Offshoring, migrants and native workers: the optimal choice under asymmetric information

Gianluca Orefice*

University of Milano

December 11, 2010

Abstract

This paper presents a theoretical model about the optimal choice for a firm between offshoring and hiring immigrant workers under asymmetric information about their ability and effort in production (symmetric information is assumed about home born workers). When a domestic firm hires an immigrant it doesn't know his ability; while when the firm goes abroad it uses local agent in order to buy additional information about workers, thus enforceable contracts may be set. We show that it is optimal for firms to produce low quality products offshoring the production abroad, while intermediate quality level products will be produced at home using foreign born workers. Finally, high quality products will be produced using native workers.

Keywords: International migration, Offshoring, Asymmetric Information.

JEL-Classification: F22, F23.

*Gianluca Orefice, Department of Economics, Business and Statistics, University of Milano, via Conservatorio 7, 20122 Milano. E-mail: gianluca.orefice@unimi.it. Mob. +39 3284361452

1 Introduction

When a migrant arrives in his host country, he brings along a lot of things with him but he cannot transfer his homeland's information structure. Therefore the host country employers are not well informed about immigrant workers, their ability and effort. This is the reason why we decide to model migration under asymmetric information. Some works focus on the role of asymmetric information in determining the skill composition of migrants (Katz and Stark, 1987), others study the role of information asymmetries on the decision to migrate. Recent papers on the optimal international organization of firms when both, offshoring and hiring immigrant workers are feasible options (Ottaviano et al., 2010), consider perfect information about immigrants. But, since asymmetric information modifies the wage schedule for immigrants, asymmetric information can change the traditional trade-off between offshoring and hiring immigrant workers. Moreover because of imperfect monitoring (on both natives and immigrants) workers may not deliver on their promises about effort, so incentives must be provided to workers for their effort. This paper will not analyze the nature of the relation between native and immigrant workers (complementarity or substitutability[1]). We start from a stylised fact: recent immigration flows into rich countries allow local employers to hire immigrants, this strategy potentially substitutes for the more traditional offshoring of production. Under asymmetric information about immigrants, employers don't observe the ability and the effort level by immigrants. Thus, foreign born workers will be paid the average of the overall immigrant workers output. The main result of the analysis is that it will be optimal to offshore the production when the firm decides to produce low quality goods, while it will be optimal to produce high quality goods at home using native workers. If the firm decides to produce intermediate quality level goods, it will be optimal to produce at home using immigrant workers.

The rest of the paper is organized as follows. Section 2 presents a review of existing literature. Section 3 presents the baseline model; results are presented in section 4. Section 5 extends the baseline model to a continuum of types of workers. Section 6 concludes.

[1] See Ottaviano and Peri (2008), Peri and Sparber (2009), Borjas (2003), Borjas et al. (2008).

2 Review of the literature

This paper relies on two main streams of literature: (i) one concerning the relation between migration and offshoring, (ii) the other concerning the role of asymmetric information in the economics of migration. Although traditional Heckscher-Ohlin models predict substitutability between immigration and offshoring[2], a consensus has not been reached in giving a sign to the relation between immigration and offshoring. The question was first analyzed by Ramaswami (1968), who argued that a capital abundant country can either offshore parts of the production abroad (enjoying higher return on capital and lower wages) or invite foreign workers paying them a lower wage than natives. Bhagwati and Srinivasan (1983) doubted the possibility of hiring foreign born workers at a lower wage than natives, but recent empirical studies show that immigrants earn less than natives (Antecol et al., 2003; Butcher and Di Nardo, 2002; Chiswick et al. 2008) giving new lymph to this debate. Recent theoretical works by Jones (2005) and Ottaviano et al. (2010) shed light on the relation between offshoring and immigration. The main conclusion in Ottaviano et al. (2010) is that easy production tasks are offshored, intermediate tasks are covered by immigrants in the home country, while complicated tasks are covered by native workers at home.

Empirically, Javorcik et al. (2006) find a positive relation between immigrants in the U.S. and the outward FDI by American firms, this kind of complementarity becomes stronger if we consider skilled immigrants (El Yaman et al., 2007). Indeed an increase in the number of immigrants increases the information about their country of origin reducing the cost of offshoring. On the contrary Barba Navaretti et al. (2008) find substitutability between immigration and offshoring. Finally Ottaviano et al. (2010) find empirical evidence of complementarity between offshoring and migration, because only easy tasks are offshored, while as tasks become more complex they are covered by immigrants, and finally the tasks at the upper end of complexity are assigned to natives.

This literature considers the characteristics of immigrants and their abilities perfectly known to employers in host country's firms. In our view, however, employers in host countries are not perfectly informed about the ability of new immigrants, due to their inability to assess the education level,

[2] Immigrants increase the labor endowment in receiving countries, in the short run it reduces the capital labor ratio and thus it increases the return on capital. The increased return on capital deters offshoring.

the experience, and other dimensions related to cultural differences. This may potentially change the relation between migration and offshoring in theoretical models.

The basic idea underlying all works in the field of migration under asymmetric information is that when information on the ability of immigrants in unknown to receiving country's employer, all migrants will receive the same wage, based on the average product of the group of migrants. The seminal work in this field was by Katz and Stark (1984); they observed that employers in the immigrants receiving country have less information than employers in the country of origin, as to the type of worker in terms of productivity and effort. The reason is that when a worker migrates, he cannot take his home country information structure. Katz and Stark (1987, 1989) argue that under asymmetric information (and without the possibility to invest in devices to identify migrant's skill level) the individual wage offered to immigrant workers is equal to the average product of the immigrant workers group.

3 The baseline model

Under symmetric information each worker receives a wage equal to his productivity; but under asymmetric information on foreign born workers and assuming immigrants do not engage in any "signaling" about their skill level, employers will pay an average (on the base of the skill composition of the labour force) wage to all migrant workers in production (Katz and Stark, 1987). Thus a kind of discrimination in wages may arise between home and foreign born workers due to asymmetric information on immigrants ability[3]. Hence each firm can carry out two strategies (alternative to using native workers) to reduce costs: (i) stay at home and hire immigrants, (ii) localize a production plant abroad in order to enjoy a lower labour cost (offshoring).

