A Simple Model of Brain Circulation

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Abstract

This paper considers the allocation of two types of individuals differentiated by levels of talent within and between two countries when they choose to be workers or entrepreneurs. The equilibrium with international migrations requires both countries to be sufficiently different in talent endowments and is consistent with individuals moving in one or in both directions whether they are entrepreneurs or workers. Average welfare per capita falls in the country losing highly talented individuals and rises in the country attracting them. However, in both countries, the liberalization of migrations for immigrants, emigrants or both is always supported by majority voting.

1 Introduction

The paper investigates a two-country model of one- and two-way international migrations of individuals differentiated by levels of talent and working in a single industry. During the last 20 years, migrations of skilled labor have increased significantly (OECD, 2001) and they are now influencing the size and the structure of several industries. This phenomenon has become sufficiently widespread and multi-faceted that it is now often described as 'brain circulation' (Johnson and Regets, 1998). In North America for instance, an average of about 29,000 individuals migrated yearly from the US to Canada between 1997 and 2002 while about 73,000 individuals moved in the other direction.[1] Although these flows are small with respect to population, evidence suggests that these migrants are highly skilled in terms of education or income (Gera et al., 2004). They are mostly concentrated in professions like managers, executives, engineers, scientists and entrepreneurs, and work predominently in knowledge-based industries like services and information technology.[2] Zucker and Darby (1995, 1999) have documented the flows of star scientists across borders and how these highly talented individuals have shaped the biotechnology industry in its early stages.[3] Efforts to attract foreign software specialists in Germany, return migrations to India and to China are other examples of the growing importance of talent for many industries. Clearly, economists should investigate brain circulation.

To address this issue, we consider a model with two key components. First, individuals working in a given industry are differentiated according to talent (skill or ability), which for our purpose is treated as exogenous. Second, all individuals choose to be workers or entrepreneurs. This determines wage and the number of firms (i.e., entrepreneurs). Because

[1] See Gera et al. (2004) and Harris (2004). A large proportion of these flows are temporary migrating professionals benefiting from NAFTA-TN visas.

[2] OECD (2002) reports that 'a quarter of Silicon Valley firms in 1998 were headed by immigrants from China and India and collectively created 52'300 jobs and generated almost USD17 billion in sales'.

[3] For example, during the 1990s, they identified 417 star bioscientists worldwide; the US attracted 26 of them and lost 20 while Canada, Switzerland and the UK had a net total loss of 19, despite attracting 9 (Zucker and Darby, 1999).

individuals differ in talent levels, the model exhibits increasing returns to entrepreneur's ability. Accordingly, firms may be differentiated in terms of size and profitability. Migrations modify directly the industry structure and indirectly by influencing who is entrepreneur. The model then allows us to analyze whether a country wishes to liberalize migrations of talented individuals.

Restricting the analysis to two types of talent, the paper makes four points. First, migrations require the countries not only to be different but to be sufficiently so. Second, the equilibrium can exhibit two-way or one-way international migrations by talent types and because migrations involve both workers and entrepreneurs, migrations can also be expressed with respect to activities. Third, migrations impact the number, the size and the distribution of firms. Finally, although countries with different talent endowments have generally conflicting incentives about migrations based on average welfare per capita, they always choose to allow migrations when such a decision is taken by majority voting. This is true whether migration policy is about immigrants, emigrants or both.

The literature on international mobility of skilled individuals has traditionally investigated the impact of the loss of human capital and of the loss of returns to public investments in training. We ignore these issue reviewed by Bhagwati and Wilson (1989). Treating talent as exogenous, we also ignore how migrations can affect human capital formation (Stark, 2003). This paper is related to Rauch (1991) who uses Lucas (1978)'s model of agent's choice of activity. However Rauch sets the choice of activity in a Heckscher-Ohlin-Samuelson model to investigate the links between patterns of trade and migrations. To concentrate on the patterns of migrations and on industry structure, our model has only one sector. Several articles have considered the role of talent and entrepreneurs in international trade. Among them, Manasse and Turrini (2001) look at trade in products differentiated by quality where quality depends on entrepreneur's skill. Grossman (1984) investigates how opening a country to trade or to FDI affects the choice of becoming entrepreneurs when entrepreneurship involves risk. These papers however do not consider international migrations.

The paper is organized as follows. In the next Section, the basic structure of the model is laid out and the equilibrium without migrations is derived. The different pattern of migrations are analyzed in Section 3. In Section 4, we consider welfare and whether these countries allow migrations to occur. Section 5 concludes.

2 The Model and Equilibrium without Migration

The model is based on Lucas (1978) and Murphy et al. (1991). Consider two countries, A and B, trading freely one homogeneous good but with no international migration. There are two types of talent in the population of each country, $[\theta_1, \theta_2]$ with $\theta_1 < \theta_2$. The number of individuals with talent θ_1 (θ_2) in country i is $\varphi_1^i \geq 0$ (respectively, $\varphi_2^i \geq 0$). The population is fully employed and each individual can always choose to be either a worker or an entrepreneur. A firm is defined as an entrepreneur with talent θ_j ($j = 1, 2$) and employs workers at wage w^i. Talent measures how an entrepreneur exploits the country-specific technology χ^i and a worker supplies one unit of labor.[4] The entrepreneur's earning is equal to firm profit and thus to,

$$\pi^i(\theta_j) = p\chi^i\theta_j f(l) - w^i l, \tag{1}$$

where p is the output price and $f(l)$, the production function for l workers employed by the firm. We assume $f(.)$ is the same in both countries and exhibits decreasing marginal labor productivity. The labor and the output markets are competitive in both countries. With free trade, the output price is given and identical in both countries. Without loss of generality, we set $p = 1$ and assume that $f(l) = l^{\frac{1}{2}}$.

