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Immigration and Outsourcing: A General Equilibrium Analysis*

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Abstract

This paper analyzes immigration and outsourcing in a general-equilibrium model of international factor mobility. In our model, legal immigration of skilled labor is controlled through a quota, while outsourcing is determined both by the firms in response to market conditions and through policy-imposed barriers. A loosening of the immigration quota reduces outsourcing, enriches capitalists, leads to losses for native workers, and raises national income. If the nation targets an exogenously determined immigration level, the second-best outsourcing tax can be either positive or negative. If in addition to the immigration target there is a wage target arising out of income distribution concerns, an outsourcing subsidy is required. We extend the analysis to consider illegal immigration of unskilled labor. A higher legal immigration quota will lead to more (less) illegal immigration if skilled and unskilled labor are complements (substitutes) in production.

JEL Codes: F22, O24
Keywords: Legal Immigration, Illegal Immigration, Outsourcing, General Equilibrium

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1. Introduction

Because of its potential effects on segments of the US economy, outsourcing has become one of the major issues confronting US policymakers. The outsourcing of services, in particular, has taken on increased importance. In a recent contribution, Bhagwati, Panagariya, and Srinivasan (2004) write

> In the early 1980s, "outsourcing" typically referred to the situation when firms expanded their purchases of manufactured physical inputs...But in 2004, outsourcing took on a different meaning. It referred now to a specific segment of the growing international trade in services. This segment consists of arm's length, or what Bhagwati (1984) called "long-distance" purchase of services abroad, principally, but not necessarily, via electronic mediums such as the telephone, fax, and the internet...[1]

While outsourcing has become more prominent, policies toward both legal and illegal immigrants have continued to occupy a central place in policy debates. Although immigration and outsourcing are interrelated, to our knowledge there has been little work that links them in a formal economic model. In the present paper, we provide a single-good model that allows for a systematic analysis of immigration policy in the context of the outsourcing of services.[2] While the focus in this paper is on the demand side, there are implications of these policies for developing nations like India, who constitute the supply side of this issue. Therefore, we seek to contribute to an area of overlap of the fields of trade, development, and labor.

To see the potential links between outsourcing and immigration, consider the software development industry. One of the inputs required is innovation by research engineers cum

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[1] The paper also notes that such transactions are categorized as Mode 1 trade in services in WTO terminology.

[2] Let us think of this single good being software. Two factors are used to produce this good, entrepreneurial capital and skilled labor. Because of the nature of the good produced, and because of the advances in communication technology, it is possible to combine labor located in India (say) with capital located in the US (say), to make the final product. Therefore, outsourcing of labor in this paper refers to the hiring of labor services that are located in a foreign nation. It is also important to note that because we assume a single good, this paper is not about trade in goods. Nor is about general equilibrium in the goods markets. The general equilibrium that we refer to is in the interactions between the goods market and the factor markets. The assumed single good structure is standard in the

entrepreneurs in the nation (say, the US) that will own the copyright for the product. Routine programming skills, which can be performed by skilled labor in either the US or in another nation (say India) that has an abundance of skilled labor, is also used to develop the final product. When hiring programmers, firms in the US can hire US natives, hire Indian immigrants, or outsource the programming to Indian residents.[3] When choosing among their three sources of programmers, legal immigration is restricted by quotas (of the temporary immigration varieties, like the H1 visa) determined by the US government. US firms hire domestic programmers up to the point in which the wage of the domestic workers equals the wage of the immigrant workers. The wage paid to the worker in the foreign country equals the foreign wage rate, which is lower than the domestic wage rate. There are limits to the amount of outsourcing that a firm will do because it incurs a rising marginal cost. At the margin, jobs are outsourced to the point where the marginal cost of outsourcing the job to a unit of foreign labor equals the domestic wage rate.

A larger immigration quota raises the ratio of labor to capital. The rise in labor intensity reduces the marginal product of labor, the domestic wage, and, with a given foreign wage, the marginal benefit and the level of outsourcing. It is through this mechanism that immigration and outsourcing are substitutes: A loosening of the immigration quota hurts the native workers but benefits native capital. The gains of this loosening outweigh the losses because the fall in the immigrant wage is a net terms-of-trade benefit in the factor market for the nation.

It is well understood that immigration is regulated for economic reasons as well as for social and political considerations. For example, perhaps to maintain social or cultural identity

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international economics literature on factor mobility (for example, see Ethier, 1986, or Bond and Chen, 1987). It allows one to focus on the factor markets without complicating the model through the goods markets.

the government might want to fix the ratio of natives to immigrants. In nations where naturalization is allowed, the government might look at the immigrants as potential future citizens and therefore want them to be better assimilated in the society. This might require costs for the government, thereby limiting the socially optimal level of immigration.

It is beyond the scope of this paper to account for all factors that affect immigration, so we follow Ethier (1986) and consider an exogenously given policy target for immigration. We show that, in the presence of such a target, there are two conflicting effects of levying a tax on outsourcing. The tax will reduce outsourcing, reduce the labor-to-entrepreneurial-capital ratio, and raise the domestic wage. While the rise in the wage paid to immigrants reduces national income, a fall in outsourcing will reduce the demand for labor in the source nation. This reduces the wage at which US firms buy Indian labor and confers a terms-of-trade benefit to the US. The relative strengths of these effects determine whether the optimal policy toward outsourcing is a tax or a subsidy.

