Immigration, Offshoring and American Jobs

Online Appendix

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1 Appendix: Endogenous Native Wages

In the main text we have assumed that each sector is not large enough to affect the domestic wage w. Here we discuss how w would react if such an assumption did not hold.

Intuition is better served by focusing on the simple case of an economy with only two sectors indexed $s = 1, 2$. In each sector immigrant, offshore and native labor demands are given by expressions like (B2) with corresponding price indices like (B3). The two sectors may differ in terms of offshoring and immigration costs, technological parameters, demand parameters, goods prices, and specific factor endowments. As in the model in the main text, goods prices p_Y^s are exogenously determined in international markets and foreign workers are in infinitely elastic supply at foreign wage w^*. Their utility maximizing decisions determine whether they are employed as immigrants or offshore workers in the two sectors, or in some other non-modeled occupation abroad. In contrast to the model in the main text, native workers are now in fixed supply $\overline{N}_D$ and their allocation between sectors is determined, together with their wage w, by the clearing of the native labor market: the sum of the two sectors' native labor demands has to equal native labor supply ($N_D^1 + N_D^2 = \overline{N}_D$). The equilibrium native wage then determines immigrant and offshore employment levels in the two sectors, N_M^1 and N_O^2, through the corresponding labor demands as in (B2).

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Specifically, given (B1), (B2), and (B3) native labor demand in sector s can be rewritten as

$$w = (N_D^s)^{-(1-\alpha^s)} (a_L^s)^{-\alpha^s} (1 - I_{NO}^s)^{1-\alpha^s} [\Omega^s(I_{MO}^s, I_{NO}^s)]^{(\sigma^s-1)(1-\alpha^s)-\alpha^s} (B^s)^{1-\alpha^s}$$

with $B^s = (\alpha p_Y^s A^s)^{\frac{1}{1-\alpha}} H^s$ and

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

Equilibrium in the native labor market is represented in Figure A3. This depicts a standard box diagram in which the horizontal dimension measures native labor supply $\overline{N}_D$, the vertical dimension measures the native wage, and (log-linearized) labor demands in the two sectors are depicted as decreasing in the native wage from their respective origins O_1 and O_2. Accordingly, the equilibrium allocation of native workers between the two sectors and the corresponding common wage are to be found at the crossing of the two labor demand schedules where, by graphical construction, the native labor market clears. Figure A3 can be used to assess the effects of changes in migration and offshoring costs on the wage of native workers as well as on their sectoral allocation. For example, under our working assumptions, a fall in migration costs in sector 1 (lower δ^1) does not affect I_{NO}^1 and increases I_{MO}^1. This leads to a fall in $\Omega^1(I_{MO}^1, I_{NO}^1)$. What then happens in the figure depends on whether $\left(\sigma^1 - 1\right)$ is larger or smaller than $\alpha^1/\left(1 - \alpha^1\right)$, with the former measuring the substitutability of tasks and the latter the importance of the task bundle for final production. When tasks are not easily substitutable (small σ^1) and the task bundle contributes a lot to final production (large α^1), so that $\left(\sigma^1 - 1\right) < \alpha^1/\left(1 - \alpha^1\right)$, a lower $\Omega^1(I_{MO}^1, I_{NO}^1)$ shifts the labor demand schedule of sector 1 upwards increasing the wage of natives and their employment in sector 1. The opposite happens when tasks are easily substitutable (larger σ^1) and the task bundle does not contribute much to final production (small α^1), so that $\left(\sigma^1 - 1\right) > \alpha^1/\left(1 - \alpha^1\right)$.

The effect of lower offshoring costs is, instead, more complex as a fall in β^1 not only decreases I_{MO}^1 but also increases I_{NO}^1, thus reducing $\Omega^1(I_{MO}^1, I_{NO}^1)$. However, additionally, the native labor demand schedule shifts upward when tasks are not easily substitutable (small σ^1) and the task bundle contributes a lot to final production (large α^1), and vice-versa. So, whether easier migration and easier offshoring lead to higher employment and a higher native wage is, in the end, an empirical question that depends on sectoral characteristics.

