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# The effects of offshoring on the elasticity of labor demand

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ABSTRACT

In this paper, I use detailed plant-level data to analyze the relationship between offshoring and labor demand elasticities in the U.S. manufacturing sector during the 1972–2001 period. The results suggest that conditional demand elasticities for production workers are positively associated with increased exposure to offshoring both in the short-run and in the long-run. This relationship holds both for the unbalanced panel of plants and, for plants which continue their operations throughout the sample period. Controlling for skill biased technical change does not alter the magnitude or the significance of the estimated positive relationship between offshoring and labor demand elasticities.



## 1. Introduction

During the past few decades, the U.S. economy has become much more integrated into the world economy through increased openness to international trade and as a source and host of capital flows. At the same time, many countries have abandoned policies that restrict foreign investment and have started offering better infrastructure and tax incentives aimed at encouraging foreign capital inflows. Together with improvements in technology that decreased transportation and monitoring costs significantly, this era is characterized by increased global production and vertical specialization of countries. However, during this period mobility of goods and capital has remained significantly higher than that of labor (Rodrik, 1997). Understanding the implications of these new aspects of globalization on labor markets is important and has policy implications concerning a large portion of the U.S. population and the rest of the world. In this paper I contribute towards this understanding of globalization by investigating the effect of offshoring on conditional labor demand elasticities using confidential plant-level data for the U.S. manufacturing sector.

Much of the previous research on labor market effects of international trade focuses on the change in the skill premium observed in the U.S. and other developed nations.[1] Most of these studies have focused on trade with developing countries as predicted by the Heckscher-Ohlin model and the Stolper-Samuelson theorem. Most have found that trade in final goods explains only a small portion of increased wage inequality. Although the debate still continues, many economists see skill biased technical change and offshoring (trade in intermediate inputs) as the two main factors contributing to the rise in observed wage gap, mainly because other potential explanations such as trade in final goods, immigration and the decline of unions fail to explain the extent of the wage gap.

Rodrik (1997) identifies labor demand elasticities as an equally important channel through which an increase in international trade can affect labor markets. He argues that greater product market competition, due to a decline in trade protection and the entry of less developed nations into the manufacturing sector, should make labor demand more elastic. The increased possibility of substituting foreign labor for domestic through offshoring is also likely to flatten the labor demand curve. Importantly, offshoring could impact labor markets even though its share is small in most industries. An increase in the threat of offshoring could increase labor demand elasticities, even if actual levels of offshoring do not change.

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[1] See Gaston and Trefler (1994), Berman et al. (1994), Autor et al. (1998) among others. Harrison and Hanson (1999), Feenstra and Hanson (2001), Goldberg and Pavcnik (2004, 2007), Harrison and McMillan (2007) provide comprehensive surveys of the literature on trade and wages. Related literature examines the impact of capital flows on skill upgrading; see Feenstra and Hanson (1997), Blonigen and Slaughter (2001).

Increased labor demand elasticities have important labor market consequences, and it is important to understand the significance of this channel. First, an increase in labor demand elasticity alters the incidence of non-wage labor costs, such as payroll taxes or improved working conditions. Increased responsiveness of employers to wage changes increases workers' share of such costs. Second, higher elasticities result in greater instability in the labor market. If labor demand is more elastic, shocks to labor demand caused by changes in labor productivity will lead to higher volatility of employment and wages. Third, higher elasticities lead to a decline in the bargaining power of labor, weakening unions and decreasing labor's share of industry rents (Rodrik, 1997). The decline of unionism (Card, 2001), and the increase in within-group volatility in labor market conditions (Gottschalk and Moffitt, 1994) in recent decades are well documented for the U.S. economy. Recent studies also document an increase in income risk (Krishna and Senses, 2009) and a reduction in the scope for risk-sharing arrangements between workers and firms (Bertrand, 2004) especially in industries with higher exposure to foreign competition. These findings are consistent with the idea that labor demand elasticities have increased as the U.S. economy has become more integrated with the rest of the world.

The literature on the impact of international trade on labor demand elasticities has mainly focused on developing countries during trade liberalization periods.[2] Slaughter (2001) is the first to test the relationship between openness and labor demand elasticities for a country that increasingly engages in offshoring activity. He estimates labor demand elasticities for eight manufacturing sectors in the U.S. from 1961 through 1991, using industry-level data. His estimation results suggest that the demand for production labor has become more elastic in this period, but the contribution of openness to change in these elasticities is unclear. More recently, Hijzen and Swaim (2008) document a substantial increase in elasticity of labor demand over the past two decades using industry-level data for a large number of OECD countries. They find that offshoring is associated with a more elastic demand in the cross section.[3]

In this paper I use disaggregated data at the plant-level to analyze the link between offshoring and labor demand elasticities in the U.S. manufacturing sector during the 1972–2001 period. I begin by estimating conditional labor demand elasticities for production workers in each industry for every year.[4] These elasticities are derived from cost share equations both in the short-run when capital is treated as a quasi-fixed input, and in the long-run when all factors of production are assumed to be variable. The next step of the analysis focuses on the relationship between industry-level, time varying estimates of elasticities and various measures of exposure to offshoring. I evaluate the importance of this relationship both for the short run and long run elasticities, controlling for technological change, in addition to year and industry fixed effects.

The use of plant-level data in the estimation of labor demand elasticities has various advantages over using data at the industry-level. First, it allows me to control for plant-level heterogeneity and to estimate these labor demand elasticities at the industry-level. Second, the identifying assumption of perfectly elastic labor supplies is more appropriate at the disaggregated level of the plant (Hamermesh, 1986a,b). Third, plant-level data allow me to distinguish between within-plant changes in labor demand elasticities and changes due to plant entry and exit.

The results suggest that conditional demand elasticities for production workers both in the short-run and in the long-run are positively associated with increased exposure to offshoring. This relationship holds both for the unbalanced panel of plants and, for plants which continue their operations throughout the sample period. Controlling for skill biased technical change does not alter the magnitude or the significance of the estimated positive relationship between offshoring and labor demand elasticities. Evidence on the link between skill biased technical change and labor demand elasticities is mixed at best.

This paper is organized as follows. The next section introduces the empirical specifications for estimating labor demand elasticities and provides summary statistics for these estimates. Section 3 describes the analysis examining the relationship between offshoring and labor demand elasticities and presents the estimation results. Section 4 concludes.

## 2. Own price elasticity of demand for production labor

The first step of the analysis is to estimate labor demand elasticities for each industry and year. In estimating conditional labor demand elasticities, I follow previous work on the relative importance of trade and technology on rising income inequality and use a translog framework.[5] This flexible functional form is preferable in this context, as it places no *a priori* restrictions on substitutability between inputs, as do CES, Cobb-Douglas or Leontief, and contains these simpler forms as special cases.

