

Migration of Skilled Workers: Policy Interaction between Host and Source Countries

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Abstract

This paper examines the interaction between policies of the host and source countries in the context of a model of skilled-worker migration. The host country aims to provide low-cost labor for its employers while also taking into consideration the fiscal burden of providing social services to migrant workers and their dependants. It optimizes by setting a limit on the time duration of a guest-worker's permit. The source country seeks to maximize its own welfare by optimally choosing the amount of training it offers to its citizens, some of whom may end up working abroad. Within this framework, we solve for the Nash equilibrium values of the policy instruments and compare them with the case where both countries cooperate to maximize joint welfare.

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1 Introduction

Introduction

Migration of skilled workers from the developing to the advanced countries has attracted considerable attention ever since Jagdish Bhagwati brought the brain-drain problem into focus in the 1970s. By recruiting skilled professionals from the developing countries, where education is heavily subsidized by the public sector, the advanced countries were widely viewed as pursuing policies detrimental to the source countries. When migration of skilled workers is permanent, the bulk of the potential benefits stemming from public expenditures on training are lost from the perspective of taxpayers. When it is temporary, there is scope for gains, especially if the returnees bring with them productive human capital accumulated while working abroad [see, e.g., Wong (1997), Domingues Dos Santos and Postel-Vinay (2003)].

The vast majority of skilled migrants come from the developing and transition economies with the main poles of attraction being the U.S.A. and Canada, but also the economies of Western Europe (see Lucas (2005)). Recent efforts to measure the magnitudes of these flows, including the works of Salt (1997), Carrington and Detragiache (1998), Docquier and Marfouk (2006), and Beine et al (2006), reveal that the brain drain is a particularly acute problem for the relatively small developing countries. In terms of regions, small island economies of the Caribbean and the Pacific, as well as countries in Central America, Sub-Saharan Africa, and South-East Asia have the highest skilled-emigration rates as a proportion of their skilled population.

In the 21st century, emigration of skilled workers from the developing countries continues with a growing number of advanced countries offering fast-track labor-market access for skilled migrants through special temporary visa programs, such as the H1-B visa in the U.S.A. or the “Blue Card” in the EU. Other countries aim to increase

their stocks of highly trained workers by means of permanent immigration programs. The Canadian points system is a prominent example of this policy, also followed in slightly different forms by Australia, New Zealand and, more recently, Great Britain. In the U.S.A., special permanent residence visas for highly talented individuals have been available for decades. In the medical profession, foreign recruiters can be found throughout the developing world offering contracts for employment in hospitals of the advanced countries.

These practices and policies clearly have an impact on the flows of highly trained migrants from the developing economies. The outflows of skilled workers reduce, in turn, the incentive for the authorities to provide public subsidies for higher education [see Justman and Thisse (1997)]. In an important recent paper, Docquier et al. (2008) examine this question both theoretically and empirically. On the basis of a sample of 108 middle-income and low-income countries they find a negative relationship between education subsidies and skilled emigration rates. An obvious consequence is that the level of training and human capital possessed by the graduates (and thus skilled emigrants) is likely to be lower than it would be otherwise. Lower skills of migrants, in turn, affect the relationship between the costs and benefits of immigration from the perspective of the host countries. This can and does influence their immigration policies. The points systems of Canada, Australia and New Zealand are designed to filter out those with low training and skills. In the U.S.A., whether an H1-B worker can renew her temporary three-year visa depends on the willingness of the employer to sponsor a renewal, which depends to a large extent on the worker's training and ability.

The purpose of this study is to examine the brain-drain problem within a game-theoretic framework, where both the immigration policy of the host country and the optimal provision of higher education and training in the source country are endogenously determined. The analysis is conducted in the context of a simple two-country

model developed in Section 2. The host country's objective is to support the profitability of enterprises employing skilled labor while also taking into account the fiscal impact of immigration. The latter consists of immigration-induced increase in tax revenues minus the cost of public services absorbed by the skilled immigrants and their dependents. The policy instrument at the disposal of the host country is assumed to be the duration of time it allows migrants to work in the economy, which may be either temporary or permanent. The source country is assumed to provide education free of charge to its citizens, with the objective of maximizing its GDP. How much education is optimally provided depends on whether or not its citizens work abroad and, if they do, how long they stay.

Within this simple framework, Section 3 solves for the Nash equilibrium values of the policy instruments of both countries and examines how they respond to changes in the model's parameters. It is found that host countries that have relatively higher tax rates on incomes, that attribute a larger weight to employers' rents in their objective function, and that provide lower levels of public services, have an incentive to allow their skilled immigrants to work in the economy for a longer period of time. Whether a longer duration of stay raises or lowers the optimal level of training provided by the source country depends on the rate at which immigrants accumulate skills while working abroad and the valuation of those skills after return to the source country. It is also found that an increase in the cost of providing public education reduces the equilibrium level of training and the amount of time immigrants are allowed to work in the host country. An increase in the home-country valuation of skills acquired by migrant workers abroad has the opposite effects on the two policy instruments: The source country provides more training and the host country allows migrants to stay longer. Finally, if the host country chooses to increase its $\$stock\$$ of immigrants, this will lower(increase) the level of training provided by the source country if migration results in a brain drain(brain

gain). Section 4 extends the analysis to a setting where both countries set their policies to maximize joint welfare. In that case the level of training provided by the source country and the duration of stay of immigrants in the host country are both higher in comparison with their Nash equilibrium values. Section 5 looks at the equilibrium with permanent migration and Section 6 concludes the paper with a summary of the main findings.

