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On the formation of international migration policies when no country has an exclusive policy-setting say

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Abstract

This paper identifies the migration policies that emerge when both the sending country and the receiving country wield power to set migration quotas, when controlling migration is costly, and when the decision how much human capital to acquire depends, among other things, on the migration policies. The paper analyzes the endogenous formation of bilateral agreements in the shape of transfers to support migration controls, and in the shape of joint arrangements regarding the migration policy and the cost-sharing of its implementation. The paper shows that in equilibrium both the sending country and the receiving country can participate in setting the migration policy, that bilateral agreements can arise as a welfare-improving mechanism, and that the sending country can gain from migration even when it does not set its preferred policy.

JEL Classification: F22; I30; J24; J61

Keywords: Human capital formation; International migration; Migration policies; Welfare analysis

1. Introduction

The management of migration is one of the most topical issues in current world affairs. The keen interest in migration policy has lead to a strand of economics literature on how migration policies are formed. Ethier (1986), Bond and Chen (1987), and Djajic (1989) were among the first scholars who studied specifically the management of migration inflows by the receiving countries. More recent contributions have been made, among others, by Woodland and Yoshida (2006), Benhabib and Jovanovic (2007), and Bianchi (2010).[1] The received writings share the feature that the "quality" of each potential migrant, in particular his endowment of human capital, is taken as given and is orthogonal to (not determined endogenously by) the migration policy. This assumption does not seem to fit with a recent and fast evolving literature that maintains that under well specified conditions, the migration of human capital from a developing (sending) country to a developed (receiving) country enhances human capital formation and raises welfare *within* the sending country (Stark and Wang, 2002; Fan and Stark, 2007a, 2007b; Sorger, Stark, and Wang, 2011). We contend that the formation of migration policies should better not be oblivious to the endogeneity of the human capital decision and to the dependence of that decision on those policies.

In this paper, we contribute to the research on the management of international migration by developing substantially the model of Stark and Wang (2002). In that model, the level of human capital of migrants and non-migrants alike is affected by the migration policy. We relax two of the key assumptions of Stark and Wang (2002): that the sending country alone wields the power to set the migration policy; and that the policy can be implemented costlessly. These assumptions do not seem to tally with a reality in which quite often neither the sending country nor the receiving country fully controls migration, and does so at no cost. To this end, we develop a two-country framework in which in terms of their level of human capital, workers within each country are ex ante (that is, prior to migration) homogeneous. We study how migration policies are determined when both countries wield power to set migration policies, and when controlling migration is costly. The policy instrument that we employ is a migration quota which, for a given number of workers in the sending country, corresponds to a probability of migration.[2] We model the

[1] There is also a growing literature on the political economy of the determination of immigration quotas. The focus in that literature is on the perspective of the receiving countries. Examples are Benhabib (1996), Facchini and Willmann (2005), and Ortega (2005). Razin et al. (2011) study migration policy restrictions in political-economic models when the destination country is a welfare state.

[2] While receiving countries have lately focused on the development of screening policies in order to affect the skill-mix of the migrant inflow, migration quotas are also common. A striking example of a migration quota is the Green Card Lottery in the United States (United States Immigration Support, 2011). Every year, the United States issues 50,000 Green Cards through the Diversity Immigrant Visa Program, which allocates visas randomly to prospective migrants on the basis of a computer-generated draw. Migration quotas are also common in EU countries. Boeri and Bruecker (2005)

interaction between the two countries, first as a simultaneous non-cooperative game, and second as a sequential non-cooperative game. We also consider the endogenous emergence of bilateral agreements between countries.[3] We do so in two alternative settings: first, when the country that does not set the migration probability can nonetheless influence the equilibrium migration policy by resorting to the device of side-payments, which take the form of transfers for the support of control activities (say, funds for border enforcement); and second, when the two countries (Nash) bargain over the migration policy and over the sharing of the costs of implementing the policy.

We find that, in equilibrium, both the sending country and the receiving country can set the migration policy. We also find that bilateral agreements can arise as a welfare-improving mechanism. In addition, we show that the sending country can *gain* from migration even when the receiving country plays an active role in setting the migration policy, and when implementing that policy is costly.

Section 2 presents the benchmark model. Section 3 introduces the migration policy and establishes the equilibrium migration quota for a simultaneous game and a sequential game. Section 4 discusses bilateral agreements. Section 5 assesses whether under the equilibrium migration policy, the welfare of the sending country improves in comparison with the "no migration" situation. Section 6 presents conclusions.

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provide evidence of restrictions imposed by the old Member States on citizens of the new Member States during the transitional period in the wake of the two latest enlargement rounds of 2004 and 2007. Restrictions applying to citizens of non-EU countries are also widespread, as documented, for example, by the ILO (2004). These restrictions are often specific to certain sectors (agriculture in Austria, France, Greece, Portugal, and Sweden; tourism in Austria; and mining in France, Greece, and Portugal). Several receiving countries (the Czech Republic, Slovakia, Spain, and Switzerland) distinguish quotas according to the country of origin of the migrants, and on the basis of bilateral agreements. Several sending countries (including China) restrict issuing passports or granting exit visas so as to prevent (some of) their citizens from leaving. In China, in spite of a significant relaxation of migration controls in recent years, permission to leave the country may not be granted to those whose departure will, in the opinion of the competent department, be harmful to state security or cause major damage to national interests (cf. the Law of the People's Republic of China on the Control of the Exit and Entry of Citizens, 1986). More generally, the perception that it is the receiving countries that control incoming migration ("fix the migration policy") rather than the sending countries is often a myth. Spain has been at pains to forge an agreement with Senegal such that Senegal will curtail illegal migration to Spain, with Spain offering in exchange development aid and other financial incentives. Senegal will be allowed to grant a limited number of permits for Senegalese to work in Spain, and will otherwise exercise strict control over departures and cooperate fully in a swift repatriation of illegal migrants. (Similar pacts were made by Spain with Mauritania and with Morocco, for example.) Italy has had a similar agreement with Libya. The EU has been going out of its way to get sending countries in Africa to clamp down on EU-bound migration. The current (2011) preliminary talks between the EU and Tunisia's interim government on an agreement that will grant Tunisia preferential trade in return for a commitment to curb "irregular migration" is another illustration of the say that the sending country has in regulating migration flows. The US has long sought to have the Mexican government cap US-bound migration, essentially admitting that Mexico is as much in control of (illegal) migration to the US as is the US itself. Even in security-conscious Israel, it is Sudan rather than Israel that for the past few years has determined the (illegal) flow to Israel (via Egypt and the Sinai Peninsula) of thousands of its nationals.

[3] Fernandez-Huertas (2008) shows that bilateral agreements can be mutually beneficial for the sending country and the receiving country. In his setting, however, the human capital level of each potential migrant is given and is exogenous to the migration policy.

2. The model

In this section, we present our basic model. We draw on, and adjust for our current purposes, the model of Stark and Wang (2002). We consider a two-country world where, prior to migration, workers within each country are homogeneous. The assumption of a homogeneous workforce in the sending country is not critical however for the subsequent derivation of the results reported in the paper. In Appendix 1 we show that the equilibrium migration policies obtained in the homogeneous workforce setup are unchanged when there are two types of workers. Let $m \in [0,1]$ denote the probability that a worker in the sending country *S* migrates to the receiving country *R*. N^j denotes the measure of the continuum of homogeneous workers in country $j = S, R$. Workers produce a single commodity, the price of which is normalized at 1. Labor, measured in efficiency units, is the only factor of production.

In each country, the decision of workers how much human capital to acquire is undertaken in the presence of human capital externalities. Let the gross earnings in country *j*, f^j, of a native worker depend on the worker's human capital, ϑ^j, with a productivity parameter weight of $\beta^j > 0$, and on the average level of human capital, $\bar{\vartheta}^j$, with a productivity parameter weight of $\eta > 0$. Thus,

$$f^j = \beta^j \ln(\vartheta^j + 1) + \eta \ln(\bar{\vartheta}^j + 1). \qquad (1)$$

In an Appendix available on request, we show that an alternative specification of the earnings functions of workers, based on an economy modeled along the lines of a CRS Cobb-Douglas production technology, yields the same essential results regarding the implications of a prospect of migration for human capital formation and for the average level of human capital in the sending country as the results obtained and drawn upon below.