When the immigration quota is relaxed, wages of native workers fall along with those of the immigrants. Such a policy will face political opposition in the absence of appropriate income redistribution schemes. In light of this, section 3 considers a policy environment that targets a certain acceptable wage for native workers. In the absence of any outsourcing tax or subsidy, like Ethier (1986) we find that the target wage implies an immigration target (i.e., the two cannot be "unbundled"). With an outsourcing tax or subsidy in place, this problem is resolved and a desirable level of immigration that is consistent with the wage target can be attained. Such a

[3] To focus on outsourcing and immigration issues as they pertain to the high-tech sector, we abstract in this section from the presence of unskilled labor. We relax this assumption in a later section where we consider the additional issue of illegal immigration.

policy is not costless, however, because an outsourcing subsidy that is required to reduce immigration and raise native wages to its target level must reduce national income.

To consider the problem of illegal immigration of unskilled labor, we extend our model in section 4 to include unskilled labor as a third factor of production. There is a fixed stock of native unskilled workers that is supplemented with unskilled illegal immigrants. Higher US unskilled wages (compared to say Mexico, a source nation of illegal immigrants) leads to this kind of immigration, whose level is determined endogenously through an equilibrium migration process. The government employs both internal and border-detection policies to deter illegal immigration, the level of which adjusts so that the expected wage from migration for a potential migrant in the source nation equals the certainty wage available in the source nation.

General equilibrium linkages tie together legal and illegal immigration and outsourcing. A rise in the legal immigration quota will reduce outsourcing but raise illegal immigration if skilled and unskilled labor are complements in the production process. On the other hand, under complementarity, stricter enforcement will reduce illegal immigration and also outsourcing. Thus, depending on the source of the policy change illegal immigration and outsourcing can either be positively or negatively related in an *ex post* sense. A rise in the legal immigration quota must necessarily raise national income under complementarity, but might reduce it under substitutability between skilled and unskilled labor.

Section 4 complements the analysis of Jones (2005), which shows that immigration or outsourcing can actually raise the wage rates of the native workers. Although his discussion on outsourcing is somewhat different from our context, his remarks on immigration are closely related. He argues that, although immigration can lower wages in low-dimensional models that ignore heterogeneity, it might actually raise wages of low-skilled natives in models where different skill levels co-exist. We explore this issue at length in our discussion of the co-existence of illegal and legal immigration of different skill types.

The rest of the paper is organized as follows. Section 2 presents the basic model and discusses optimal immigration policy. Section 3 considers immigration and outsourcing in the presence of exogenous targets on immigration and the wage rate, respectively. Section 4 augments the analysis by including unskilled labor and illegal immigration. Section 5 concludes.

2. The Model and Analysis

Let there be two nations, home and foreign. Home produces a single good in quantity Q by using inputs T and S. The entrepreneurial capital is measured by T, whereas S is the effective units of skilled labor used in making Q. The production function is CRS and can be described by

$$Q = F(T, S)\,. \tag{1}$$

Let the stock of domestic skilled labor be denoted by S^D and immigrant skilled labor by I. The home firm uses n units of skilled labor residing in the foreign nation to produce Q (i.e., n is the level of employment of outsourced labor). Because of the foreign country's inferior infrastructure, employing a foreign worker in the foreign country is more costly than employing the same worker in the home country. This is captured by $\delta(n)$, which converts a unit of foreign labor into its domestic equivalent. Given the fixed costs associated with outsourcing, $\delta(n)$ is assumed to be negatively related to n, contributing to diminishing marginal productivity of foreign labor as outsourcing rises. As we explain later, this is an alternate way of modeling increasing marginal costs of outsourcing at the firm level. Thus,

$$S = S^D + I + \delta(n)n\,, \text{ where } \delta(n) < 1 \text{ and } \delta'(n) < 0\,. \tag{2}$$

Profit of a domestic firm is

$$\pi = F\{T, S^D + I + \delta(n)n\} - w^T T - w^S(S^D + I) - w^* n \,. \qquad (3)$$

The first order conditions of profit maximization are[4]

$F_1(1,\rho) = w^T$, $F_2(1,\rho) = w^S$, and $F_2(1,\rho)\{\delta(n) + n\delta'(n)\} = w^*$, where

$$\rho = \frac{S^D + I + n\delta(n)}{T} = \rho(I, n) \,. \qquad (4)$$

Relation (4) implicitly defines

$$n = n(I, w^*) \,. \qquad (5)$$

Let Q^* be the quantity of the foreign good that is produced under CRS:

$$Q^* = F^*(T^*, S^*) \,. \qquad (6)$$

Let the foreign labor force be denoted by $\overline{S}^*$. Profit maximization by foreign producers, along with the fact that $S^* = \overline{S}^* - I - n$, yields

$w^* = F_2^*(T^*, \overline{S}^* - I - n) \Rightarrow w^* = w^*(I + n)$ and

$$\frac{\partial w^*}{\partial I} = \frac{\partial w^*}{\partial n} = w^{*\prime} = -F_{22}^*(T^*, \overline{S}^* - I - n) > 0 \,. \qquad (7)$$

Using (7) in (4), we have

$$F_2\{1, \rho(I, n)\}\{\delta(n) + n\delta'(n)\} = w^*(I + n) \,. \qquad (8)$$

Relation (8) implicitly defines

$$n = n(I) \,. \qquad (9)$$

[4]Note that while some of the factors of production are given to the industry (and in this model to the nation as well), they are choice variables at the firm level under perfect competition. Also, note the following convention: For all functions of the form $f(x^1, x^2, ..., x^n)$, $f_i(.)$ is the partial of the function with respect to its *i*-th argument, and $f_{ij}(.)$ is the partial of $f_i(.)$ with respect to its *j*-th argument. Because the home nation endowments of skilled labor (S^D) and capital (T) are assumed to be given, we suppress them (as appropriate) in several functional forms in the rest of the analysis.