2 Appendix: No Discrimination between Natives and Immigrants

In the model presented in the main text, the productivity effect due to easier immigration stems from the fact that falling costs of immigration create rents for domestic firms $c_D - c_M(i) = wa_L - w^*\delta\tau(i)a_L$ per unit task for $i \in [0, I_{MO}]$, just as the productivity effect due to easier offshoring stems from the fact that falling costs of offshoring create rents for domestic firms $c_D - c_O(i) = wa_L - w^*\beta t(i)a_L$ per unit task for $i \in [I_{MO}, I_{NO}]$. These effects arise because we have assumed that firms can discriminate between immigrants and natives since they know the wage w^* in the country where immigrants come from as well as their common migration cost δ.

This ability to discriminate is crucial for the productivity effect due to easier immigration to materialize. The argument can be spelled out following Grossman and Rossi-Hansberg (2008). In discussing the different effects of easier offshoring and easier immigration, these authors assume, as we also do, that foreign workers can stay in the foreign country and earn the wage w^* or can move to the home country, at the cost of a fraction of their working time, and earn the wage $\widetilde{w}$. To avoid the existence of corner outcomes with no migration or infinite migration, they also assume that foreign workers are heterogeneous in terms of their moving costs. Specifically, a foreign worker z captures only a fraction $1/\delta\mu(z)$ of $\widetilde{w}$ when she moves to the home country. Without loss of generality, foreign workers can be indexed in increasing order of moving costs so that $\mu'(z) > 0$. Moreover, Grossman and Rossi-Hansberg (2008) assume that immigrants are as productive as natives and that domestic firms are not able to discriminate between natives and immigrants nor between immigrants with different moving costs.

In terms of our notation, all these assumptions imply $\tau(i) = 1$ and $\widetilde{w} = w$. They also imply that the marginal immigrant Z earns the same net income in both locations so that $w = w^*\delta\mu(Z)$. This replaces our condition $\widetilde{w} = w^*\delta$ in the main text and uniquely determines Z, which in turn determines the number of immigrants given some distribution of foreign workers across moving costs.

To sum up, when firms are unable to discriminate, native, immigrant and offshore marginal costs become $c_D = wa_L$, $c_M(i) = w^*\delta\mu(Z)a_L = wa_L$ and $c_O(i) = w^*\beta t(i)a_L$, respectively. Accordingly, an inframarginal immigrant $z < Z$ earns rents $w - w^*\delta\mu(z)$. This implies that as the common immigration cost δ falls, additional rents are created at both the intensive and the extensive task margins. Accordingly, new immigrants enter the home country (Z increases). More rents also accrue to the incumbent immigrants, but not to the home firms whose profitability, therefore, does not change.

"The difference between falling costs of offshoring and falling costs of immigration is that the former create rents for domestic firms ... whereas the latter create rents for the immigrants" (Grossman and Rossi-Hansberg, 2008).

In contrast, when firms can discriminate between natives and immigrants they fully appropriate the rents. Ruling out offshoring for simplicity, in our model the rents per unit task when cheaper immigrants are employed instead of natives amount to

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

so that total rents correspond to the striped area in Figure A4. Being entirely appropriated by firms, these rents are the source of the productivity effect due to immigration. Note that our assumption of perfect discrimination is not crucial in order to generate a productivity effect due to immigration—as long as there is any degree of discrimination some rent is generated.

3 Appendix: Cognitive, Communication and Manual Intensities

The *O*NET* variables used to construct the cognitive, communication and manual intensity indices are the following. Cognitive Intensity is the average of 10 variables: Fluency of Ideas, Originality, Problem Sensitivity, Deductive Reasoning, Inductive Reasoning, Information Ordering, Category Flexibility, Mathematical Reasoning, Number Facility, Memorization. Each variable is the intensity of use of the skill associated to the occupation. The value of the variable is the percentile of the occupation in the ranking of workers according to that skill intensity. Communication Intensity is the average of 4 variables: Oral Comprehension, Written Comprehension, Oral Expression, Written Expression. Manual Intensity is the average of 19 variables: Arm-Hand Steadiness, Manual Dexterity, Finger Dexterity, Control Precision, Multi-limb Coordination, Response Orientation, Rate Control, Reaction Time, Wrist-Finger Speed, Speed of Limb Movement, Static Strength, Explosive Strength, Dynamic Strength, Trunk Strength, Stamina, Extent Flexibility, Dynamic Flexibility, Gross Body Coordination, Gross Body Equilibrium.