To concentrate on essentials, we assume that the externality parameter η is constant and that it is the same in each of the two countries, whereas the private returns to human capital differ between countries.[4]

[4] Two features of the earnings function (1) merit comment. First, by including the economy-wide average level of human capital, we incorporate a measure of externality that captures spillover effects that accrue within the national economy. For a succinct review of evidence on geographical and intertemporal spillover effects of human capital, see Moretti (2005). The externality assumption is common in the theoretical literature on endogenous economic growth, and it has recently been adopted to address the relationship between migration, human capital accumulation, and growth (Fan and Stark, 2007a, Sorger, Stark, and Wang, 2011). Second, the chosen functional form relies on a constant private returns parameter. This assumption is employed to facilitate tractability and is taken from Stark and Wang (2002). A helpful property of the constant private returns assumption, which is quite valuable for the questions addressed in this

How much human capital to acquire is determined by maximization of the expected net earnings, which are equal to the expected gross earnings minus the cost of forming human capital, $k\vartheta^j$, where $0 < k < \beta^j$ is a constant.

For a native worker of *S*, the objective function is

$$W^S(\vartheta^S) = m\left\{\beta^{mR}\ln(\vartheta^S+1)+\eta\ln(\overline{\vartheta}^R+1)\right\}+(1-m)\left\{\beta^S\ln(\vartheta^S+1)+\eta\ln(\overline{\vartheta}^S+1)\right\}-k\vartheta^S, \tag{2}$$

where $\beta^{mR} \in \left(\beta^S+\eta, \beta^R\right]$ denotes the private returns to the worker if he is a migrant in *R*, an event which occurs with probability *m*. The private returns to human capital are higher in *R* than in *S*, that is, $\beta^R > \beta^S$; when countries differ in their technologies, and when technologies are country-specific, the superior technology of an advanced, developed country renders the application of a given level of human capital in that country more productive than in the developing country. The assumption $\beta^R \geq \beta^{mR}$ allows the productivity of the natives to differ from the productivity of the migrants. It also enables us to capture, in a simplified manner, the imperfect transferability of human capital between countries. Still, the degree of transferability is assumed to be sufficiently large to preserve a positive difference in the private returns to human capital between *R* and *S.* The assumption $\beta^{mR} > \beta^S + \eta$ is discussed further below, following equation (8). To further enable us to concentrate on essentials, we assume that migration entails no cost of movement.[5]

When workers choose their optimal level of human capital, they take into consideration the private returns to human capital and the costs of acquiring human capital, but they do not factor in the repercussions of their choices on the productivity of others. This disregard of the externality effect of human capital results in underinvestment in human capital from a social point of view. It also invites corrective public policy.

Differentiating (2) with respect to ϑ^S yields

$$\frac{dW^S(\vartheta^S)}{d\vartheta^S} = \frac{m\beta^{mR}}{\vartheta^S+1}+\frac{(1-m)\beta^S}{\vartheta^S+1}-k = \frac{m(\beta^{mR}-\beta^S)+\beta^S}{\vartheta^S+1}-k. \tag{3}$$

Consequently, the optimal level of human capital of workers in country *S* is [6]

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paper, is that it provides a setting in which migration controls can be used as a "pure" policy instrument to restrict migration since in and by itself, migration is not restricted by decreasing marginal returns to human capital at destination.

[5] Introducing a fixed cost of migration will not affect the individual's human capital formation decision.

[6] The second-order condition for a maximum, $\frac{d^2W^S(\vartheta^S)}{d(\vartheta^S)^2} = -\frac{m(\beta^{mR}-\beta^S)+\beta^S}{(\vartheta^S+1)^2} < 0$, holds.

$$\vartheta^{S*}(m) = \frac{m(\beta^{mR} - \beta^{S}) + \beta^{S}}{k} - 1. \qquad (4)$$

Given that $\beta^{mR} > \beta^{S}$, for any $0 < m \leq 1$ the level of human capital of a worker in *S* exceeds the corresponding level when $m = 0$, which is $\vartheta^{S*}(0) = \frac{\beta^{S}}{k} - 1$.[7]

Referring next to *R*, since, by construction, workers in *R* face a probability of migration $m = 0$, their objective function is

$$W^{R}(\vartheta^{R}) = \left[\beta^{R}\ln(\vartheta^{R} + 1) + \eta\ln(\overline{\vartheta}^{R} + 1)\right] - k\vartheta^{R}, \qquad (5)$$

and the first order condition for the maximization of their net earnings yields an optimal level of human capital

$$\vartheta^{R*} = \frac{\beta^{R}}{k} - 1. \qquad (6)$$

From a comparison of (4) and (6), and recalling our assumptions regarding β^{S}, β^{mR}, and β^{R}, it follows that[8] $\vartheta^{S*} < \vartheta^{R*}$, namely the level of human capital formed in *S* is lower than the level of human capital prevailing in *R*.[9]

This observation is important since, as elucidated momentarily, it points to a drawback, from *R*'s point of view, of *R* opening its borders to migration from *S*: the impact of such migration on *R*'s welfare manifests itself through the effect of migration on the average level of human capital in *R*, and this effect is deleterious.

3. Forming a migration policy

In this section we study the interaction between *S* and *R*. In sub-section 3.2 we characterize this interaction as a non-cooperative game in which *S* and *R* set their optimal policies simultaneously,

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[7] The socially optimal level of human capital per worker in *S* in the closed economy setting, that is when m=0, is $\hat{\vartheta}^{S^*}(0) = \frac{\beta^{S} + \eta}{k} - 1$, cf. Stark and Wang (2002). There, it is also shown that an appropriately chosen migration policy can bring the economy to the social optimum, substituting for human capital subsidies.

[8] When doing so does not cause any confusion, we simplify the writing that follows by dropping the argument in $\vartheta^{S*}(m)$.

[9] To see this, note that for $m < 1$, and recalling that $\beta^{mR} > \beta^{S}$, $m(\beta^{mR} - \beta^{S}) + \beta^{S} = m\beta^{mR} + (1-m)\beta^{S} < \beta^{mR} \leq \beta^{R}$. For a hypothetical $m = 1$, $\vartheta^{S*} = \vartheta^{R*}$ if and only if $\beta^{mR} = \beta^{R}$.

each taking the other's move as given. In sub-section 3.3 we study a non-cooperative two-stage (Stackelberg) game in which one country is the first mover, setting its optimal policy anticipating the best reply of the other country.

As already noted, the policy instrument that we study is setting a migration quota, M. Even though countries frequently employ both screening and quotas as migration policy instruments, in this paper we study the latter. As noted in the Introduction, quotas are practiced often. For a given size, N^S, of the sending country's workforce, the setting of a quota M is equivalent to setting a migration probability for that country of $m = \frac{M}{N^S}$.

Undoubtedly, implementing a restrictive policy is costly. We assume that the cost of implementation is a function of the number of individuals that country S (R) wants to let out (in) over the total number of potential out-migrants (in-migrants), which in turn represents the migration pressure that each country faces. We denote by $C^j(m)$ the cost of migration controls for country j, with j=S, R. Taking into account plausible differences between S and R in the technologies of control, this cost can well be country-specific. We assume that $C^j(0) \equiv \hat{C}^j > 0$, $C^j(1) = 0$ and that $\frac{dC^j(m)}{dm} < 0$, namely, a tighter policy requires a larger financial outlay. Enforcing a closed-economy regime entails the highest cost $\hat{C}^j$, whereas policy-wise, an unhindered movement is cost free.[10] We also assume that the cost function is convex, $\frac{d^2C^j(m)}{dm^2} > 0$, and that $\lim_{m \to 1} \frac{dC^j(m)}{dm} = 0$, namely, as we approach fully open borders, the marginal cost goes to zero.

It stands to reason that if either of the two countries chooses a migration probability m, the probability space of the other is $[0, m]$: in a two-country world, emigration and immigration flows must be equal, and once one country chooses a probability level m, the other country cannot choose a less restrictive (that is, a higher) probability. We thus assume that the country that fixes the smaller migration probability will incur the control costs which, in per capita terms, are $c^j(m) = \frac{C^j(m)}{N^j}$.[11]

[10] The properties of this cost function are akin to those of the cost function used by Ethier (1986), with the main difference being that here we allow for the enforcement of a closed economy policy.
[11] However, the assumption that only one country at a time bears the migration control cost is relaxed in Section 4.

