# Spillover Effects and Migrant Employment*

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**Abstract**

We build and empirically test a trade in task model that extends the one of Ottaviano et al. (2010) to three countries, to study the effects of immigration and offshoring costs on migrant employment. Tasks, ordered on a continuum according to increasing degree of face-to-face interaction, can be performed by migrants, offshore workers or natives, with sorting along the continuum being determined by cost-minimization. For two alternative specifications of the model – one in which the ordering of low-end and intermediate tasks is pinned down by workers' characteristics and one in which it is pinned down by countries' characteristics – we derive testable predictions on 'direct', 'domestic spillover' and 'international spillover' effects of migration and offshoring costs on the number of migrant workers. Direct effects refer to the impact of own migration costs on the number of migrants. Domestic spillovers capture the effect of own offshoring costs on the number of migrants. International spillovers refer to the direct effect of country $j$'s migration costs to destination country $d$ on country $i$'s migration to $d$. Overall, we find empirical support of negative direct effects, positive domestic spillover effects and null international spillover effects, leading to conclude that the second ordering of tasks is a better fit of the data. Two broad policy implications follow. First, host countries can affect the number of migrants by acting both on bilateral migration policies and on bilateral offshoring policies. Second, *de jure* discriminatory migration policies need not be *de facto* so.

**Keywords:** Trade in tasks, employment, spillover effects

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# 1 Introduction

The reduction in the costs of relocating production activities abroad and the increasing availability of low-wage foreign-born workers[1] in industrialized countries allows firms to engage in offshoring or to hire immigrant workers when it is profitable to do so. Economists and policy makers have long been interested in how changes in migration and offshoring costs affect native employment. This paper sets aside the effects on native employment, to focus on the effects of migration and offshoring costs on immigration flows. We discuss and empirically test the theoretical implications of a three country model that features heterogeneous offshoring and migration costs across migration-sending (and offshoring-receiving) countries. In a model with trade in tasks *à la* Grossman and Rossi-Hansberg (2008), these differences determine which tasks will be assigned to native workers and which tasks will be assigned to migrant or offshore workers from each of two partner countries $i$ and $j$.[2] This framework produces a rich set of empirical predictions, not only on what we define 'direct' effects of own migration costs on own migration, but also on what we define 'spillover' effects of such costs.

There are two types on spillover effects that are of particular interest from a policy-making perspective. First, 'domestic' spillover effects refer to the impact of own offshoring costs on the number of migrant workers. Qualifying the nature and the impact of such effects allows to answer the policy question of whether a host government can influence the number of migrant workers not only by acting directly on its migration policy, but also indirectly, by providing incentives for firms to source labor abroad via offshoring. This is particularly relevant in the light of the stylized fact that individuals tend to be more pro-trade than pro-immigration (Mayda, 2008), and such differences in public opinion towards trade and immigration are reflected in policy outcomes, with immigration being much more restricted than trade.

Domestic spillover effects act across policies, but not across countries. The second type of spillovers effects we are interested in is the 'international' ones, which refer to the impact of country $j$'s migration costs to destination country $d$ on country $i$'s migration to $d$. The interest in direct international spillover effects stems from another stylized fact concerning attitudes towards migration, namely that the public in host countries is

[1] Recent empirical evidence (Antecol et al. 2003; Butcher and Nardo, 2002; Chiswick et al. 2008) shows that immigrants earn lower wages than native workers, after controlling for workers' characteristics.

[2] Throughout the paper, $i$ and $j$ are the countries that send migrants to, and receive offshoring, from a destination country $d$.

more favorable to migration from certain sending countries than others. In particular, it has been shown that perceived cultural differences between immigrant and native born population are among the main drivers of public resistance to immigration.[3] Moreover, ethnicity matters when it comes to attitudes, as shown by a large body of sociological research. As a consequence, the public (and representative governments) may prefer migration from culturally close or ethnically similar countries, at the expense of migration from culturally distant or ethnically dissimilar ones. For instance, Ford (2011) has shown that the British public is consistently more opposed to migrants from the "Indian sub-continent" (India, Pakistan and Bangladesh) and from the Caribbean, relative to migrants from Europe and Australia.

International spillovers effects can answer the policy question of whether discriminatory migration policies (that is, policies that apply unequal treatment to migrants, depending on their country of origin) are effective in attracting relative more migration from most desired origin countries. As we show in the empirical part of the paper, this does not seem to be the case, reducing potential concerns about policy discrimination.

The remainder of the paper is organized as follows. The next section presents a brief review of the relevant literature on offshoring and migration. Section 3 introduces the theoretical model. Section 4 presents the data, methodology and empirical results. We conclude with some policy implications in Section 5.

## 2 Literature review

Although we present, to the best of our knowledge, the first attempt to address spillover effects between migration and offshoring, we build on a large literature on the relation between the two phenomena, starting with Ramaswami (1968) – who argued that using immigrant workers (rather than offshoring the production abroad) is the optimal strategy for firms located in capital-abundant countries.[4] The central issue in the literature following Ramaswami's seminal contribution has been to understand whether immigrant employment substitutes or complement offshore employment. In a theoretical paper by Jones (2005), offshoring and

[3]Ivarsflaten (2005) and Sides and Citrin (2007) provide evidence that a preference for cultural unity is the strongest predictor of hostility to immigration in a wide range of European societies. The PEW Global Attitudes Report (2007) argues that opinions about immigration are closely linked to perceptions about threats to a country's culture. In 46 of 47 surveyed countries, those who favor stricter immigration controls are also more likely to believe their way of life needs to be protected against foreign influence. Importantly, such preferences need not be related to economic factors. In a pioneering experimental study mentioned by Ford (2011), Sniderman e al. (2004) have demonstrated that Dutch hostility to immigrants is greatly magnified simply by describing the migrant group in cultural rather than economic terms.

[4]The result relies on the assumption that immigrant wages in host countries are lower than wages for native workers. As mentioned in Section 1, recent empirical evidence supports this assumption.

immigration are both used by firms to reduce the marginal cost of production, but given a certain fixed cost of offshoring, it is optimal to use immigrant workers for small scale of production, and offshoring when the scale is large. In a model with one good, two factors and two countries, Bandyopadhyay and Wall (2010) show that an exogenous migration inflow implies a decrease in outward capital flows (that is, there is substitutability between immigration and offshoring).

Most of the empirical literature has used macro-level data on outward Foreign Direct Investment (FDI), finding evidence of complementarity between FDI and migration. The underlying idea is that immigrants convey information about their origin countries, reducing the firm's cost (risk) of doing FDI. Kugler and Rapoport (2005) show that unskilled immigration into the US stimulates offshoring activity by US firms towards immigrants origin countries. Similarly, Javorcik et al. (2011) find a positive correlation between US outward FDI and high-educated immigrants: a 1% increase in the stock of tertiary educated immigrants in US is associated with a 4% increase in the stock of US FDI in immigrants' origin countries.

Only two studies, to our knowledge, analyze the relation between migration and offshoring at the micro level, using firm-level data. They both find substitutability among the two strategies. Using data on 4289 manufacturing Italian firms, Barba Navaretti et al. (2008) find a negative relation between offshoring and the share of foreign born workers (over total firm's employees). They find that offshoring on average substitutes for immigrants in production, and that the higher the skill level in firm's employment (i.e. the higher the firm's need for competencies that immigrants on average do not own), the lower the immigrant workers' share in production. In a recent paper, Olney (2011) uses data on 192 US Metropolitan Statistical Areas from 1998 to 2004 to estimate the relocation behavior of firms, both in terms of net birth rate and expansion rate, as response to an exogenous change in high and low skilled immigration. He finds that a 1% increase in the share of low-skilled immigrants leads to a 0.11% increase in the net birth of firms in the metropolitan area (offshoring is deterred), while a 1% increase in the high-skilled share of immigrants leads to a 0.26% decrease in net birth rate of firms (offshoring is stimulated).

This paper is mostly related to Ottaviano et al. (2010), who propose a common structure, based on trade in tasks *à la* Grossman and Rossi-Hansberg (2008), to study offshoring and migration. While in all the former empirical studies the choice between migration and offshoring concerns the entire production process, Ottaviano et al. (2010) allow for the possibility that firms offshore some low-skilled tasks to a foreign country where the prevailing wage rate is lower, and cover other low-skilled tasks by hiring immigrant or native workers. In their model, a firm decides its optimal strategy minimizing the cost of production of each single task.[5] The optimal strategy is to (i) offshore the easiest tasks abroad; (ii) using native workers to perform very difficult tasks at home and (iii) produce intermediate tasks at home by employing immigrants workers. A reduction in the cost of offshoring increases the number of offshore tasks through a reduction in the number of tasks assigned to immigrants and natives at home; similarly, a reduction in the cost of migration increases the number of tasks assigned to immigrants through a reduction in tasks offshored abroad (in their model, immigrants do not compete with natives). The authors find empirical support for their theoretical conclusions.

