Immigration, Offshoring and American Jobs

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Abstract

Increased immigration and offshoring over the last decades has generated deep concerns about the effect of both phenomena on the jobs of American workers. How many "American jobs" are taken away from US-born workers due to immigration and offshoring? Or is it possible, instead, that immigration and offshoring, by promoting cost-savings and enhanced efficiency in firms, spur the creation of native jobs? We consider a multi-sector version of the Grossman and Rossi-Hansberg (2008) model with a continuum of tasks in each sector and we augment it to include immigrants with heterogeneous productivity in tasks. We use this model to jointly analyze the impact of a reduction in the costs of offshoring and of the costs of immigrating to the U.S. The model, with resonable parameter restrictions, predicts that while cheaper offshoring reduces the share of natives among less skilled workers, cheaper immigration does not, but rather reduces the share of offshored jobs instead. Moreover, since both phenomena have a positive "cost-savings" effect they may leave unaffected, or even increase, total native employment of less skilled workers. Our model also predicts that offshoring will push natives toward jobs that are more intensive in communication-interactive skills and away from those that are intensive in manual-routine skills. We test the predictions of the model on data for 58 manuafacturing industries over the period 2000-2007 and find evidence in favor of a positive productivity effect such that immigration has a positive net effect on native employment while offshoring has no effect on it. We also find some evidence that offshoring has pushed natives toward more communication-intensive tasks while it has pushed immigrants away from them.

Key Words: Employment, production tasks, immigrants, offshoring

JEL Codes: F22, F23, J24, J61.

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1 Introduction

The relocation of jobs abroad by multinationals and increased labor market competition due to immigrant workers are often credited with the demise of many manufacturing jobs, once held by American citizens. While it is certainly true that manufacturing production and employment, as a percentage of the total economy, have declined over recent decades in the U.S., measuring the impact of globalization on jobs has been difficult. The reason is that, on the one hand, offshoring some production processes or hiring immigrants to perform them directly reduces the demand for native workers, while on the other hand the cost-savings effect of such restructuring of production increases the productivity and size of firms and improves their competitiveness. As a consequence, this process may indirectly increase the demand for native workers, if not exactly in the same tasks that were offshored and given to immigrant workers, then certainly in tasks that are complementary to them. Several recent papers have emphasized the potential cost-savings effect of offshoring (Grossman and Rossi-Hansberg 2008, Harrison and McMillan 2009, Wright 2009) arguing that this effect could reverse the "direct displacement effect" on employment and thereby generate a net increase in employment for less educated native workers. Other papers (Peri and Sparber 2009, Peri 2009) have suggested that immigrants may generate similar productivity-enhancing effects by increasing the demand for less educated native workers, especially in production tasks that are complementary to those performed by immigrants.

This paper develops a model and presents empirical evidence with respect to 58 U.S. manufacturing industries over the period 2000-2007 in order to make progress on two important questions. First, how did the decrease in offshoring and immigration costs, accompanied by the higher share in jobs contested by offshore and immigrant workers, affect the employment of native workers within manufacturing sectors? Second, what kinds of production tasks suffered most from the competition created by offshore and immigrant workers and what kinds of tasks benefited (if any)? Our model features a manufacturing sector in which native, immigrant and offshore workers compete to perform a range of productive tasks (and the associated jobs) in each sub-sector of manufacturing. Building on Grossman and Rossi-Hansberg (2008) the model predicts that lower costs of offshoring and immigration in a sub-sector of manufacturing will increase, respectively, the share of offshore and immigrant workers in production in that sector. However, since those workers perform their tasks at a lower cost for the firm, an increase in the share of "globalized" jobs also leads to an expansion of the sector (productivity effect), increasing total employment in it and possibly even increasing the overall employment of native workers (although not their share in the sector). The model, by arraying productive tasks from manual- and routine-intensive to cognitive-, communication-, and non-routine-intensive and postulating that the productivity of immigrants and cost of offshoring are respectively decreasing and increasing along this spectrum, provides predictions on the range of tasks that will be performed by immigrants, those that will be offshored, and those that will be performed by natives. Moreover, the model makes predictions regarding the impact on

the "average task" (in the spectrum) performed by natives (and immigrants) and on its level of employment when offshoring (and immigration) costs decline.

The model focuses on employment effects. It assumes a manufacturing economy with many sub-sectors and one factor (unskilled workers) this is mobile across sectors and another (skilled workers, or knowledge, or capital) that is fixed for each sector. In this way, all the testable effects of offshoring and immigration that differ across sub-sectors are translated into differential employment effects (for natives) due to the fact that since wages are equalized across sectors the common effect on wages cannot be estimated. In particular, the model has three main predictions with respect to employment and the average tasks performed by natives and immigrants. First, in equilibrium each manufacturing sector offshores the "intermediate tasks" (in the manual-routine to cognitive-non-routine spectrum), hires immigrants for the more manual-routine tasks, and hires natives for the more cognitive-non-routine ones. Hence, a decrease in offshoring costs increases the range of offshored tasks, reducing the share of tasks performed by natives and immigrants, and pushing natives towards more cognitive-intensive tasks and immigrants towards more manual-intensive tasks. Second, a decrease in immigration costs increases the share of tasks performed by immigrants, reduces those that are offshored by absorbing some of the most manual-intensive tasks previously done offshore, but has only a small or no effect on the share of employment (and the average task) of native workers. Immigrants, in other words, compete more with offshore workers than with native workers due to their more "extreme" specialization in manual jobs relative to natives, who are concentrated in the communication-cognitive part of the spectrum. Thus, lower immigration costs leads to substitution of immigrants for offshore workers. Third, and most importantly, lower costs of offshoring and immigration produce cost-savings and, therefore, productivity-enhancing effects for the sector. This increases its total labor demand, offsetting either partially or totally the negative effect on the labor share of natives so that total native employment of less educated workers may be unaffected or even expanded as a consequence of either cost reduction.

We test the predictions of the model using employment data from two different sources. The American Community Survey (ACS) data (2000-2007) allow us to measure the employment of natives and foreign-born in manufacturing for each of 58 industries in the U.S. Next, the Bureau of Economic Analysis (BEA) dataset on the operations of U.S. multinationals allows us to measure employment in U.S. multinational affiliates abroad for the same 58 industries over the same period. We then look at the impact of increased ease of offshoring and ease of immigration on each type of employment in a sector (immigrants, natives and offshore workers). Following Feenstra and Hanson (1999) we define the "ease of offshoring" as the share of intermediate inputs that are imported. This varies across industries and over the considered period. Following Card (2001) we consider as "ease of immigration" the constructed share of immigrants in a sector, using the composition of immigrant workers in the sector by nationality in 2000 and the growth of immigrants for each national group. The

underlying assumption is that these two indicators vary, respectively, with the costs of offshoring (which varies across sectors in relation to its reliance on foreign-produced inputs) and with the cost of immigration (which varies by country of origin and affects sectors unevenly according to the initial distribution of immigrants). We find that an increase in the ease of offshoring reduces the share of both native and immigrant workers in total sector employment while an increase in the ease of immigration reduces the share of offshore workers with no impact on the share of native workers. However, looking at employment levels (rather than shares) an increase in the ease of offshoring does not have an effect on the employment of natives in a sector whereas an increase in the ease of immigration has a positive impact on it. This is consistent with, and in fact it is a test of, the existence of a positive productivity effect due to immigration and offshoring within manufacturing sectors. Finally, by matching occupation data from the ACS with the content of "manual", "communication" and "cognitive" skills (and routine and non-routine activities) from the O*NET database we can assess the response of the average task performed by native and immigrants workers (on a manual and routine-cognitive and non-routine scale). Our final finding is that an increase in offshoring pushes the average task performed by natives towards higher cognitive and non-routine content and the average task of immigrants towards more manual and routine content. In contrast, an increase in the share of immigrants has no effect on the average task performed by natives. The empirical results together imply that immigrant workers do not compete much with natives since they specialize in manual tasks, so that an increase in immigrants is more likely to reduce the range of offshored tasks in a sector without affecting the employment level and type of tasks performed by natives. Offshore workers, on the other hand, compete more directly with natives and so an increase in offshoring pushes natives towards more cognitive-intensive tasks. However, the positive productivity effect of offshoring eliminates any negative effect on native employment. In sum, over the period 2000-2007, manufacturing sectors that increased their global participation (by offshoring more and hiring more immigrants) were more likely to increase employment of natives than those that did not.

The rest of the paper is organized as follows. Section 2 presents the model and derives the main results and predictions. Section 3 presents the data, describing sources and trends. Section 4 produces the empirical evidence on the model's predictions. Section 5 concludes the paper.

2   A Labor Market Model of Task Allocation

Consider an economy consisting of several sectors, indexed $s = 1, .., S$. Each sector is not large enough to affect aggregate factor prices. All markets are perfectly competitive and all technologies are constant returns to scale. We focus on a sector and leave both the sector index s and the time dependence of variables t implicit for ease of notation. We will make them explicit when we get to the empirics.

2.1 Production Choices

There are two primary factors, high skill workers (with employment level N_H) and low skill workers (with employment level N_L), with the former being sector-specific. Each worker is endowed with one unit of labor. High and low skill workers are employed in the production of high skill intermediates (called 'H-tasks') and low skill intermediates (called 'L-tasks'), which are then assembled in a high skill composite input (H) and a low skill composite input (L), respectively. The two composite inputs are then transformed into final output (Y) by the following Cobb-Douglas production function

$$Y = AL^\alpha H^{1-\alpha} \tag{1}$$

where A is a technological parameter.

Each composite input is produced by assembling a fixed measure (normalized to 1) of horizontally differentiated tasks (indexed $i \in [0,1]$). In particular, the low skill composite is assembled through the following CES technology

$$L = \left[\int_0^1 L\left(i\right)^{\frac{\sigma-1}{\sigma}} di \right]^{\frac{\sigma}{\sigma-1}} \tag{2}$$

where $L\left(i\right)$ is the input of task i and $\sigma > 0$ is the elasticity of substitution between tasks. An analogous expression holds for the high skill composite.[1]

All goods are freely traded and there are two possible locations for production, home and abroad. Each L-task can be managed in three modes: domestic production by native workers (D), domestic production by immigrant workers (M) and production abroad by offshore workers (O). Low skill native, immigrant and offshore workers are perfectly substitutable in L-tasks so that in equilibrium any L-task will be performed by only one type of worker: the one that yields the lowest marginal cost. In contrast, H-tasks are assumed to be prohibitively expensive to perform by immigrant and offshore workers. The underlying idea is that H-tasks require language and relational skills that foreign-born workers lack or find too expensive to acquire.[2]

L-tasks are defined so that they all require the same unit labor requirement a_L when performed by native workers. If task i is offshored, its unit input requirement is $\beta t(i)a_L$, with $\beta t(i) \geq 1$ and $t'(i) \geq 0$ so that higher i corresponds to higher offshoring costs. Hence, $1/\left[\beta t(i)a_L\right]$ is the marginal productivity of offshore workers and varies across tasks depending on their "offshorability". The parameter $\beta \geq 1$, which is common to all tasks, can be used to capture technological change that decreases the cost of offshoring. Due to perfect substitutability among the three groups of low skilled workers, a task is offshored rather than performed by natives whenever

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[1] In Grossman and Rossi-Hansberg (2008) tasks are not substitutable. This corresponds to the limit case of $\sigma = 0$ where (2) becomes a Leontief production function.

[2] We focus on the extreme case in which H-tasks can be performed only by native workers for parsimony. By analogy our analysis can be readily extended to the case in which immigrant and offshore workers can also perform those tasks.

offshoring is cheaper:

$$w \geq w^* \beta t(i) \tag{3}$$

where w and w^* are the domestic and foreign wages, respectively. Assuming $w > w^* \beta t(0)$ ensures that at least some task is offshored.

Additionally, when assigning tasks to immigrants firms face a task-specific cost $\tau(i) \geq 1$ implying that immigrants' marginal productivity in task i is $1/a_L \tau(i)$. The underlying idea is that immigrants are better at some tasks (such as manual-routine tasks) than others (such as cognitive-communication tasks) depending on relational content. We assume that $\tau'(i) \geq 0$ so that there is a positive correlation between the offshorability of a task and its cognitive-communication intensity. We will come back to this issue in the empirics.