Maximizing (1) with respect to l, the number of workers hired by θ_j-entrepreneur is

$$l^i(\theta_j) = \left(\frac{\chi^i\theta_j}{2w^i}\right)^2 \tag{2}$$

and the corresponding profit is

$$\pi^i(\theta_j) = \frac{(\chi^i\theta_j)^2}{4w^i}. \tag{3}$$

[4] The fact that talent matters only for entrepreneur is without consequence; what is important is that the returns to entrepreneurs' talent increases relative to alternative occupations.

Hence, firm size, measured by employment, and profit decrease with higher wages and increase with talent because revenue increases with talent but not cost. Increasing returns to talent induce individuals to become entrepreneurs on two counts: they earn higher profit for a given firm size and they spread their talent over a larger firm scale.

The individual's decision to be a worker or an entrepreneur is based on the higher return of the two activities. Since profit increases with θ_j, there are three possible talent allocations: some (but not all) θ_1-individuals are entrepreneurs; all θ_1-individuals are workers and all θ_2-individuals are entrepreneurs (specialization by talent); and some (but not all) θ_2-individuals are entrepreneurs.

Each of these cases is valid under different parameter values. Since θ_1-individuals can be entrepreneurs and workers in the first case, they must be indifferent between the two activities and profit must equal wage. From (3), $\widehat{\pi}^i(\theta_1) = \widehat{w}^i = \frac{\chi^i \theta_1}{2}$ and it follows that $\widehat{\pi}^i(\theta_2) = \frac{\chi^i \theta_2}{2}\frac{\theta_2}{\theta_1}$. Thus there are two groups of firms in terms of size and profitability. The larger and more profitable firms are headed by θ_2-entrepreneurs and the smaller and less profitable firms are headed by θ_1-entrepreneurs. The proportion of θ_1-individuals who are entrepreneurs in country i (λ_1^i) is determined by the equilibrium in the labor market. Since workers are only found among θ_1-individual, the supply of workers is $L_S^i = (1-\lambda_1^i)\varphi_1^i$. Using (2) and given the two groups of firms, the demand for workers is $L_D^i = \lambda_1^i \varphi_1^i \left[\frac{\chi^i \theta_1}{2w^i}\right]^2 + \varphi_2^i \left[\frac{\chi^i \theta_2}{2w^i}\right]^2$ so that $\lambda_1^i = \frac{1}{2}[1 - \frac{\varphi_2^i}{\varphi_1^i}(\frac{\theta_2}{\theta_1})^2]$. Since $0 < \lambda_1^i < 1$, this case arises when $0 < \frac{\varphi_2^i}{\varphi_1^i} < \left(\frac{\theta_1}{\theta_2}\right)^2 < 1$, implying there are relatively few θ_2-individuals. We call it the 'few-talent case'.

In the second case where there is specialization by talent, all θ_1-individuals are workers and all θ_2-individuals are entrepreneurs. Hence, the labor supply is equal to φ_1^i and the labor demand is $L_D^i = \varphi_2^i \left[\frac{\chi^i \theta_2}{2w^i}\right]^2$, resulting in an equilibrium wage $\widehat{w}^i = \frac{\chi^i \theta_2}{2}\left(\frac{\varphi_2^i}{\varphi_1^i}\right)^{1/2}$. Given (3), profit becomes $\widehat{\pi}^i(\theta_2) = \frac{\chi^i \theta_2}{2}\left(\frac{\varphi_1^i}{\varphi_2^i}\right)^{1/2}$. Thus, all the firms have the same size and profitability but wage and profit now directly depend on the θ_1- and θ_2-population. This is an equilibrium provided that no individual wants to switch activity and thus this case requires $\left(\frac{\theta_1}{\theta_2}\right)^2 < \frac{\varphi_2^i}{\varphi_1^i} < 1$. There are now relatively more θ_2-individuals than in the first case and we call it the 'intermediate case'.

In the third case, θ_2-individuals can be entrepreneurs or workers and must be indifferent between the two activities ($\widehat{w}^i = \widehat{\pi}^i(\theta_2)$). All workers (be they θ_1 or θ_2) have the same wage $\widehat{w}^i = \frac{\chi^i \theta_2}{2}$ and all the firms are identical in size and profitability. The proportion of entrepreneurs in the θ_2-population (λ_2^i) is determined by the labor market equilibrium and is equal to $\lambda_2^i = \frac{1}{2}[\frac{\varphi_1^i}{\varphi_2^i} + 1]$. This case requires a relatively large number of θ_2-individuals ($\frac{\varphi_2^i}{\varphi_1^i} > 1$) and we call it the 'many-talent case'.

Defining earnings by type of individuals (i.e., $G_0^i(\theta_1)$, $G_0^i(\theta_2)$), relative earnings for each of the three cases, few-talent, intermediate and many-talent case, are respectively,

$$\begin{array}{ll} G_0^i(\theta_1) = \frac{\chi^i\theta_1}{2} < G_0^i(\theta_2) = \frac{\chi^i\theta_2}{2}\frac{\theta_2}{\theta_1} & \text{if } 0 \leq \frac{\varphi_2^i}{\varphi_1^i} < \left(\frac{\theta_1}{\theta_2}\right)^2; \\ G_0^i(\theta_1) = \frac{\chi^i\theta_2}{2}\left(\frac{\varphi_2^i}{\varphi_1^i}\right)^{1/2} > G_0^i(\theta_2) = \frac{\chi^i\theta_2}{2}\left(\frac{\varphi_1^i}{\varphi_2^i}\right)^{1/2} & \text{if } \left(\frac{\theta_1}{\theta_2}\right)^2 < \frac{\varphi_2^i}{\varphi_1^i} < 1; \\ G_0^i(\theta_1) = G_0^i(\theta_2) = \frac{\chi^i\theta_2}{2} & \text{if } \frac{\varphi_2^i}{\varphi_1^i} > 1. \end{array} \quad (4)$$

