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The Provision of Public Inputs and Foreign Direct Investment

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Abstract: A general equilibrium model of a small open economy is developed that incorporates *direct* and *indirect* effects on multinational location decisions associated with public input provision. It is shown that when agglomeration externalities are present, public input provision can affect firms directly by lowering the fixed costs of production and indirectly by decreasing the costs of intermediate inputs. It is further shown that a policy of public input provision that provides a threshold level of public inputs can generate greater increases in GNP for a host country than a policy of subsidies or tax incentives.

*Key Words***:** Public Infrastructure; Multinational corporations; Intermediate goods; Development

*JEL classification***:** F2**;** H4; O1

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I. Introduction

Foreign direct investment by multinational corporations has played a significant role in the success of developing nations that have grown out of poverty and into developed economies. Since the 1950's, Taiwan, South Korea, Hong Kong and Singapore have been but a few that have actively pursued multinationals from the U.S., Japan, and Europe in an effort to create jobs and raise wages. Proximity to markets, subsidies, low wages, and tax incentives are common reasons cited for why multinationals choose to invest in these economies.

A critical link, often mentioned but given far less attention in theory, has been the role of public inputs[1]. It is no coincidence that multinational activity began to take place in South Korea after the 1953-56 Post War Reconstruction, or in Singapore after massive public investment in telecommunications, or Taiwan after government funded research institutes and industrial parks were built[2].

Recently, researchers have begun to examine linkages between multinational corporations and indigenous intermediate input suppliers in the context of the 'new trade theory.' This approach has helped to shed light on the welfare impacts of host countries that accept, or choose to compete for, multinational activity. Because the approach is new, many questions regarding upstream and downstream linkages have not yet been addressed in the literature, especially with respect to public inputs as factors of

[1] The statement here refers specifically to the role public inputs play in the context of the multinational location literature. Public inputs generally, and with respect to capital mobility, have received much more attention; see for example Clarida and Findlay [1994], Martin and Rogers [1995], Keen and Marchand [1996], Manning et. al. [1997], and Feehan and Matsumoto [2000].

[2] See Hobday [1995] and Li [2002].

production and the interaction they create between intermediate goods suppliers and final goods producers. This paper contributes to that literature by examining how the provision of public inputs affect multinational location decisions as well as the subsequent wage and domestic market effects associated with competing policy proscriptions.

Recent empirical research suggests that public inputs have a non-negligible impact on the productivity and cost structure of private firms (Aschauer [1989], Haughwout [2001], Morrison et. al. [1996], Nadiri et. al. [1994]). Cost elasticity estimates with respect to infrastructure capital in the Nadiri et. al. [1994] study range from –0.11 to –0.21 depending on the industry, while Morrison et. al. [1996] estimate an output elasticity of 0.11 for private firms with respect to public infrastructure[3]. In simple bivariate regressions found in the *Global Competitiveness Report 2000*, strong and significant correlations exist between GDP growth and a wide range of public infrastructure measures.

Despite this evidence, universal agreement regarding the contribution of public investment to private sector productivity does not exist. Conflicting studies have found that public investment does not have a statistically significant *direct* impact on productivity in the private sector (Holtz-Eakin [1994], Holtz-Eakin et. al. [1995]). Even if such infrastructure has no *direct* role in the cost structure and productivity of private firms, ample evidence suggests that the *indirect* spillovers from agglomeration and clustering created by public infrastructure lower the costs of firms (Houghwout [2001]).

[3] See also Röller and Waverman [2001] for the effects of telecommunications infrastructure on growth.

The model developed in this paper incorporates both the *direct* and *indirect* aspects of cost savings for multinationals created by the provision of public inputs.

The approach here is different from other papers that look at the impact of public inputs on firm location decisions (such as Martin and Rogers [1995] or Baldwin et. al. [2003]). Prior work has focused on two-country models with agglomeration externalities, where public inputs (infrastructure) are modeled as iceberg trade costs that affect firms' ability to get their products to consumers. In this paper, public inputs are modeled as factors of production for intermediate as well as final goods producers in the host country rather than as iceberg trade costs. This approach sheds light on two important aspects of infrastructure development that are not explicitly captured by previous models. First, infrastructure can have both direct effects on multinational firms by lowering the fixed costs of production as well as indirect effects on marginal costs through agglomeration in intermediate goods markets. Second, by incorporating intermediate goods markets we allow for new firms to be created as suppliers to final goods producers, rather than final goods producers simply relocating from one country to another (as found in the two-country models).