The supply side of the economy is here described by a simplified Kremer (1993) production function[4], where the manufacture of a unit of final goods requires only labour and a number of

[3] We assume symmetric information about native workers.

[4] The Kremer (1993) production function has the following form:
$E(y) = k^{\alpha} \left(\Pi_{i=1}^{n} q_i\right) nB$
where $E(y)$ is the expected output level, n is the number of tasks in production, B is the output per worker with a single unit of capital k, and q is the worker's skill (or quality) as the expected percentage of maximum value the

tasks (at the end of each task the employer checks the quality of the intermediate output). Let's assume two tasks: a "communication intensive" task, unfeasible for foreign born workers because of lack in language skills, and a "manual intensive" task which in principle can be carried out by both native and foreign born workers[5]. The manual task requires n workers and the quality of the final output depends on the quality of the manual task.

Let's assume two countries, a rich country (R) and a poor country (P); two types of workers may be used in the manual task: the high skilled one α_H and the low skilled one α_L; where α_i is the skill type of workers. Each worker may choose his effort level $e_j = 1, 2$ in production. We also assume that every type of worker is represented in the pool of hired workers[6], but:

- the effort by immigrant and native workers in production (e_j) is private information
- the employer is not able to distinguish between types (α_i) of foreign workers in production
- the employer is able to distinguish between types (α_i) of home born workers in production

To keep things simple let's assume only two workers in manual task (this assumption will be relaxed subsequently) so the overall quality level depends on the workers skills in manual task production and on their effort level. Let q denote quality of the product, four quality levels can be produced:

$$[1] \quad q_i = \begin{array}{l} q_o = \alpha_H e_0 + \alpha_L e_0 \\ q_1 = \alpha_H e_0 + \alpha_L e_1 \\ q_2 = \alpha_H e_1 + \alpha_L e_0 \\ q_3 = \alpha_H e_1 + \alpha_L e_1 \end{array}$$

The quality level can be thought of as a joint probability of having more or less skilled workers in production exerting low or high effort in production. Assuming that, effort being equal, the productivity in terms of quality is higher for the high-skilled workers than for the low-skilled workers ($\alpha_H > \alpha_L$) we may conclude:

product retains if the workers performs the task.

[5] The distinction between "comunicative" and "manual" tasks has been made by Peri and Sparber (2009).

[6] Results don't change if we relax this assumption.

[2] $q_0 < q_1 < q_2 < q_3$.

We assume that the firm has all the bargaining power in contracting, it makes a take-it or leave-it offer to the worker; the worker can accept or reject the contract. If he rejects the contract he receives a wage (w_u) provided by the government or alternatively by other firms in other sectors. The price of a unit of output is assumed to be increasing with the quality level and the wage for a communication intensive task can be omitted because it does not make a difference among the three alternatives (producing at home using natives or immigrants, or producing abroad). Each firm at home will maximize a unit profit function, namely revenue less costs in the following form:

[3] $\pi(q_i) = p(q_i) - 2w(q_i)$[7]

Similarly each worker maximizes utility as a function of wage and effort cost (e):

[4] $u = w(q_i) - e$.

each worker of type α_i will choose the effort that maximizes his utility. In order for q_i to be attainable, wage schedules have to satisfy the following participation (IR) and incentive constraints (IC):

[5] (IR) $w(q_i) - e_j \geqq w_u \qquad \forall q_i$

[6] (IC) $w(q_i) - e_j \geqq w(q_i^-) - e_{k \neq j} \qquad \forall q_i$

where i stands for the quality level of the output, j stands for the effort level (1 or 2) required by worker H or L, as it applies, in order to achieve q_i; q_i^- is a quality level lower than q_i if the worker who receives the incentive produces a low effort, as a consequence $w(q_i^-)$ is the "punishing" wage provided by the employer if the actual quality level is lower than the expected one (see appendix for more details). Notice that the (IR) in [5] has to be binding, otherwise the employer could reduce the wage still satisfying the participation constraint. The (IC) constraint here assures that the worker who gets the incentive will exert a high effort level. Indeed, ex-ante the employer decides

[7] Where only labor is assumed in production.

for how many workers he wants high effort (according to the quality level he wants to reach), so according to (IC) and (IR) the employer defines a contract (take it or leave it) for workers. If the employer decides to provide incentives to the workers, because of hidden actions, they may receive the incentive and shirk. This opportunistic behaviour is avoided by IC constraint (see appendix for details).

Let's start looking at what happens under perfect information about native worker types. If the employer knows the type of workers in manual task (but he still does not observe their effort level), he may set ad hoc wages and incentives according to each quality level, thus the following profit functions derive (effort is not observable):

[7] $\pi(q_0) = p(q_0) - 2w_r^{h,n}$

[8] $\pi(q_1) = p(q_1) - 2w_r^{h,n} - \Delta$

[9] $\pi(q_2) = p(q_2) - 2w_r^{h,n} - \Delta$

[10] $\pi(q_3) = p(q_1) - 2w_r^{h,n} - 2\Delta$

where $w_r^{h,n} = w_u^{h,n} + e_0$ is the reservation wage at home for native workers and $\Delta = e_1 - e_0$. Thus functions in [7] - [10] may be thought of as profits functions for every attainable quality level when natives are employed in production (because there is perfect information about the ability of natives).

But, if the firm hires immigrants, it cannot distinguish the type of immigrants in production and their effort level (asymmetric information) even if each individual knows his type and effort. Under asymmetric information about immigrants, each firm will pay immigrants a uniform wage as a function of the quality level that the firm wants to reach (see Kats and Stark, 1984, 1987). If the firm wants to produce q_0 there is no reason for providing incentives and only participation constraints have to be satisfied:

[11] $w^{h,m}(q_0) = w_u^{h,m} + e_0 = w_r^{h,m}$

so when the employer wants to reach the lower quality level, he has to pay both workers the reservation wage. If the firm wants to produce a higher quality level, a high effort by the low

productive worker is needed, so the firm has to provide incentive to him. From the incentive compatibility constraint we derive the wage:

[12] $w^{h,m}(q_1) = w_r^{h,m} + (e_1 - e_0) = w_r^{h,m} + \Delta$

But because of asymmetric information about the type of the two immigrant workers in production (the employer is not able to distinguish among them in setting ad hoc contracts), the firm will pay an equal wage to both workers in production. This implies that in order to obtain a quality level higher than q_0 the firm has to pay the incentive to both workers. So that intermediate quality levels cost as much as the highest quality level (q_3), so they are dominated. Thus, if the firm wants to reach the higher quality level (q_3) it has to induce high effort by both workers paying them the following wage:

[13] $w^{h,m}(q_3) = w_r^{h,m} + (e_1 - e_0) = w_r^{h,m} + \Delta.$

So the firm can realize a higher quality level q_3 by spending the same wage cost as for q_1 or q_2. If the firm keeps production at home hiring immigrants in the manual task (enjoying the lower reservation wage by immigrants, as we will see in what follows) just two output strategies are not dominated: q_0 and q_3. Assuming $p(q_i) = q_i$ the profit functions associated to these strategies are:

[14] $\pi^{h,m}(q_0) = q_0 - 2w(q_0) = e_0\alpha_H + e_0\alpha_L - 2w_r^{h,m}$

[15] $\pi^{h,m}(q_3) = q_3 - 2w(q_3) = e_1\alpha_H + e_1\alpha_L - 2w_r^{h,m} - 2\Delta$

If the firm chooses to produce abroad, it has to pay a local agent $\big($costing ϕ[8]$\big)$ who reveals both the type of local workers and how to produce quality level higher than the minimum one abroad. This allows the firm to pay a customized wage. If the firm wants to produce q_0 abroad, it has to guarantee the participation contraint (as at home). The wage schedule and profit function will be[9]:

[16] $w^f(q_0) = w_u^f + e_o = w_r^f$

[9] Notice that because just a low effort level is requested by the firm, there is no reason to pay for the local agent to reveal the worker's effort.

[17] $\pi^f(q_0) = q_0 - 2w(q_0) = e_0\alpha_H + e_0\alpha_L - 2w_r^f$

When the firm wants to reach a higher quality level, it has to provide an incentive to the low type to obtain q_1 or to the high type to obtain q_2. But as in the domestic case, the incentive provided to the high productive worker is the same as the incentive provided to the low productive worker, so that the strategy q_2 dominates the strategy q_1. Quality q_1 remains dominated as it is at home but the quality q_2 does not. Thus the wage schedule paid to the high productive worker for an intermediate output level (q_2) and the correspondent unit profit functions are:

[18] $w^f(q_2) = w_r^f + \Delta$

[19] $\pi^f(q_2) = q_2 - 2w_r^f - \Delta - \phi = e_1\alpha_H + e_0\alpha_L - 2w_r^f - \Delta - \phi$

Finally, if the firm wants to reach the highest quality level (q_3) it has to provide incentive to both workers ending up with the following profit function:

[20] $\pi^f(q_3) = q_2 - 2w_r^f - 2\Delta - \phi = e_1\alpha_H + e_1\alpha_L - 2w_r^f - 2\Delta - \phi.$

The following table summarizes the unit profit functions for each quality-strategy combination[10]:

	Natives	**Immigrants**	**Offshoring**
$\mathbf{q}_0$	$e_0\alpha_H + e_0\alpha_L - 2w_r^{h,n}$	$e_0\alpha_H + e_0\alpha_L - 2w_r^{h,m}$	$e_0\alpha_H + e_0\alpha_L - 2w_r^f$
$\mathbf{q}_2$	$e_1\alpha_H + e_0\alpha_L - 2w_r^{h,n} - \Delta$	$e_1\alpha_H + e_0\alpha_L - 2w_r^{h,m} - 2\Delta$	$e_1\alpha_H + e_0\alpha_L - 2w_r^f - \Delta - \phi$
$\mathbf{q}_3$	$e_1\alpha_H + e_1\alpha_L - 2w_r^{h,n} - 2\Delta$	$e_1\alpha_H + e_1\alpha_L - 2w_r^{h,m} - 2\Delta$	$e_1\alpha_H + e_1\alpha_L - 2w_r^f - 2\Delta - \phi$

4 The baseline model results

Under symmetric information the employer knows the ability of workers at home (and abroad) and he also knows how to produce abroad, so that there is no need to pay a local agent abroad. Assuming that the reservation wage for workers at home is higher than workers abroad (this is plausible if the home country is richer and gives a higher unemployment subsidy than the poor

[10] Remember that quality level q_1 is dominated for all the strategies.

country) producing abroad is always better than producing at home (remark that we assume no fixed cost for offshoring the production abroad).

Let's assume now asymmetric information about immigrants workers, and assume $w_r^{h,n} > w_r^{h,m} > w_r^f$[11] with $w_r^{h,n} - w_r^{h,m} > \Delta$[12] ; the model in its simplest version gives to the firm an instrument to decide its optimal localization strategy given the level of quality it would produce. If a firm wants to produce q_0 it will be optimal for the firm to produce abroad, because there is no reason for paying the local agent and the reservation wage is lower than at home.

If a firm wants to produce an intermediate quality level (q_2), it has to compare profits for q_2 at home using either native or immigrant workers with profits obtained producing abroad. The strategy of using natives is dominated by immigrants, and then it will be optimal to produce q_2 abroad only if $\left(w_r^{h,m} - w_r^f\right) > (\phi - \Delta)/2$.

Finally, when a firm wants to produce the maximum quality level, the strategy of producing at home using natives is dominated again and it will be optimal to produce abroad q_3 if, and only if, $\left(w_r^{h,n} - w_r^f\right) > \phi/2$. Since the conditions under which it is optimal to produce abroad become more restrictive with the increasing quality level[13], we conclude that:

Proposition 1 *the higher the quality level required the larger the range of circumstances under which the firm decides to keep production at home*[14].

In this model the role of the local agent's cost is crucial because it represents the cost of information. So now we go deeper in the role of ϕ in choosing the firm's optimal strategy. Up to this point we found that: (i) there is no place for a native workforce (except for the comunication intensive task), (ii) the quality level q_1 is dominated for all the strategies by the highest quality

[11] Reservation wage for immigrants is lower than for natives because w^u for immigrants is lower than for natives. This is clear if we imagine the immigrant as a guest worker (the case of Turkish migration to Germany) who works, consumes and saves during his working age and consumes savings during the retired age enjoing the PPP in his origin country

[12] This means that home born workers have a reservation wage higher than the wage given to an immigrant worker who receive the incentive to produce a high effort.