### *2.1. Translog specification: capital is quasi-fixed*

I begin by deriving the cost share equations from a short-run cost function with quasi-fixed inputs. In this part of the analysis, as in Berman, Bound and Griliches (1994) and Feenstra and Hanson (1999), I assume that the level of capital (K) is fixed. This choice is primarily due to lack of data on rental prices of capital at the disaggregated level of the firm (or the industry). These conditional demand elasticities derived from the short-run cost function, reflect the responsiveness of the demand for production workers to changes in own wages when firms are constrained in their choice of capital levels.

The translog cost function is a second order approximation to an arbitrary cost function and takes the following form:

$$\log C = \alpha_0 + \sum_f \alpha_f \ln w_f + \sum_k \beta_k \ln x_k + \frac{1}{2}\sum_f \sum_{f'} \gamma_{ff'} \ln w_f \ln w_{f'} + \frac{1}{2}\sum_f \sum_k \delta_{km} \ln x_k \ln x_m + \sum_f \sum_k \phi_{fk} \ln w_f \ln x_k + \gamma_t t + \frac{1}{2}\gamma_{tt} t^2 + \sum_f \gamma_{tf} t \ln w_f + \sum_k \gamma_{tk} t \ln x_k \quad (1)$$

where $w_f$ denotes prices of variable inputs and $x_k$ denotes quantities of output and fixed inputs.

The coefficients on $t$ represent technological change.

[2] Krishna et al. (2001) are the first to examine this relationship using panel data at the firm level for Turkey. Fajnzylber and Maloney (2000) estimate dynamic labor demand equations using establishment level panel data from Chile, Mexico and Colombia. They test for structural breaks in the labor demand equations across time, during a period in which all of these countries experienced changes in their trade policies. Hasan et al. (2007) implement a similar analysis for India using industry level data. They find positive effects of trade liberalization on labor demand elasticities, especially in states with more flexible labor regulations.

[3] Interestingly, Hijzen and Swaim (2008) find this relationship between average offshoring and labor demand elasticities to be weaker in countries with stricter employment protection legislation, consistent with Hasan et al. (2007).

[4] In this paper I only focus on conditional labor demand elasticities since the increased possibility of outsourcing mainly affects labor demand elasticities through the substitution effect (see Lommerud et al. (2008), for an exception under specific assumptions). However, it should be noted that increased product market competition faced by domestic firms (due to reduced trade protection in the U.S., the decline in transportation costs and entry of developing countries into the world trade market) will also make labor demand more elastic through the scale effect. Using plant-level data Levinsohn (1993) and Harrison (1994) find support for the idea that intensified trade competition curtails domestic market power. While neither of these studies focuses directly on labor demand elasticities, the resulting increase in the elasticity of final good demand should make the derived labor demand curve even flatter over time.

[5] See for example, Berman, Bound and Griliches (1994), Feenstra and Hanson (1999) and Canals (2006).

By differentiating Eq. (1) with respect to $\ln w_f$, I obtain the following system of cost shares:

$$s_f = \alpha_f + \sum_f \gamma_{ff'} \ln w_f + \sum_k \phi_{fk} \ln x_k + \gamma_{tf} t \quad f = 1, \ldots, F \tag{2}$$

Imposing homogeneity of degree one in input prices and symmetry implies:

$$\sum_f \alpha_f = 1 \quad \sum_f \alpha_{ff'} = 0 \quad \sum_f \phi_{fk} = 0 \text{ and } \gamma_{ff'} = \gamma_{f'f}$$

Assuming skilled and unskilled labor are the two variable factors, system of Eq. (2) can then be written as:

$$s_{U_{WBijt}} = \alpha_0 + \gamma_{US} \ln \frac{w_{Uijt}}{w_{Sijt}} + \phi_K \ln K_{ijt} + \phi_Y \ln Y_{ijt} + \phi_Y \ln z_{ijt} + \gamma_{tf} t \tag{3}$$

where $s_{U_{WBijt}}$ is the share of production worker wages in total wage bill (variable cost), $w_{Uijt}$ and $w_{Sijt}$ are the wage rates for production and non-production workers in plant $i$ in industry $j$ (three digit SIC) at time $t$. $z_{ijt}$ denotes any structural variables that shifts costs.

Unobserved heterogeneity at the plant level due to differences in organization, the amount and quality of management inputs, vintage of capital equipment, extent of unionization, and quality of output produced can lead to permanent differences in plant employment, wages and therefore cost (Dunne and Roberts, 1993). Since many of these factors change slowly over time, they will be treated as time-invariant plant specific effects. I will estimate Eq. (3) in first differences for each three-digit industry $j$ and year $t$ in order to control for these unobserved time-invariant plant fixed effects[6]:

$$ds_{U_{WBijt}} = \gamma_{tf} dt + \gamma_{US} d \ln \frac{w_{Uijt}}{w_{Sijt}} + \phi_K d \ln K_{ijt} + \phi_Y d \ln Y_{ijt} + \phi_Y d \ln z_{ijt} + u_{ijt}$$

Any factor that shifts the production function and therefore affects costs, such as price of imported inputs, the range of activities outsourced and technological change should also be included in Eq. (3) (Feenstra and Hanson, 2001). To the extent that these factors are constant across plants in a given four-digit industry, inclusion of industry dummies at the four-digit SIC level $(m)$ in the differenced specification will yield unbiased estimates of $\gamma_{USjt}$. The final specification to be estimated is[7]:

$$ds_{U_{WBijt}} = \alpha_m + \gamma_{US} d \ln \frac{w_{Uijt}}{w_{Sijt}} + \phi_K d \ln K_{ijt} + \phi_Y d \ln Y_{ijt} + u_{ijt} \tag{4}$$

Note that constant returns to scale implies $\phi_K = -\phi_Y$. I will estimate Eq. (4) with and without this restriction imposed. After estimating Eq. (4) for each industry and year, the own price elasticity of demand for production workers can be calculated using the parameter estimates and factor shares as:

$$\varepsilon_U^{SR} = \frac{\gamma_{US}}{s_{U_{WB}}} + s_{U_{WB}} - 1$$

where $\gamma_{US}$ is estimated for each industry and year from Eq. (4) and $s_{U_{WB}}$ is the share of production labor in total wage bill calculated at its mean for the regression sample.

