# Regional Effects of Offshoring on Labor Demand: Evidence from Sweden*

Karolina Ekholm, Department of Economics, Stockholm University†

Katariina Hakkala, The Research Institute of Industrial Economics, Stockholm‡

PRELIMINARY VERSION, PLEASE DO NOT QUOTE!

September 4, 2006

**Abstract**

We estimate the effect of offshoring of intermediate input production on the relative demand for workers with different levels of educational attainment at the regional level for Sweden. We find no evidence of offshoring having reduced the relative demand for the least educated workers; on the contrary, if anything it seems to have increased the relative demand for this group. On the margin, the effect of offshoring on relative labor demand tends to be larger in peripheral and rural regions compared to central and urban regions. However, peripheral and rural regions have been less affected overall since there has been less offshoring from these regions.

JEL Classification: F16

Keywords: offshoring, labor demand, translog cost function, factor-biased technological change

*This study has been carried out as part of the research project "Labour Market Consequences of the Globalisation of Firms" funded by the Foundation for Work Life Research.

†E-mail: karolina.ekholm@ne.su.se

‡E-mail: katariina.hakkala@industrialeconomics.se

# 1 Introduction

Offshoring of services and production to low-wage countries in Asia and Central and Eastern Europe is often viewed as a threat to unskilled as well as skilled workers in Western Europe. A few studies have examined the effect of offshoring on employment and on the relative demand for workers with different skill levels. Most of these studies find only small effects on the employment level and the relative demand for workers with low or intermediate skill levels (e.g. Amiti and Wei, 2005, Hijzen, Görg and Hines, 2005, and Ekholm and Hakkala, 2005).

However, small effects at the aggregate national level may very well hide strong regional variation. Studies on the development of European regions suggest that urban regions and regions with good access to the European core have performed better than rural and peripheral regions. Urban regions, in particular, seem to assert strong attraction on high-skilled labor and a concentration of technologically advanced industries. At same time several rural and peripherial regions experience a depletion of the traditional industries that are typically intensive in low-skilled labor. The differences in industrial structure and specialization pattern across regions may lead offshoring to affect labor demand in some regions more than in others. The fact that regional differences average out at a national level may explain the tendency for studies of offshoring to find relatively small effects on labor demand.

In this paper we investigate the effect of offshoring of intermediate inputs on relative labor demand at the regional level. We define offshoring as the sourcing of intermediate inputs from abroad and measure it using information on imports of material inputs from input-output tables together with information on the industry and country distribution of imports. We estimate the effect of offshoring on the relative demand for labor with different educational attainment in Sweden 1995-2000. In doing so, we use a translog cost function approach (see e.g. Feenstra and Hanson, 1996, 1999, Falk and Koebel, 2001, Hijzen, Hines and Gorg, 2005). We let the estimated parameters of the cost function vary between regions that differ in terms of market potential and agglomeration tendencies.

Our results do not give any support to the hypothesis that offshoring shifts labor demand away from the least educated workers. On the contrary, if anything it seems to increase the relative demand for these workers. The main reason for this is that most of Swedish offshoring is related to imports from other high-income economies, implying that the factor content is likely to be biased towards skilled rather than unskilled labor.

On the margin, the effect of offshoring seems to be larger in rural and to some extent peripheral regions. This suggests that the kind of activities that are located in these regions are more directly affected by firms' decision to offshore intermediate input production than activities located in urban and central regions. However, this does not imply that the labor demand in rural and peripheral regions have been affected more by actual offshoring of intermediate input production. On the contrary, these regions have been less affected on account of their having experienced less offshoring.

# 2 Offshoring and Regional Labor Demand

There are several reasons why we might expect offshoring of intermediate input production and services to affect labor demand differently across regions. The most obvious reasons are that offshoring in itself and the effect of offshoring are likely to vary across industries, and regions differ with respect to their industry structure. For instance, in Sweden most of the electronics industry – the industry that seems to have experienced the largest increase in offshoring to low-wage countries (see Ekholm and Hakkala, 2006) – is concentrated in the Southern parts of the country and in particular in the Stockholm region. Northern regions have much less activity in this industry. Because of this, we would expect Stockholm and other southern regions to be affected differently by offshoring to low-wage countries than northern counties.

Alongside with offshoring to other countries there is also a relocation of activities within a country and an inflow of activities from abroad. Thus, regional labor demand is not only affected by offshoring but also by inshoring and a domestic reallocation of industries. The long-term impact of offshoring on regional labor demand will depend on the region's capability to restructure and reallocate resources laid off because of offshored activities. In the Stockholm region, for example, at the same time as there may be a considerable increase in offshoring in skill-intensive industries, the relative demand for high-skilled workers may very well increase because the region attracts both domestic and foreign firms operating skill-intensive types of activities. In Northern counties, on the other hand, there may be little offshoring taking place on account of there being few firms operating in offshoring industries at the same time as there may be considerable shifts in labor demand on account of a relocation of activities to other parts of the country.

Following the terminology used by Feenstra and Hanson (1999), we distinguish between *narrow* and *broad* offshoring. Narrow offshoring only includes imported intermediate inputs from the importing industry, i.e. an industry's purchases of imported intermediate inputs produced in the same industry. Broad offshoring also includes imported non-energy intermediate inputs from all other industries. Both the *narrow* and the *broad* measures of offshoring are defined as imported intermediate inputs in relation to industry output:

$$z_i^N = \frac{m_{ii}}{Y_i} \tag{1}$$

$$z_i^B = \frac{\sum_{j=1}^{N} m_{ij}}{Y_i}, \tag{2}$$

where $m_{ij}$ is industry $i$'s use of imported intermediate inputs from industry $j$ and $Y_i$ is production. Direct information about industry use of imported intermediates through input-output tables is only available for 1995 and 2000; the years for which detailed input-output tables have been constructed. However, by interpolating information from these input-output tables, we construct offshoring also for the intermittent years (see Ekholm and Hakkala, 2006).

By utilizing information about the industry structure of regions we can get some idea of the variation in offshoring across regions. Table A1 in appendix shows region-specific measures of offshoring in 1995 and 2000 based on this information. This table shows that there is considerable variation in the level of and change in offshoring. Whereas the Stockholm region and some of its surrounding regions (Södermanland and Uppsala) have experienced increases in the share of imported inputs by a couple of percentage points between 1995 and 2000, other regions have experienced a substantial decrease (i.e.Jämtland

and Örebro).