A task is assigned to an immigrant rather than a native whenever it is cheaper to do so:

$$w^{\maltese} \tau(i) \leq w \tag{4}$$

where $w^{\maltese} < w$ is the wage per unit of immigrant labor. The discrepancy between $w^{\maltese}$ and w implies that firms are able to discriminate between natives and immigrants in the home labor market.[3]

Assigning a task to an immigrant also requires that foreign workers are willing to migrate and accept the job. This is the case whenever

$$\frac{w^{\maltese}}{\delta} \geq w^* \tag{5}$$

where $\delta \geq 1$ captures a frictional cost incurred by the immigrant as they may lose some skills and productivity by moving to the country of destination. In other words, an immigrant endowed with one unit of labor in her country of origin is able to provide only $1/\delta$ units of labor in the country of destination. As firms are able to discriminate among workers, they pay immigrants the lowest wage compatible with their participation constraint (5). This implies $w^{\maltese} = w^* \delta$, which allows us to rewrite (4) as:

$$w^* \delta \tau(i) \leq w \tag{6}$$

To conclude the comparisons between the different production modes, we need to state the condition under which a task is offshored rather than performed by immigrants. This is the case whenever offshore workers are more productive than immigrants:

$$\beta t(i) \leq \delta \tau(i) \tag{7}$$

---

[3]If this possibility is removed, then immigration will not have a "productivity effect" on native wages as shown by Grossman and Rossi-Hansberg (2008). There is much empirical evidence that, for similar observable characteristics, immigrants are paid a lower wage than natives. Using data from the 2000 Census, Antecol, Cobb-Clark and Trejo (2003), Butcher and DiNardo (2004) and Chiswick, Le and Miller (2008) all show that recent immigrants from non-English speaking countries earn on average 17 to 20% less than natives with identical observable characteristics. Hendricks (2002) also shows that the immigrant-native wage differential, controlling for observable characteristics, is highly correlated with the wage diferential between the US and their country of origin.

2.2 Task Allocation

Conditions (3), (6) and (7) clearly suggest that the allocation of tasks among the three types of workers depends on the wages (w and w^*), the sector specific frictional cost parameters (β and δ), and the shapes of the task-specific costs ($t(i)$ and $\tau(i)$). To avoid a tedious taxonomy of subcases, we characterize the equilibrium of the model under a set of "working hypotheses" whose relevance will be discussed in the empirics. Nonetheless, although the following arguments are general, they could be readily applied to alternative hypotheses.

In particular, we assume that $\gamma\tau'(i) \geq \beta t'(i)$ so that as i increases the difficulty of assigning a task to immigrants rises faster than the difficulty of offshoring it. We further assume that $\delta\gamma\tau(0) < \beta t(0)$ so that the first task is more difficult to offshore than to assign to immigrants. These two assumptions capture the idea that assigning simple tasks to immigrants incurs a lower set-up cost than offshoring them. However, as the variety and 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.

Denote native, immigrant and offshore marginal costs as $c_D = wa_L$, $c_M(i) = w^*\delta\tau(i)a_L$ and $c_O(i) = w^*\beta t(i)a_L$, respectively. Then, our working hypotheses ensure that, when represented as a function of i, $c_M(i)$ and $c_O(i)$ cross only once, with the former cutting the latter from below. Single crossing then implies that there exists only one value of i such that $c_O(i) = c_M(i)$ and (7) holds with equality. This value defines the "marginal immigrant task" I_{MO} such that

$$\beta t(I_{MO}) = \delta\gamma\tau(I_{MO}) \tag{8}$$

For all tasks $i \leq I_{MO}$ it is cheaper to employ immigrants than offshore workers (i.e. $c_M(i) < c_O(i)$). For all tasks with $i \geq I_{MO}$ employing immigrants is more expensive (i.e. $c_M(i) > c_O(i)$).

Finally, for all three modes to be adopted for some tasks in equilibrium we assume that $c_O(I_{MO}) = c_M(I_{MO}) < c_D < c_M(1)$. This allows us to determine the "marginal offshore task" I_{NO} satisfying (3) with equality:

$$w = w^*\beta t(I_{NO}) \tag{9}$$

with $\beta t(I_{NO}) \geq 1$.

The allocation of tasks among the three groups of workers is portrayed in Figure 1, where the task index i is measured along the horizontal axis and the production costs along the vertical axis. The flat line corresponds to c_D and the upward sloping curves correspond to $c_M(i)$ and $c_O(i)$, with the former starting from below but steeper than the latter. Since each task employs only the type of workers yielding the lowest marginal cost, tasks from 0 to I_{MO} are assigned to immigrants, tasks from I_{MO} to I_{NO} are offshored, and tasks from I_{NO} to 1 are assigned to natives.

$c_M(i), c_O(i), c_D$

$c_M(i) = w^* \delta \tau(i) a_L$

$c_O(i) = w^* \beta t(i) a_L$

$c_N = w a_L$

I_{MO}

I_{NO}

0

Immigrant Workers
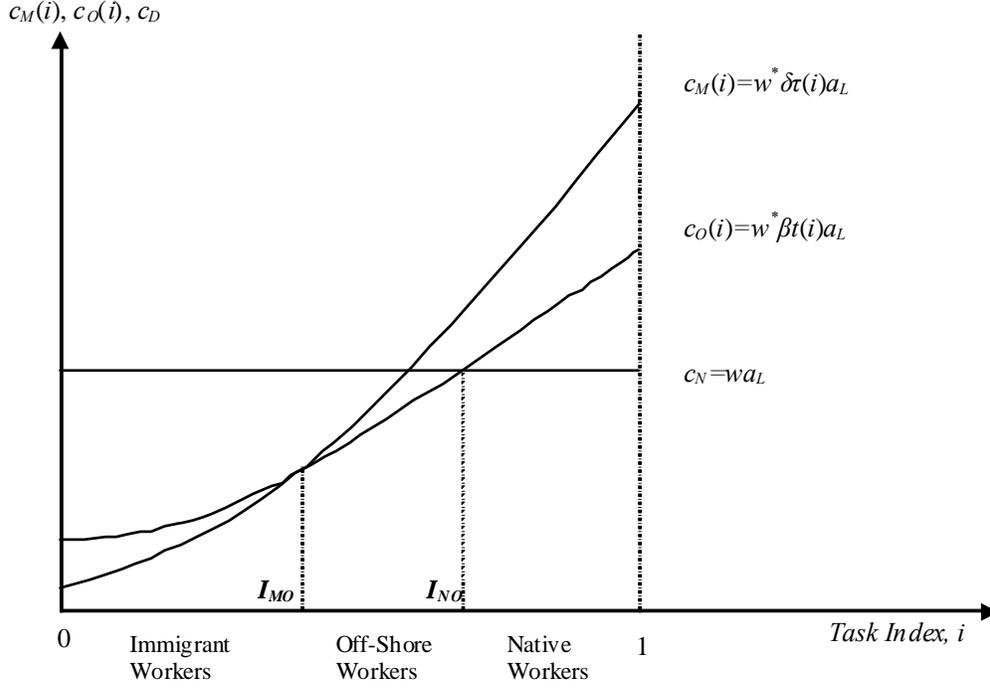
Off-Shore Workers

Native Workers

1

Task Index, i

Figure 1: Unit Costs in the Task Range

2.3 Employment Levels and Shares

Given the above allocation of tasks, marginal cost pricing implies that tasks are priced as follows

$$
p\left(i\right) = \begin{cases}
c_M(i) = w^* \delta \tau(i) a_L & 0 \leq i < I_{MO} \\
c_O(i) = w^* \beta t(i) a_L & I_{MO} \leq i < I_{NO} \\
c_D = w a_L & I_{NO} < i \leq 1
\end{cases}
$$

Then, by (1) and (2), the demand for task i is

$$
L(i) = \left[\frac{p\left(i\right)}{P_L} \right]^{-\sigma} (P_L)^{-\frac{1}{1-\alpha}} (\alpha p_Y A)^{\frac{1}{1-\alpha}} H
$$

where P_L is the exact price index of the low skill composite, defined as

$$
P_L = a_L \left\{ \int_0^{I_{MO}} [\delta \tau(i) w^*]^{1-\sigma} \, di + \int_{I_{MO}}^{I_{NO}} [\beta t(i) w^*]^{1-\sigma} \, di + (1 - I_{NO}) w^{1-\sigma} \right\}^{\frac{1}{1-\sigma}}
$$

8

Since $i \in [0,1]$, P_L is also the average price (and average marginal cost) of low skill tasks.[4]

Taking into account the different marginal productivity of the three groups of workers, the amount of labor demanded to perform task i is

$$
N(i) = \begin{cases} a_L \delta \tau(i) L(i) & 0 \leq i < I_{MO} \\ a_L \beta t(i) L(i) & I_{MO} \leq i < I_{NO} \\ a_L L(i) & I_{NO} < i \leq 1 \end{cases}
$$

so that immigrant, offshore and native employment levels are given by

$$
N_M = \int_0^{I_{MO}} N(i)\, di = \frac{1}{w^*} \left(\frac{P_M}{P_L} \right)^{1-\sigma} (P_L)^{-\frac{\alpha}{1-\alpha}} B \tag{10}
$$

$$
N_O = \int_{I_{MO}}^{I_{NO}} N(i)\, di = \frac{1}{w^*} \left(\frac{P_O}{P_L} \right)^{1-\sigma} (P_L)^{-\frac{\alpha}{1-\alpha}} B
$$

$$
N_D = \int_{I_{NO}}^1 N(i)\, di = \frac{1}{w} \left(\frac{P_D}{P_L} \right)^{1-\sigma} (P_L)^{-\frac{\alpha}{1-\alpha}} B
$$

where $B = (\alpha p_Y A)^{\frac{1}{1-\alpha}} H > 0$ is a combination of parameters and exogenous variables and the exact price indices of immigrant, offshore and native tasks are given by

$$
P_M = a_L \left\{ \int_0^{I_{MO}} [\delta \tau(i) w^*]^{1-\sigma}\, di \right\}^{\frac{1}{1-\sigma}}, \quad P_O = a_L \left\{ \int_{I_{MO}}^{I_{NO}} [\beta t(i) w^*]^{1-\sigma}\, di \right\}^{\frac{1}{1-\sigma}}, \quad P_D = a_L \left\{ (1 - I_{NO}) w^{1-\sigma} \right\}^{\frac{1}{1-\sigma}}
$$

Note that N_M is the number of immigrants employed whereas, due to the frictional migration cost, the corresponding number of units of immigrant labor is N_M/δ. Hence, sector employment is $N_L = N_M + N_O + N_D$. The shares of the three groups of workers in sectorial employment are thus

$$
s_M = \frac{(P_M)^{1-\sigma}}{(P_M)^{1-\sigma} + (P_O)^{1-\sigma} + (P_D)^{1-\sigma}(w^*/w)} \tag{11}
$$

$$
s_O = \frac{(P_O)^{1-\sigma}}{(P_M)^{1-\sigma} + (P_O)^{1-\sigma} + (P_D)^{1-\sigma}(w^*/w)}
$$

$$
s_D = \frac{(w^*/w)(P_D)^{1-\sigma}}{(P_M)^{1-\sigma} + (P_O)^{1-\sigma} + (P_D)^{1-\sigma}(w^*/w)}
$$

While (8) and (9) identify the marginal tasks as cutoffs between tasks performed by different groups of workers,

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[4]Using (9) we can rewrite the low skill composite price index as $P_L = w a_L \Omega(I_{MO}, I_{NO})$ with

$$
\Omega(I_{MO}, I_{NO}) = \left\{ \int_0^{I_{MO}} \left[\frac{\delta \tau(i)}{\beta t(I_{NO})} \right]^{1-\sigma}\, di + \int_{I_{MO}}^{I_{NO}} \left[\frac{t(i)}{t(I_{NO})} \right]^{1-\sigma}\, di + (1 - I_{NO}) \right\}^{\frac{1}{1-\sigma}}
$$

This highlights the relationship between P_L and the bundling parameter Ω in Grossman and Rossi-Hansberg (2008), which we encompass as a limit case when σ goes to zero and δ goes to infinity.

the distinction is not so stark in reality. For the empirical analysis, it is therefore also useful to characterize the "average task" performed by each group. This is defined as the employment-weighted average across the corresponding i's:

$$
\begin{aligned}
I_M &= \frac{\int_0^{I_{MO}} iN(i)\,di}{N_M} = \frac{\int_0^{I_{MO}} i\tau(i)^{1-\sigma}\,di}{\int_0^{I_{MO}} \tau(i)^{1-\sigma}\,di} \\
I_O &= I_{MO} + \frac{\int_{I_{MO}}^{I_{NO}} iN(i)\,di}{N_O} = I_{MO} + \frac{\int_{I_{MO}}^{I_{NO}} it(i)^{1-\sigma}\,di}{\int_{I_{MO}}^{I_{NO}} t(i)^{1-\sigma}\,di} \\
I_D &= I_{NO} + \frac{\int_{I_{NO}}^{1} N(i)\,di}{N_D} = \frac{I_{NO}+1}{2}
\end{aligned}
\tag{12}
$$

2.4 Comparative Statics

We are interested in how marginal and average tasks as well as employment shares and levels vary across the three types of workers when offshoring and migration costs change.