Since legal immigration is controlled by the government, I is a policy variable. For $I = \overline{I}$, we obtain n from (9) and w^* from (7). From (4) we obtain ρ, w^T, and w^S. From (1) and (6) we obtain the output levels in the two nations. The effect of a change in the immigration quota on the level of outsourcing can be obtained as

$$n'(\overline{I}) = \frac{dn}{d\overline{I}} = \frac{[\{\delta(n) + n\delta'(n)\}F_{22}\rho_1(.) - w^{*\prime}]}{w^{*\prime} - SOC^n}, \text{ where}$$

$SOC^n < 0$ is the second order condition of profit maximization. (10)

Note from (4) that

$$\delta(n) + n\delta'(n) = \frac{w^*}{F_2(1,\rho)} > 0, \ \rho_1(\overline{I}, n) = \frac{1}{T} > 0, \text{ and}$$

$$\rho_2(\overline{I}, n) = \frac{\delta(n) + n\delta'(n)}{T} > 0 \Rightarrow \frac{\rho_2}{\rho_1} = \delta + n\delta'(n) > 0. \tag{11}$$

Using (11) in (10), $n'(\overline{I}) < 0$. Thus, a rise in the immigration quota will reduce outsourcing. In other words, immigration and outsourcing are substitutes. Total differentiation of ρ yields

$$\frac{d\rho}{d\overline{I}} = \rho_1(\overline{I}, n)\left[1 + \{\delta(n) + n\delta'(n)\}\frac{dn}{d\overline{I}}\right]. \tag{12}$$

It can be shown that a sufficient condition for $\frac{d\rho}{d\overline{I}}$ to be positive is that

$$\frac{d}{dn}\{\delta + n\delta'(n)\} = 2\delta'(n) + n\delta''(n) < 0. \tag{13}$$

Recall from (4) that the marginal product of outsourcing is $F_2(1,\rho)\{\delta + n\delta'(n)\}$. For a given ρ, the assumption of diminishing marginal product from outsourcing is equivalent to assuming that (13) holds. Alternatively, this can be thought of as an assumption that captures increasing marginal costs associated with outsourcing. Assuming that (13) holds, (12) implies that ρ will rise with a rise in the immigration quota. In view of (4), a rise in ρ must reduce w^S and raise w^T. This result makes intuitive sense; a larger immigration quota benefits the capitalists while it hurts the existing immigrants and native workers. In terms of lobbying by different groups, one would then expect support for immigration control from native workers and opposition to such controls from the employers (capitalists). These results do fit the stylized facts regarding support and opposition for immigration of skilled workers to the US.

Let us now explore the effect of immigration policy on the national income (Y) of the home nation. Following the tradition in this literature, we consider the national income of the native population, which excludes immigrant income and outsourced labor income. The government realizes that outsourcing is guided by (9) above. Therefore, national income is

$$Y = F[T, S^D + \bar{I} + n(\bar{I})\delta\{n(\bar{I})\}] - w^S\bar{I} - w^*\{\bar{I} + n(\bar{I})\}n(\bar{I}). \tag{14a}$$

From (4), we know that w^S is a function of $\rho(\bar{I}, n)$. Using (4) and (9), (14a) reduces to

$$Y = F[T, S^D + \bar{I} + n(\bar{I})\delta\{n(\bar{I})\}] - w^S[\rho\{\bar{I}, n(\bar{I})\}]\bar{I} - w^*\{\bar{I} + n(\bar{I})\}n(\bar{I}) = Y(\bar{I}). \tag{14b}$$

Using (14b) and the first order conditions of profit maximization, we get

$$\frac{dY}{d\bar{I}} = -\{(\bar{I}F_{22}\rho_2 + nw^{*\prime})n'(\bar{I}) + (\bar{I}F_{22}\rho_1 + nw^{*\prime})\}. \tag{15a}$$

The optimal immigration level is[5]

$$\bar{I}^0 = -\frac{nw^{*\prime}\{1 + n'(\bar{I})\}}{F_{22}\rho_1\left[1 + n'(\bar{I})\dfrac{\rho_2}{\rho_1}\right]}. \tag{15b}$$

[5] This policy is first best only if we consider a world where it is impossible to offer a lower wage to a legal immigrant compared to a native. If on the other hand, we can impose a wage tax on legal immigrants which will extract rents from them, we can always use this tax to raise national income above the level that can be achieved by the immigration quota. In that sense, one can say that this optimal immigration quota is not necessarily a first-best policy. However, as a practical matter, at least in the US context, tax laws do not allow for such policies.

The optimal immigration level exploits the monopsony power in the international labor market, which is reflected in the term $w^{*\prime}$, showing the extent to which a marginal reduction in immigration will influence the foreign wage.[6] Alternatively, using (4) note that

$$dw^S = F_{22}\{\rho_1 + \rho_2 n'(\bar{I})\}d\bar{I} \ . \tag{16}$$

Using (14a) and (16),

$$dY = -\bar{I}dw^S - nw^{*\prime}\left(1 + \frac{dn}{d\bar{I}}\right)d\bar{I} = -\bar{I}dw^S - ndw^* \ . \tag{17}$$