Except for the intermediate case, the equilibrium earnings are independent of the relative number of φ_j-individuals. Keeping in mind that, although θ_1-individual's earnings could be firm's profit (as in the few-talent case), it always represents wage since there are always workers among θ_1-individuals. Similarly, although θ_2-individual's earnings could be wage, it always represents profit. Fig.1a and 1b illustrate (4) and the easiest way to interpret them is thus to consider $G_0^i(\theta_1)$ as wage and $G_0^i(\theta_2)$ as profit.

In the first case, since θ_1-individuals are relatively numerous, the wage is low relative to profit. When there are relatively more θ_2-individuals (the intermediate case), the smaller and less profitable firms disappear and all entrepreneurs are θ_2-type. As the relative size of the θ_2-population rises, the number of firms increases, the demand for labor rises and so does the equilibrium wage. With costs rising, firm profitability and size shrink. In the many-talent case, wage and profit are identical, and the demand for labor is sufficiently high for some θ_2-individuals to be workers. As a result, wage is the highest and profit is the lowest of the three cases.

Fig.1c shows employment per firm and Fig.1d, the proportion of entrepreneurs (or firms) in the total population h_i. In the few-talent case, the number of firms falls when φ_2^i/φ_1^i

increases. This is because, although the number of firms with θ_2-entrepeneurs rises, the number of firms with θ_1-entrepreneurs falls even more. Supply and demand of labor remain constant however and wage is constant. This means that, on average, firms are becoming bigger with φ_2^i/φ_1^i rising. As soon as all the less efficient firms have disappeared, the wage starts increasing as the number of firms with θ_2-entrepreneurs keeps rising. As a result, employment per firm falls. When $\varphi_2^i/\varphi_1^i > 1$, the proportion of entrepreneurs in the population remains constant and so are wages and profits.[5] Since the average employment per firm is now the lowest of the three cases, there is a relatively large number of small firms.

Even though quite simple, the model generates three distinct cases where profit, wage, firm size and the number of firms are different. We now set the model in a two-country environment with international mobility to investigate the patterns of migrations and their effects on activity choices.

3 Equilibria with Migrations

To concentrate on migration patterns, we assume that the two countries use the same technology ($\chi^A = \chi^B = 1$). Then, in our model, a difference in talent endowments is not sufficient to generate migrations. For example, the two countries could be different while both belonging to the few-talent case without migrations happening. This is so because earnings are the same for both types of individuals across the two countries. To generate migrations, the two countries should be *sufficiently different* (i.e., belong to different cases or be both in the intermediate case). From now on, we assume that country A is a many-talent case ($\alpha_0^A = \varphi_2^A/\varphi_1^A > 1$) and B is a few-talent case ($\alpha_0^B = \varphi_2^B/\varphi_1^B < (\theta_1/\theta_2)^2 < 1$). Then, Fig.1a and 1b show that θ_1-individuals, relatively abundant in B, may have an incentive to migrate to A because of earnings differential. Conversely, θ_2-individuals, relatively abundant in A,

[5] In the few talent case, the number of firms N^i is $\lambda_1^i\varphi_1^i + \varphi_2^i$. Given λ_1^i and $h^i = \varphi_1^i + \varphi_2^i$, $\partial(N^i/h^i)/\partial(\varphi_2^i/\varphi_1^i) < 0$ and $\partial^2(N^i/h^i)/\partial(\varphi_2^i/\varphi_1^i)^2 > 0$. In the intermediate case, the number of firms is $N^i = \varphi_2^i$ so that $\partial(N^i/h^i)/\partial(\varphi_2^i/\varphi_1^i) > 0$ and $\partial^2(N^i/h^i)/\partial(\varphi_2^i/\varphi_1^i)^2 < 0$. In the many talent case, $N^i = \lambda_2^i\varphi_2^i$. Given λ_2^i, $N^i/h^i = 1/2$.

may have an incentive to migrate to B. While this pattern of migrations is standard, the fact that two-way migrations can be evaluated not only for types of individuals but also for activities is interesting. This is so because, as shown in Section 2, in few-talent country B, θ_1-individuals are both workers and entrepreneurs and have an incentive to migrate. Similarly for country A with respect to θ_2-individuals. Hence, the model can generate two-way migrations among workers *and* entrepreneurs and two questions require further analysis. First, what are the circumstances under which one-way or two-way migrations between A and B occur? Second, how do the two countries compare in the migration equilibrium and what are the possible outcomes?

Assume that c_1 (respectively, c_2) is the migration cost of a θ_1- (θ_2-) individual. Clearly, migrations will occur only when, in the equilibrium without migrations, earnings net of migration costs is higher in the destination country than earnings in the country of origin. Given the migration pattern described above, we denote by $x \geq 0$ the number of θ_1-individuals (workers and entrepreneurs) who migrate from B to A and by $y \geq 0$, the number of θ_2-individuals who migrate from A to B. These individuals have an incentive to move ($x > 0$, $y > 0$) when the no-migration equilibrium net earnings (NG_0) are

$$NG_0(\theta_1) = \left[G_0^A(\theta_1) - c_1\right] - G_0^B(\theta_1) > 0; \tag{5}$$

$$NG_0(\theta_2) = [G_0^B(\theta_2) - c_2] - G_0^A(\theta_2) > 0. \tag{6}$$

Suppose both conditions hold, the equilibrium with two-way migrations determining x and y requires that

$$NG(\theta_1) = \left[G^A(\theta_1) - c_1\right] - G^B(\theta_1) = 0; \tag{7}$$

$$NG(\theta_2) = [G^B(\theta_2) - c_2] - G^A(\theta_2) = 0, \tag{8}$$

since individuals must be indifferent between net earnings in the destination country and earnings in the country of origin.

