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Labour demand with heterogeneous workers: Migrations and unemployment☆

Carlo Carraro[a,*], Antoine Soubeyran[b]

[a]*Department of Economics, University of Venice, San Giobbe 873, Venice, Italy*
[b]*Université de Marseirlle/Aix-en-Provence and GREQAM*

Abstract

This paper provides a unified theory of the labour market in which the workforce is assumed to be heterogeneous. In the model, workers may be skilled or unskilled, natives or migrants, employed or unemployed. Each worker is characterised by a different productivity level and effort aversion. Moreover, the social costs of migrant integration and the costs of unemployment are also accounted for. The model derives the equilibrium wages and the demand for labour for all types of workers. It is then used to analyse the effects of different migration and unemployment policies. Should the government introduce quotas on the flows of skilled and/or unskilled migrant labour? How should the government subsidise the re-training of unemployed unskilled native workers? Are social goals consistent with private ones?

1. Introduction

Labour migrations increasingly influence the performance of modern industrialised economies and often require government intervention. In particular, recent events in Eastern-Europe have created the necessary pre-conditions for a realisation of migration potential by providing freedom of travel and the opening of borders. Similarly, on the southern side of the Mediterranean sea, economic, political, environmental, and demographic factors may lead to resurging migratory phenomena, thus raising difficult policy issues for the governments of EU countries. It is therefore important to understand

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* Corresponding author. Tel.: +41 2349 166; fax: +41 2349 176.
E-mail address: ccarraro@unive.it (C. Carraro).

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the role of labour migrations, and their costs and benefits, in order to clarify the interests of different social groups and to define appropriate policy interventions.[1]

It is often argued that labour migrations provide two benefits. On the one hand, firms hiring low wage migrants reduce their production costs and become more competitive in their output market. On the other hand, natives are protected against economic recessions if migrants can more easily be laid-off and act as a temporary employment buffer. Some costs are however associated with labour migrations. For example, when migrants replace natives, the economic and social costs of unemployment among natives increase. Moreover, integrating migrants into the host country may prove difficult, thus raising adaptation costs both at the level of the work environment and society in general.

The goal of this paper is to provide a theoretical framework to understand what determines a firm's demand for different types of labour. We assume that the labour force is heterogeneous: workers can be skilled or unskilled. The firm's constant returns to scale technology is such that the two categories skilled and unskilled workers are complements. Moreover, workers may be natives or migrants. In order to simplify the analysis, we assume that migrants and natives are perfect substitutes. Finally, we assume that a firm offers a labour contract to each type of worker, who can decide whether or not to accept the contract. Hence, a worker's labour supply is defined by its participation constraint.[2]

In order to capture the social dimension of migrations and unemployment, we assume that introducing migrants into the host country is costly. These social costs are paid partly by the state and partly by the firm. Government policy decides what share of these costs should be charged to firms. The remaining costs are charged to tax-payers, through the introduction of distortionary taxation.

The government could reduce immigration costs by introducing quotas on the flows of skilled and/or unskilled migrant labour. However, this might damage a firm's profits. Yet, it seems expedient to assess whether or not migration quotas maximise social welfare (if not profits).

Finally, unemployment is also costly, because governments have to pay unemployment benefits, and because unemployment has social and political costs and consequences. In order to reduce unemployment, the government can subsidise the retraining of unemployed unskilled native workers, thus increasing their productivity. Policy decisions aimed at stopping migrations can also help reduce unemployment in the host country.

The above economic and policy issues are assessed by analysing the equilibrium demand for all types of labour (native, migrant, skilled, unskilled). Hence, with respect to the existing literature on labour migrations, the focus of this paper is on the demand for

[1] Labour migrations have initially been studied in the context of dual economies. See Harris-Todaro (1970), Bhagwati and Srinivasan (1974), Zylberberg (1985). Other approaches to labour migrations have been proposed, for example, in Doeringer-Piore (1971), Bulow and Summers (1985). A quantitative assessment of the economic and demographic fundamentals that have driven and are driving world migration, across different historical epochs and around the world, can be found in Hatton and Williamson (2002).

[2] Similar assumptions characterise the model by Dolado et al. (1996). The main difference is that in their framework wages are determined by a model of bargaining. In addition, our model is richer in terms of disaggregation of the labour market and provides a more detailed representation of socio economic factors and policy measures.

migrants in the host country, rather than on the supply of migrants from origin countries.[3] Moreover, the effects of different migration and unemployment policies are also analysed in this paper. We try to provide an answer to the following questions: should the government introduce quotas on the flows of skilled and/or unskilled migrant labour? Should firms pay the social costs of immigration? How should the government subsidise the retraining of unemployed unskilled workers? Are social goals consistent with private ones?

The structure of the paper is as follows. The model is presented in Section 2. Section 3 discusses the equilibrium conditions and determines labour demand for all types of workers under different assumptions on market structure (oligopoly, monopoly). Section 4 analyses some preliminary policy implications of our results. Section 5 specifies the government's welfare function and analyses the effects of different policy measures: subsidising education and training for the unemployed; quotas on skilled and/or unskilled migrant flows; transfers to reduce the immigration costs incurred by firms. The final section summarises our results and discusses the scope for further work.

2. A model of the labour market with heterogeneous workers

This section outlines the basic model of the labour market. Two types of workers, skilled and unskilled, are necessary to produce one unit of output. These workers may be natives or migrants. Moreover, a worker can be either employed or unemployed. Therefore, the following definitions are necessary:

N_H employed skilled (High-skill) Natives
N_{UH} Unemployed skilled Natives
N_L employed unskilled (Low-skill) Natives
N_{UL} Unemployed unskilled Natives
M_H employed skilled (High-skill) Migrants
M_{UH} Unemployed skilled Migrants
M_L employed unskilled (Low-skill) Migrants
M_{UL} Unemployed unskilled Migrants

Let us assume that unemployed unskilled natives N_{UL} are offered retraining programs that provide them with a skill. If a share β of N_{UL} accepts these programs, we can add a further group of workers: $\beta N_{UL} = N_T =$ reTrained Natives. We will see that, at the equilibrium, all these types of workers, with the exception of unskilled natives, are (partly) employed.