There are two effects on the national income of a change in the immigration quota. The first is through a change in the wage rate of immigrants. An increase in the quota raises ρ and lowers w^S. The wage reduction is a net gain for the home nation because it reduces the payment to immigrant labor. Of course, there is also a loss for domestic skilled labor, but that is compensated for by a rise in the gains of the other domestic factor of production *T*. Further, although a rise in $\bar{I}$ reduces *n*, ($n + \bar{I}$) can be shown to rise. Thus, the foreign wage w^* must rise. This leads to a terms of trade loss in the factor market for the home nation because it is a net importer of skilled labor. At the optimum immigration level (if one exists without outsourcing being driven to zero) the marginal benefit from a lower immigrant wage is exactly balanced by a marginal loss from a higher wage paid to outsourced labor. Notice that if the foreign labor supply were to be perfectly elastic (i.e., $w^{*\prime} = 0$), then

$$\frac{dY}{d\bar{I}} = -\bar{I}\,\frac{dw^S}{d\bar{I}} = -\bar{I}F_{22}\{\rho_1 + \rho_2 n'(\bar{I})\} > 0 \tag{18}$$

and national income rises monotonically with $\bar{I}$ as long as outsourcing and immigration coexist. If unfettered immigration is allowed it will eventually drive outsourcing to zero and the model

[6] It should be noted that (15b) does not hold if the foreign labor supply curve (for immigration or outsourcing) is

will degenerate to a pure immigration model. In this case, immigration will continue unless the foreign labor supply is exhausted or wages are equalized between the host and the source nation.

3. Second Best Policies Under Immigration or Wage Targets

We have already described above are the first-best from the economic perspective of the home nation. It is well understood, however, that immigration is often restricted for noneconomic reasons to achieve social and/or political goals. Immigration reduces native wages and causes a more unequal distribution of income between the native capitalists and workers. This can lead to political tensions that can necessitate support of the domestic wage through controls on immigration and/or outsourcing. In recognition of these realities, this section explores optimal policy in the context of an exogenously given immigration target and discusses wage targets as well as the joint determination of wage and immigration targets.[7]

3.1 Policy Choices Under an Immigration Target

Suppose that there is no wage target but that the government wants to achieve a socially desirable target level of immigration I^{τ}. Suppose also that the government regulates outsourcing through barriers such as requirements that a firm must hire a certain proportion of domestic workers, outsourcing quotas, etc. Here we model barriers to outsourcing in a way that is similar to Bond and Chen's (1987) modeling of barriers to capital flows. A tax *t* per unit of outsourced labor is levied on the firm. The profit-maximization conditions (4) become

$$F_1(1,\rho) = w^T,\ F_2(1,\rho) = w^S, \text{ and } F_2(1,\rho)\{\delta + n\delta'(n)\} = w^* + t. \tag{19}$$

perfectly elastic (i.e., if $w^{*\prime}$ =0). We discuss that case below.

[7] We have discussed the rationale for such targets in the introduction. For the related literature using such targets, see Ethier (1986) and Bandyopadhyay (2006).

National income in this situation is[8]

$$Y = F[T, S^D + I^\tau + n\delta(n)] - w^S I^\tau - nw^*(I^\tau + n)\ . \tag{20}$$

Using the first order condition for the choice of national-income-maximizing choice of n in the presence of an outsourcing tax, we have

$$dY = \left[t - \frac{I^\tau F_{22}(\delta + n\delta')}{T} - nw^{*\prime} \right] dn\ . \tag{21}$$

A rise in outsourcing raises ρ, which in turn reduces w^S and benefits the home nation. It also raises the foreign wage w^*, which reduces home welfare. If the foreign labor supply is relatively elastic (i.e., if $nw^{*\prime}$ is small), national income will rise if outsourcing is raised (maybe by using a subsidy). More generally, (21) suggests that the second-best outsourcing tax is

$$t^{SB} = \frac{I^\tau F_{22}(\delta + n\delta')}{T} + nw^{*\prime}. \tag{22}$$

It is clear from (22) that whether outsourcing should be subsidized or taxed depends on the relative weights of the first and second terms on the right hand side. Given that these terms are weighted by the immigration and outsourcing levels, respectively, one would expect a subsidy to be more likely for a higher target level of immigration (which will be associated with lower n because of their inverse relationship for any given t).

3.2 Policy Choices Under Wage and Immigration Targets

For the sake of exposition, let us first suppose that there is no immigration target but that there is a wage target $\tilde{w}$ for native workers.[9] Using (4) we have

[8] Notice that the revenues from the outsourcing tax are simply a transfer from domestic firms to the domestic government and therefore do not appear in the expression for national income.
[9] A given w^S implies a corresponding factor reward for domestic capital (in a CRS model) and that there is a trade-off between the two factor rewards. One can think of $\tilde{w}$ as the wage that the government chooses to optimally balance the political pressure from the two groups of natives.

$$F_2(1,\rho)=\tilde{w}\Rightarrow \rho=\rho(\tilde{w})=\tilde{\rho}\Rightarrow \rho(I,n)=\tilde{\rho}\Rightarrow I=I(\tilde{\rho},n)\,. \tag{23}$$

Note that

$$-\frac{dI}{dn}(\rho=\tilde{\rho})=\frac{\rho_2}{\rho_1}=\delta+n\delta'<1 \text{ and } -\frac{d^2 I}{dn^2}=2\delta'+n\delta''<0\,. \tag{24}$$

Based on (23) and (24) we trace the n and I combinations that guarantee $\tilde{w}$ in Figure 1. Recall that the first order condition for the choice of n requires that

$$F_2(1,\tilde{\rho})\{\delta(n)+n\delta'(n)\}-w^*(I+n)=0\,. \tag{25}$$

Using (25) we find that

$$-\frac{dI}{dn}=\frac{-\{F_2(2\delta'+n\delta'')-w^{*\prime}\}}{w^{*\prime}}>1. \tag{26}$$