2 The Analytic Framework

We consider a world consisting of two countries: An advanced labor-importing country and a less-developed country of emigration. The latter provides higher education and training to its citizens so as to maximize its GNP, net of training costs. Because potential earnings of skilled workers are higher abroad, some of the graduates will choose to migrate and thereby contribute to the GDP of the foreign rather than the home country. Migration opportunities may be temporary or permanent, depending on immigration policy of the host country, to which we now turn.

2.1 Host Country

The authorities of the host country are typically concerned with two key issues when choosing the structure of their immigration policy. One of them is the fiscal impact of immigration: While employment of immigrants increases the economy's output and revenues of the fiscal authority, immigration also implies greater absorption of services provided by the public sector.¹ Another key issue is the impact of immigration on the distribution of income between the native workers and their employers. Immigration

¹DeVoretz (2001) examines the fiscal implications of immigration to Canada. An immigrant's age, gender, education, training and the number of accompanying dependents are crucial factors that determine the net fiscal effect of immigration.

allows employers to enjoy larger rents by hiring foreign workers at wages below the levels that would clear the local labor markets in the absence of immigration. If the demand for labor expands, this prevents wages of natives from rising as much as they otherwise would, serving to redistribute income from native workers (and immigrants) to their employers. Broadly speaking, the number of immigrants allowed to work in the economy reflects the influence that employers have in relation to native workers in shaping immigration policy.

We will not address this important domestic political-economy issue in the present study, as it has already received considerable attention.² We will simply assume that the stock of immigrants, M , allowed to hold a valid work permit at any point in time is exogenously given, having been determined behind the scenes in a bargaining process involving various stakeholders in the host country. This strategy will enable us to sharpen our focus on another aspect of immigration policy that has not been treated in the theoretical literature on skilled-worker migration: The problem of setting the optimal duration of the work permit.

With respect to the duration of stay, employers have a strong preference for having the same foreign worker over a relatively long period of time. High turnover is especially undesirable in the skilled occupations where the productivity of an employee can grow significantly with experience and on-the-job training, much of it being specific to the firm. We try to capture this in our analysis below by assuming that H , the marginal productivity of a skilled foreign worker, is an increasing function of the amount of time, t , spent on the job abroad, as well as his level of training, ε , at the time of arrival. A migrant's marginal productivity in host-country employment is thus given by $H(\varepsilon, t)$, where $H_\varepsilon > 0$, $H_t \geq 0$, $H_{\varepsilon\varepsilon} \leq 0$, $H_{tt} < 0$. One would also expect that $H_{\varepsilon t} \geq 0$.

Let the wage paid to foreign workers be a constant, w , which is lower than the

²References on immigration and the distribution of income.

marginal productivity of labor.³ The average amount of rent, measured as a flow, enjoyed by an employer of a migrant worker is then

$$\frac{1}{\tau} \int_0^{\tau} [H(\varepsilon, t) - w] dt, \quad (1)$$

where τ represents the maximum duration of the work permit provided by the authorities.⁴ If the permit is temporary, it is not renewable, requiring the migrant to return to the source country on the date of expiration. Alternatively, if the host country offers permanent residence to a migrant worker, we assume that he does not return to the source country.

With respect to the fiscal impact of immigration, let us suppose that all income, whether from labor or capital, is taxed at the rate θ . The average flow of tax revenue per migrant worker is then simply

$$\frac{1}{\tau} \int_0^{\tau} \theta H(\varepsilon, t) dt. \quad (2)$$

With respect to the cost of providing public services to an immigrant per unit of time, we shall assume that it amounts to a flow c if the migrant comes alone and $(1 + a)c$ if s/he is accompanied by family members. The probability, π , that a migrant comes accompanied by family members, is clearly an increasing function of the expected duration of stay, τ . The average cost of providing a migrant and any accompanying dependents with public services, measured as a flow, is therefore given by $c[1 + a\pi(\tau)]$, where $0 < \pi(\tau) \leq 1$, $\pi_{\tau} > 0$ and a is likely to exceed unity. It seems most realistic to

³For foreign contract workers in Taiwan, the wage set by the authorities is roughly one third lower than that paid to native workers. In the case of skilled HI-B workers in the USA, Martin, Chen and Madamba (2000) report evidence that foreign workers are paid less than the natives with comparable skills.

⁴As hiring low-cost foreign labor generates a rent for an employer, there is an excess demand for migrant workers. For simplicity, we assume that employers are invited to participate in the program after being chosen at random by the authorities. The wage they are permitted to pay foreign workers is assumed to be strictly regulated and set below that received by native workers.

assume that the second derivative of $\pi(\tau)$, $\pi_{\tau\tau} > 0$ for low values of τ , but becomes negative at some point as $\tau \rightarrow T$, where T is the length of the migrant's planning horizon. We shall therefore posit that the function $\pi(\tau)$ is initially increasing in a convex manner to a certain point after which it becomes concave.⁵ A good candidate is any cumulative distribution function (CDF) since it is bounded from below at zero and from above at unity. In this particular context it is convenient to use the CDF of the logistic distribution which has the form $\pi(\tau) = 1/[1 + e^{\frac{\mu-\tau}{S}}] - 1/[1 + e^{\frac{\mu}{S}}]$. This is illustrated in Figure 1 for values of $\mu = 4$ and $S = 1$, thus the inflection point of the $\pi(\tau)$ function is assumed to be at $\tau = 4$. Note that π_{τ} is increasing for low values of τ and decreasing if $\tau > 4$.⁶