The paper builds on the partial equilibrium model first developed by Markusen and Venables [1999] and extended to a general equilibrium framework by Haaland and Wooton [1999]. The model is theoretically similar to Markusen and Venables in that *linkage effects* create positive agglomeration externalities in domestic markets. However, like Haaland and Wooton the tension between the *linkage* and *competition effects* associated with Markusen and Venables is replaced by the opposing forces of positive

agglomeration externalities in intermediate goods markets (*linkage effects*) and rising labor costs.

Another contribution of this model is that allows for the identification of a threshold level of public inputs, which is the minimum public input level necessary to induce the first MNE to invest in the economy. Once the first MNE invests, it is more attractive for more MNE's to invest as the cost of intermediate inputs is falling in the number of multinational firms located in the host country. If the government invests in a public input level that is lower than the threshold level of public inputs, the possibility of a *low-level production trap* is present. Without enough government assistance, no multinational firms will choose to invest and the intermediate goods market will never get off the ground. A public input level higher than the threshold will result in a stable equilibrium. It is shown that because of the direct and indirect effects that public inputs have on multinational and indigenous intermediate producers, public input provision can yield greater returns for a host country than expenditure neutral policies of direct subsidization or tax relief.

In Section II, a model is developed that incorporates public inputs into the cost functions of multinational and indigenous firms. Section III presents the equilibrium conditions and compares alternative policies for attracting multinational corporations in the presence of agglomeration externalities. Section IV compares national income under the alternative policies, Section V reports sensitivity analysis, and Section VI concludes.

II. The Model

Imagine a small open economy with four distinct sectors: (i) a *traditional* sector, which can be thought of as a composite good consisting of food, housing, clothing and

other domestic essential goods whose product is consumed exclusively by the home country, (ii) a *public inputs* sector where the government produces public goods as inputs in the production of intermediate and final goods, (iii) an *intermediate goods* sector that supplies inputs for the modern sector, and (iv) a *multinational* sector, which consists of assembly operations of final goods for export.

The Traditional Sector

The traditional sector consists of M perfectly competitive firms that produce a homogenous good (Y), using a primary factor of production (L_Y)[4] with a decreasing returns-to-scale technology[5]:

$$Y = \frac{L_Y^{\gamma}}{\gamma} \text{ for } \gamma < 1. \quad (1)$$

Y is not traded and is consumed entirely in the home country. The Y good is the numeraire good at home and the wage rate of the primary factor is equal to its marginal product:

$$L_Y = w^{-\varepsilon} , \quad (2)$$

4

where $\varepsilon = -1/(\gamma - 1)$ is the elasticity of the primary factor of production with respect to the traditional good.

The Public Inputs Sector

Public inputs are produced by the government using tax revenues obtained by taxation of traditional sector output[6]. For simplicity, the amount of public inputs provided is equal to the tax revenue collected such that:[(provid21b9113 TD-0.00e7Ɐ(.00e7338.3199 526.06

$$c(z) = (a + bz)w, \tag{4}$$

where z

lowering fixed costs for each intermediate firm[8]. These two assumptions are incorporated into equation[9] (7):

$$a = \frac{A}{R^{\eta} n^{\theta}} \ , \tag{7}$$

where $\theta > 0$, $0<\eta<1$, and R is the sum of endowed public inputs (i.e. from past infrastructure projects), $\underline{P}$, and new investment in public inputs, P: $R = \underline{P} + P$. Each firm's fixed cost is a declining function of both the level of public inputs provided and the number of varieties offered in the domestic market. The parameter η can be thought of as the degree to which public inputs substitute for private fixed costs. For example, $\eta=1$ would correspond to public inputs that substitute perfectly for private fixed costs. Small levels of η would correspond to public inputs that were less substitutable and would substitute imperfectly for private fixed costs. Output per firm is found by substituting equation (7) into equation (6) to get

$$z = \frac{A(\sigma - 1)}{R^{\eta} n^{\theta} b} . \tag{8}$$

Total demand for the primary factor of production in the intermediate goods market will be a function of the total number of firms operating there and the output of each firm:

[8] For example, government investment in a power plant would lower the fixed costs for each intermediate firm of hiring the primary factor to build their own power generators.