The resources required to implement the preferred migration policy are marshaled by levying a lump-sum tax on the country's native workforce. Therefore, $c^j(m)$ also denotes the per capita lump-sum tax. The assumption of a lump-sum tax implies that the decision to acquire human capital is not affected by the tax-based financing of the migration policy.[12]

With regard to the choice of the migration policy, we assume that *R* cares only about the wellbeing of its own natives. As to *S*, its concern rests with the non-migrant members of its workforce, since the representative migrant worker who ends up subjecting his human capital to the $\beta^{mR}(>\beta^S)$ productivity parameter (that is, to the superior *R* country technology) is clearly better off than an otherwise identical worker who stays behind in *S*.[13] The migration policy of country *j* is decided through maximization of the objective function

$$G^j_{I^j}(m) = \beta^j \ln(\vartheta^{j*}+1) + \eta \ln(\overline{\vartheta}^{j*}+1) - k\vartheta^{j*} - c^j(m)I^j, \tag{7}$$

where $I^j = \{0;1\}$ is an indicator function which takes the value of 1 when country *j* fixes the migration quota in equilibrium, and 0 otherwise. We use $G^j_{I^j=1}$ and $G^j_{I^j=0}$ to denote the corresponding objective function.

Equation (7) displays the net earnings of a representative worker in country *j*, minus the per capita control cost, where the net earnings are evaluated at the optimal level of investment in human capital, ϑ^{j*}.

Prior to introducing the simultaneous and sequential game, we make several preliminary observations. These are pooled together in the following sub-section.

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12 In equations (2) and (5) we did not include the lump-sum tax because at that point of the analysis, we did not as yet introduce migration policy choices. Given that the individual takes as given the migration probability *m*, inclusion of the lump-sum tax $c^j(m)$ will not affect the first order condition of the individual's optimization problem, however.

13 Stark and Wang (2002) discuss the choice of the objective function for the sending country. From Stark and Wang (2002) and from our discussion thus far we know that there is a threshold migration probability such that for quotas that entail a larger probability, non-migrants are actually worse off than when the quotas are set equal to zero; overinvestment in education can be detrimental to wellbeing. In such a case, in the wake of the migration opportunity the source economy will experience a reduction of welfare. However, as we show in Section 5, in equilibrium this possibility does not materialize.

3.1 Preliminary observations

Focusing first on country *S*, we note that its objective function, $G_{I^S}^S$, depends on *m* both via the impact of the per capita cost of control, and via the optimal individual level of human capital and the average level of human capital. From (7) and (4), the objective function of country *S* is:

$$G_{I^S}^S(m) = \left(\beta^S + \eta\right)\ln\left(\frac{m(\beta^{mR} - \beta^S) + \beta^S}{k}\right) - k\left(\frac{m(\beta^{mR} - \beta^S) + \beta^S}{k} - 1\right) - c^S(m)I^S, \qquad \text{(7a)}$$

which captures that the government takes into account the externality in human capital accumulation and knows that $\overline{\vartheta}^{S*} = \vartheta^{S*}$. Differentiating (7a) with respect to *m* yields

$$\frac{dG_{I^S}^S(m)}{dm} = \left(\beta^{mR} - \beta^S\right)\left[\frac{\beta^S + \eta}{m\left(\beta^{mR} - \beta^S\right) + \beta^S} - 1\right] - \frac{dc^S(m)}{dm}I^S. \qquad \text{(8)}$$

The first of the two terms on the right hand side of (8) captures the impact that a change in the migration probability *m* has on the earnings of the non-migrants via the change in the individual human capital and the average level of human capital. The second term captures the change in migration control costs, if incurred. In determining the optimal migration probability for *S*, we distinguish between two cases. If $I^S = 0$, then the migration probability that maximizes (7a) is $m^{S*} = \frac{\eta}{\beta^{mR} - \beta^S}$. The assumptions that $\eta > 0$ and that $\beta^{mR} > \beta^S + \eta$ ensure that $0 < m^{S*} < 1$. This probability also represents the equilibrium migration policy when *S* wields the exclusive power to set the migration policy, and when policy implementation is costless (cf. Stark and Wang, 2002).

If $I^S = 1$, the optimal policy for *S* is $m_C^{S*} > m^{S*}$, where the subscript *C* stands for incurring the control cost.[14] The intuition for this result is straightforward: if migration controls are costly then, as already noted, the cost component becomes lower as *m* becomes larger. It is therefore beneficial to select a migration policy that is less tight.[15] We note that as $\lim_{m \to 1} \frac{dC^j(m)}{dm} = 0$, the maximization

[14] For a large enough N^S, $c^S(m_C^{S*})$ will be small enough to yield $G_{I^S=1}^S(m_C^{S*}) > 0$. It is this case that we consider throughout the present paper. From the convexity of the cost function it follows that the second order condition for a maximum holds.

[15] Formally, for $m = m^{S*}$, the bracketed term in (8) is equal to zero, while the term $-\frac{dc^S(m)}{dm}$ is positive. Hence, the optimal *m* cannot be equal to m^{S*}. For the bracketed term in (8) to be negative, it is necessary that $\frac{\beta^S + \eta}{m(\beta^{mR} - \beta^S) + \beta^S} < 1$, which in turn yields an optimal migration probability $m_C^{S*} > \frac{\eta}{\beta^{mR} - \beta^S} = m^{S*}$

problems when $I^S = 0$ and $I^S = 1$ coincide as m approaches 1, and therefore the assumption $\beta^{mR} > \beta^S + \eta$ also ensures that m_C^{S*}<1.

Regarding *R*, its objective function $G_{I^R}^R$ depends on *m* via the per capita cost of control, and via the average level of human capital in *R*, $\overline{\vartheta}^{R*}$, where

$$\overline{\vartheta}^{R*} = \frac{N^R \vartheta^{R*} + mN^S \vartheta^{S*}}{N^R + mN^S} \quad . \tag{9}$$

From (7), the objective function of country *R* (recalling that for the natives in *R* their individual optimal level of human capital does not depend on the migration opportunities) is thus

$$G_{I^R}^R(m) = \beta^R \ln(\vartheta^{R*} + 1) + \eta \ln(\overline{\vartheta}^{R*} + 1) - k\vartheta^{R*} - c^R(m) I^R \tag{7b}$$

Differentiating (7b) with respect to *m*, we obtain

$$\frac{dG_{I^R}^R(m)}{dm} = \frac{\eta}{\overline{\vartheta}^{R*} + 1} \frac{d\overline{\vartheta}^{R*}}{dm} - \frac{dc^R(m)}{dm} I^R , \tag{10}$$

where, using (4) and (9), $\dfrac{d\overline{\vartheta}^{R*}}{dm}$ is given by

$$\frac{d\overline{\vartheta}^{R*}}{dm} = \frac{-(\overline{\vartheta}^{R*} - \overline{\vartheta}^{S*})N^S + mN^S \dfrac{d\vartheta^{S*}}{dm}}{N^R + mN^S} . \tag{11}$$

From (11) we can see that migration has two opposite effects on *R*: a negative average human capital diluting effect, and a positive inducement effect. This can be discerned upon considering the first line of the right-hand side of (11). A higher *m* leads to a larger number of migrants (as can be gleaned from the first term in the numerator). The average level of human capital of these migrants is below the level of human capital formed by workers in *R*. Yet, a higher probability of migration increases the optimal level of human capital that workers in *S* choose to acquire and migrate with (this is the inducement effect, captured by the second term in the numerator).

If $I^R = 0$, the migration probability which maximizes (7b) is 0. If $I^R = 1$, any $m \in [0,1]$ can be a solution to the maximization problem, depending on the exogenous parameters of the cost function, and on the degree of transferability of human capital between the two countries. We consider the two corner solutions, 0 and 1, uninteresting, unrealistic, and hence we do not dwell on them. For an interior solution, $m_C^{R*} \in (0,1)$ to exist, it is required that $\dfrac{dG_{I^R=1}^R(m_C^{R*})}{dm} = 0$ and that

$\frac{d^2 G^R_{I^R=1}(m_C^{R*})}{dm^2} < 0$. Then, m_C^{R*} represents a global maximum if $G^R_{I^R=1}(m_C^{R*}) > G^R_{I^R=1}(1)$ and $G^R_{I^R=1}(m_C^{R*}) > G^R_{I^R=1}(0)$: the first of these two inequalities arises from the limited transferability of human capital; the second follows from the assumptions regarding the parameters of the model. Figure 1 provides a graphical representation.[16]

3.2 The simultaneous game

We here characterize the Nash equilibria of the simultaneous one-shot game. The best reply of country *j* is

$$br^j(c^i(m^i)) = \begin{cases} c^j(m_C^{j*}) & \text{if } 0 \le c^i(m^i) < c^i(\tilde{m}^j) \\ 0 & \text{if } c^i(\tilde{m}^j) \le c^i(m^i) \le \hat{c}^i, \end{cases} \tag{12}$$

where *i=S, R*, $j \neq i$, and with $\tilde{m}^j$ such that

$$\tilde{m}^j = \max\{m^j : G^j_{I^j=0}(\tilde{m}^j) = G^j_{I^j=1}(m_C^{j*})\}, \tag{13}$$

that is, $\tilde{m}^j$ is the highest migration probability that equalizes the level of welfare in country *j* when it does not pay any migration control cost with the level of welfare that it achieves when it sets its optimal policy and pays the corresponding migration control cost.