Ottaviano et al. (2010) assume however that all origin countries are the same in terms of migration and offshoring costs. Their model cannot capture potential externalities to a third country of a change in bilateral migration (offshoring) costs. This is the main novelty introduced by this paper, which extends the Ottaviano et al. (2010) model to a third country.

As a last remark, it should be noted that we are not interested here in the effects of offshoring and migration on native employment. Offshoring is often perceived as a simple relocation of jobs abroad, reducing native employment. In fact, Görg and Hanley (2005), Amiti and Wei (2009) and Crinò (2010) find a mild negative effect of offshoring on domestic employment. But if the relocation of jobs results in a business increasing productivity (or innovation) – a result shown by Amiti and Wei (2009), Görg et al. (2008) and Görg and Hanley (2011) – sales can expand, increasing employment (Hijzen and Swaim, 2007). Similarly, migration has been considered for a long time as detrimental for native employment because of substitutability between native workers ad migrants (Borjas, 2003; Aydemir and Borjas, 2006; Borjas et al., 2008). But new empirical evidence reverses this conclusion arguing that migrant and native workers might be imperfect substitute (D'Amuri et al., 2010; Ottaviano and Peri, 2012) and productivity gains in using migrants in production could offset the direct negative effect on native employment (Peri, 2012).

[5] The two crucial assumptions in the model are that the cost of tasks' offshoring is increasing in tasks' difficulty, and that the productivity of immigrants employed by firms at home is decreasing in tasks' difficulty.

# 3 A model of task allocation

Consider a small open economy, denoted as country $d$, producing a good $Y$ using labor. The labor input is a constant elasticity of substitution (CES) aggregate of tasks, indexed by $k \in [0,1]$, with elasticity of substitution between tasks $\sigma > 1$.[6] Along the $[0,1]$ continuum, tasks are ordered by increasing degree of face-to-face interaction. The production function of the economy is:

$$Y = AL = \left[ \int_0^1 [L(k)]^{\frac{\sigma-1}{\sigma}} \, di \right]^{\frac{\sigma}{\sigma-1}} \tag{3.1}$$

where $A$ is a technology parameter (marginal productivity of the labor aggregate).[7] We assume a linear cost function $c[\omega(k)] = \omega(k)$, where $\omega(k)$ is the marginal cost of task $k$.[8] Profit maximization yields the following conditional demand for labor input of task $k$:

$$L(k) = [\omega(k)]^{-\sigma} \frac{W}{\Omega^{1-\sigma}} \tag{3.2}$$

where $W \equiv \int_0^1 \omega(k) L(k) \, dk$ is the wage bill in the economy and $\Omega \equiv \left[ \int_0^1 [\omega(k)]^{1-\sigma} dk \right]^{\frac{1}{1-\sigma}}$ is a CES aggregate of marginal costs.[9]

## 3.1 Participation constraints

The tasks along the continuum $[0,1]$ can be performed by three types of workers: natives from country $d$; immigrants and offshore workers from foreign countries $i$ and $j$. A task is offshored to country $c$, $c = i, j$ rather than performed by natives, if it is cheaper for firms to do it, namely if $[\omega(k)]^{NAT} \geq [\omega(k)]_c^{OS}$, where $NAT$ stands for natives and $OS$ stands for offshore workers. This condition can be expressed as:

$$w \geq w_c \beta_c \chi_c(k) \tag{3.3}$$

[6]This assumption is restrictive. In order to have substitutability between tasks, it suffices to have $\sigma > 0$. With this assumption, however, we would have to distinguish between the two cases (i) $0 < \sigma < 1$ and (ii) $\sigma > 1$. In Appendix C, we survey the literature that has estimated elasticity of substitution across different types of workers. Based on the results of this literature, the assumption $\sigma > 1$ seems justifiable.

[7]Without loss of generality, we set $A = 1$.

[8]We justify the assumption of linearity of the cost function by noting that, by perfect competition in the labor market, each task is remunerated its marginal productivity $\omega(k)$.

[9]Using Walras law, we have normalized the price of $Y$ to one.

The left-hand side of this expression is the marginal cost of performing a task domestically, equal to the wage times the unit input requirement (one). The right-hand side is the marginal cost of offshoring the task, equal to the wage in country $c$ times the unit input requirement of offshored tasks, $\beta_c \chi_c(k)$.[10] The unit input requirement comprises $\beta_c \geq 1$, a policy parameter common to all tasks, and $\chi_c(k) \geq 1$, a task-specific offshoring cost. We assume $\chi'(k) \geq 0$. Since tasks are ordered by increasing degree of face-to-face interaction, this assumption implies that the more interaction-intensive a task, the higher the marginal cost of performing it via offshoring. To make sure that at least some tasks are offshored, we assume that $w > w_c \beta_c \chi_c(0)$. Similarly, a task is assigned to immigrants, rather than performed by natives, if $[\omega(k)]^{NAT} \geq [\omega(k)]_c^{MIG}$, $MIG$ stands for migrants. This condition can be expressed as:

$$w \geq w_c^{\oplus} \tau_c(k) \tag{3.4}$$

In equation (3.4), $w^{\oplus}$ represents the wage firms from the host country are willing to pay to immigrants.[11] $\tau_c(k) \geq 1$ is a task-specific cost of assigning a task to migrant workers. We assume $\tau_c'(k) \geq 0$, so that the marginal cost of assigning a task to migrant workers is increasing in the interaction-intensity of the task.[12] We further assume that immigrants incur a frictional cost of foregone productivity, $\delta_c$, which is independent of the task performed in the host country ($\delta_c \geq 1$). In other words, an immigrant endowed with one unit of labor in the country of origin – with corresponding wage equal to $w_c$ – is effectively endowed with $1/\delta_c$ units of labor in the host country. Consequently, firms from Home are willing to offer migrant workers a wage equal to $w_c^{\oplus}/\delta_c$. Positive supply of both immigrant and offshore workers in country $c$ requires the indifference condition $w_c^{\oplus}/\delta_c = w_c$, which allows to rewrite equation (3.4) as:

$$w \geq w_c \delta_c \tau_c(k) \tag{3.5}$$

[10] One could think at $\beta_c \chi_c(k)$ as an inverse measure of 'offshorability'. This concept has been qualified by Van Welsum and Vickory (2006) using the following criteria: intensive use of ICTs (information and communication technologies); output that is ICT transmittable; codifiable knowledge content; little face-to-face interaction. See Blinder (2009) and Blinder and Krueger (2009) for alternative measures of 'offshorability'.

[11] Home firms are assumed to be able to discriminate between natives and immigrants. For one unit of labor, they are willing to pay $w$ to a native, but only $w^{\oplus} \leq w$ to an immigrant.

[12] As it will become clear in Section 3.2, the functions $\tau_c(k)$ and $\chi_c(k)$ have different slopes (and intercepts). This allows migration and offshoring costs to increase at different pace for different types of workers from different origin countries $i$ and $j$, allowing a clear, testable sorting of tasks along the $[0, 1]$ continuum.

The left-hand side of equation (3.5) can be interpreted as an inverse measure of 'ease of migration' (see Ottaviano et al., 2010).

Next, a task is offshored to country $c$, rather than performed by migrant workers from $c$, if $[\omega(k)]_c^{MIG} \geq [\omega(k)]_c^{OS}$. This condition can be rewritten as:

$$\delta_c \tau_c(k) \geq \beta_c \chi_c(k)$$

Finally, to make sure that at least a task is assigned to native workers, we assume:

$$w < \min\{w_c \delta_c \tau_c(1), w_c \beta_c \chi_c(1)\}$$

This condition implies that sufficiently high-end tasks will be performed by native workers, a plausible result considering that high-end tasks require complex face-to-face interaction. We let migrant and offshore workers only differ in offshoring and migration costs, not in productivity in the country of origin. Therefore, $w_i = w_j = w^*$.