[9] d25 -0.02 336.88 3.9518P

$$L_Z = n(a + bz). \tag{9}$$

its own infrastructure to support its operations. Q is the intermediate goods price index such that

$$Q = \left[\sum_{j=1}^{J} q_j^{1-\sigma} \right]^{\frac{1}{1-\sigma}}, \tag{12}$$

where q_j is the price of variety j of the intermediate goods. Since it is assumed in the previous section that all intermediate goods have identical technology and costs, it follows that q_j will be the same for all varieties, and we can rewrite (12) as:

$$Q = n^{\frac{1}{1-\sigma}} q . \tag{13}$$

Using equations (11), (12) and (13) we can solve for each multinational's demand for each variety of intermediate input, z as:

$$z = \alpha n^{\frac{\alpha+\sigma-1}{1-\sigma}} \left(\frac{w}{q} \right)^{1-\alpha} X . \tag{14}$$

Taking the price for each intermediate that we established earlier in equation (5), plugging it into equation (14), and multiplying by the number of multinationals operating in the home country yields the total demand for each variety of intermediate good produced:

$$Z = \alpha \lambda^{\alpha-1} n^{\frac{\alpha+\sigma-1}{1-\sigma}} FX . \tag{15}$$

In a similar fashion, we can determine the total demand for the primary factor of production in the X sector using equations (11), (13), and (5), and multiplying by the number of multinational firms, F:

$$L_F = (1-\alpha) n^{\frac{\alpha}{1-\sigma}} \lambda^{\alpha} FX . \tag{16}$$

The final equilibrium condition is the multinational's iso-cost condition. It is assumed that each multinational has the option of opening its facility in an alternative country at cost $\overline{C}$. For the multinational to locate in the host economy, its costs minus any subsidies offered by the host country must be less than or equal to the costs of opening a facility in a competing country[12]. The equilibrium condition is

$$C - Xs = \overline{C}. \tag{19}$$

The firms' equilibrium iso-cost condition is derived using the cost function in (11), the pricing equation in (5), and (19) to obtain:

$$w = \lambda^{-\alpha} n^{\frac{\alpha}{\sigma-1}} \left(\overline{C} + sX - \frac{B}{R^{\eta}} \right). \tag{20}$$

Equation (20) reflects the fact that multinational's average costs of production decrease in the number of intermediate firms and the level of public inputs. The wage that the multinational is willing to pay increases in the number of intermediate firms and the public inputs available for its use.

Solving the system yields two equations that describe the wage rate as function of the number of multinational firms operating in the country. The first of these is the iso-cost condition and describes the wage multinationals are willing to pay the primary factor of production as the number of multinationals in the country increases. This equation is obtained by substituting equations (5) and (18) into (20) to get:

$$w = \left[\overline{C} + sX - \frac{B}{R^{\eta}} \right] \left[\lambda^{-\alpha\beta} \left(R^{\eta} \right)^{\alpha} F^{\alpha} X^{\alpha} \delta^{-\alpha} \right]^{\frac{1}{\alpha+\beta}}. \tag{21}$$

[12] The discussion focuses on production subsidies but the analysis can equally be thought of as a lowering of taxes on output.

more public inputs will increase the marginal productivity of the primary factor in both

wage. In Fig. 3, this corresponds to eH[19] and is a stable equilibrium. Above eH, the market wage is higher than what firms are willing to pay and firms will exit.

IV. National Income

Direct subsidies to multinationals and investment in public inputs can attract multinational activity and raise wages in the home country. The pertinent question faced by decision makers is which policy will yield the greatest benefits at least cost. To analyze this question we examine national income measures under each policy prescription for a given government expenditure level. Define gross domestic product, $D(F, P)$, as the sum of the traditional sector output and wages paid to the primary factor of production from multinational and intermediate goods sectors, minus the value of public inputs provided by the government[20]:

$$P) \quad Y(L \ ) \quad (\bar{L} \quad L \ )w - P$$

Gross national product will be defined as gross domestic product minus any subsidy payments to multinational firms[21]:

$$G(F,P,s) = D(F,P) - sFx \ . \tag{27}$$

National income increases occur in the home country if the ratio of GNP after a policy prescription to GNP in the baseline is greater than 1. Define growth of GNP as:

$$g(F,P,s) = \frac{G(F,P,s)}{G(F,P^0,s^0)}, \tag{28}$$

where P^o and s^o represent the initial levels of public inputs and subsidy payments.