4 Appendix: 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 (2011) 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.

In order to calculate total offshore employment due to U.S. offshoring, by MNCs and at arm's length, 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 by 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 main text, this procedure assumes an equivalent labor requirement per unit of exports for affiliates and non-affiliates.

5 Appendix: Information Technology Agreement Tariffs

The Information Technology Agreement is a tariff cutting agreement enacted by several World Trade Organization members. The first stage reduction in tariffs under the ITA occurred on 1 July 1997. The number of signatories has steadily grown and now includes Albania, Australia, Bahrain, Bulgaria, Canada, China, Costa Rica, Croatia, Dominican Republic, Egypt, El Salvador, the European Community, Georgia, Guatemala, Honduras, Hong Kong, Iceland, India, Indonesia, Israel, Japan, Jordan, Korea, Kuwait, Kyrgyz Republic, Macao, Malaysia, Mauritius, Moldova, Morocco, New Zealand,

Nicaragua, Norway, Oman, Panama, Peru, Philippines, Romania, Saudia Arabia, Singapore, Switzerland, Chinese Taipei, Thailand, Turkey, Ukraine, United Arab Emirates, United States, and Vietnam.

The products covered by the ITA include data processing and storage products, audio and visual devices, various electronics, various machines and parts and accessories to all of these. More specifically, the ITA products are those under the following Harmonized System headings: 3818, 846911, 847010, 847021, 847029, 847030, 847040, 847050, 847090, 847110, 847130, 847141, 847149, 847150, 847160, 847170, 847180, 847190, 847290, 847321, 847329, 847330, 847350, 850440, 850450, 851711, 851719, 851721, 851722, 851730, 851750, 851780, 851790, 851810, 851830, 851829, 852020, 852311, 852312, 852313, 852320, 852390, 852431, 852439, 852440, 852491, 842499, 852510, 852520, 852540, 852790, 852910, 852990, 853120, 853190, 853210, 853221, 853222, 853223, 853224, 853225, 853229, 853230, 853290, 853310, 853321, 853329, 853331, 853339, 853340, 853390, 853650, 853669, 853690, 854110, 854121, 854129, 854130, 854140, 854150, 854160, 854190, 854212, 854213, 854214, 854219, 854230, 854240, 854250, 854290, 854381, 854389, 854441, 854449, 854451, 854470, 900911, 900921, 900990, 902610, 902620, 902680, 902690, 902720, 902730, 902750, 902780, 902790, 903040.

For more information on the ITA, see: http://www.wto.org/english/tratop_e/inftec_e/itaintro_e.htm

6 Appendix: Horizontal versus Vertical Offshoring

We re-run our regressions of Table 5 on a sample of industries that are relatively intensive in vertical offshoring. This is also more consistent with our theoretical framework, which is a model of vertical rather than horizontal offshoring.

In our sample we are able to identify those industries for which re-exporting to the headquarters, as opposed to generating purely local sales, is a more important activity for the affiliates. Specifically, using the BEA data we can calculate the aggregate value of exports from affiliates to headquarters as well as the total value of local sales of affiliates. Then, we can rank industries in terms of their import-to-local-sales ratios, which we take as a measure of the intensity of vertical offshoring. Finally, we re-run our regressions focusing on industries whose import-to-local-sales ratios are above some thresholds. Based on Harrison and McMillan (2011), as well as on the logic of our model, we expect to find stronger results for industries with higher import-to-local-sales ratios.