## 3.2 Two possible ordering of tasks

As shown above, whether a task is performed by migrant, offshore or native workers depends on a simple comparison of marginal costs. So far, we have assumed that is optimal to employ native workers for high-end tasks. However, we have not specified how low- and medium-end tasks will be allocated, which depends on the sign of following inequality: $\delta_c \tau_c(0) \lesseqgtr \beta_c \chi_c(0)$. To address this point, we go back to the assumption that tasks are ordered by increasing degree of face-to-face interaction. One could easily imagine that tasks requiring minimal levels of face-to-face interaction are offshored (as also assumed by Van Welsum and Vickory, 2006). Considering that sufficiently high-end tasks are performed by native workers (see above), intermediate tasks would then be assigned to migrants. In terms of this model, this implies that:

$$w_c \delta_c \tau_c(0) > w_c \beta_c \chi_c(0) \tag{3.6}$$

The empirical results of Ottaviano et al. (2010), however, show that low-end tasks (in their model, the 'easy' ones) are covered by migrant workers rather than offshored.[13] In terms of the model, this would imply a reversion of inequality (3.6). Fortunately, it can be shown that none of the results below depend on the sign of (3.6). In particular, direct and spillover effects of offshoring and migration costs on migrant employment are the same in a model where low-end tasks are performed by offshore workers and medium-end tasks by migrant workers and in a model where low-end tasks are performed by migrant workers and intermediate tasks by offshore workers.[14]

Two possible ordering of tasks remain to be analyzed: (i) one in which the ordering of low-end and intermediate tasks is pinned down by workers' characteristics; (ii) one in which the ordering of low-end and intermediate tasks is pinned down by countries' characteristics. Since, to our knowledge, there is no theoretical or empirical literature on this point, in the next subsections we develop a model for each of these two ordering of tasks, respectively denoted as 'ordering 1' and 'ordering 2'. In Section 4 we then shed light on which of the two ordering better fits the data.

#### 3.2.1 Ordering 1

Consider the following ordering of tasks:

$$O_i < O_j < M_i < M_j \tag{3.7}$$

which is graphically represented in panel (a) of Figure 1.[15] Recall that tasks are ordered by increasing degree of face-to-face interaction. This model, therefore, assumes that offshore workers, independently of whether they are from country $i$ or from country $j$, have lower cost of performing less interactive tasks than migrant workers. Intuitively, 'offshorability' and 'ease of migration' along the task continuum are more determined

[13] In particular, Ottaviano et al. (2010) note that "assigning simple tasks to immigrants incurs a lower set-up cost than offshoring them. However, as the complexity of tasks increases, it is hard to find immigrants able to do them, whereas once set-up costs are paid it is relatively easy to access the marginal offshore worker". Consistently, they show that a reduction in migration costs does not affect the level of native employment, while a reduction in offshoring costs does. The fact that migrant workers do not compete with native workers indicates that easy tasks are performed by migrants rather than offshored.

[14] The only difference is in the cross-country, cross-policy impact of country $j$'s offshoring costs on country $i$'s migration. We are not interested in this type of effect because it is more of an intellectual curiosity in the model than a policy relevant effect.

[15] In Figure 1, the marginal cost functions are linear just because of simplicity of exposition. All the results are derived without assuming any functional form, only using the assumptions in (3.8) and in (3.14) for ordering 1 and ordering 2, respectively.

by workers' characteristics than by countries' characteristics. Mathematically, this is obtained by letting:

$$\begin{cases} \beta_i \chi_i' (k) > \beta_j \chi_j' (k) > \delta_i \tau_i' (k) > \delta_j \tau_j' (k) \\ \beta_i \chi_i (0) < \beta_j \chi_j (0) < \delta_i \tau_i (0) < \delta_j \tau_j (0) < \frac{w}{w^*} \end{cases} \tag{3.8}$$

As shown in Appendix A, employment of immigrant workers from country $i$ is equal to:

$$NM_i = \int_{O_j}^{M_i} N(k)\, dk = \kappa (\delta_i)^{1-\sigma} \rho_1 \tag{3.9}$$

where $\kappa \equiv (w^*)^{-\sigma} \frac{W}{\Omega^{1-\sigma}}$ and $\rho_1 \equiv \int_{O_j}^{M_i} [\tau_i (k)]^{1-\sigma} dk$.[16]

The relevant derivatives of $NM_i$ with respect to migration and offshoring costs are:

$$\frac{\partial NM_i}{\partial \delta_i} = \kappa \left[ (1-\sigma) (\delta_i)^{-\sigma} \rho_1 + (\delta_i)^{1-\sigma} \frac{\partial \rho_1}{\partial \delta_i} \right] < 0 \tag{3.10}$$

$$\frac{\partial NM_i}{\partial \beta_i} = \kappa (\delta_i)^{1-\sigma} \frac{\partial \rho_1}{\partial \beta_i} = 0 \tag{3.11}$$

$$\frac{\partial NM_i}{\partial \delta_j} = \kappa (\delta_i)^{1-\sigma} \frac{\partial \rho_1}{\partial \delta_j} > 0 \tag{3.12}$$

(see Appendix B). It follows that under this ordering we expect a negative direct effect (see (3.10)), a null domestic spillover effect (see (3.11)) and a positive international spillover effect (see (3.12)).

### 3.2.2 Ordering 2

As depicted in panel (b) of Figure 1, this second ordering of tasks is:

$$O_i < M_i < O_j < M_j \tag{3.13}$$

Intuitively, this ordering of tasks is consistent with a world where country, rather than workers' characteristics, are the main drivers of 'offshorability' and 'ease of migration'. Therefore, workers from country $j$,

[16] In Appendix A we also report the expressions for offshore employment $NO_i$ and $NO_j$, migrant employment from country $j$ ($NO_j$) and native employment $NN$. These are omitted from the main text because the empirical application focuses on migrant employment from country $i$ as dependent variable.

independently of whether they are migrant or offshore, have lower cost of performing more interactive tasks than workers from country $i$. Mathematically, this is obtained by assuming:

$$\begin{cases} \beta_i \chi_i' (i) > \delta_i \tau_i' (i) > \beta_j \chi_j' (i) > \delta_j \tau_j' (i) \\ \beta_i \chi_i (0) < \delta_i \tau_i (0) < \beta_j \chi_j (0) < \delta_j \tau_j (0) < \frac{w}{w^*} \end{cases} \tag{3.14}$$

As shown in Appendix A, employment of immigrant workers from country $i$ is equal to:

$$NM_i = \int_{O_j}^{M_i} N(k)\, dk = \kappa (\delta_i)^{1-\sigma} \rho_2 \tag{3.15}$$

where $\rho_2 \equiv \int_{O_i}^{M_i} [\tau_j (i)]^{1-\sigma} dk$.

The relevant derivatives of $NM_i$ with respect to migration and offshoring costs are:

$$\frac{\partial NM_i}{\partial \delta_i} = \kappa \left[ (1-\sigma) (\delta_i)^{-\sigma} \rho_2 + (\delta_i)^{1-\sigma} \frac{\partial \rho_2}{\partial \delta_i} \right] < 0 \tag{3.16}$$

$$\frac{\partial NM_i}{\partial \beta_i} = \kappa (\delta_i)^{1-\sigma} \frac{\partial \rho_2}{\partial \beta_i} > 0 \tag{3.17}$$

$$\frac{\partial NM_i}{\partial \delta_j} = \kappa (\delta_i)^{1-\sigma} \frac{\partial \rho_2}{\partial \delta_j} = 0 \tag{3.18}$$

(see Appendix B). It follows that under this ordering we expect a negative direct effect (see (3.16)), a negative domestic spillover effect (see (3.17)) and a null international spillover effect (see (3.18)).

## 3.3 Testable predictions

Table 1 summarizes the theoretical predictions of ordering 1 and 2. The direct effect of own migration costs on migrant employment is negative in both ordering, consistently with simple economic intuition. The difference between the two ordering lies in the predictions on spillover effects. While ordering 1 only predicts international spillover effects, ordering 2 only predicts domestic spillover effects. We shed some light on which ordering is more empirically relevant in the next section.

Table 1: Testable predictions

| Type of effect | Formula | Description: Impact of... | Sign | |
|---|---|---|---|---|
| | | | Ordering 1 | Ordering 2 |
| Direct | $\frac{\partial NM_i}{\partial \delta_i}$ | Own migration costs on the number of migrants | $-$ | $-$ |
| Domestic spillover | $\frac{\partial NM_i}{\partial \beta_i}$ | Own offshoring costs on the number of migrants | 0 | $+$ |
| International spillover | $\frac{\partial NM_i}{\partial \delta_j}$ | $j$'s migration costs on $i$'s number of migrants | $+$ | 0 |

# 4 Empirical evidence

## 4.1 Methodology

To test the implications of the model in terms of migrant employment, we run the following baseline regression equation:

$$\ln (NM)_{dit} = x'_{dijt}\beta + w'_{dijt}\gamma + \varepsilon_{dijt} \tag{4.1}$$

where $t$ indexes time, $d$ denotes the destination country (recipient of immigrants and source of offshoring), $i$ and $j$ respectively denote origin countries $i$ and $j \neq i$, $\beta$ and $\gamma$ are vectors of coefficients to be estimated, $x_{dijt} = [mc_{dit}, mc_{djt}, oc_{dit}, oc_{djt}]$ is a vector of bilateral migration costs ($mc$) and offshoring costs ($oc$). The matrix $w_{dijt}$ contains fixed effects. The details of which fixed effects are included in each specifications can be found in tables 2, 3 and 4. Depending on whether ordering 1 or ordering 2 is a better fit of the data, we expect the signs to be in line with the second-last (last) column of table 1.[17]