### 2.2. Translog specification: capital is variable

Although the quasi-fixed cost function is commonly used in the literature, keeping capital fixed restricts the analysis of changes in labor demand elasticities as a result of increased offshoring to the *short-run*. The elasticity estimates from Eq. (4) reflect responsiveness of the demand for production workers when the only possibility of substitution in response to changes in wages is between workers with different levels of skill. The elasticities are likely to be higher in the long run when firms can adjust the level of other factors of production, such as capital, in response to changes in production worker wages. In order to estimate long-run elasticities, ideally Eq. (4) will be estimated with share of production labor in total cost (instead of wage bill) as the dependent variable and by allowing the stock of capital as well as quantities of other factors of production to adjust.

In addition to wage bill, the Longitudinal Research Database provides data on value of materials and stock of capital at the plant level. Combining the plant-level data on input usage with data on the rental price of capital (reported separately for equipment and structures) at the two-digit SIC level from the BLS, I calculate the share of production labor in total cost ($s_{U_{TCijt}}$) at the plant level. Total cost is calculated as the sum of value of materials, cost of capital and wage bill. Assuming that plants operating in the same 3-digit industry face the same rental prices, I then estimate the following specification:

$$ds_{U_{TCijt}} = \alpha_o + \gamma_U d \ln w_{Uijt} + \gamma_S d \ln w_{Sijt} + \gamma_M d \ln P^M_{mt} + \gamma_E d \ln P^E_{mt} + \phi_Y d \ln Y_{ijt} + u_{ijt} \tag{5}$$

where $P^M_{mt}$ and $P^E_{mt}$ are prices of materials and energy inputs at the 4-digit SIC level $(m)$ from the NBER Productivity Database. Note that while it is possible that certain plants within a given 4-digit industry, always face favorable prices for capital as well as other factors of production, estimating the equation in differences addresses this issue by taking out these plant fixed effects that could bias the elasticity estimates otherwise.

As an additional robustness check, instead of including prices of energy and materials at the industry-level, I estimate Eq. (5) by including industry dummies at the 4-digit SIC level:

$$ds_{U_{TCijt}} = \alpha_m + \gamma'_U d \ln w_{Uijt} + \gamma'_s d \ln w_{Sijt} + \phi'_Y d \ln Y_{ijt} + u_{ijt} \tag{5'}$$

In addition to prices of factor inputs that are determined at the 4-digit industry-level, this specification allows me to also control for other industry-level factors that shift the production function and therefore affect cost, such as change in the available variety of inputs, or the substitutability of foreign and domestic varieties of inputs. Both specifications (5) and (5′) will also be estimated by imposing constant returns to scale, which amounts to excluding value added from each specification.[8]

[6] Note that time-differencing the data can exaggerate the measurement error by decreasing the amount of systematic variation in the explanatory variables. This bias will generally be lower for estimations based on specifications using longer time differences (Griliches and Hausman, 1986). In order to check the robustness of the results with respect to the differencing used, I also report elasticity estimates from five and three-year differenced specifications. In the absence of such measurement error the estimates from these specifications should not be significantly different from each other.

[7] The identification of Eq. (4) is based on the assumption that plants face perfectly elastic labor supplies and hence, wages are exogenous at the plant level. The validity of this assumption rests on the degree of aggregation of the data. The simultaneity bias resulting from the failure of this assumption is less of a concern when plant-level data is used. In fact, the existing estimates of labor demand elasticities using plant-level data invariably rely on the assumption that wages are exogenous at the plant-level for identification.

[8] Since data on prices of all inputs are not available, I estimate Eqs. (5) and (5′) without imposing the homogeneity and symmetry conditions.

The own price elasticity of demand for production labor for each industry and year can then be calculated as:

$$\varepsilon_U^{LR} = \frac{\gamma_U}{s_{U_{TC}}} + s_{U_{TC}} - 1$$

where $\gamma_U$ is estimated for each industry and year and $s_{U_{TC}}$ is the share of production labor in total cost and is calculated at the mean for the regression sample.

### 2.3. Elasticity estimates

I estimate labor demand elasticities for each year and industry using the U.S. Census Bureau's Longitudinal Research Database (LRD), which includes the Annual Survey of Manufacturers (ASM) and the Census of Manufacturers (CM). LRD includes detailed information at the establishment level on value of shipments, employment, industry, input usage and wage bill. CM are conducted every five years (in years ending with 2 and 7) and survey all the plants under operation in the U.S. manufacturing sector. ASM are series of five year panels constructed as a representative sample of the full population of plants.

In Table 1, I report summary statistics for elasticities estimated for the unbalanced panel from the specifications described in Section 3 using one-year (1d) and five-year (5d) differenced data.[9] Estimated short-run elasticities $\varepsilon_U^{SR}$ vary within a wide range between −0.01 and −2.27, with a mean of −0.21. As expected, elasticity estimates from specifications (5) and (5′) when capital is not held constant, are larger in magnitude compared to the short-run estimates from Eq. (4). The average value of estimated elasticities from the long-run specification is −0.51 and −0.71 for the one-year and five-year differenced data, respectively. Estimates from specification (5) with industry-level prices $\varepsilon_U^{LR,p}$ and from Eq. (5′) with industry dummies $\varepsilon_U^{LR,ind}$ differ very little. Imposition of constant returns to scale does not significantly alter the magnitude of the elasticity estimates neither in the short-run nor in the long-run.

Industry-level elasticity estimates from the unbalanced panel over time reflect variation in elasticities due to within-plant changes as well as changes due to the composition of plants in the sample. Plant-level data allow me to separate the changes in elasticities due to entry and exit of plants from the changes due to increased elasticity among continuing plants. This distinction is important as both the probability of exit and the labor demand elasticities of exiting plants could vary across industries with differing degrees of exposure to offshoring.[10] To illustrate this point, I estimate production labor demand elasticities for a sub-sample of plants that were surveyed in all six of the Census of Manufacturers between 1972 and 2001 (the Census sample). This sample consists of plants that began operation prior to 1972, and had not shut down by 1997, as they enter the ASM sample.[11] The summary statistics for the elasticity estimates from the Census sample are reported in Table 1. The mean level of labor demand elasticities for continuing plants are slightly lower in absolute value, particularly in the long-run specification.

[9] I restrict my analysis to industries and years for which elasticity estimates are negative and greater than −3.

[10] For example, both the probability of exit and labor demand elasticities of exiting plants could be higher in outsourcing industries if prior to moving all their operations abroad (exit), these plants initially start by buying some of their inputs from abroad.