Before showing the regression results, Figure A2 in the Web Appendix compares two subsets of our 58 industries, partitioned according to the ratio of multinationals' re-imports from affiliates to

local sales–i.e., according to the degree of "vertical" (foreign production gets re-imported) versus "horizontal" (foreign production is sold locally) offshoring. Since across industries the median value of that ratio is 0.20 with standard deviation 0.10, we compare industries with ratios larger than 30 per cent with industries with ratios below 10 per cent, omitting industries with values between 0.1 and 0.3 in order to make the comparison starker. The figure shows that industries with high ratios exhibit a positive and significant correlation between the share of offshore workers and native complexity. There is, instead, no significant correlation in industries with low ratios. This is consistent with the idea that vertical offshoring is the one fitting better our story of offshoring tasks in the medium-complexity range (to reduce costs). Horizontal offshoring, instead, may be associated with sending abroad a larger range of tasks, specific also to marketing and sales, rather than only to production.

Looking at the regression results, Table A2 in the Web Appendix, columns (1)-(3), report the 2SLS effect of variation in offshoring costs on native task complexity when we limit the sample to industries with high intensity of vertical offshoring, as defined according to three different threshold values[1]. Since this procedure selects subsets of industries, in each case the sample of observations is reduced accordingly. As expected, the effect is stronger for industries at the highest relative intensity of vertical offshoring (Columns 1-3) and it is increasing, the larger is the percentage of re-import relative to local sales. In columns (4)-(6), the corresponding estimates for industries with low intensity of vertical offshoring show instead a weak (not significant) effect on native task complexity. Hence, it is the vertical nature of offshoring activities that seems to generate competition between natives and offshore workers, thereby altering the allocation of production tasks within industries.

7 Appendix: Wage Effects

Our model and empirical strategy have examined employment across industries in order to capture the productivity consequences of immigration and offshoring. However, in the presence of imperfect mobility of workers, or barriers to transferring skills from one industry to another, a portion of the industry-specific effects of immigration and offshoring could be captured by wage rather than employment differentials. In particular, while the U.S. labor force is mobile geographically, as well as across industries, in the short run wages may not be perfectly equalized.

[1] We choose thresholds of the ratio of re-imports to total local sales of 0.3, 0.2 and 0.1. This range spans the intermediate range of values as the median ratio in the whole sample is 0.2.

To address this issue, we check directly whether industry wages are affected by offshoring and immigration by running a specification like (1) and (2) in Table 2, except using the average wage of natives instead of their employment as the dependent variable. The average wage is constructed from ACS data, as detailed in the paper. The results reported in Table A3 are quite clear and consistent across each specification (with each effect estimated via separate regressions to be consistent with the specification in Table 2). While the point-estimates of the effect of increased offshoring and immigration on native wages are always positive, those effects are never significant. These results confirm that, while there may be a productivity effect of offshoring and immigration on wages, the assumption of inter-sector mobility of workers is reasonable as the adjustment to cross-sector productivity differences takes place mainly through employment reallocation.

Web Appendix: Tables and Figures

Table A1 – Industries and Code

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

Table A2: Vertical versus Horizontal Offshoring

	Dependent Variable: Complexity of Native jobs					
Specification:	**(1) Industries with import/local sales>0.3**	**(2) Industries with import/local sales>0.2**	**(3) Industries with import/local sales>0.1**	**(4) Industries with import/local sales<0.3**	**(5) Industries with import/local sales<0.2**	**(6) Industries with import/local sales<0.1**
			2SLS Estimates			
Offshore share of employment	1.09*	0.95*	0.92*	0.19	0.18	0.17
	(0.59)	(0.57)	(0.49)	(0.23)	(0.23)	(0.23)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	144	200	272	320	264	192
			First Stage			
	Offshore share of employment	Offshore share of employment	Offshore share of employment	Offshore share of employment	Offshore share of employment	Offshore share of employment
Sector-specific tariffs	-0.014**	-0.009**	-0.009**	-0.06**	-0.06**	-0.06**
	(0.004)	(0.003)	(0.003)	(0.02)	(0.01)	(0.01)
F-stat	9.33	8.10	9.56	14.4	13.5	13.5