The main challenge is how to measure migration and offshoring costs. As a proxy for bilateral migration costs between $d$ and any origin country $o$, we use the negative of the fitted values from a gravity regression with the ratio of total bilateral flows of migrants to resident population as a dependent variable. Similarly,

[17]Regression (4.1) is of the reduced-form type. The model cannot be linearized, even assuming simple linear functional forms for the functions $\tau(k)$ and $\chi(k)$. The dependent variable of regression (4.1) is expressed as $\ln(x+1)$ in order not to lose zero observations. Note that we do not square the dataset and replace missing observations with zeros, simply we also include in the regressions the zero migration stocks. The number of zeros in the dataset used for the regressions reported in tables 4, 3 and 2 is 9,050 in columns (1) and (4) (6.2% of observations), 4,531 in columns (2) and (5) (6.1% of observations) and 2,319 in columns (3) and (6) (5.9% of observations).

we approximate offshoring costs by using the negative of fitted values from a gravity regression with bilateral offshoring flows (proxied by trade in parts and components) as dependent variable.[18] In the gravity regressions, we use as explanatory variables geography, differences in labor costs (approximated by differences in GDP per capita), stock of migrants (only in the migration gravity) and stock of FDI (only in the offshoring gravity). We also include variables that capture the effect of policy choices on outcomes. In the migration regression, we include the variable PTA, a dummy equal to one if countries $d$ and $o$ have signed a preferential trade agreement (PTA) containing provisions on trade in services (GATS mode IV), or provisions on visa and asylum or provisions on labor market regulation. This variable reflects the effect of migration policies (within preferential trade agreements) on migration costs. In the offshoring regression, we include the variable BIT, a dummy equal to one if countries $d$ and $o$ have signed a bilateral investment treaty. This variable reflects the potential facilitation effect on offshoring of such treaties.

The fitted values used to compute migration and offshoring costs do not include the contribution of the fixed effects (see Appendix D for details). Migration and offshoring costs calculted including such fixed effects are, however, highly correlated with the ones calculated exluding them.

In the regressions of Tables 2, 3 and 4, each unit of observation is a triplet $dij$ in a given year. This implies that for any pair of origin country $i$ and destination country $d$ in a given year, there are $J$ observations that include a set of origin countries $j = 1, ..., J$. In the theoretical model, country $j$ should be similar to country $i$ in terms of nominal wage rate, and should differ from $i$ only in terms of migration and offshoring costs. While in baseline specifications $J$ includes all origin countries available in the sample, we also include: i) specifications in which $J$ is the set of origin countries that are similar to $i$, in the sense that the similarity index in per capita GDP between $i$ and $j$ is higher than the median of its sample distribution;[19] ii) specifications in which $J$ is the set of origin countries that are very similar to $i$ ($SI_{ijt}$ larger than the 75$^{\text{th}}$ percentile of its sample distribution).

Direct and domestic spillover effects can be studied within an origin-destination pair and without including any third country $j$. This is done in the regressions of Table 5, where each unit of observation is an $id$ pair

[18] The measures of migration and offshoring costs used in all regressions are expressed in units of standard deviation, to facilitate economic interpretation of results.

[19] Following Helpman (1987), we define the similarity index in per capita GDP between $i$ and $j$ as $SI_{ijt} \equiv 1 - \left\{ \frac{GDP_i}{GDP_i + GDP_j} \right\}^2 - \left\{ \frac{GDPj}{GDP_i + GDP_j} \right\}^2$. Per capita GDP is used as a proxy for nominal wages.

in a given year.

In all regressions (except column (1) of Table 5 – where standard errors are calculated using the Huber-White sandwich estimator), we use robust standard errors that are clustered at the level of the panel variable. Namely, in columns (1)–(3) of Tables 2, 3 and 4, we use $di$ pairs as panel variable, thus standard errors are clustered within $id$ pairs. In columns (4)–(6) of the same tables, we use $dij$ triplets as panel variable, thus standard errors are clustered within $dij$ triplets. Finally, in columns (2) and (3) of Table 5 we use standard errors clustered within $id$ pairs.[20]

## 4.2 Data

Migration data are from the OECD's International Migration Dataset. We use the stock of foreign-born workers in destination country $d$ from origin $o$ as a measure of migrant employment ($NM_{dit}$).[21] The raw data contain information on migration from 199 origin countries to 29 destination countries, for the period 1990-2008.

The similarity index $SI_{ijt}$ uses data on per capita GDP from the World Bank's World Development Indicators. Gravity data are from the CEPII dataset assembled by Head, Mayer, and Ries (2010). Finally, data on the presence/content of a preferential trade agreement (PTA) or a bilateral investment treaty (BIT) between country $d$ and country $o$ used in the gravity regressions of Appendix D are respectively from World Trade Organization (2011) and from the UNCTAD website.[22]

## 4.3 Results

The baseline results are in Table 2. In this table, $dt$, $it$ and $jt$ fixed effects are constructed using the following five time periods: $t_1 \leq 1997$; $1998 \leq t_2 \leq 1999$; $2000 \leq t_3 \leq 2001$; $2002 \leq t_3 \leq 2003$; $t_4 \geq 2005$.[23] Columns (1)–(3) use destination-origin $i$ pairs as panel variable. Columns (4)–(6) use destination-origin $i$-origin $j$

[20]Ideally, standard errors should also be bootstrapped, to take into account the fact that offshoring and migration costs are a linear transformation of the fitted values of the gravity regressions. Unfortunately, this was not be feasible due to computational limitations.

[21]To build the proxy for migration costs, we instead use the net inflows of foreign workers as dependent variable of the gravity regression described in Appendix D. This follows the standard approach in the migration literature. Such variable is calculated as the difference in the stock of foreign workers between $t$ and $t-1$.

[22]UNCTAD provides the list of Bilateral Investment Treaties for 178 economies, concluded as of 1 June 2011, at http://www.unctadxi.org/templates/docsearch____779.aspx.

[23]These fixed effects could not be contructed using country-year combinations due to computational limits. Year fixed effects are however always included.

triplets as panel variable. Reading through columns, (1) and (4) present results using the full set of $j$ countries; (2) and (5) present results using the set of $j$ countries that are similar to $i$ (similarity index larger than the median of its sample distribution); (3) and (6) present results using the set of $j$ countries that are very similar to $i$ (similarity index larger than the$75^{\text{th}}$percentile of its sample distribution).

We find overwhelming evidence that direct effects are negative. Own migration costs $mc_i$ reduce own migration. In particular, in all specifications, a one standard deviation increase in the cost of migration reduces migrants employment level by 3.5%. These results are in line with economic intuition and with the predictions of ordering 1 and 2.

Consider now domestic spillover effects. The effect of a change in offshoring costs $oc_i$ on own migration is positive and significant in all specifications. That is, when the cost of offshoring to country $i$ increases, this has an indirect effect on the employment level of migrants from that country, which increases. In particular, according to results in columns (4)–(6), a one standard deviation increase in the offshoring cost from country $i$ rises the employment level of migrants from $i$ by 0.76 to 0.56%, depending on the specification. This result is consistent with the predictions of ordering 2, but not ordering 1, providing a first piece of evidence in support of ordering 2.

Third, international spillover effects are found to be not significant: the coefficient on $mc_j$ is never statistically different from zero, indicating that migration costs do not have cross-border effects. This is again in line with the predictions of ordering 2.[24]

#### 4.3.1 Robustness checks

In Tables 3 and 4 we use alternative definitions of the time periods used to construct $dt$, $it$ and $jt$ fixed effects. In particular, Table 3 uses four, rather than five time periods: $t_1 \leq 1998$; $1999 \leq t_2 \leq 2001$; $2002 \leq t_3 \leq 2004$; $t_4 \geq 2005$. The results on direct and domestic spillover effects are basically the same as in Table 2. International spillover effects are predicted to be null in the regressions with $di$ fixed effects (columns (1)–(3)). In the regressions with $dij$ fixed effects, there are two instances in which they are different from zero, columns (4) and (6). However, the result in columns (4) is only significant at the 10% confidence

[24] It shoud be noted that in the regressions of this table, as well as in the ones of Tables 3 and 4, we always include $oc_j$. The results are not reported because, as explained in Section 3.2, they are not of policy interest.

level; the result in column (6) is the only problematic one. This, however, remains an exception. In fact, the results of Table 4 wholly confirm the baseline (and most restrictive) ones. This table uses three time periods: $t_1 \leq 1999$; $2000 \leq t_2 \leq 2003$; $t_3 \geq 2004$.