Another possible outcome is one-way migration. If it is from B to A ($x > 0$; $y = 0$), (5) and (7) still hold but (6) and (8) must be negative or equal to zero and conversely for one-way migration from A to B ($x = 0$; $y > 0$ when (6) and (8) hold and (5) and (7)

≤ 0). The conditions (5) and (6) indicate immediately that two-way migrations necessitate relatively low migration costs with respect to the talent (or productivity) differential (i.e., $c_1 < [\theta_2 - \theta_1]/2$ and $c_2 < [\theta_2/\theta_1][\theta_2 - \theta_1]/2$) and thus that one-way migration requires one of the migration costs to be relatively high. If these conditions are necessary, they are not sufficient (we have ignored (7) and (8)). We now characterize the migration equilibria more precisely, especially the two-way migration equilibrium.

Migrations change country A's relative talent endowment such that $\alpha^A = \frac{\varphi_s^A - y}{\varphi_1^A + x} < \alpha_0^A$ and country B's such that $\alpha^B = \frac{\varphi_s^B + y}{\varphi_1^B - x} > \alpha_0^B$. Suppose first migrations make A and B more alike by bringing both countries in the intermediate-case space ($\alpha_0^B < (\theta_1/\theta_2)^2 < \alpha^B < 1$ and $(\theta_1/\theta_2)^2 < \alpha^A < 1 < \alpha_0^A$). In this case, earnings in the migration equilibrium are $G^A(\theta_1) = \frac{\theta_2}{2}\sqrt{\alpha^A}$, $G^A(\theta_2) = \frac{\theta_2}{2}(1/\sqrt{\alpha^A})$; $G^B(\theta_1) = \frac{\theta_2}{2}\sqrt{\alpha^B}$ and $G^B(\theta_2) = \frac{\theta_2}{2}(1/\sqrt{\alpha^B})$ (see (4)).

Proposition 1 *Two-way migrations ($x > 0$, $y > 0$), such that countries A and B fall in the intermediate range, require $c_1\theta_2/(\theta_2 - 2c_1) < c_2 < c_1\theta_2^2/(\theta_1^2 + 2c_1\theta_1)$. In this equilibrium, the migration cost for θ_1-individuals is lower than for θ_2-individuals and the two countries are never identical ($\alpha^B < \alpha^A$).*

Proof. Observe from (4) that $G^i(\theta_1)G^i(\theta_2) = [\theta_2/2]^2$ ($i = A, B$), so that (8) can be rewritten as $c_1\theta_2^2/4c_2 = G^A(\theta_1)G^B(\theta_1)$. In the intermediate case with migrations, this last equality and (7) become respectively $\sqrt{\alpha^A}\sqrt{\alpha^B} = n_1/n_2$ and $\sqrt{\alpha^A} - \sqrt{\alpha^B} = n_1$ where $n_1 = 2c_1/\theta_2$ and $n_2 = 2c_2/\theta_2$. Solving these two equations,

$$\sqrt{\alpha^A} = (1/2n_2)[n_1 n_2 + \sqrt{(n_1 n_2)^2 + 4n_1 n_2}]; \quad (9)$$

$$\sqrt{\alpha^B} = (1/2n_2)[-n_1 n_2 + \sqrt{(n_1 n_2)^2 + 4n_1 n_2}]. \quad (10)$$

Hence, $\alpha^B < \alpha^A$. Since $0 < \alpha^A < 1$, $0 < \sqrt{\alpha^A}\sqrt{\alpha^B} = n_1/n_2 < 1$ and $c_2 > c_1 > 0$. Moreover, in the intermediate case, $(\theta_1/\theta_2)^2 < \alpha_B < \alpha_A < 1$ which gives rise to two conditions: $\theta_1/\theta_2 < \sqrt{\alpha_B}$ and $\sqrt{\alpha_A} < 1$. With (9) and (10), the first inequality leads to $n_2 > n_1/(1-n_1)$ and the second to $(\theta_1/\theta_2)^2 + n_1(\theta_1/\theta_2) < n_1/n_2$. Together they define the sufficient range of c_2 over which two-way migrations hold when A and B fall in the intermediate case. ■

In addition to be low relative to the talent differential, the two migration costs must be relatively similar but they cannot be identical. Since at least one migration cost is positive, the two countries cannot become identical with two-way migrations. To understand why c_1 and c_2 are *different*, consider Fig.1a,b. In equilibrium, the difference between C' and D' (equal to c_2) is greater than the difference between C and D (equal to c_1). This comes from the property that, in the intermediate case, $G(\theta_2)$ is more sensitive than $G(\theta_1)$ to a change in φ_2^i/φ_1^i.[6] This arises because a difference in wage between A and B must translate into a more than proportional difference in profits since a higher wage lowers profit directly and indirectly through a smaller firm size.