Let us assume that employers' rents and the net fiscal impact of hosting M migrant workers are the two key arguments in the objective function of the immigration authorities.⁷ In this context, the problem for the host country is to choose τ that maximizes its objective function, W , which has two components: The flow of average annual rents enjoyed by the employers and the expected average annual net fiscal impact of hosting

⁵This reflects the observation that for low values of τ , it is not economical for a migrant to bring the family along to the host country, as the associated migration costs impose a heavy burden without necessarily generating the offsetting benefits. For a low τ it makes more sense to leave the family in the source country, where the cost of consumption is typically lower and where the family can enjoy the continuity of residence along with a net increase in its standard of living due to higher earnings generated abroad by the household head. The vast majority of temporary migrants do in fact leave their family behind when the duration of the contract abroad is for just a year or two. For more extended stays abroad, separation can become increasingly difficult to cope with and the advantage of avoiding migration costs and benefiting from the lower cost of family consumption at home can become small relative to the benefits of family unity. As the duration of stay abroad increases to the range of roughly 2-6 years, we would therefore expect π to rise quickly with τ and family migration to become the dominant mode. Further increases in τ can be expected to raise π further, but at a diminishing rate.

⁶The exact shape of the $\pi(\tau)$ function under various conditions in the host and source countries is an empirical question on which very little systematic data is available. Since the precise shape of this function is not crucial for the theoretical analysis of this paper, we leave this issue on the agenda for future research.

⁷One can easily add integration costs of immigration as a separate argument. For simplicity, we prefer to consider such costs as being reflected in the values of c and α .

M migrant workers:

$$W = M \left[\frac{\lambda}{\tau} \int_0^\tau [H(\varepsilon, t) - w] dt + \frac{\theta}{\tau} \int_0^\tau H(\varepsilon, t) dt - c[1 + a\pi(\tau)] \right], \quad (3)$$

where λ is the weight attached by the government to the employers' rents, captured by the first term in the large brackets, while the net fiscal impact is represented by the difference between the last two terms. A necessary condition for the maximization of W with respect to τ is that

$$\frac{\partial W}{\partial \tau} = W_\tau = \frac{M(\lambda + \theta)}{\tau} \left[H(\varepsilon, \tau) - \frac{1}{\tau} \int_0^\tau H(\varepsilon, t) dt \right] - Mca\pi_\tau = 0, \quad (4)$$

where $H(\varepsilon, \tau)$ is the marginal productivity of a migrant worker at the moment just before s/he returns to the source country. Since we assumed that $H_t \geq 0$, $H(\varepsilon, \tau)$ is larger than the productivity of an average migrant worker, $\frac{1}{\tau} \int_0^\tau H(\varepsilon, t) dt$. This guarantees that the expression in the brackets of eq. (4) is positive. The last term captures the increase in the fiscal burden associated with the higher propensity for migrants to arrive accompanied by family members as τ is allowed to increase. In a highly developed welfare state, both c and a can be sufficiently large for the term $Mca\pi_\tau$ to potentially dominate the first term in (4) for certain values of τ . This is more likely if the productivity of skilled migrants does not rise significantly with the duration of stay in the host country (i.e., if the expression in the brackets is sufficiently small). The key question, of course, is whether π_τ at the inflexion point of the $\pi(\tau)$ function in Figure 1 is large enough so that $\partial W/\partial \tau < 0$ for the corresponding value of τ . If it is, temporary migration of skilled workers is the optimal policy for the host country with τ chosen to satisfy eq. (4).⁸ It is also clear from (4) that this is more likely to be the case, the higher the values of c and a ,

⁸It may be the case that the corresponding value of τ is only a local maximum for the host country's objective function. The latter may take on an even higher value if a permanent migration policy is chosen. This is unlikely to be the case, however, if H_t is relatively small at $t = \tau$.

and the smaller the effect of the duration of stay abroad on the migrant's productivity at $t = \tau$. On the other hand, allowing the migrants to stay permanently is optimal if $Mca\pi_\tau$ is smaller than the first term of eq. (4) for all τ or if permanent migration dominates the temporary migration solution, as explained in the previous footnote. We shall focus for the time being on the case where temporary migration is the optimal policy for the host country and examine the case of permanent migration later on in the paper.

2.2 Source Country

Suppose that the objective of the source country, S, is to maximize the welfare of its residents, while allowing them to have the freedom of international labor mobility. There is obviously a range of instruments available, but the one we wish to focus on in the context of a model of skilled-worker migration is the level of public education and training, ε , provided to the labor force. We shall assume that only the public educational system exists as liquidity-constrained households are unable to offer their children private education.

Education is costly, with government expenditure per individual assumed to be $x\varepsilon$, where x is the constant cost of providing more ε . The benefit of education for the economy manifests itself in a higher level of output, with the marginal productivity of a worker in source-country employment given by $H^*(\varepsilon)$ with $H_\varepsilon^* > 0$ and $H_{\varepsilon\varepsilon}^* < 0$.⁹

As some of the students will migrate at the time of graduation, the full benefits of the educational program are not captured by the source country. Some of the benefits spill over to the host country. This externality will obviously affect the optimal level

⁹Note that we are assuming that local workers do not become more productive with experience in the source-country labor market. This is to sharpen our focus on the technological differences between countries and the possible benefits that a source country may enjoy due to return migration from a more advanced host country. None of the principal findings of the paper would change if we assumed that a worker's productivity is an increasing function of experience in the domestic labor market.

