ($K_f$) in the domestic economy is determined by the following condition where $\bar{K}$ is the supply of domestic capital, which is assumed to be fixed.

$$\left[ \frac{Y}{G} \right] c^*(w,\bar{\tau}) + (\alpha + \beta G)e^\delta(w,\bar{\tau}) = \bar{K} + K_f$$

The first and the second terms on the left-hand side of equation (6) respectively are the demand for capital in industry $Y$ and $G$, whereas the right hand side is the aggregate supply of capital.

This completes the description of the model. Equations (3) to (6) encapsulate the model. These equations are four equilibrium conditions that involve four endogenous ($Y$, $G$, $K_f$ and $w$) and three exogenous variables ($\bar{\tau}$, $\bar{K}$ and $\bar{L}$).\footnote{It is clear that the framework of this paper does not allow one to consider spillover issues associated with international public goods. Within the context of selected East Asian economies, Wang (2002) has attempted to estimate the spillover effects associated with the provision of public infrastructure. While viewing infrastructure as an international public good, Bougheas, Demetriades and Morgenroth (2003) have shown that, from a global perspective, the equilibrium level of infrastructure provided by each country can be suboptimal.}

### 3. Effect of Increased Labour Supply on the Private and Public Sectors

The results presented in this section are derived by making use of equilibrium conditions (3) to (6). Specifically, total differentiation of these conditions with respect to $\bar{L}$ allows one to
relate the impact of an exogenous increase in the supply of labour on the wage rate, provision of public infrastructure, production of the final good and foreign investment. The relationship between the supply of labour and the wage rate may be examined by means of equation (7) below where a circumflex is used to denote proportional changes.

\[ \hat{w} = \left[ \frac{\delta L}{\Delta} \right] \left[ \frac{K_f}{K_f + K} \right] \hat{L} \]

(7)

\[ \Delta = \left\{ \frac{\beta G}{\alpha + \beta G} \right\} \eta_w^y \hat{L} + \delta \left( (\eta_{ww}^y - \eta_{ww}^\beta) L_y + (\eta_{ww}^\beta - \eta_{ww}^\gamma) L_g \right) \left[ \frac{K_f}{K_f + K} \right] \]

where \( \eta_w^y \) and \( \eta_w^\gamma \) respectively are the elasticity of the final good and the public infrastructure’s unit cost function with respect to the wage rate.

Both elasticities (i.e., \( \eta_w^y \) and \( \eta_w^\gamma \)) are a measure of demand for labour per-unit of output. Since the demand for labour cannot be negative, both elasticities are positive. \( \eta_{ww}^y \) and \( \eta_{ww}^\gamma \) are negative because the cost functions are convex in factor prices.\(^8\) The sign of the above derivative depends on the sign of \( \Delta \) which depends on the size of the external economies enjoyed by final good producers arising from public infrastructure provision. The size of the external economies depends on the size of \( \delta \). For example, \( \Delta \) is unambiguously positive if \( \delta \) is zero. The rest of this paper assumes the size of the external economies is sufficiently small thereby ensuring \( \Delta \) is positive.\(^9\) It is also clear that the size of \( \Delta \) also depends on the size of the fixed cost (i.e., \( \alpha \)) associated with the provision of public

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\(^8\) This paper makes extensive use of the properties of cost functions (see Varian, 1992). An extensive review of various trade models can be found in Rivera-Batiz and Oliva (2003) Feenstra (2004).

\(^9\) This assumption also ensures that the equilibrium is stable. In fact one of the Routh-Hurwitz stability conditions requires \( \Delta \) being positive which ensures that price-output responses are normal. See Wong (1995) for further discussion of the stability condition. It is well known that the presence of external economies can result in multiple-equilibrium which gives rise to stability problem. This paper however focuses on a stable equilibrium.
infrastructure. Specifically, the value of \( \Delta \) would be higher if the fixed cost was lower. In other words, the size of the impact of increased labour supply on equilibrium wage rate, production of the final good, provision of infrastructure, foreign investment and welfare also depends on the size of the fixed cost.