Figure 1 shows how the employment shares for workers with different levels of educational attainment vary across Swedish counties. Stockholm and Uppsala – a county bordering Stockholm – have distinctly higher shares of employees with tertiary education than the rest of the counties. Stockholm is also the county with the lowest share of employees with only lower secondary education, defined as workers with at most 9 years of schooling (which is the mandatory length of schooling in Sweden). Figure 1 also reveals that the counties with the highest share of employees with tertiary education in natural sciences are counties in the Southern part of Sweden, either being located close to Stockholm (Västmanland, Östergötland and Uppsala) or on the west coast (Västra Götaland). This picture then quite clearly shows the Stockholm region to be a region which is relatively abundant in high-skilled workers within the country. Finally, it is worth noting that the counties with larger shares of well-educated labor force are also among the counties were offshoring has increased between 1995 and 2000, as seen in Table A1, with exception of Västra Götaland (Gothenburg region).

[Figure 1 about here]

The three major cities in Sweden, Stockholm, Göteborg and Malmö, are all located in the Southern part of the country. In addition to having relatively abundant endowments of skilled labor, these regions have a larger market potential than other regions, working as a centripetal force in attracting activities for which proximity to large markets is important. To the extent that such activities tend to be skill-intensive, this is a factor that would contribute to a shift in relative labor demand towards high-skilled labor in urban regions and away from high-skilled labor in rural and remote regions.

In Table 1 we show the changes in regional shares of industry employment between mid 1990s and mid 2000s. In doing so, we distinguish between regions along three different dimensions: (*i*) north-south, (*ii*) urban-rural, and (*iii*) central-peripheral vis-à-vis the European core.[1] They capture in a sense different aspects of the market potential of

[1] See Table A2 in appendix for classification of counties.

regions, since most of the Swedish population can be found in the south, which is also the region closest to the European continent. The table presents the change in a particular type of region's share of different manufacturing industries. The changes are listed for Southern and urban counties and for counties classified as belonging to the core.[2] Southern regions are defined as counties south of Dalarna and Gävleborg whereas urban regions are defined as counties whose area classified as urban constitutes more than two percent of the total area. Core regions are defined as counties with more than average market potential calculated as the distance weighted sum of the GDPs of European regions (we use the measure of market potential developed by Harris (1954)). (A list of the counties and the classification can be found in appendix).

[Table 1 about here]

Table 1 shows that in an industry such as electrical and optical equipment, there has been a substantial shift towards southern, urban counties located closer to the large European markets. The southern and urban counties' share of employment increased with about 9 percent 1995-2004 while the "core" counties' share of employment increased with 6 percent 1995-2003. A similar pattern is found for basic metals, other non-metallic mineral products and textiles and leather. The latter may appear surprising, since textiles and leather is a relatively labor-intensive industry. However, this is an industry that has been shrinking over time and that those activities that now remain in Sweden are likely to be more skill-intensive than those that have been disappeared from Sweden.

Other manufacturing (including recycling) and rubber and plastic products are industries that appear to have been moved in the other direction, i.e. towards northern, rural and remote counties. The shift of employment in other manufacturing is substantial; the northern and rural regions' share of employment has increased with 8-9 percent while the peripheral regions' share has increased with almost 15 percent.

[2] Northern regions are defined as counties with county code 20 or higher while rural regions are defined as counties whose area classfied as "tätort" by Statistics Sweden is less than two percent. A list of the counties and the classification can be found in Table A2 in appendix

That there has been a tendency for overall manufacturing employment to shift towards the central, urban and southern regions is shown in Table 2. In all types of regions, there has been a decrease in the employment of workers with lower secondary education and an increase in the employment of workers with upper secondary and tertiary education between 1995 and 2000. The increase in employment of workers with tertiary education is larger than the increase in employment for workers with upper secondary education. However, for the central, urban and southern regions the decrease in employment is lower and the increase in employment higher than the peripheral, rural and northern regions. This implies that these regions have attracted an increasing share of overall employment in the manufacturing industry.

[Table 2 about here]

In the next section, we analyze the effect of offshoring on relative labor demand using region and industry distributed data. We use a cost-function approach, letting offshoring affect technology in a potentially non-uniform way across different types of workers. We control for output levels, capital stocks and R&D as a potential additional source of factor-biased technological change (FBTC) and we let the parameters of the cost function vary across different types of regions. We then use our estimates to address to what extent actual offshoring has affected labor demand in different types of regions.

# 3 Empirical Model

The assumption underlying the approach chosen is that technological change as well as offshoring will affect productivity, but not necessarily uniformly across factor inputs. Cost-reducing offshoring will increase productivity in the sense of increasing net revenue per unit of factor input. However, when labor intensive assembly activities are being offshored, the productivity of workers involved in headquarters activities and intermediate input production is likely to increase, whereas the productivity of domestic assembly workers is unaffected. As with FBTC, this may then lead to a reduction in the relative demand for assembly workers.

We carry out the analysis based on a translog cost function, first introduced in the context of trade and demand for skills by Berman et al. (1994) and used to estimate the effect of offshoring by e.g. Feenstra and Hanson (1996), Gieshecker (2002), Strauss-Kahn (2004) and Hijzen et al. (2005) and Ekholm and Hakkala (2006). We assume firms to be price takers in the factor markets. Industry $i$, $i = 1, ...I$ located in region $j$, $j = 1, ...R$, produces an output using labor belonging to skill-group $s$, $s = 1, ...S$, capital and intermediate inputs. Intermediate inputs are either sourced domestically or from abroad. By differentiating such a cost function and applying Shephard's lemma, we can express the cost share of factors as a function of factor prices, output levels and technical change.

In setting up the empirical model we need to make assumptions about common parameters for some set of industries and/or regions. We have two basic alternatives: restricting parameters to be the same across industries or across regions. We have carried out the analysis for both approaches but for reasons discussed later the former approach works better.[3]

Assuming then that manufacturing firms face a common short-run translog cost function, which may differ depending on location, where capital is quasi-fixed, industry $i$'s cost share of labor belonging to skill group $s$ in region $j$ is given by

$$\theta_{ijs} = \alpha_k + \sum_{k=1}^{S} \gamma_{ks} \ln w_k + \phi_s \ln Q_{ij} + \delta_s \ln K_{ij} + \sum_{h=1}^{H} \lambda_s^h z_{ij}^h \qquad (3)$$
$$(s = 1, ...S, k = 1, ...S),$$

where $\theta_{ijk} \equiv w_j L_{ijk} / \sum_{s=1}^{S} w_s L_{ijs}$, $K_{ij}$ is the capital stock, $Q_{ij}$ is value added, and $z_{ij}^h$ variables capturing factor-biased technical change in the industry.

The value of parameters $\gamma_{ks}$ will depend on whether different types of labor tend to be substitutes for or complements to one another, while the value of $\delta_s$ will depend on

[3] We are not able to reject the hypothesis that the parameters are the same across industries. We think this has to do with our relatively aggregated industries encompassing activities with different factor-, R&D and offshoring intensities.

whether capital tends to substitute or complement labor belonging to skill group $s$. The values of parameters $\lambda_s^h$ depend on whether technical change is biased towards or away from the usage of labor belonging to skill group $s$.

