International Brain Circulation and Intra-Industry Trade*

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1. Introduction

The purpose of this paper is to investigate how the pattern of intra-industry trade is influenced by the pattern of international mobility of skilled individuals. To do so, we develop a model of international mobility of heterogeneous skilled individuals in an environment with intra-industry trade. The link between international labor mobility and international trade is useful to show how a relatively small movement of individuals may have significant economic impacts.

An important aspect of globalization is the growing importance of international labor mobility. This concerns both skilled and unskilled labor. Although in overall volumes, migrations remain largely traditional (i.e., non-skilled labor from non-OECD countries to OECD countries; see Gross and Schmitt, 2003), there is a growing perception that skilled people have a tremendous impact on innovation and on economic growth and therefore that the migration of a relatively small number of individuals in comparison to overall migration may have significant economic impacts. It is well known for instance that, in the US, the contribution of foreign-born scientists to innovation (measured for instance by the number of Nobel laureates awarded to researchers of European or Asian origin) is quite significant. More importantly for our purpose, `skilled migrants are a source of high technology entrepreneurship. It is estimated that a quarter of Silicon Valley firms in 1998 where headed by immigrants from China and India and collectively created 52300 jobs and generated almost USD 17 billion in sales' (OECD, 2002). The role of a very small number of scientists often coming from abroad has also been shown to be a key component in the development of the biotechnology industry in the US from where ¾ of worldwide sales originate (see for instance Zucker, Darby and Bremer, 1998). The critical role of highly skilled individuals is now recognized by governments. Many of them have introduced policies aimed at attracting and at retaining them.

Another characteristic that has been noted lately is that the international mobility of individuals has become largely a multi-way flow. If Canada is losing some of its best talents to the US, it is also attracting highly skilled individuals. The same is largely true for other OECD countries like the UK, Germany or Switzerland. It is because of this feature that this phenomenon is no longer described as `brain drain' but more and more as `international brain circulation'.

If there is an abundant economic literature on international trade and on factor mobility, this literature is often interested in determining whether trade and factor mobility are substitutes or complements. This is of course an important issue and the general consensus now points toward a complementarity between trade and international labor mobility. However, the above considerations suggest that one should go one step further. In particular, a model of international labor mobility for modern economies should allow for the possibility of two-way international mobility of skilled labor. One way of generating such a two-way flow is to introduce differentiation among skilled labor. Accordingly, we propose in this paper a model with differentiation both at the skilled worker level and at the product level allowing us to have something to say about the link between the pattern of trade and the pattern of migration at the industry level. This allows us to evaluate some of the economic impacts of international labor mobility in a modern economy and of policies aimed at encouraging the immigration of specific skills.

Of course, any such evaluation depends on the model that is adopted. In order to understand how we tackle these issues, consider the following. The comparison between two countries like Canada and the United States over the last two decades or so generally leads to three key observations (see Harris and Schmitt, 2001): (i) there is an increase in wage inequality across skill groups in both Canada and the US; (ii) there is a large growth in trade (and in foreign direct investment) following trade liberalization in North America, and (iii) increased pressures on skilled labor to move from Canada to the US. The model developed below essentially links trade liberalization with earning inequalities and through this with international brain circulation.

The basic structure is due to Manasse and Turrini (2001). Their main contribution is to generate increased income inequality from trade liberalization (or technological changes) in a model with labor heterogeneity. Their paper is thus not about international brain circulation. We adopt their basic structure because we believe that the underlying forces they model are relevant, especially among developed economies. It allows us to introduce international labor mobility on the simple ground that, if it is true that, everything else being equal, trade liberalization (or technological change) creates income inequality within a country and across countries, it must also create individual's incentives to move across borders to take advantage of these increased international differences in the return to a given skill. Such incentives may be especially significant at the high end of the skilled spectrum. Hence, the model is one where there is potentially complementarity between trade and international labor flows through income inequality created by freer trade.

The principle dictating the international mobility of workers is not novel except that it works at the individual level. In a standard model of international labor mobility with homogeneous labor force, the necessary ingredient for international mobility is a difference in (uniform) country real wages. With labor heterogeneity, not only the average real wage may be different across countries but individual real wages as well. This means that, for an individual skill level, the wage difference between two countries can be positive, negative or nil and that if international trade creates more inequalities in the absence of such international mobility then trade liberalization and international mobility may induce certain categories of workers to emigrate to a particular country while other categories immigrate. In a two-country model, this generates two-way brain circulation. Using simulations with the help of a simple general equilibrium model, it is the economic impacts of these links between trade liberalization, international mobility and the location of firms/entrepreneurs that we wish to investigate.

The paper is organized as follows. In the next Section, the model is presented and in Section 3 we outline some of the basic forces associated with trade liberalization and skilled worker mobility. Section 4 discusses the results of three simulations while Section 5 concludes.

2. The Model

Consider two countries indexed i,j with two sectors indexed x,y. In each country, sector y (called hereafter High Tech) produces differentiated goods (imperfect substitutes) while sector x (called hereafter Low Tech) produces a homogeneous good. There is monopolistic competition in the High Tech sector while perfect competition prevails in the Low Tech sector.

In each country, consumers allocate their income according to a two-stage budgeting decision. They first allocate their income over the two sectors according to the Cobb-Douglas utility function

$$Con_i = (c_i^x)^{\theta}(c_i^y)^{1-\theta}$$

where c_i^x is country i's consumption demand for good x which we assume hereafter is non traded[1], c_i^y represents the aggregate consumption of differentiated products from sector y, and θ_i is the consumption share devoted to the Low Tech sector. Since each consumer spends a fixed fraction of her income in each sector, an allocation rule is needed to determine how the income devoted to the High Tech sector is allocated. This allocation comes from a standard representative consumer's Dixit-Stiglitz sub-utility function augmented for the role of quality. In short, consumers are assumed to have a `love for variety' corrected for quality in the sense that higher *perceived* product quality increases utility and thus the demand for a product. This quality effect is captured by a quality index $T_n(a)$ translating the representative consumer's perception of the quality of each differentiated product at his disposal. Hence, the representative consumer's utility function, over the set of N products available to him, takes the general CES form

$$(1) \qquad c_y^{(\sigma-1)/\sigma} = \sum_{n\in N} T_n(a)^{1/\sigma} d_n^{(\sigma-1)/\sigma}, \qquad \sigma > 1,$$

where σ is the elasticity of substitution among the High Tech products, d_n is the quantity consumed of product n and $T_n(a)$ is the quality of the product n as perceived by the representative consumer.