If country *i* fixes a migration probability m^i paying the implied cost $c^i(m^i)$, the best reply of country *j* is to set its optimal policy m_C^{j*} with the corresponding cost $c^j(m_C^{j*})$ when $0 \le c^i(m^i) < c^i(\tilde{m}^j)$, that is, when $\tilde{m}^j < m^i \le 1$ and therefore, m^i is less restrictive than $\tilde{m}^j$.[17] This holds because in the interval $\tilde{m}^j < m^i \le 1$, $G^j_{I^j=0}(m^i) < G^j_{I^j=1}(m_C^{j*})$. The best reply of country *j* is to accept the proposed $c^i(m^i)$ if $c^i(\tilde{m}^j) \le c^i(m^i) \le \hat{c}^i$ with $\hat{c}^i = \frac{\hat{C}^i}{N^i}$, that is, if $0 \le m^i \le \tilde{m}^j$ and country *i* sets a quota that is equal to, or more restrictive than $\tilde{m}^j$.

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[16] In Figures 1 and 2 we plot $c^j(m)$ and $\bar{G}^j_{I^j}$, where the latter is the objective function $G^j_{I^j}$ normalized with respect to the level of the net earnings of country *j* when it is closed, which is equivalent to $G^j_{I^j=0}(0)$, that is, $\bar{G}^j_{I^j} = G^j_{I^j} - G^j_{I^j=0}(0)$. While this representation is a convenient normalization for the sake of graphical representation, it does not affect either the first order conditions that we identified in the preceding text or the Propositions that follow. Figures 1 and 2 display instances where an interior global maximum obtains. (In Appendix 2 we provide the parameterization that we have used in order to draw the Figures).

[17] The best reply functions are defined over the space c^j, c^i. Since the cost function is monotonic and decreasing in m, $c^j(m^j)$ identifies a unique m^j with $j = S, R$. It is straightforward to see that if $c^j(m) < c^j(m')$, then $m' < m$.

To see why in the interval $c^i(\tilde{m}^j) \leq c^i(m^i) \leq \hat{c}^i$ accepting $c^i(m^i)$ and not paying any cost is the best reply, it is convenient to look separately at country *S* and at country *R*. For *j=R*, the condition $G^R_{I^R=0}(\tilde{m}^R) = G^R_{I^R=1}(m_C^{R*})$ in (13) identifies a unique $\tilde{m}^R$, given that m_C^{R*} is a global maximum. For $m^S \in \left[0, \tilde{m}^R\right]$, $G^R_{I^R=0}(m^S) \geq G^R_{I^R=1}(m_C^{R*})$, and the receiving country cannot improve its welfare by setting its own preferred policy. For $j = S$, condition $G^S_{I^S=0}(\tilde{m}^S) = G^S_{I^S=1}(m_C^{S*})$ identifies two different migration probabilities: $\tilde{m}^S$ as in (13), and $\tilde{m}^S_{-} = \min\{m^S : G^S_{I^S=0}(\tilde{m}^S) = G^S_{I^S=1}(m_C^{S*})\}$. The interval $\left[0, \tilde{m}^S\right]$ can therefore be divided in two sub-intervals: $\left[0, \tilde{m}^S_{-}\right)$, and $\left[\tilde{m}^S_{-}, \tilde{m}^S\right]$. For $m^R \in \left[\tilde{m}^S_{-}, \tilde{m}^S\right]$, it holds that $G^S_{I^S=0}(m^R) \geq G^S_{I^S=1}(m_C^{S*})$, namely, the sending country is better off, or equally well off, by accepting the migration probability proposed by the receiving country compared to choosing m_C^{S*}. For $m^R \in \left[0, \tilde{m}^S_{-}\right)$, we note that the sending country will be better off at m_C^{S*}. However, it cannot choose a less restrictive migration policy than m_C^{R*}, since m_C^{R*} limits the space of choice for the sending country. Consequently, the point $\tilde{m}^S_{-}$ is irrelevant in the construction of the best reply of country *S*. Figure 1 illustrates $\tilde{m}^S_{-}$, $\tilde{m}^S$, $\tilde{m}^R$.

The Nash equilibria are identified by the intersection of the two best reply functions $br^R(c^S(m^S))$, and $br^S(c^R(m^R))$. Each of these functions takes only two values: 0 and $c^R(m_C^{R*})$ for the receiving country, and 0 and $c^S(m_C^{S*})$ for the sending country, with discontinuity points at $c^S(\tilde{m}^R)$, and at $c^R(\tilde{m}^S)$, respectively. In establishing the equilibria, we seek to be as general as possible and consider all potential orderings of $c^R(m_C^{R*})$, $c^S(\tilde{m}^R)$, $c^S(m_C^{S*})$, and $c^R(\tilde{m}^S)$.[18] We now state and prove the following proposition.

Proposition 1: The Nash equilibria of the simultaneous-move game are:

$$\begin{array}{lll} \left[c^R(m_C^{R*}), 0\right] & \text{if} & c^S(\tilde{m}^R) > c^S(m_C^{S*}) \text{ and } c^R(\tilde{m}^S) \leq c^R(m_C^{R*}) \\ \left[0, c^S(m_C^{S*})\right] & \text{if} & c^S(\tilde{m}^R) \leq c^S(m_C^{S*}) \text{ and } c^R(\tilde{m}^S) > c^R(m_C^{R*}) \\ \left[c^R(m_C^{R*}), 0\right] \text{ or } \left[0, c^S(m_C^{S*})\right] & \text{if} & c^S(\tilde{m}^R) \leq c^S(m_C^{S*}) \text{ and } c^R(\tilde{m}^S) \leq c^R(m_C^{R*}). \end{array} \tag{14}$$

[18] There are 24 (4!) potential orderings. Six of them are characterized by $c^S(\tilde{m}^R) > c^S(m_C^{S*})$ and $c^R(\tilde{m}^S) > c^R(m_C^{R*})$. Note that these last two inequalities are mutually exclusive once we take into account that $\tilde{m}^j > m_C^{j*}$. For example, the first inequality implies $m_C^{S*} > \tilde{m}^R$, which, recalling that $\tilde{m}^S > m_C^{S*} > \tilde{m}^R > m_C^{R*}$, contradicts $\tilde{m}^S < m_C^{R*}$, a condition that follows from the second inequality. The remaining eighteen possible orderings are discussed in Proposition 1.

Proof: According to (12), the best reply functions can only intersect at $\left[c^R(m_C^{R*}),0\right]$ and at $\left[0,c^S(m_C^{S*})\right]$. If $c^S(\tilde{m}^R) \le c^S(m_C^{S*})$ and $c^R(\tilde{m}^S) \le c^R(m_C^{R*})$, the best reply functions intersect twice. This happens for six possible orderings of $c^R(m_C^{R*})$, $c^S(\tilde{m}^R)$, $c^S(m_C^{S*})$, and $c^R(\tilde{m}^S)$. If $c^S(\tilde{m}^R) \le c^S(m_C^{S*})$ but $c^R(\tilde{m}^S) > c^R(m_C^{R*})$, the discontinuity point of the best reply of country S $c^R(\tilde{m}^S)$ is to the right of the optimal control cost of the receiving country $c^R(m_C^{R*})$, and the only intersection is at $\left[0,c^S(m_C^{S*})\right]$. Following the same reasoning, if $c^R(\tilde{m}^S) \le c^R(m_C^{R*})$ but $c^S(\tilde{m}^R) > c^S(m_C^{S*})$, the best reply functions only intersect at $\left[c^R(m_C^{R*}),0\right]$. Each of these three different cases is satisfied by six out of the eighteen possible orderings of $c^R(m_C^{R*})$, $c^S(\tilde{m}^R)$, $c^S(m_C^{S*})$, and $c^R(\tilde{m}^S)$. □

The first two lines in (14) describe a situation in which the equilibrium is unique and either the receiving country or the sending country sets its preferred policy. Consider for example the first line: the receiving country sets its preferred policy m_C^{R*} and pays the corresponding cost $c^R(m_C^{R*})$; the sending country accepts and pays no migration control cost. This is an equilibrium because $m_C^{R*} < \tilde{m}^S$, and the best reply of country *S* is to accept m_C^{R*}. The equilibrium is unique because, if the sending country plays m_C^{S*}, given that $m_C^{S*} > \tilde{m}^R$, the receiving country will react by setting its own preferred policy m_C^{R*}, in which case it is optimal for the sending country to accept. In the third line, there are two Nash equilibria in which the receiving country and the sending country can be the equilibrium migration policy setter: multiple equilibria arise because both m_C^{R*} and m_C^{S*} do not exceed the thresholds $\tilde{m}^S$ and $\tilde{m}^R$, respectively, and therefore, the best reaction of each country is to accept the preferred policy of the other country.