In the main part of the analysis, we distinguish between three different skill groups based on educational attainment: workers with at most lower secondary (9 years of schooling), upper secondary (12 years of schooling), and tertiary education. This results in a system of three equations such as (3); one for each skill group. Homogeneity in prices implies $\sum_{s=1}^{S} \gamma_{js} = 0$ and symmetry of the underlying translog cost function that $\gamma_{st} = \gamma_{ts}$; restrictions imposed in the analysis.

To control for any FBTC induced by domestic innovation, we also include R&D intensity. We then consider two measures of FBTC: offshoring (denoted $z_{ij}^o$) and R&D intensity (denoted $z_{ij}^r$).

Only two of the three cost share equations are independent, since the third cost share is one minus the sum of the other two. (Note that $\sum_{s=1}^{S} \theta_{ijs} = 1$ implies that parameters $\gamma_{ks}$, $\phi_s$, $\delta_s$, and $\lambda_s^h$ sum to zero across the $S$ equations.) Therefore, we only estimate two equations. To take possible correlation between the residuals into account, we estimate the system using iterated SUR (ISUR). In all specification we include industry and time dummies.

Our measure of offshoring only vary across industries and time, not across regions (region-specific information on imports is unavailable) Implicitly, we thus assume that the ratio of imported inputs to output within and industry does not vary across locations. This assumption is of course somewhat restrictive, but there is no obvious way in which this proportion is likely to vary across regions. We thus view our measure of offshoring as a proxy for regional offshoring.

## 3.1 Data

Our information about employees and wages stems from a database called RAMS (Regional Arbetsmarknadsstatistik). Industry and country distributed trade data for 1993–2002, collected by Statistics Sweden, are available. Input-output tables containing information about imports, however, are only available for 1995 and 2000 (through Statistics Sweden). This information is combined to create time series of imports of intermediate inputs at the country-industry level.

Industry-and region distributed data on output, capital stocks and R&D expenditures have been provided by Statistics Sweden as well. Industry-distributed information about employment at Swedish multinationals have been provided by the Swedish Institute for Growth Policy Studies (ITPS), Stockholm. More detailed information about the data used can be found in one of the appendices.

# 4 Results

## 4.1 Main analysis

In addition to total offshoring, we use offshoring measures distinguishing between imports from low-income and high-income countries.[4] Due to differences in the factor-intensity of imports depending on the source of imports, the two offshoring measures are expected to have different effects on relative labor demand. In carrying out the estimations we assume wages to be set economy-wide. With economy-wide wages, we get a set of three wages for each year, which will be linearly dependent of any time dummies included. Thus, we have a choice of estimating the system with either wages or time dummies. Since we believe time dummies to be important for capturing a trendwise increase in the cost share of workers with tertiary education and a trendwise decrease in the cost share of workers with lower secondary education, we choose the latter.[5] We carry out estimations both with contemporaneous and lagged values of offshoring (the latter to reduce potential endogeneity problems). Since the results are fairly similar (with a tendency for less precise estimates with lagged values) we only present results with contemporaneous values below.[6]

[4] We use the World Bank classification to group countries into a high-income and a low-income group.

[5] A specification with industry-specific wages would suffer from a potential endogeneity problem since industry wages are likely to reflect the composition of different types of workers, which also affects the industry's wage cost shares for these different types of workers.

[6] The results using lagged values will be provided upon request.

Our statistical inference is based on bootstrapped standard errors, i.e. standard errors based on the distribution of estimates from repeated regressions on samples created by resampling using the actual data. The reason for choosing this method is that the only available analytically derived standard errors are based on the assumption of normally distributed errors; an assumption which is violated in this case.[7]

We start by presenting the results for a basic specification with the narrow measure of offshoring, without any distinction between different types of regions. Table 3 shows the elasticities derived from the regression results at regional level for two specifications: one with a measure of overall offshoring and another with separate measures of offshoring to high-income and low-income countries, respectively (see the Appendix for the derivation of the elasticities).[8] According to the results in Table 3, overall offshoring tends to shift labor demand away from workers with upper secondary education, that is the group with intermediate level of education (cf. Ekholm and Hakkala, 2006). The skill group that is estimated to be affected positively is the one with the lowest level of education; lower secondary education. In quantitative terms, for a given level of output and capital, a one percentage point increase in the offshoring measure is estimated to decrease demand for workers with upper secondary education by 0.7 percent (the elasticity being significant at the 10 percent level) while increasing demand for workers with lower secondary education by 1.7 percent (the elasticity being significant at the 5 percent level). The effect on workers with tertiary education is not statistically significant.

[Table 3 about here]

Looking at offshoring to high-income and low-income countries separately (the last columns in Table 2) we find that the results seem to be driven mainly by the effects of offhoring to high-income countries. The estimated elasticity for workers with the lowest level of education is again positive and significant (at the 5 percent level). But here it is the estimated elasticity for workers with tertiary education that is negative and significant,

[7] Our standard errors are based on 1,000 bootstrap replications with replacement, using the same sample size as the regressions.

[8] The regression results may be obtained from the authors upon request.

indicating that offshoring to high-income countries mainly hurts workers in the highest skill group. The effect on workers with upper secondary education, on the other hand, is not statistically significant. One percentage point increase in the measure of offshoring to high-income countries is estimated to reduce the demand for workers with tertiary education by about 1.6 percent and increase the demand for workers with lower secondary education by 2 percent. Offshoring to low-income countries does not have any significant effect on the relative labor demand.

It is useful to compare these elasticities with those obtained for R&D variables, our other measure of factor-biased technological change. Industry-specific R&D variable is not statistically significant, but region-specific R&D is significant and has the expected effect. For a given level of output and capital, increases in R&D quite clearly shift labor demand away from workers with the lowest and towards workers with the highest level of education. This is consistent with results from Machin and Van Reenen (1998), Haskel and Heden (1999), Hansson (2005), Hijzen et al. (2005) and Ekholm and Hakkala (2006).

In Table 4A, we show results distinguishing between central and peripheral regions. Both total offshoring and offshoring to low-income countries are estimated to shift labor demand away from workers with an intermediate level of education. The estimated elasticities for workers with upper secondary education are negative and significant. According to our estimates, a one percentage point increase in overall offshoring is associated with a decrease in the demand for workers with an intermediate level of education by 1.3 percent irrespective of the type of region. A one percentage point increase in offshoring to low-income countries is associated with a decrease in the demand for these workers by 4.6 percent in the core and 5.1 percent in the periphery.