Figure 1 shows the two loci of I and n that satisfy (23) and (25). Note from (24) and (26) that the slopes of both have to be negative, and that the schedule defined by (23) has to be flatter than the one defined by (25). The equilibrium combination of n and I is shown in Figure 1. The analytical solution can be obtained from (23) and (25) as

$$\tilde{n}=n(\tilde{w}) \text{ and } \tilde{I}=I(\tilde{w})\,. \tag{27}$$

This finding is reminiscent of Ethier (1986), where the native wage could not be unbundled from the illegal immigration target. One could not have two independent targets for immigration and the native wage in the absence of some other policy instrument. The same issue resurfaces here in a somewhat different context. With an outsourcing tax in addition to a wage target $\tilde{w}$, equation (23) still holds. Equation (25) is modified to

$$F_2(1,\tilde{\rho})\{\delta(n)+n\delta'(n)\}-w^*(I+n)-t=0\,. \tag{28}$$

Relations (23) and (28) simultaneously determine

$$\tilde{n}(t)=n(\tilde{w},t) \text{ and } \tilde{I}(t)=I(\tilde{w},t)\,. \tag{29}$$

From (29) it is clear that now we can unbundle wage and immigration by a suitable choice of *t*. In Figure 1, the locus defined by (28) will shift to the right as *t* is reduced. The outsourcing tax (subsidy) is chosen at t^{τ} such that it intersects with the locus defined by (23) at the immigration level I^{τ}.[10]

Let us now turn to the effect on national income of such a wage and immigration-targeting policy. First, let us allow both *I* and *n* to vary while fixing wage at its target level $\tilde{w}$. Under the outsourcing tax, using (23) we have a modified version of (14b):

$$Y = F[T, S^D + I + n\delta(n)] - w^S I - nw^*(I+n)$$

$$= TF(1,\tilde{\rho}) - F_2(1,\tilde{\rho})I(\tilde{\rho},n) - nw^*\{I(\tilde{\rho},n)+n\}. \tag{30}$$

Differentiating (30) and using (23), (24), and (28):[11]

$$\frac{dY}{dt} = \left[t + nw^{*\prime}\left(\frac{\rho_2}{\rho_1} - 1\right)\right]\frac{dn}{dt}. \tag{31}$$

Note from Figure 1 that an outsourcing subsidy ($t^{\tau} < 0$) needs to be used to reduce immigration to the target level. Given that $\frac{dn}{dt} < 0$ and $\frac{\rho_2}{\rho_1} < 1$, (31) implies that $\frac{dY}{dt} > 0$ if $t \le 0$. Thus, the relationship between *Y* and *t* is monotonic and positive for any non-positive value of *t* (and also for positive values of *t* that are sufficiently small). Figure 2 demonstrates this. It is easy to see

[10] Note that the point of this analysis is not to suggest that outsourcing should be subsidized. What it shows is that there is a difficult trade-off for the policy maker. An alternate way of viewing this trade-off is to consider raising the barriers to outsourcing (presumably in response to political pressure from native workers). In that case as *t* is raised, one cannot maintain the domestic wage target without accepting a higher immigration level.

[11] Equation (31) implies that in the absence of an immigration target, a wage target implies that it is optimal to tax outsourcing, $\tilde{t}^{SB} = nw^{*\prime}(1 - \rho_2/\rho_1) > 0$. A reduction of outsourcing below $n(\tilde{w}, t = 0)$ in Figure 1 raises *I* along the target wage locus [i.e., $\rho(I,n) = \tilde{\rho}$]. From (24) we know that this locus requires that: $-dI/dn < 1$. Therefore, the fall in *n* must be larger than the rise in *I*. The net effect of the tax will then be to reduce (*I* + *n*), the net demand for labor from the source nation. The demand reduction reduces w^* and this justifies an outsourcing tax (for a fixed $\tilde{w}$ and a variable *I*). However, when we have an immigration target I^{τ} in addition to the wage target ($\tilde{w}$), we cannot impose such a tax, because immigration cannot be raised above $I(\tilde{w}, t = 0)$. Indeed, a subsidy needs to be used to lower it to $I^{\tau} = I(\tilde{w}, t^{\tau} < 0)$.

that national income must go down from Y^0 to Y^τ as *t* is reduced from zero to t^τ to meet the immigration target. For large values of *t*, the relationship is negative. Figure 2 (and footnote 13 below) shows that, as long as the second order conditions are satisfied, there exists a second best outsourcing tax $\tilde{t}^{SB}$ (where $w^S = \tilde{w}$, but *I* is allowed to vary).

4. The Model with Illegal Immigration

This section extends the basic model presented in section 2 to consider jointly the issues of legal and illegal immigration in the presence of outsourcing. As in section 2, immigration is allowed in the skilled labor category. Also, outsourcing is considered in the context of skilled labor. In addition, this section introduces unskilled labor. Illegal immigration is considered in this latter context. We assume that there are no legal immigrants in the unskilled category (this assumption is for simplicity and can be easily relaxed). Therefore, there are only two types of unskilled workers: natives and illegal immigrants. Illegal immigrants enter the country through a porous border in response to expected wage differences between their source nation and the potential host nation. Enforcement policy by the host nation is used to deter illegal immigrants, but because such policy is costly, some illegal immigration occurs. The host nation chooses its legal immigration quota and enforcement policies. The section analyzes the effects of the legal immigration quota in the presence of enforcement policies.