Let us denote by N the total amount of natives, and by M the total amount of migrant workers who are resident in the country. Let N_E (N_U) and M_E (M_U) be the employed (unemployed) natives and migrants, respectively. The following identities hold:

[3] Examples of this literature are Bhagwati and Srinivasan (1974), Bulow and Summers (1985), Doeringer-Piore (1971), Harris-Todaro (1970) and Zylberberg (1985). A survey can be found in Stark (1991). An analysis of the migration problem using a demand-side approach is contained in Ethier (1985).

$N=N_E+N_U, \quad N_E=N_H+N_T+N_L, \quad N_U=N_{UH}+(1-\beta)N_{UL}$
$M=M_E+M_U, \quad M_E=M_H+M_L, \quad M_U=M_{UH}+M_{UL}$
Let us now analyse the behaviour of all agents who interact in the labour market.

2.1. Firms

Each firm produces a good y that is not consumed by workers employed in the industry.[4] Let p denote the price of this good. The demand function is $p(Q)$, where Q is the total output produced in the industry. We consider two cases:

(i) monopoly: $p(Q)=p(Y)$, where Y is the production of the domestic firm;
(ii) international oligopoly: $p(Q)=p(Y_1^e+\cdots+Y_{n-1}^e)$, where $Y^e=Y_1^e+\cdots+Y_{n-1}^e$ is total production by foreign firms;

The firm's technology is defined as follows. Native workers are characterised by the production function:

$y_i=f_i(n_i), \quad i=H,T,L$ whereas a migrant's production function is: $z_i=g_i(m_i), \quad i=H,L$ where $n_i(m_i)$ are hours per year worked by type i natives (migrants); $f_i(.)$ $(g_i(.))$ is a function representing the productivity of each type of native (migrants). We assume $f_i(.)$ and $g_i(.)$ to be twice differentiable. In the production process, skilled and unskilled workers are complements, whereas natives and migrants are substitutes. The production function is therefore the following:

$$Y=\min(\alpha_H Y_H, \alpha_L Y_L) \tag{1}$$

where $Y_H=y_H N_H+y_T N_T+z_H M_H=f_H(n_H)N_H+f_T(n_T)N_T+g_H(m_H)M_H \quad Y_L=y_L N_L+z_L M_L=f_L(n_L)N_L+g_L(m_L)M_L$

Let $w_i(v_i)$ be the total wage (labour income) paid to type i natives (migrants) for $n_i(m_i)$ hours of work. The domestic firm's profit function is:

$$\pi=p(Q)Y-w_H N_H-w_T N_T-w_L N_L-v_H M_H-v_L M_L-\alpha_I C_I(M)-\alpha_T C_T(N_T) \tag{2}$$

where:

- $C_I(M)$ denotes the social cost of immigration, which is a function of the total number of migrants $(M=M_H+M_{UH}+M_L+M_{UL})$;
- $C_T(N_T)$ is the total costs of retraining N_T unskilled natives;
- α_I is the share of the social cost of immigration paid by firms, whereas α_T is the retraining cost apportioned to firms when a share $(1-\alpha_T)$ is subsidised by the government.

The profit function is maximised in two stages. In the first, the firm sets the optimal employment level and hours of work; in the second, the firm offers a specific wage contract

[4] This is just a useful approximation to the fact that workers' consumption of the good they produce is a small share of their total consumption.

to each worker who is free to accept or refuse. Moreover, the firm offers retraining programs and related specific contracts to unskilled natives.

2.2. Workers

Workers are differentiated with respect to their productivity and effort aversion. A representative worker of type i has this utility function[5]:

$$\text{Natives}: \ uN_i(cN_i, n_i) = cN_i - eN_i(n_i) \ \ i = \text{H, T, L} \tag{3a}$$

$$\text{Migrants}: \ uM_i(cM_i, m_i) = cM_i - eM_i(m_i) \ \ i = \text{H, L} \tag{3b}$$

where cN_i, cM_i is the consumption of a numeraire good whose price p_c is normalised to one; $eN_i(n_i)$ ($eM_i(m_i)$) denotes natives' (migrants') disutility from working n_i (m_i) hours and is a measure of effort aversion. We assume $eN_i(.)$ and $eM_i(.)$ to be twice differentiable, monotonically increasing, and strictly convex. This assumption implies a positive and increasing marginal effort aversion.

Utility maximisation is subject to the budget constraint $p_c cN_i = w_i$ or $p_c cM_i = v_i$. Replacing these constraints into the utility functions, we obtain:

$$\text{Natives}: \ uN_i(w_i, n_i) = w_i - eN_i(n_i) \ \ i = \text{H, T, L} \tag{4a}$$

$$\text{Migrants}: \ uM_i(v_i, m_i) = v_i - eM_i(m_i) \ \ i = \text{H, L} \tag{4b}$$

Natives (migrants) accept the contract (w_i,n_i) $((v_i,m_i))$ only if their utility defined by (4) is greater than their reservation utility (normalised to zero). The participation constraint is therefore:

$$\text{Natives}: \ w_i \geq eN_i(n_i) \ \ i = \text{H, T, L} \tag{5a}$$

$$\text{Migrants}: \ v_i \geq eM_i(m_i) \ \ i = \text{H, L} \tag{5b}$$

Labour supply is modelled as a participation decision. Given n_i, if the actual total wage w_i is larger than the reservation wage $eN_i(n_i)$, then all type i natives decide to participate. A similar condition defines migrants' participation decision. Without loss of generality, unemployment benefits are set to zero.

Let us now define workers' relative productivity and effort aversion. First consider unskilled workers. We assume that:

Assumption 1. : Unskilled natives are more effort averse than unskilled migrants, who are ready to accept jobs that natives consider too effort demanding. Moreover, low skill jobs are such that all workers have the same productivity.

This assumption has the following implication: let $n_i = f_i^{-1}(y_i)$, i=H,T,L, and $m_i = g_i^{-1}(z_i)$, i=H,L; define $\mathrm{d}N_i(y_i) = eN_i[f_i^{-1}(y_i)]$, i=H,T,L, and $\mathrm{d}M_i(z_i) = eM_i[g^{-1}(z_i)]$,

[5] A model of the labour market in which workers have heterogeneous preferences was also proposed in Killingsworth (1987).