of training provided to citizens. To define the problem in more concrete terms, let us assume that the objective of the source country is to maximize its steady-state GDP, net of educational expenditures. Suppose that L^* individuals are born at each instant, with their working lives being from the age of 0, when they graduate, to the age of T . The steady-state outflow of emigrants, M/τ , is set by the immigration policy of the host country, where M is the stock of migrants and τ is the duration of their stay abroad.¹⁰ Focusing here on the case of temporary migration, we may express the objective function of the source country as

$$W^* = (L^* - \frac{M}{\tau}) \int_0^T H^*(\varepsilon) dt + \frac{M}{\tau} \int_\tau^T \phi H(\varepsilon, \tau) dt - xL^*\varepsilon, \quad (5)$$

where $\phi \leq 1$ is the proportion of a migrant's productivity in the host country, just before return, that is transferrable to the labor market of the source country. The first term in (5) corresponds to the productivity of the non-migrant population, the second term reflects the contribution of all the returnees and the last term corresponds to the public cost of education. One can assume that the returnees bring back valuable skills acquired abroad, so that $\phi H(\varepsilon, \tau) \geq H^*(\varepsilon)$ or, at the other extreme, that the skills accumulated in the foreign country are largely firm specific and that having been away for τ units of time actually makes returnees less productive in comparison with similarly educated non-emigrants [i.e., $\phi H(\varepsilon, \tau) < H^*(\varepsilon)$]. We shall ignore this second possibility on the grounds that it is much less likely to be empirically relevant than the first.

The source country will set ε to maximize W^* . That is,

$$\frac{\partial W^*}{\partial \varepsilon} = W'_\varepsilon = (L^* - \frac{M}{\tau}) \int_0^T H'_\varepsilon(\varepsilon) dt + \frac{M}{\tau} \int_\tau^T \phi H'_\varepsilon(\varepsilon, \tau) dt - xL^* = 0. \quad (6)$$

If there is no migration (i.e., $M = 0$), the optimal level of training is such that, x , the

¹⁰If the host country is willing to keep a stock M of foreign workers and allows each worker to remain for τ units of time, the steady state flow of migrants leaving (and returning to) the source country is M/τ .

marginal cost of an extra unit of education is equal to $\int_0^T H_\varepsilon^*(\varepsilon)dt$, which is the increase in the undiscounted lifetime productivity of a non-migrant. With migration, either a lower or a higher level of training is optimal, depending on whether

$$D \equiv \int_0^T H_\varepsilon^*(\varepsilon)dt - \int_\tau^T \phi H_\varepsilon(\varepsilon, \tau)dt \quad (7)$$

is positive or negative, respectively. The first term in (7) corresponds to the increase in the lifetime productivity of a non-migrant due to an increase in training by one unit. The second term corresponds to a returnee's contribution to source-country output due to the same extra unit of training provided before emigration. If $H_{\varepsilon t}$ and ϕ are sufficiently large, it is conceivable that $D < 0$. In that case there is no "brain-drain" problem associated with temporary migration in the sense that the source country benefits more by providing extra training to a worker who emigrates than it does by providing it to one who remains at home. Accordingly, it has an incentive to provide more public training to its citizens when there is migration than it does in the absence of migration. We shall refer to this as the case of "brain gain" or BG. More realistically, $D > 0$, in which case there is a "brain drain" (BD) and the source country finds it optimal to provide less training in the presence of temporary migration than it does under autarky. We shall consider both possibilities in the analysis below.

3 Nash Equilibrium with Temporary Migration

Eqs. (4) and (6) are the reaction functions of the host and source countries. To determine the slope of the host-country reaction function, we first take the partial derivatives of

(4) with respect to τ .

$$\begin{aligned} \frac{\partial W_\tau}{\partial \tau} = W_{\tau\tau} &= \frac{M(\lambda + \theta)}{\tau^2} \left[\tau H_t(\varepsilon, \tau) - H(\varepsilon, \tau) + \frac{1}{\tau} \int_0^\tau H(\varepsilon, t) dt \right] - \\ &\quad - \frac{M(\lambda + \theta)}{\tau^2} \left[H(\varepsilon, \tau) - \frac{1}{\tau} \int_0^\tau H(\varepsilon, t) dt \right] - Mca\pi_{\tau\tau} < 0. \end{aligned} \quad (8)$$

The fact that $W_{\tau\tau} < 0$, satisfying the the second-order condition for welfare maximization, can be ascertained by noting that if, as we assumed, $H_{tt} < 0$, the first term in (8) is negative. So are the second and third terms when condition (4) is satisfied, given the assumed shape of the $\pi(\tau)$ function.

The partial derivative of (4) with respect to ε is given by

$$\frac{\partial W_\tau}{\partial \varepsilon} = W_{\tau\varepsilon} = M \left\{ \frac{(\lambda + \theta)}{\tau} \left[H_\varepsilon(\varepsilon, \tau) - \frac{1}{\tau} \int_0^\tau H_\varepsilon(\varepsilon, t) dt \right] \right\} > 0. \quad (9)$$

The sign of $W_{\tau\varepsilon}$ is positive because we assumed that $H_{t\varepsilon} \geq 0$, so that H_ε evaluated at $t = \tau$ is greater than the average of H_ε for $t \in [0, \tau]$. From (8) and (9), it follows that the slope of the host-country reaction function, RR, displayed in Figure 2, is positive (i.e., $d\tau/d\varepsilon|_{W_\tau=0} = -W_{\tau\varepsilon}/W_{\tau\tau} > 0$).