Total offshoring and offshoring to high-income countries are estimated to shift labor demand towards the workers with the lowest level of education. In both cases, the effect is estimated to be somewhat larger in the periphery compared with the core.

[Table 4A about here]

The last column of Table 4A shows the estimated effect in percentage terms from the region belonging to the core rather than the periphery. Somewhat surprisingly, our estimates suggest that when we control for other factors, relative demand for workers with the lowest level of education tends to be higher in the core. This implies that the observed difference in cost shares between these regions – where the share of workers with lower secondary education is considerably lower in the core than in the periphery – is explained by the observed differences in industry characteristics such as capital-intensity and R&D intensity.

Table 4B presents the results from the specification where we distinguish between southern and northern regions. Total offshoring is here estimated to shift labor demand towards workers with the lowest level of education, and primarily to shift demand away from workers with tertiary education. This tendency is the same for both types of regions, but the estimated elasticities are larger for the northern ones.

Using the separate measures of offshoring to high-income and low-income countries, we see that in northern regions workers with the highest level of education are affected in two opposing ways: offshoring to low-income countries shifts demand away from workers with intermediate level of education towards the workers with the highest level of education, while offshoring to high-income countries shifts demand away from the workers with the highest level towards workers with the lowest level of education. The only statistically significant estimate for the southern regions is the positive elasticity for offshoring to high-income countries with respect to demand for workers with the lowest level of education.

The results in the last column suggest that when we control for other factors, relative demand for workers with the lowest level of education tends to be higher in the south.

[Table 4B about here]

Table 4C, shows the results for a classification of regions in urban and rural. Southern and urban counties are overlapping to a great extent and the results are quite similar to those obtained in Table 4B. As with the southern regions in the previous table we find that offshoring elasticities tend to be smaller for the urban counties than for the rural ones. However, here overall offshoring is estimated to shift demand away from workers with intermediate education and towards workers with the lowest level of education in urban counties. It is estimated to shift demand away from workers with tertiary education only in the rural counties.

Again we see that the estimated effects of total offshoring seem to be driven by the effects of offshoring to high-income countries. Offshoring to high-income countries is estimated to shift labor demand towards workers with low education for both urban and rural regions, and away from workers with high education in rural regions. The estimated elasticities of offshoring to low-income countries are insignificant for urban regions. For rural regions, on the other hand, offshoring to low-income countries is estimated to shift labor demand away from workers with an intermediate level of education and towards workers with a high level of education. For rural counties, a percentage point increase in offshoring to low-income countries is estimated to decrease demand for workers with upper secondary education by 4.8 percent (1.3 percent in urban) and increase demand for workers with tertiary education by 8.5 percent (3.4 percent in urban).

[4C about here]

Tables 5A-5C show similar results based on the broad measure of offshoring. [TO BE INCLUDED]

[Table 5A-5C about here]

Overall the results suggest that there is little evidence of offshoring being associated with a shift of labor demand away from the least educated workers. On the contrary, if anything, the workers with only nine years of schooling seems to face an increased relative demand for their services on account of offshoring. The main reason for this result is that most of the offshoring that we measure is really due to imports from other high-income economies, implying that the factor content of this imports is rather biased away from low-skilled workers. However, even when we focus on offshoring to low-income countries, we do not see any clear evidence of this shifting labor demand away from workers with only nine years of schooling We do find evidence of a positive effect on the relative demand for workers with tertiary education, but this is primarily mirrored in a negative effect on the relative demand for workers with an intermediate level of education.

### 4.2 Implied effect of actual offshoring

We use our estimated elasticities to calculate to what extent actual offshoring has affected labor demand. We focus on the distinction between core and periphery, since the results for the other groupings are quite similar. Table 6 shows the predicted changes in percentage terms from actual offshoring (the actual change in employment for each skill group is evident from Table 2).

[Table 6 about here]

Table 6 shows that offshoring is estimated to have contributed very little to the actual change in employment. Offshoring essentially does not contribute anything to the observed decline in employment for the least educated workers and to only about a tenth of the increase in employment of the most educated ones (the implied change in demand amount to about a tenth of the actual increase in employment of workers with tertiary education in both core and periphery).

Another noteworthy result in Table 6 is that the overall impact of offshoring on labor demand is larger in the core than in the periphery. The predicted change in labor demand by offshoring is in all cases larger in percentage terms in the core counties than in the peripheral counties. The reason for this is that the increase in offshoring has been smaller in peripheral counties than in core counties.

## 5 Conclusions

We do not find any support for the hypothesis that offshoring shifts labor demand away from the least educated workers. On the contrary, according to our estimates, offshoring seems to have been a factor counteracting a decrease in the relative demand for these workers stemming from other sources, such as technological change driven by domstic

R&D. The main reason for this is that most of Swedish offshoring is related to imports from hhigh-income rather than low-income economies. However, even when focusing on the effect of offshoring to low-income economies, we do not find strong negative effects on the relative demand for the least educated. Instead, our results suggest that offshoring to low-income countries primarily shifts labor demand away from workers with an intermediate level of education.

The estimated elasticities tend to be larger for the rural, northern and peripheral regions. We believe this reflects a tendency for these regions to host the kind of activities that are directly affected by the firms' decision to offshore production. However, at the same time these regions are less affected by actual offshoring of intermediate input production since they have less of it than the urban, southern and central regions.

# References


[1] Amiti, M. and S.J. Wei (2005), "Fear of Service Outsourcing: Is it Justified?", *Economic Policy*, 20, pp. 308-348..

[2] Anderton, B. and P. Brenton (1998), "Outsourcing and Low-Skilled Workers in the UK", GSGR Working Paper No. 12/98, University of Warwick.

[3] Ekholm, K. and K. Hakkala (2006), "The Effect of Offshoring on Labor Demand: Evidence from Sweden", CEPR Working Paper No. 5648.

[4] Falk, M. and B. M. Koebel (2002), "Outsourcing, Imports and Labour Demand", *Scandinavian Journal of Economics*, 104, 567-586.

[5] Feenstra, R.C. and G.H. Hanson (1996), "Globalization, Outsourcing, and Wage Inequality", *American Economic Review*, 86, pp. 240-45.

[6] Feenstra, R.C. and G.H. Hanson (1999), "The Impact of Outsourcing and High-Technology Capital on Wages: Estimates for the United States, 1979-1990", *The Quarterly Journal of Economics*,114, pp. 907-41.

[7] Hansson, P. (2000), ”Relative Demand for Skills in Swedish Manufacturing: Technology or Trade?”, *Review of International Economics,* 8, 533-555.

[8] Hansson, P. (2005), "Skill Upgrading and Production Transfer Within Swedish Multinationals", *Scandinavian Journal of Economics* 107, 673-692.