$i = $H,L. The functions $dN_i(y_i)$ and $dM_i(z_i)$ denote the disutility to produce the output level y_i, for natives and migrants respectively. Then, Assumption 1 can be written as:

$$eN_L(h) > eM_L(h) \text{ for all } h > 0 \tag{6a}$$

$$f_L(h) = g_L(h) \text{ for all } h > 0 \tag{6b}$$

which implies:

$$dN_L(k) > dM_L(k) \text{ for all } k > 0 \tag{7}$$

Now consider skilled workers. We assume that:

Assumption 2. : Skilled natives are more effort averse than skilled migrants. However, their productivity may be greater:

$$eN_T(h) = eN_H(h) > eM_H(h) \text{ for all } h > 0 \tag{8a}$$

$$f_H(h) \geq f_T(h) > g_H(h) \text{ for all } h > 0 \tag{8b}$$

Taking into account both characteristics, we assume that:

$$dN_T(k) < dM_H(k) < dN_H(k) \text{ for all } k > 0 \tag{9}$$

In other words, we assume that even if more effort averse than skilled migrants, retrained natives become more efficient after having taken the retraining program proposed by the firm. The final outcome is that their function $dN_T(k)$, which accounts for both the effort aversion and the productivity effect, is lower than $dM_H(k)$, which defines a skilled migrant's disutility to produce. Vice versa, we assume that the effort aversion effect dominates the productivity effect when skilled migrants and skilled natives are compared. Hence, $dM_H(k) < dN_H(k)$. The relationship between productivity, effort aversion, and the disutility to produce of the three types of skilled workers is shown in Fig. 1.

A final assumption concerns the function describing the productivity of unskilled and skilled workers. We assume that:

Assumption 3. $f_L(.)$ and $g_L(.)$, the production functions of unskilled workers, are monotonically increasing and concave, i.e. unskilled workers' marginal productivity is decreasing. By contrast, skilled workers' positive marginal productivity first increases and then decreases.

Formally:

$$f_i''(h) > 0 \text{ for } h \in [0, h_i^{\#}) \tag{10a}$$

$$f_i''(h) \leq 0 \text{ for } h \geq h_i^{\#} \quad i = \text{H, T} \tag{10b}$$

$$g_H''(h) > 0 \text{ for } h \in [0, h_H^*) \tag{10c}$$

$$g_H''(h) \leq 0 \text{ for } h \geq h_H^* \tag{10d}$$

where the symbol $''$ denotes the second derivative of the functions $f_i(.)$ and $g_i(.)$. Having assumed that the marginal productivity of skilled workers is first increasing and then

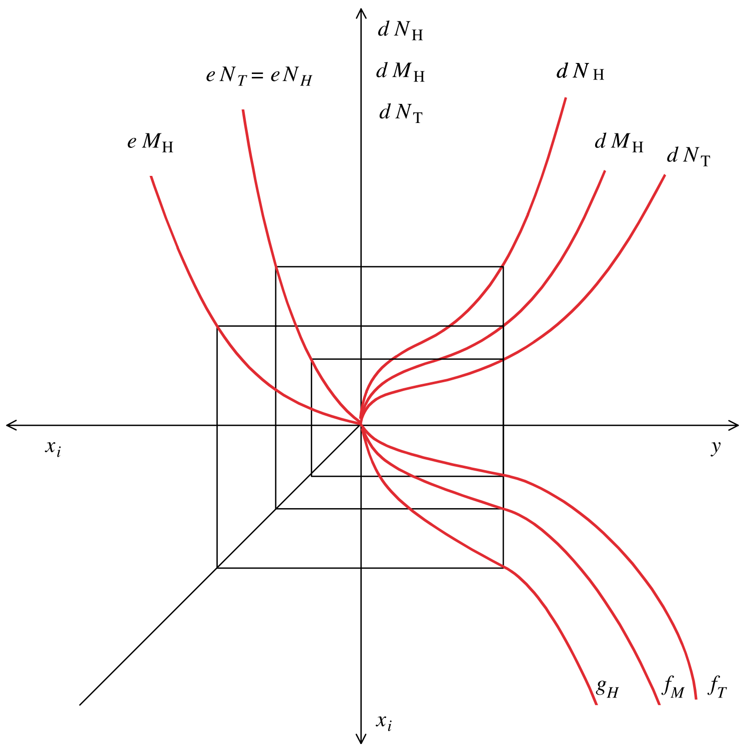

Fig. 1. The relationship between productivity, effort eversion and disutility to produce for the three types of skilled workers.

decreasing, there exist production levels $k_i^{\#}$, i = H,T, and $k_{\mathrm{H}}^{\#}$ such that a skilled worker's marginal disutility to work is decreasing up to $k_i^{\#}$ and increasing after this production level. The functions $\mathrm{d}N_i(.)$, $i=\mathrm{H,T}$, and $\mathrm{d}M_{\mathrm{H}}(.)$ are shown in Fig. 1.

Notice that the shape of the functions $\mathrm{d}N_i(.)$, $i=\mathrm{H,T}$, and $\mathrm{d}M_{\mathrm{H}}(.)$ implies that there exist output levels $\hat{y}_i$, $i=\mathrm{H,T}$, and $\hat{z}_{\mathrm{H}}$ such that $\mathrm{d}N_i'(\hat{y}_i)=\mathrm{d}N_i(\hat{y}_i)/\hat{y}_i \equiv aN_i(\hat{y}_i)$, $i=\mathrm{H,T}$, and $\mathrm{d}M_{\mathrm{H}}'(\hat{z}_{\mathrm{H}})=\mathrm{d}M_{\mathrm{H}}(\hat{z}_{\mathrm{H}})/\hat{z}_{\mathrm{H}} \equiv aM_{\mathrm{H}}(\hat{z}_{\mathrm{H}})$, i.e. such that the marginal disutility to produce is equal to the average disutility to produce. Notice that $\hat{y}_{\mathrm{i}}$, $i=\mathrm{H,T}$, and $\hat{z}_{\mathrm{H}}$ define skilled workers' efficient production levels, because, as shown below, at $\hat{y}_{\mathrm{i}}$, i = H,T, and $\hat{z}_{\mathrm{H}}$ the firm registers the minimum average cost per worker.