Before deriving the demands implied by (1), it is useful to specify the supply side of the model. Each country has two factors of production: skilled labor and raw labor. They are both in fixed domestic supply. Unskilled raw labor is homogeneous, freely mobile between the two sectors, and competitively priced. Skilled labor on the other hand is a specific factor used only in the High Tech sector. It is also differentiated according to skills n such that $n \in \left[\underline{n}, \overline{n}\right]$ with a density of $\phi_{i,n}$ individuals at the skill level n in country i.

The production in the Low Tech sector is standard: firms are price takers and the production function is Ricardian in raw labor: $c_i^x = A_i^x L_i^x$ and $v_i = A_i^x p_i^x$, where c_i^x is demand for good *x* priced p_i^x, A_i^x is a productivity factor (calibrated to unity), L_i^x is raw labor input and v_i is the price of the raw labor.

The production of each differentiated good requires one unit of skilled labor (called hereafter the entrepreneur) and a variable amount of raw labor proportional to the quantity produced. Firms in sector *y* act as monopolistic-competitive profit-maximizing firms and like in any model where consumers love variety and where firms face a fixed cost of production, no firm has an incentive to imitate the product of another competing firm. The entrepreneur plays a key role since it is an essential complementary input to raw labor and his skill determines the consumer's perceived quality of the product. Simply, the higher the entrepreneur's talent, the higher is the perceived product quality. The precise link takes the form $T_{i,n}(a) = c + an_i$, where *a* can be interpreted as a technology parameter and n_i is the entrepreneur's skill associated with product *i*. Hence producing differentiated goods has both a horizontal component in the Dixit-Stiglitz tradition and a vertical component since quality matters.[2]

International trade in High Tech products involves two specific costs. First, there is a variable cost which can be interpreted as a transport cost of the iceberg type on trade flows from country *i* to *j*. Second, there is a fixed cost (expressed in terms of raw labor), denoted $v_i\gamma_i$, interpreted as a cost to access a foreign market (for instance to establish a sales network). This fixed cost to trade is critically important because it partitions the firms from sector *y* into two subsets: those able to export and those confined to the domestic market only.

Given (1), country *i*'s demand for a domestic and a foreign variant are respectively,

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[1] A version of the model relaxes this assumption: good x is then differentiated in demand by its geographic origin (the Armington assumption), in which case c_i^x is modeled as a CES aggregate of goods produced by the two countries.

[2] It should be clear that instead of introducing a demand effect linking skills to quality as above, one could introduce an efficiency effect linking skills to volume of production. Simply, more talented entrepreneurs are then able to organize their firms so as to produce a higher volume of production from given raw inputs.

$$E_{i,i,n} = T_{i,n}(a_i)\left[\frac{p_i^y}{p_i}\right]^{\sigma} c_i^y$$

$$E_{j,i,n} = T_{j,n}(a_j)\left[\frac{p_i^y}{p_j/\tau_{j,i}}\right]^{\sigma} c_i^y.$$

Hence, the demand in country *i* for a domestic (foreign) variant depends on its quality $T_{i,n}(a_i)$ $(T_{j,n}(a_j))$, on the income devoted to the consumption of differentiated products c_i^y, on the price aggregator over available differentiated products p_i^y, and on the individual price of the variant p_i (respectively, p_j adjusted for the iceberg-type barrier to trade τ_{ji}).

Because the utility function is CES, firms with the same technology have the same markup equal to

$$\frac{p_i - v_i}{v_i} = \frac{1}{\sigma - 1}$$

where v_i is the variable unit cost (as well as the price of raw labor). Thus, a higher product quality simply translates into a higher volume of sales and not into a higher price. The quality index acts on the demands through two channels: a direct one since the demands are directly function of *T* and an indirect one through the price aggregator p_i^y has the following form

$$[p_i^y]^{1-\sigma} = \sum_{n_i} \phi_{i,n} T_{i,n} [p_i]^{1-\sigma} + \sum_{n_j > z_j} \phi_{j,n} T_{j,n} \left[\frac{p_j}{\tau_{j,i}}\right]^{1-\sigma}$$

Note that in this expression, the summations run on two different sets of varieties, because all internationally produced goods will not be available to consumers due to the presence of a fixed export cost. This important aspect of the model calls for some elaborations. Indeed, each country has a fixed number of entrepreneurs. This implies that the overall number $N_i + N_j$ of differentiated goods being produced in this two-country world is also fixed.[3] The number of goods produced in each country will of course

See Lucas (1978), Murphy et al. (1991), Rauch (1991), or Schmitt and Soubeyran (2002) for such a formulation.

[3] The exogenous number of goods produced (or of entrepreneurs) can be relaxed in one of two ways: one is to endogenize the number of products, the other is to endogenize the number of entrepreneurs. In the first case, this can be achieved by introducing a fixed cost of production. In this case, full employment of resources dictates that a product can become traded only if some other non-traded products exit the industry

critically depend on whether skilled entrepreneurs can move across the border or not. Still, each firm in the High Tech sector earns zero profit in equilibrium. This is the case simply because the entrepreneur is assumed to be the residual claimant. Hence the quasi-rent generated by talent *n* is the measure of the entrepreneur's wage and thus of the skilled workers. Since the entrepreneur's wage is equal to the operating profit, the wage of the non-trader-entrepreneur in the High Tech sector, $w_{i,n}^{low}$, is equal to

(2) $$w_{i,n}^{low} = \left[p_i - v_i \right] E_{i,i,n}$$

while the wage of the trader-entrepreneur is equal to

(3) $$w_{i,n}^{high} = \left[p_i - v_i \right] \left(E_{i,i,n} + \frac{E_{i,j,n}}{\tau_{i,j}} \right) - v_i \gamma_i \phi_{i,n}{}^{\eta}$$

where the last term is the fixed cost of exporting.[4] This cost is assumed to decline ($\eta < 0$) with the number of type-*n* exporters (penetration of foreign markets is easier when many are willing to sell abroad).[5] Since *E* depends on *T* and thus on *n,* the entrepreneur's profit depends on her skill whether her product is exported or not. The main difference between a trader and a non-trader-entrepreneur is that the trader-entrepreneur's skill allows for sales at home and abroad. In other words, talents gain from market size and the trader-entrepreneur's wage increases more than proportionally with skill. The general relationship between entrepreneur's wage and skill is illustrated in Figure 1.