The migration flows can now be characterized. Since $\alpha^A = \frac{\varphi_s^A - y}{\varphi_1^A + x}$ and $\alpha^B = \frac{\varphi_s^B + y}{\varphi_1^B - x}$, (9) and (10) define two equations with x and y as the two unknowns. Defining $\mu^A = \left[(1/2n_2)(n_1n_2 + \sqrt{(n_1n_2)^2 + 4n_1n_2})\right]^2$ and $\mu^B = \left[(1/2n_2)(-n_1n_2 + \sqrt{(n_1n_2)^2 + 4n_1n_2})\right]^2$, the migrations flows of θ_1- and θ_2-individuals when the two economies are in the intermediate range are respectively

$$x = \frac{\varphi_2^A + \varphi_2^B - (\mu^A\varphi_1^A + \mu^B\varphi_1^B)}{\mu^A - \mu^B} \text{ and } y = \frac{\mu^A\mu^B(\varphi_1^A + \varphi_1^B) - (\mu^A\varphi_2^B + \mu^B\varphi_2^A)}{\mu^A - \mu^B}.$$

Since workers and entrepreneurs have the same incentive to migrate among θ_1-individuals in B and among θ_2-individuals in A, x and y include both workers and entrepreneurs. Hence, this equilibrium is consistent with two-way migrations of both entrepreneurs and workers. Observe however that some migrants switch activity. Since all θ_1-individuals are workers and all θ_2-individuals are entrepreneurs in the equilibrium with migrations, some θ_1-individuals who were entrepreneurs in country B before migrating are now workers in country A and some θ_2-individuals who where workers before migrating are now entrepreneurs in country B. Overall, allowing migrations increases the number of entrepreneurs (or firms) in the two countries provided that $\varphi_2^A + \varphi_2^B(\theta_2/\theta_1)^2 - (\varphi_1^A + \varphi_1^B) > 0$ and thus provided that the overall population of θ_1-individuals is not too large as compared to θ_2-individuals.[7]

[6] Specifically, $|\partial G(\theta_1)/\partial(\varphi_2/\varphi_1)| < |\partial G(\theta_2)/\partial(\varphi_2/\varphi_1)|$ when $\varphi_2/\varphi_1 < 1$.

[7] The change in the total number of firms from allowing migrations is equal to the difference between the number of entrepreneurs with migrations ($\varphi_2^A + \varphi_2^B$) and without migrations ($\lambda_2\varphi_2^A + \lambda_1\varphi_1^B + \varphi_2^B$).

As soon as the parameters of the model are outside the range given in Proposition 1, there cannot be two-way migrations. This implies that one-way migrations involve neither too low, nor too similar migration costs. The following proposition summarizes the results.

Proposition 2 *One-way migration of θ_1-individuals ($x > 0$; $y = 0$) is consistent with the equilibrium in which the two countries fall in the intermediate case provided that $c_1 < [\theta_2 - \theta_1]/2$ and $c_2 \geq [\theta_2/\theta_1][\theta_2 - \theta_1]/2$. One-way migration of θ_2-individuals ($x = 0$; $y > 0$) is consistent with the equilibrium in which the two countries fall in the intermediate case provided that $c_1 \geq [\theta_2 - \theta_1]/2$ and $c_2 < [\theta_2/\theta_1][\theta_2 - \theta_1]/2$. The first case requires $c_2 > c_1$ and the second case is consistent with $c_1 = c_2 > 0$.*

Proof. See the Appendix. ■

Since $c_2 > c_1$ is needed for two-way migrations, it must be a fortiori the case when only θ_1-individuals migrate. Similarly, there must be a relatively high migration cost c_1 to discourage θ_1-individuals from migrating when $x = 0$. This explains why $c_1 = c_2$ is consistent with this equilibrium. However since migration costs are positive when equal, the two countries cannot become identical even in this case.

Other equilibria with migrations are possible. With higher migration costs for instance, we could still have migration equilibria in which the two countries are less different than in the intial equilibrium but more different than when both countries fall in the intermediate case. Proposition 3 summarizes the possibilities.

Proposition 3 *Given the equilibrium without migration in which country A has many talents and country B as few talents, allowing migrations of θ_1- and θ_2-individuals leads to two additional equilibria: (i) A has still many talents and B falls in the intermediate case, and (ii) A falls in the intermediate case and B has still few talents. These cases involve one-way migrations of θ_1- or θ_2-individuals.*

Proof. See the Appendix. ■

All other combinations are inconsistent with an equilibrium with migrations[8]. Even if a country stays the same type with migrations, changes do occur. For instance, from Section 2, A has a proportion of $\lambda_2^A = \frac{1}{2}[\frac{1}{\varphi_2^A/\varphi_1^A} + 1]$ entrepreneurs among θ_2-individuals so that $\frac{\partial \lambda_2}{\partial(\varphi_2/\varphi_1)} < 0$. Since φ_2^A/φ_1^A falls with migrations, the proportion of entrepreneurs among θ_2-individuals rises even if A remains a many-talent country. Similarly, when country B remains a few-talent country with migrations, the proportion of entrepreneurs among θ_1-individuals must fall with respect to the initial equilibrium since $\lambda_1^B = \frac{1}{2}[1 - \frac{\varphi_2^B}{\varphi_1^B}(\frac{\theta_2}{\theta_1})^2]$ and $\frac{\varphi_2^B}{\varphi_1^B}$ always increase in B.

Hence, given the initial no-migration equilibrium in A and B, migrations always involve both workers and entrepreneurs, and they make both countries more similar but never identical. In addition, an equilibrium with migrations requires that at least one country falls in the intermediate case and that both do so when migrations are two ways. In all these cases, industry structure in both countries is affected not only by migrations but also by non-migrants' changes in activities. In the next Section, we consider the implications of these changes for the choice of migration policies.