Finally, let us assume that $f_i(0)=0$, $i=\mathrm{H,T,L}$, $g_i(0)=0$, $i=\mathrm{H,L}$, $eN_i(0)=0$, $i=\mathrm{H,T,L}$, $eM_i(0)=0$, $i=\mathrm{H,L}$ which imply $\mathrm{d}N_i(0)=0$, $i=\mathrm{H,T,L}$ and $\mathrm{d}M_i(0)=0$, $i=\mathrm{H,L}$.

2.3. Government

The government in the host country can set three policy variables: the quota on skilled and/or unskilled migrants, the share of immigration costs which is charged to firms, and the subsidy to the retraining programs offered by firms to unemployed unskilled natives. These policy decisions are taken by maximising the following social welfare function:

$$W = \pi + S - C_S - C_U \tag{11}$$

where π are the domestic firm's profits, S is the consumers' surplus, and C_S is the sum of the cost of subsidising the retraining programs and of the social costs of immigration which are not charged to the firms. Let σ be the parameter capturing the cost of financing retraining and immigration costs through distortionary taxation. Then:

$$C_S = (1+\sigma)(1-\alpha_I)C_I(M) + (1+\sigma)(1-\alpha_T)C_T(N_T) \tag{12}$$

Finally, C_U are the social and political costs of unemployment. We assume that these costs only relate to the unemployment of native workers:

$$C_U = \tau(N_U) \quad N_U = N_{UH} + N_{UL} - N_T \tag{13}$$

Hence, we can write:

$$\begin{aligned} W = {} & p(Q)Y - w_L N_L - w_H N_H - w_T N_T - v_H M_H - v_L M_L + S(Y) \\ & - [1+\sigma(1-\alpha_I)]C_I(M) - [1+\sigma(1-\alpha_T)]C_T(N_T) - \tau(N_U) \end{aligned} \tag{14}$$

where the consumer's surplus $S(Y)$ is an increasing function of Y.

2.4. Rules of the game

In the first stage of the game, the government sets its policy variables: the tax $\alpha_I \geq 0$ (where α_I is the amount of immigration costs which is charged to firms), the subsidy $(1-\alpha_T)$ with $1 \geq \alpha_T \geq 0$ (where α_T is the share of retraining costs which is subsidised), and possible quotas on skilled and/or unskilled migrants, i.e. $M_H + M_{UH}$ and/or $M_L + M_{UL}$. In the second stage of the game, the firm determines its optimal production level. In the oligopoly case, we assume that the strategic variable is output (Cournot oligopoly). Moreover, the firm determines employment, the number of workers to be retrained, and the contracts to be offered to all types of workers. In the last stage of the game, workers decide whether or not to accept the contract offered by the firm, i.e. whether or not to participate in the labour market. As usual, the game is solved backwards in order to determine its subgame perfect equilibrium.

3. Wages, employment, and hours

First of all, let us exploit the complementarity of skilled and unskilled workers. From Eq. (1), we have:

$$Y = \alpha_H Y_H = \alpha_L Y_L \tag{15}$$

Hence we can separate the problem of determining the equilibrium employment of unskilled workers from the one which determines the equilibrium employment of skilled workers.

Consider unskilled workers. By maximising the firm's profit function[6]:

$$\pi = p(Q)Y - w_H N_H - w_T N_T - w_L N_L - v_H M_H - v_L M_L - \alpha_I C_I(M) - \alpha_T C_T(N_T)$$

with respect to N_L, n_L, M_L, m_L, subject to the constraint $y_L N_L + z_L M_L = Y/\alpha_L$, where $Y = \alpha_H y_H$ is given, we obtain the following first order conditions:

$$\partial L/\partial N_L = 0 \Rightarrow \lambda y_L = w_L \Rightarrow [f - aN_L(y_L)]y_L = 0 \tag{16a}$$

$$\partial L/\partial M_L = 0 \Rightarrow \lambda z_L = v_L + a_I C_I'(M) \Rightarrow [f - aM_L(z_L)]z_L - \alpha_I C_I'(M) = 0 \tag{16b}$$

$$\partial L/\partial n_L = 0 \Rightarrow [\lambda - dN_L'(y_L)]f_L'(n_L)N_L = 0 \tag{16c}$$

$$\partial L/\partial m_L = 0 \Rightarrow [\lambda - dM_L'(z_L)]g_L'(m_L)M_L = 0 \tag{16d}$$

$$\partial L/\partial \lambda = 0 \Rightarrow y_L N_L + z_L M_L = Y/\alpha_L \tag{16e}$$

where L denotes the Lagrangean and λ is the Lagrange multiplier. The participation constraints are binding (the firm has no incentive to pay a wage larger than the workers' disutility to produce). Hence:

$$w_L = dN_L(y_L) > v_L = dM_L(z_L) \tag{17}$$

This condition and the convexity of the functions $dN_L(.)$, $dM_L(.)$ imply that Eq. (16) cannot be satisfied as equalities, i.e. there is no interior solution. Hence the firm employs the most efficient of the two types of workers, i.e. unskilled migrants. This is proved by the following proposition:

Proposition 1. : *Let* Assumptions 1 *Eqs*. (6) and (3) *hold*. *Given condition* (17) *and the convexity of the functions* $dN_L(.)$, $dM_L(.)$, *at the equilibrium, the firm employs no unskilled natives* ($N^*_L = 0$). *The employment of unskilled migrants is*:

$$M_L^* = Y/(\alpha_L z_L^*) \tag{18a}$$

where z^*_L *is implicitly defined by the equation*

$$aN_L(0) = dM_L'(z_L^*). \tag{18b}$$

Hence, the salary of unskilled migrants is $v^*_L = dM_L(z^*_L)$. *As a consequence the employment of skilled migrants is*:

$$M_H^* = (C_I')^{-1}[z_L^* \Phi_L(z_L^*)/\alpha_I] - M_L^* \tag{18c}$$

where

$$\Phi_L(z_L^*) \equiv dM_L'(z_L^*) - aM_L(z_L^*)$$

Proof: see the Appendix.

[6] Re-call that $p(Q)$ was defined above as a function of industry structure.