In Figure 4, equation (28) is graphed for the threshold subsidy found in equation (23)[22]. Assuming that firms are continuous, then 9.64 modern sector firms will enter the country and there is an increase in national income of 6.68% associated with a subsidy. If firms are discrete then 9 is the maximum number of firms that will enter the country and national income increases by 4.47%. Although not obvious, an examination of equation (26) reveals that even though the subsidy leads to a national income gain, for different exogenous parameters, it is possible for the subsidy to yield a national income loss.

[Insert Figure 4]

A policy of financing the provision of public inputs has a different impact on national income. To compare the effects of the two policy proposals, solve for the expenditure level under the subsidy proposal above and set it equal to the level of public

[21] Again, s in equation (27) can be thought of as a per unit subsidy payment or as a reduction in a production tax.

[22] In Figure 4, *s=0.02* and *P=0*. In Figure 5, *P=1.08* and *s=0*.

inputs such that: $\tilde{s}\tilde{F}x = \tilde{P}(L_p)$, where $\tilde{s}$ and $\tilde{F}$ are the stable equilibrium values at *eH* in Figure 4 (i.e. under the minimum subsidy policy). Setting $P = \tilde{P}$ in equations (21), (22), and (28) gives the equilibrium number of firms, wage level, and national income change under a policy of public input provision when expenditures are the same as a policy of direct subsidization.

[Insert Figure 5]

In Figure 5, notice that using the same level of expenditure on the provision of public inputs ensures that the first firm enters and a stronger positive effect is created on national income. Depending on whether firms are continuous or discrete, increases in national income are 32.5% and 25.33% respectively. This is a significant improvement over a policy of direct subsidization of multinational firms. Given a fixed expenditure level, a policy of financing public inputs dominates a policy of direct subsidization for a broad range of parameter values.

There are two important influences that lead to this result. First, as represented in equations (7) and (11), the *direct effect* of the public input decreases the average cost of multinational and intermediate goods firms by lowering the fixed costs of production. Second, the *indirect effect*, attributable to agglomeration, lowers the marginal cost for multinationals by increasing the number of intermediate firms, making intermediate goods cheaper. Direct subsidization of multinationals triggers the *indirect effect* associated with agglomeration, but at a cost, as resources leave the country in the form of subsidy payments to foreign firms. Public input provision generates the *indirect effect* as well as the *direct effect* to multinationals and intermediate goods producers and underscores a significant policy point. When there are local agglomeration externalities

and fixed costs to production, host countries can address both issues with a single policy of public input provision.

V. Sensitivity Analysis

Tables 1(a)-1(d) report sensitivity analysis when we change a few of the key parameters of the model. The four parameters under investigation are the share of intermediate goods in multinational affiliate costs (α), the elasticity of substitution between intermediate inputs (σ), the strength of agglomeration externalities (θ), and the substitution parameter between public and private fixed inputs (η). In all four tables, column (2) reports the baseline parameter values used in the analysis of the previous sections.

[Insert Table 1]

The analysis proceeds as follows. First, for each new set of parameter values the threshold subsidy in equation (24) is calculated. This is reported as the "Threshold Subsidy" in Tables 1(a)-1(d). Second, the minimum expenditure necessary to achieve the high equilibrium (such as *eH* in Figure 2) is obtained by multiplying the threshold subsidy by the number of firms that enter at the high equilibrium and output per firm, such that *Expenditure* = $\tilde{s}\tilde{F}x$. The "# of firms (subsidy)" and "Growth (subsidy)" in Tables 1(a)-1(d) report the respective number of modern sector firms that enter the host country at the high equilibrium and the resulting growth in GNP over the initial equilibrium of having no modern sector firms[23]. The "# of firms (public)" and "Growth (public)" rows report the total number of modern sector firms that present at the high

[23] For simplicity, the table reports the highest discrete number of firms rather than reporting the firms as a continuous variable.

equilibrium, such as *eH* in Figure 3, when the same expenditure spent under a subsidy policy is spent on the provision of the public input; the "Growth (public)" row gives the growth in gross national product under the public provision policy.