From (8) and (9), our working hypotheses imply that marginal tasks exhibit the following properties:

$$
\begin{aligned}
\frac{\partial I_{NO}}{\partial \beta} &< 0, \frac{\partial I_{MO}}{\partial \beta} > 0 \\
\frac{\partial I_{NO}}{\partial \delta} &= 0, \frac{\partial I_{MO}}{\partial \delta} < 0
\end{aligned}
$$

These highlight the adjustments in employment occurring in terms of the number of tasks allocated to the three groups of workers. They can be readily interpreted using Figure 1. For example, a reduction in offshoring costs (lower β) shifts $c_O(i)$ downward, thus increasing the number of offshored tasks through a reduction of both the number of tasks assigned to immigrants ($\partial I_{MO}/\partial\beta > 0$) and the number of tasks assigned to natives ($\partial I_{NO}/\partial\beta < 0$). Analogously, a reduction in the migration costs (lower δ) shifts $c_M(i)$ downward, thus increasing the number of tasks assigned to immigrants through a decrease in the number of offshored tasks (higher I_{MO}). Accordingly, given (12) we also have the following properties for average tasks:

$$
\begin{aligned}
\frac{\partial I_D}{\partial \beta} &< 0, \frac{\partial I_M}{\partial \beta} > 0 \\
\frac{\partial I_M}{\partial \delta} &< 0, \frac{\partial I_O}{\partial \delta} < 0
\end{aligned}
\tag{13}
$$

These are driven by compositional changes due to adjustments both in the number of tasks allocated to the three groups and in the employment shares of the different tasks allocated to the three groups. Note that changes in migration costs have no impact on the average native task ($\partial I_D/\partial\delta = 0$). The impact of offshoring costs on the

average offshore task $(\partial I_O/\partial\beta)$ is, instead, ambiguous. This is due to opposing adjustments in the allocation of tasks given that when β falls some of the additional offshore tasks have low i (i.e. I_{MO} falls) while others have high i (i.e. I_{NO} rises).

Looking at (11), the impacts of declining β and δ on employment shares are all unambiguous. By making offshore workers more productive and therefore reducing the price index of offshore tasks relative to all tasks, a lower offshoring cost β reallocates tasks from immigrants and natives to offshore workers. By reducing the price index of immigrant tasks relative to all tasks, a lower migration cost δ moves tasks away from offshore and native workers toward immigrants:

$$
\begin{aligned}
\frac{\partial s_M}{\partial\beta} &> 0, \frac{\partial s_O}{\partial\beta} < 0, \frac{\partial s_D}{\partial\beta} > 0 \\
\frac{\partial s_M}{\partial\delta} &< 0, \frac{\partial s_O}{\partial\delta} > 0, \frac{\partial s_D}{\partial\delta} > 0
\end{aligned}
\tag{14}
$$

We call these the "relative productivity effects" on low skill workers.

Finally, turning to the impact of declining β and δ on employment levels, expressions (10) reveal an additional effect beyond the substitution among groups of workers in terms of employment shares. This is due to the fact that lower β and δ ultimately cause a fall in the price index P_L of the low skill composite because, as a whole, low skill workers become more productive. We call this the "absolute productivity effect" on low skill workers Specifically, as is evident by the term $(P_L)^{-\frac{1}{1-\alpha}}$ on the right hand side of (10), a fall in the price index of the low skill composite has a positive impact on sectorial employment (through the absolute productivity effect), which is then distributed across groups depending on how the relative price indices P_M/P_L, P_O/P_L and P_D/P_L vary (via the relative productivity effect). Note that, given $(P_L)^{1-\sigma} = (P_M)^{1-\sigma} + (P_O)^{1-\sigma} + (P_D)^{1-\sigma}$, P_L cannot change when P_M, P_O and P_D are all fixed. This is why we have chosen not to collect the P_L terms in (10), allowing us to disentangle the absolute and relative productivity effects.

The impact of declining β and δ on employment levels can be signed only when the absolute productivity effect and the relative productivity effect go in the same direction. In particular, since $\partial P_L/\partial\beta > 0$ and $\partial P_L/\partial\delta > 0$, we have

$$
\frac{\partial N_O}{\partial\beta} < 0, \frac{\partial N_M}{\partial\delta} < 0
$$

while the signs of $\partial N_M/\partial\beta$, $\partial N_D/\partial\beta$, $\partial N_O/\partial\delta$ and $\partial N_D/\partial\delta$ are generally ambiguous. In other words, whether the absolute productivity effect is strong enough to offset the relative productivity effect for all groups of workers is an empirical question that we will address in the next sections. Lower β and δ certainly raise sector employment $N_L = N_M + N_O + N_D$, as only the absolute productivity effect matters in this case.

3 Data

In order to make operational the predictions of the model we need to provide an empirical definition and empirical measures for three sets of variables. First, we need to measure employment of less-skilled workers in each sector-year, identifying separately native workers operating in the U.S. (D), immigrant workers operating in the U.S. (M) and workers operating abroad for U.S. multinationals or sub-contracting for them (O). Second, we need a measure of the average intensity of production tasks performed by less-skilled native workers (I_D), offshore workers (I_O) and immigrant workers (I_M). Third, we need to construct an index or a proxy for the offshoring costs β and for the immigration costs δ by sector in each year. It turns out that to produce these variables using a consistent and comparable sector classification we need to merge data on multinational employment from the BEA, data on imports of intermediate goods from Feenstra et al. (2002) and data on native and foreign-born workers from the IPUMS samples of the Census and the American Community Survey. The only years for which this merge can be done consistently and reliably are the years 2000-2007, and we therefore use these as our sample. We will describe each set of variables and their trends and summary statistics in the sections 3.1, 3.2 and 3.3 below. Section 4 uses these variables to test empirically the main predictions of the model.

3.1 Employment and Shares

The data on offshore employment are obtained by adding up two groups of workers. We start with data on U.S. Direct Investment Abroad from the BEA which collects data on the operations of U.S. parent companies and their affiliates. From this dataset we obtain the total number of employees working in foreign affiliates of U.S. parent companies, by sector of the U.S. parent. These are jobs directly generated abroad by multinationals. However, of growing importance are jobs created as multinationals offshore production tasks to foreign sub-contractors that are unaffiliated with the multinational, so-called *arm's length* offshoring (see Antras, 2003). We would also like to include these offshored jobs in the count of total offshore employment. Hence this second group of offshored jobs is calculated as follows. Assuming that a large part of the production output of these offshored tasks is subsequently imported as intermediate inputs by the U.S. parent company, we calculate the ratio of imports of intermediates by the U.S. parent coming from affiliates and employment in those affiliates. We then scale the imports of the U.S. parent coming from *non-affiliates* (data that are also available from the BEA) by this ratio to impute the employment in sub-contracting companies. This procedure assumes that the labor content per unit of production of sub-contracted intermediate inputs is the same as for production in U.S. affiliates in the same sector. Then we add the employment in affiliates (first group) and the imputed outsourced offshore employment (second group) to obtain total offshore employment. Adding the imputed employment increases offshore employment by 60-80% in most sectors, confirming the importance of arm's length offshoring of production tasks.

The employment of less-skilled native and immigrant workers in the U.S. is obtained from the American Community Survey (ACS) and Census IPUMS samples (2000-2007)[5] obtained from Ruggles et. al. (2008). We added up all workers not living in group quarters who worked at least one week during the year and have a high school diploma or less, weighting them by the sample weight assigned by the ACS in order to make the sample nationally representative. We define as immigrants all foreign-born workers who were not a citizen at birth. The relevant industry classification in the Census-ACS data 2000-2007 is the INDNAICS classification which is based on the North American Industry Classification System (NAICS). Since the BEA industries are also associated with unique 4-digit NAICS industries we are able to develop a straightforward concordance between the two datasets. The 58 final industries on which we have data and their BEA codes are reported in Table A1 of the Appendix.

The evolution of the share of immigrants and offshore workers in total employment is shown in Table A2 in the Appendix. Figures 1 and 2 report the distribution of those shares in each year across the 58 industries and the connecting line shows their average over time. While during the 2000-2007 period there has been only a modest increase in the overall share of immigrants and offshore employment in total manufacturing employment (the first increases from 12.8% to 14% and the second from 22.3% to 29.3%) different sectors have experienced very different changes in their share of immigrants and offshore labor among workers. For instance, "Apparel and Textile Mills" has experienced the largest increase among all sectors in the share of immigrant workers (+7.6% of total employment) and at the same time has experienced an almost identical and negative (-7%) change in offshore employment. On the other hand, "Plastic Products" has experienced a decline in the share of immigrant employment (-2.3%) and a large increase (+16.8%) in offshore employment. "Basic Chemicals" experienced the largest increase in offshore employment as a percentage of total employment over this period (+30%) and "Other Transportation Equipment" experienced the largest decline (-32%). The variation across sectors, therefore, promises to be large enough to allow us to identify the differential effects of changes in the cost of immigration and offshoring on employment, even over a relatively short period.

3.2   Average Task Intensity

Our model (based on the Grossman and Rossi-Hansberg, 2008 framework) assumes that the contribution of less educated workers to production can be represented in a continuum of tasks that can be ranked from those with a low cost to offshore to those with a high cost to offshore. At the same time we assume that this ranking is also positively correlated with the inverse productivity of immigrants in performing tasks. Recent empirical studies (Becker, Ekholm and Muendler, 2007, Blinder, 2007, Ebenstein, Harrison, McMillan, Phillips, 2009,

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[5]For year 2000 we use the 5% Census sample. For 2001 we use the 1-in-232 national random sample. For 2002, we use the 1-in-261 national random sample. For 2003 we use the 1-in-236 national random sample. For 2004 we use the 1-in-239 national random sample. For 2005, 2006 and 2007 the 1-in-100 national random samples are used.

Jensen and Kletzer, 2007, Levy and Murnane, 2006, Wright, 2009) have also argued that jobs that are intensive in more routine-codifiable types of tasks and less intensive in tasks requiring communication and cognitive interactions with other people are less costly to offshore. Moreover, Peri and Sparber (2009) have shown that due to their imperfect knowledge of language and local norms, immigrants have a comparative advantage in manual-intensive and simple physical tasks and a comparative disadvantage in communication-intensive and interactive tasks. Combining these two type of studies we rank the tasks "i" from 0 to 1 as progressively having a larger communication-interaction intensity and a lower manual and routine content. Hence 0 is a task with the highest content of manual-routine skills to be performed and 1 is a task that requires the highest content of interactive-cognitive skills to be performed. Our assumption is that the cost of offshoring tasks and the inverse productivity of immigrants in performing them are both positively correlated with the index, so that they increase as the index progresses from 0 to 1.