For reference in what follows, we note that the optimal migration probability that corresponds to Proposition 1 is

$$m^* = \begin{cases} m_C^{R*} & \text{if} \quad c^S(\tilde{m}^R) > c^S(m_C^{S*}) \text{ and } c^R(\tilde{m}^S) \le c^R(m_C^{R*}) \\ m_C^{S*} & \text{if} \quad c^S(\tilde{m}^R) \le c^S(m_C^{S*}) \text{ and } c^R(\tilde{m}^S) > c^R(m_C^{R*}) \\ m_C^{R*} \text{ or } m_C^{S*} & \text{if} \quad c^S(\tilde{m}^R) \le c^S(m_C^{S*}) \text{ and } c^R(\tilde{m}^S) \le c^R(m_C^{R*}). \end{cases} \tag{15}$$

Figure 1 illustrates a case in which m_C^{R*} emerges as the unique equilibrium of the simultaneous game.

In sum: Proposition 1 states that any of the two countries can be the equilibrium setter, highlighting the fact that assigning ex-ante exclusive power of setting the migration policy to either the sending country or to the receiving country, as is often assumed in the received literature, can be inappropriate.

3.3 The sequential game

We next characterize the equilibrium of the sequential game and identify the country that controls migration. We begin by considering the case in which the receiving country moves first and sets its optimal policy, anticipating the sending country's reaction.

Proposition 2: The equilibrium migration probability, m^*, of the two-stage game when the receiving country moves first is

$$m^* = \begin{cases} m_C^{R*} & \text{if } \tilde{m}^R < m_C^{S*} \\ m_C^{S*} & \text{otherwise.} \end{cases} \tag{16}$$

Proof: The receiving country *R* moves first and decides whether to set a migration policy, or to let the sending country *S* set the migration policy. In the latter case, the sending country will clearly choose its optimal migration policy m_C^{S*}. If $m_C^{S*} \leq \tilde{m}^R$, then the best strategy of the receiving country is to set its control cost to 0 and to let the sending country choose its own optimal policy m_C^{S*}. If $m_C^{S*} > \tilde{m}^R$, the receiving country is better off by setting m_C^{R*} and paying the corresponding cost. The sending country accepts the migration probability proposed by the receiving country because $m_C^{R*} < \tilde{m}^R < m_C^{S*} < \tilde{m}^S$. Note that for $m_C^{R*} \in \left[0, \tilde{m}_-^S\right)$, the sending country will be better off at m_C^{S*}. However, it cannot choose a less restrictive migration policy than m_C^{R*}, since m_C^{R*} limits the choice space of the sending country □

In Figure 1, we illustrate one of the cases listed in Proposition 1, namely, a configuration in which $\tilde{m}^R < m_C^{S*}$. In this case, it is easy to see that *R* can reduce the loss it incurs by setting a more restrictive migration policy than that which is optimal for *S*, even though it has to bear the cost of control and therefore m_C^{R*} is the equilibrium.

In Figure 2, we illustrate the case where $\tilde{m}^R > m_C^{S*}$. In this case, R cannot reduce its loss by choosing a more restrictive migration policy, and m_C^{S*} emerges as the equilibrium.[19]

Consider next the case in which the sending country moves first.

Proposition 3: The equilibrium migration probability, m^*, of the two-stage game when the sending country moves first is

$$m^* = \begin{cases} m_C^{R*} & \text{if } (\tilde{m}_-^S \le m_C^{R*} \le \tilde{m}^S) \text{ or } (m_C^{R*} < \tilde{m}_-^S \text{ and } m_C^{S*} > \tilde{m}^R) \\ m_C^{S*} & \text{if } (m_C^{R*} > \tilde{m}^S) \text{ or } (m_C^{R*} < \tilde{m}_-^S \text{ and } m_C^{S*} \le \tilde{m}^R). \end{cases} \tag{17}$$

Proof: Consider the case where the sending country S moves first and decides whether to set a migration policy or to let the receiving country set the migration policy. In the latter case, the receiving country will clearly choose its optimal migration policy m_C^{R*}. If $\tilde{m}_-^S \le m_C^{R*} \le \tilde{m}^S$, the best strategy of the sending country is to set its control cost to 0, and to let the receiving country choose its own optimal policy m_C^{R*}. When $m_C^{R*} > \tilde{m}^S$, the sending country is better off by setting m_C^{S*} and paying the corresponding cost. The receiving country accepts the migration probability proposed by the sending country because $m_C^{S*} < \tilde{m}^S < m_C^{R*} < \tilde{m}^R$. When $m_C^{R*} < \tilde{m}_-^S$, the sending country is better off by setting its optimal policy m_C^{S*}. This policy emerges as the equilibrium of the sequential game only if the receiving country is willing to accept it, which will be the case when $m_C^{S*} \le \tilde{m}^R$. When $m_C^{S*} > \tilde{m}^R$, the receiving country sets m_C^{R*}, which becomes the equilibrium of the game. □

As in the simultaneous game, both countries can be the equilibrium migration policy setters. However, there is no more multiplicity of equilibria because the country that has the first-mover's advantage can avoid ending up in an equilibrium that accords it the lowest level of welfare.

We now have in place a foundation for analyzing cases in which the migration control cost is shared.

4. Bilateral agreements

Since the 1990s, there has been a global upsurge in bilateral agreements, as countries have come to realize that restricting migration is difficult, and that "cooperative migration management can better

[19] The orderings of the *m*'s is such that in the simultaneous game we have multiple equilibria.

achieve goals for both sending and receiving countries" (ILO, 2004, 15-16).[20] Bilateral agreements often go hand in glove with some burden-sharing between the sending and receiving countries, as exemplified by the monitoring of the regulations in the agreements, and by the management of the migration process (IOM, 2004).

In the preceding section, we considered a non-cooperative setting, and we presented the equilibrium migration policy, m^*, which is implemented by the country that consequently incurs the associated cost. In this section, we consider two other scenarios. In the first scenario, the country that does not set the migration probability can nonetheless influence the equilibrium policy by resorting to the device of side-payments. With the solution m^* as a starting point, we study the possibility of the emergence of bilateral agreements on cost sharing, and we show how they can be rationalized. We assume that the possibility of side-payments opens up unexpectedly.[21] In the second scenario, the two countries bargain over both the migration policy and the sharing of the costs of implementing the policy. We nest the problem in a Nash bargaining model where the threat points of the two countries, should they fail to come to an agreement, are identified by the welfare of the representative worker of country *R* and of the representative worker of country *S* at m^*. An agreement between the two countries is binding.

In both scenarios, we consider a specific type of transfer between the countries, say funds for border enforcement.

4.1 Side-payments

We let the parameter $\alpha \in [0,1]$ capture the degree of cost-sharing in controlling migration. In the presence of a cross-country "subsidization," the actual per capita control cost for country *j*, $c_\alpha^j(m)$, when country *j* sets the equilibrium migration policy, is

$$c_\alpha^j(m) = (1-\alpha)c^j(m). \tag{18}$$

[20] In the European Union, there is no common migration policy regarding the nationals of non-EU countries, with the exceptions of refugees and asylum seekers (cf. the European Refugee Fund) and the intelligence-wise protection of the external borders (cf. Frontex). In the Communication of the European Commission (2008), the need for a common, comprehensive immigration policy has been recognized, and the basis for this stand has been laid down. Until such time that such a policy will be implemented, Member States will continue to resort to individual agreements with one or several sending countries.