In Table 1(a) the share of intermediate inputs in the modern sector cost function (α) is altered holding the other parameters in the model constant. As the share of intermediates in the modern cost function rises, the benefits associated with GNP growth from a policy of public input provision is far greater than an expenditure neutral subsidy policy. This is due to the fact that public inputs create a *direct* effect on modern sector cost structures by lowering fixed cost requirements and an *indirect* effect by facilitating agglomerative externalities in the intermediate goods sector. The subsidy policy only creates the *indirect* effect. As intermediates become less important in the modern sector cost structure (smaller α), a policy of subsidy provision may be preferable to a policy of public input provision, all else equal. This statement needs qualification because it is contingent on having a fixed expenditure level. Notice in columns (3) and (4) of Table 1(a) that the number of modern sector firms under the provision of public inputs policy is zero. Since the share of intermediates in modern sector costs are declining, so too is the importance of agglomerative externalities in that sector. Therefore, the threshold level of public inputs to attract the first modern sector firm to the country is rising. Zero firms means that the total expenditure under the subsidy policy would not be enough to attract the first firm to the country if the money were instead spent on public inputs. The result

is a loss in GNP from public input provision (-6.47%) because money would be taxed out of the domestic sector to pay for a public good that is not useful[24].

In Table 1(b), sensitivity to the elasticity of substitution between intermediate inputs (σ) is examined. The results are similar to those in Table 1(a), with an expenditure neutral policy of public input provision providing greater increases in GNP than a subsidy policy for a broad range of parameter values. As the elasticity of substitution between intermediate inputs rises, market power for each intermediate producer falls, thus fewer intermediate goods producers will enter the market in equilibrium [see equation (19)]. This has two important effects, it acts to dampen agglomerative externalities and reduces the number of modern sector firms that choose to enter the country. As a result, there are fewer intermediate and modern sector firms to benefit from lower fixed costs due to the provision of the public input. With an elasticity of substitution of $\sigma = 4$, the threshold subsidy expenditure would not be enough to attract the first modern sector firm to the country and so GNP would fall if it were spent on a policy of public input provision[25].

Tables 1(c) and 1(d) allow for changes in the strength of agglomeration (θ), and the substitution parameter between public and private fixed inputs (η), respectively. The results remain the same, the expenditure neutral policy of public input provision dominates the policy of direct subsidies. The exception being column 4 in Table 1(d)

[24] Modern sector firms would not be using the public input because none of them have entered the country and intermediate goods firms would not be using the public input because without modern sector firms then an intermediate goods sector cannot exist.

[25] Again, resources would be taxed away from the primary factor and spent on an unproductive public input that failed to attract any firms.

where the threshold subsidy expenditure is not enough to attract the first modern sector firm under a policy of public input provision.

An interesting result has emerged that cannot be solved for analytically (since the threshold level of public inputs can only be solved for computationally) but is strongly suggested by the sensitivity analysis. An observational sufficient condition for a policy of public input provision to dominate a subsidy policy is that $\tilde{s}\tilde{F}x$ be greater than or equal to the threshold level of public inputs necessary to attract the first modern sector firm into the country. That is, if the resources spent on providing production subsidies to modern sector firms could instead be spent on the provision of public inputs *and* enough to get the first modern sector firm to enter the country, then the country will get greater benefits in terms of higher GNP levels from a policy of public input provision than by offering subsidies. This is attributed to the fact that the multinational firms will experience both *direct* and *indirect* effects on their cost structures.

It is important to reiterate though, that a policy of public input provision may not,

input markets. The first is that public inputs can influence firm cost structures in two ways: the *direct effect*, that acts to lower fixed costs of production, and the *indirect effect*, which acts to lower the marginal costs of intermediate goods. Public inputs decrease the fixed cost requirements for multinational and intermediate goods producers while at the same time facilitate agglomeration externalities in the intermediate goods sector. This is an important point to keep in mind in thinking about the effects of public input provision on multinational investment decisions and subsequent domestic growth effects.

Second, it is shown that small developing economies must achieve a threshold level of public inputs if they hope to be successful in attracting foreign direct investment. By providing the threshold level of public inputs, countries can jump from a 'low-level production trap' to a higher level of national income as intermediate goods producers arise to supply multinational firms for final goods production. Tax incentives, access to markets, and tariff jumping are but a few well documented and important influences on multinational location decisions, but as the analysis in this paper shows, adequate levels

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Figure 1
"Initial State of the Economy"