While the model identifies "marginal" tasks that establish a cut-off between production tasks performed by one group (say immigrants) and another (say offshore workers) the distinction between tasks performed by different groups is not so stark in reality. However, the predictions of the model regarding the impact of shifts in the cost-curves on the *average* task index performed by each group are more continuous in nature and can be empirically tested. Thus, the way in which we impute task performance in an industry is as follows. First, we associate with each worker (native or immigrant) in sector s the intensity (standardized between 0 and 1) of each one of five task-skill measures assigned to the worker's occupation by the Bureau of Labor Statistics via its O*NET database. As described in greater detail in the Appendix A we use the original O*NET variables to construct the indices for proxying "cognitive", "communication", "interactive", "manual" and "routine" skills. Those indices capture the intensity (between 0 and 1) of that skill as used in the productive activities performed in the occupation. By associating to each individual the indices specific to her occupation (classified using the Standard Occupation Classification (SOC)) we construct for each individual the index $i =$("cognitive"+ "communication"+ "interactive"-"manual"-"routine")/5+2/5, ranging between 0 and 1, which identifies on that scale the position of the typical task supplied by the individual (occupation). We then average the index (weighted by hours worked) across all U.S.-born workers with a high school diploma or less in industry s and year t to obtain I_{Dst} and across immigrant workers with a high school degree or less to obtain I_{Mst}. Our empirical analysis will be based on the implications derived using these two indices. Hence the range 0 to 1 for the index i spans a "task space" that goes from the most manual-routine intensive tasks to the most cognitive-communication-non-routine intensive ones. Because the BEA database does not contain the occupations of offshore workers we are unable to calculate I_{Ost}.

Figures 3 and 4 show the range of variation across sectors and the average values of the indices I_D and I_M. The average value of the index is quite stable (much more than the shares of employment) which indicates a

slower change in the task-composition (occupational distribution) of natives and immigrants within each sector. The value of the index, averaging across all manufacturing sectors, is around 0.33 for immigrants and 0.37 for natives, confirming that natives perform tasks ranked higher by this index. The standard deviation of the average native index across sectors is around 0.025 and similarly the standard deviation of the average immigrant index is about 0.026. Also, the variation in the skill-index growth over the 7 years across sectors is quite limited. For instance, the sector with the largest growth in I_D is "Semi-conductor and other electronic components", which experienced an increase in the index of 0.02, while the largest decrease was -0.009, experienced by "Coating, Engraving and Heat-treating". Hence, over the period considered (2000-2007) a change in the skill-index of 0.01 in a sector constitutes significant variation. Also notice that, on average, the index for natives I_D in the entire manufacturing sector increased by 0.003 while the index for immigrants I_M decreased by 0.003. While this may be due to many factors, an increase in offshore employment (and in its range of tasks) in the model presented above would have exactly this effect as offshored tasks would drive a wedge between those performed by natives (whose average index would grow) and those performed by immigrants (whose index would decrease).

3.3   Imputed Offshoring and Immigration

Driving the shifts in employment shares and average skill-indices are the changes in accessibility of offshore and immigrant workers. In particular, our model has a simple and parsimonious way of capturing changes in the overall cost of offshoring in a sector (β_s) and in the overall cost of immigration in a sector (δ_s). As we do not observe sector-specific offshoring and immigration costs, we construct a measure of imputed offshoring and imputed immigration that are likely to be driven by changes in those costs, and that also differ across sectors. In particular, following Feenstra and Hanson (1999) we construct an index of offshoring activity, imputing to each industry the share of imported intermediate inputs coming from other industries that share the same 3-digit NAICS code[6]. Thus, this index varies according to the input-output structure of each manufacturing sector and the differential degree of offshoring of intermediate inputs. The data on U.S. imports come from Feenstra et. al. (2002) and are then restricted according to their End-Use classification to consist only of imports destined for use as production inputs. We then assume that variation in offshored input shares are due to cost-differences and affect different manufacturing sectors in different ways. We call this measure for sector s and year t "Imputed Offshoring$_{st}$", and because it depends negatively on offshoring costs (β_s) we will sometimes refer to it as the "ease of offshoring". Its movement should co-vary with changes in offshore employment.

For immigrants, on the other hand, we exploit the observation that foreigners from different countries have increased or decreased their relative presence in the U.S. according to changes in the cost of migrating from

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[6]This is the *narrow* definition of offshoring from Feenstra and Hanson (1999). As described in that paper this definition more closely captures the idea that offshoring occurs when a firm chooses to have inputs produced abroad that it could otherwise produce itself.

their countries as well as with domestic conditions in their countries of origin. The different initial presence of immigrants from different countries in a sector makes that sector more or less subject to those shifts in cost- and push-factors. Hence we impute the population of each of 10 main groups of immigrants[7] using the initial share of workers in the sector combined with their total population growth in the U.S., assuming that cross-country differences in immigration are solely driven by changes in cost- and push-factors. We calculate the imputed immigration index by sector as the imputed share of foreign-born in total employment. We call this measure for sector s and year t "Imputed Immigration$_{st}$", and because it depends negatively on immigration costs (δ_s) we will sometimes call it "ease of immigration". This index is similar to the constructed shift-share instrument often used in studies of immigration in local labor markets (e.g., Card, 2001), except that it exploits differences in the presence of immigrant groups (from different countries) across sectors, rather than across localities. The changes in this index, which are due solely to changes in the country-of-origin specific immigration costs, will differ across sectors due to the weighting of each country-specific change by the initial cross-country distribution of workers in a sector. Finally, we divide each index by its standard deviation so that the estimated coefficients can be easily compared.

4   Empirical Specifications and Results

The strategy in this section is to test the main empirical predictions of the model. In particular, we are interested in estimating the impact of decreasing offshoring and immigration costs, which should result in a larger amount of production carried out by offshore workers and foreigners within the U.S., on the employment and task specialization of natives. As suggested by the model, we will exploit differences in costs across sectors and over time in order to identify the impact of reduced offshoring and immigration costs on native and immigrant employment as well as on native and immigrant task specialization.

4.1   Effects on Employment Shares

Our empirical strategy is to first estimate the effects of the ease of immigration and offshoring on the share of native, immigrant and offshore employees among less educated workers. We then analyze the impact on the actual employment of these groups and then on the task-specialization of natives and immigrants. Using the same notation as developed in the model we first estimate the following three equations:

$$s_{Dst} = \phi_s^D + \phi_t^D + b_{DO}(\text{Imputed Offshoring}_{st}) + b_{DI}(\text{Imputed Immigration}_{st}) + \varepsilon_{st}^D \qquad (15)$$

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[7]The ten countries/regions of origin are: Mexico, Rest of Latin America, Canada-Australia-New Zealand, Western Europe, Eastern Europe, China, India, Rest of Asia, Africa, Others.

$$s_{Mst} = \phi_s^M + \phi_t^M + b_{MO}(\text{Imputed Offshoring}_{st}) + b_{MI}(\text{Imputed Immigration}_{st}) + \varepsilon_{st}^M \tag{16}$$

$$s_{Ost} = \phi_s^O + \phi_t^O + b_{OO}(\text{Imputed Offshoring}_{st}) + b_{OI}(\text{Imputed Immigration}_{st}) + \varepsilon_{st}^O \tag{17}$$

Equation (15) estimates the impact of the ease of offshoring and immigration on native workers' share of less skilled employment. By including sector effects we only exploit variation within a 4-digit NAICS manufacturing sector (there are 58 of them) over time. We also control for common year-effects. Hence, any time-invariant difference in offshoring across sectors and any common trend in offshoring over time will not contribute to the identification of the effect. Less skilled employment is calculated by adding the employment of natives and foreign-born in the U.S. to the employment of foreign affiliates of U.S. companies plus imputed employment of foreign sub-contractors of U.S. multinationals (arm's length employment). At first we assume that all offshore employment is less skilled so that the total employment of less skilled workers in a sector is the sum of native, immigrant and offshore employment. Equation (16) estimates the effect of the ease of offshoring and immigration on the immigrant share of less skilled employment, and equation (17) estimates the effect on offshore employment as a share of less skilled employment. From section 2.4 the predictions of the model are as follows: $b_{DO} < 0, b_{DI} \approx 0, b_{MO} < 0, b_{MI} > 0, b_{OO} > 0$ and $b_{OI} < 0$. Table 1 reports the estimated effects. Specifications 1 to 3 show the effects of imputed immigration and offshoring on the native share, including them separately (specifications 1 and 2) or together (column 3). Specifications 4 to 6 show the effects on the share of immigrants (of each variable separately and together), and specifications 7 to 9 report the effects on offshore employment (also separately in 7 and 8 and together in 9). The method of estimation used is OLS with sector and time fixed effects and the reported coefficients are heteroskedasticity robust.

The results are interesting and encouraging as all six predictions of the model are matched by the estimates. Looking along the first row and focusing on the estimates obtained when including both explanatory variables together, (namely 3, 6 and 9) we see that increased offshoring in one sector implies a significant decline in the share of native employment in that sector, a significant decline in the share of immigrant employment and a significant increase in the share of offshore employment. These three effects are as predicted in equations (14). The intuition is obtained by considering a downward shift in the offshoring curve in Figure 1. A higher share of offshored jobs, implied by lower offshoring costs, takes place at the expense of both a lower share of immigrant and native employment (both margins are affected). Also of interest in quantitative terms, we notice that an increase in the ease of offshoring erodes a larger share of native employment relative to immigrant employment. It is possible that over the seven years considered (2000-2007) the phases of production that were offshored were more in competition with native workers than with immigrant workers.

On the other hand, focusing on the second row of Table 1 that reports the effects of the ease of immigration

on employment shares, we observe that an increase in imputed immigration has no effect on the share of native employment whereas it reduces the share of offshore employment and increases the share of immigrant employment. Again, this is as predicted by the model and the intuition for the results is provided again by Figure 1. A downward shift of the immigration cost curve will increase the share of tasks performed by immigrants and reduce the share of offshored tasks. However, it will leave the share of native tasks unchanged because they are performing tasks that are higher in the skill-index and not affected by the shifting margin of immigrant jobs[8]. This is interesting since it may provide a new explanation for why a large part of the labor literature (e.g., Card, 2001 or Ottaviano and Peri, 2006) does not find a significant negative impact of immigrants on native employment: on the margin immigrants compete more with offshore workers than with natives. Conversely, if the share of immigrants were to decrease due to an increase in the cost of immigration–for instance, due to more restrictive immigration laws–our results imply that the production tasks relinquished by immigrants are more likely to be substituted by offshore workers than by native ones. Such a differential impact of offshoring and immigration on the native share of employment confirms the intuition and results of the model, which implies that offshored tasks exist in an intermediate position along the task continuum, between those performed by natives and those performed by immigrants.

Table 2 reports the estimated coefficients obtained from specifications following those in Table 1, except now measuring total employment (rather than the employment of less educated workers). Since the model predicts no impact on the employment of more educated workers the results presented for less educated workers should hold also for the share in total employment. Moreover, as we are not able to separate more and less skilled offshore workers, Table 2 provides a check of the overall employment impact of offshoring on native and immigrant workers, considering labor as one unique factor of production. The estimated coefficients and their significance are very similar to those in Table 1, confirming that most of the effect of offshoring takes place through its impact on less skilled workers in the U.S. An increase in the ease of offshoring reduces the share of natives and immigrants in total employment by substituting for those workers with an increase in the share of offshore workers. On the other hand, an increase in the ease of immigration has only a negative impact on the share of offshore employment, leaving the native share unchanged.