As mentioned in Section 4.1, direct and domestic spillover effects can be studied in a 'collapsed' dataset with origin-destination pairs as units of observations in a given year. With such dataset, we estimate a regression of the form:

$$\ln{(NM)}_{dot} = x'_{dot}\beta + w'_{dot}\gamma + \varepsilon_{dot} \tag{4.2}$$

The results of regressions using the specification in (4.2) are in Table 5.[25] In column (1), we include year, origin and destination fixed effects separately. In column (2), we include year and pair fixed effects. Finally, in column (3), we include *do*, *dt* and *ot* fixed effects. The result of negative direct effect is obtained in all specifications. Domestic spillover effects are positive, but statistically significant only in columns (1) and (2), while in columns (3) they are not statistically different from zero. However, it should be noted that the regression in column (3) is very demanding because of the inclusion of a large set of interacted fixed effects.

**Additional robustness checks (work in progress)**

We use lags of PTA and BIT in the estimation of (E-1) and (E-2), then use these newly-constructed offshoring and migration costs in the main estimation (equation (4.1)). We use alternative measures of offshoring and migration costs (including the set of fixed effects in the fitted values of (E-1) and (E-2)). We use measures of offshoring and migration costs directly in the estimation of (4.1), taking into account endogeneity concerns.

# 5 Conclusions and policy implications

We have developed and empirically tested a trade-in-tasks model on the effects of migration and offshoring costs on employment of migrant workers. Since the model features three countries, $d$ (recipient of immigration and source of offshoring), $i$ and $j$ (sources of migration and recipients of offshoring), we have been able to shed light not only on what we have defined 'direct' effects of own migration costs on the number of migrants,

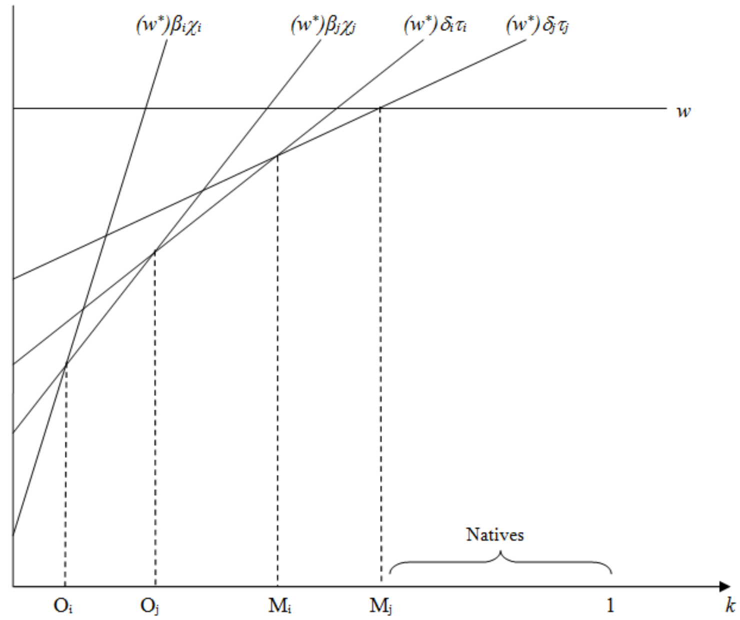
[25]The dependent variable of regression (4.2) is expressed as $\ln{(x+1)}$ in order not to lose the 127 zero observations (2.8% of the sample).

but also on spillover effects. We have shown that 'domestic spillovers' (the effects of own offshoring costs on the number of migrants) are positive. Further, we have shown that 'international spillovers' across countries within policies are mostly null.

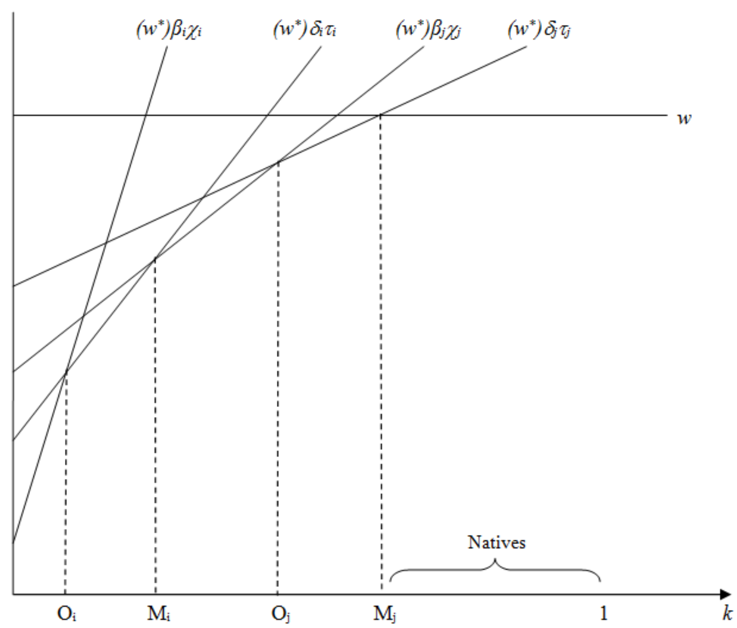
In this paper, the tasks needed to produce a final good have been ordered according to the degree of face-to-face interaction. Consistently, we have assumed that relatively low-end tasks can be offshored, while high-end tasks can only be performed by native workers. In this general framework, we have shown that the results on spillover effects support an ordering of tasks in which 'offshorability' and 'ease of migration' along a task continuum are more determined by countries' characteristics than by workers' characteristics. This result, however, would also obtain in a model in which, within each destination country, relatively low-end tasks are assigned to migrant rather than to offshore workers.

We have focused on the effects of migration and offshoring costs on migrant employment because of an interest in the implications on the politically sensitive issue of migration policy. In particular, domestic and international spillover effects produce two interesting implications. First, the evidence of positive domestic spillover effects implies that a host country can impact migration from a sending country $j$ by reducing the cost of offshoring to the same country. This can be relevant for governments that have their hands tied on migration policy (for instance, because of participation to international agreements on migration, like the Schengen Treaty) and would like to discourage migration for political or other reasons. Second, the weak evidence on international spillover effects of migration implies that *de jure* discriminatory migration policies need not be *de facto* discriminatory.

Figure 1: Ordering of tasks in models 1 and 2




(a) Ordering 1




(b) Ordering 2

Table 2: Results with time horizon divided into five periods

| Dependent variable | ln (migrant employment) | | | | | |
|---|---|---|---|---|---|---|
| Model | (1) | (2) | (3) | (4) | (5) | (6) |
| Migration cost i | -3.589*** | -3.574*** | -3.576*** | -3.584*** | -3.591*** | -3.604*** |
| | (0.282) | (0.283) | (0.272) | (0.0379) | (0.0525) | (0.0731) |
| Offshoring cost i | 0.756** | 0.726** | 0.701** | 0.759*** | 0.696*** | 0.562*** |
| | (0.320) | (0.316) | (0.310) | (0.0350) | (0.0478) | (0.0606) |
| Migration cost j | 0.000269 | 0.00431 | 0.00322 | -0.00222 | 0.0280 | 0.0192 |
| | (0.000329) | (0.00329) | (0.00273) | (0.00957) | (0.0218) | (0.0327) |
| Fixed effects | | | | | | |
| Destination*origin i | yes | yes | yes | no | no | no |
| Destination*origin i*origin j | no | no | no | yes | yes | yes |
| Sample | Complete | $SI_{ij} > 50^{th}$ pct. | $SI_{ij} > 75^{th}$ pct. | Complete | $SI_{ij} > 50^{th}$ pct. | $SI_{ij} > 75^{th}$ pct. |
| Observations | 146,358 | 74,644 | 39,465 | 146,358 | 74,644 | 39,465 |
| R-squared | 0.694 | 0.699 | 0.704 | 0.690 | 0.693 | 0.696 |
| Number of id | 371 | 371 | 371 | | | |
| Number of dij | | | | 30,769 | 17,767 | 10,667 |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Coefficients on constant and $oc_j$ not reported
Fixed effects always included: year, destination, origin i, origin j, destination-period, origin i-period, origin j-period
Period 1: $t \leq 1997$; period 2: $1998 \leq t \leq 1999$; period 3: $2000 \leq t \leq 2001$; period 4: $2002 \leq t \leq 2003$; period 5: $t \geq 2004$