[11] Due to the ASM sampling strategy, the Census sample is a more representative sample of the continuing plants, compared to a balanced sample (including plants that began operation prior to 1972, had not shut down by 2001 and were surveyed in each Annual Survey of Manufacturers in the 1972–2001 period). Approximately one third of the ASM panel is rotated in and out of the sample every five years in order to minimize the reporting burden on small plants. Only establishments with 250 employees or more, and major producers in each of the product classes covered by the ASM are continued from sample to sample. As a result, the balanced panel includes a higher proportion of large plants and therefore is not a random sample of continuing plants.

**Table 1**
Summary statistics: labor demand elasticities.

| | Mean | Std. Dev. | Min | Max | *N* |
|---|---|---|---|---|---|
| *Unbalanced Panel (1D)* | | | | | |
| $\varepsilon_U^{SR}$ | −0.214 | 0.103 | −2.267 | −0.006 | 3870 |
| $\varepsilon_U^{LR,p}$ | −0.510 | 0.238 | −2.801 | 0.000 | 3771 |
| $\varepsilon_U^{LR,\ ind}$ | −0.512 | 0.237 | −2.801 | −0.004 | 3776 |
| *Unbalanced Panel (5D)* | | | | | |
| $\varepsilon_U^{SR}$ | −0.209 | 0.104 | −1.542 | −0.003 | 3276 |
| $\varepsilon_U^{LR,p}$ | −0.713 | 0.199 | −2.807 | −0.003 | 3287 |
| $\varepsilon_U^{LR,ind}$ | −0.712 | 0.199 | −2.807 | −0.003 | 3289 |
| *Census Sample (1D)* | | | | | |
| $\varepsilon_U^{SR}$ | −0.208 | 0.115 | −1.960 | 0.000 | 3732 |
| $\varepsilon_U^{LR,p}$ | −0.474 | 0.221 | −1.997 | 0.000 | 3041 |
| $\varepsilon_U^{LR,ind}$ | −0.475 | 0.222 | −1.997 | 0.000 | 3048 |

Summary statistics are calculated across point estimates for 3-digit SIC industries during the 1972–2001 period.

## 3. Offshoring and labor demand elasticities

Next step of the analysis is to use the time-varying, industry-specific estimates of labor demand elasticities from various specifications in conjunction with proxies of offshoring to examine the relationship between labor demand elasticities, and the degree of exposure to offshoring. I relate the changes in these elasticities to industry-level explanatory variables associated with an increase in offshoring as well as with technological change.

### 3.1. Theoretical motivation

Feenstra and Hanson (1996) suggest that being able to fragment production into self-contained stages of differing skill intensity is a common feature of offshoring industries. Facing a higher relative wage for unskilled labor at home, domestic firms in these industries move unskilled labor-intensive production stages abroad. An example of this practice is described in a U.S. International Trade Commission publication (1994) on the developments in production sharing in the manufacturing sector. “Most major U.S. semiconductor manufacturers engage in production sharing to perform the labor-intensive stages of production in low wage regions. The industry conducts its most skilled and capital-intensive operations, IC (integrated circuits) design and fabrication, in the U.S.… These wafers are then sent to affiliates in production-sharing countries for assembly and testing … The assembled items are then re-imported into the U.S under HTS provision 9802.” (p. 4–9). This reflects the disproportionate threat of offshoring on production labor in the U.S. manufacturing sector until recently.

**Table 2**
Summary statistics: explanatory variables.

| | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|
| Outsourcing | 0.118 | 0.044 | 0.036 | 0.294 |
| Import penetration | 0.129 | 0.151 | 0 | 0.891 |
| Import weighted average tariff | 0.057 | 0.060 | 0 | 0.442 |
| Import weighted freight rate | 0.061 | 0.035 | 0.002 | 0.348 |
| Share of low wage country imports | 0.068 | 0.117 | 0 | 0.875 |
| Share of office computing and accounting machinery | 0.018 | 0.013 | 0.001 | 0.079 |
| Share of computing and communication machinery | 0.048 | 0.042 | 0.007 | 0.197 |
| Share of computers and software | 0.028 | 0.022 | 0.003 | 0.113 |

Outsourcing: value of imported intermediate inputs as a share of total intermediate inputs from Canals (2006).
Import penetration: Imports/Shipments-exports + imports from Bernard et al. (2006).
Imported weighted average tariff: duties/customs value from Bernard et al. (2006).
Imported weighted freight rate: 1-cif/fob from Bernard et al. (2006).
All three measures of high-technology capital are from the BEA and are calculated as a share of total capital stock.

**Table 3**
Short-run elasticities and offshoring.

| | 1D | | | 3D | | | 5D | | |
|---|---|---|---|---|---|---|---|---|---|
| | Only Industry | Industry and Year | N | Only Industry | Industry and Year | N | Only Industry | Industry and Year | N |
| *A. Constant Returns to Scale Imposed* | | | | | | | | | |
| Outsourcing | −0.723*** | −0.716*** | 2073 | −0.507*** | −0.469*** | 1800 | −0.505*** | −0.174 | 1533 |
| | (0.075) | (0.170) | | (0.069) | (0.184) | | (0.071) | (0.184) | |
| Import penetration | −0.210*** | −0.140** | 3228 | −0.180*** | −0.151*** | 2940 | −0.092*** | −0.050 | 2651 |
| | (0.048) | (0.060) | | (0.038) | (0.048) | | (0.031) | (0.040) | |
| Import weighted average tariff | 0.453*** | 0.151*** | 3485 | 0.285*** | 0.036 | 3337 | 0.344*** | 0.166** | 3046 |
| | (0.047) | (0.047) | | (0.049) | (0.057) | | (0.057) | (0.067) | |
| Import weighted freight rate | 0.502*** | 0.185*** | 3485 | 0.399*** | 0.143** | 3337 | 0.301*** | 0.061 | 3046 |
| | (0.060) | (0.061) | | (0.061) | (0.061) | | (0.064) | (0.069) | |
| Share of low wage country imports | −0.203 | −0.139*** | 3228 | −0.199*** | −0.180*** | 2940 | −0.109*** | −0.083** | 2651 |
| | (0.045) | (0.049) | | (0.046) | (0.051) | | (0.037) | (0.040) | |
| *B. Constant Returns to Scale Not Imposed* | | | | | | | | | |
| Outsourcing | −0.667*** | −0.663*** | 2071 | −0.526*** | −0.465*** | 1803 | −0.556*** | −0.430** | 1536 |
| | (0.060) | (0.150) | | (0.056) | (0.143) | | (0.094) | (0.250) | |
| Import penetration | −0.169*** | −0.090** | 3231 | −0.151*** | −0.096* | 2937 | −0.109*** | −0.087** | 2654 |
| | (0.030) | (0.037) | | (0.040) | (0.055) | | (0.029) | (0.036) | |
| Import weighted average tariff | 0.437*** | 0.152*** | 3488 | 0.289*** | 0.019 | 3335 | 0.299*** | 0.112* | 3047 |
| | (0.042) | (0.048) | | (0.049) | (0.062) | | (0.053) | (0.062) | |
| Import weighted freight rate | 0.462*** | 0.152** | 3488 | 0.435*** | 0.184** | 3335 | 0.330*** | 0.101 | 3047 |
| | (0.059) | (0.062) | | (0.067) | (0.072) | | (0.065) | (0.065) | |
| Share of low wage country imports | −0.190*** | −0.133** | 3231 | −0.185*** | −0.152*** | 2937 | −0.088*** | −0.065** | 2654 |
| | (0.053) | (0.059) | | (0.046) | (0.048) | | (0.029) | (0.031) | |

Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

The effect of a decrease in the share of production workers in total cost (or wage bill) on labor demand elasticities is given by:

$$\frac{\partial \varepsilon_U}{\partial s_U} = -\frac{\gamma_U}{s_U^2} + 1 > 0 \ \text{if} \ \gamma_U < 0$$

This suggests that if demand for production labor is elastic $\gamma_U<0$, then an increase in offshoring, which would lead to a decline in the share of production workers, will result in an increase in conditional labor demand elasticities. Note that any other factor that results in a decrease in the share of production labor in total cost would have a similar effect on labor demand elasticities. For example, skill biased technical change by increasing the relative productivity of skilled labor within industries, is also likely to decrease the elasticity of demand for production workers by decreasing their share in cost. In the empirical analysis, I will control for measures of both offshoring and technical change in order to separately identify their relative impact on labor demand elasticities.

Similarly, a decline in the estimated effect of a change in unskilled labor wages on its cost share, $\gamma_U$ will result in an increase in labor demand elasticities. An increase in substitutability between foreign and domestic intermediate inputs over time could result in such a decline. Anecdotal evidence provides some support for the decline in the magnitude of $\gamma_U$. Developments in communication and information technologies increasingly allow enhanced monitoring and coordination of production activities in different locations. Similarly, the increase in the rate of technological diffusion and the spread of knowledge contribute to higher levels of competence in intermediate input production in developing countries. Businesses that engage in outsourcing activities in Mexico often cite the continuing rise in proficiency levels and productivity of Mexico's labor force and the ease with which producers can monitor the quality and efficiency of production in Mexico, along with cost-based advantages, as primary reasons for the ongoing increase in outsourcing to Mexico (U.S. International Trade Commission, 1994). This increased substitutability between foreign and domestic workers could lead to a decline in estimated $\gamma_U$ and therefore contribute further to an increase in labor demand elasticities especially in offshoring industries.[12]

### 3.2. Specification

In the regression analysis that follows, I estimate:

$$\hat{\varepsilon}_{Ujt} = \beta_j + \beta_t + \gamma_1 X_{jt} + u_{jt} \tag{6}$$

where $\hat{\varepsilon}_{Ujt}$ is the own price labor demand elasticity for production workers estimated for industry $j$ at time $t$ from the translog specifications described in the previous section. $X_{jt}$ is an industry level variable, that proxies for offshoring. I estimate Eq. (6) using multiple measures of offshoring described below. Since these alternative measures are highly correlated, I enter them one at a time to avoid multicollinearity. Each specification includes industry dummies at the 3-digit SIC level $\beta_j$ to control for any time-invariant industry-specific factors that may affect the magnitude of labor demand elasticity in that industry. $\beta_t$ are year dummies that control for time-specific level differences in elasticities. While this ensures that the estimation results reported are not driven by changes in macroeconomic conditions (such as business cycle effects and/or long-run structural changes) not related to offshoring, it also means that identification of the relationship between elasticities and offshoring are based on the differential rate of change in exposure to offshoring across sectors over time. Finally, since the dependent variable is estimated rather than measured, I adjust the standard errors for heteroscedasticity using a White correction.[13]

Table 2 provides the summary statistics for the industry-level explanatory variables used in this section. First, I use a measure of

[12] Rauch and Trindade (2003) provide a theoretical model emphasizing the role of improvements in information technology in increasing the elasticity of substitution between foreign and domestic inputs. Similarly, in Kohler (2004) endogenous international fragmentation, results in an increase in the substitutability between capital and (domestic) labor. In both cases, conditional labor demand elasticities would increase with offshoring consistent with the predictions above.

[13] I also use weighted least squares (WLS) to correct for a heteroscedastic error structure, as suggested by Saxonhouse (1976). This correction has little effect on the magnitude or the significance of the coefficients on proxies of offshoring reported in the paper.

the “outsourcing share” from Canals (2006) calculated as imported intermediate inputs as a share of total intermediate inputs.[14] This measure is constructed by augmenting the outsourcing measure introduced in Feenstra and Hanson (1999) by also accounting for domestic intermediate inputs that use imported intermediate inputs as in Hummels et al. (2001). This measure is available at the 2-digit level for 16 years during the 1973–2000 period.[15] During this period share of outsourcing almost doubles from 5.19% to 9.22%.

In addition to observed outsourcing share, I will use additional variables that proxy for the threat of offshoring in a given industry. Feenstra and Hanson (1996) report that, in general, industries with high levels of final good imports also import high levels of intermediate inputs. They argue that this observation is consistent with the idea that offshoring is a response to import competition. Accordingly, I use the ratio of imports to shipments and import weighted average tariffs for each industry as alternative proxies for offshoring. An increase in import penetration or a decrease in tariffs, by increasing the threat of offshoring should lead to an increase in labor demand elasticities.

During the past two decades, offshoring in the manufacturing sector has mainly been a threat for unskilled-labor-intensive production stages. Thus, I use a measure of import competition from low wage countries constructed by Bernard et al. (2006), as another proxy for the threat of offshoring. This measure reflects the share of an industry's import value that originates in low wage countries which have less than 5% of the U.S. per capita GDP.

Finally, I use transportation costs to capture the increased possibility of substituting domestic labor with its foreign counterparts. Transportation costs for each industry and year are constructed by Bernard et al. (2006) as the ratio of c.i.f. (cost, insurance, and freight) import value to customs import value. A decline in transportation costs is likely to increase offshoring by decreasing the cost of intermediate inputs from the same industry, and should make labor demand more elastic.