4.2   Effects on Employment Levels

A second crucial implication of the model is that if there is a "productivity effect" from hiring immigrant labor and/or offshore workers, arising from the infra-marginal cost-savings generated by their lower wages, then an increase in the ease of offshoring and/or immigration will result in an increase in the overall demand for less

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[8]While the relative productivity effect of a decrease in the cost of off-shoring would also imply a decrease in the share of native workers in employment (as predicted by the comparative statics in 14) this effect is likely to be small, as there is no decrease in the task range by natives, certainly smaller than the negative effect on the share of immigrant workers.

skilled labor. This positive overall effect, combined with the share-effect, would imply a mitigated or even null or positive effect of offshoring on native employment and a positive effect of immigration on native employment, as stated in section 2.4. Tables 3 and 4 show the estimated coefficients from the following 4 regressions:

$$N_{Dst} = \phi_s^D + \phi_t^D + B_{DO}(\text{Imputed Offshoring}_{st}) + B_{DI}(\text{Imputed Immigration}_{st}) + \varepsilon_{st}^D \qquad (18)$$

$$N_{Mst} = \phi_s^M + \phi_t^M + B_{MO}(\text{Imputed Offshoring}_{st}) + B_{MI}(\text{Imputed Immigration}_{st}) + \varepsilon_{st}^M \qquad (19)$$

$$N_{Ost} = \phi_s^O + \phi_t^O + B_{OO}(\text{Imputed Offshoring}_{st}) + B_{OI}(\text{Imputed Immigration}_{st}) + \varepsilon_{st}^O \qquad (20)$$

$$N_{Lst} = \phi_s^O + \phi_t^O + B_{LO}(\text{Imputed Offshoring}_{st}) + B_{LI}(\text{Imputed Immigration}_{st}) + \varepsilon_{st}^L \qquad (21)$$

Following the notation used in section 2, N_{Dst} is the total employment of less skilled native workers in sector s and year t, N_{Mst} is the employment of less skilled immigrant workers in sector s and year t and N_{Ost} is the total offshore employment in the sector-year. Finally, $N_{Lst} = N_{Dst} + N_{Mst} + N_{Ost}$ is what we call overall less skilled employment in the sector-year. Keep in mind that it includes jobs performed in the U.S. by all firms and abroad by affiliates of U.S. parents and by subcontractors working for affiliates of U.S. parents. From the results of section 2.4 we see that B_{LO} and B_{LI} are essentially a measure of the intensity of the productivity effect due to increased offshoring and increased immigration, while the other effects combine this productivity effect with the relative share effects estimated in Tables 1 and 2.

The results are again interesting and very much in line with the predictions of the model. First, both when considering the employment of less educated workers as well as the total employment impact (the last columns of Tables 3 and 4, respectively) we estimate a positive and significant productivity effect of imputed immigration and offshoring. An increase of one standard deviation in the ease of offshoring increases the total employment of less educated workers by 2% and increases total employment by 1.53%. An increase in the ease of immigration of one standard deviation increases employment of less educated workers by close to 1% and total employment by 1.25%. These productivity effects imply that offshoring has a null effect on employment of less educated natives, while immigration actually increases this employment by 1.3%. Moreover, while increased offshoring has a negative effect on employment of less educated immigrants (-2.75% for one standard deviation), an increase in immigration does not affect total offshore employment (the productivity effect cancels the negative share effect).

Interestingly, the presence of such a productivity effect due to immigration and offshoring, predicted by our model, implies that even taken together these two forms of globalization of labor have not harmed native employment in the manufacturing sectors that have been most exposed to them. To the contrary, by allowing those sectors to save on the tasks supplied by immigrants and offshore workers they have promoted an expansion

of those sectors relative to others and have attracted more native workers than they would have if all tasks were performed by natives.

4.3   Effects on Average Skill Intensity

Our model also carries predictions regarding the effect of increased offshoring and immigration on the average task "index" performed by natives and immigrants. To make these predictions empirically operational we have followed the lead of previous empirical studies that have indicated that tasks that intensively use cognitive-communication and non-interactive skills (Blinder, 2007; Jensen and Kletzer, 2007; Peri and Sparber, 2009) are harder to offshore and, furthermore, immigrants have a comparative disadvantage (lower productivity) in performing them. Similarly, we follow the literature (Levy and Murnane, 2006; Becker, Ekholm and Muendler, 2007; Peri and Sparber, 2009) that indicates that jobs that are more intensive in routine and manual tasks are easier to offshore and immigrants have higher productivity in these. Hence, as described in section 3 above, we construct (observable) averages I_D and I_M for each sector and for domestic and immigrant workers separately. The distribution of workers across tasks is based on the task-skill content of each occupation as assessed by O*NET and on the distribution of workers across occupations in the industries as revealed in the American Community Survey data. We then run the following regressions:

$$I_{Dst} = \phi_s^D + \phi_t^D + d_{DO}(o_{st}) + d_{DI}(m_{st}) + \varepsilon_{st}^D \tag{22}$$

$$I_{Mst} = \phi_s^M + \phi_t^M + d_{MO}(o_{st}) + d_{MI}(m_{st}) + \varepsilon_{st}^M \tag{23}$$

where the explanatory variables are the share of offshore employment, o_{st}, and the share of immigrant employment, m_{st}, and the dependent variables are the average task indices. Both task indices and shares are calculated for workers with a high school degree or less. We first estimate the effect on the average skill index using OLS (Table 5) and then we estimate them with 2SLS using the imputed offshoring and immigration indices (described in section 3.3) as instruments for the shares o_{st} and m_{st}. Empirically, then, we observe the average intensity of tasks used by workers in an industry where we have ranked those tasks on a zero to one interval according to the index I that increases as the cognitive-communication-interaction intensity grows and decreases as the routine-manual intensity grows. As a result, if the costs of offshoring and the inverse productivity of immigrants are positively correlated with this index then the predictions of the model can be tested on this index.

Table 5 column 1 shows the impact of an increase in the shares of offshore and immigrant workers on the average index for natives, I_D. As predicted by the model a larger share of offshore employment pushes natives to specialize in tasks with a higher index I, while a higher share of immigrants has no effect on the average

task-index of natives. The estimated effects, however, while consistent with the theoretical model, are small and not always significant. The estimate implies that an increase of 1% in the share of offshore employment (which is half of the standard deviation of the explanatory variable over the considered period) increases the average index I_D by 0.014 (the standard deviation of the index in the period is 0.03). In contrast, an increase in the immigrant share is not associated with any change in the average task index of natives. Columns 2, 3 and 4 show that the upward shift in the average native index I_D is due to an increase in the cognitive-interactive skills used by natives in response to offshoring (reported effects in columns 2 and 3) while very small negative effects are estimated on the intensity of use of manual (and routine, not reported) skills. Column 5 also shows that an increase in the share of offshore employment has an insignificant, negative effect on the average task index for immigrants. Decomposing the effect between cognitive-interactive tasks and manual ones the first fall and the second increase, but all the effects are not significant. Thus, though not statistically significant, the results suggest that offshoring may push immigrants toward less cognitive-interactive and more manual tasks, also a prediction of the model.

Table 6 focuses only on the summary indices I_D and I_M. The method of estimation, however, is 2SLS, using imputed offshoring as an instrument for the share of offshore employment and imputed immigrants for the share of immigrant employment. The first stage is not very strong, however the F-test of the instruments is 8.75 for the share of offshore employment and 10.79 for the share of immigrant workers. The first column in Table 6 shows a positive effect of offshoring on the skill-index of natives and a negative effect of immigration on the skill-index of natives. Neither effect is significant. The second column shows that increased offshoring decreases the average skill index of immigrants (-0.16) while an increase in the immigration share increases the skill index of immigrants (+0.31). While, again, the standard errors are large enough to make each effect not very significant it is interesting to note that, in conformance with the model, an increase in the share of offshore employment has opposing effects on the average index of natives (increased) and immigrants (decreased). Offshored jobs place a wedge in the skill-index between jobs performed by natives and those performed by immigrants. This is consistent with the model in which offshore workers take the "intermediate" tasks. In contrast, an increase in immigrant employment shares should only increase the average skill index of immigrants, pushing it closer to that of natives. The last column reports the effect of increased immigration and offshoring on the difference in the average (native-immigrant) index. As predicted by the model, and confirming the results in columns 1 and 2, a higher share of offshore employment increases the difference in the average native-immigrant skill index ($I_D - I_M$). In contrast, an increase in the share of immigrants is associated with a decrease in that index. Both effects are significant and in line with the idea that an increase in the importance of offshoring would polarize the specialization of natives and immigrants, while an increase in the share of immigrants would push the average immigrant task closer to that of natives.

5 Conclusions

This paper analyzes the effect of increased globalization, in the form of easier offshoring and increased immigration into the U.S. labor market, on employment in U.S. manufacturing. There are few attempts to combine analyses of immigration and offshoring on labor markets[9], but analyzing each of these in isolation misses the possibility that hiring immigrants or offshoring productive tasks may be alternatives, simultaneously available to firms, to hiring a native worker. Here we develop a simple extension to the model by Grossman and Rossi-Hansberg (2008) to analyze allocation of productive tasks (arrayed from the most manual and routine-intensive to the most cognitive and non-routine intensive) between native, immigrant and offshore workers. We test the predictions of the model on U.S. data from 58 manufacturing industries over the years 2000-2007. The results are interesting and point to an interpretation that is consistent with our model. First, less educated immigrants are employed in the more manual-routine tasks and furthermore do not compete within the occupations in which the bulk of native workers are employed, which tend to be more non-routine and communication intensive. In fact, they compete more with offshore workers such that more immigration seems to induce firms to move production from offshore workers to immigrants. At the same time immigration seems to be associated with cost-savings and a corresponding increase in productivity so that its aggregate effect on the level of low skilled native employment is positive. We also find that increased offshoring reduces the share of native employment in a sector. However, it also stimulate overall sector employment (via the productivity effect predicted by our model) so that it also has no overall impact on the level of native employment. In spite of the widely held belief that immigrants and offshoring are reducing the job opportunities of natives we actually find that sectors with a larger increase in global exposure (through offshoring and immigration) fared better than those with less exposure in terms of native employment growth.

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[9]We are only aware of Barba Navaretti, Bertola and Sembenelli (2008), who present a model of immigration and offshoring and test its implications on firm-level data for Italy.

References

Antecol, H., Cobb-Clark, D.A. and Trejo, S. (2003). 'Immigration Policy and the skills of Immigrants to Australia, Canada and the United States', Journal of Human Resources, Vol. 38, No. 1, pp. 192-218.,

Antras, Pol (2003) "Firms, Contracts, and Trade Structure" *Quarterly Journal of Economics,* Vol. 118 No. 4, pp. 1375-1418

Bertola, Giuseppe, Sembenelli, Alessandro and Giorgio Barba Navaretti (2008) "Offshoring and Immigrant Employment - Firm-Level Theory and Evidence" Centro Studi Luca d'Agliano Development Studies Working Paper No. 245.

Becker, Sasha O., Ekholm, Karolina and Marc-Andreas Muendler (2009) "Offshoring and the Onshore Composition of Tasks and Skills" EFIGE Working Paper.

Blinder, Alan (2007) "How Many U.S. Jobs Might Be Offshorable?" CEPS Working Paper No. 142.

Butcher, K.F. and DiNardo, J. (2002). 'The Immigrant and Native Born Wage Distributions: Evidence from United States Censuses', Industrial and Labor Relations Review, Vol. 56, No. 1, pp. 97-121.

Card, David (2001) "Immigrant Inflows, Native Outflows, and the Local labor Market Impacts of Higher Immigration" *Journal of Labor Economics*, XIX (2001), 22-64.

Barry R. Chiswick & Anh T. Le & Paul W. Miller, (2008). "How Immigrants Fare across the Earnings Distribution in Australia and the United States," Industrial and Labor Relations Review, ILR Review, ILR School, Cornell University, vol. 61(3), pages 353-373, April.

Ebenstein, Avraham, Harrison, Ann, McMillan, Margaret and Shannon Phillips (2009) "Estimating the Impact of Trade and Offshoring on American Workers Using the Current Population Surveys", NBER Working Paper No. 15107.

Feenstra, Robert, Romalis, John and Peter K. Schott (2002) "U.S. Imports, Exports and Tariff Data" The Center for International Data, UC Davis

Feenstra, Robert and Gordon Hanson (1999) "The Impact of Outsourcing and High Technology Capital on Wages: Estimates for the United States 1979-1990" *Quarterly Journal of Economics.*

Grossman, Gene and Esteban Rossi-Hansberg (2008) "Trading Tasks: A Simple Theory of Offshoring." *American Economic Review*, 98 (5), pp. 1978-1997.

Harrison, Ann and Margaret McMillan (2008) "Offshoring Jobs? Multinational and U.S. Manufacturing Employment" NBER Working Paper.

Hendricks, Lutz (2002). "How Important Is Human Capital for Development? Evidence from Immigrant Earnings," American Economic Review, American Economic Association, vol. 92(1), pages 198-219, March.