Table 3: Results with time horizon divided into four periods

| Dependent variable | ln (migrant employment) | | | | | |
|---|---|---|---|---|---|---|
| Model | (1) | (2) | (3) | (4) | (5) | (6) |
| Migration cost i | -3.116*** | -3.105*** | -3.105*** | -3.111*** | -3.118*** | -3.119*** |
| | (0.262) | (0.263) | (0.263) | (0.0349) | (0.0486) | (0.0677) |
| Offshoring cost i | 0.728*** | 0.719*** | 0.719*** | 0.721*** | 0.683*** | 0.633*** |
| | (0.216) | (0.213) | (0.213) | (0.0237) | (0.0320) | (0.0418) |
| Migration cost j | -0.000789 | 0.00148 | 0.00148 | -0.0179* | 0.0316 | 0.0642** |
| | (0.000521) | (0.00324) | (0.00324) | (0.00957) | (0.0209) | (0.0308) |
| Fixed effects | | | | | | |
| Destination*origin i | yes | yes | yes | no | no | no |
| Destination*origin i*origin j | no | no | no | yes | yes | yes |
| Sample | Complete | $SI_{ij} > 50^{th}$ pct. | $SI_{ij} > 75^{th}$ pct. | Complete | $SI_{ij} > 50^{th}$ pct. | $SI_{ij} > 75^{th}$ pct. |
| Observations | 146,358 | 74,644 | 74,644 | 146,358 | 74,644 | 39,465 |
| R-squared | 0.635 | 0.635 | 0.635 | 0.633 | 0.630 | 0.628 |
| Number of id | 371 | 371 | 371 | | | |
| Number of dij | | | | 30,769 | 17,767 | 10,667 |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Coefficients on constant and $oc_j$ not reported
Fixed effects always included: year, destination, origin i, origin j, destination-period, origin i-period, origin j-period
Period 1: $t \leq 1998$; period 2: $1999 \leq t \leq 2001$; period 3: $2002 \leq t \leq 2004$; period 4: $t \geq 2005$

Table 4: Results with time horizon divided into three periods

| Dependent variable | ln (migrant employment) | | | | | |
|---|---|---|---|---|---|---|
| Model | (1) | (2) | (3) | (4) | (5) | (6) |
| Migration cost i | -3.538*** | -3.528*** | -3.519*** | -3.531*** | -3.541*** | -3.542*** |
| | (0.274) | (0.276) | (0.265) | (0.0366) | (0.0508) | (0.0703) |
| Offshoring cost i | 0.682*** | 0.644*** | 0.620*** | 0.682*** | 0.654*** | 0.600*** |
| | (0.164) | (0.164) | (0.155) | (0.0198) | (0.0277) | (0.0378) |
| Migration cost j | -4.08e-05 | 0.00423 | 0.00327 | -0.00964 | 0.0196 | 0.00947 |
| | (0.000464) | (0.00328) | (0.00334) | (0.00987) | (0.0215) | (0.0317) |
| Fixed effects | | | | | | |
| Destination*origin i | yes | yes | yes | no | no | no |
| Destination*origin i*origin j | no | no | no | yes | yes | yes |
| Sample | Complete | $SI_{ij} > 50^{th}$ pct. | $SI_{ij} > 75^{th}$ pct. | Complete | $SI_{ij} > 50^{th}$ pct. | $SI_{ij} > 75^{th}$ pct. |
| Observations | 146,358 | 74,644 | 39,465 | 146,358 | 74,644 | 39,465 |
| R-squared | 0.668 | 0.674 | 0.681 | 0.666 | 0.670 | 0.673 |
| Number of id | 371 | 371 | 371 | | | |
| Number of dij | | | | 30,769 | 17,767 | 10,667 |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Coefficients on constant and $oc_j$ not reported
Fixed effects always included: year, destination, origin i, origin j, destination-period, origin i-period, origin j-period
Period 1: $t \leq 1999$; period 2: $2000 \leq t \leq 2003$; period 3: $t \geq 2004$

Table 5: Results on $mc_i$ and $oc_i$ with 'collapsed' dataset

| Dependent variable | ln (migrant employment) | | |
|---|---|---|---|
| Model | (1) | (2) | (4) |
| Migration cost i | -2.923*** | -2.900*** | -3.505*** |
| | (0.0374) | (0.230) | (0.269) |
| Offshoring cost i | 0.934*** | 0.498*** | 0.0114 |
| | (0.0470) | (0.0851) | (0.670) |
| Fixed effects | | | |
| Destination*origin | no | yes | yes |
| Destination*year | no | no | yes |
| Origin*year | no | no | yes |
| Observations | 4,509 | 4,509 | 4,509 |
| R-squared | 0.964 | 0.610 | 0.759 |
| Number of id | | 372 | 372 |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Coefficient on constant not reported
Fixed effects always included: year, destination, origin

# Appendices

# A Employment levels

## Ordering 1

If the ordering of tasks is as in (3.7), marginal cost is:

$$\omega(k) = \begin{cases} (w^*)\,\beta_i\chi_i(k) & 0 \le k \le O_i & (OS_i) \\ (w^*)\,\beta_j\chi_j(k) & O_i < k \le O_j & (OS_j) \\ (w^*)\,\delta_i\tau_i(k) & O_j < k \le M_i & (MIG_i) \\ (w^*)\,\delta_j\tau_j(k) & M_i < k \le M_j & (MIG_j) \\ w & M_j < k \le 1 & (NAT) \end{cases} \tag{A-1}$$

The cutoffs $O_i$, $O_j$, $M_i$ and $M_j$ are implicitly determined by the iso-cost conditions:

$$\begin{cases} [\omega(O_i)]_i^{OS} = [\omega(O_i)]_j^{OS} & \Rightarrow \quad \beta_i\chi_i(O_i) = \beta_j\chi_j(O_i) \\ [\omega(O_j)]_j^{OS} = [\omega(O_j)]_i^{MIG} & \Rightarrow \quad \beta_j\chi_j(O_i) = \delta_i\tau_i(O_j) \\ [\omega(M_i)]_i^{MIG} = [\omega(M_i)]_j^{MIG} & \Rightarrow \quad \delta_i\tau_i(M_i) = \delta_j\tau_j(M_i) \\ [\omega(M_j)]_j^{MIG} = [\omega(M_j)]^{NAT} & \Rightarrow \quad \delta_j\tau_j(M_i) = w \end{cases} \tag{A-2}$$

From (A-2), using the Implicit Function Theorem and the assumptions in (3.8), we can compute and sign the derivatives of the marginal tasks with respect to offshoring and migration costs:

$$\frac{\partial M_i}{\partial \delta_i} = -\frac{\tau_i(M_i)}{\delta_i\tau_i' - \delta_j\tau_j'} < 0 \quad \frac{\partial M_i}{\partial \delta_j} = \frac{\tau_j(M_i)}{\delta_i\tau_i' - \delta_j\tau_j'} > 0 \quad \frac{\partial M_i}{\partial \beta_i} = 0 \quad \frac{\partial M_i}{\partial \beta_j} = 0 \tag{A-3}$$

$$\frac{\partial M_j}{\partial \delta_i} = 0 \quad \frac{\partial M_j}{\partial \delta_j} = -\frac{\tau_j(M_j)}{\delta_j\tau_j'} < 0 \quad \frac{\partial M_j}{\partial \beta_i} = 0 \quad \frac{\partial M_j}{\partial \beta_j} = 0 \tag{A-4}$$

$$\frac{\partial O_i}{\partial \delta_i} = 0 \quad \frac{\partial O_i}{\partial \delta_j} = 0 \quad \frac{\partial O_i}{\partial \beta_i} = -\frac{\chi_i(O_i)}{\beta_i\chi_i' - \beta_j\chi_j'} < 0 \quad \frac{\partial O_i}{\partial \beta_j} = \frac{\chi_j(O_i)}{\beta_i\chi_i' - \beta_j\chi_j'} > 0 \tag{A-5}$$

$$\frac{\partial O_j}{\partial \delta_i} = \frac{\tau_i(O_j)}{\beta_j\chi_j' - \delta_i\tau_i'} > 0 \quad \frac{\partial O_j}{\partial \delta_j} = 0 \quad \frac{\partial O_j}{\partial \beta_i} = 0 \quad \frac{\partial O_j}{\partial \beta_j} = -\frac{\chi_j(O_j)}{\beta_j\chi_j' - \delta_i\tau_i'} < 0 \tag{A-6}$$

Labor demand for each task is:

$$N(k) = \begin{cases} \beta_i \chi_i(k) L(k) & 0 \leq k \leq O_i \\ \beta_j \chi_j(k) L(k) & O_i < k \leq O_j \\ \delta_i \tau_i(k) L(k) & O_j < k \leq M_i \\ \delta_j \tau_j(k) L(k) & M_i < k \leq M_j \\ L(k) & M_j < k \leq 1 \end{cases}$$

which, using (3.2) and (A-1), gives the following employment of immigrant, offshored and native workers:

$$\begin{cases} NO_i = \int_0^{O_i} N(k)\, dk = \kappa (\beta_i)^{1-\sigma} \phi_1 \\ NO_j = \int_{O_i}^{O_j} N(k)\, dk = \kappa \left(\beta_j\right)^{1-\sigma} \phi_2 \\ NM_i = \int_{O_j}^{M_i} N(k)\, dk = \kappa (\delta_i)^{1-\sigma} \rho_1 \\ NM_j = \int_{M_i}^{M_j} N(k)\, dk = \kappa \left(\beta_j\right)^{1-\sigma} \phi_3 \\ NN = \int_{M_j}^{1} N(k)\, dk = \lambda (1 - M_j) \end{cases}$$

where $\lambda \equiv (w)^{-\sigma} \frac{W}{\Omega^{1-\sigma}}$, $\phi_1 \equiv \int_0^{O_i} [\chi_i(k)]^{1-\sigma} dk$, $\phi_2 \equiv \int_{O_i}^{O_j} \left[\chi_j(k)\right]^{1-\sigma} dk$ and $\phi_3 \equiv \int_{M_i}^{M_j} [\tau_j(k)]^{1-\sigma} dk$.