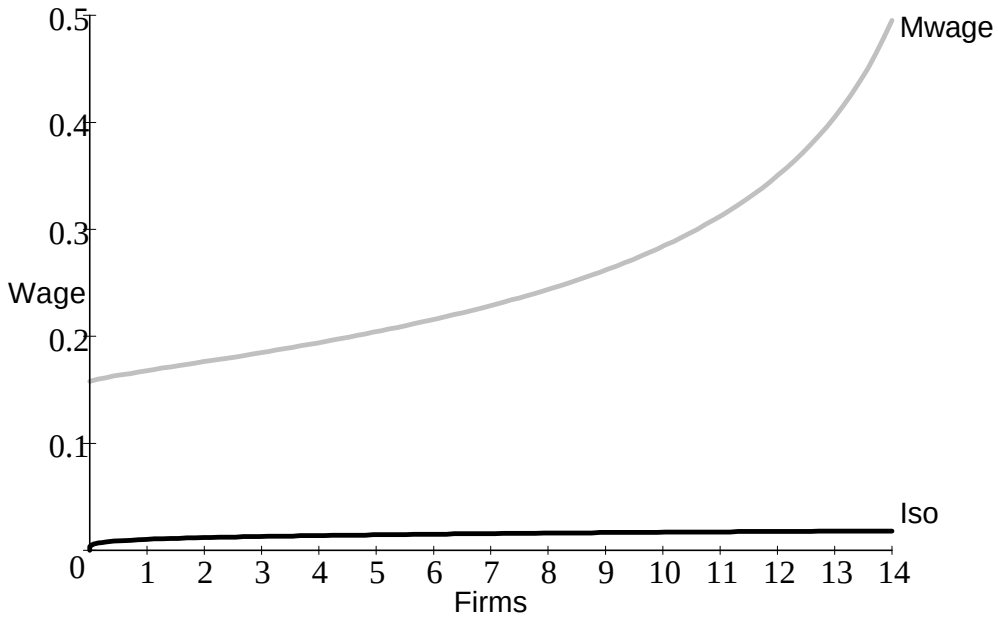

Figure 2
"State of the Economy with a subsidy policy"

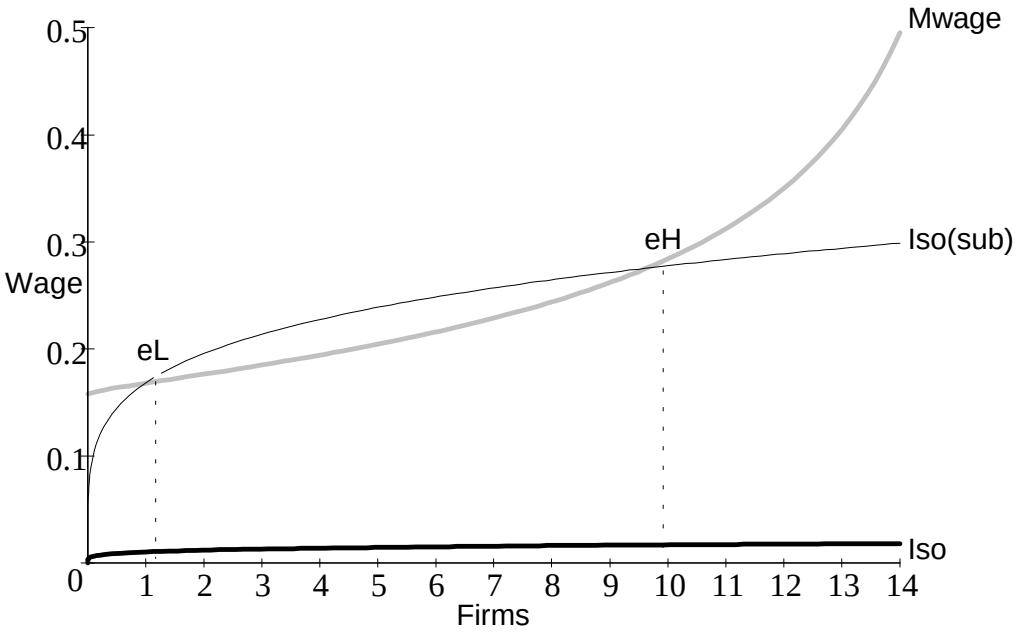

Figure 3
"State of the Economy with public input provision"