Jensen, Bradford J. and Lori Kletzer (2007) "Measuring Tradable Services and the Task Content of Offshorable Services Jobs" Manuscript, University of California, Santa Cruz.

Levy, Frank and Richard J. Murnane (2006) "How Computerized Work and Globalization Shape Human Skill Demands" First International Conference on Globalization and Learning Conference Volume.

Mataloni, Raymond J. and Daniel R. Yorgason (2002) "Operations of U.S. Multinational Companies" Survey of Current Business March 2002, Bureau of Economic Analysis

Ottaviano Gianmarco I.P. and Giovanni Peri (2008) "Immigration and National Wages: Clarifying the Theory and the Empirics" National Bureau of Economic Research Working Paper #14188, July 2008.

Peri, Giovanni (2009) "The Effect of Immigration on Productivity: Evidence from U.S. states" NBER Working Paper, November 2009.

Peri, Giovanni and Chad Sparber (2009) "Task Specialization, Immigration and Wages", *American Economic Journal*: *Applied Economics,* Vol 1:3.

Ruggles, Steven , Matthew Sobek, Trent Alexander, Catherine A. Fitch, Ronald Goeken, Patricia Kelly Hall, Miriam King, and Chad Ronnander (2008). *Integrated Public Use Microdata Series*: Version 3.0 [Machine-readable database]. Minneapolis, MN: Minnesota Population Center [producer and distributor], 2004. http://www.ipums.org.

Wright, Greg C. (2009) "Tasks Offshoring: A Structural Approach to Estimating the Employment Impact", UC Davis Dissertation

A   Appendix: Task Data

By merging occupation-specific task values with individuals across years, we are able to obtain these task-intensity measures for natives and immigrants by education level in each state over time. The U.S. Department of Labor's *O*NET* abilities survey provides information on the characteristics of occupations. This dataset assigns numerical values to describe the importance of 52 distinct employee abilities (skills) required by each occupation[10] as well as 40 distinct employee "Activities" (tasks). We then re-scale each skill and task variable so that it equals the percentile score in 2000 (between 0 and 1) representing the relative importance of that skill-task among all workers in 2000. For instance, an occupation with a score of 0.02 for a specific skill indicates that only 2 percent of workers in the U.S. in 2000 were supplying that skill less intensively. We then assign these *O*NET* percentile scores to individuals from 2000 to 2007 using the ACS variable *occ1990*, which provides an occupational crosswalk over time. The indices "cognitive", "communication" and "manual" are constructed by averaging the Ability variables. Specifically, "cognitive" includes 12 variables classified as "Cognitive and Analytical", "communication" includes four variables capturing written and oral expression and understanding, and "manual" includes 19 variables capturing dexterity, strength and coordination. Finally, the variable "interactive" includes three activities that emphasize person-to-person interaction while "routine" includes four activities that emphasize the importance of doing routine tasks.

B   Appendix: Construction of Offshoring Cost Variable

We use an updated version of the offshoring measure described in Feenstra and Hanson (1999), defined formally for any industry k purchasing inputs j as:

$$\frac{\sum_j (\text{industry k purchases of good j})\left(\frac{\text{intermediate imports of good j}}{\text{total domestic intermediates consumption of j}}\right)}{\sum_j (\text{industry k purchases of good j})}$$

Here, we need to separate imports of final goods from imports of intermediates in constructing the ratio in the numerator. The data source for these imports and their classifications is Feenstra et al (2002). While the measure itself is constructed at the 4-digit North American Industry Classification System (NAICS) level, within these NAICS categories are more disaggregate Harmonized System (HS) categories, and these are associated with end-use codes that characterize imports according to their final use. In short, these end-use codes are used by the BEA in generating the National Income and Product Accounts, and here we use them to select only goods intended for use as intermediates (see Wright, 2009 for more details).

Next, domestic consumption of intermediates by industry is constructed as imports of intermediates minus exports of intermediates (restricted in the same manner as imports) plus domestic shipments of intermediates.

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[10]Classified using the Standard Occupation Classification (SOC).

This final value needs a brief explanation. Rather than use the total domestic shipments of industry j, we instead apportioned those domestic shipments into various HS products by assuming that the share of domestic shipments for each HS product within industry j equals the share of U.S. exports in that HS product and industry. We then sum domestic shipments over just those HS products that are also intermediate inputs (as defined by their end-use classification).

The other component of the measure consists of industry input purchases, which are obtained from the Materials Purchases tables in the1997, 2002 and 2007 Economic Censuses, with values in intervening years obtained via interpolation between these. Finally, the 4-digit NAICS measure is merged to BEA industries using a concordance created by the authors.

C   Appendix: Construction of Offshore Employment Variables

Our measures of offshore employment draw from data on the employment and exports of affiliates of U.S. multinational corporations (MNCs) from the BEA, U.S. Direct Investment Abroad: Operations of U.S. Parent Companies and Their Foreign Affiliates, 2000-2007. According to Mataloni and Yorgason (2006), MNC output in 1999 accounted for around half of manufacturing output and 63 percent of manufacturing exports. We also restrict the sample further by using only majority-owned, non-bank MNC affiliates, however this restriction is minor. The quality of this data has been investigated by Harrison and McMillan (2008) using inward FDI data from Germany and Sweden, and while the authors find some discrepancies, these seem to be at least somewhat explained by differences in the timing of reporting.

Specifically, we collect information on multinational affiliate employment by industry and year (58 manufacturing industries over 2000-2007), imports from MNC affiliates to their parents by industry and year, and imports from non-affiliates to U.S. MNCs by industry and year. Affiliate employment is also available separately for "Managerial, professional, and technical employees" and "All other employees", which we use to distinguish high- and low-skill affiliate workers.

In order to calculate total offshore employment due to U.S. MNC offshoring, we begin with the actual employment of multinational affiliates and the aggregate exports of those affiliates to the multinational parent firm. We then take the ratio of affiliate employment to affiliate exports for each industry and year. This ratio is then set aside as a scaling factor, or an export labor requirement, for each industry and year. Next, we multiply U.S. parent firm imports from non-affiliates with respect to this scaling factor and the result is our imputed arm's length offshore employment. This is then combined with the affiliate employment values. As mentioned in the text above, this value assumes an equivalent labor requirement per unit of exports for affiliates and non-affiliates.

Table 1:

Effects of ease of offshoring and immigration on the <u>shares</u> of natives, immigrants and offshore <u>less educated</u> workers

<u>Only workers with a high school degree or less are included</u>

58 manufacturing industries, 7 years: 2000-2007

Dependent variable: Explanatory variable:	Share of US-National in Employment of less educated workers			Share of Immigrants in employment of less educated workers			Share of offshore employees in employment of less educated workers		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Imputed offshoring		-0.67** (0.21)	-0.66** (0.20)	-0.30** (0.10)		-0.23** (0.10)		0.96** (0.24)	0.90** (0.24)
Imputed Immigration:	0.09 (0.21)		0.02 (0.21)		0.39** (0.09)	0.34** (0.09)	-0.48** (0.24)		-0.36* (0.21)
Observations	464	464	464	464	464	464	464	464	464
Sector fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time effects:	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: The dependent variable in each regression is specified in the first row. The explanatory variables are specified in the first column. The method of estimation is Ordinary Least Squares; Imputed offshoring is calculated as the share of intermediate imported in the sector, using the Feenstra and Hanson (1999) definition. Imputed immigration is calculated using initial employment composition by country and overall population growth by nationality in the US. Both indices are divided by their standard deviation in the sample so that a change in one unit of the explanatory variable corresponds to a change by one standard deviation. Heteroskedasticity-robust standard errors are reported in parentheses.

Table 2:

Effects of ease of offshoring and imputed immigration on <u>shares</u> of <u>all</u> natives, immigrants and offshore workers

<u>All native, immigrant and offshore workers are included</u>

58 manufacturing industries, 7 years: 2000-2007

Dependent variable:	Share of US-National in Total Employment			Share of Immigrants in Total Employment			Share of Offshore Employees in Total Employment		
Explanatory variable:									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Imputed offshoring		-0.60**	-0.59**		-0.21**	-0.16**		0.80**	0.75**
		(0.21)	(0.21)		(0.08)	(0.08)		(0.25)	(0.24)
Imputed Immigration:	0.04		-0.004	**0.35****		**0.30****	-0.39*		-0.30
	(0.20)		(0.20)	**(0.08)**		**(0.08)**	(0.21)		(0.20)
Observations	464	464	464	464	464	464	464	464	464
Sector fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time effects:	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: The dependent variable in each regression is specified in the first row. The explanatory variables are specified in the first column. The method of estimation is Ordinary Least Squares; Imputed offshoring is calculated as share of intermediate imported in the sector, using the Feenstra and Hanson (1999) definition. Imputed immigration is calculated using initial employment composition by country and overall population growth by nationality in the US. Both indices are divided by their standard deviation in the sample so that a change in one unit of the explanatory variable corresponds to a change by one standard deviation. Heteroskedasticity-robust standard errors are reported in parentheses.

Table 3

Effects of ease of offshoring and immigration on the <u>employment</u> of natives, immigrants and offshore <u>less educated</u> workers

<u>Only workers with a high school degree or less are included</u>.

58 manufacturing industries, 7 years: 2000-2007

Dependent variable: Explanatory variable:	Total Employment of US Born (in log points)	Total Employment of Immigrants (in log points)	Total Offshore Employment (in log points)	Total Employment, Native plus Immigrants plus Offshore (in log points)
	(1)	(2)	(3)	(4)
Imputed offshoring	-0.20	-2.75*	0.52**	2.03**
	(0.74)	(1.50)	(0.12)	(0.69)
Imputed Immigration:	1.30**	1.11	0.97	0.96*
	(0.58)	(0.90)	(1.20)	(0.54)
Observations	646	646	646	646
Sector fixed effects	Yes	Yes	Yes	Yes
Time effects:	Yes	Yes	Yes	Yes

Note: The dependent variable in each regression is specified in the first row. The explanatory variables are specified in the first column. The method of estimation is Ordinary Least Squares; Imputed offshoring is calculated as share of intermediate imported in the sector, using the Feenstra and Hanson (1999) definition. Imputed immigration is calculated using initial employment composition by country and overall population growth by nationality in the US. Both indices are divided by their standard deviation in the sample so that a change in one unit of the explanatory variable corresponds to a change by one standard deviation. Heteroskedasticity-robust standard errors are reported in parentheses.

Table 4

Effects of ease of offshoring and imputed immigration on the <u>total</u> <u>employment</u> of natives, immigrants and offshore workers

<u>All native, immigrant and offshore workers are included</u>

58 manufacturing industries, 7 years: 2000-2007

Dependent variable: Explanatory variable:	Total Employment of US Born (in log points)	Total Employment of Immigrants (in log points)	Total Offshore Employment (in log points)	Total Employment, Native plus Immigrants plus Offshore (in log points)
	(1)	(2)	(3)	(4)
Imputed offshoring	0.43	0.01	**5.22***	**1.53****
	(0.60)	(0.10)	**(1.27)**	**(0.57)**
Imputed Immigration:	**1.17****	**2.37****	0.97	**1.25****
	(0.53)	**(0.76)**	(1.20)	**(0.43)**
Observations	646	646	646	646
Sector fixed effects	Yes	Yes	Yes	Yes
Time effects:	Yes	Yes	Yes	Yes

Note: The dependent variable in each regression is specified in the first row. The explanatory variables are specified in the first column. The method of estimation is Ordinary Least Squares; Imputed offshoring is calculated as share of intermediate imported in the sector, using the Feenstra and Hanson (1999) definition. Imputed immigration is calculated using initial employment composition by country and overall population growth by nationality in the US. Both indices are divided by their standard deviation in the sample so that a change in one unit of the explanatory variable corresponds to a change by one standard deviation. Heteroskedasticity-robust standard errors are reported in parentheses.

Table 5:

Effects of the share of offshore employment and immigrant employment on average task intensity of natives and immigrants.