[13] Notice that $\frac{\phi}{2} > \frac{\phi - \Delta}{2}$.

[14] If the firm had the possibility of knowing the type of immigrant workers (symmetric information) and if producing abroad had a fixed cost (ϑ), under the assumption that $w_r^h > w_r^f$ it would be optimal to produce abroad if and only if $\left(w_r^h - w_r^f\right) > \vartheta/2$ for each quality level. So we can conclude that asymmetric information introduces a new threshold for the intermediate quality level q_2 making it less likely to be produced at home.

level (q_3), (iii) it is always optimal to produce the minimum quality level abroad. So we can restrict the analysis to the quality levels q_2 and q_3 comparing offshoring and hiring immigrants. When the firm wants to produce q_2 the profit differential between the immigrant and offshoring strategy can be written as follows:

$$[21]\ \pi^{h,m}(q_2) - \pi^f(q_2) = 2\left(w_r^f - w_r^{h,m}\right) + \phi - \Delta$$

thus when $\left(w_r^{h,m} - w_r^f\right) < \frac{\phi}{2} - \frac{\Delta}{2}$ the firm finds optimal producing at home, conversely when $\left(w_r^{h,m} - w_r^f\right) > \frac{\phi}{2} - \frac{\Delta}{2}$ the firm finds optimal producing abroad. Similarly when the output level is q_3 the profits difference will be:

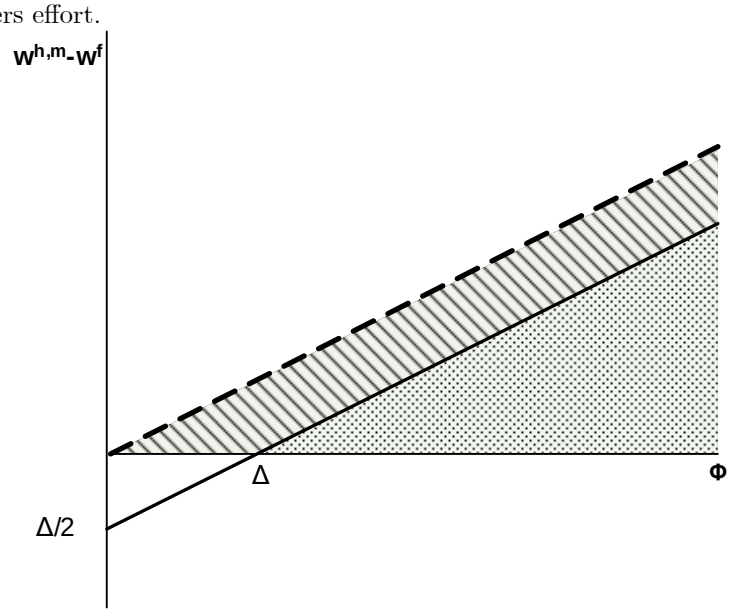
$$[22]\ \pi^{h,m}(q_3) - \pi^f(q_3) = 2\left(w_r^f - w_r^{h,m}\right) + \phi$$

thus the firm will find efficient to produce at home when $\left(w_r^{h,m} - w_r^f\right) < \frac{\phi}{2}$ and to produce abroad if $\left(w_r^{h,m} - w_r^f\right) > \frac{\phi}{2}$. Notice that the migrants' productivity levels do not matter because they clear out in the profit difference $\pi^{h,m}(q) - \pi^f(q)$. So, given a certain difference in reservation wage between home and foreign country, the profits difference depends upon the cost of the local agent. The resulting situation can be represented by the graph in figure 1, where the dashed line represents the case in which the firm is indifferent to produce q_3 at home or abroad, while the continuous line has the same meaning but in the case of q_2. The area under the line represents the circumstances for which it is optimal to produce at home using immigrants. It is easy to observe that an increase in the cost of the local agent makes producing at home more and more profitable. Comparing the areas under the two curves we can conclude that the higher the quality level, the greater the circumstances under which firm decides to keep production at home.

4.1 Lower productivity abroad

Up to now we assumed a worker exerting a certain effort level produces a quality level that is equal both at home and abroad. This may be a restrictive assumption if we imagine very different countries in our model. The organization of labour and the technological level may differ between countries, in particular between poor and rich ones. In order to take into account this issue, we

Figure 1: relation between the wage differential and the cost of the local agent to have information about the workers effort.



simply assume that the effort level abroad produces a lower quality level than at home, in other words we assume that $\tilde{e}_i^f = ke_i$ (where $0 < k < 1$). Since the disutility by effort is not affected, the IC and the IR constraints remain unchanged. The parameter k can be seen as the similarity between home and foreign country in terms of organization of labour and technological level.

This assumption does not change the profit functions for the home strategy, but it changes profit function in [17], [19] and [20] for the production abroad[15]:

[23] $\pi^f(q_0) = \alpha_H \tilde{e}_0 + \alpha_L \tilde{e}_0 - 2w_r^f = k(\alpha_H e_0 + \alpha_L e_0) - 2w_r^f$

[24] $\pi^f(q_2) = \alpha_H \tilde{e}_1 + \alpha_L \tilde{e}_0 - 2w_r^f - \Delta - \phi = k(\alpha_H e_1 + \alpha_L e_0) - 2w_r^f - \Delta - \phi$

[25] $\pi^f(q_3) = \alpha_H \tilde{e}_1 + \alpha_L \tilde{e}_1 - 2w_r^f - 2\Delta - \phi = k(\alpha_H e_1 + \alpha_L e_1) - 2w_r^f - 2\Delta - \phi$

Given these new profits functions, as in the former section, the strategy of using natives at home is still dominated, so we will consider the two other strategies in the rest of the paragraph. It would be optimal to produce quality q_0 at home using immigrants if $(w_r^{h,m} - w_r^f) < \frac{1}{2}[(1-k)(\alpha_H e_0 + \alpha_L e_0)]$;

[15] Remember that q_1 is dominated both at home and abroad.

so when k is close to one (i.e. effort in foreign country produces a quality level similar to that at home) it is optimal to offshore the production; while if the foreign country has an organization of labour and/or a technological level such that effort produces a lower quality level than at home (so k decreases), the strategy of staying at home using immigrants is allowed to be optimal for the firm[16]. If the firm wants to reach the quality level q_2 it would be optimal to produce at home using immigrants if $(w_r^h - w_r^f) < \frac{1}{2}\left[(1-k)(\alpha_H e_1 + \alpha_L e_0) - \Delta + \phi\right]$. Again the lower the k parameter the lower the probability that the firm finds optimal to offshore the production abroad.