Notice that the exact price index of the task composite $L$ is equal to:

$$\Omega \equiv w^* \left[\Phi_1 + \left(\frac{w}{w^*}\right)^{1-\sigma} (1 - O_j)\right]^{\frac{1}{1-\sigma}}$$

where $\Phi_1 \equiv (\delta_i)^{1-\sigma} \rho_1 + (\beta_i)^{1-\sigma} \phi_1 + \left(\beta_j\right)^{1-\sigma} \phi_2 + (\delta_j)^{1-\sigma} \phi_3$.

## Ordering 2

If the ordering of tasks is as in (3.13), marginal cost is:

$$\omega(k) = \begin{cases} (w^*)\,\beta_i\chi_i(k) & 0 \le k \le O_i & (OS_i) \\ (w^*)\,\delta_i\tau_i(k) & O_i < k \le M_i & (MIG_i) \\ (w^*)\,\beta_j\chi_j(k) & M_i < k \le O_j & (OS_j) \\ (w^*)\,\delta_j\tau_j(k) & O_j < k \le M_j & (MIG_j) \\ w & M_j < k \le 1 & (NAT) \end{cases} \tag{A-7}$$

The cutoffs $O_i$, $M_i$, $O_j$ and $M_j$ are implicitly determined by the iso-cost conditions:

$$\begin{cases} [\omega(O_i)]_i^{OS} = [\omega(O_i)]_i^{MIG} & \Rightarrow & \beta_i\chi_i(O_i) = \delta_i\tau_i(O_i) \\ [\omega(M_i)]_i^{MIG} = [\omega(M_i)]_j^{OS} & \Rightarrow & \delta_i\tau_i(M_i) = \beta_j\chi_j(M_i) \\ [\omega(O_j)]_j^{OS} = [\omega(O_j)]_j^{MIG} & \Rightarrow & \beta_j\chi_j(O_j) = \delta_j\tau_j(O_j) \\ [\omega(M_j)]_j^{MIG} = [\omega(M_j)]^{NAT} & \Rightarrow & \delta_j\tau_j(M_j) = w \end{cases} \tag{A-8}$$

From (A-8), using the Implicit Function Theorem and the assumptions in (3.14), we can compute and sign the derivatives of the marginal tasks with respect to offshoring and migration costs

$$\frac{\partial M_i}{\partial \delta_i} = -\frac{\tau_i(M_i)}{\delta_i\tau_i' - \beta_i\chi_i'} < 0 \quad \frac{\partial M_i}{\partial \delta_j} = 0 \quad \frac{\partial M_i}{\partial \beta_i} = 0 \quad \frac{\partial M_i}{\partial \beta_j} = \frac{\chi_j(M_j)}{\delta_i\tau_i' - \beta_i\chi_i'} > 0 \tag{A-9}$$

$$\frac{\partial O_i}{\partial \delta_i} = \frac{\tau_i(O_i)}{\beta_i\chi_i' - \delta_i\tau_i'} > 0 \quad \frac{\partial O_i}{\partial \delta_j} = 0 \quad \frac{\partial O_i}{\partial \beta_i} = -\frac{\chi_i(O_i)}{\beta_i\chi_i' - \delta_i\tau_i'} < 0 \quad \frac{\partial O_i}{\partial \beta_j} = 0 \tag{A-10}$$

$$\frac{\partial M_j}{\partial \delta_i} = 0 \quad \frac{\partial M_j}{\partial \delta_j} = -\frac{\tau_j(M_j)}{\delta_j\tau_j'} < 0 \quad \frac{\partial M_j}{\partial \beta_i} = 0 \quad \frac{\partial M_j}{\partial \beta_j} = 0 \tag{A-11}$$

$$\frac{\partial O_j}{\partial \delta_i} = 0 \quad \frac{\partial O_j}{\partial \delta_j} = \frac{\tau_j(O_j)}{\beta_j\chi_j' - \delta_j\tau_j'} > 0 \quad \frac{\partial O_j}{\partial \beta_i} = 0 \quad \frac{\partial O_j}{\partial \beta_j} = \frac{\chi_j(O_j)}{\beta_j\chi_j' - \delta_j\tau_j'} < 0 \tag{A-12}$$

Labor demand for each task is

$$N(k) = \begin{cases} \beta_i \chi_i(k) L(k) & 0 \le k \le O_i \\ \delta_i \tau_i(k) L(k) & O_i < k \le M_i \\ \beta_j \chi_j(k) L(k) & M_i < k \le O_j \\ \delta_j \tau_j(k) L(k) & O_j < k \le M_j \\ L(k) & M_j < k \le 1 \end{cases}$$

which, using (3.2) and (A-7), gives the following employment of immigrant, offshored and native workers:

$$\begin{cases} NO_i = \int_0^{M_i} N(k)\, dk = \kappa (\beta_i)^{1-\sigma} \widetilde{\phi_1} \\ NM_i = \int_{O_i}^{M_i} N(k)\, dk = \kappa (\delta_i)^{1-\sigma} \rho_2 \\ NO_j = \int_{M_i}^{O_j} N(k)\, dk = \kappa \left(\beta_j\right)^{1-\sigma} \phi_4 \\ NM_j = \int_{O_j}^{M_j} N(k)\, dk = \kappa (\delta_j)^{1-\sigma} \phi_5 \\ NN = \int_{M_j}^{1} N(k)\, dk = \lambda (1 - M_j) \end{cases}$$

where $\widetilde{\phi_1} = \phi_1$, $\phi_4 \equiv \int_{M_i}^{O_j} \left[\chi_j(k)\right]^{1-\sigma} dk$ and $\phi_5 \equiv \int_{O_j}^{M_j} \left[\tau_j(k)\right]^{1-\sigma} dk$.[26]

Notice that the exact price index of the task composite $L$ is equal to

$$\Omega \equiv w^* \left[\Phi_2 + \left(\frac{w}{w^*}\right)^{1-\sigma} (1 - M_j)\right]^{\frac{1}{1-\sigma}}$$

where $\Phi_2 \equiv (\delta_i)^{1-\sigma} \rho_2 + (\beta_i)^{1-\sigma} \widetilde{\phi_1} + \left(\beta_j\right)^{1-\sigma} \phi_4 + (\delta_j)^{1-\sigma} \phi_5$.

[26] We use the slight abuse of notation in writing $\widetilde{\phi_1} = \phi_1$ because the derivatives of $\phi_1$ are not the same in ordering 1 and in ordering 2.