[Insert Figure 1 about here]

Entrepreneur n_i chooses to be a trader or a non-trader depending on whether exporting provides a higher operating profit or not. At low levels of *n*, the non-trader

(see Schmitt and Yu, 2001 for such a model). Alternatively, one can endogenize the number of entrepreneurs. For instance, labor can work as entrepreneurs or as workers depending on the comparison or earnings in each activity. Hence, depending on his skill level, an individual can be in the unskilled or in the skilled group (see Schmitt and Soubeyran, 2002 for such a model).

[4] Recall that the markup is the same on domestic and on foreign sales. This implies that *p* in (3) is also the producer price on foreign sales.

[5] The reason for the presence of such an externality is twofold. First, realism suggests that it is more costly to pioneer than to follow. The second reason is more technical. As is easily seen, our assumptions imply that, in absence of the externality, $w_{i,n}^{high}$ depends on *n* exclusively through the quality index $T_{i,n}$, so that a technological link ties together the rents earned by entrepreneurs of different skills. Introducing this externality breaks this unrealistic tie.

entrepreneur's wage increases with skill. As soon as the firm trades internationally, her wage increases more than proportionally as a given level of entrepreneur's talent reaches now a much larger market. The exporting firm necessarily generates a higher gross profit than a non-trading firm. However, because exporting involves a fixed cost, only the most talented entrepreneurs participate to the export market. Of course the skill level z_i of the entrepreneur who is just indifferent between trading and not trading is endogenous. Therefore, at z_i, we have $w_{i,z_i}^{low} = w_{i,z_i}^{high}$.

The key characteristic of the model is thus to generate positive return to skill through international trade as a single entrepreneur is needed to each firm. It is this non-convexity that give a `superstar' flavor (Rosen, 1981) to the model.

We now introduce the possibility to have international labor mobility for the skilled labor. A skilled entrepreneur moving across the border can either become a trading or a non-trading entrepreneur in the other country. In other words, being of one type in one country does not pre-determine the type of entrepreneur in the other country.[6] Since we have just established that, in country *i*, an individual with skill n_i chooses to be a trader or a non-trader according to $Max\left\{\frac{w_{i,n}^{low}}{p_i^{con}}, \frac{w_{i,n}^{high}}{p_i^{con}}\right\}$, this entrepreneur will migrate from country *i* to country *j* if and only if

$$(4) \qquad Max\left\{\frac{w_{i,n}^{low}}{p_i^{con}}, \frac{w_{i,n}^{high}}{p_i^{con}}\right\} < Max\left\{\frac{w_{j,n}^{low}}{p_j^{con}}, \frac{w_{j,n}^{high}}{p_j^{con}}\right\}$$

where p_i^{con}, p_j^{con} are the consumer price indices in each country.[7] Searching for an international equilibrium with migration therefore implies solving for the densities of entrepreneurs $\phi_{i,n}$, $\phi_{j,n}$ such that no talent is better valued abroad:

$$\left(Max\left\{\frac{w_{i,n}^{low}}{p_i^{con}}, \frac{w_{i,n}^{high}}{p_i^{con}}\right\} - Max\left\{\frac{w_{j,n}^{low}}{p_j^{con}}, \frac{w_{j,n}^{high}}{p_j^{con}}\right\}\right)\phi_{in}\phi_{jn} = 0, \qquad n \in [\underline{n}, \overline{n}];$$

[6] For instance, a non-trading entrepreneur in Canada could be a trading entrepreneur in the US. It is through this type of trade creating mechanism that the model can capture `gains' from `brain drain'.

[7] That is, $p_i^{con} = \left(p_i^x\right)^{\theta_i} \left(p_i^y\right)^{(1-\theta_i)}$.

$$\phi_{in}, \phi_{jn} \geq 0, \qquad \phi_{in} + \phi_{jn} = \overline{\phi}_n, \qquad n \in [\underline{n}, \overline{n}].$$

It is of course quite possible that for some n , there exists no interior solution, that is, all entrepreneurs with a given skill level migrate without equalizing the earnings at that skill level. Note also that the model is consistent with two-way migration pattern of skilled workers: for some range of skills, entrepreneurs may have an incentive to move from one country to another while for other ranges, they have no incentive to migrate or have an incentive to migrate in the other direction.[8]

To complete the model, we need some equilibrium conditions: the determination of total income in country i , the full-employment condition and the balance of trade condition. Total income in country i, that is the income generated by raw and skilled labor, is given by

$$Inc_i = v_i L_i^{\sup} + \sum_{n_i \leq z_i} \phi_{i,n} w_{i,n}^{low} + \sum_{n_i > z_i} \phi_{i,n} w_{i,n}^{high}$$

The full employment condition for raw labor is given by

$$L_i^{\sup} = L_i^x + L_i^y ,$$

where

$$L_i^y = \sum_{n_i \leq z_i} \phi_{i,n} E_{i,i,n} + \sum_{n_i > z_i} \phi_{i,n} \left(E_{i,i,n} + \frac{E_{i,j,n}}{\tau_{i,j}} \right) + \gamma_i \phi_{i,n}^{\eta}$$

The right-hand side represents the demand for unskilled labor respectively from non-trading firms, trading firms and from resources devoted to export cost.[9] In equilibrium, the trade balance implies:

$$\sum_{n > z_1} \phi_{i,n} p_i \frac{E_{i,j,n}}{\tau_{i,j}} = \sum_{n > z_2} \phi_{j,n} p_j \frac{E_{j,,ni}}{\tau_{j,i}}$$

Given the barriers to trade, the endowment of skilled and unskilled labor in each country and the parameters of the model, the most important elements determined by the model are the distribution of the wages of the skilled entrepreneurs, the wage of the

[8] Note that we have assumed no cost of moving from one country to the other one. It is of course easy to introduce such a cost, for instance as a fixed cost of moving.

[9] As far as the skilled labor is concerned, the total number of skilled labor is always equal to the total number of firms (or products) in the two countries so that either this number is exogenous in the absence of labor mobility or, if the mobility of skilled workers is possible, the number of skilled workers (and products) in each country is determined by (4) and (5).

unskilled labor, the number of trading and non-trading firms in each country and thus the number of products consumed in each country. In the next Section, we briefly develop how trade liberalization and international factor mobility operate before discussing simulations results in Section 4.