[21] This assumption guarantees that the simultaneous and the sequential games studied in the preceding section are immune to the possibility of potential side-payments. Therefore the outcome m^* of the games is a proper starting point for our analysis. If side-payments could be anticipated, the optimal strategies of the receiving country and of the sending country in the determination of *m* will take this prospect into account ex ante.

When $\alpha = 0$, country *j* does not receive any side-payment, $c^j_\alpha(m) = c^j(m)$, and we are back at the case of $m^* = m^{j*}_C$. For $\alpha > 0$, the country which implements its preferred migration policy incurs only a fraction $(1-\alpha)c^j(m)$ of the per capita control cost, while the remaining fraction, $\alpha c^j(m)\dfrac{N^j}{N^i}$, is borne by country *i*. Therefore, the term $\alpha c^j(m)\dfrac{N^j}{N^i}$ denotes the per capita side-payment from country *i* to country *j*. When solving for the optimal migration probability from the perspective of country *j*, an increase in α is analytically equivalent to a proportional reduction in per capita costs, $c^j(m)$. Starting from the case of no transfers, an increase in side-payments between the countries is represented by a variation in α.

Denoting by m^{j*}_α the optimal migration policy chosen by country *j* when a transfer takes place, we have the following Proposition.

Proposition 4. Consider the equilibrium $m^* = m^{j*}_C$ in the absence of side-payments. An increase in α is Pareto improving if

$$\left.\frac{dG^i_{I^i=0}(m)}{dm}\frac{dm^{j*}_\alpha}{d\alpha}\right|_{m=m^{j*}_C} > c^j(m^{j*}_C)\frac{N^j}{N^i}. \tag{19}$$

Proof: See Appendix 3.

Starting at $\alpha = 0$, the left-hand side of (19) captures the marginal benefit to country *i*. This benefit is conferred upon country *i* by a variation in the optimal policy of country *j*, in the wake of the side-payments that that country receives. The right-hand side represents the (positive) per capita marginal cost to country *i* which arises from the transfer to country *j*. The proof of Proposition 4 reveals that starting from $m^* = m^{j*}_C$, a Pareto improvement can obtain when the marginal benefit of changing the migration policy is larger than the marginal cost.

Consider the case in which *S* fixes the migration probability at $m^* = m^{S*}_C$ and incurs all the control costs, that is, $\alpha = 0$. Note that $\dfrac{dm^{S*}_\alpha}{d\alpha} < 0$ always, as can be inferred from equation (18) and from the observation of Subsection 3.1 that an increase in α, that is, a decrease in cost, entails a more restrictive migration policy. The latter benefits country *R*, given that $\left.\dfrac{dG^R_{I^R=0}(m)}{dm}\right|_{m=m^{S*}_C} < 0$. A transfer from *R* to *S*, which reduces $c^S(m)$ to some $c^S_\alpha(m)$, can be Pareto improving if condition (19) holds.

Thus far, our analysis shows that *R* can "seduce" *S* to limit migration: *S* is willing to trade off a more restrictive migration probability for a control cost subsidy, and *R* is willing to pay such a subsidy because the benefit that it stands to reap is larger than the cost that it has to bear. We note that if N^R is large, side-payments are more likely to increase welfare (cf. equation (19)).

We consider next the case in which $m^* = m_C^{R*}$, that is, the case when absent side-payments, the equilibrium migration probability is the probability that minimizes the welfare loss of *R*. In this case, can *S* resort to side-payments in order to tilt the equilibrium migration probability in its favor? If $\left.\frac{dG^S_{I^S=0}(m)}{dm}\right|_{m=m_C^{R*}} > 0$, which holds when $m_C^{R*} < m^{S*}$, the answer is negative: when it comes to sharing the migration-control costs, there is no scope for side-payments from *S* to *R*. This follows from the consideration that when $m^* = m_C^{R*}$ and $\alpha = 0$, an increase in α, that is, a transfer from *S* to *R*, will induce *R* to decrease its optimal migration probability even further, since $\frac{dm_\alpha^{R*}}{d\alpha} < 0$. (We recall that if *R* were to receive a sufficiently large transfer, it would choose $m^* = 0$). Given that a lower migration probability makes *S* worse off, there is no point for it to incur the transfer. Only when $m^{S*} < m_C^{R*} < m_C^{S*}$, $\left.\frac{dG^S_{I^S=0}(m)}{dm}\right|_{m=m_C^{R*}} < 0$ and therefore, *S* may find it attractive to resort to side-payments in order to maximize its welfare, provided that condition (19) holds.[22]

In sum, bilateral agreements on the sharing of border-control costs can emerge endogenously, and can be Pareto-improving.

4.2 A Nash bargaining solution

We next consider the case in which the two countries can jointly determine the division of the enforcement costs and the migration policy in a cooperative way. The objective function is given by the product of the utility surplus to country *R* and to country *S* from *R* and *S* of coming to an

[22] Recall that if $m^{S*} < m_C^{S*} < m_C^{R*}$ then, in the absence of any side-payments, *S* fixes the migration probability at $m^* = m_C^{S*}$, and we are back in the case that we have already analyzed (cf. the second paragraph that follows equation (19)).

agreement, compared to the disagreement point, with each surplus being weighted by the countries' bargaining power. As already noted, the threat points of the two countries, should they fail to come to an agreement, are identified by the welfare of the representative worker of country *R* and of the representative worker of country *S* at m^*.

We first consider the case $m^* = m_C^{S*}$. The maximization problem is

$$\max_{\alpha,m} \Phi(m,\alpha) = \left[G_{I^R=0}^R(m) - \alpha c^S(m)\frac{N^S}{N^R} - G_{I^R=0}^R(m_C^{S*}) \right]^{\gamma} \left[G_{I^S=0}^S(m) - (1-\alpha)c^S(m) - G_{I^S=1}^S(m_C^{S*}) \right]^{1-\gamma}, \tag{20}$$

where γ is the bargaining power of country *R*, and $1-\gamma$ is the bargaining power of country *S*.

Taking logs of (20), differentiating with respect to m and α, and simplifying, we obtain the optimality conditions

$$N^R \frac{dG_{I^R=0}^R(m_b^*)}{dm} + N^S \frac{dG_{I^S=0}^S(m_b^*)}{dm} - \frac{dC^S(m_b^*)}{dm} = 0, \tag{21}$$

$$\alpha_b^* C^S(m_b^*) = (1-\gamma)N^R \left[G_{I^R=0}^R(m_b^*) - G_{I^R=0}^R(m_C^{S*}) \right] - \gamma N^S \left[G_{I^S=1}^S(m_b^*) - G_{I^S=1}^S(m_C^{S*}) \right], \tag{22}$$

where *b* denotes the bargaining solution, and where we make use of $C^S(m) = N^S c^S(m)$.

Equation (21) implicitly defines the optimal migration policy m_b^*. At m_C^{S*}, the left-hand side of equation (21) is negative.[23] Consequently, $m_b^* < m_C^{S*}$. Starting from the outside option m_C^{S*}, it is optimal to decrease the migration probability as long as the total marginal benefit to country *R* outweighs the sum of the total marginal loss to country *S* and the marginal increase in the total costs of control.

Equation (22) identifies the optimal transfer $\alpha_b^* C^S(m_b^*)$ from country *R* to country *S*. The transfer of resources from country *R* to country *S* increases in the surplus from bargaining reaped by country *R*, that is, in $G_{I^R=0}^R(m_b^*) - G_{I^R=0}^R(m_C^{S*}) > 0$, and in the bargaining power of country *S*. Given that by moving from m_C^{S*} in the direction of a lower migration probability m_b^* the sending country

[23] This result obtains since m_C^{S*} is defined as the migration probability such that $N^S \frac{dG_{I^S=0}^S(m_C^{S*})}{dm} - \frac{dC^S(m_C^{S*})}{dm} = 0$ (cf. equation (8) and the paragraph following equation (8)), and $N^R \frac{dG_{I^R=0}^R(m_C^{S*})}{dm} < 0$ given that m_C^{S*} is on the declining segment of the $G_{I^R=0}^R$ curve.

incurs a welfare loss, we have that $G^S_{I^S=1}(m_b^*) - G^S_{I^S=1}(m_C^{S*}) < 0$. The higher the loss, the higher must be the transfer from country *R* to country *S*.