Differentiating the source-country reaction function (6), the partial derivatives with respect to ε and τ are

$$\frac{\partial W_\varepsilon^*}{\partial \varepsilon} = W_{\varepsilon\varepsilon}^* = (L^* - \frac{M}{\tau}) \int_0^T H_{\varepsilon\varepsilon}^*(\varepsilon) dt + \frac{M}{\tau} \int_\tau^T \phi H_{\varepsilon\varepsilon}(\varepsilon, \tau) dt < 0, \quad (10)$$

because of the diminishing marginal effectiveness of education and

$$\frac{\partial W_\varepsilon^*}{\partial \tau} = W_{\varepsilon\tau}^* = \frac{M}{\tau} \left[\frac{D}{\tau} - \frac{\partial D}{\partial \tau} \right] = \frac{MD}{\tau^2} (1 - \eta_{D\tau}), \quad (11)$$

where D is defined in (7) and $\eta_{D\tau} \equiv (\partial D/\partial \tau)(\tau/D)$. **If D is positive and the**

elasticity of D with respect to τ is greater than unity, then a lengthening of a migrant's duration of stay abroad magnifies the brain-drain effect in the sense that a higher τ (accompanied by a proportional reduction in the flow of migrants such that the stock, M , remains constant) lowers the effectiveness of ε in raising source-country welfare. We then have the case of ultra brain drain (UBD), where 1) migration lowers the incentive of the source country to train its citizens and 2) an increase in τ (combined with a proportional reduction in the outflow of migrants) reduces that incentive even further **by increasing the size of the brain drain**. $W_{\varepsilon\tau}^*$ is then negative and the slope of the reaction function of the source country, R^*R^* , given by $d\tau/d\varepsilon|_{W_{\varepsilon}^*=0} = -W_{\varepsilon\varepsilon}^*/W_{\varepsilon\tau}^* < 0$, as illustrated in Figure 2. **The sign of $W_{\varepsilon\tau}^*$ and the slope of the reaction function is also negative if we have a brain gain (i.e., $D < 0$) but $\eta_{D\tau} < 1$.** Alternatively, if there is a brain gain (i.e., $D < 0$) **and** $\eta_{D\tau} > 1$, or $D > 0$ but $\eta_{D\tau} < 1$, the source country is better off by raising ε in response to an increase in τ . In that case $W_{\varepsilon\tau}^* > 0$ and R^*R^* is positively sloped. Stability of the equilibrium requires that

$$\Delta \equiv W_{\tau\tau}W_{\varepsilon\varepsilon}^* - W_{\tau\varepsilon}W_{\varepsilon\tau}^* > 0,$$

which implies that if R^*R^* is positively sloped, it must be steeper than RR , as illustrated in Figure 3. We shall assume this to be the case.

3.1 Comparative Statics

To examine the implications of changes in the key exogenous variables on the Nash-equilibrium values of the two policy instruments, we differentiate totally the reaction functions (4) and (6) to obtain

$$\begin{bmatrix} W_{\tau\tau} & W_{\tau\varepsilon} \\ W_{\varepsilon\tau}^* & W_{\varepsilon\varepsilon}^* \end{bmatrix} \begin{bmatrix} d\tau \\ d\varepsilon \end{bmatrix} = \begin{bmatrix} -W_{\tau\theta}d\theta - W_{\tau c}dc - W_{\tau\lambda}d\lambda \\ -W_{\varepsilon\delta}^*d\delta - W_{\varepsilon\phi}^*d\phi - W_{\varepsilon M}^*dM \end{bmatrix},$$

which enables us to solve for the effects of changes in the exogenous variables $\theta, c, \lambda, \phi, x$, and M on the optimal values of τ and ε in a non-cooperative equilibrium. The results are presented in the following subsections.

3.2 Increase in the tax rate in country H

An increase in the tax rate, θ , of the host country has the following implications:

$$\Delta \frac{d\tau}{d\theta} = -W_{\tau\theta}W_{\varepsilon\varepsilon}^* > 0, \quad (12)$$

$$\Delta \frac{d\varepsilon}{d\theta} = W_{\tau\theta}W_{\varepsilon\tau}^* \quad (13)$$

where $W_{\tau\theta} = \frac{M}{\tau} \left[H(\varepsilon, \tau) - \frac{1}{\tau} \int_0^{\tau} H(\varepsilon, t) dt \right] > 0$. As noted earlier, this inequality stems

from the assumption that the productivity of an immigrant in H increases over time. It follows that a higher θ increases the Nash equilibrium value of τ . Host countries with higher tax rates on earnings (including employer rents) can therefore be expected to allow skilled immigrants to stay longer. As we have assumed that the stock of migrants, M , is held constant, this comes at the expense of a smaller inflow of foreign workers.

The effect of a higher tax rate on the Nash equilibrium amount of training provided by country S is ambiguous and depends on the sign of $W_{\varepsilon\tau}^*$. In the UBD case, (i.e., $W_{\varepsilon\tau}^* < 0$), an increase in the tax rate lowers the amount of training as that is the optimal response of the source country to a rise in τ . In terms of Figure 2, an increase in θ shifts the RR schedule up and to the left, causing it to intersect the unaffected R*R* locus at a lower value of ε . Alternatively, if $W_{\varepsilon\tau}^* > 0$, we have the case depicted in Figure 3, with an upward shift of RR giving rise to an increase in the Nash equilibrium value of ε . This reflects the fact that when $W_{\varepsilon\tau}^* > 0$, an increase in each migrant's duration of stay abroad (along with a proportional reduction in the flow of migrants) actually

raises the source-country benefit of training relative to the cost, making an increase in ε optimal.