The host country for illegal labor (i.e., the home nation) produces a single good with entrepreneurial capital (*T*), skilled labor (*S*), and unskilled labor (*U*). Let λ be the level of illegal immigration, U^D be the domestic unskilled labor force. The total unskilled labor supply is the sum of λ and U^D. Let w^* and w^{**} be the source country wages of skilled and unskilled labor, respectively. For analytical simplicity, we assume that these prices are given.[12] Border and internal enforcement can both be used to restrict illegal immigration. Internal enforcement takes the form of random checks on firms, which are fined z per illegal worker detected. Where e^i is the internal enforcement effort, the probability of internal detection is

$$p^i = p^i(e^i)\text{, for which } p^i(0) = 0,\ p^{i\prime} > 0\text{, and } p^{i\prime\prime} < 0. \tag{32}$$

Let Q be domestic output produced through a CRS technology:

$$Q = F(T, S, U) = F\{T, S^D + I + \delta(n)n, \lambda + U^D\}. \tag{33}$$

Along the lines of Bond and Chen (1987), we assume that firms can hire illegal labor by paying a wage w^λ. Also, let the wage of domestic unskilled labor be w. When firms hire a unit of illegal labor they know that with probability p^i that labor unit will be detected and the firm will have to pay a fine z for that unit. Therefore, a firm's profit is

$$\pi = F\{T, S^D + I + \delta(n)n, \lambda + U^D\} - w^T T - w^S(S^D + I) - w^* n - wU^D - w^\lambda \lambda - zp^i \lambda. \tag{34}$$

The first order conditions of profit maximization are

$$F_1(.) = w^T,\ F_2(.) = w^S,\ F_2(.)\{\delta + n\delta'(n)\} = w^*\text{, and } F_3(.) = w = w^\lambda + zp^i. \tag{35}$$

Now, let us turn to the supply of illegal labor. Where e^b is the border enforcement effort by the host nation, let p^b be the probability of border detection:

$$p^b = p^b(e^b)\text{, for which } p^b(0) = 0,\ p^{b\prime}(.) > 0\text{, and } p^{b\prime\prime}(.) < 0, \tag{36}$$

Along the lines of Harris-Todaro (1970) and Ethier (1986), we assume that risk-neutral migrants equate their certainty wage in the source nation to the expected wage from illegal migration:

[12] Endogenizing these prices yields results that depend on the monopsonistic power in the respective labor markets. Because we have already discussed this issue, we focus here on the links between the two types of immigration.

$$w^{**} = w^{\lambda}(1-p^b) + (w^{**} - f)p^b \,, \tag{37}$$

where f is the cost incurred by the illegal immigrant if detected and returned to the source nation. Using (35) and (37),

$$w^{**} = w^{\lambda} - f\frac{p^b}{1-p^b} = w - p^i z - f\frac{p^b}{1-p^b} \Rightarrow w = w^{**} + R(e^i, e^b) \,,$$

$$\text{where } R(e^i, e^b) = p^i(e^i)z + f\frac{p^b(e^b)}{1-p^b(e^b)} \,. \tag{38}$$

Using (35) through (38) we obtain

$$F_2\{T, S^D + I + n\delta(n), \lambda + U^D\}\{\delta(n) + n\delta'(n)\} = w^* \text{ and}$$

$$F_3\{T, S^D + I + n\delta(n), \lambda + U^D\} = w^{**} + R(.) \,. \tag{39}$$

Using (39) and suppressing T, S^D, U^D, w^*, and w^{**}, we can define the equilibrium values of n and λ as

$$n = n(I, R) \text{ and } \lambda = \lambda(I, R) \,. \tag{40}$$

Totally differentiating (39), and solving using Cramer's rule, we obtain

$$n_1(.) = \frac{(\delta + n\delta')\{F_{22}F_{33} - (F_{23})^2\}}{D'} < 0 \,,$$

$$n_2(.) = \frac{(\delta + n\delta')F_{23}}{D'} \Rightarrow sign\{n_2(.)\} = sign\{-F_{23}(.)\} \,,$$

$$\lambda_1(.) = \frac{F_2 F_{23}(2\delta' + n\delta'')}{D'} \Rightarrow sign\{\lambda_1(.)\} = sign\{F_{23}(.)\} \text{, and}$$

$$\lambda_2(.) = -\frac{F_2(2\delta' + n\delta'') + F_{22}(\delta + n\delta')^2}{D'} < 0 \text{, where}$$

$$D' = -(\delta + n\delta')^2\{F_{22}F_{33} - (F_{23})^2\} - F_2 F_{33}(2\delta' + n\delta'') < 0 \,. \tag{41}$$

As in the previous section, a larger immigration quota reduces outsourcing. Also, as expected, the effect of stricter enforcement is a reduction in illegal immigration. The cross effects are interesting. A rise in the immigration quota will raise illegal immigration if and only if the two inputs—skilled and unskilled labor—are complements in the production process (i.e., if $F_{23} > 0$). The intuition is that if the immigration quota is raised for legal immigration, then under complementarity, the marginal product of unskilled labor rises. This will raise the demand for unskilled labor along with the legal unskilled wage. In turn, through the equilibrium migration condition this will raise the illegal wage w^{λ} and encourage more illegal immigration. Also, recall that *n* must fall when *I* is raised. Thus, we can say that when F_{23} is positive the flow of illegal labor is a complement to the flow of legal labor, while outsourcing is a substitute for the latter.