4 Welfare, Voting and Migration Policies

To understand some of the policy implications of migrations, we first consider average welfare per capita. For country i, the welfare index is measured by total earnings, that is profit and wage. The proportion of θ_2-individuals in the economy is $z_2^i = \varphi_2^i/h^i$, where h^i is total population. Average welfare per capita is then,

$$\frac{W^i}{h^i} = \begin{cases} \frac{\theta_1}{2}\left[1 + z_2^i\left(\left(\frac{\theta_2}{\theta_1}\right)^2 - 1\right)\right] & \text{if } 0 < z_2^i < \frac{\theta_1^2}{\theta_1^2+\theta_2^2}; \\ \theta_2\left[(1-z_2^i)z_2^i\right]^{1/2} & \text{if } \frac{\theta_1^2}{\theta_1^2+\theta_2^2} < z_2^i < \frac{1}{2}; \\ \frac{\theta_2}{2} & \text{if } z_2^i > \frac{1}{2}, \end{cases} \tag{11}$$

[8] They are inconsistent with conditions (5) to (8). For instance, there is no migration when A (B) has still many (few) θ_2-individuals. Similarly, migrations cannot make one or both countries become the other country's initial type.

for the few-talent, the intermediate and the many-talent case. It is easy to check that average welfare per capita increases with z_2^i up to the many-talent case where it is constant. This is because total welfare is a positive convex combination of earnings. In the few-talent case, most individuals have low earnings. In the many-talent case, all the firms are run by the most able entrepreneurs and all the workers earn as much as the entrepreneurs and more than in the few-talent case.[9] Since half the population is entrepreneurs, this case is characterized by many small firms. Clearly, if country i could select z_2^i, it would always choose to be a many-talent country and despite increasing returns to talent, 'small is beautiful'.

It is easy to extend the welfare analysis when migrations are allowed. With migrations, the proportion of θ_2-individuals in the population changes in both countries such that z_2^A always falls and z_2^B always rises since $z_2^A = (\varphi_2^A - y)/(h^A + x - y)$ and $z_2^B = (\varphi_2^B + y)/(h^B + y - x)$. The effect of migrations on average welfare per capita is immediate. Remembering that before migrations, B is a few-talent country, its average welfare per capita always increases with migrations. In A, the average welfare per capita decreases except when A remains a many talent country. Although it is a standard result in the literature that the country attracting highly talented individuals (here θ_2-individuals) gains while the other one loses, it is interesting to note that country A may not suffer from losing θ_2-individuals. This arises because some non-migrating θ_2-individuals switch activities and maintain constant the proportion of entrepreneurs in A's population. Similarly, country B gains whether it attracts θ_2-individuals or whether it loses θ_1-individuals. This arises because migrations induce some individuals in B also to switch activities in response to these migration patterns. However, average welfare per capita does not take into account heterogeneity among individuals. Accordingly, we now consider the case where migration decisions are based on majority voting and thus are determined by self interest.[10]

Recall that, when both countries belong to the intermediate case in the migration equilib-

[9] Hence, there is also an equal distribution of earnings. However, θ_2-entrepreneurs have higher earnings in the few-talent and in the intermediate case.

[10] See Benhabib (1996), and Bilal, Grether and de Melo (2003) on median voter decisions with migrations issues.

rium, earnings change such that $G_0^A(\theta_1) > G^A(\theta_1)$, $G_0^A(\theta_2) < G^A(\theta_2)$, $G_0^B(\theta_1) < G^B(\theta_1)$ and $G_0^B(\theta_2) > G^B(\theta_2)$. Hence, in A, θ_2-individuals prefer migration to no migration and, since it is the many-talent country ($\alpha_0^A = \varphi_2^A/\varphi_1^A > 1$), their choice reflects the majority decision. Similarly, in B, θ_1-individuals prefer migration to no migration and, since $\alpha_0^B = \varphi_2^B/\varphi_1^B < 1$, their choice also reflects the majority vote. Whether migrations are one way or two ways, the above earnings inequalities do not change and therefore, both countries always choose to allow migrations when this decision is based on majority voting. This conclusion also holds when one country remains in its inital range with migrations.[11] This means that both countries support migration policies be they about immigrants, emigrants or both. This strong result arises because activity choices are endogenous and individual's earnings are linked whether they are workers, entrepreneurs, θ_1-type or θ_2–type individuals.

5 Conclusions

The paper has developed a simple two-country-one sector model where individuals are differentiated according to two types of talent. The countries are different in talent endowment and all individuals choose to be workers or entrepreneurs. Allowing migrations generates incentives for the relatively abundant type of individuals to migrate to the other country. There are both workers and entrepreneurs among migrants and, depending on the parameters of the model, there may be one-way or two-way migrations. Because the choice of activity is endogenous, some individuals switch activities when crossing the border and migrations induce some non-migrants to switch activities. As a result industry structure is sensitive to migrations of talented individuals. Finally, the endogenous choice of activities and the interdependance among individual's earnings imply that if a country allows migrations, it does not matter whether the migration policy is about immigrants, emigrants or both.

The model is admittedly simple but it captures some important sylized facts associated

[11] Since the other country necessarily falls in the intermediate case, the individuals benefiting from migrations win the decision. Both countries choose to allow migrations but in one, individuals are indifferent between migration and no migration.

with current patterns of migrations and in particular with brain circulation. It is also sufficiently simple to be used to address more complex issues associated with contemporary migration questions. For instance, the model could be expanded to investigate the links between trade and migration flows by linking individuals' types to differentiated products (Manasse and Turrini, 2001; Yeaple, 2003). One could also increase the number of destination countries to understand better why some countries, like the US, seem more successful at attractings talented individuals than others. Finally, talent could be endogenized with the introduction of human capital formation. These are only some of the issues that need to be analyzed to understand the positive and normative aspects of brain circulation, a phenomenon the importance of which is likely to keep growing.