3. Trade Liberalization and International Labor Mobility

Finding an analytical solution to the above model is not trivial. Manasse and Turrini (2001) are forced to invoke complete symmetry between the two countries to derive closed form solutions helping them to analyze the effects of bilateral trade liberalization alone. Given our purpose, it should be clear that complete symmetry is not an interesting case as the model would generate no international any labor mobility even if intra-industry trade still occurs. Since we need some form of asymmetry between the two countries to generate international labor mobility, we do not attempt to solve this model analytically and we use simulations to generate results. Before doing this, it is useful to understand how the model operates.

Consider first the effects of trade liberalization in the High Tech sector in the absence of any international factor mobility. This can occur through two possible channels: a lower unit trade cost $\tau_{i,j}$ or a lower fixed export cost γ_i. Assume then a *unilateral* decrease in the barrier to trade by country *i* (i.e. a decrease in $\tau_{j,i}$). This induces a higher demand for the products of country *j* from consumers in country *i*. Since there is no change in country *j,* this must raise the operating profit of the trading firms in *j* and thus the wage of the entrepreneurs associated with these trading firms. This also means that some of the marginal non-trading firms in *j* have now an incentive to export resulting in a lower z_j : the proportion of trading firms in the High Tech sector of country *j* increases. Of course, a higher level of exports requires resources that must come from the Low Tech sector. This tends to raise the price of raw labor in country *j* . This effect mitigates the positive effect of trade liberalization on the wage of the entrepreneurs in the trading firms and it unambiguously reduces the wage of the entrepreneurs in the non-trading firms. In so far as the direct effect of the trade liberalization is stronger than the indirect unskilled wage effect, z_j still decreases and trade liberalization creates more wage inequality among skilled individuals (although not necessarily between the skilled entrepreneurs and the unskilled workers). In terms of Figure 1, the entrepreneur's wage schedule tends to become steeper.

Suppose now that country *j* also reduces its barrier to trade in the High Tech sector. All the High Tech firms in country *j* must now compete with cheaper products from country *i*. This must decrease their sales and thus, everything else being equal, their scale of production. This effect clearly runs in the opposite direction with respect to the effect of unilateral trade liberalization by country *i* both as far as the partial and the general equilibrium effects are concerned. What is then the overall effect of trade liberalization by county *i* and by country *j*? Essentially, if the price effect on exports is stronger than the volume effect due to import competition, then bilateral trade liberalization results both in having a greater share of exporting firms in the High Tech sector and more inequality among entrepreneurs in this sector. Manasse and Turrini (2001) show that it is always the case in their symmetric model.

Suppose now that there is some difference between the countries. This may be due to asymmetric endowment of skilled or unskilled labor, to different technologies in sector *x* or to a different distribution of skilled workers between the two countries. While skilled workers have no incentive to migrate before trade liberalization, there might be one once trade liberalization has taken place insofar as inequalities have risen between the two countries. Naturally these migrations tend to equalize earnings at the skill level (if there is an interior solution). These migrations create two main changes. First they affect the market for raw labor. This has important consequences since the variable costs and the fixed cost of exporting depend on the price of raw labor. Second, these migrations affect the balance of trade since trade flows are directly affected by the locations of the firms and thus the terms of trade. As we will see below, the combinations of these two effects may lead to interesting patterns of two-way migrations of entrepreneurs.

4. Simulation Experiments

The simulations presented below deal exclusively with the effects of freeing migrations of skilled workers given a quasi-free trade environment and some exogenous difference between the two countries. Because of calibration difficulties we are thus not yet able to carry out the simulations to see whether trade liberalization induces migrations. Since the simulations deal with skilled worker mobility in response to asymmetric situations between the two countries, they are mainly helpful to evaluate the sensitivity of the model to these migrations. We proceed then in two steps. First we set the model in a free-migration environment (migration costs are set to zero) and in a quasi free-trade environment (i.e., per unit transport cost is equal to zero but the fixed export cost is positive) and we simply ask: Given a specific asymmetry between the two countries, what are the effects of introducing free international mobility of entrepreneurs?

As already mentioned, investigating the effect of international labor mobility requires the presence of some asymmetries between the two countries. We consider three different types: (i) Country 1 has a larger endowment of skilled individuals than Country 2 (but the same endowment of raw labor); (ii) Country 1 has a larger endowment of unskilled labor than Country 2; (iii) The technology in the Low Tech sector is more productive in Country 1 than in Country 2. In all these experiments, the homogeneous product is assumed to be a non-trade good.

For each of these cases, we compare the equilibrium with and without the international mobility of the skilled labor (entrepreneurs). We show the results with two graphs: one representing the distribution of entrepreneur's wage per skill (similar to Figure 1) and the other displaying the distribution of firms in each country per skill (and thus quality). We also summarize some aggregate results for each of the two equilibria, with and without international mobility of talents. We set the model in such a way that in the initial distribution of firms without international mobility (and thus the initial distribution of skills) is the same and is uniform in both countries.

(i) Country 1 has 20% more skilled labor than Country 2

Consider the case where Country 1 has 20% more skilled labor than Country 2 but both countries have the same endowment of raw labor. As Figure 2b illustrates, this difference is uniformly distributed over the range of entrepreneur's skills (Country 1 has a uniform density of entrepreneurs equal to 1.2, while Country 2 has a uniform density equal to 1). To understand the working of the model and the results, we start from the initially symmetric international equilibrium, and implement a 20% increase in Country

1's endowment of entrepreneurs. We first assume no migration and an exogenous skill level z_i that separates exporters from non-exporting entrepreneurs. At given prices, the resource constraint implies that the increase in ϕ_{in} $\forall n$ induces a 20% decrease of the individual firm's size for each type of good *n*; hence, both w_1^{low} and w_1^{high} fall. Because of the fixed export cost, the downward shift of the w_1^{high} curve is more important and the intersection between the two curves moves to the right. However, a higher ϕ_{in} implies more diversity to the Dixit-Stiglitz household, both domestic and foreign: substitution in consumption follows at the expense of the competitively produced good: c_j^y $\forall j$ rise. The individual domestic firm's sales increase both to the local ($\forall n$) and to the foreign ($\forall n > z_1$) market so that both w_1^{low} and w_1^{high} now increase. However, competition for raw resources induces v_1 to rise, which hurts the exporters' profits relatively more (through the fixed cost) than the others so that the upward shift of the w_1^{low} curve exceeds the second; the new intersection between the two curves is moved further to the right. Endogenizing z_1 therefore results in an increase in the minimal talent level required for exporting (in Table 1-Exp 1, *PopExp* represents 42.6% of all firms in the sector *y* of country 1 whereas *PopExp* represented 50% of all firms in the initial equilibrium. There is no significant change in Country 2). Not surprisingly, given the initial rise in ϕ_{1n}, at the resulting equilibrium, an individual entrepreneur's real earning is lower domestically than abroad, for all skill levels (see Figure 2a).