Stricter enforcement (through a rise in *R*) will reduce outsourcing if and only if the two types of labor are complements in production. When enforcement is raised (with a given *I*), λ falls, reducing the marginal product of skilled labor. The resulting decline in the demand for skilled labor leads to a reduction in *n*.[13] Thus, when enforcement is used to reduce illegal immigration, outsourcing declines along with it, unlike the previous case in which illegal immigration and outsourcing move in opposite directions when *I* is raised.

Turning our attention to national income,[14]

[13] Note that given *I*, $S^D + I$ is fixed. Thus, *n* has to fall in response to the lower demand for skilled labor.

[14] The expression for national income is somewhat different from that in the previous section. The differences are that we have the costs of two types of enforcement as well as the cost of hiring illegal labor that must be subtracted from *Q*. Also, the fine collections from internal enforcement ($zp^i\lambda$) must be added in the expression for national income. This would normally be a transfer from the firms to the government and not appear in the expression for national income. However, note from (35) that: $w - zp^i = w^{\lambda}$. Thus the fine per illegal worker (zp^i) that is collected from the firms is passed on to the illegal workers by the firms in the form of a lower illegal wage. Therefore, this is ultimately a transfer from an immigrant to the government and therefore appears in (42) above. Alternately, we can view zp^i as an effective wage tax on a unit of illegal labor (as explained in Bond and Chen, 1987).

$$Y = F\{T, S^D + I + n\delta(n), \lambda + U^D\} - w^S I - w^* n - w\lambda + zp^i \lambda - e^i - e^b \, . \tag{42}$$

Differentiating (42) and using (38) and the first order conditions of profit maximization, we have

$$dY = [\lambda_1(.)(zp^i - IF_{23}) - IF_{22}\{1 + n_1(.)(\delta + n\delta')\}]dI$$

$$+\{\lambda_2(.)(zp^i - IF_{23}) - \lambda - n_2(.)IF_{22}(\delta + n\delta')\}dR - de^b - (1 - \lambda zp^{i'})de^i \, . \tag{43}$$

Thus,

$$\frac{\partial Y}{\partial I} = \lambda_1(.)(zp^i - IF_{23}) - IF_{22}\{1 + n_1(.)(\delta + n\delta')\}$$

$$= \lambda_1(.)zp^i - I[\lambda_1(.)F_{23} + F_{22}\{1 + n_1(.)(\delta + n\delta')\}] \, . \tag{44}$$

It can be shown that

$$\frac{dw^S}{dI} = \frac{dF_2(.)}{dI} = \lambda_1(.)F_{23} + F_{22}\{1 + n_1(.)(\delta + n\delta')\} < 0 \, , \tag{45}$$

making the second term on the right hand side of the last equation in (44) unambiguously positive. This term captures the effect of a rise in the immigration quota on the skilled wage rate. From (45) we see that as the immigration quota is raised, the skilled wage rate falls. As discussed in section-2, this is good for the host nation, because it means that less has to be paid to skilled immigrants. Using (35), we can write the first term in the last equality of (44) as

$$\lambda_1(.)zp^i = zp^i \frac{d\lambda}{dI} = (w - w^\lambda)\frac{d\lambda}{dI} \, . \tag{46}$$

If I rises, we know from (41) that illegal immigration must rise (fall) when F_{23} is positive (negative). For every additional illegal immigrant, the wedge between the legal and illegal wage ($= zp^i$) is collected as government revenues. Therefore, if illegal immigration rises (i.e., if $F_{23} > 0$), national income will rise. In this case, both terms in the last equality of (44) suggest that a rise in the legal immigration quota raises national income, and no national income maximizing quota exists. If $F_{23} < 0$, the effect of the immigration quota is ambiguous. For a sufficiently small immigration level, the first term n the last equality of (44) is likely to dominate and a relaxation (tightening) in the immigration quota will locally reduce (increase) national income. However, for a large immigration level, the second term should dominate. In general, no interior maximum exists for the national income level.[15]

5. Conclusion

To our knowledge this is the first paper that addresses immigration and outsourcing problems simultaneously in a general equilibrium framework. The model presented here can be easily adapted to address other important policy questions. In future research we can use this model to consider issues in trade policy and how that can interact with immigration and outsourcing policy. For example, Bandyopadhyay and Bandyopadhyay (1998) show that trade and factor mobility can either be complements or substitutes in a multi-good trade model where illegal immigration and trade co-exist. Recognizing the presence of outsourcing and exploring its inter-linkages in a similar context should be a useful line of research. Another direction in which we will like to pursue our research is to consider oligopolistic firms and how they use outsourcing to compete in international markets. The insights developed in this paper should be useful for pursuing these and related lines of inquiry.

[15] Unlike previous sections we assume here that the source nation wage is given. Without market power, there is no monopsonistic reason to restrict legal immigration. Of course, this does not suggest that legal immigration should be unlimited in practice. We are just capturing the effect of the quota on national income. The government's objective function can give higher weight to incomes of native skilled workers, or include potential social costs of legal immigration [as discussed in Ethier, 1986], which we do not consider here. These factors will suggest that the government should impose an immigration quota even if it can reduce national income.