3.3 Higher cost of public services absorbed by immigrants

Consider next the implications of an increase in c , the cost of public services provided to immigrants.

$$\Delta \frac{d\tau}{dc} = -W_{\tau c} W_{\varepsilon\varepsilon}^* < 0 \quad (14)$$

$$\Delta \frac{d\varepsilon}{dc} = W_{\tau c} W_{\varepsilon\tau}^* \quad (15)$$

where $W_{\tau c} = -\alpha\pi_{\tau} < 0$. With an increase in c , the Nash equilibrium duration of stay decreases. This stems from the assumption that if immigrants stay for a shorter period of time, they are less likely to bring with them their families that absorb costly public services. Thus, the more the public sector spends per unit of services provided to immigrants, the lower the Nash equilibrium value of τ . Host countries with highly developed welfare systems, particularly when it comes to services provided to dependent members of an immigrant household, can thus be expected to favor temporary immigration programs with relatively tight restrictions on the duration of stay.

The amount of training provided by the source country to its citizens either increases or decreases, depending on whether $W_{\varepsilon\tau}^*$ is positive or negative. The intuition here is similar to what we have seen in the previous subsection. The source country increases or cuts ε in response to a reduction in τ , depending on whether $W_{\varepsilon\tau}^*$ is negative or positive.

3.4 Increase in the weight of employers' rents

If the rents of host-country employers obtain a larger weight, λ , in the objective function of country H, we have the following implications for the Nash equilibrium values of τ

and ε .

$$\Delta \frac{d\tau}{d\lambda} = -W_{\tau\lambda} W_{\varepsilon\varepsilon}^* > 0 \quad (16)$$

$$\Delta \frac{d\varepsilon}{d\lambda} = W_{\tau\lambda} W_{\varepsilon\tau}^* \quad (17)$$

where $W_{\tau\lambda} = \frac{M}{\tau} [H(\varepsilon, \tau) - \frac{1}{\tau} \int_0^\tau H(\varepsilon, t)] > 0$, since the productivity of immigrants at the point of return is higher than the average productivity. A rise in λ therefore increases the Nash equilibrium duration of stay while having an effect on ε that depends, once again, on the sign of $W_{\varepsilon\tau}^*$. This is precisely the same result that we had for an increase in θ and the same intuition follows.

3.5 Higher transferability of skills acquired abroad

An increase in ϕ has the following effects:

$$\Delta \frac{d\tau}{d\phi} = W_{\tau\varepsilon} W_{\varepsilon\phi}^* > 0 \quad (18)$$

$$\Delta \frac{d\varepsilon}{d\phi} = -W_{\tau\tau} W_{\varepsilon\phi}^* > 0 \quad (19)$$

where $W_{\varepsilon\phi}^* = \frac{M}{\tau} \int_\tau^T H_\varepsilon(\varepsilon, \tau) dt > 0$. Greater source-country valuation of skills acquired by migrants in H increases the Nash equilibrium amount of training and the duration of stay. The intuition is simple. Since immigrants are effectively more productive at the point of return, it is optimal for country S to increase the amount of training it provides to all its citizens and for country H to keep each of the skilled immigrants for a longer period of time.

3.6 Increase in the cost of training

An increase in x is found to lower the Nash equilibrium values of both ε and τ .

$$\Delta \frac{d\tau}{dx} = W_{\tau\varepsilon} W_{\varepsilon x}^* < 0 \quad (20)$$

$$\Delta \frac{d\varepsilon}{dx} = -W_{\tau\tau} W_{\varepsilon x}^* < 0 \quad (21)$$

where $W_{\varepsilon x}^* = -L^* < 0$. If there is an increase in the cost of training in country S, it no longer pays to provide as much of it as when the cost was lower. The optimal response of the host country is to cut the duration of stay of its skilled immigrants. In terms of Figures 2 and 3, an increase in x shifts the R^*R^* schedule to the left to intersect the unaffected RR locus at lower values of both ε and τ .

3.7 Increase in the stock of immigrants

Consider next a shift in immigration policy of country H that results in a larger desired stock migrants, M , employed in the economy at any point in time. We have

$$\Delta \frac{d\tau}{dM} = W_{\tau\varepsilon} W_{\varepsilon M}^* \quad (22)$$

$$\Delta \frac{d\varepsilon}{dM} = -W_{\tau\tau} W_{\varepsilon M}^* \quad (23)$$

where $W_{\varepsilon M}^* = -D/\tau$, with D being a measure of the brain drain defined in eq. (7). Since $W_{\tau\varepsilon} > 0$ and $W_{\tau\tau} < 0$, the Nash equilibrium values of τ and ε move in the same direction. They both decline in the case of BD (i.e., $D > 0$) and increase in the case of BG (i.e., $D < 0$). This is because a loss of a larger proportion of the labor force to temporary migration calls for a cut in the provision of training when country S suffers from a brain drain and to increase training when it enjoys a brain gain. The optimal

response of country H is to shorten τ when training is reduced and to increase it when immigrants arrive with more skills.

4 Maximization of Joint Welfare

In this subsection we consider the case where country H choose the duration of stay and country S choose the amount of training to maximize joint welfare $W + W^*$. The value of τ must then be set such that

$$W_\tau + W_\tau^* = 0. \quad (24)$$

Differentiating the welfare function of country S with respect to τ yields

$$W_\tau^* = \frac{MT}{\tau^2} [H^*(\varepsilon) - \phi H(\varepsilon, \tau)] + \frac{M}{\tau} (T - \tau) \phi H_t(\varepsilon, \tau). \quad (25)$$

W_τ^* is positive, assuming immigrants at the point of return are more productive in the source country than the nonmigrants. This implies that joint welfare maximization calls for a longer duration of stay for migrants in country H than what we had when both countries behave non-cooperatively.