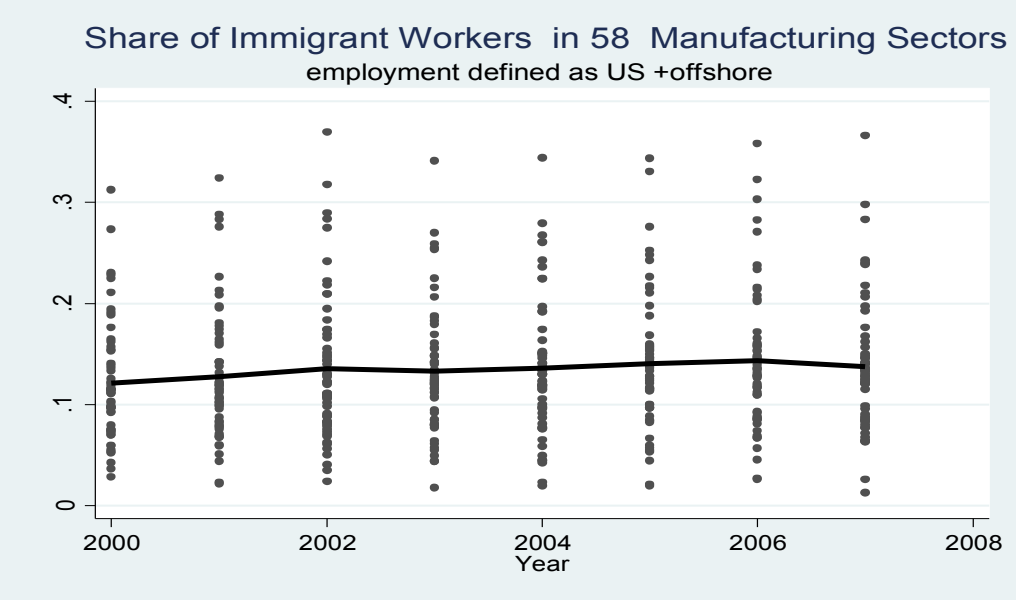
Note: The Upper part of the Table shows the coefficients from an OLS estimation, the lower part from a 2SLS estimation. All regressions include industry and year fixed effects. Standard errors are heteroskedasticity robust. **,*= significant at the 5%, 10% level.

Table A3: Effects of Offshoring and Immigration on Native Wages, 2SLS Estimates

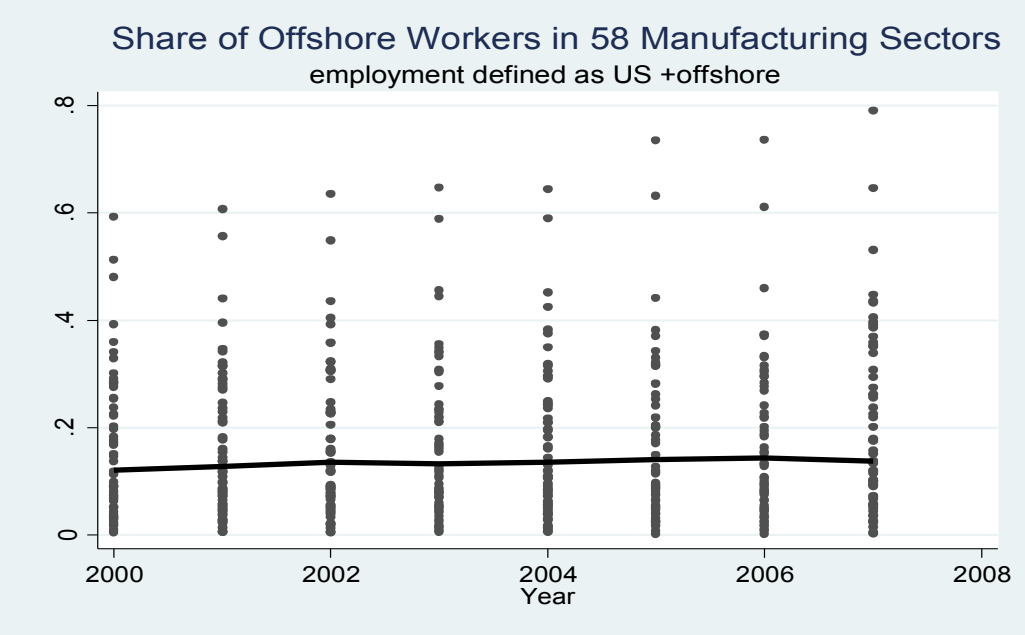
Method of estimation: 2SLS	**Dependent Variable: logarithm of native wage in the sector**		**Dependent Variable: logarithm of Immigrant wage in the sector**
Specifications	**(3) 2SLS**	**(4) 2SLS**	**(5) 2SLS**
Immigrant share of employment	0.82 (0.83)		
Offshore share of employment		0.24 (0.43)	0.02 (0.78)
Number of observations	464	464	464
First Stage:	Immigrant share of employment	Offshore share of employment	Immigrant share of employment
Imputed sector-specific Share of immigrants	1.94** (0.48)		1.94** (0.48)
Sector-specific tariffs		-0.06** (0.008)	
F-staistic	16.32	52.2	16.32