Alternatively, we consider the case $m^* = m_c^{R*}$. Then, equations (21) and (22) become, respectively,

$$N^R \frac{dG^R_{I^R=0}(m_b^*)}{dm} + N^S \frac{dG^S_{I^S=0}(m_b^*)}{dm} - \frac{dC^R(m_b^*)}{dm} = 0, \tag{23}$$

$$\alpha_b^* C^R(m_b^*) = \gamma N^S \left[G^S_{I^S=0}(m_b^*) - G^S_{I^S=0}(m_C^{R*}) \right] - (1-\gamma) N^R \left[G^R_{I^R=1}(m_b^*) - G^R_{I^R=1}(m_C^{R*}) \right]. \tag{24}$$

The interpretation of equations (23) and (24) is akin to the interpretation pertaining to the case in which $m^* = m_C^{S*}$. In the current case as well, there is room for implementing a joint cost-sharing and migration policy arrangement that confers a Pareto improvement upon both countries.[24] The only difference is the possibility that a less restrictive migration policy emerges as the equilibrium outcome of the bargaining game. Indeed at m_C^{R*}, equation (23) is positive if $m_C^{R*} < m^{S*}$, in which case $m_b^* > m_C^{R*}$.

When an endogenous formation of bilateral agreements is in evidence, it could serve as an indication that in order to secure welfare gains to both the receiving country and the sending country, the two countries are willing to make concessions in the form of policy adjustments.

5. A comment on welfare

In this section we ask whether the prevalence of a welfare gain to *S*, brought about by the prospect of migration as claimed by recent research of Stark and Wang (2002), Fan and Stark (2007a, 2007b), and Sorger, Stark, and Wang (2011) holds in a setting in which controlling migration is costly, and in which both *S* and *R* wield power to set the migration policy.

To this end, we have the following Corollary.

Corollary 1: With m^*, there is a welfare gain for the sending country as compared to the closed-economy setting, and the receiving country minimizes its welfare loss.

[24] In a dynamic set-up, that m_b^* constitutes a Pareto improvement for both countries would provide a rationale for the countries not to deviate from the static Nash bargaining solution that we have presented.

If $m^* = m_C^{S*}$, S certainly gains in comparison with the closed economy setting due to the increase in its average level of human capital which is triggered by the prospect of migration. When $m^* = m_C^{R*}$, we have to distinguish between the simultaneous game and the sequential game. In the case of a simultaneous game, for the equilibrium migration policy to be m_C^{R*}, it has to hold that $\tilde{m}^S \geq m_C^{R*}$, which secures a welfare gain for the sending country. In the case of a sequential game when R moves first, $m^* = m_C^{R*}$ requires $\tilde{m}^R < m_C^{S*}$, which guarantees that $m_C^{R*} < \tilde{m}^S$. This inequality is fulfilled also when S moves first (cf. Proposition 3). Therefore, country S experiences a welfare improvement even when R sets the equilibrium policy.

The result of a welfare gain for the sending country holds a fortiori when $m^* = m_\alpha^{j*}$, that is if side-payments are operative.

When with Nash bargaining $m^* = m_b^*$, both countries are not worse off than at m_C^{S*} or m_C^{R*}. Having established that country S experiences a welfare gain at m_C^{S*} and m_C^{R*}, S stands to enjoy a welfare gain much more so when $m^* = m_b^*$.

6. Conclusions

We have shown how migration restrictions can arise in a non-cooperative framework, and that both the receiving country and the sending country can be the setters of the equilibrium policy. The observation that most migration restrictions are imposed by receiving countries can be rationalized within our model when we admit that the receiving country prefers levels of migration that are lower than those preferred by the sending country. This does not imply that the conduct of the sending country is immaterial: its actions constrain the actions of the receiving country. We have also identified instances in which bilateral agreements can arise as welfare-improving devices. We considered two cases: an agreement on side-payments, and a joint agreement on the migration policy and the cost-sharing of its implementation. Our analytical findings align with the observation that bilateral agreements often go hand in glove with some burden-sharing between the sending and receiving countries.

We have expanded the analysis of Stark and Wang (2002) to a setting in which the receiving country plays an active role in the determination of the migration policy, yet the implementation of the policy involves a cost. We have shown that even in such a setting, the sending country can still stand to benefit from its workers' decisions to acquire human capital in the presence of a prospect of migration. For the sending country alone to decide its migration policy (probability) is a sufficient condition for it to reap a welfare gain but, as we have shown, this is not a necessary condition. A welfare gain can be obtained by the sending country in a more realistic setting where the migration restrictions are set non-cooperatively in a game that allows both countries to have a say in the choice of the migration policy. More so if we allow for some degree of cooperation between the two countries.

Appendix 1

We consider a setup that differs from the one in the main text of the paper in that in terms of innate ability, the workers in each country are heterogeneous. For simplicity, we assume that there are two types of workers both in *S* and in *R*, and that they are equally represented in the *S* and *R* populations.[25] We denote by k_i the cost of forming human capital by worker *i*, $i = 1, 2$, and we assume that $k_1 < k_2$. Because we analyze a setting of quotas, we retain the assumption that the probability to migrate is the same for the two types of workers.

For a native *S* country worker *i*, the objective function (2) is

$$W_i^S(\vartheta_i^S) = m\left\{\beta^{mR}\ln(\vartheta_i^S + 1) + \eta\ln(\overline{\vartheta}^R + 1)\right\} + (1-m)\left\{\beta^S\ln(\vartheta_i^S + 1) + \eta\ln(\overline{\vartheta}^S + 1)\right\} - k_i\vartheta_i^S. \quad \text{(A.1)}$$

Differentiating (A.1) with respect to ϑ_i^S, we obtain:[26]

$$\vartheta_i^{S*}(m) = \frac{m(\beta^{mR} - \beta^S) + \beta^S}{k_i} - 1. \quad \text{(A.2)}$$

Referring next to *R*, the objective function of an *R* country worker *i* is

$$W_i^R(\vartheta_i^R) = \left[\beta^R\ln(\vartheta_i^R + 1) + \eta\ln(\overline{\vartheta}^R + 1)\right] - k_i\vartheta_i^R, \quad \text{(A.3)}$$

and his optimal level of human capital is

[25] We could just as well assume that the share of workers of one type is γ and the share of workers of the other type is $1-\gamma$.

[26] The second-order condition for a maximum, $\frac{d^2W_i^S(\vartheta_i^S)}{d(\vartheta_i^S)^2} = -\frac{m(\beta^{mR} - \beta^S) + \beta^S}{(\vartheta_i^S + 1)^2} < 0$, holds.

$$\vartheta_i^{R*} = \frac{\beta^R}{k_i} - 1. \tag{A.4}$$

As in the case of a homogeneous workforce, we have that $\vartheta_i^{S*} < \vartheta_i^{R*}$.[27]

The wellbeing of a non-migrant worker *i* in country *S* and of a native worker in country *R* can be written as net earnings minus the per capita control cost

$$\beta^j \ln(\vartheta_i^{j*} + 1) + \eta \ln(\overline{\vartheta}^{j*} + 1) - k_i \vartheta_i^{j*} - c^j(m) I^j, \tag{A.5}$$

evaluated at the optimal level of investment in human capital, ϑ_i^{j*}. Net earnings are used to formulate the two countries' objective functions, which we denote by $G_{I^j}^j$.

Looking first at country *S*, the objective function $G_{I^S}^S$ is

$$G_{I^S}^S(m) = \frac{1}{2}\left[\beta^S \ln(\vartheta_1^{S*} + 1) - k_1 \vartheta_1^{S*}\right] + \frac{1}{2}\left[\beta^S \ln(\vartheta_2^{S*} + 1) - k_2 \vartheta_2^{S*}\right] + \eta \ln(\overline{\vartheta}^{S*} + 1) - c^S(m) I^S. \tag{A.6}$$

From (A.6) and (A.2), the objective function of country *S* can be rewritten as

$$\begin{aligned} G_{I^S}^S(m) &= \frac{1}{2}\beta^S \ln \frac{m(\beta^{mR} - \beta^S) + \beta^S}{k_1} + \frac{1}{2}\beta^S \ln \frac{m(\beta^{mR} - \beta^S) + \beta^S}{k_2} - \overline{k}\left(\frac{m(\beta^{mR} - \beta^S) + \beta^S}{\overline{k}} - 1\right) \\ &+ \eta \ln \left\{\left[m(\beta^{mR} - \beta^S) + \beta^S\right] \frac{1}{2}\left(\frac{1}{k_1} + \frac{1}{k_2}\right)\right\} - c^S(m) I^S \end{aligned} \tag{A.7}$$

where $\overline{k} = \dfrac{k_1 + k_2}{2}$, and where we have substituted $\overline{\vartheta}^{S*}$ with

$$\overline{\vartheta}^{S*} = \left[m(\beta^{mR} - \beta^S) + \beta^S\right] \frac{1}{2}\left(\frac{1}{k_1} + \frac{1}{k_2}\right) - 1. \tag{A.8}$$

Differentiating (A.7) with respect to *m* yields

$$\frac{dG_{I^S}^S(m)}{dm} = \left(\beta^{mR} - \beta^S\right)\left[\frac{\beta^S + \eta}{m\left(\beta^{mR} - \beta^S\right) + \beta^S} - 1\right] - \frac{dc^S(m)}{dm} I^S.$$

This expression is the same as equation (8) in the main text.