[Insert Figure 2 about here]

Not surprisingly, allowing for migration re-establishes international symmetry (see Figure 2b). The relative abundance of entrepreneurs has increased the lowest skill level required for profitable exports in both countries (with respect to the equilibrium without the population asymmetry). With the introduction of international mobility of entrepreneurs, welfare (of the representative consumer) decreases in Country 1 and increases in Country 2 by about 1% (see Table 1). This is due, among other things, to the change in product variety faced by consumers in each country. Without mobility, consumers in Country 1 benefit from a larger set of products than consumers in Country 2 since there are more entrepreneurs in Country 1 and some of the additional products are non-traded. The mobility of entrepreneurs re-equilibrates the number of products faced by consumers irrespective of their location. The welfare effect is relatively small simply because two forces act in opposite directions. Some non-traded products are no longer available to consumers in Country 1 with mobility, but Country 2 exports a larger fraction of the total number of its differentiated products than it did without international mobility).

(ii) Country 1 has a 20% greater endowment of unskilled workers

Consider now the case where the asymmetry is with respect to the endowment of unskilled (or raw) labor: Country 1 is endowed with a 20% larger number of unskilled workers than Country 2. We again trace the effects of this asymmetry by using as starting point: the initially symmetric international equilibrium assuming z_i fixed and no migration. Since the number of entrepreneurs is the same in both countries, so is the number of firms in the High Tech sector in absence of mobility of the international entrepreneurs. However, more abundant and therefore cheaper raw labor implies that the scale of these firms is larger in Country 1 (compare for instance v_i between the two countries without mobility: see Table 1-Experiment 2). Although the profit of all the firms increases, the impact on the trading firms is larger because of the (now lower) fixed export cost. The intersection between the two wage profiles is moved to the left, indicating that less-talented entrepreneurs are now able to undertake profitable export activities. Not surprisingly, the entrepreneurs' real wages are higher in Country 1 for all skills (see Figure 3a)

Costless migration induces entrepreneurs to move into Country 1 in order to take advantage of cheaper resources and a larger market. Most interestingly, there is a strong composition effect in the sense that those who massively move into Country 1 are the *non-trading* entrepreneurs. Furthermore, there is a two-way flow of medium/high skills: some intermediate skills are attracted into the home country, while there is an outflow of high talents. Why is that? At one level, a two-way mobility of talents must take place in this model simply because of the constraint imposed by the balance of trade (and this is reinforced by the fact that product x is non-traded). But why this particular pattern? Two effects contribute to explain this pattern. First, observe that $z_1 < z_2$ in the no-migration equilibrium, which implies that moving into Country 1 makes it possible for some skilled entrepreneurs from Country 2 to become exporters and, every thing else equal, to increase their profit. This motivation for migration is not shared by the most talented who are exporters independently of their geographical location. Second, the incentive to migrate to Country 1 implies that the number of exporters increases in this Country with respect to the initial equilibrium. This makes penetration of Country 2 less costly, thanks to the export externality. This effect is obviously particularly crucial for the marginal traders since it is for these firms that the export cost is most significant in their decision. Still the large inflow of entrepreneurs in Country 1 raises the cost of producing High Tech goods (v_i increases by 3.6% in Country 1 while remaining unchanged abroad - see Table 1-Experiment 2). Since the fixed cost of exporting is expressed in terms of raw labor, there are two opposite effects on the cost of exporting from Country 1. The net effect could still result in a lower fixed cost of exporting in Country 1 despite the difference in v_i. Hence, the fact that skilled entrepreneurs with intermediate skills migrate to Country 1 can be traced back to the incentives to become exporters there as well as to the role of the fixed cost of exporting.

Allowing for entrepreneur mobility increases in this case welfare by about 2% in Country 1 and decreases it by 2.1% in Country 2 (see Table 1). This significant welfare effect is not surprising given the appreciation of the home country's terms-of-trade, as well as the substantial net increase in the number of differentiated goods available to consumers in Country 1.

[Insert Figure 3 about here]

We see from the two previous experiments that the size of the relative skilled versus unskilled labor endowment matters a lot in this model. Depending on where the asymmetry lies, the introduction of international entrepreneur mobility has very different qualitative and quantitative effects. When the endowment of skilled entrepreneurs in Country 1 is greater than in Country 2, entrepreneurs move to Country 2, whereas when the endowment of unskilled labor is larger in Country 1, the dominant movement come from entrepreneurs moving into Country 1. These asymmetries also result in different production specialization and trading patterns. In the first experiment, more High Tech products (traded and non traded) are being produced in Country 1 without mobility than with mobility. This means that, with mobility of entrepreneurs, less resources are being used in the High Tech sector and Country 1 exports relatively less High Tech products than in the absence of this mobility. With the second asymmetry, the opposite occurs. With mobility, there is a relative specialization in production toward the High Tech sector at the expense of the Low Tech sector in Country 1. More interestingly, it leads to relative specialization along the quality dimension within the High Tech sector. Indeed mobility leads Country 1 to specialize mainly in low and intermediate quality variants, while Country 2 tends to specialize in high quality export products.

The quantitative effects are also quite different. In the first experiment (+20% skilled workers in Country 1), the flow of skilled entrepreneurs moving from Country 1 to Country 2 is roughly equal to half the difference in endowment (representing 10% of the initial number of entrepreneurs in Country 2). In the second case (+20% raw labor in Country 1), the *total number* of skilled entrepreneurs migrating between the two countries represents about 34% of the initial endowment of entrepreneurs in each country (for a net change representing 27% of the initial endowment). This is quite a significant effect.