6 Appendix:

6.1 Proof of Proposition 2:

i) $x > 0$; $y = 0$: Since A and B fall in the intermediate case, $(\theta_1/\theta_2)^2 < \alpha^A = \varphi_2^A/(\varphi_1^A + x) < 1 < \alpha_0^A$ and $0 < \alpha_0^B < (\theta_1/\theta_2)^2 < \alpha^B = \varphi_2^B/(\varphi_1^B - x) < 1$. In equilibrium, x is determined by (7), which can be written as $\sqrt{\alpha^A} - \sqrt{\alpha^B} = 2c_1/\theta_2$. Hence, $\alpha^A \geq \alpha^B$ when $c_1 \geq 0$. This case also requires $G_0^A(\theta_1) - G_0^B(\theta_1) > c_1$; $G_0^B(\theta_2) - G_0^A(\theta_2) \leq c_2$ and $G^B(\theta_2) - G^A(\theta_2) \leq c_2$. It is easy to check that $G^B(\theta_2) - G^A(\theta_2) < G_0^B(\theta_2) - G_0^A(\theta_2) \leq c_2$ so that the relevant parameters are determined only by $G_0^B(\theta_2) - G_0^A(\theta_2) = (\theta_2 - \theta_1)(\theta_2/2\theta_1) \leq c_2$ and $G_0^A(\theta_1) - G_0^B(\theta_1) = (\theta_2 - \theta_1)/2 > c_1$. It follows that c_2 (c_1) must be relatively high (low). Since $G_0^A(\theta_1)G_0^A(\theta_2) = [\theta_2/2]^2$ and $G_0^B(\theta_1)G_0^A(\theta_1) = \theta_1\theta_2/4$, $G_0^B(\theta_2) - G_0^A(\theta_2) = [\theta_2/2]^2 \left[1/G_0^B(\theta_1) - 1/G_0^A(\theta_1)\right] = [\theta_2/2]^2 \left[1/G_0^B(\theta_1)G_0^A(\theta_1)\right] \left[G_0^A(\theta_1) - G_0^B(\theta_1)\right] = (\theta_2/\theta_1) \left[G_0^A(\theta_1) - G_0^B(\theta_1)\right]$. Hence, $G_0^A(\theta_1) - G_0^B(\theta_1) > c_1$ implies $c_2 \geq G_0^B(\theta_2) - G_0^A(\theta_2) > c_1(\theta_2/\theta_1)$ and thus $c_2 > c_1 \geq 0$.

ii) $x = 0$; $y > 0$: Since A and B fall in the intermediate case, $(\theta_1/\theta_2)^2 < \alpha^A = (\varphi_2^A - y)/\varphi_1^A < 1 < \alpha_0^A$ and $0 < \alpha_0^B < (\theta_1/\theta_2)^2 < \alpha^B = (\varphi_2^B + y)/\varphi_1^B < 1$. In equilibrium, y is determined by (8), which can be written as $1/\sqrt{\alpha^B} - 1/\sqrt{\alpha^A} = 2c_2/\theta_2$. Hence, $\alpha^A \geq \alpha^B$ when $c_2 \geq 0$. This case also requires $G_0^A(\theta_1) - G_0^B(\theta_1) \leq c_1$; $G_0^B(\theta_2) - G_0^A(\theta_2) > c_2$; $G^A(\theta_1) -$

$G^B(\theta_1) \le c_1$ and the relevant parameters are determined only by $G_0^A(\theta_1) - G_0^B(\theta_1) \le c_1$ and $G_0^B(\theta_2) - G_0^A(\theta_2) > c_2$. Hence, c_1 (c_2) must be relatively low (high) but positive. As above, $G_0^B(\theta_2) - G_0^A(\theta_2) = (\theta_2/\theta_1)\left[G_0^A(\theta_1) - G_0^B(\theta_1)\right]$ so that $c_2 < G_0^B(\theta_2) - G_0^A(\theta_2) \le (\theta_2/\theta_1)c_1$ which implies $c_2 < (\theta_2/\theta_1)c_1$. Thus, $c_1 = c_2$ is consistent with these inequalities as long as they are positive.

6.2 Proof of Proposition 3:

Suppose A has still many θ_2-individuals and B falls in the intermediate case with migrations. This case implies $0 < \alpha_0^B < (\theta_1/\theta_2)^2 < \alpha^B = (\varphi_2^B + y)/(\varphi_1^B - x) < 1 < \alpha^A = (\varphi_2^A - y)/(\varphi_1^A + x) < \alpha_0^A$ with $G_0^A(\theta_1) = G^A(\theta_1) = G_0^A(\theta_2) = G^A(\theta_2) = \theta_2/2$, $G_0^B(\theta_1) = \theta_1/2$, $G_0^B(\theta_2) = (\theta_2/2)(\theta_2/\theta_1)$, $G^B(\theta_1) = (\theta_2/2)\sqrt{\alpha^B}$ and $G^B(\theta_2) = (\theta_2/2)(1/\sqrt{\alpha^B})$. When $x > 0$ and $y > 0$, (7) and (8) can be written as $1 - \sqrt{\alpha^B} = n_1$ and $\sqrt{\alpha^B} = c_1/c_2$, which implies that $c_2 = \theta_2 c_1/(\theta_2 - 2c_1)$. This case almost never arises since this is the only possible parameter combination. When $x > 0$ and $y = 0$, $1 - \sqrt{\alpha^B} = n_1$ determines x. Among the three inequalities that must also hold, only $G_0^A(\theta_1) - G_0^B(\theta_1) > c_1$ and $G_0^B(\theta_2) - G_0^A(\theta_2) \le c_2$ matter. They are $c_2 > (\theta_2/2\theta_1)(\theta_2 - \theta_1)$ and $(1/2)(\theta_2 - \theta_1) > c_1$ implying that $c_2 > c_1$. When $x = 0$ and $y > 0$, $1/\sqrt{\alpha^B} - 1 = n_2$ determines y uniquely. Among the three inequalities that must hold in equilibrium, only $G_0^A(\theta_1) - G_0^B(\theta_1) \le c_1$ and $G_0^B(\theta_2) - G_0^A(\theta_2) > c_2$ matter so that $c_1 = c_2$ is consistent with the equilibrium. The proof for the case in which A falls in the intermediate case and B has still few θ_2-individuals is similar.