OLS Estimates, *58 manufacturing industries, over the period 2000-2007.*

Index-value for the following skill:	Native, Low-skilled workers				Immigrant, Low-skilled workers			
	Average index "I_D"	Cognitive	Interactive	Manual	Average index "I_M"	Cognitive	Interactive	Manual
Share of Immigrants among low-skilled workers	-0.009 (0.024)	0.09 (0.04)	0.031 (0.040)	0.059 (0.038)	-0.013 (0.016)	-0.028 (0.098)	-0.10 (0.09)	0.10 (0.07)
Share of Offshore among low-skilled workers	**0.014*** **(0.007)**	**0.025*** **(0.013)**	**0.034**** **(0.013)**	-0.004 (0.012)	-0.040 (0.049)	-0.011 (0.033)	-0.03 (0.03)	0.004 (0.02)
Observations	464	464	464	464	464	464	464	464
Industry effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: The dependent variable in each column is the average (employment-weighted) measure of skill indicated in the first cell of the column. The "average index" is constructed by averaging five indicators in order to produce a variable whose range of variation is one unit, and that increases with the intensity of cognitive-communication-routine type of tasks and decreases with the intensity of manual-routine tasks. The average index "i" is constructed as: (Cognitive+Interactive+Communication-Manual –Routine)/5+2/5. Each of the five basic indicators is an average of several O*NET abilities, Activities or Job Context variables. Their detailed description is in the Appendix. The explanatory variable is the share of immigrant and offshored employment among workers with high school degree or less. Method of estimation is OLS; heteroskedasticity-robust standard errors are reported in parentheses.

Table 6:

Effects of the share of offshore employment and immigrant employment on average task intensity of natives and immigrants.

2SLS estimates using imputed offshoring and immigration as IV for shares

58 manufacturing industries, yearly 2000-2007.

Dependent variable: Explanatory Variable:	Average Skill Index "I_D" for less educated Natives	Average Skill Index "I_M" for less educated Immigrants	Average Skill Index "I" difference between less educated (Natives-Immigrants)
Share of Immigrants in employment	-0.12 (0.09)	0.31 (0.19)	**-0.44**** **(0.21)**
Share of Offshore employment	0.050 (0.043)	-0.16 (0.10)	**0.22**** **(0.11)**
Observations	464	464	464
Industry Effects	Yes	Yes	Yes
Year effects	Yes	Yes	Yes

Note: The dependent variable in each column is the average (employment-weighted) skill index. In the first column it is measured for less educated native workers and in column 2 for less educated immigrant workers. In Column 3 it is the difference of the two. The index is constructed by averaging five indicators in order to produce a variable whose range of variation is one unit, that increases with the intensity of cognitive-communication-routine type of tasks and decreases with the intensity of manual-routine tasks. The explanatory variables are the share of immigrant and offshore low-skilled workers. The estimation method is 2SLS using the indices of offshoring and of immigration as IV for the shares in employment.

Figures

Figure 1

Offshore workers as a share of total (US + offshore) employment in 58 manufacturing industries
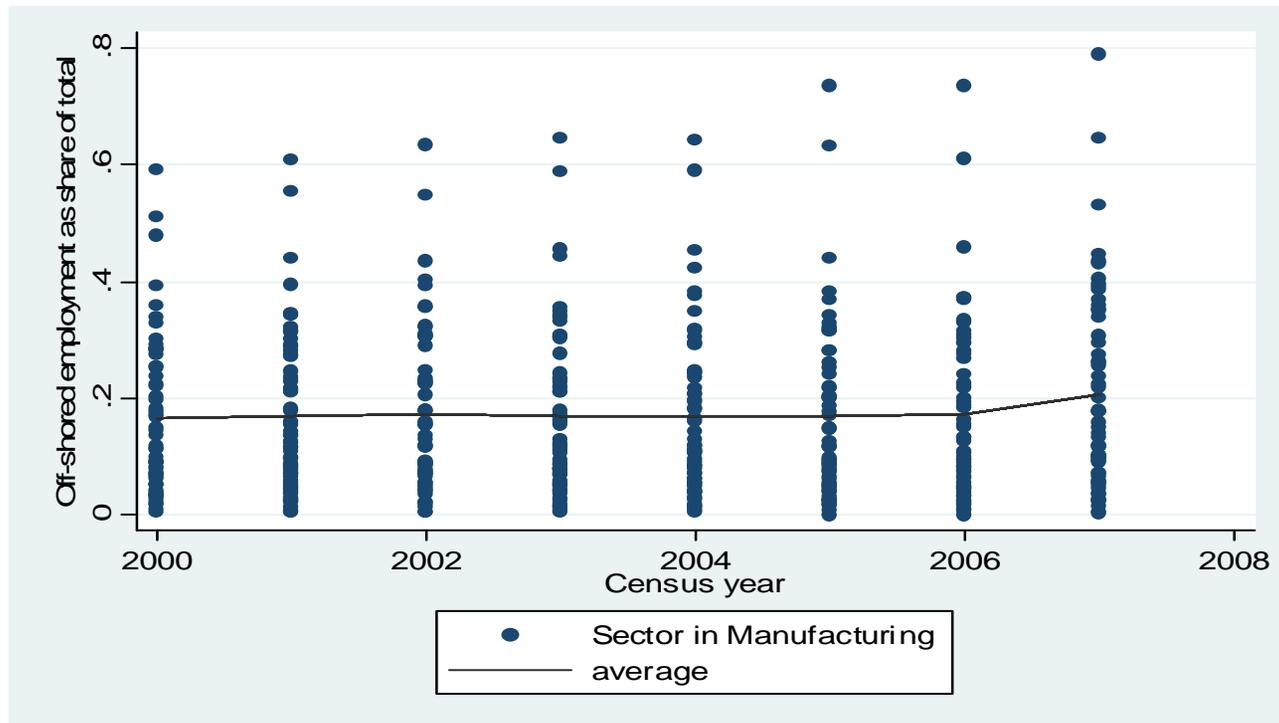
Figure 2

Immigrant workers as a share of total (US +offshore) employment in 56 manufacturing industries
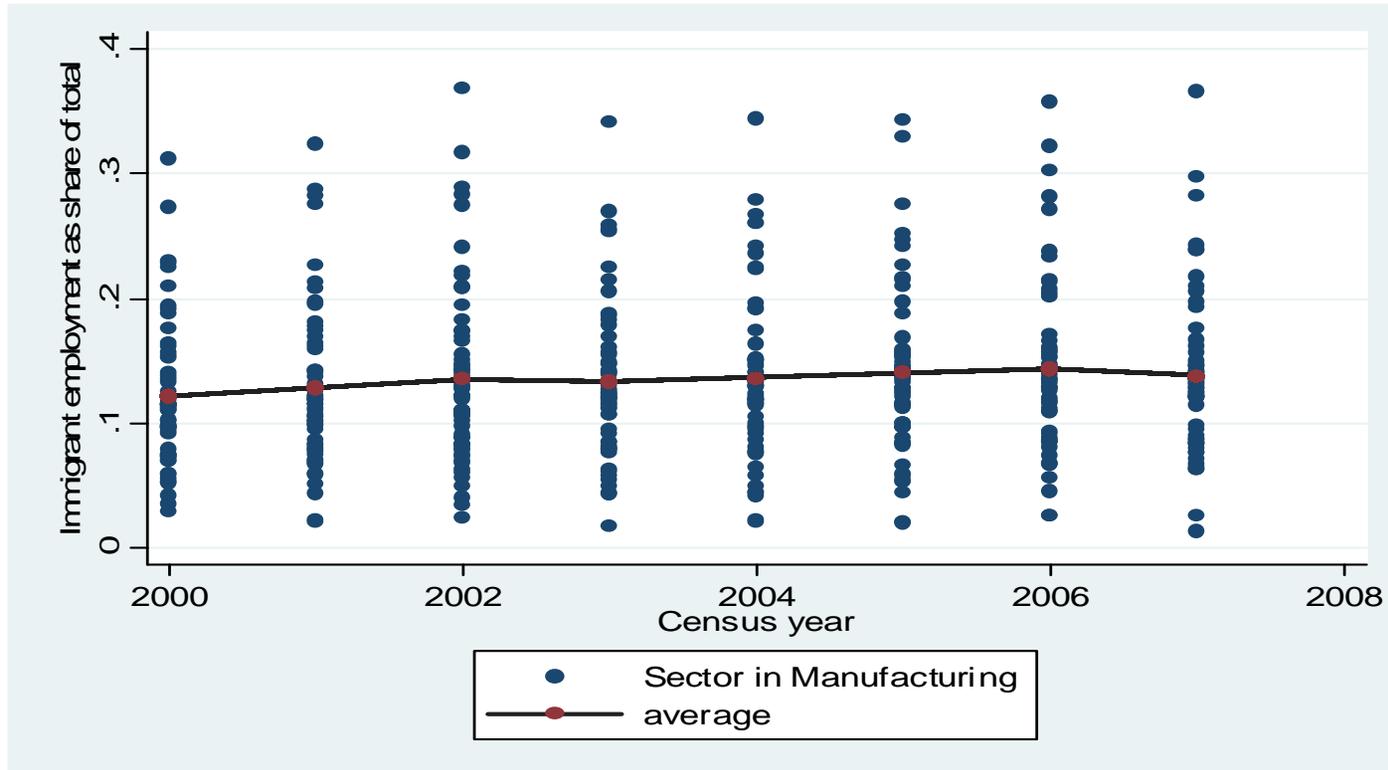
Figure 3

Average index for native workers with high school diploma or less (I_D)