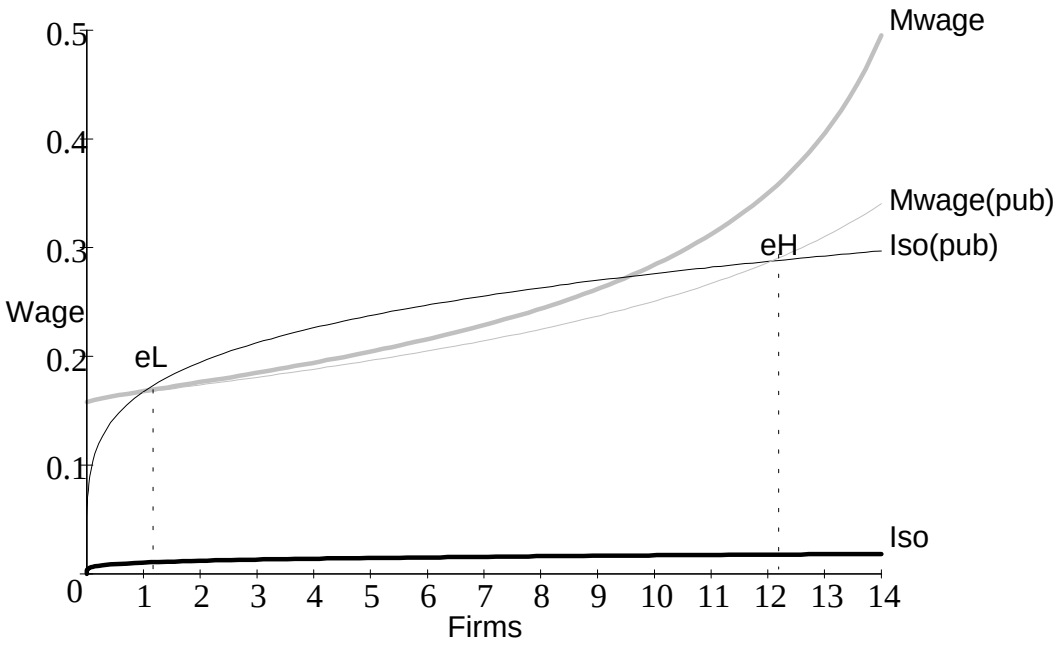

Figure 4
"GNP with a subsidy policy"

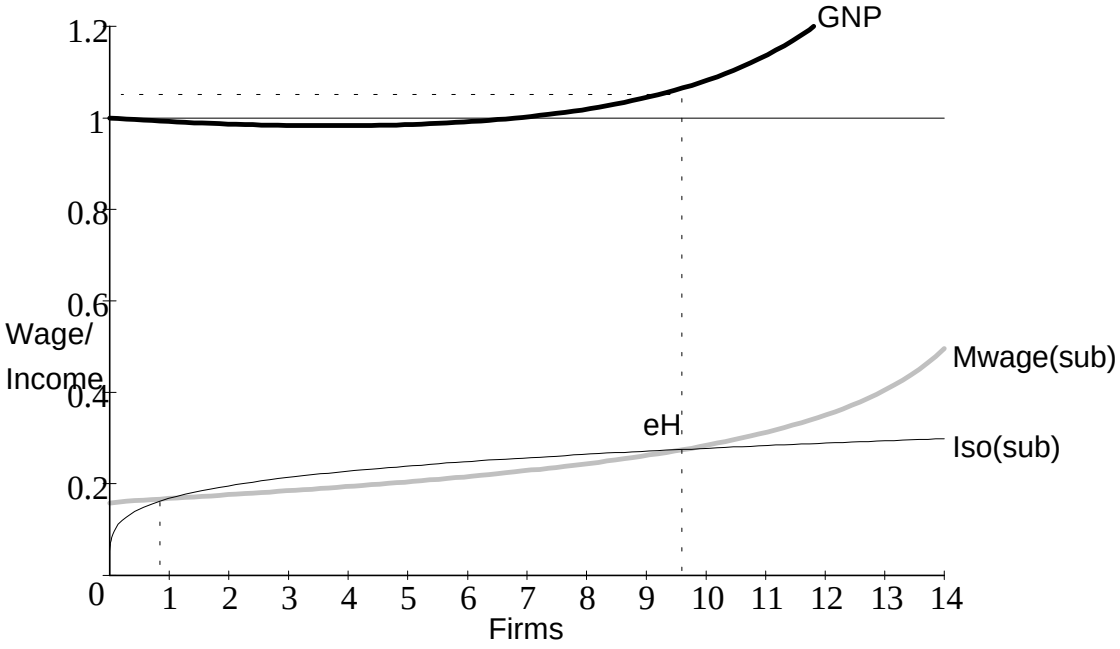

Figure 5
"GNP with public input provision"