(iii) Country 1 has a higher labor productivity in the Low Tech sector

The last experiment is one where the factors are more productive in Country 1 than in Country 2 in the Low Tech sector (+20% in total factor productivity in the Low Tech sector of Country 1). In the absence of international labor mobility, resources will be heavily used in the Low Tech sector as the price of the Low Tech product is low. Because the consumption function is Cobb-Douglas over the Low and the High Tech products and because the Low Tech product is a non-traded good, the effect of this higher productivity shock is confined to the Low Tech sector. Mobility of entrepreneurs still takes place when it is allowed since the real value of the quasi rents in the High-Tech sector is now higher in Country 1 than in Country 2. In other words, the purchasing power of the rent earned in sector y is systematically higher in Country 1 than in Country 2 in the absence of mobility. Hence migration goes from Country 2 to Country 1 with its effects on non-trading as well as on the trading firms. The fact that the incentive to move comes mainly from the trading firms is due to the fact that the absolute difference in real earnings necessarily rises with the level of these earnings. Hence the incentive to migrate is stronger the higher the skill of the entrepreneurs. As a result, the number of trading firms increases in Country 1 with a similar externality effect and, through it, with a similar production specialization (at least for the trading firms) and trade pattern effects as in previous simulations.

[Figure 4 about here]

5. Conclusions

What to make of these simulations? Of course, we have used artificial data so that none of these simulations directly apply to the Canada-US case. We have also completely disregarded how we might make the model operational with real data. The particular model we have used however raises a number of important issues: about the meaning of skills, the correspondence between skills and firms without mentioning the correspondence between skills and product quality. Though specific, we believe this type of model has great potential for a number of reasons.

First, there is a link between trade, earning inequality and labor mobility. The link between trade and inequality comes from two sources. Since trade affects the wage of the unskilled and of the skilled workers (entrepreneurs) and among entrepreneurs, trade induced increase in inequality may mean here the wage of the skilled workers increases with respect to the wage of the unskilled and it can mean that the wage of the highly skilled (in trading firms) increases with respect to the wage of the less highly skilled (in non-trading firms). Since these inequalities occur not only within a country but across countries, they create incentives to migrate across the border in order to take advantage of earning differentials. Second, skills matter in this model and returns to skills are positive giving the model a Rosen-superstar flavor.

Third because individuals (at least skilled labor) are differentiated, migration decisions are potentially different among individuals. Introducing international labor mobility leads to changes in specialization at the production level across sector and within sectors producing differentiated products. In turn this leads to changes in the patterns of trade. This is interesting because the changes in trade patterns across and within sectors are not due to trade liberalization per se but are by-products of liberalizing international labor migration.

In order to illustrate why this last point may make this model relevant for the Canada-US case, consider the following. In a study commissioned by the EU Commission, Fontagné, Freudenberg and Péridy (1998) have uncovered interesting changes in the trade patterns within the European Union between 1980 and 1994. They have first divided trade between every pair of EU members into inter- and intra-industry trade and further divided intra-industry trade into horizontal (Helpman-Krugman type) and vertical (Shaked and Sutton-quality type) intra-industry trade. To do so, they simply compared the price of export with the price of import. If, at the level of the variants, the price of export is roughly similar to the price of import, then trade in this variant belongs to the horizontal intra-industry trade. If there is a significant difference (positive or negative) in these two prices, then trade in this variant belongs to vertical intra-industry trade. Aggregating these trade shares, they discovered that if, as expected, the share of overall intra-industry in total trade has increased over the period, it is not due to an increase in the share of horizontal intra-industry trade but to an increase in the share of vertical intra-industry trade. In other words, given their methodology, some kind of specialization has taken place within Europe at the country level despite the presence of similar countries (say France and Germany) and trade liberalization. Nobody today has a good explanation for this phenomenon.

Applying a similar methodology for the Canada-US case over the period 1989-99 period, Andresen, Harris and Schmitt (2001) find similar changes but on a much smaller scale than in Europe. Why? We do not really have a good answer either. However, our simulations now suggest this may have a very simple explanation: this difference between the results found in Europe and in North America might well simply be associated with differences in the degrees of economic integration. The 1992 Unique Market (decided well before 1992) may well have triggered firm location decisions (for instance) that were focused at serving Europe as a whole and not simply at serving a specific European country, whereas NAFTA did not have the same impact on firm location decisions (or on individual decision location) because of its more limited focus. This suggests that, in evaluating the effects of a deeper integration between Canada and the US and in particular measures of integration dealing with international labor mobility, an important component in this evaluation is the consequences of these measures on international trade and on the pattern of trade.

The above advantages are purely static. Useless to say that in a dynamic environment, other elements can be added to this type of model whether it is human capital formation, the impact of an ageing population, or quality-ladder/endogenous growth type components.

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Table 1: The effects of four simple asymmetries

	Country 1		Country 2	
	No mobility	**With mobility**	**No mobility**	**With mobility**
	Experiment 1: +20% entrepreneurs in Country 1			
Welfare	1.018	1.009	.998	1.008
$p_i^x = v_i$	1.026	1.00	1.00	1.00
p_i^y	.34	.338	.345	.338
c_i^x	343.1	343.3	343.4	343.3
c_i^y	1037	1017	995.7	1017
Pop	360	329.7	300	330.3
PopExp	153.6	151.1	149.0	151.6
	Experiment 2: + 20% unskilled labor in Country 1			
Welfare	1.199	1.222	1.008	.987
$p_i^x = v_i$	.969	1.004	1.00	1.00
p_i^y	.335	.334	.336	.351
c_i^x	413	412.9	342.4	342.4
c_i^y	1194.5	1242.1	1018.5	976.3
Pop	300	381.4	300	218.6
PopExp	166	168.3	162	162.7
	Experiment 3: +20% labor productivity in Low-Tech sector-Country 1			
Welfare	1.095	1.1	1.00	.995
p_i^x	.883	.845	1.00	1.00
p_i^y	.343	.344	.343	.348
v_i	1.00	1.013	1.00	1.00
c_i^x	411.9	411.3	343.2	343.9
c_i^y	1000	1010.6	1000	988.9
Pop	300	327.5	300	272.5
PopExp	151	158.9	151	142.1