Equation (7) shows that there is a positive relationship between the supply of labour and the domestic wage rate. This follows from the fact that increased labour supply increases the optimal level of public infrastructure which increases the size of external economies enjoyed by producers of the final good. In other words, increased labour supply effectively increases the productivity in the final good sector and hence the equilibrium wage rate increases. It is clear that increased labour supply has no effect on the wage rate if the external economies were not present (i.e. \( \delta = 0 \)). It can also be easily confirmed that due to the presence of the fixed cost associated with public infrastructure provision, an increase in the supply of labour leads to a larger increase in the wage rate.

The impact of increased labour supply on public infrastructure provision can be examined by means of equation (8) as follows:

\[
\hat{G} = \left[ \frac{\eta_y L}{\Delta} \right] \left[ \frac{K_f}{K_f + K} \right] \hat{L}
\]

Equation (8) shows that increased supply of labour increases the provision of public infrastructure. For a given supply of public infrastructure, an increase in the supply of labour increases the marginal benefits of infrastructure provision through an increase in the output of the final good. Since the increase in marginal benefits is larger than the increase in the average cost of public infrastructure production, the supply of public infrastructure increases. Once again it can be easily confirmed that due to the presence of the fixed cost involving

\[\delta = 0 \text{ implies that the public infrastructure is unproductive.}\]
infrastructure production, increased labour supply leads to a larger increase in infrastructure provision.

The impact of increased labour supply on production of the final good can be examined by means equation (9) as follows:

\[ \hat{Y} = \left[ \frac{\beta G}{\alpha + \beta G} \right] \eta_y^w + \delta \eta_y^w \left[ \frac{K_f \hat{L}}{(K_f + \hat{K}) \Delta} \right] \hat{L} \]  

(9)

Equation (9) shows the presence of external economies affects the size of the increase in final good production. For a given supply of public infrastructure, an increase in labour supply increases the final good production. Since increased labour supply increases the provision of public infrastructure there is a further increase in production of the final good. In other words, the presence of the external economies in the final good industry leads to a larger increase in the production of the final good. It is clear that the size of the fixed cost (i.e., the size of \( \alpha \)) also affects the size of the above comparative static response.

The impact of increased labour supply on foreign investment can be examined by means of equation (10) as follows:

\[ \hat{K}_f = \left[ \frac{\beta G}{\alpha + \beta G} \right] (\hat{K} + K_f) + \delta \left( K_y \left( \eta_y^g - \eta_y^w \right) - \left( \eta_y^w K_y + \eta_y^g K_y^g \right) \right) \left[ \frac{\hat{L}}{\Delta} \right] \hat{L} \]  

(10)

Equation (10) shows that an increase in the supply of labour leads to an unambiguous increase in foreign investment as long as the production of public infrastructure is equally (or more labour) intensive as compared to the final good (i.e., \( \eta_y^g \geq \eta_y^w \)). Increased labour supply can decrease foreign investment if the final good is labour intensive as compared to public infrastructure (i.e., \( \eta_y^g < \eta_y^w \)). It is clear that the size of the external economies affects the size of the increase in foreign investment. In the absence of external economies, an increase in labour supply increases foreign investment was not present irrespective of the
relative labour intensity. In addition, the size of the fixed cost associated with the provision of public infrastructure has no bearing on the size of the increase in foreign investment if the external economies were not present.

3.1 Welfare Effect of Increased Labour Supply

Within the context of this paper, welfare can be measured by net income \( I \) as follows:

\[
I = wL + \tau K - (\alpha + \beta G)c^\delta(w, \tau)
\]  \hspace{1cm} (11)

where \( wL + \tau K \) is the gross income of domestic labour and capital.