Industries characterized by a more flexible production technology may also be more likely to engage in offshoring. Similar to offshoring, investment in new technology could make labor demand more elastic by increasing the substitutability of production workers with computers (instead of foreign workers) and decreasing the cost share of production labor. Failing to control for technological change could result in biased estimates, if the set of industries that outsource coincides with those that experience higher levels of technological change. This could be the case if industries respond to increased foreign competition by investing in new technologies in addition to offshoring. In order to address this issue, in alternate specifications I include three separate measures of technological change to specification (7): Share of office computing and accounting machinery in total capital stock, share of computing and communication machinery[16] in total capital stock and share of computers and software in total capital stock.

In industries characterized by high levels of offshoring, failing to take into account changes in the composition of the underlying sample might result in an underestimation of the importance of offshoring on elasticities. For example, if a plant with high labor demand elasticity exits and moves its operations abroad, the labor demand elasticity estimates will be lower in the following year for the unbalanced panel. To test for this possibility, I estimate Eq. (7) with labor demand elasticities for the Census sample, which consists of plants that have operated continuously throughout the 1972–2001 period, as the dependent variable.

**Table 4**
Short-run elasticities and offshoring: with high-technology share.

| | Share of office computing and accounting machinery | | | | | Share of computing and communication machinery | | | | | Share of computers and software | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Outsourcing | −0.636*** | | | | | −0.704*** | | | | | −0.663*** | | | | |
| | (0.169) | | | | | (0.163) | | | | | (0.157) | | | | |
| Import penetration | | −0.095** | | | | | −0.102*** | | | | | −0.101*** | | | |
| | | (0.039) | | | | | (0.037) | | | | | (0.037) | | | |
| Import weighted average tariff | | | 0.179*** | | | | | 0.166*** | | | | | 0.172*** | | |
| | | | (0.048) | | | | | (0.049) | | | | | (0.049) | | |
| Import weighted freight rate | | | | 0.130** | | | | | 0.135** | | | | | 0.129** | |
| | | | | (0.062) | | | | | (0.061) | | | | | (0.062) | |
| Share of low wage country imports | | | | | −0.134** | | | | | −0.136** | | | | | −0.137** |
| | | | | | (0.059) | | | | | (0.060) | | | | | (0.060) |
| High-tech share | 0.029 | 0.055 | 0.265 | 0.241 | 0.174 | −0.202** | −0.224*** | −0.175** | −0.192*** | −0.195** | −0.148 | −0.218 | −0.192 | −0.208 | −0.180 |
| | (0.208) | (0.182) | (0.168) | (0.167) | (0.157) | (0.098) | (0.081) | (0.074) | (0.074) | (0.081) | (0.148) | (0.151) | (0.136) | (0.135) | (0.143) |

Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

[14] I thank Claudia Canals for generously making this variable available to me.

[15] The years for which the offshoring variable is constructed are 1973–76, 1978–81, 1983–86, 1996–99.

[16] This measure is the sum of computers and peripheral equipment, software, communication and photocopy and related equipment.

**Table 5**
Short-run elasticities and offshoring: Census sample.

| | Without high-tech | Share of computing and communication machinery | | | | | Share of computers and software | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Outsourcing | −0.167 | −0.198 | | | | | −0.130 | | | | |
| | (0.168) | (0.169) | | | | | (0.166) | | | | |
| Import penetration | −0.077* | | −0.076* | | | | | −0.071* | | | |
| | (0.044) | | (0.043) | | | | | (0.043) | | | |
| Import weighted average tariff | 0.124* | | | 0.130* | | | | | −0.141* | | |
| | (0.074) | | | (0.080) | | | | | (0.074) | | |
| Import weighted freight rate | 0.171** | | | | 0.204** | | | | | 0.197** | |
| | (0.086) | | | | (0.083) | | | | | (0.083) | |
| Share of low wage country imports | −0.125*** | | | | | −0.131*** | | | | | −0.133*** |
| | (0.037) | | | | | (0.037) | | | | | (0.037) |
| High-tech share | | −0.226 | −0.255** | −0.236** | −0.252** | −0.222** | −0.087 | −0.101 | −0.191 | −0.202 | −0.069 |
| | | (0.139) | (0.106) | (0.100) | (0.099) | (0.108) | (0.213) | (0.182) | (0.179) | (0.179) | (0.184) |

Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

### 3.3. Estimation results

In Tables 3–8, I report the estimation results from Eq. (7) where I relate the changes in labor demand elasticities to various proxies of offshoring. The set of results differ in terms of the specification and the sample used in estimating the labor demand elasticities. All the specifications include industry dummies at the 3-digit level and are estimated both with and without year dummies.

#### 3.3.1. Results: elasticities from the short-run cost function

In Table 3, I report the estimation results when the dependent variable is the labor demand elasticities estimated from the short-run cost function holding capital fixed. Table 3A and 3B report the results with elasticities estimated with and without the constant returns to scale assumption imposed, respectively. Results suggest that an increase in offshoring share contributes to an increase in labor demand elasticities (as indicated by the negative sign). This is also true, when I consider other variables that are correlated with offshoring: both an increase in overall import competition and an increase in imports from low wage countries are associated with increased labor demand elasticities. Similarly, an increase in trade costs, measured as the freight rate or the average tariff rate, decreases labor demand elasticities (as indicated by the positive sign). These findings are robust to the level of differencing (one-year, three-year and five-year) as well as the imposition of the constant returns to scale assumption. Although inclusion of year fixed effects in addition to industry fixed effects, somewhat decrease the magnitudes of the estimated coefficient for various measures of exposure to offshoring, these coefficients remain significant with the predicted sign in almost all specifications. This suggests that part of the within-industry changes in labor demand elasticities over time is explained by changes in exposure to offshoring. This robust positive relationship between labor demand elasticities and offshoring based on plant-level data differs from the results based on industry level data for the U.S. manufacturing sector in Slaughter (2001), where the time series variation in labor demand elasticities are explained largely by a residual, time itself.

The estimated coefficients suggest that the relationship between offshoring and labor demand elasticities is economically significant. The estimated coefficient of the outsourcing measure for the one-year differenced specification indicates that a 10 percentage-point increase in outsourcing raises demand elasticities for production workers by 0.07 percentage-points. This corresponds to a 31% percent increase in these elasticities over their mean value. When instead five-year differenced specification is used to derive the labor demand elasticities, the estimated effect is somewhat smaller at 20%.

Next, I estimate Eq. (7) by including various measures of the share of high-technology capital to take into account the possibility that industries that engage in offshoring are also those that invest heavily in new technology. In Table 4, I report the estimates of Eq. (6) with labor demand elasticities estimated without imposing constant returns to scale using one-year differenced data. All the proxies for offshoring continue to be significant with little change in the magnitude of their estimated effects when various measures of skill biased technical change are included in the specification. The effect of high-technology capital is mixed with only one of the three measures (share of computing and communication machinery) significant and negative. The sign and the magnitude of the coefficients of interest are robust to imposing the constant returns to scale assumption and estimating the dependent variable (demand elasticity for production labor) using longer differenced data.