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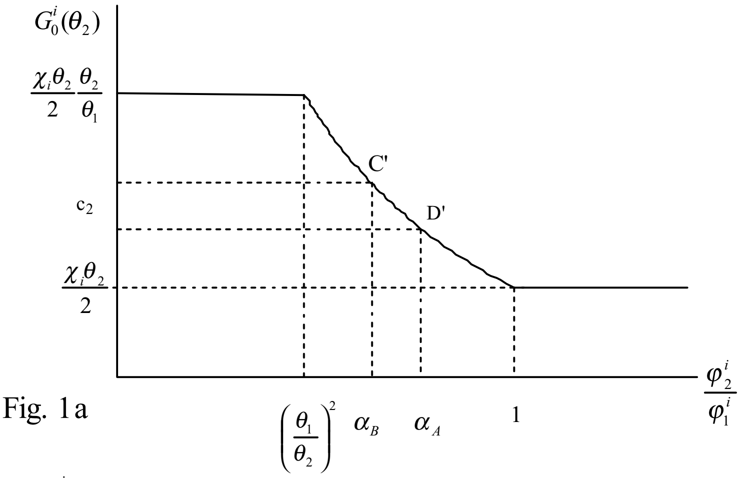

Fig. 1a

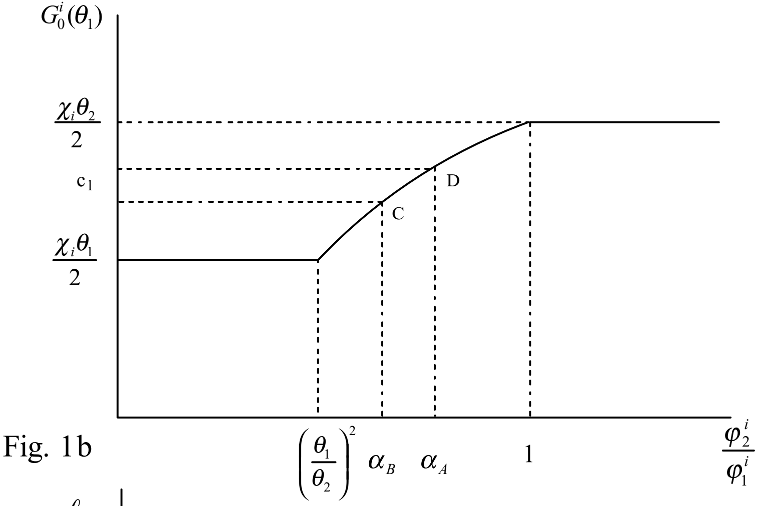

Fig. 1b

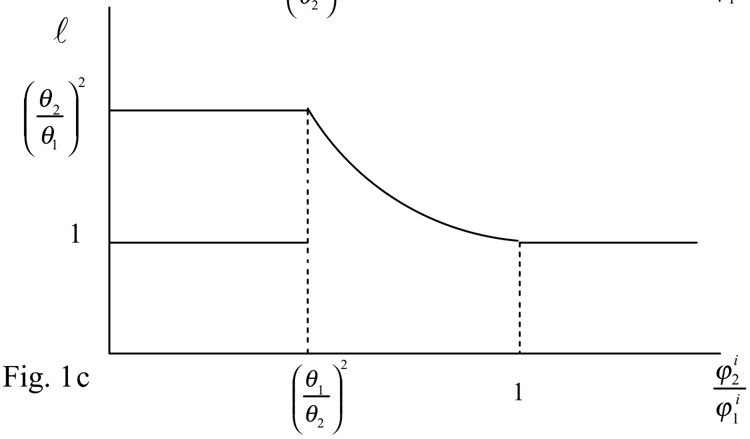

Fig. 1c

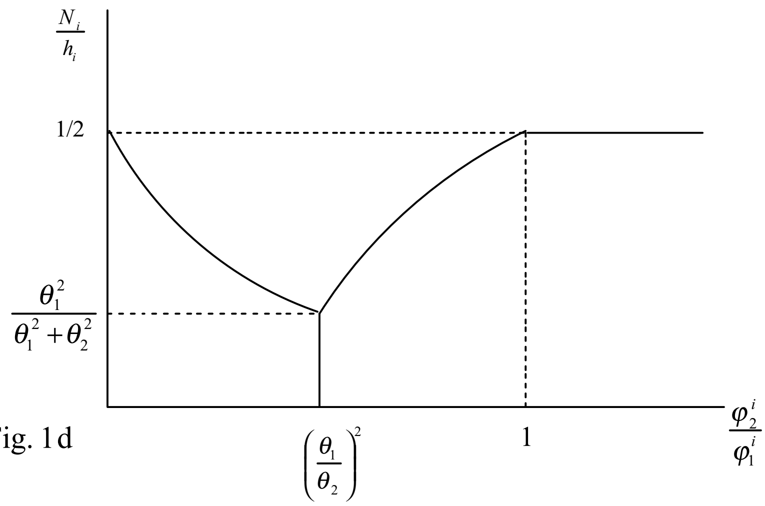

Fig. 1d