Finally if the firm wants to reach the highest quality level q_3 it would be optimal to produce it at home if $(w_r^h - w_r^f) < \frac{1}{2}\left[(1-k)(\alpha_H e_1 + \alpha_L e_1) + \phi\right]$. Notice that with respect to the simple case in which effort produces the same quality level in both countries, here the conditions of optimality for every quality level for the home strategy are increased by a positive term $(\frac{1}{2}(1-k)(\alpha_H e_1 + \alpha_L e_0))$, that increases the circumstances under which it is optimal to produce at home using immigrants[17]. Intuitively, wide technological differences between home and foreign countries discourage the home employer to delocalize the production abroad.

5 Many workers with a continuum of types

The results so far rely on the assumption of only two workers, one for each type, in production. Now we relax this assumption allowing for many workers $(n = 0, .., N)$ in a continuum of skill levels. Each worker still provides a certain level of effor $(e_j = 1, 2)$. The distribution of workers in the continuum of types follows a Pareto distribution[18] with density function $f(\alpha) = \gamma \frac{\alpha_m^\gamma}{\alpha^{\gamma+1}}$, support

[16] This conclusion was not possible under the assumption that the two countries have the same technology and the same organization of labor.

[17] Moreover, even if the firm producing abroad would be free to save the local agent cost (ϕ) and behaving under asymmetric information, there is still place for the strategy of using immigrants at home. In particular the conditions under which it is optimal to produce abroad (without paying the local agent) are:

[a] $(w_r^{h,m} - w_r^f) < \frac{1}{2}[(1-k)(\alpha_H e_1 + \alpha_L e_0)]$ for quality level q_2

[b] $(w_r^{h,m} - w_r^f) < \frac{1}{2}[(1-k)(\alpha_H e_1 + \alpha_L e_1)]$ for quality level q_3

[18] The Pareto distribution is quite convenient to our purpose because it has a support positively defined (it would not be intuitive to have negative productivity types) and because it allows us to have a high share of low productive workers and a low share of high productive workers and it fits well the real world. Moreover by changing the γ parameter between home and abroad, and assuming $\gamma^{\text{hom}\,e} < \gamma^{abroad}$ we can replicate the actual situation in which a poor country (abroad) has an higher share of low productive workers than rich country (home).

$\alpha \in [\alpha_m; \infty]$[19], and where α_m is the lowest type of the distribution. The distribution of skills in the firm reflects the overall distribution of skill in the country.

The employer chooses the quality level he wants to reach (q^*) and consequently the scheme of incentives to give to workers (in other words he defines α_j as the last type of worker receiving the incentive); so the firm will provide incentive to workers type from α_m to α_j and the higher α_j the higher the quality of the output. The quality level of the output is now a continuous variable defined as follows:

$$[26]\ q(\alpha_j) = e_1 n \int_{\alpha_m}^{\alpha_j} \alpha f(\alpha) d\alpha + e_0 n \int_{\alpha_j}^{\infty} \alpha f(\alpha) d\alpha$$

Before going into defining the profits functions, we need to set up the new participation and incentive constraints. The (IC) constraints will assure us that each worker who receives the incentive will exert a high effort, while the (IR) constraint reflects the fact that agent of type α has the option of rejecting the contract and having w_u but he prefers to take the contract, and this has to be valid for each type $\alpha \in [\alpha_m; \infty]$:

$$[27]\ \ \text{(IR)}\ w(q(\alpha_j, e)) - e_j \geq w_u \quad \forall \alpha \in [\alpha_m; \infty]$$

$$[28]\ \ \text{(IC)}\ w(q(\alpha_j, e)) - e_j \geq w(q^-(\alpha_j, e)) - e_{k \neq j} \quad \forall \alpha \leq \alpha_j \in [\alpha_m; \infty]$$

The IR constraint has to be binding because otherwise the employer may reduce the wage and increase profits without losing the worker. The IC constraint assures that the incentive scheme is respected by workers, in other words, the utility by each worker if he respects the incentive scheme ($w(q(\alpha_j, e)) - e_j$) is greater than the utility in the case of shirking behaviour ($w(q^-(\alpha, e)) - e_{k \neq j}$). The problem here is that for a huge number of workers in production, the shirking behaviour of a single worker has no effect on the overall quality, so it can be the case that shirking behaviour cannot be detected and punished by the employer by giving $w(q^-(\alpha, e))$. Thus our model only works perfectly in cases of a small number of workers. Using the model in the case of large firms (great number of workers) requires the additional assumption that each worker that receives the

[19] Results don't change allowing for a truncated support (i.e $\alpha \in [\alpha_m; 1]$); it simply implies to divide the density function by the term $1 - \alpha_m^{\gamma}$

incentive will exert the high effort for sure[20]. In order to make the model more realistic we assume a training cost $T(\alpha_j)$[21] for immigrants (if used in production) increasing with the quality level and so essentially increasing in α_j (i.e. this is the cost for language skills); moreover we assume the cost of information ϕ increases with the quality level $(\phi(\alpha_j))$[22].