# B Derivation of the results in Table 1

## Ordering 1

The negative sign in (3.10) is obtained because

$$\frac{\partial \rho_1}{\partial \delta_i} = \frac{\partial M_i}{\partial \delta_i} \left[\tau_i \left(M_i\right)\right]^{1-\sigma} - \frac{\partial O_j}{\partial \delta_i} \left[\tau_i \left(O_j\right)\right]^{1-\sigma} < 0 \tag{B-1}$$

The derivative $\frac{\partial NM_i}{\partial \beta_i}$ is predicted to be equal to zero in (3.11) because

$$\frac{\partial \rho_1}{\partial \beta_i} = \frac{\partial M_i}{\partial \beta_i} \left[\tau_i \left(M_i\right)\right]^{1-\sigma} - \frac{\partial O_j}{\partial \beta_i} \left[\tau_i \left(O_j\right)\right]^{1-\sigma} = 0 \tag{B-2}$$

The positive sign in (3.12) is obtained because

$$\frac{\partial \rho_1}{\partial \delta_j} = \frac{\partial M_i}{\partial \delta_j} \left[\tau_i \left(M_i\right)\right]^{1-\sigma} - \frac{\partial O_j}{\partial \delta_j} \left[\tau_i \left(O_j\right)\right]^{1-\sigma} > 0 \tag{B-3}$$

Notice that the signs of the derivatives above easily follow from the results in (A-3).[27]

## Ordering 2

The negative sign in (3.16) is obtained because

$$\frac{\partial \rho_2}{\partial \delta_i} = \frac{\partial M_i}{\partial \delta_i} \left[\tau_i \left(M_i\right)\right]^{1-\sigma} - \frac{\partial O_i}{\partial \delta_i} \left[\tau_i \left(O_i\right)\right]^{1-\sigma} < 0 \tag{B-4}$$

The positive sign in (3.17) is obtained because

$$\frac{\partial \rho_2}{\partial \beta_i} = \frac{\partial M_i}{\partial \beta_i} \left[\tau_i \left(M_i\right)\right]^{1-\sigma} - \frac{\partial O_i}{\partial \beta_i} \left[\tau_i \left(O_i\right)\right]^{1-\sigma} > 0 \tag{B-5}$$

[27] Using the results in (A-3)-(A-6) and (A-9)-(A-12), it is possible to sign all the derivatives of migrant and offshore employment from countries $i$ and $j$ and native employment with respect to $\delta_i$, $\delta_j$, $\beta_i$ and $\beta_j$. Here and in the next subsection on ordering 2, we only report the results in (B-1)-(B-3) and (B-4)-(B-6) because they are the focus of the empirical application.

The derivative $\frac{\partial NM_i}{\partial \delta_j}$ is predicted to be equal to zero in (3.18) because

$$\frac{\partial \rho_2}{\partial \delta_j} = \frac{\partial M_i}{\partial \delta_j} \left[\tau_i \left(M_i\right)\right]^{1-\sigma} - \frac{\partial O_i}{\partial \delta_j} \left[\tau_i \left(O_i\right)\right]^{1-\sigma} = 0 \tag{B-6}$$

Again, the signs of the derivatives above easily follow from the results in (A-9).

# C Elasticity of substitution

The estimation of the elasticity of substitution among tasks in a production function with a continuum of tasks is a theoretical exercise which is hardly amenable to empirical estimation. Wright (2011) argues that the choice of such elasticity can be narrowed down by using the elasticity between manual and communication tasks estimated by Peri and Sparber (2009). Their estimate is between 0.63 and 1.42, depending on the model specification. As argued by Wright (2011), most tasks are likely more substitutable on the task continuum than these two broad task types. Therefore, the upper bound, which is larger than one, seems to be a sensible estimate for $\sigma$ in our model.

The results of some studies that have estimated the elasticity of substitution between workers of different education levels at values between 1.5 and 2 (Angrist, 1995; Ciccone and Peri, 2005) also support the assumption $\sigma > 1$. Moreover, a wide literature has estimated elasticities of substitution among three factors in a CES production function with physical capital and two types of labor: white and blue collar. In a *Journal of Labor Economics* article, Chiswick (1985) concludes: "[...] when human capital is properly specified in the aggregate production function, the elasticity of factor substitution is greater than unity. [...] This production function has three factors (physical capital, high level human capital and other human capital) and is characterized by a moderately high elasticity of substitution (about 2.5) between each pair of factors". The fact that, with a continuum of tasks, there is likely more substitutability than across three factors of production further justifies the assumption that $\sigma$ is larger than one.

# D Results of gravity regressions

## Migration gravity

The estimated equation for migration flows is:

$$\ln\left(\frac{immi\_flow_{odt}}{population_{dt}}\right) = \alpha_t + \alpha_{ot} + \alpha_{dt} + x'_{odt}\beta + \varepsilon_{odt} \tag{E-1}$$

Fitted values do not include the contribution of the fixed effects in explaining migration flows because they may not necessarily reflect the cost of migration. Drawing from literature on the determinants of migration flows from origin country $o$ to destination $d$ (see for instance Mayda, 2010), the vector $x$ of explanatory variables (sources of migration costs) includes the following bilateral variables: geographic distance, dummies for common border, common language and past colonial relationship, the stock of migrants in country $d$ from country $o$ (in logs), difference in per capita GDP between $o$ and $d$ (in logs) and a dummy for the existence of a preferential trade agreements between $d$ and $o$, containing provisions on trade in services (GATS mode IV), visa and asylum or labor market regulation. This is a variable capturing the effect of migration policies (within preferential trade agreements) on migration costs. We also include controls for per capita GDP (in logs) in $d$ and $o$ (not reported in Table E-1) and a set of year ($\alpha_t$), origin country-year and destination country-year ($\alpha_{ot}$ and $\alpha_{dt}$) fixed effects.[28] Geographic distance is expected to be a source of migration costs while common border, language and colony have been thought as cost-reducing factors. The stock of migrants in destination country reduces the cost of migration because it makes the assimilation of new migrants easier. Difference in per capita GDP between destination and origin country reduces the resistance to migrate for potential migrants. Similarly having a PTA including provisions on trade in services (GATS mode IV), or provisions on visa or labor market regulation should facilitate bilateral migration. According with the former expectations, results show that geographic distance discourages migration flows, which conversely are stimulated by common language and past colonial relationship between home and partner country (see column (1) of Table E-1). We also find a strong network and income effect: the stock of immigrants in home country and the difference in per capita GDP with respect the partner country increase flows of migrants.

[28] Country pair fixed effects could not be included in the estimation since they would prevent us to use geographic explanatory variables, which have been highlighted as crucial sources of migration costs in the relevant literature.

Finally, there is a strong positive effect of PTA on migration flows, suggesting that the latter are significantly affected by policies. Having a PTA containing migration-related provision stimulates bilateral migration flows by $exp\,(0.435) - 1 = 0.54\%$.

### Offshoring gravity

The estimated equation for offshoring flows is:

$$\ln\,(tpc)_{odt} = \theta_t + \theta_{ot} + \theta_{dt} + z_{odt}^{'}\gamma + \varepsilon_{odt} \tag{E-2}$$

where, following Yeats (2001) and Hummels et al. (2001), we use trade in parts and components (*tpc*) as a proxy for offshoring.[29] Similarly to the migration gravity, we exclude fixed effects from the computation of fitted values. As potential sources of offshoring costs, we include in the vector $z$ geographic variables such as distance, common border, common language and past colonial relationship dummies. We include also the difference in per capita GDP between $o$ and $d$ (in logs) as a proxy for the difference in labor cost – which has been shown as a good explanatory variable for offshoring activities (see for instance Hanson, Mataloni, and Slaughter, 2005) – and the stock of existing FDI as a proxy for the information that firms in country $d$ own about partner country $o$. Finally, we include a dummy for the presence of a bilateral investment treaty (BIT) between $d$ and $o$. This is a policy variable capturing the potential facilitation effect on offshoring of such treaties. The estimated regression, but not its fitted values approximating the offshoring costs, also includes a set of year ($\theta_t$), origin country-year and destination country-year ($\theta_{ot}$ and $\theta_{dt}$) fixed effects. Results show that distance deters offshoring activities (i.e. increases offshoring costs) while common language, border and colonial relation reduce offshoring cost by favoring trade in parts and components (see column (2) of Table E-1). As expected, the higher the difference in income between $d$ and $o$, the higher the incentive to offshore activities to country $o$. Finally, the presence of a BIT stimulates offshoring by $exp\,(0.174) - 1 = 0.19\%$.

[29] We employ the methodology described in World Trade Organization (2011, pp. 64-5) to define parts and components. They are the SITC Rev. 3 equivalent of codes 42 and 53 in the Broad Economic Categories (BEC) classification, supplemented with unfinished textile products in division 65 of the SITC classification.

Table E-1: Results of migration and offshoring gravities

| Model | (1) | (2) |
|---|---|---|
| Dependent variable | $\ln\left(\frac{immi\_flow}{population}\right)$ | $\ln(tpc)$ |
| Distance | -0.256*** | -1.325*** |
| | (0.0455) | (0.0331) |
| Common border | -0.103 | 0.811*** |
| | (0.0953) | (0.0967) |
| Colony 1945 | 0.916*** | 1.206*** |
| | (0.140) | (0.0860) |
| Common language | 0.356*** | 0.421*** |
| | (0.0678) | (0.0610) |
| GDP difference | 0.0796** | 0.172*** |
| | (0.0402) | (0.0610) |
| PTA | 0.539*** | |
| | (0.101) | |
| BIT | | 0.174*** |
| | | (0.0426) |
| Stock of migrants | 0.512*** | |
| | (0.0176) | |
| FDI stock | | 0.406*** |
| | | (0.112) |
| Observations | 3,923 | 10,346 |
| R-squared | 0.914 | 0.844 |

Robust standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$
Year, destination-year and origin-year fixed effects always included

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