Regarding *R*, its objective function $G_{I^R}^R$ is

[27] As in the main text, we drop the argument in $\vartheta^{S*}(m)$ and $\overline{\vartheta}^{S*}(m)$ when doing so causes no confusion.

$$G^R_{I^R}(m)=\frac{1}{2}\left[\beta^R\ln(\vartheta_1^{R*}+1)-k_1\vartheta_1^{R*}\right]+\frac{1}{2}\left[\beta^R\ln(\vartheta_2^{R*}+1)-k_2\vartheta_2^{R*}\right]+\eta\ln(\overline{\vartheta}^{R*}+1)-c^R(m)I^R\ . \quad (A.9)$$

where

$$\overline{\vartheta}^{R*}=\frac{N^R\overline{\vartheta}^{R*}_{m=0}+mN^S\overline{\vartheta}^{S*}}{N^R+mN^S}, \quad (A.10)$$

and where $\overline{\vartheta}^{R*}_{m=0}$ denotes the average level of human capital of the native workers in *R*.

Differentiating (A.9) with respect to *m*, we obtain

$$\frac{dG^R_{I^R}(m)}{dm}=\frac{\eta}{\overline{\vartheta}^{R*}+1}\frac{d\overline{\vartheta}^{R*}}{dm}-\frac{dc^R(m)}{dm}I^R. \quad (A.11)$$

Finally, from (A.10), we have that

$$\frac{d\overline{\vartheta}^{R*}}{dm}=\frac{-(\overline{\vartheta}^{R*}-\overline{\vartheta}^{S*})N^S+mN^S\dfrac{d\overline{\vartheta}^{S*}}{dm}}{N^R+mN^S}, \quad (A.12)$$

an expression that is akin to equation (11) in the main text.

Appendix 2

For the purpose of graphical representation, we make the following parameter assumptions: $\beta^S=1,\ \beta^R=4,\ \beta^{mR}=2,\ \eta=0.2,\ k=0.4,\ N^S=N^R=1$. The cost function is specified as

$$c^j(m)=\frac{(m-1)^a}{N^j}\hat{C}^j$$

where $\hat{C}^j=0.05$ and *a* is an even number. We recall that $\overline{G}^j_{I^j}=G^j_{I^j}-G^j_{I^j=0}(0)$ is a normalization that we use to graphically represent the objective functions.

Varying the speed at which costs decrease as measured by *a*, Figures 1 and 2 illustrate two different cases: the curves in Figure 1 are drawn for $a=14$, and in Figure 2 they are drawn for $a=12$.

In both Figures, the chosen parameters guarantee that m^{R*}_C is a global maximum.

Appendix 3

Proof of Proposition 4

Control costs $c_\alpha^j(m) < c^j(m)$ lead to a smaller optimal migration quota, $\frac{dm_\alpha^{j*}}{d\alpha} < 0$, as can be inferred from (18) in conjunction with our observations in Subsection 3.1.

Two effects are at work for country *i*, which contemplates transferring side-payments to country *j*. The country's natives experience an increase in per capita costs due to the transfer. This is given by $\left[c^j(m_C^{j*}) + \alpha \frac{dc^j(m)}{dm}\frac{dm_\alpha^{j*}}{d\alpha}\right]\frac{N^j}{N^i}$, which reduces to $c^j(m_C^{j*})\frac{N^j}{N^i}$ at $\alpha = 0$.

At the same time, the reduction of migration makes country *i* better off if $\left.\frac{dG_{I^i=0}^i(m)}{dm}\right|_{m=m_C^{j*}} < 0$. In this case, the total effect for country *i* is positive if the increase in per capita welfare exceeds the increase in its per capita cost, that is, if

$$\left.\frac{dG_{I^i=0}^i(m)}{dm}\frac{dm_\alpha^{j*}}{d\alpha}\right|_{m=m_C^{j*}} > c^j(m_C^{j*})\frac{N^j}{N^i}.$$

If, on the contrary, $\left.\frac{dG_{I^i=0}^i(m)}{dm}\right|_{m=m_C^{j*}} > 0$, a reduction in migration makes country *i* worse off, $\left.\frac{dG_{I^i=0}^i(m)}{dm}\frac{dm_\alpha^{j*}}{d\alpha}\right|_{m=m_C^{j*}} < 0$. Paying transfers to achieve a lower migration probability can then never be optimal. □

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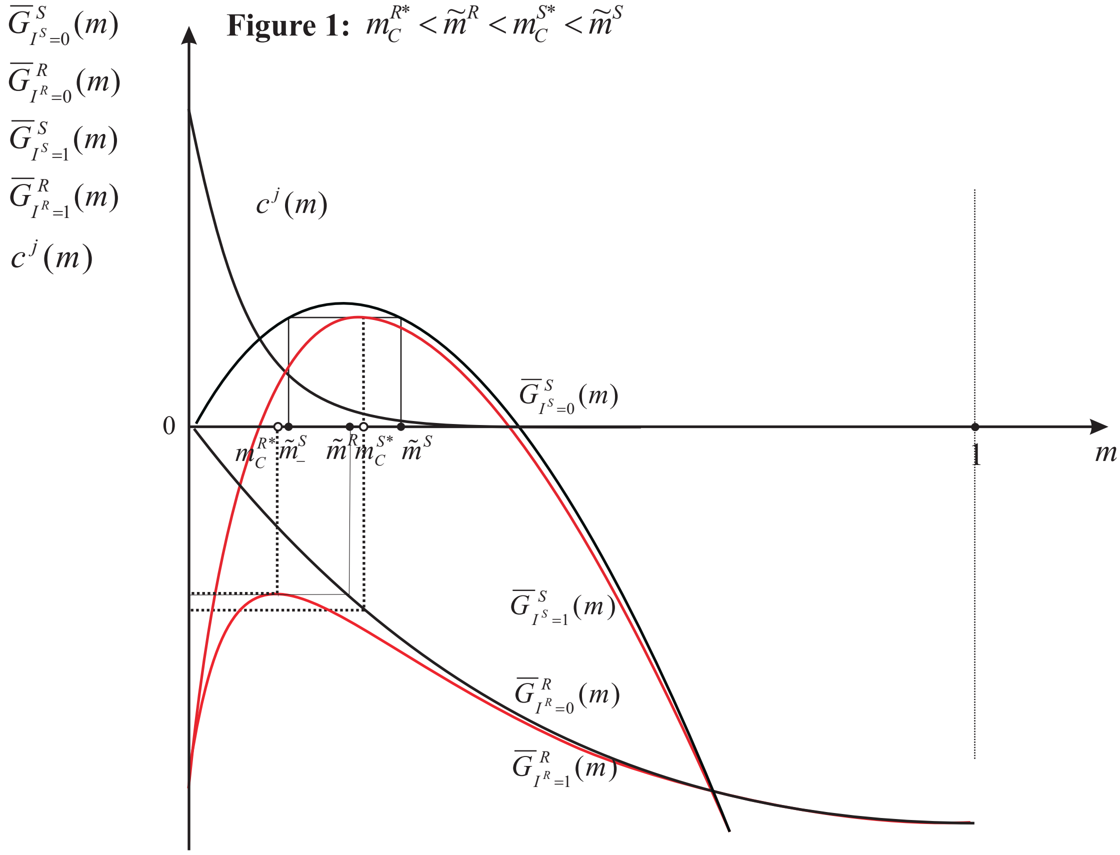

Figure 1: $m_C^{R*} < \widetilde{m}^R < m_C^{S*} < \widetilde{m}^S$

Figure 2: $m_C^{R*} < m_C^{S*} < \tilde{m}^R < \tilde{m}^S$