Under this set up the unit profit function when the firm stays producing at home using natives (perfect information) and immigrants (asymmetric information) are respectively:

$$[29]\ \pi_i^{h,n} = e_1 n \int_{\alpha_m}^{\alpha_j} \alpha f(\alpha) d\alpha + e_0 n \int_{\alpha_j}^{\infty} \alpha f(\alpha) d\alpha - w_r^{h,n} n \int_{\alpha_m}^{\infty} f(\alpha) d\alpha - \Delta n \int_{\alpha_m}^{\alpha_j} f(\alpha) d\alpha^{23}$$

$$[30]\ \pi_i^{h,m} = e_1 n \int_{\alpha_m}^{\alpha_j} \alpha f(\alpha) d\alpha + e_0 n \int_{\alpha_j}^{\infty} \alpha f(\alpha) d\alpha - (w_r^{h,m} + \Delta) n \int_{\alpha_m}^{\infty} f(\alpha) d\alpha - T(\alpha_j)$$

if the firm decides to offshore the production abroad, it will pay a local agent to reveal worker's type, so the firm will pay ad hoc wages and the unit profit function has the following form:

$$[31]\ \pi_i^{f} = e_1 n \int_{\alpha_m}^{\alpha_j} \alpha f(\alpha) d\alpha + e_0 n \int_{\alpha_j}^{\infty} \alpha f(\alpha) d\alpha - w_r^{f} n \int_{\alpha_m}^{\infty} f(\alpha) d\alpha - \Delta n \int_{\alpha_m}^{\alpha_j} f(\alpha) d\alpha - \phi(\alpha_j).$$

Notice that the profit function in the case of production with immigrants workers includes the cost of incentives, this is because we are considering the case in which the firm wants to realize a quality level higher that the minimum. If the firm would produce the minimum level of quality, it does not need to provide incentives, there is no reason for paying the local agent, and no reason for meet the cost of training. Thus we may conclude again that, if the firm wants to produce the lowest quality level, it would be optimal to produce abroad.

Since once α_j is fixed (quality is fixed) the revenue side of equations [29]-[31] does not make a difference between the alternative strategies, we can analyse the cost side (c_i) in order to conclude

[20] Alternatively we may think a large firm that splits the production in many stages, in which a small number of employees work.

[21] The training cost function $T(\alpha_j)$ is assumed to be monotonically increasing and concave in α_j (i.e. $\dot{T}(\alpha_j) > 0$ and $\ddot{T}(\alpha_j) < 0$), and $T(\alpha_m) = 0$

[22] The cost of information $\phi(\alpha_j)$ is assumed to be monotonically increasing and concave in α_j (i.e. $\dot{\phi}(\alpha_j) > 0$ and $\ddot{\phi}(\alpha_j) < 0$), and $\phi(\alpha_m) = 0$.

[23] Notice that $\int_{\alpha_m}^{\alpha_j} f(\alpha) d\alpha$ is simply the share of workers that receive the incentive.

about the optimal choice for the firm:

$$[32]\ c_i^{h,n} = w_r^{h,n} n \int_{\alpha_m}^{\infty} f(\alpha)d\alpha + \Delta n \int_{\alpha_m}^{\alpha_j} f(\alpha)d\alpha$$

$$[33]\ c_i^{h,m} = (w_r^{h,m} + \Delta) n \int_{\alpha_m}^{\infty} f(\alpha)d\alpha + T(\alpha_j)$$

$$[34]\ c_i^{f} = w_r^{f} n \int_{\alpha_m}^{\infty} f(\alpha)d\alpha + \Delta n \int_{\alpha_m}^{\alpha_j} f(\alpha)d\alpha + \phi(\alpha_j).$$

But the share of workers who receive incentives under a Pareto distribution has the following form:

$$[35]\ \int_{\alpha_m}^{\alpha_j} f(\alpha)d\alpha = 1 - \left(\frac{\alpha_m}{\alpha_j}\right)^{\gamma}$$

thus the cost functions in [32] - [34] can be written as:

$$[36]\ c_i^{h,n} = w_r^{h,n} n + \Delta n - \Delta n \left(\frac{\alpha_m}{\alpha_j}\right)^{\gamma_h}$$

$$[37]\ c_i^{h,m} = (w_r^{h,m} + \Delta) n + T(\alpha_j)$$

$$[38]\ c_i^{f} = w_r^{f} n + \Delta n - \Delta n \left(\frac{\alpha_m}{\alpha_j}\right)^{\gamma_f} + \phi(\alpha_j).$$

Figure 2 shows the cost functions in [36] - [38] that are monotonically increasing (and concave) in α_j (i.e in the quality level). As in paragraph 4 we assume that:

$$[39]\ w_r^{h,n} - w_r^{h,m} > \Delta.$$

It assures that $c^{h,n}(\alpha = \alpha_m) > c^{h,m}(\alpha = \alpha_m) > c^{f}(\alpha = \alpha_m)$ thus for low quality output level, it is optimal to produce abroad. We also assume that:

$$[40]\ \frac{\delta c_i^f}{\delta \alpha_j} > \frac{\delta c_i^{h,m}}{\delta \alpha_j} > \frac{\delta c_i^{h,n}}{\delta \alpha_j},$$

so that as α_j increases (i.e and the quality level increases), the difficulty (cost) of producing abroad rises faster than producing using both natives and immigrants; moreover the difficulty in producing using immigrants rises faster than producing using natives. The assumptions [39]-[40]

guarantee that $c^f(\alpha = \infty) > c^{h,m}(\alpha = \infty) > c^{h,n}(\alpha = \infty)$ thus for high quality output level, it is optimal to produce at home using native workers. Given assumptions [39]-[40] only two scenarios may emerge, the case in which the strategy of using immigrants at home is not dominated (figure 2(a)) or the case in which it is dominated (figure 2(b)); it depends both on the reservation wage $(w_r^{h,n}, w_r^{h,m}, w_r^f)$ and on the speed at which cost functions in [36]-[38] increase with α_j.