[9] Hijzen, A. and Görg, H. and R.C. Hine (2005) “International Outsourcing and the Skill Structure of Labor Demand in the United Kingdom”, *Economic Journal,* 115, 506, pp. 860-78.

[10] Haskel, J.E. and Y. Heden (1999), “Computers and the Demand for Skilled Labour: Industry- and Establishment-level Panel Evidence for the UK”, *Economic Journal*, 109, 454, pp. 68-79.

[11] Machin, S. and J. van Reenen (1998), "Technology and Changes in Skill Structure: Evidence form Seven OECD Countries", *Quarterly Journal of Economics*, 113, pp. 1215-1244.

[12] Strauss-Kahn, V. (2004), ”The Role of Globalization in the Within-Industry Shift Away from Unskilled Workers in France”, Chapter 6 in R. E. Baldwin and L. A. Winters (eds.), *Challenges to Globalization: Analyzing the Economics*, NBER Conference Report, University of Chicago Press, Chicago.

# A Data

## R&D

We use two R&D variables: the industry-specific R&D is computed as the share of R&D expenditures of total sales at industry level and the region-specific R&D is computed as the share of man-years of R&D expenditure of total number of employees at the county level. Data for both R&D variables are provided by Statistics Sweden.

## Capital stocks

We have constructed region and industry specific capital stocks for 1995-2000 in the following way: We start with industry-specific capital stocks for 1995 ($K_{i,95}$). We set the industry and region specific capital stock in 1995 to:

$$K_{ij,95} = \frac{Q_{ij,95}}{\sum_{j \in R} Q_{ij,95}} \times K_{i,95}$$

where $Q_{ij,95}$ is industry and region specific value added.

For all subsequent years, $t = (96, 97, 98, 99, 00)$, we calculate capital stocks as:

$$K_{ijt} = K_{ijt-1} + I_{ijt-1}(1 - \rho_{it-1})$$

where $I_{ijt-1}$ is industry and region specific investments and

$$\rho_{it-1} \equiv \frac{\sum_{j \in R} \widetilde{K}_{ijt} - K_{it}}{\sum_{j \in R} I_{it-1}}, \quad \widetilde{K}_{ijt} \equiv K_{ijt-1} + I_{ijt-1}.$$

In words, we let the capital sotck in industry $i$ in region $j$ be the stock the previous year plus the industry and region specific investment that year, adjusted to take into account depreciation by using the industry-specific depreciation rate implicit in the data for capital stocks collected at the industry level.

## Market potential

The Swedish counties that we use correspond to regions at the NUTS3 level. We define market potential as the distance weighted GDP of all European regions,using the Harris formula:

$$MP_j = \sum_{k \in R} \frac{GDP_k}{dist_k}$$

where $GDP$ for Swedish regions are measured at the NUTS3 level and for other European regions at the NUTS1 level (or country level in the case of Norway and Switzerland). We do not account for non-European countries. Distance is measured as the great circle distance between the main cities in the regions (capital cities or other major cities). For the own region we set $dist_j = 2/3 \times \sqrt{area_j/\pi}$.

# B Regional groupings and characteristics

Table A1 shows how offshoring measured as imported inputs as a share of output (in percent) varies across regions. Regions are listed according to their rank using the narrow measure of offshoring in 1995. The last two columns show the change in the narrow and broad measure of offshoring between 1995 and 2000.

[Table A1 about here]

# C Derivation of the elasticities

In this section, we shall show how the elasticities calculated in the paper are derived from the translog cost function. The starting point is the following cost function for industry $i$:

$$C_i = \beta_i + \sum_{j=1}^{S} \alpha_j \ln w_j + \sum_{j=1}^{S} \sum_{s=1}^{S} \gamma_{js} \ln w_j \ln w_s + \phi \ln Q_i \tag{4}$$

$$+ \sum_{j=1}^{S} \phi_j \ln Q_i \ln w_j + \delta \ln K_i + \sum_{j=1}^{S} \delta_j \ln K_i \ln w_j \tag{5}$$

$$+ \eta \ln Q_i \ln K_i + \sum_{r=1}^{R} \kappa_r z_{ir} + \sum_{j=1}^{S} \sum_{r=1}^{R} \lambda_{jr} z_{ir} \ln w_j \tag{6}$$

$(j = 1, ...S, s = 1, ...S, r = 1, ...R)$, where the variables are as defined in the main text. By differentiating (4) with respect to $w_j$ we get:

$$\theta_{ij} = \alpha_j + \sum_{s=1}^{S} \gamma_{js} \ln w_s + \phi_j \ln Q_i + \delta_j \ln K_i + \sum_{r=1}^{R} \lambda_{jr} z_{ir}, \tag{7}$$

where

$$\theta_{ij} \equiv \frac{\partial C_i}{\partial w_j} \frac{w_j}{C_j}.$$

and $\frac{\partial C_i}{\partial w_j} = L_{ij}$ according to Shephard's lemma. Industry $i$'s demand for factor $j$ can then be written as:

$$L_{ij} = \frac{C_j}{w_j} \left[ \alpha_j + \sum_{s=1}^{S} \gamma_{js} \ln w_s + \phi_j \ln Q_i + \delta_j \ln K_i + \sum_{r=1}^{R} \lambda_{jr} z_{ir} \right]. \tag{8}$$

Differentiation of expression (8) yields:

$$\widehat{L}_{ij} = \widehat{C}_j - \widehat{w}_j + \frac{1}{\theta_{ij}} \left[ \sum_{s=1}^{S} \gamma_{js} \widehat{w}_s + \phi_j \widehat{Q}_i + \delta_j \widehat{K}_i + \sum_{r=1}^{R} \lambda_{jr} dz_{ir} \right] \tag{9}$$

utilizing the equality in (7).

Substituting $\widehat{C}_j$ in (9) for $\sum_{s=1}^{S} \theta_{is} \widehat{w}_s$ and collecting terms result in:

$$\widehat{L}_{ij} = \left( \frac{\gamma_{jj} + \theta_{ij}^2}{\theta_{ij}} - 1 \right) \widehat{w}_j + \sum_{k=1}^{S-1} \left( \frac{\gamma_{jk} + \theta_{ik}\theta_{ij}}{\theta_{ij}} \right) \widehat{w}_k + \frac{1}{\theta_{ij}} \left[ \phi_j \widehat{Q}_i + \delta_j \widehat{K}_i + \sum_{r=1}^{R} \lambda_{jr} dz_{ir} \right], \tag{10}$$

where $k \neq j$ and a hat above a variable indicates relative change (i.e. $\widehat{x} \equiv dx/x$). From this expression, it is easily seen that Hicksian wage elasticities can be expressed as:

$$\frac{\widehat{L}_{ij}}{\widehat{w}_j} = \frac{\gamma_{jj} + \theta_{ij}^2}{\theta_{ij}} - 1$$

$$\frac{\widehat{L}_{ij}}{\widehat{w}_k} = \frac{\gamma_{jk} + \theta_{ik}\theta_{ij}}{\theta_{ij}}.$$

The technology variables, $z_{ir}$, are expressed as shares. Therefore, we will report the results for them as semi-elasticities:

$$\frac{\widehat{L}_{ij}}{dz_{ir}} = \frac{\lambda_{jr}}{\theta_{ij}}.$$

These will tell us the percentage response in labor demand to a one-percentage point change in the technology variable. In our calculations, we evaluate these elasticities using parameter estimates and sample means.