58 sectors, 7 years

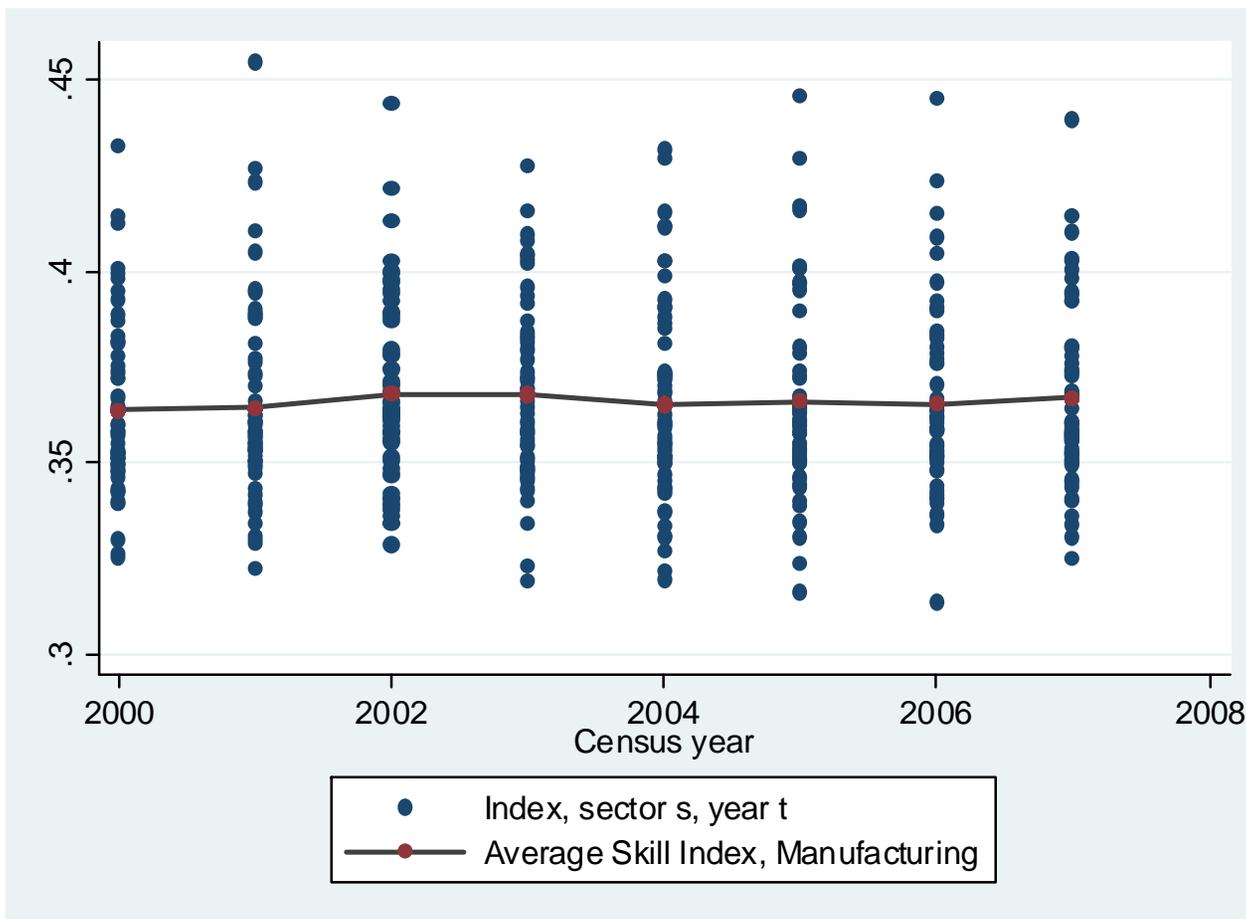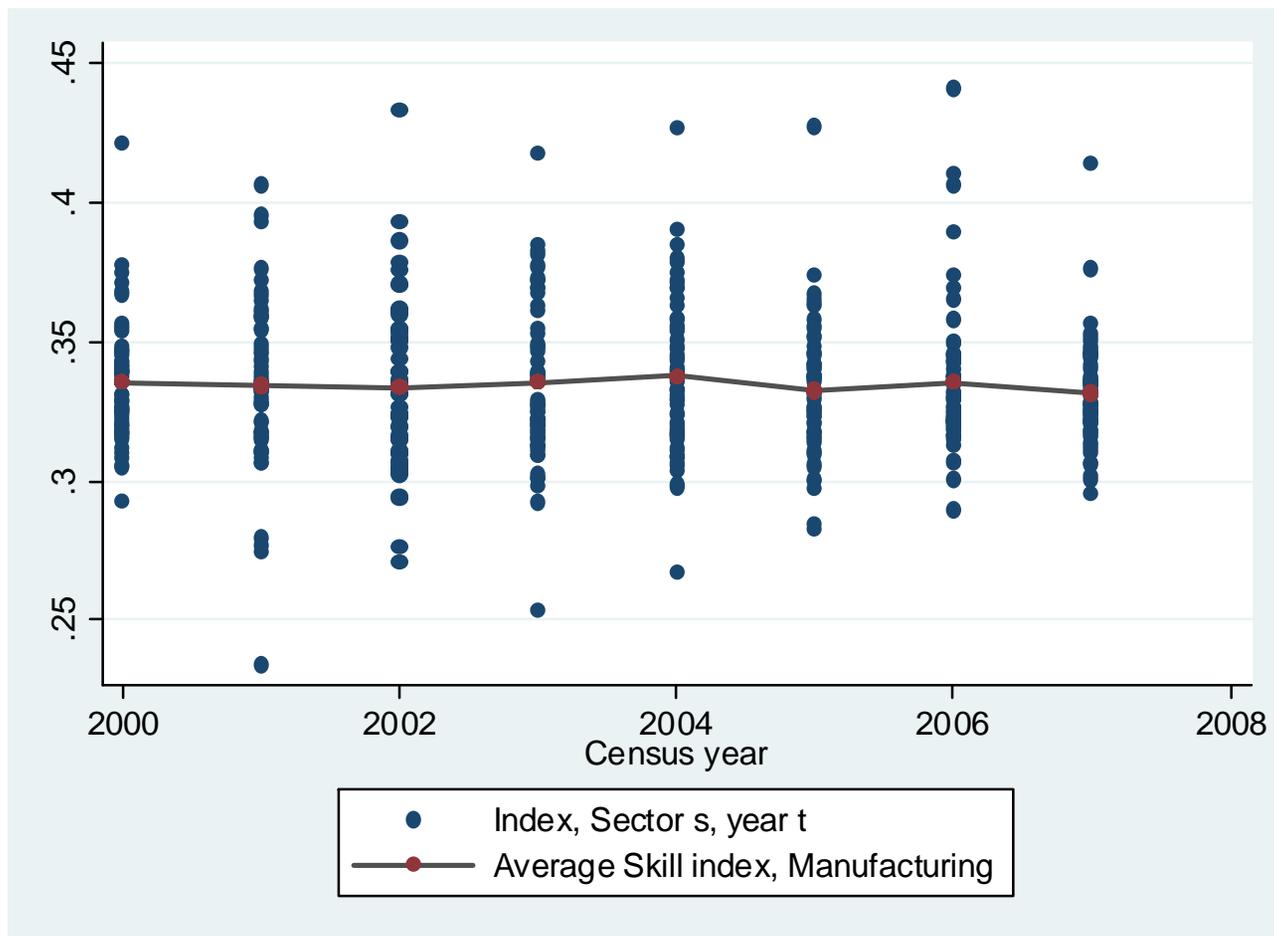**Figure 4**

Average index for immigrant workers with high school diploma or less (I$_M$)

58 sectors, 7 years

Appendix

<table>
<tr><td colspan="6" align="center">Table A1</td></tr>
<tr><th>BEA Industry Code</th><th>Description</th><th>BEA Industry Code</th><th>Description</th><th>BEA Industry Code</th><th>Description</th></tr>
<tr><td>1</td><td>Animal foods, Grain and oilseed milling</td><td>28</td><td>Paints, coatings, and adhesives</td><td>54</td><td>Metalworking machinery</td></tr>
<tr><td>3</td><td>Sugar and confectionery products</td><td>30</td><td>Plastics products</td><td>55</td><td>Engines, turbines, and power transmission equipment</td></tr>
<tr><td>4</td><td>Fruit and vegetable preserving and specialty foods</td><td>31</td><td>Rubber products</td><td>57</td><td>Computers and peripheral equipment</td></tr>
<tr><td>5</td><td>Dairy products</td><td>32</td><td>Clay products and refractory</td><td>58</td><td>Communications equipment, Audio and video equipment</td></tr>
<tr><td>6</td><td>Animal slaughtering and processing</td><td>33</td><td>Glass and glass products</td><td>60</td><td>Semiconductors and other electronic components, Magnetic and optical media</td></tr>
<tr><td>7</td><td>Seafood product preparation and packaging and Other food products</td><td>34</td><td>Cement and concrete products, Lime and gypsum products</td><td>61</td><td>Navigational, measuring, and other instruments</td></tr>
<tr><td>8</td><td>Bakeries and tortillas</td><td>36</td><td>Other nonmetallic mineral products</td><td>64</td><td>Electric lighting equipment, Electrical equipment, Other electrical equipment and components</td></tr>
<tr><td>10</td><td>Beverages</td><td>37</td><td>Iron and steel mills and ferroalloys, Steel products from purchased steel</td><td>65</td><td>Household appliances</td></tr>
<tr><td>11</td><td>Tobacco products</td><td>39</td><td>Alumina and aluminum production and processing</td><td>68</td><td>Motor vehicles, Motor vehicle parts</td></tr>
<tr><td>12</td><td>Apparel and Textile mills</td><td>40</td><td>Nonferrous metal (except aluminum) production and processing</td><td>71</td><td>Aerospace products and parts</td></tr>
<tr><td>13</td><td>Textile product mills</td><td>41</td><td>Foundries</td><td>72</td><td>Railroad rolling stock</td></tr>
<tr><td>15</td><td>Leather and allied products</td><td>42</td><td>Forging and stamping</td><td>73</td><td>Ship and boat building</td></tr>
<tr><td>16</td><td>Wood products</td><td>43</td><td>Cutlery and hand-tools</td><td>74</td><td>Other transportation equipment</td></tr>
<tr><td>17</td><td>Pulp, paper, and paperboard mills</td><td>44</td><td>Architectural and structural metals, Boilers, tanks, and shipping containers</td><td>75</td><td>Furniture and related products</td></tr>
<tr><td>18</td><td>Converted paper products</td><td>46</td><td>Hardware, Spring and wire products and Other fabricated metal products</td><td>76</td><td>Medical equipment and supplies</td></tr>
<tr><td>19</td><td>Printing and related support activities</td><td>48</td><td>Machine shops, turned products, and screws, nuts, and bolts</td><td>77</td><td>Other miscellaneous manufacturing</td></tr>
<tr><td>23</td><td>Basic chemicals and Other chemical products and preparations</td><td>49</td><td>Coating, engraving, heat treating, and allied activities</td><td></td><td></td></tr>
<tr><td>24</td><td>Resins and synthetic rubber, fibers, and filaments</td><td>50</td><td>Other fabricated metal products</td><td></td><td></td></tr>
<tr><td>25</td><td>Pharmaceuticals and medicines</td><td>51</td><td>Agriculture, construction, and mining machinery</td><td></td><td></td></tr>
<tr><td>26</td><td>Soap, cleaning compounds, and toilet preparations</td><td>52</td><td>Commercial and service industry machinery</td><td></td><td></td></tr>
<tr><td>27</td><td>Pesticides, fertilizers, and other agricultural chemicals</td><td>53</td><td>Ventilation, heating, air-conditioning, and commercial refrigeration equipment and Other general purpose machinery</td><td></td><td></td></tr>
</table>

Table A2

Percentage of offshore and immigrant employment in Manufacturing and selected sectors within it

	2000	2001	2002	2003	2004	2005	2006	2007
Percentage of Offshored Employment in **Manufacturing**	23.3	22.7	22.5	23.9	24.4	23.3	22.4	29.3
Percentage of immigrant employment in **Manufacturing**	12.8	13.7	14.5	14.0	14.1	14.8	15.2	14.0
Percentage of Immigrants (and offshored) in the sector with the Fastest growing immigrant share **Apparel and Textile Mills**	27.1 (14.4)	28.5 (13.8)	33.6 (10.6)	31.5 (9.2)	30.1 (13.9)	30.6 (12.1)	31.6 (13.1)	34.7 (7.5)
Percentage of Immigrants (and offshored) in the sector with the Slowest growing immigrant share **Plastics Products**	14.7 (12.2)	16.0 (15.9)	16.3 (17.4)	14.4 (22.8)	12.5 (25.0)	13.6 (26.7)	14.1 (22.9)	12.4 (29.4)
Percentage of Offshored (and immigrants) in the sector with the Fastest growing offshored share **Basic Chemicals**	18.3 (6.8)	22.1 (7.5)	19.5 (8.3)	19.3 (7.6)	18.3 (8.7)	31.1 (6.9)	33.0 (6.8)	48.5 (5.4)
Percentage of Offshored (and immigrants) in the sector with the Slowest growing offshored share **Other Transportation Equipment**	54.9 (4.8)	61.6 (6.9)	57.5 (5.5)	39.4 (6.5)	20.7 (4.0)	14.5 (9.0)	15.0 (7.6)	21.0 (8.1)

Note: Immigrant, native and offshore employment are calculated as described in the text. These statistics include all workers in the computation of native and immigrant employment.

Table A3:

Effects of imputed offshoring and imputed immigration on shares of natives, immigrants and offshore workers among less educated employees

(As in table 1, but the offshore employment only includes employment in affiliates of US parents)

Dependent variable: Explanatory variable:	Share of US-Nationals in Total Employment			Share of Immigrants in Total Employment			Share of Offshore Employees in Total Employment—IN US AFFILIATES ONLY --		
Imputed Offshoring		-0.14	**-0.13**		-0.25**	-0.20*		**0.40****	0.34
		(0.21)	**(0.21)**		(0.10)	(0.10)		**(0.22)**	(0.22)
Imputed Immigration:	0.06		0.06	**0.34****		0.31**	-0.41**		-0.37**
	(0.10)		(0.15)	**(0.08)**		(0.09)	(0.13)		(0.14)
Observations	464	464	464	464	464	464	464	464	464
Sector fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time effects:	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: The dependent variable in each regression is specified in the first row. The explanatory variables are specified in the first column. The method of estimation is Ordinary Least Squares; Imputed offshoring is calculated as share of intermediate imported in the sector, using the Feenstra and Hanson (1999) definition. Imputed immigration is calculated using initial employment composition by country and overall population growth by nationality in the US. Both indices are divided by their standard deviation in the sample so that a change in one unit of the explanatory variable corresponds to a change by one standard deviation. Heteroskedasticity-robust standard errors are reported in parentheses.