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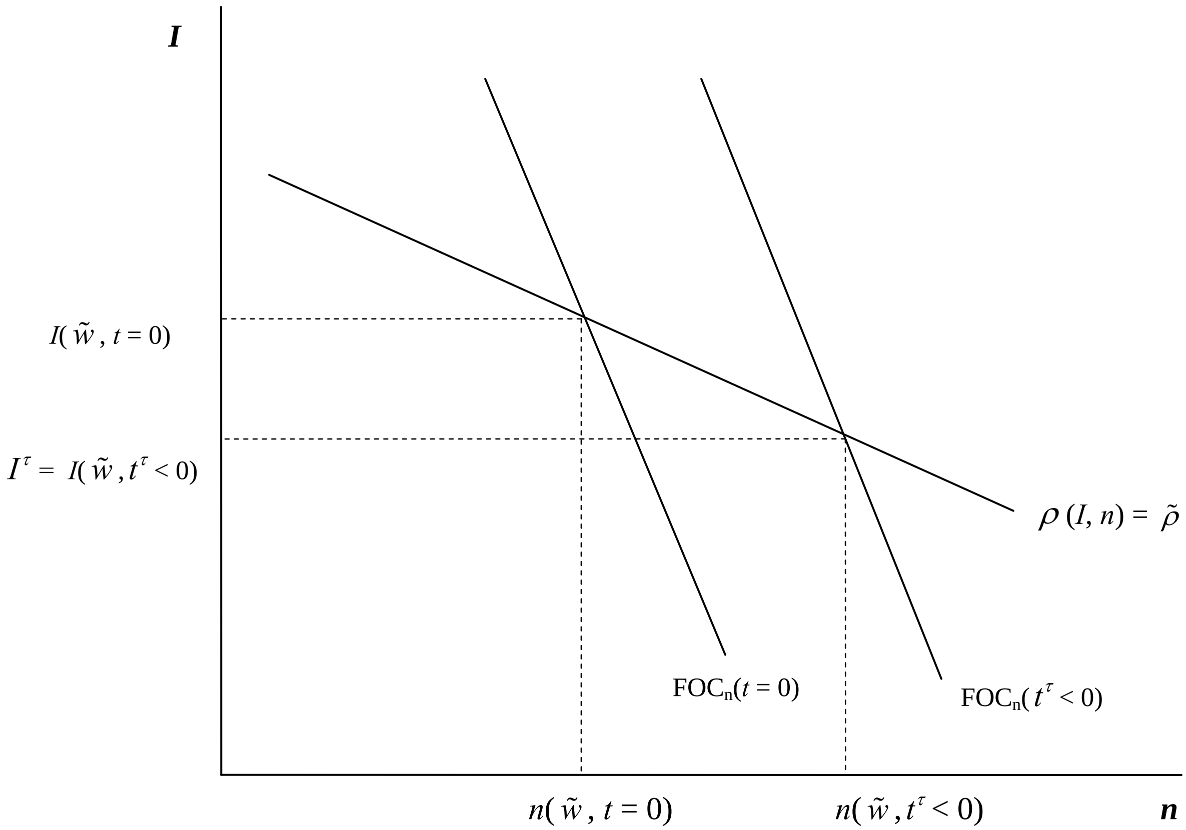
I
$I(\tilde{w}, t = 0)$
$I^{\tau} = I(\tilde{w}, t^{\tau} < 0)$
$\rho(I, n) = \tilde{\rho}$
$FOC_n(t = 0)$
$FOC_n(t^{\tau} < 0)$
$n(\tilde{w}, t = 0)$
$n(\tilde{w}, t^{\tau} < 0)$
n

Figure 1

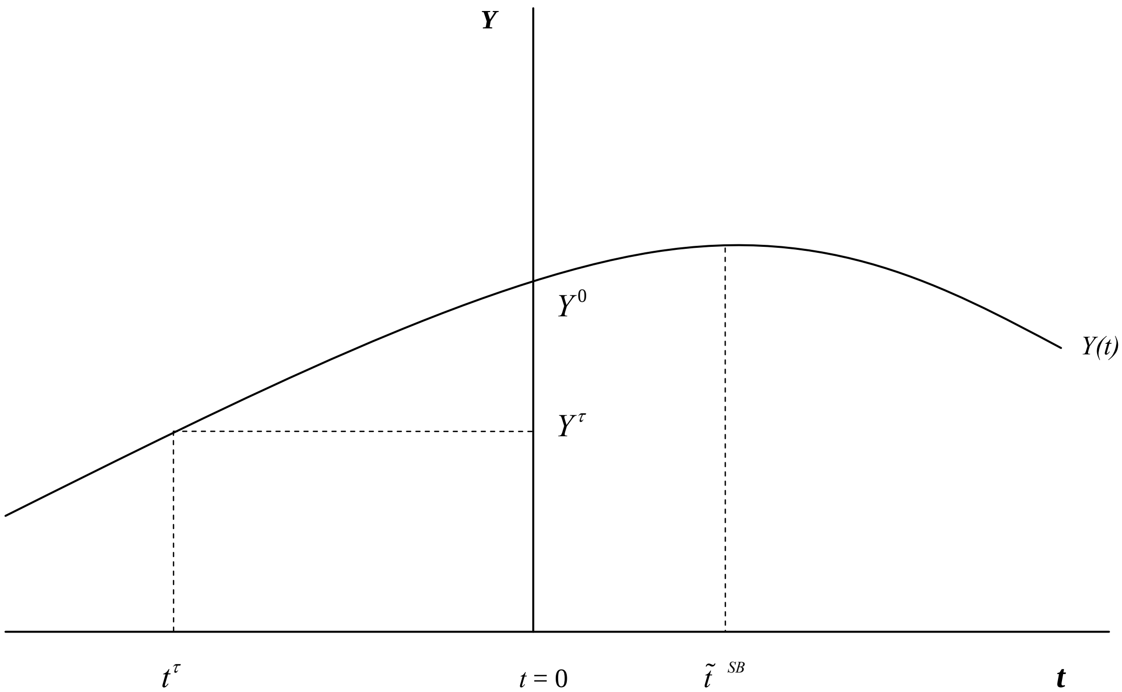

Figure 2