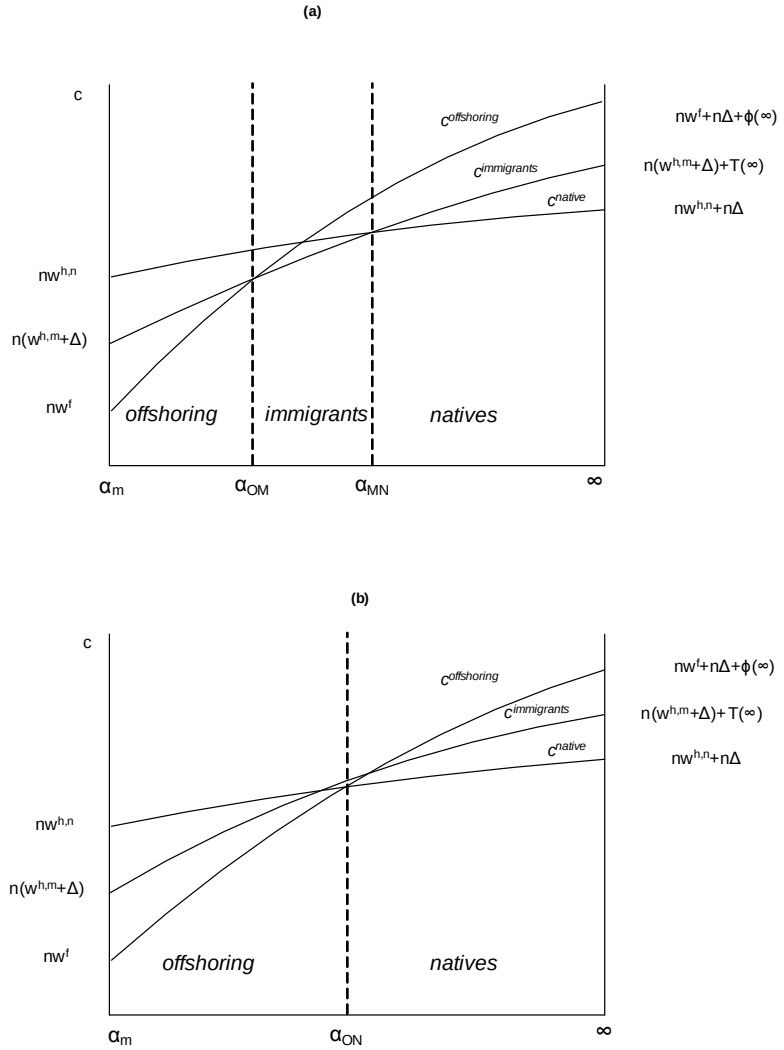
When the strategy of using immigrants is not dominated (figure 2(a)) it will be optimal to produce low quality goods (from quality α_m to α_{OM}) abroad, to produce intermediate quality goods (from quality α_{OM} to α_{MI}) at home using immigrants and high quality goods (from quality α_{MI} to ∞) at home using natives.

Scenario in figure 2(b) represents the case in which the strategy of using immigrants is dominated; it occurs (for example) when the reservation wage for immigrants at home and natives are very similar[24], so also intuitively there is no place for the strategy of using immigrants being optimal: when immigrants at home and natives have similar reservation wage, the employer has not convenience of paying the training cost for immigrants, and natives will be used also for intermediate quality levels of output. Empirical results in Ottaviano et al. (2010) suggest that there are some tasks covered by natives, others covered by immigrants and others offshored; so it seems that there is place for immigrants in domestic production. For this reason we focus on the case in which immigrants using strategy is not dominated. Finally we can conclude that the extension of the baseline model to a continuum of types doesn't change the main conclusion:

Proposition 2 *under asymmetric information about immigrants, the higher the quality level of the output that the firm wants to reach, the greater the range of circumstances under which it is optimal for the firm to continue producing at home. In particular, for intermediate quality level of output, the firm may prefer to produce at home by using immigrant workers in production.*

[24] The same thing happens if the reservation wage abroad is very low with respect the reservation wage of immigrants at home. Alternatively the strategy of using immigrants is dominated if the cost function of the strategy of using immigrants at home is very steep.

Figure 2: cost functions for each alternative in the skills range



5.1 Implications for the brain drain process

The span of quality levels (described by α_m - α_{OM} in figure 2) for which it is optimal to offshore the production, depends also on the γ_f parameter of the Pareto distribution of skills abroad: the higher γ_f is the lower the availability of skilled workers in the poor country is. Since the brain drain process implies a reduction in the availability of high skilled workers in the poor country, we can conclude that (everything else being constant) brain drain, by increasing γ_f, reduces the stretch of quality for which it is optimal to produce abroad (figure 3). From equation [38] we know that an increase in γ_f, due to the brain drain process, makes the cost function of producing abroad steeper in the early quality levels[25] (from dashed to continuous line of offshoring cost function in figure 3). This reduces the circumstances for which it is optimal to produce abroad (from α_m - α_{OM} to α_m - α'_{OM} in figure 3) and increases the cases for which.it would be optimal to produce at home by using foreign born workers.

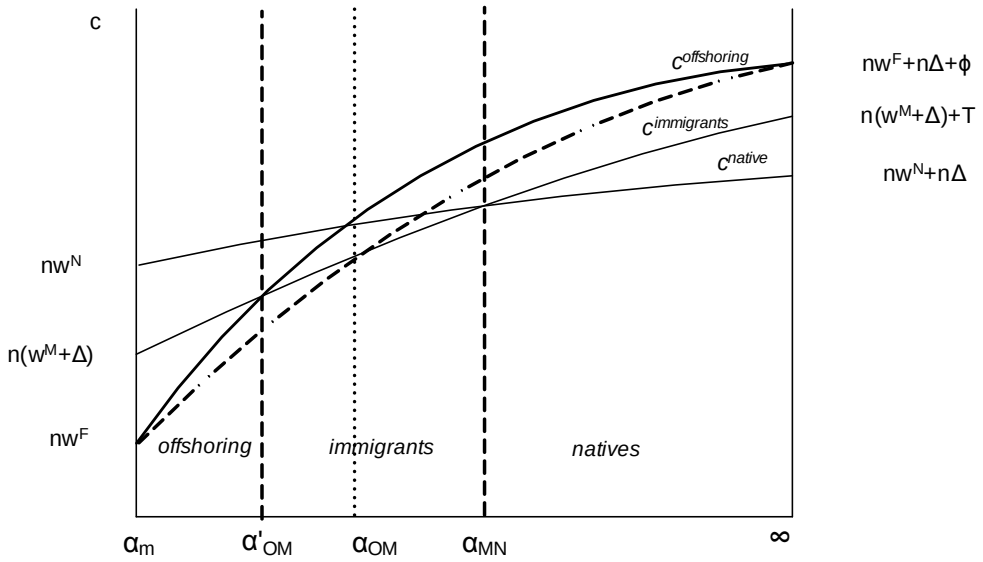
So the brain drain process, reducing the number of high skilled workers in poor countries, reduces also the span of quality levels that are worthwhile to produce abroad, stimulating domestic firms to produce at home using immigrants workers.