Similarly, if country S chooses ε in order to maximize joint welfare of S and H,

$$W_\varepsilon + W_\varepsilon^* = 0 \quad (26)$$

Differentiating the welfare function of country H with respect to ε , we find that

$$W_\varepsilon = M \frac{(\lambda + \theta)}{\tau} \int_0^\tau H_\varepsilon(\varepsilon, t) dt > 0. \quad (27)$$

Since $W_\varepsilon^* = 0$ in the Nash equilibrium, joint welfare maximization requires a higher value of ε than the one that emerges in a non-cooperative setting. Maximization of joint

welfare therefore results in more training of workers by the source country and longer duration of stay of skilled immigrants in the host country when compared with the Nash equilibrium values of these policy instruments.

Maximization of joint welfare does not necessarily give rise to an increase in the individual level of welfare of both countries. Consider for example the case where W_τ^* is zero or close to zero. The cooperative duration of stay is then approximately the same as at Nash, while the cooperative amount of training is higher. This means that the welfare of S is necessarily lower with joint welfare maximization than was in the Nash equilibrium, while the welfare of H is unambiguously higher. In this case, S has no incentive to cooperate in maximizing joint welfare and some side payment is needed in order to induce it to do so.

5 Permanent Migration

If migration is permanent, the host country simply retains a stock, M , of permanent immigrants, with a steady-state inflow of M/T skilled migrants filling the jobs of the retiring ones. The structure of the problem is then much simpler than in the case of temporary migration as τ is set at its maximum value of T . For the source country, the problem becomes that of maximizing

$$W^* = (L^* - \frac{M}{T}) \int_0^T H^*(\varepsilon) dt - xL^* \varepsilon, \quad (28)$$

with respect to ε . This yields,

$$\frac{\partial W^*}{\partial \varepsilon} = L^* \left[\left(1 - \frac{M}{L^*T} \right) \int_0^T H_\varepsilon^*(\varepsilon) dt - x \right] = 0, \quad (29)$$

which implies that the marginal cost of training must be equated to the product of the increase in lifetime productivity of its workers due to the extra unit of training and the proportion of graduates that remain at home. As the marginal productivity of training is assumed to be diminishing, it follows that the larger the stock of skilled migrants recruited on a permanent basis by the host country, the lower the optimal level of training provided by the public educational system of the source country.

6 Conclusions

The vast literature on migration of skilled workers and the brain drain does not provide a systematic analysis of the interaction between immigration policy of the host country and the provision of public education in the source country. The present study attempts to fill this gap by developing a two-country model of skilled-worker migration where the host country chooses the optimal duration of stay of skilled migrants and the source country sets the level of training provided to its citizens.

In our analysis of the Nash equilibrium with temporary migration, we find that host countries that have relatively high tax rates on incomes, that attribute a larger weight to employers' rents in their objective function, and that provide low levels of public services, have an incentive to allow their skilled immigrants to work in the economy for a relatively longer period of time, including permanently. Whether an immigration policy that allows for a longer duration of stay raises or lowers the optimal level of training provided by the source country depends on the rate at which immigrants accumulate skills while working abroad and the valuation of such skills after return to the source country. If the skills acquired abroad are more valuable in the labor market at home, more training is provided. Finally, if the host country chooses to increase its *stock* of immigrants, this will lower(increase) the level of training provided by the host country if

migration results in a brain drain(brain gain). We also examine the implications of both countries acting to maximize joint welfare. In that case, the level of education provided to citizens of the source country is greater and the maximum duration of stay of migrant workers in the host country is longer when compared with the Nash equilibrium values of these instruments.

Concerning the agenda for future research, there are a number of directions in which the present model could be extended. In some cases this would complicate the analysis considerably, requiring simplifications of the model in other dimensions. For example, our model has only one sector employing skilled labor with the authorities providing education to the entire labor force. A richer framework would consist of a two-sector economy, with one sector requiring skilled labor and the other unskilled labor. The size of the skilled relative to the unskilled sector and the pattern of international trade in goods would then depend on the immigration and educational policies of the host and source countries, respectively. Second, as in Djajic (1989), one may look at emigration of skilled workers from an economy where individuals have heterogeneous abilities. In such a world, the workers with the highest abilities will have the strongest incentives to migrate, which in most modelling scenarios will accentuate the brain-drain effect for any given stock of migrants admitted abroad. Allowing for endogenous investment in one's education, along the lines of recent work referred to in the Introduction, would enrich the analysis further by capturing the complementarities between public subsidies to education and private effort to acquire it. These and other possible extensions of our model would contribute significantly to our understanding of the interaction between the optimal immigration and education policies of the host and source countries in a world where international mobility of skilled labor is becoming increasingly important.