The results from estimating Eq. (7) with the labor demand elasticities for the Census sample as the dependent variable are reported in Table 5. While the first column reports the estimation results when

**Table 6**
Long-run labor demand elasticities and offshoring.

| | With input prices at the industry level | | | | | | With industry dummies | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1D | | | 5D | | | 1D | | | 5D | | |
| | No year | With year | N | No year | With year | N | No year | With year | N | No year | With year | N |
| Outsourcing | −0.798*** | −1.348*** | 2039 | −0.775*** | −1.891*** | 2679 | −0.778*** | −1.334*** | 2039 | −0.812*** | −1.891*** | 1537 |
| | 0.1896 | 0.4963 | | 0.2656 | 0.7013 | | (0.186) | (0.495) | | (0.268) | (0.705) | |
| Import penetration | −0.230*** | −0.161* | 3160 | −0.305*** | −0.229** | 1536 | −0.213*** | −0.119 | 3157 | −0.315*** | −0.249** | 2676 |
| | 0.0756 | 0.0972 | | 0.0735 | 0.0948 | | (0.076) | (0.097) | | (0.075) | (0.098) | |
| Import weighted average tariff | 0.568*** | 0.462* | 3417 | 0.381** | 0.113 | 3067 | 0.578*** | 0.487** | 3414 | 0.439*** | 0.326* | 3064 |
| | 0.1953 | 0.2505 | | 0.1663 | 0.2098 | | (0.191) | (0.246) | | (0.156) | (0.179) | |
| Import weighted freight rate | 0.555*** | 0.487** | 3417 | 0.502*** | 0.371* | 3067 | 0.560*** | 0.487** | 3414 | 0.483*** | 0.343* | 3064 |
| | 0.1719 | 0.192 | | 0.1825 | 0.1997 | | (0.175) | (0.197) | | (0.185) | (0.205) | |
| Share of low wage country imports | −0.160** | −0.0751 | 3160 | −0.241*** | −0.178* | 2679 | −0.176** | −0.0872 | 3157 | −0.209*** | −0.141* | 2676 |
| | 0.07 12 | 0.0779 | | 0.0855 | 0.0976 | | (0.08 1) | (0.092) | | (0.073) | (0.082) | |

Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

**Table 7**
Long-run elasticities and offshoring: with high-technology share.

| | Share of office computing and accounting machinery | | | | | Share of computing and communication machinery | | | | | Share of computers and software | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *A. Elasticity Estimates with input prices at the industry-level* | | | | | | | | | | | | | | | |
| Outsourcing | −1.257** | | | | | −1.380** | | | | | −1.222** | | | | |
| | 0.6072 | | | | | 0.5761 | | | | | 0.5566 | | | | |
| Import penetration | | −0.231** | | | | | −0.224** | | | | | −0.226** | | | |
| | | 0.1101 | | | | | 0.1066 | | | | | 0.1065 | | | |
| Import weighted average tariff | | | 0.3829 | | | | | 0.3699 | | | | | 0.3839 | | |
| | | | 0.2379 | | | | | 0.23 83 | | | | | 0.2375 | | |
| Import weighted freight rate | | | | 0.346* | | | | | 0.378* | | | | | 0.366** | |
| | | | | 0.1863 | | | | | 0.186 | | | | | 0.1858 | |
| Share of low wage country | | | | | −0.1282 | | | | | −0.1264 | | | | | −0.1296 |
| | | | | | 0.1065 | | | | | 0.1066 | | | | | 0.1065 |
| High-tech share | −0.834 | −0.693 | −0.113 | −0.120 | −0.284 | −0.868*** | −0.482** | −0.420** | −0.471*** | −0.415** | −0.7601 | −0.681* | −0.5063 | −0.5589 | −0.5363 |
| | 0.7251 | 0.5116 | 0.4825 | 0.4795 | 0.4761 | 0.2793 | 0.1948 | 0.1719 | 0.1713 | 0.1908 | 0.4655 | 0.3753 | 0.3439 | 0.3441 | 0.3708 |
| N | 1923 | 2992 | 3230 | 3230 | 2992 | 1923 | 2992 | 3230 | 3230 | 2992 | 1923 | 2992 | 3230 | 3230 | 2992 |
| *B. Elasticity Estimates with industry dummies* | | | | | | | | | | | | | | | |
| Outsourcing | −1.037* | | | | | −1.166** | | | | | −1.021* | | | | |
| | 0.607 | | | | | 0.5762 | | | | | 0.557 | | | | |
| Import penetration | | −0.204* | | | | | −0.198* | | | | | −0.198* | | | |
| | | 0.1102 | | | | | 0.1063 | | | | | 0.1063 | | | |
| Import weighted average tariff | | | 0.2991 | | | | | 0.2803 | | | | | 0.2932 | | |
| | | | 0.2249 | | | | | 0.2247 | | | | | 0.2243 | | |
| Import weighted freight rate | | | | 0.408** | | | | | 0.422** | | | | | 0.410** | |
| | | | | 0.1916 | | | | | 0.1906 | | | | | 0.1911 | |
| Share of low wage country | | | | | −0.115 | | | | | −0.361* | | | | | −0.116 |
| | | | | | 0.1063 | | | | | 0.191 | | | | | 0.1063 |
| High-tech share | −0.696 | −0.624 | 0.020 | −0.010 | −0.2635 | −0.810*** | −0.421** | −0.343** | −0.379** | −0.1137 | −0.724 | −0.579 | −0.380 | −0.411 | −0.4519 |
| | 0.7175 | 0.5164 | 0.4909 | 0.4841 | 0.4759 | 0.2778 | 0.194 | 0.1755 | 0.174 | 0.1064 | 0.4685 | 0.3814 | 0.3559 | 0.3529 | 0.377 |
| N | 1925 | 2993 | 3232 | 3232 | 2993 | 1925 | 2993 | 3232 | 3232 | 2993 | 1925 | 2993 | 3232 | 3232 | 2993 |

Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

**Table 8**
Long-run elasticities and offshoring: Census sample.

| | Without high-tech | Share of computing and communication machinery | | | | | Share of computers and software | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *A. Elasticity Estimates with input prices at the industry-level* | | | | | | | | | | | |
| Outsourcing | −0.881* | −1.579*** | | | | | −1.362*** | | | | |
| | (0.471) | (0.518) | | | | | (0.492) | | | | |
| Import penetration | −0.284** | | −0.271** | | | | | −0.266** | | | |
| | (0.117) | | (0.118) | | | | | (0.119) | | | |
| Import weighted average tariff | 0.655** | | | 0.686** | | | | | 0.709** | | |
| | (0.027) | | | (0.278) | | | | | (0.278) | | |
| Import weighted freight rate | 0.372* | | | | 0.369* | | | | | 0.349 | |
| | (0.220) | | | | (0.221) | | | | | (0.222) | |
| Share of low wage country imports | −0.211** | | | | | −0.185** | | | | | −0.195** |
| | (0.094) | | | | | (0.094) | | | | | (0.094) |
| High-tech share | | −0.969*** | −0.708*** | −0.700** | −0.747*** | −0.616*** | −1.102** | −0.874** | −1.105*** | −1.135*** | −0.728* |
| | | (0.298) | (0.239) | (0.222) | (0.221) | (0.235) | (0.492) | (0.422) | (0.393) | (0.391) | (0.415) |
| *B. Elasticity Estimates with Industry Dummies* | | | | | | | | | | | |
| Outsourcing | −0.792* | −1.445*** | | | | | −1.230** | | | | |
| | (0.474) | (0.527) | | | | | (0.500) | | | | |
| Import penetration | −0.213* | | −0.204* | | | | | −0.197* | | | |
| | (0.119) | | (0.121) | | | | | −(0.122) | | | |
| Import weighted average tariff | 0.561** | | | 0.599** | | | | | 0.621** | | |
| | (0.268) | | | (0.274) | | | | | (0.271) | | |
| Import weighted freight rate | 0.307 | | | | 0.320 | | | | | 0.302 | |
| | (0.221) | | | | (0.222) | | | | | (0.223) | |
| Share of low wage country imports | −0.170** | | | | | −0.147 | | | | | −0.157 |
| | (0.098) | | | | | (0.097) | | | | | (0.098) |
| High-tech share | | −0.979*** | −0.682*** | −0.691*** | −0.731*** | −0.613*** | −1.131** | −0.747* | −1.027*** | −1.055*** | −0.637 |
| | | (0.299) | (0.244) | (0.226) | (0.225) | (0.240) | (0.494) | (0.427) | (0.395) | (0.393) | (0.419) |

Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

the proxies of offshoring are entered one by one, the remaining columns also include a measure of high-technology capital.[17] All measures of exposure to offshoring except the measure at the 2-digit SIC level from Canals (2006) are significant with the expected sign, both with and without the high-technology share in the specification. As is the case for the unbalanced panel, the effect of high-technology capital on labor demand elasticities is dependent on the particular measure used and therefore ambiguous.

### *3.3.2. Results: Elasticities from the Long-run Cost Function*

In Table 6, I report the estimation results when the dependent variable is the labor demand elasticities estimated from the long-run cost function when capital is not held constant. For brevity, I report here only the results from one- and five-year differenced data without imposing constant returns to scale. The results are very similar to those reported here when I impose constant returns to scale or use three-year differenced data instead.

I find that as in the case for short-run labor demand elasticities, the estimated effect of offshoring share is negative and significant both with and without industry dummies. This is the case when the dependent variable is the elasticity estimates from specification (5), which includes industry-level prices for materials and energy or from specification (5′) which includes industry dummies at the 4-digit level. These results are reported separately in Table 6. The estimated coefficients of the outsourcing measure indicate that a 10 percentage-point increase in outsourcing raises the demand elasticity for production workers by about 25% above its mean value both for the one- and five-year differenced specifications. The magnitude of the estimated effect does not change much between alternate specifications employed in estimating the labor demand elasticities.

The estimation results including various measures of technological change are reported in Table 7A and 7B with elasticities estimated using Eqs. (5) and (5′) as the dependent variable. The inclusion of technology measures does not alter the magnitude or the significance of the estimated coefficients for the proxies for offshoring. The evidence on the effect of technological change on elasticity of production labor demand is mixed. As in the case for short-run elasticities, the coefficient of technological change is significant and negative only in some of the specifications estimated.

Next, I use estimated elasticities for the continuing plants as the dependent variable. My results suggest that entry or exit do not introduce a significant bias in the estimation results: An increase in exposure to offshoring is associated with an increase in within plant labor demand elasticities in the long-run. As before, the association between labor demand elasticities and high-technology capital is dependent on the particular measure used. While the (positive) effects of high technology capital on labor demand elasticities are significantly estimated for the two technology measures reported in Table 8, the (unreported) estimated coefficient on the share of office computing and accounting machinery is not significant.[18]

## 4. Conclusion

In this paper I use detailed plant-level data to analyze the relationship between offshoring and labor demand elasticities in the U.S. manufacturing sector during the 1972–2001 period. Both for the full sample and for the subset of continuing plants, I find that the demand elasticities for production workers increase in industries that experience an increase in offshoring over time. I find this positive relationship to be robust to various specifications of labor demand and to the inclusion of industry-level controls for skill biased technical change in the second stage specification (linking offshoring and labor demand elasticities). I find mixed evidence on the association between skill biased technical change and labor demand elasticities.

Further use of plant level data in understanding the implications of an increase in offshoring on U.S. workers is likely to be fruitful. Plant-

[17] For brevity the results for the Census sample with Share of office computing and accounting machinery are not reported. These results are very similar to those from the specifications that include share of computers and software as the high-technology measure and are available upon request.

[18] The proxies for offshoring remain significant when the share of office computing and accounting machinery is used as the technology measure.

level data will allow identification of within-industry movements in relative employment and relative wages due to offshoring, as well as the plant characteristics that affect the ease with which foreign labor can be substituted for domestic labor. Similarly, there is very little work which analyzes the impact of increased production-sharing in countries at the receiving end of offshoring, for which the main predictions of the model are also applicable. Cross-country comparisons, as in Hijzen and Swaim (2008), with emphasis on differences in labor market institutions across countries are also an important avenue for future research.

Offshoring is becoming increasingly important in other sectors of the economy, especially in the service sector. Increase in offshoring has begun to affect not only blue-collar workers but also white-collar workers. Although there is intensifying political pressure to restrict offshoring, this trend in the globalization of production is likely to continue and become increasingly more prevalent with important consequences on the labor market. Earlier studies by Feenstra and Hanson find that this trend has contributed to the observed increase in wage inequality in the U.S. The results of this paper suggest that an increase in offshoring is associated with an increase in labor demand elasticities during the past three decades. Further work analyzing the full implications of the increased mobility of capital and goods is necessary in designing policies that will reduce the burden of these new aspects of globalization on workers.

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