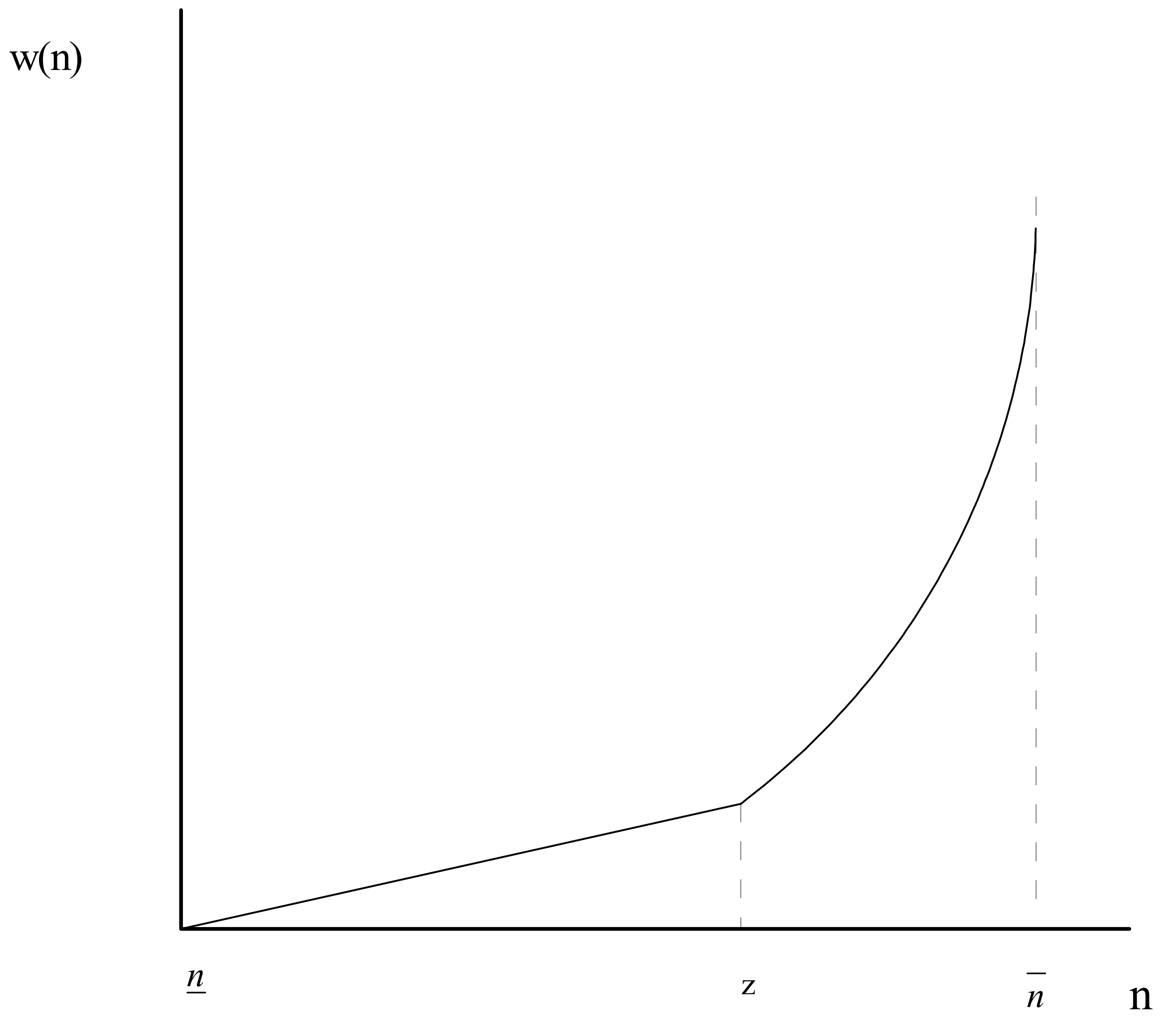

Figure 1

Figure 2a: Skilled Labor Asymmetry

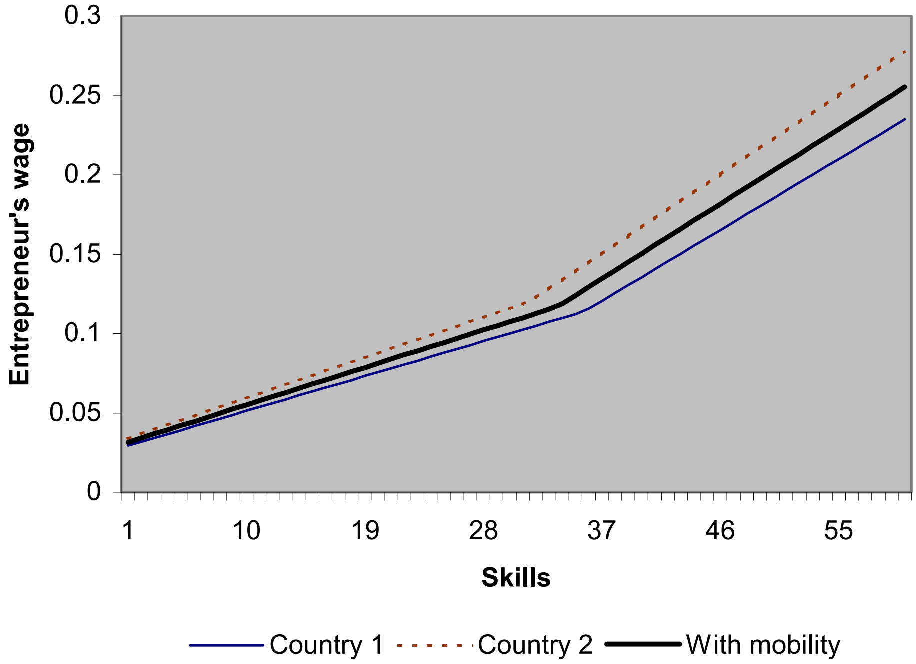

Figure 2b: Skilled Labor Asymmetry

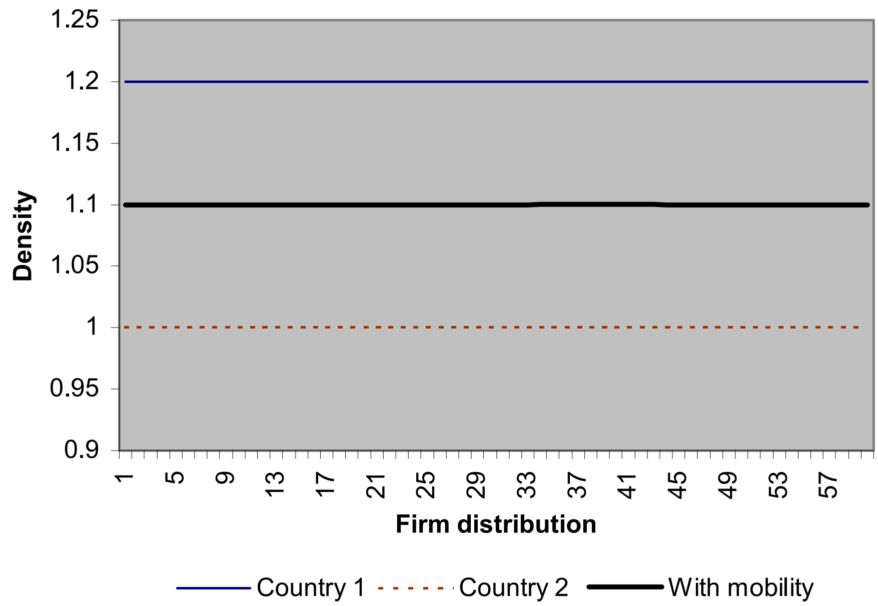

Figure 3a: Unskilled Labor Asymmetry