6 Conclusion

The increasing globalization and international factor movement are making more and more easy both to offshore the production in countries where labour cost is low, and to hire immigrants maintaining the plant in the home country. To our knowledge only two recent contributions tried to develop a model combining offshoring and migrants hiring (Ottaviano et al., 2010; Barba Navaretti et al., 2008). The model we present in this paper contributes to the literature considering the fact that employers don't have perfect information about the ability of immigrants when they are used in production. Coherently with Ottaviano et al. (2010) we find a kind of substitutability between the three alternatives that firms may take (offshoring, immigrants or natives in home production).

[25] When α_j approximate to infinity the cost of producing abroad does not depend of the γ_f parameter

Figure 3: change in the cost function of producing abroad after the brain drain process out of the poor country



From the baseline model, where only two skill levels are assumed in production, we conclude that the higher the quality level that the firm wants to reach, the larger the circumstances under which it is optimal for the firm to stay producing at home. Allowing for a continuum of worker types in production, we find that for low quality goods it would be optimal for a firm to offshore the production abroad. For high quality level it will be optimal to produce at home using native workers; but it may be the case that for intermediate quality levels, hiring foreign born workers at home is the best choice. Finally we find that brain drain process, by reducing the number of high skilled workers in the poor country, shrinks the span of quality levels for which it is optimal to produce abroad, increasing the cases for which it would be optimal to produce at home using immigrants workers.

7 Acknowledgements

I would like to thank G.Peri, F. Docquier and J. Thisse for helpful comments and suggestions. I'm particularly indebted to Paolo Garella for his precious help. All errors are mine.

References

[1] Antecol, H., Cobb-Clark, D.A., Trejo, S., 2003. Immigration Policy and the skills of Immigrants to Australia, Canada and the United States, Journal of Human Resources, 38, 192-218.

[2] Barba Navaretti, G., Bertola, G., Sembenelli, A., 2008. Offshoring and immigrant Employment: Firm Level theory and Evidence, CEPR discussion paper n.6743.

[3] Bhagwati, J., Srinivasan, T.N., 1983. On the choice between capital and labor mobility, Journal of International Economics, 14, 209-221.

[4] Borjas, G., 2003. The Labor Demand Curve Is Downward Sloping: Reexamining the Impact of Immigrationon on the labor market, Quarterly Journal of Economics, 118, 1335-1374.

[5] Borjas, G., Grogger, J.,Hanson G.H., 2008. Imperfect Substitution between Immigrants and Natives: a reappraisal, NBER working paper n.13887.

[6] Butcher, K.F., Di Nardo, J., 2002. The Immigrant and Native Born Wage Distributions: Evidence from United States Censuses, Industrial and Labor Relations Review, 56, 97-121.

[7] Chau, N.H, Stark, O., 1999. Migration under Asymmetric Information and Human Capital Formation, Review of International Economics, 7, 455-483.

[8] Chiswick, B.R, Le, A.T, Miller, P.W., 2008. How Immigrants Fare across the Earnings Distribution in Australia and the United States, Industrial and Labor Relations Review, 61, 353-373.

[9] El Yaman, S., Kugler, M., Rapoport, H., 2007. Migrations et investissements directs etrangers dans l'espace européen (UE-15), Revue economique, 58, 725-733.

[10] Javorcik, B.S., Özden, Ç., Spatareanu, M., Neagu, C., 2006. Migrant Network and Foreing Direct Investment, World Bank policy research working paper series 4046.

[11] Jones, R.W., 2005. Immigration vs. Outsourcing: Effects on labor markets, International Review of Economics and Finance, 14, 105-114.

[12] Katz, E., Stark, O., 1984. Migration and Asymmetric Information, The American Economic Review, 74, 533-534.

[13] Katz, E., Stark, O., 1987. International Migration under Asymmetric Information, The American Economic Review, 97, 718-726.

[14] Katz, E., Stark, O., 1989. International Labor Migration under Alternative Informational Regimes: A Diagrammatic Analysis, European Economic Review, 33, 127-142.

[15] Kremer, M., 1993. The O-ring Theory of Economic Development, The Quarterly Journal of Economics, 108, 551-575.

[16] Ottaviano, G.I., Peri, G., 2008. Immigration and National Wages: clarifying the Theory and the Empirics, NBER Working Paper 14188.

[17] Ottaviano, G.I., Peri, G., Wright, G., 2010. Immigration, Offshoring and American Job, NBER working paper 16439.

[18] Peri, G., Sparber, C., 2009. Task Specialization, Immigration and Wages, American Economic Journal: Applied Economics, 1, 135-169.

[19] Ramaswami, V.K., 1968. International factor movement and the national advantage", Economica, 35, 309-310.

[20] Stark, O., 1995. Return and Dynamics: The Path of Labor Migration when Workers Differ in their Skills and Information as Asymmetric, Scandinavian Journal of Economics, 97, 55-71.

8 A1: Why the incentive compatibility constraint avoids opportunistic behaviour

Before starting the production, the employer decides how many workers to incentivate according to the desired quality level, so he sets a contract (in the form of take it or leave it) to the workers. At the end of the period the employer pays workers according to the observed quality level, in particular he will pay $w(q_i)$ if the observed quality level is equal to the planned one (i.e no shirking behaviour), otherwise he will pay a punishing wage $w(q_i^-)$ if one of the two workers does not exert effort, or $w(q_i^{--})$ if both workers avoid the effort. This is credible because the employer observes the quality level at the end of the period and he can recognize how one or both workers behaved. This may be represented with the Prisoner's Dilemma game as follows:

	$high\ effort$	$low\ effort$
$high\ effort$	$w(q_i) - e_1; w(q_i) - e_1$	$w(q_i^-) - e_1; w(q_i^-) - e_0$
$low\ effort$	$w(q_i^-) - e_0; w(q_i^-) - e_1$	$w(q_i^{--}) - e_0; w(q_i^{--}) - e_0$

given the payoff scheme each worker will not engage an opportunistic behaviour if $w(q_i) - e_1 \geq w(q_i^-) - e_0 \geq w(q_i^{--}) - e_0$ which is our incentive compatibility constraint. From the payoff scheme it is easy to derive the incentive as $\Delta = e_1 - e_0$.