Let us now determine the demand for skilled labour. Replacing the equilibrium values thus obtained in the profit function, we have:

$$\pi = p(Q)Y - dM_L(z_L^*)[Y/(\alpha_L z_L^*)] - w_H N_H - w_T N_T - v_H M_H - \alpha_I C_I(M) - \alpha_T C_T(N_T) \tag{19}$$

where $M = Y/(\alpha_L z_L^*) + M_H^* + M_{UL} + M_{UH}$. By maximising π with respect to N_H, N_T, n_H, n_T, m_H, we obtain:

$$\partial\pi/\partial n_i = 0 \Rightarrow [\mu - dN_i'(y_i)]f_i'(n_i)N_i = 0 \; i = \mathrm{H, T} \tag{20a}$$

$$\partial\pi/\partial m_H = 0 \Rightarrow [\mu - dM_H'(z_H)]g_H'(m_H)M_H = 0 \tag{20b}$$

$$\partial\pi/\partial N_H = 0 \Rightarrow [\mu - aN_H(y_H)]y_H = 0 \tag{20c}$$

$$\partial\pi/\partial N_T = 0 \Rightarrow [\mu - aN_T(y_T)]y_T - \alpha_T C_T'(N_T) = 0 \tag{20d}$$

where μ is the firm's marginal revenue, and $Y = \alpha_H Y_H = a_H(y_H N_H + y_T N_T + z_H M_H^*)$. Again, the participation constraints are binding (the firm has no incentive to pay a wage larger than the workers' disutility to produce). Hence:

$$w_H = dN_H(y_H) > v_H = dM_H(z_H) > w_T = dN_T(y_T) \tag{21}$$

However, the functions $dN_i(.)$, $i = $ H,T and $dM_H(.)$ are no longer convex, i.e. there exists an interior solution to the firm's maximisation problem. This is proved by the following proposition:

Proposition 2. : *Let* Assumptions 1–3 *hold. Then the equilibrium employment for retrained skilled natives is*:

$$N_T^* = (C_T')^{-1}[y_T^* \Phi_T(y_T^*)/\alpha_T] \tag{22a}$$

whereas it is:

$$N_H^* = Y/\alpha_H \hat{y}_H - (y_T^* N_T^* + z_H^* M_H^*)/\hat{y}_H. \tag{22b}$$

for the non-retrained skilled natives workers, where:

$$y_H^* = \hat{y}_H \tag{22c}$$

and $y_T^*(\hat{y}_H)$ *and* $z_T^*(\hat{y}_H)$ *are defined by*:

$$dN_T'(y_T^*) = dN_H'(\hat{y}_H) \tag{22d}$$

$$dM_H'(z_H^*) = dN_H'(\hat{y}_H) \tag{22e}$$

The equilibrium wages are:

$$w_H^* = dN_H(\hat{y}_H), \quad w_T^* = dN_T(y_T^*), \quad v_H^* = dM_H(z_H^*) \tag{22f}$$

Proof: see the Appendix.

Fig. 2 provides a geometric interpretation of some results contained in Proposition 2. First, notice that the three curves represented in Fig. 2 reproduce the inequalities (21). Second, notice that for native skilled workers the equilibrium condition is such that the marginal wage is equal to the average wage (the wage per unit of production).

Hence, the equilibrium production for skilled natives is defined by point A in Fig. 2 where the tangent $dN'_H(y_H)$ to the curve $dN_H(y_H)$ coincides with the average $dN_H(y_H)/y_H$. The equilibrium production for skilled migrants and retrained skilled natives is also determined by $dN'_H(\hat{y}_H)$. Hence the three straight lines must be parallel, and equilibrium is defined by the tangency of $dN'_H(\hat{y}_H)$ to the cost functions of skilled migrants and retrained natives (point B and C in Fig. 2). At the equilibrium, the marginal wage for these two types of workers is larger that the average wage, i.e. they are asked to work above the efficient production level (because they are relatively more efficient). The equilibrium number of hours for the three types of skilled workers can directly be determined from the equilibrium production by inverting the functions $f_i(.)$, $i=$H,T and $g_i(.)$, $i=$H.

The last variable to be determined is total equilibrium production Y. This depends on market demand and industry structure. Replacing the equilibrium values provided by Proposition 2 into the profit function (19) and differentiating with respect to Y yields:

$$\partial\pi/\partial Y = 0 \Rightarrow \mu = [dN_H(\hat{y}_H)/\alpha_H\hat{y}_H][1 + (\alpha_H z_H^*/(\alpha_L z_L^*)] + [dM_L(z_L^*) - dM_H(z_H^*)]/(\alpha_L z_L^*) \quad (23)$$

where μ is the positive marginal revenue. Assuming, for simplicity's sake, a linear demand function, in the monopoly case we have $\mu = A - 2bY$, whereas in the oligopoly case $m = A - 2bY - bY^e$. In the symmetric case, this becomes $m = A - b(n+1)Y$ where n is the number of firms.

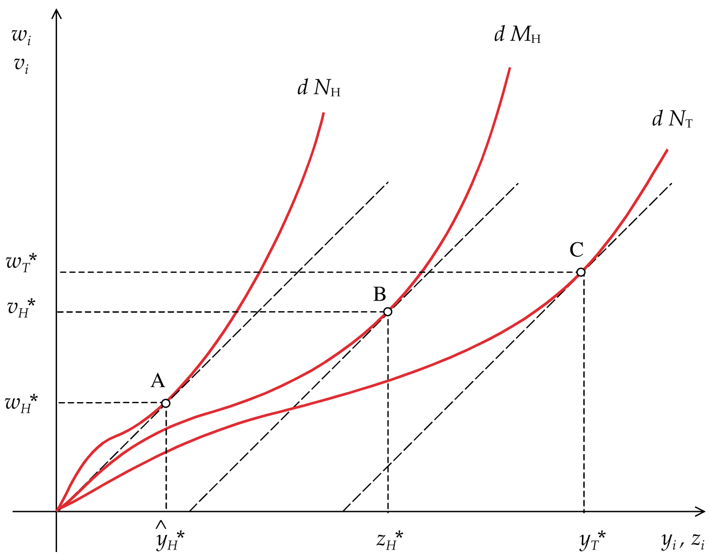

Fig. 2. Equilibrium production levels and wages for the three types of skilled workers.