Note: The dependent variable in each regression is specified at the top of the Table. The units of observations are industry by year. All regressions include industry and year effects. Heteroskedasticity-robust standard errors, clustered at the sector level are reported. **,* significant at the 5, 10% level.

Figure A1 – Shares of immigrants and offshore workers in US manufacturing industries (2000-2007)

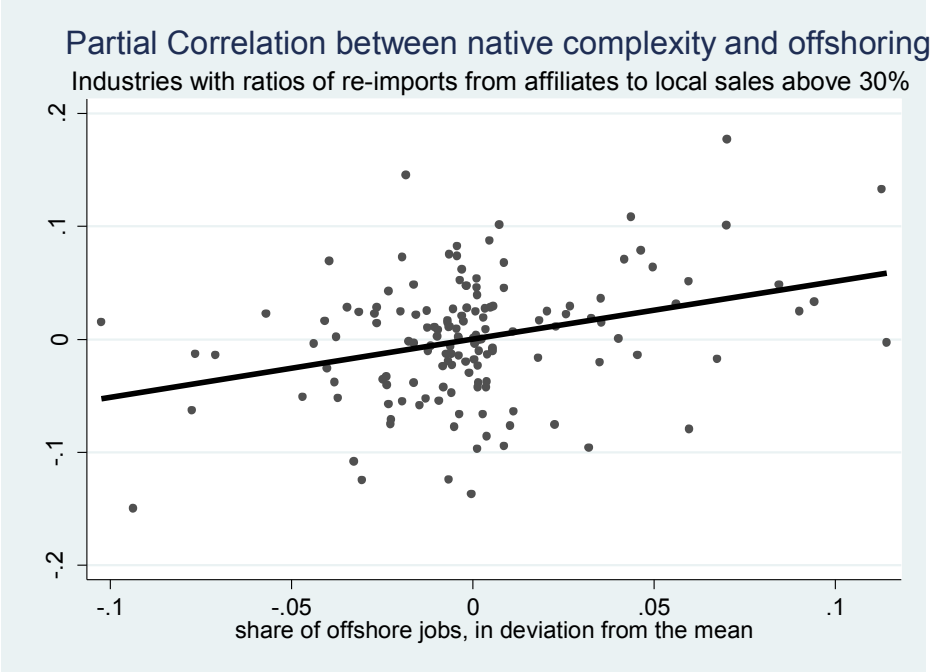


(a)