Table A1: Regional measures of offshoring expressed as imported inputs as a share of output in percent

| | 1995 | | 2000 | | Change 1995-2000 | |
|---|---|---|---|---|---|---|
| **Region** | **Narrow** | **Broad** | **Narrow** | **Broad** | **Narrow** | **Broad** |
| Västra Götaland | 11.6 | 20.7 | 11.3 | 20.7 | -0.3 | 0.1 |
| Västmanland | 11.0 | 20.3 | 11.2 | 20.9 | 0.2 | 0.6 |
| Stockholm | 10.8 | 18.4 | 12.1 | 20.7 | 1.3 | 2.4 |
| Örebro | 10.0 | 19.3 | 8.4 | 17.2 | -1.6 | -2.1 |
| Södermanland | 9.9 | 19.1 | 10.5 | 20.3 | 0.6 | 1.2 |
| Blekinge | 9.7 | 18.6 | 11.4 | 20.4 | 1.7 | 1.8 |
| Östergötland | 9.6 | 19.0 | 10.0 | 19.5 | 0.4 | 0.5 |
| Dalarna | 9.4 | 17.0 | 8.7 | 16.7 | -0.7 | -0.3 |
| Västerbotten | 8.9 | 17.5 | 9.3 | 18.4 | 0.4 | 0.9 |
| Uppsala | 8.9 | 16.2 | 11.2 | 17.4 | 2.3 | 1.3 |
| Gävleborg | 8.3 | 15.8 | 9.8 | 18.4 | 1.5 | 2.6 |
| Kronoberg | 7.9 | 17.8 | 8.0 | 18.2 | 0.2 | 0.4 |
| Kalmar | 7.8 | 16.3 | 8.2 | 16.9 | 0.4 | 0.6 |
| Norrbotten | 7.5 | 14.4 | 6.7 | 13.6 | -0.9 | -0.9 |
| Jämtland | 7.5 | 16.1 | 5.2 | 13.3 | -2.3 | -2.8 |
| Skåne | 7.4 | 15.2 | 7.9 | 15.5 | 0.4 | 0.3 |
| Värmland | 7.2 | 14.4 | 7.7 | 15.9 | 0.5 | 1.5 |
| Jönköping | 7.1 | 18.8 | 7.7 | 18.8 | 0.6 | -0.1 |
| Västernorrland | 6.3 | 13.4 | 6.5 | 13.9 | 0.2 | 0.5 |
| Halland | 6.1 | 13.9 | 6.3 | 14.0 | 0.2 | 0.2 |
| Gotland | 3.5 | 8.5 | 4.8 | 9.0 | 1.4 | 0.5 |

Table A2: Classification of Swedish NUTS3 regions

| **Region** | **South** | **Urban** | **Core** |
|---|---|---|---|
| Västra Götaland | 1 | 1 | 1 |
| Västmanland | 1 | 1 | 0 |
| Stockholm | 1 | 1 | 1 |
| Örebro | 1 | 1 | 0 |
| Södermanland | 1 | 1 | 0 |
| Blekinge | 1 | 1 | 1 |
| Östergötland | 1 | 1 | 1 |
| Dalarna | 0 | 0 | 0 |
| Västerbotten | 0 | 0 | 0 |
| Uppsala | 1 | 1 | 0 |
| Gävleborg | 0 | 0 | 0 |
| Kronoberg | 1 | 0 | 1 |
| Kalmar | 1 | 0 | 1 |
| Norrbotten | 0 | 0 | 0 |
| Jämtland | 0 | 0 | 0 |
| Skåne | 1 | 1 | 1 |
| Värmland | 1 | 0 | 1 |
| Jönköping | 1 | 1 | 1 |
| Västernorrland | 0 | 0 | 0 |
| Halland | 1 | 1 | 1 |
| Gotland | 1 | 0 | 0 |