The cost of public infrastructure is financed by a proportional income tax which is paid by domestic labour and domestic capital. The government budget constraint is as follows:

\[
(\alpha + \beta G)c^\delta(w, \tau) = t[wL + \tau K]
\]  \hspace{1cm} (12)

The impact of an increase in the supply of labour on welfare can be examined by differentiating equation (11) as follows:

\[
\hat{I} = \left[ \frac{wL}{I} \right] \left[ 1 + \delta \left\{ L - L_g - \left( \frac{\beta G}{\alpha + \beta G} \right) L_y - \left\{ \frac{K_f}{(K_f + K)\Delta} \right\} \hat{L} \right] \right] \hat{L}
\]  \hspace{1cm} (13)

For a given wage rate, an increase in the supply of labour tends to increase welfare. As noted earlier, an increase in labour supply increases the wage rate and hence there is a larger increase in welfare. Equation (13) shows that the size of the welfare effect decreases as the size of the external economies approaches zero (i.e., \( \delta \to 0 \)). In other words, in the absence of productive public infrastructure, the welfare effect of increased labour supply is smaller. It is also interesting to note that the overall impact on welfare is significantly affected by the presence of the fixed cost associated with public infrastructure production.
Equation (13) shows that in the absence of the fixed cost (i.e., \( \alpha = 0 \)), the welfare effect is smaller even if the external economies are present (i.e., \( \delta > 0 \)). Due to the crucial role played by the presence of the fixed cost, one can argue that governments should not hesitate to fund productive public infrastructure that involves significant fixed cost. It should be kept in mind that within the context of this paper, the foreign capital is not taxed.

Producers welcome increased supply of labour because it increases the supply of public infrastructure and hence the external economies enjoyed by final good producers. Consumers supplying labour also benefit from the higher wage rate. Finally, it is perhaps worth mentioning that a small increase in labour supply can potentially decrease welfare if the economy was initially stuck in an unstable equilibrium (stability requires \( \Delta \) to be positive, if the economy was initially stuck in an unstable equilibrium then \( \Delta \) is going to be negative).

4. Concluding Remarks

This paper focuses on the impact of increased labour supply on foreign investment, provision of public infrastructure and welfare. The paper utilises a simple general equilibrium model of an economy that produces one final good by means of capital, labour and public infrastructure. The infrastructure is produced by means of capital and labour and its production involves fixed as well as variable cost. The cost of infrastructure is financed by means of non-distortionary income taxation. Labour is immobile across international boundaries but there are no restrictions on capital mobility, which gives rise to foreign investment in both the private and the public sectors.

The presence of public infrastructure gives rise to external economies to the producers of the final good. Because of the presence of external economies, there is a positive relationship between the wage rate and labour supply. An increase in the supply of labour increases the
optimal provision of public infrastructure. Due to the presence of external economies, an increase in the supply of labour leads to a larger increase in final good production. The size of the fixed cost associated with public infrastructure provision plays a crucial role. For example, the increase in the wage rate and the provision of public infrastructure would be smaller if the fixed cost was zero. An increase in the supply of labour increases foreign investment if the infrastructure production is more (or equally) labour intensive as compared to the final good. Otherwise, an increase in the supply of labour may decrease foreign investment. Increased labour supply leads to a larger increase in welfare, as long as external economies are present and public infrastructure production involves some fixed cost. The absence of the fixed cost nullifies the positive impact of productive public infrastructure on welfare. Finally, a small increase in labour supply can lead to a decrease in welfare if the economy was initially stuck in an unstable equilibrium.

Appendix

The results presented in this paper are derived by making use of the following equations. These equations are derived by totally differentiating equations (3) to (6).

\[ \eta^g \hat{w} - \hat{Y} + \left[ \frac{\beta G}{\alpha + \beta G} \right] \hat{G} = 0 \]  
\[ \eta^g \hat{w} - \delta \hat{G} = 0 \]  
\[ \left[ \eta^w L_y + \eta^g L_g \right] \hat{w} + L_y \hat{\hat{Y}} + \left[ \frac{\beta G}{\alpha + \beta G} L_g - \delta L_y \right] \hat{G} = L \hat{L} \]  
\[ -\left[ \eta^x K_y + \eta^g K_g \right] \hat{w} + K_y \hat{\hat{Y}} + \left[ \frac{\beta G}{\alpha + \beta G} K_g - \delta K_y \right] \hat{G} - \left[ \frac{K_f}{K_f + \hat{K}} \right] \hat{K} = 0 \]
References


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