Hence, we can write:

(i) Monopoly:

$$Y^* = [A - c(\hat{y}_H, z_H^*, z_L^*)]/2b \tag{24a}$$

where

$$c(\hat{y}_H, z_H^*, z_L^*) \equiv [w_H(\hat{y}_H)/\alpha_H\hat{y}_H][1 + (\alpha_H z_H^*/(\alpha_L z_L^*)] + [v_L(z_L^*) - v_H(z_H^*)]/(\alpha_L z_L^*)$$

(ii) Oligopoly:

$$Y^* = [A - c(\hat{y}_H, z_H^*, z_L^*) - bY^e]/2b \tag{24b}$$

which becomes:

$$Y^* = [A - c(\hat{y}_H, z_H^*, z_L^*)]/b(n+1) \tag{24c}$$

in the symmetric case. These examples make explicit the determination of the domestic firm's total production which is anyway implicitly determined by (23) once μ is defined as a function of Y (i.e. once industry structure and the functional form for market demand have been defined).

4. Some policy implications

There are some interesting conclusions that can be derived from Propositions 1 and 2:

– The employment of retrained natives is only related to the retraining marginal cost functions and to the government's subsidy to the firm's retraining programs $(1-\alpha_T)$. However, increasing this subsidy would not increase natives' employment. It would only reduce the number of skilled natives to increase the number of skilled retrained natives. On the other hand, since retrained workers' employment is independent of market demand, any positive shift of the latter may increase the demand for skilled natives.

– The total number of migrants demanded by firms only depends on the marginal immigration cost function and on the share of this cost charged to the firms. Hence, if market demand increases, the necessary increase in the demand for unskilled migrants would be matched by a reduction of the demand for skilled migrants. As a consequence, demand for skilled natives would increase. This implies that demand for skilled natives and unskilled migrants is pro-cyclical, whereas demand for skilled migrants is counter-cyclical.

– If the government increases the share of immigration costs charged to the firm (the tax parameter α_I), the firm would demand less migrants. Notice that this policy would not reduce equilibrium production, because immigration costs (as well as retraining costs) are perceived as fixed costs (i.e. costs which do not depend on Y). As a consequence, the demand for unskilled migrants would not change. Only the demand for skilled migrants would be reduced, thus increasing employment for skilled natives.

– As production does not depend on M (the total number of migrants), and as Y determines the equilibrium demand for unskilled migrants, a quota on the total number of migrants would only reduce the number of skilled migrants. Therefore, the demand for skilled natives would increase. This suggests that a restrictive policy on immigration which controls the number of migrants is likely to focus on the control of flows of skilled migrants.

– As unskilled natives are not demanded by the firm, the only way to increase their employment is to retrain this category of workers, even if this would reduce the firm's demand for skilled natives. Therefore, a policy which enhances education programs and school quality would increase domestic employment by reducing the number of unkilled natives.

– An increase in the productivity of skilled natives would modify the cost structure of all skilled workers, reducing their total wages. Hence, production would increase, thus increasing the demand for unskilled migrants and for skilled natives. The demand for skilled migrants would be reduced.

– An increase of the productivity of skilled migrants would increase their own equilibrium wage, without affecting the wage of the other skilled workers. Production would also increase, thus increasing the demand for unskilled migrants. Hence, the final effect on the employment of skilled migrants and of skilled natives is ambiguous.

These conclusions are based on the analysis of the firm's equilibrium demand for the different types of workers. These demands for native and migrant labour result from profit maximisation. Hence, it would be interesting to analyse whether similar conclusions hold when social welfare, instead of profit, is maximised. This is the goal of the next section.

5. Effects of government's policy on social welfare

Let us re-write the social welfare function (14) as follows:

$$\begin{aligned} W &= R(Y) - w_L N_L - w_H N_H - w_T N_T - v_H M_H - v_L M_L + S(Y) \\ &\quad - [1+\sigma(1-\alpha_I)]C_I(M) - [1+\sigma(1-\alpha_T)]C_T(N_T) - \tau(N_U) \\ &= R(\hat{y}_H, z_H^*, z_L^*) - w_H^*(\hat{y}_H)N_H^*(Y^*, \alpha_T, \alpha_I, M_H^*(\alpha_I, Y^*)) - w_T^*(\hat{y}_H)N_T^*((\alpha_T) \\ &\quad - v_H^*(z_H^*)M_H^*(\alpha_I, Y^*) - v_L^*(z_L^*)M_L^*(Y^*) + S(Y) \\ &\quad - [1+\sigma(1-\alpha_I)]C_I[M_H^*(\alpha_I, Y^*) + M_L^*(Y^*) + M_{UH} + M_{UL}) \\ &\quad - [1+\sigma(1-\alpha_T)]C_T[N_T^*(\alpha_T)] - \tau[N - N_H^*(Y^*, \alpha_T, \alpha_I, M_H^*(\alpha_I, Y^*) - N_T^*(\alpha_T)] \end{aligned} \tag{25}$$

where $R(.)$ is the total revenue function, using the equilibrium demand and wage functions determined in the previous section.

By differentiating with respect to α_I and α_T we have:

$$\begin{aligned} \partial W/\partial\alpha_I &= -w_H^* \partial N_H^*/\partial\alpha_I - v_H^* \partial M_H^*/\partial\alpha_I - [1+\sigma(1-\alpha_I)](C_I')\partial M_H^*/\partial\alpha_I \\ &\quad + \sigma C_I(M) + (\tau')\partial N_H^*/\partial\alpha_I \end{aligned} \tag{26}$$

$$\partial W/\partial\alpha_{\mathrm{T}} = -w^*_{\mathrm{H}}\partial N^*_{\mathrm{H}}/\partial\alpha_{\mathrm{T}} - w^*_{\mathrm{T}}\partial N^*_{\mathrm{T}}/\partial\alpha_{\mathrm{T}} - [1+\sigma(1-\alpha_{\mathrm{T}})](C'_{\mathrm{T}})\partial N^*_{\mathrm{T}}/\partial\alpha_{\mathrm{T}} + \sigma C_{\mathrm{T}}(N^*_{\mathrm{T}}) + (\tau')[\partial N^*_{\mathrm{H}}/\partial\alpha_{\mathrm{T}} + \partial N^*_{\mathrm{T}}/\partial\alpha_{\mathrm{T}}] \quad (27)$$

where $C'_{\mathrm{I}} \equiv \partial C_{\mathrm{I}}(M)/\partial M > 0$, $C'_{\mathrm{T}} \equiv \partial C_{\mathrm{T}}(N_{\mathrm{T}})/\partial N_{\mathrm{T}} > 0$, $\tau' \equiv (\tau(N_{\mathrm{U}})/(N_{\mathrm{U}} > 0$ are the marginal immigration, retraining and unemployment cost, respectively.