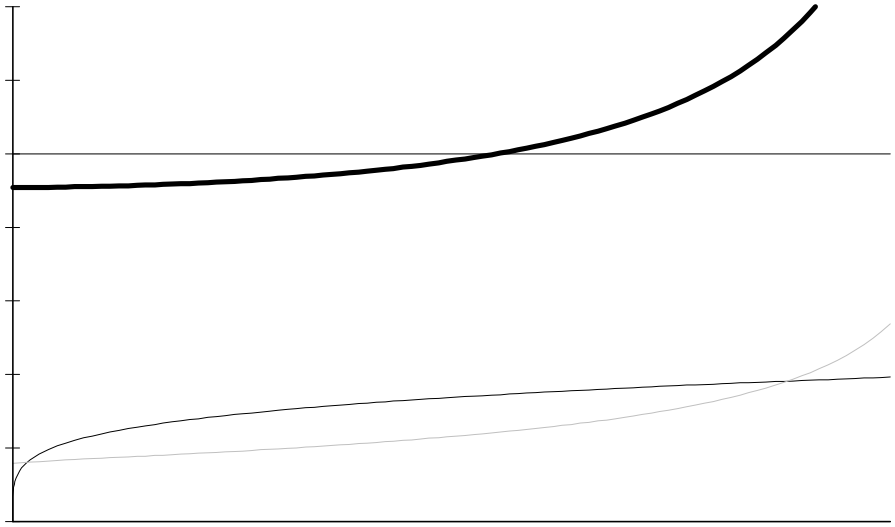

Table 1
"Sensitivity analysis"

TABLE 1(a)

Changing the share of intermediate inputs in multinational costs

	(1)	**(2)**	(3)	(4)
	α=0.8, η=1, σ=3, θ=0.1	**α=0.5, η=1, σ=3, θ=0.1**	α=0.4, η=1, σ=3, θ=0.1	α=0.3, η=1, σ=3, θ=0.1
Threshold subsidy	0.015	**0.02**	0.022	0.024
Expenditure	2.53	**1.08**	0.82	0.43
# of firms (subsidy)	28	**9**	6	3
Growth (subsidy)	43.12%	**4.47%**	1.26%	-1.17%
# of firms (public)	59	**15**	0	0
Growth (public)	237.43%	**25.33%**	-6.47%	-17.38%

TABLE 1(b)

Changing the elasticity of substitution between intermediate inputs

	(1)	**(2)**	(3)	(4)
	α=0.5, η=1, σ=1.8, θ=0.1	**α=0.5, η=1, σ=3, θ=0.1**	α=0.5, η=1, σ=3.3, θ=0.1	α=0.5, η=1, σ=4, θ=0.1
Threshold subsidy	0.014	**0.02**	0.021	0.022
Expenditure	5.54	**1.08**	0.882	0.66
# of firms (subsidy)	66	**9**	7	5
Growth (subsidy)	136.26%	**4.47%**	1.72%	0.00%
# of firms (public)	274	**15**	9	0
Growth (public)	142.05%	**25.33%**	3.92%	-5.22%

TABLE 1(c)

Changing the strength of agglomeration externalites

	(1)	**(2)**	(3)	(4)
	α=0.5, η=1, σ=3, θ=0.01	**α=0.5, η=1, σ=3, θ=0.1**	α=0.5, η=1, σ=3, θ=0.2	α=0.5, η=1, σ=3, θ=0.3
Threshold subsidy	0.02	**0.02**	0.019	0.019
Expenditure	0.84	**1.08**	1.254	1.71
# of firms (subsidy)	7	**9**	11	15
Growth (subsidy)	1.34%	**4.47%**	7.45%	18.03%
# of firms (public)	10	**15**	20	28
Growth (public)	6.52%	**25.33%**	52.16%	107.46%

TABLE 1(d)

Changing the substitution parameter between public and private fixed inputs

	(1)	**(2)**	(3)	(4)
	α=0.5, η=1.1, σ=3, θ=0.1	**α=0.5, η=1, σ=3, θ=0.1**	α=0.5, η=0.8, σ=3, θ=0.1	α=0.5, η=0.5, σ=3, θ=0.3
Threshold subsidy	0.02	**0.02**	0.019	0.018
Expenditure	1.08	**1.08**	1.03	1.08
# of firms (subsidy)	9	**9**	9	10
Growth (subsidy)	4.45%	**4.47%**	4.56%	8.17%
# of firms (public)	16	**15**	12	0
Growth (public)	31.99%	**25.33%**	9.70%	-8.39%