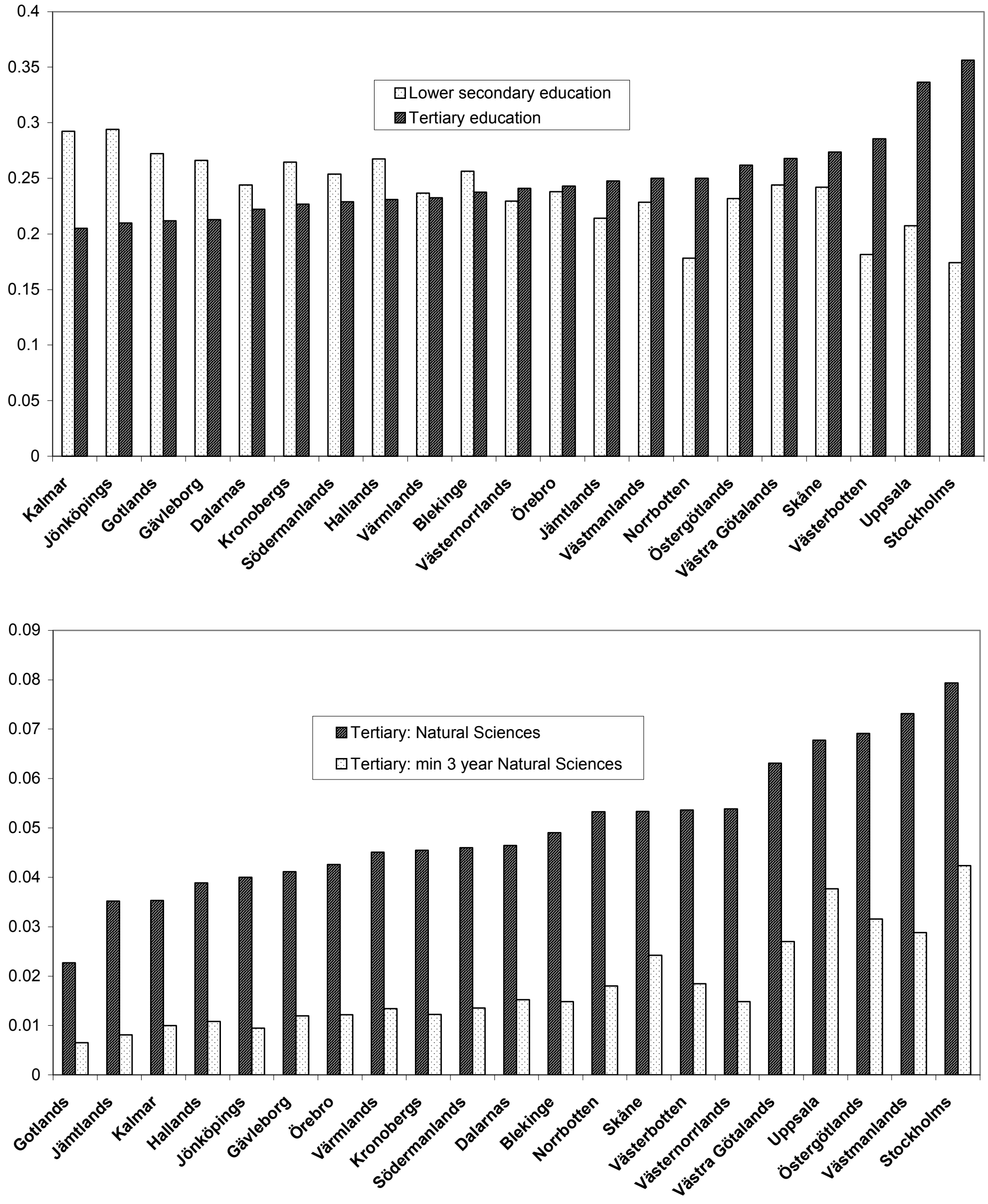


Figure 1: Employment shares of workers with different educational attainment.

Table 1: Change in employment shares 1995-2004 for different types of counties

| **Industry** | **Southern** | **Urban** | **Core*** |
|---|---|---|---|
| Basic metals and fabric. metal prod. | 0.068 | 0.070 | 0.021 |
| Chemicals, coke, refined petrol. prod. | 0.007 | 0.038 | -0.044 |
| Electrical and optical equipment | 0.088 | 0.094 | 0.060 |
| Food, beverages and tobacco | 0.005 | 0.017 | 0.009 |
| Machinery and equipment | 0.002 | -0.003 | 0.053 |
| Other manufact.and recycling | -0.093 | -0.080 | -0.148 |
| Other non-metallic mineral prod. | 0.033 | 0.067 | 0.076 |
| Paper, pulp and paper prod. | 0.001 | -0.001 | 0.000 |
| Printing and publishing | 0.016 | 0.008 | 0.011 |
| Rubber and plastic products | -0.024 | -0.054 | -0.003 |
| Textile and leather | 0.032 | 0.045 | 0.061 |
| Transport equipment | 0.020 | -0.005 | -0.013 |
| Wood and wood products | -0.015 | 0.025 | 0.018 |

*The changes between core and periphery regions have been calculated for 1995-2003.

Source: Own calculations based on data from Eurostat and Statistics Sweden.

Table 2: Change in employment 1995-2000 in percent

| **Education** | **Core** | **Urban** | **South** | **Periphery** | **Rural** | **North** |
|---|---|---|---|---|---|---|
| Lower sec. | -18.3 | -18.4 | -18.5 | -24.0 | -23.9 | -25.8 |
| Upper sec. | 9.72 | 9.85 | 10.1 | 6.21 | 5.61 | 3.47 |
| Tertiary | 22.6 | 21.8 | 21.5 | 15.6 | 17.1 | 16.9 |

Table 3. Elasticities calculated from estimations of translog cost functions. Narrow measure of offshoring

| Demand for labor with: | *Spec.* | Changes in: Capital | Value added | R&D ind | R&D reg | Off-shoring | Offshoring HI | Offshoring LI |
|---|---|---|---|---|---|---|---|---|
| Lower sec. | *(1)* | -0.039 | 0.072 | 0.137 | -2.752 | 1.729 | | |
| education | | (0.022)* | (0.023)*** | (0.864) | (0.149)*** | (0.729)** | | |
| | *(2)* | -0.040 | 0.072 | 0.129 | -2.752 | | 2.018 | 0.043 |
| | | (0.022)* | (0.023)*** | (0.832) | (0.152)*** | | (0.946)** | (3.317) |
| Upper sec. | *(1)* | 0.011 | -0.067 | -0.166 | -0.501 | -0.741 | | |
| education | | (0.010) | (0.010)*** | (0.448) | (0.081)*** | (0.417)* | | |
| | *(2)* | 0.010 | -0.066 | -0.175 | -0.501 | | -0.384 | -2.689 |
| | | (0.010) | (0.010)*** | (0.429) | (0.082)*** | | (0.539) | (2.348) |
| Tertiary | *(1)* | 0.024 | 0.054 | 0.185 | 4.332 | -0.505 | | |
| education | | (0.020) | (0.021)** | (0.774) | (0.142)*** | (0.639) | | |
| | *(2)* | 0.026 | 0.052 | 0.215 | 4.334 | | -1.600 | 5.465 |
| | | (0.020) | (0.021)** | (0.761) | (0.145)*** | | (0.881)* | (3.719) |

Note: Standard errors in parenthesis are based on bootstrapping.
Significance at the 1, 5, and 10 percent level is indicated by ***, **, and *, respectively.

**Table 4A. Elasticities calculated from estimations of translog cost functions. Narrow measure of offshoring**

| Demand for labor with: | Spec. | Changes in: Capital | Value added | R&D | R&D reg | Offshoring Core | Offshoring Periphery | Offsh. high-income Core | Offsh. high-income Periphery | Offsh. Low-income Core | Offsh. Low-income Periphery | Core Dummy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lower sec. | *(1)* | -0.037 | 0.051 | 0.141 | -2.784 | 1.579 | 1.906 | | | | | 0.149 |
| education | | (0.018)** | (0.019)*** | (0.721) | (0.149)*** | (0.705)** | (0.719)*** | | | | | (0.020)*** |
| | *(2)* | -0.038 | 0.053 | 0.136 | -2.784 | | | 1.863 | 2.155 | -0.107 | 0.775 | 0.150 |
| | | (0.018)** | (0.019)*** | (0.699) | (0.154)*** | | | (0.881)** | (0.898)** | (3.148) | (3.516) | (0.022)*** |
| Upper sec. | *(1)* | 0.018 | -0.101 | -0.298 | -0.855 | -1.320 | -1.264 | | | | | -0.099 |
| education | | (0.009)** | (0.010)*** | (0.388) | (0.082)*** | (0.417)*** | (0.416)*** | | | | | (0.011)*** |
| | *(2)* | 0.018 | -0.101 | -0.318 | -0.857 | | | -0.695 | -0.608 | -4.589 | -5.074 | -0.100 |
| | | (0.009)** | (0.010)*** | (0.378) | (0.084)*** | | | (0.520) | (2.246) | (0.519)*** | (2.501)** | (0.011)*** |
| Tertiary | *(1)* | 0.019 | 0.050 | 0.157 | 3.639 | -0.260 | -0.642 | | | | | -0.050 |
| education | | (0.019) | (0.020)** | (0.690) | (0.140)*** | (0.945) | (0.662) | | | | | (0.016)*** |
| | *(2)* | 0.020 | 0.048 | 0.182 | 3.641 | | | -1.168 | -1.548 | 4.696 | 4.299 | -0.050 |
| | | (0.019) | (0.020)** | (0.667) | (0.143)*** | | | (0.875) | (0.860)* | (3.912) | (3.953) | (0.016)*** |

Note: Standard errors in parenthesis are based on bootstrapping.