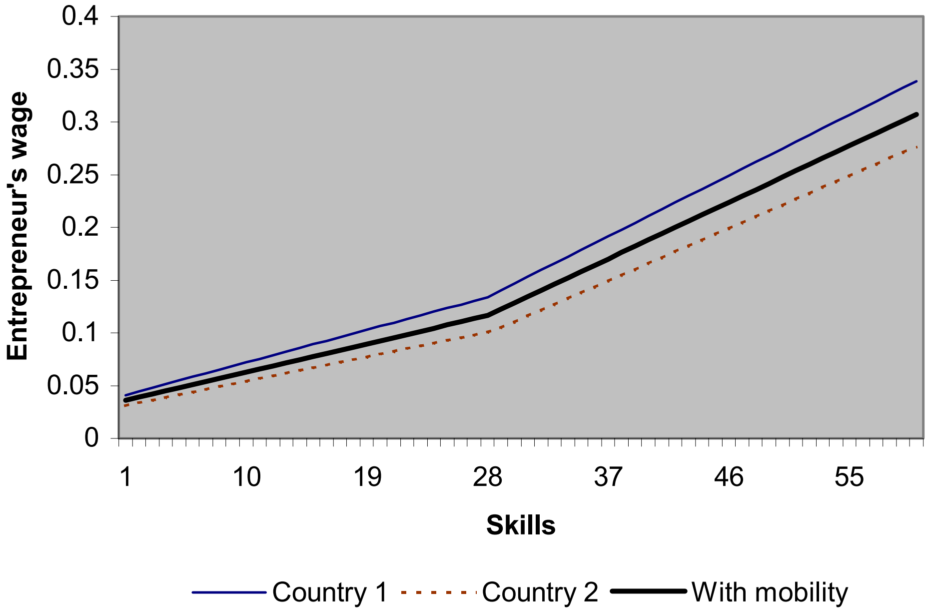

Figure 3b: Unskilled Labor Asymmetry

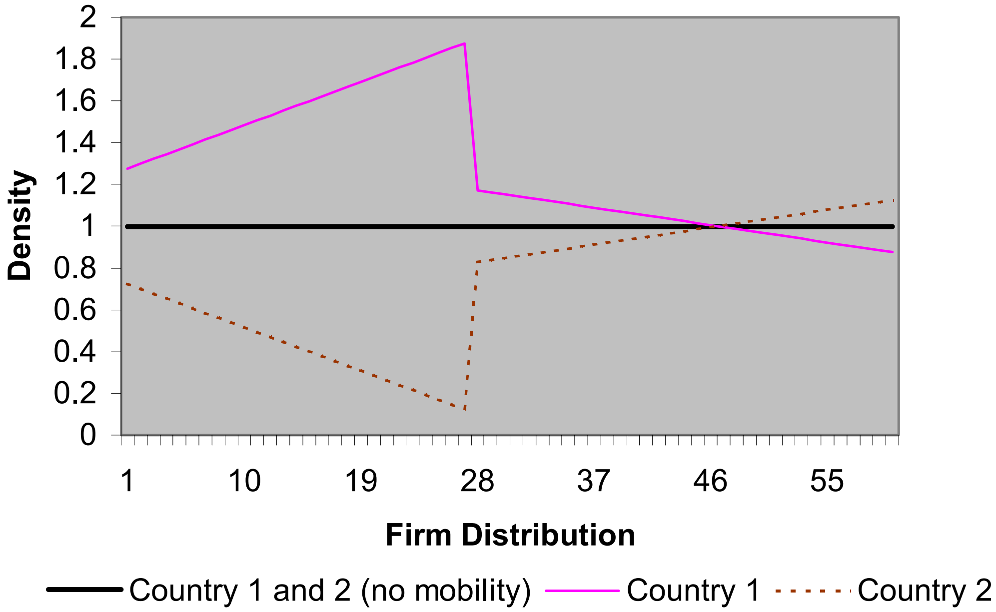

Figure 4a: Technological Asymmetry

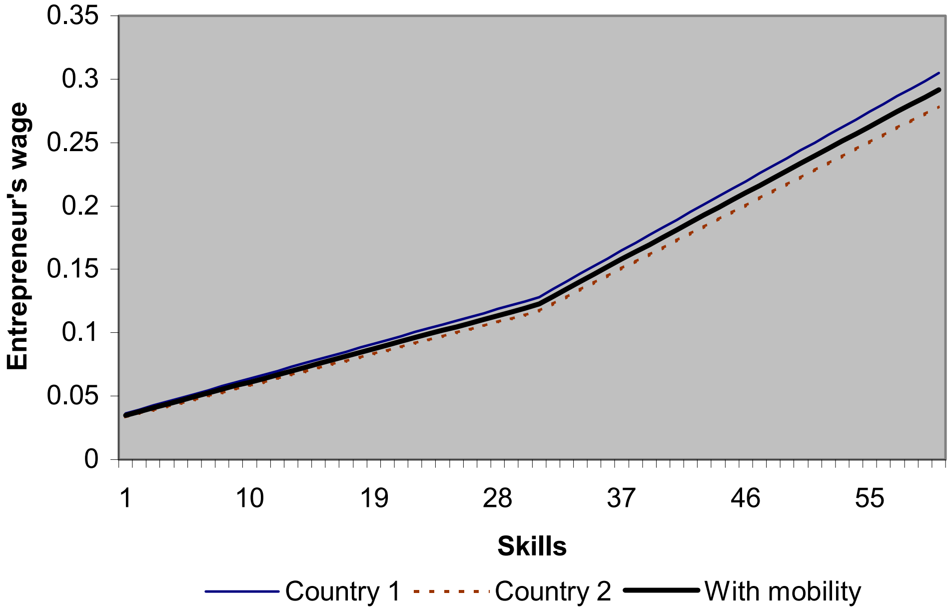

Figure 4b: Technological Asymmetry