An increase of α_{I} (a tax increase) would not be efficient from the firm's viewpoint because it would induce the firm to replace skilled migrants with skilled natives. This would raise the firm's costs because the wage per unit of production of skilled natives is higher (the slope OA is larger than OB in Fig. 2) and because their productivity is lower ($\hat{y}_{\mathrm{H}} = y^*_{\mathrm{H}} < z^*_{\mathrm{H}}$). As the total revenue would not change, the firm's profits would be reduced by an increase of α_{I}. However, it might be optimal to increase α_{I} from a social viewpoint. Welfare would increase because the cost of distortionary taxation would be lower and because less skilled migrants implies lower integration costs (the third and fourth term of (26)). The last term is the unemployment effect. As the political costs of unemployment only stem from natives' unemployment, an increase in α_{I} would reduce these costs by increasing employment among skilled natives. If the two social gains and the unemployment effect overcome the private losses (lower profits), then α_{I} ought to be raised.

An increase of α_{T} (a reduction of the subsidy) would also be inefficient from the firm's viewpoint. It would induce the firm to replace retrained natives with non-retrained skilled natives. The latter are paid a larger wage per unit of production (the slope OA is larger than OC in Fig. 2) and are less productive ($y^*_{\mathrm{H}} < y^*_{\mathrm{T}}$). Hence, the firm's costs would increase and profits would decrease. On the other hand, there are two socially beneficial effects obtained from increasing α_{T}. The cost of distortionary taxation necessary to finance the subsidy would be lower and retraining costs would also be lower. Finally, the effect of an increase of α_{T} on unemployment would be ambiguous, because the increased demand for skilled natives may be offset by a larger amount of unemployed unskilled natives (those who are not retrained).

In brief, if the unemployment problem is wide-spread, it would be socially efficient to increase α_{I}, i.e. to increase the share of immigration costs charged to the firm. On the other hand, a reduction of α_{T}, i.e. an increase of the subsidy on firm's retraining programs, is beneficial mainly because it reduces the firm's costs.

As far as quotas on migrant flows are concerned, a quota on skilled migrants has several beneficial effects. If the quota $M^{\mathrm{q}}_{\mathrm{H}}$ is lower than $M^*_{\mathrm{H}} + M_{\mathrm{UH}}$, but larger than M^*_{H}, then the only effect is to reduce the social costs of immigration. If $M^{\mathrm{q}}_{\mathrm{H}} < M^*_{\mathrm{H}}$ then other positive effects emerge. First, the firm would increase employment of skilled natives, thus reducing unemployment costs. Second, integration costs would also be lower because the total amount of migrants would be lower. However, the firm's costs would increase because skilled natives are more costly than skilled migrants. Again a quota on skilled migrants lower than M^*_{H} would be optimal only if social benefits exceed private losses.

By contrast, it would not be socially efficient to reduce the number of unskilled migrants below M^*_{L}. This would reduce production and increase market price in the monopoly case. It would increase competitors' production and the market price in the Cournot oligopoly case. In both cases, the consumers' surplus would be reduced.

Profits would also be lower in the oligopoly case; they would increase under monopoly. Moreover, the effect on output would reduce the demand for skilled natives, thus increasing unemployment. The only beneficial effects would be on immigration costs, because the employment of both unskilled and skilled migrants would be lowered.

These remarks lead to the following conclusions:

- The flows of migrants should be controlled in order to avoid large unemployment rates among migrants;
- If social and political reasons, particularly native unemployment, lead to a reduction in the number of migrants below the level demanded by the firm at the equilibrium, then it would be preferable to reduce the number of skilled migrants.[7]
- If the social costs of immigration are mainly paid by the firm, then the distortionary effects of taxes necessary to fund the subsidy are avoided. In addition, both immigration and unemployment costs would be lower, because the demand for skilled migrants would be lower.
- Labour market policies designed to increase the demand for unskilled labour (i.e. a reduction of payroll taxes on unskilled workers), are likely to induce an increased demand for unskilled migrants, thus raising both immigration costs and native unemployment.[8]

6. Conclusions

This paper has analysed the equilibrium demand for labour in a segmented labour market in which skilled and unskilled, native and migrant, workers are demanded. The aim was to analyse the impact of some policy variables on the demand for the different types of workers. Our conclusions support the need for a careful control of migrant flows. However, the model suggests that quotas, i.e. binding restrictions of a firm's optimal demand for migrants, may be optimal only if imposed on the demand for skilled migrants. Moreover, it is optimal to increase the demand for native skilled workers rather than for unskilled ones. If associated to retraining programs and immigration charges, this policy would increase natives' employment. By contrast, policies which increase the demand for unskilled workers are likely either to increase migration flows, or to reduce economic efficiency if these flows are limited.

Several extensions of the analysis are possible. First, we considered one production factor only: capital was assumed to be fixed. By contrast, capital mobility and technical progress are relevant variables to consider in order to understand migration dynamics. Second, the paper focuses on the demand side of migratory phenomena; the supply side is

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[7] This finding is consistent with the empirical analyis by Epstein, Kunze and Ward (2002) who show that the fraction of highly skilled workers recruited from the international labour market is very small. See also Bauer and Kunze (2004).

[8] The fact that reducing payroll taxes on unskilled workers may increase rather than reduce unemployment is also suggested in Granier (1994), Granier and Michel (1994). However, they use a rent-seeking argument which is quite different from the one proposed in this paper.

modelled in a very simple way. It would probably be interesting to introduce a more detailed representation of migration supply into the model (Cf. Stark, 1991). Finally, the paper belongs to the partial equilibrium tradition to which many recent developments of industrial organisation and international trade also belong. It would however be relevant to discuss the economic problem of labour migrations using a multi-sector framework.