Significance at the 1, 5, and 10 percent level is indicated by ***, **, and *, respectively.

**Table 4B. Elasticities calculated from estimations of translog cost functions. Narrow measure of offshoring**

| | | **Changes in:** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Demand for** | | | **Value** | | | **Offshoring** | | **Offsh. high-income** | | **Offsh. Low-income** | | **South** |
| **labor with:** | *Spec.* | **Capital** | **added** | **R&D** | **R&D reg** | **South** | **North** | **South** | **North** | **South** | **North** | **Dummy** |
| Lower sec. | *(1)* | -0.028 | 0.042 | 0.118 | -3.202 | 1.462 | 2.229 | | | | | 0.236 |
| education | | (0.081) | (0.018)** | (0.719) | (0.142)*** | (0.739)** | (0.749)*** | | | | | (0.019)*** |
| | *(2)* | -0.028 | 0.042 | 0.112 | -3.201 | | | 1.652 | 2.455 | 0.525 | 0.722 | 0.235 |
| | | (0.018) | (0.019)** | (0.702) | (0.143)*** | | | (0.875)* | (0.900)*** | (2.944) | (3.109) | (0.020)*** |
| Upper sec. | *(1)* | 0.004 | -0.048 | -0.157 | -0.252 | -0.651 | -0.112 | | | | | -0.095 |
| education | | (0.009) | (0.009)*** | (0.378) | (0.078)*** | (0.397) | (0.412) | | | | | (0.010)*** |
| | *(2)* | 0.004 | -0.048 | -0.169 | -0.247 | | | -0.393 | -0.182 | -2.503 | -3.970 | -0.098 |
| | | (0.009) | (0.009)*** | (0.372) | (0.078)*** | | | (0.463) | (0.473) | (2.127) | (2.286)* | (0.010)*** |
| Tertiary | *(1)* | 0.026 | 0.050 | 0.188 | 4.345 | -0.375 | -2.423 | | | | | -0.081 |
| education | | (0.019) | (0.019)** | (0.704) | (0.141)*** | (0.673)** | (0.686)** | | | | | (0.015)*** |
| | *(2)* | 0.025 | 0.052 | 0.222 | 4.335 | | | -1.143 | -2.545 | 4.633 | 7.478 | -0.074 |
| | | (0.019) | (0.020)*** | (0.698) | (0.137)*** | | | (0.868) | (0.887)*** | (3.594) | (3.595)** | (0.015)*** |

Note: Standard errors in parenthesis are based on bootstrapping.
Significance at the 1, 5, and 10 percent level is indicated by ***, **, and *, respectively.

**Table 4C. Elasticities calculated from estimations of translog cost functions. Narrow measure of offshoring**

| | | Changes in: | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Demand for** | | | **Value** | | | **Offshoring** | | **Offsh. high-income** | | **Offsh. Low-income** | | **Urban** |
| **labor with:** | *Spec.* | **Capital** | **added** | **R&D** | **R&D reg** | **Urban** | **Rural** | **Urban** | **Rural** | **Urban** | **Rural** | **Dummy** |
| Lower sec. | *(1)* | -0.038 | 0.061 | 0.128 | -3.380 | 1.467 | 2.055 | | | | | 0.158 |
| education | | (0.020)* | (0.020)*** | (0.797) | (0.162)*** | (0.738)** | (0.741)*** | | | | | (0.018)*** |
| | *(2)* | -0.039 | 0.063 | 0.121 | -3.385 | | | 1.768 | 2.276 | -0.548 | 1.370 | 0.160 |
| | | (0.020)** | (0.020)*** | (0.796) | (0.158)*** | | | (0.878)** | (0.896)** | (3.249) | (3.416) | (0.018)*** |
| Upper sec. | *(1)* | 0.008 | -0.056 | -0.163 | -0.141 | -0.894 | -0.547 | | | | | -0.046 |
| education | | (0.009) | (0.010)*** | (0.393) | (0.088) | (0.406)** | (0.415) | | | | | (0.010)*** |
| | *(2)* | 0.011 | -0.061 | -0.176 | -0.130 | | | -0.619 | -0.034 | -1.329 | -4.848 | -0.054 |
| | | (0.010) | (0.010)*** | (0.416) | (0.081) | | | (0.493) | (0.506) | (2.123) | (2.308)** | (0.009)*** |
| Tertiary | *(1)* | 0.027 | 0.045 | 0.190 | 4.326 | 0.130 | -1.300 | | | | | -0.091 |
| education | | (0.019) | (0.019)*** | (0.727)*** | (0.155)*** | (0.667) | (0.667)* | | | | | (0.014)*** |
| | *(2)* | 0.023 | 0.052 | 0.225 | 4.307 | | | -0.807 | -2.642 | 3.444 | 8.549 | -0.079 |
| | | (0.019) | (0.020)*** | (0.686) | (0.152)*** | | | (0.813) | (0.935)*** | (3.064) | (3.592)** | (0.014)*** |

Note: Standard errors in parenthesis are based on bootstrapping.

Significance at the 1, 5, and 10 percent level is indicated by ***, **, and *, respectively.

Table 6: Predicted change in labor demand, percent

| | Core | | | Periphery | | |
|---|---|---|---|---|---|---|
| **Level of** | **Predicted change by offsh.** | | | **Predicted change by offsh.** | | |
| **education** | **Total** | **High-inc** | **Low-inc** | **Total** | **High-inc** | **Low-inc** |
| Lower sec. | 1.40 | 0.81 | -0.05 | 0.97 | 0.34 | 0.27 |
| Upper sec. | -1.17 | -0.30 | -2.06 | -0.64 | -0.10 | -1.78 |
| Tertiary | -0.23 | -0.51 | 2.11 | -0.33 | -0.25 | 1.51 |