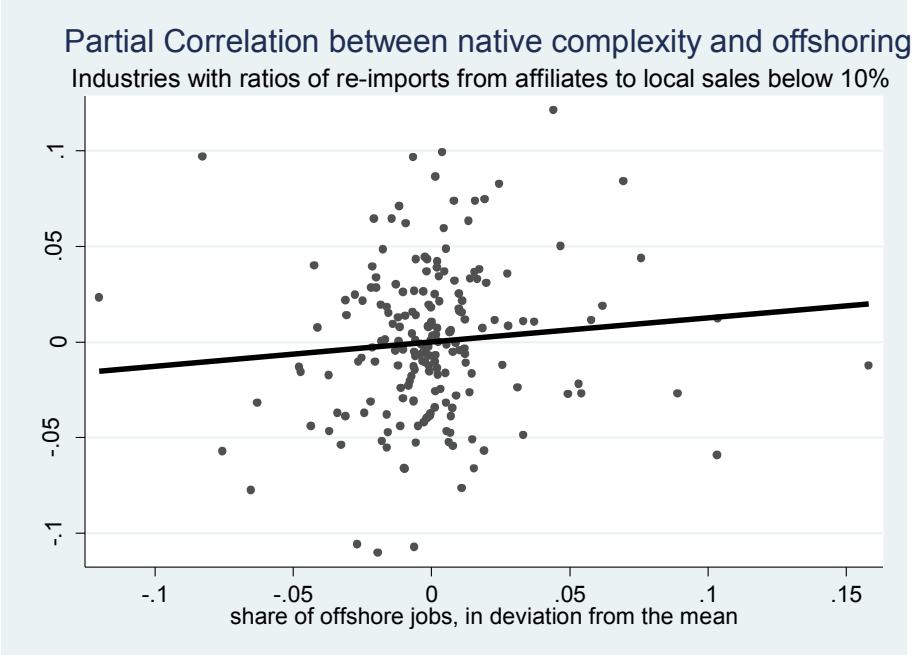
(b)

Figure A2: Offshoring Intensity and Native Complexity



Regression Slope: 0.51, standard error 0.15

(a)



Regression Slope: 0.12, standard error 0.12.

(b)

Figure A3 – Endogenous Determination of Native Wages

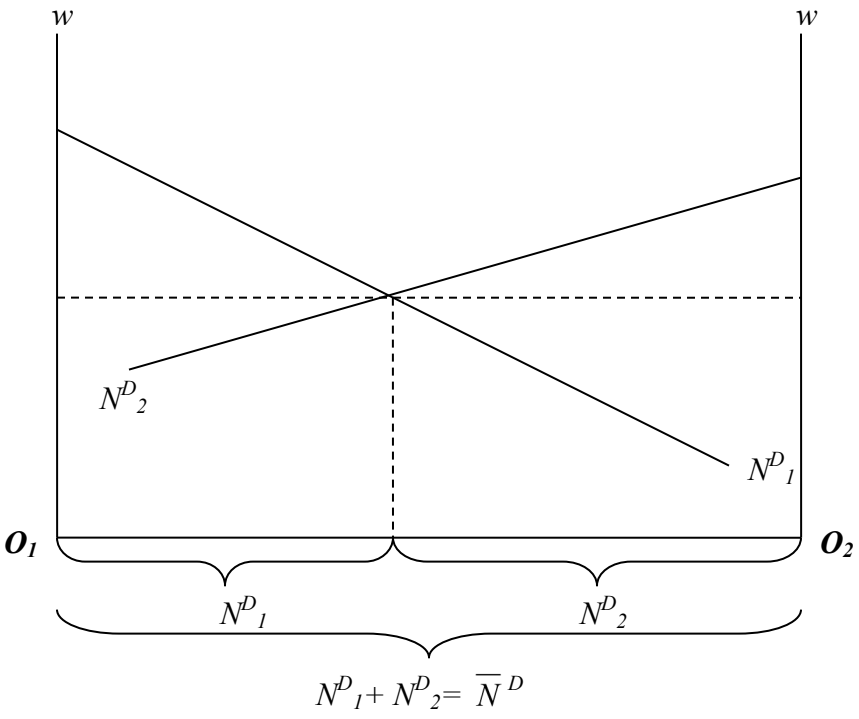


Figure A4 – Immigration, Discrimination and Rents