Appendix A. Appendix

A.1. Proof of Proposition 1

Let us determine the equilibrium employment, hours and wages of unskilled workers. By maximising the firm's profit function with respect to N_L, n_L, M_L, m_L, subject to the constraint $y_L N_L + z_L M_L = Y/\alpha_L$, where Y is given, we obtain the following first order conditions:

$$\partial L/\partial N_L = 0 \Rightarrow \lambda y_L = w_L \Rightarrow [f - aN_L(y_L)]y_L = 0 \tag{A.1.1}$$

$$\partial L/\partial M_L = 0 \Rightarrow \lambda z_L = v_L + \alpha_I C_I'(M) \Rightarrow [f - aM_L(z_L)]z_L - \alpha_I C_I'(M) = 0 \tag{A.1.2}$$

$$\partial L/\partial n_L = 0 \Rightarrow [\lambda - dN_L'(y_L)]f_L'(n_L)N_L = 0 \tag{A.1.3}$$

$$\partial L/\partial m_L = 0 \Rightarrow [\lambda - dM_L'(z_L)]g_L'(m_L)M_L = 0 \tag{A.1.4}$$

$$\partial L/\partial \lambda = 0 \Rightarrow y_L N_L + z_L M_L = Y/\alpha_L \tag{A.1.5}$$

where L denotes the Lagrangean and λ is the Lagrange multiplier. The participation constraints are binding (the firm has no incentive to pay a wage larger than the workers' disutility to produce). Hence the firms offers contracts (w_L,n_L) and (v_L,m_L) such that:

$$w_L = dN_L(y_L) > v_L = dM_L(z_L) \tag{A.2}$$

where $y_L = f_L(n_L)$ and $z_L = g_L(m_L)$. Let us determine n_L. Eq. (A.1.3) can be written as:

$$[aN_L(y_L) - dN_L'(y_L)]f_L'(n_L)N_L = 0 \tag{A.3}$$

where we have used $f = aN_L(y_L)$, i.e. (A.1.1). However, the convexity of the function $dN_L(.)$ implies $aN_L(y_L) < dN_L'(y_L)$. Hence the left hand side of Eq. (A.3) is negative, i.e. $\delta\pi/\delta n_L < 0$ which implies $n^*_L = 0$. The equilibrium contract which is offered to unskilled natives is therefore (0,0) from which $N^*_L = 0$ (it is reasonable to set $N_L = 0$ whenever $n_L = 0$). Hence, (A.1.5) implies:

$$M_L = Y/(\alpha_L z_L) \tag{A.4}$$

From (A.1.4), we have $\lambda = dM_L'(z_L) > 0$ (the constraint is binding), which replaced into (A.1.2) yields:

$$\Phi_L(z_L) \equiv dM_L'(z_L) - aM_L(z_L) = \alpha_I C_I'(M)/z_L \tag{A.5}$$

The convexity of the function $dM_L(.)$ implies $dM'_L(z_L) > aM_L(z_L)$, i.e. $\Phi_L(z_L) > 0$. Moreover, replacing (A.1.4) into (A.1.1) we have:

$$aN_L(0) = dM'_L(z_L) \tag{A.6}$$

which determines the equilibrium hours of work z^*_L. Replacing this equilibrium value of z_L into (A.4), we obtain the equilibrium demand for unskilled migrants:

$$M^*_L = Y/(\alpha_L z^*_L) \tag{A.7}$$

whereas inverting the function C'(.) in (A.5) yields the equilibrium demand for skilled migrants:

$$M^*_H = (C'_I) - 1[z^*_L \Phi_L(z^*_L)/\alpha_I] - M^*_L \tag{A.8}$$

A.2. Proof of Proposition 2

Let us determine the equilibrium employment, hours and wages of skilled workers. By maximising the firm's profit function with respect to N_H, n_H, N_T, N_T, m_H (the equilibrium value for M_H has already been determined), we obtain the following first order conditions:

$$\partial\pi/\partial n_i = 0 \Rightarrow [\mu - dN'_i(y_i)]f'_i(n_i)N_i = 0 \quad i = \text{H, T} \tag{A.9.1}$$

$$\partial\pi/\partial m_H = 0 \Rightarrow [\mu - dM'_H(z_H)]g'_H(m_H)M_H = 0 \tag{A.9.2}$$

$$\partial\pi/\partial N_H = 0 \Rightarrow [\mu - aN_H(y_H)]y_H = 0 \tag{A.9.3}$$

$$\partial\pi/\partial N_T = 0 \Rightarrow [\mu - aN_T(y_T)]y_T - \alpha_T C'_T(N_T) = 0 \tag{A.9.4}$$

Using (A.9.1) for i=H and (A.9.3) yields:

$$dN'_H(y_H) = aN_H(y_H) \tag{A.10}$$

which implies that the equilibrium number of hours for skilled native workers is:

$$y^*_H = \hat{y}_H. \tag{A.11}$$

Moreover, (A.11) and (A.9.1) for i=T yields:

$$dN'_H(\hat{y}_H) = dN'_T(y_T) \tag{A.12}$$

from which the equilibrium number of hours for retrained skilled natives y^*_T can be determined. Finally, the equilibrium number of hours for skilled migrants is given by (A.9.1), (A.9.2) and (A.11):

$$dN'_H(\hat{y}_H) = dM'_H(z_H) \tag{A.13}$$

which determines z^*_H. Notice that both y^*_T and z^*_H are determined as a function of $\hat{y}_H$. A geometric interpretation of this equilibrium is provided in Fig. 2.

Let us now consider employment. From (A.9.4) we have:

$$[dN'_T(y^*_T) - aN_T(y^*_T)]y^*_T \equiv \Phi_T(y^*_T) = \alpha_T C'_T(N_T)/y^*_T \tag{A.14}$$

from which the equilibrium employment for retrained native workers is:

$$N_T^* = (C_T')^{-1}[y_T^* \Phi_T(y_T^*)/\alpha_T] \tag{A.15}$$

We are left with the determination of the equilibrium employment of skilled (non retrained) natives. As $Y = \alpha_H Y_H = \alpha_H(y_H N_H + y_T N_T + z_H M_H)$, we have:

$$N_H^* = Y/\alpha_H \hat{y}_H - (y_T^* N_T^* + z_H^* M_H^*)/\hat{y}_H. \tag{A.16}$$

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