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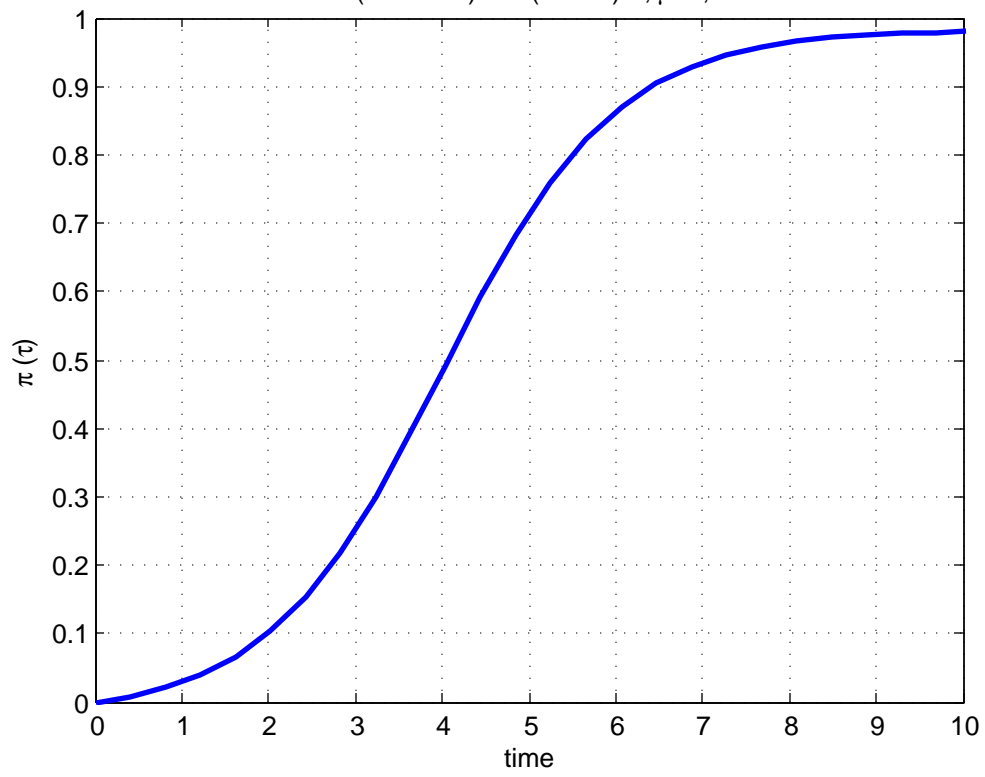
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$$\pi = (1 + e^{(\mu - \tau)/s})^{-1} - (1 + e^{\mu/s})^{-1}, \mu = 4, s = 1$$



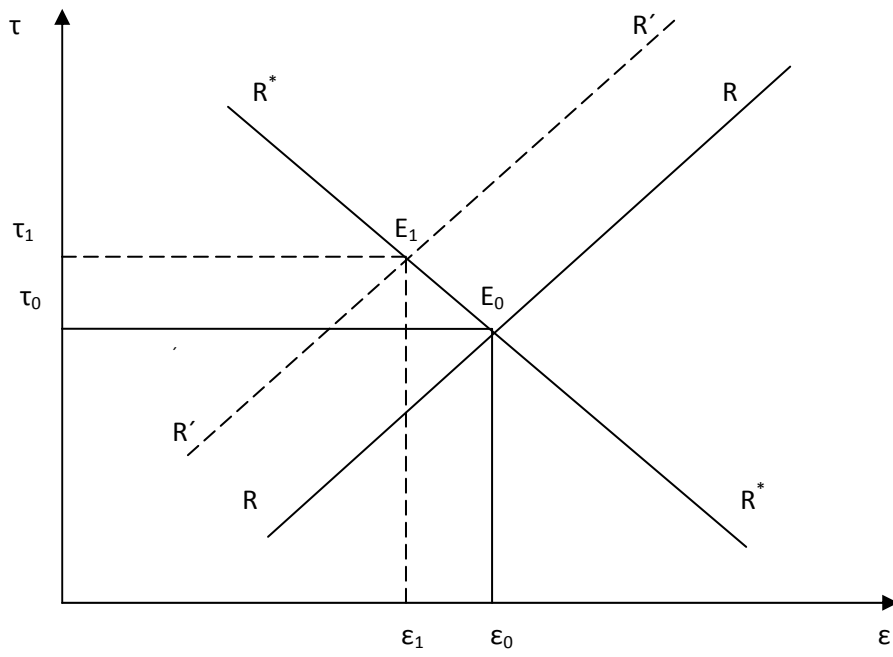


Figure 2. Nash Equilibrium when $W_{\epsilon\tau}^* < 0$

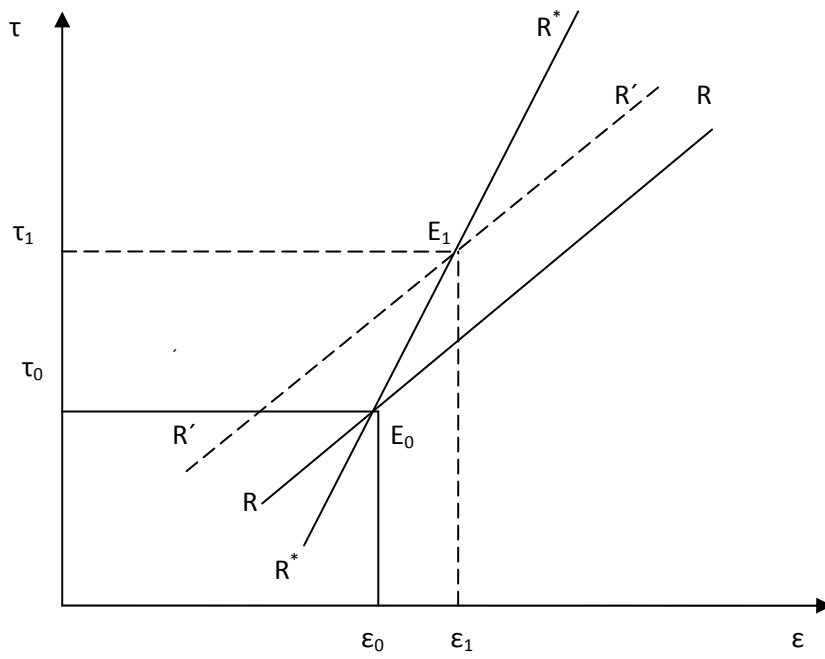


Figure 3. Nash Equilibrium when $W_{\epsilon\tau}^* > 0$