

Vries, Gaaitzen De; Foster-McGregor, Neil; Stehrer, Robert

**Working Paper**

## Offshoring and the Skill Structure of Labour Demand

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*Neil Foster, Robert Stehrer and Gaaitzen de Vries*

## **Offshoring and the Skill Structure of Labour Demand**



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Neil Foster is a research economist at the Vienna Institute for International Economic Studies (wiiw). Robert Stehrer is wiiw Deputy Director of Research. Gaaitzen de Vries is assistant professor at the University of Groningen (RUG).

*Neil Foster, Robert Stehrer  
and Gaaitzen de Vries*

**Offshoring and the  
Skill Structure  
of Labour Demand**



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**Abstract**

*In this paper we examine the link between international outsourcing – or offshoring – and the skill structure of labour demand for a sample of 40 countries over the period 1995-2009. The paper uses data from the recently compiled World-Input-Output-Database (WIOD) to estimate a system of variable factor demand equations. These data allow us to exploit both a cross-country and cross-industry dimension and split employment into three skill categories. Our results indicate that while offshoring has impacted negatively upon all skill levels, the largest impacts have been observed for medium-skilled (and to a lesser extent high-skilled) workers. Such results are consistent with recent evidence indicating that medium-skilled workers have suffered to a greater extent than other skill types in recent years.*

**Keywords:** *offshoring, trade, wages, labour demand*

**JEL classification:** *F14, J31*





## **Offshoring and the skill structure of labour demand**

### **1. Introduction**

One of the most pervasive features of the labour market in recent times has been the rising demand for skilled workers relative to unskilled workers in Europe and the United States (Autor and Dorn, 2009; Goos et al., 2011). Despite a concomitant increase in the supply of skilled workers, relative wages of skilled workers have risen in almost all industries. As a result, the wage share of skilled workers in manufacturing value added has increased in OECD countries. Timmer et al. (2011) for example measure the value added shares of production factors in global value chains and find that the value added share of high-skilled workers in global manufacturing by the U.S. and Europe has been increasing, while that of low- and medium-skilled workers has fallen. At the same time as these changes have been witnessed in the labour market, the ongoing globalisation process has seen the increasing frequency of international outsourcing – or offshoring – of production, involving the contracting out of activities that were previously performed within a production unit to foreign subcontractors. An important ongoing research question of direct policy relevance is the issue of whether increased offshoring is a cause of the rising demand for skilled workers in advanced countries.

The establishment of international production networks associated with offshoring generates trade in intermediates, as has been shown by Campa and Goldberg (1997), Hummels et al. (2001) and Yeats (2001). While this would be expected to affect the composition of international trade it may also change the pattern of trade, as firms look to source intermediates from low cost suppliers. In the international trade literature one of the main driving forces behind production offshoring is the existence of differences in factor prices across national borders (e.g. Feenstra and Hanson, 1996; Kohler, 2004). Offshoring differs importantly from import penetration in final goods in the sense that it explicitly takes into account the extent to which firms move production (and service) activities abroad. Labour demand is therefore likely to be affected not only in import-competing industries, but also in all industries that use foreign inputs and services. The impact of offshoring on the labour market may not be limited to changing labour demands between industries therefore, but may also affect the relative demand for labour within industries. In particular, unskilled labour-intensive stages of production tend to be shifted to unskilled labour-abundant developing countries, while more technologically advanced stages remain in skilled labour-abundant developed countries. This has led to the fear in developed countries especially that offshoring will tend to reduce the demand for relatively unskilled workers therefore, resulting in either falling wages of unskilled labour and/or increased unemployment of unskilled labour. From a theoretical perspective however, it is by no means clear that this will be the case in a general equilibrium setting, with the overall effect depending on a number of fac-

tors (e.g. Jones and Kierzkowski, 2001; Kohler, 2004). It remains an open and empirical question therefore as to whether outsourcing is a large enough activity to have an adverse effect on labour market outcomes.

There are a number of empirical studies examining the impact of production offshoring on the demand for skilled labour in developed countries, examples including Feenstra and Hanson (1996) for the US, Falk and Koebel (2002) for Germany, Strauss-Kahn (2003) for France and Hijzen et al. (2005) for the UK. The results tend to indicate that offshoring has had a negative impact on the demand for unskilled labour, with one or two exceptions. Feenstra and Hanson (1996) for example consider the case of the USA regressing the change in the non-production wage share on the change in the log capital-output ratio, the change in log output and the change in offshoring. They find that for the later period in their dataset (i.e. 1979-1990) that offshoring contributed around 31 percent of the increase in the nonproduction wage that occurred in the 1980s. Falk and Koebel (2002) use data for 26 German industries over the period 1978-1990. With their data they estimate a system of seven equations, one for each type of variable cost (different types of labour and materials). Their results provide little support for substitution effects between different types of labour and imported materials, with the increase in imported materials being driven by higher output growth rather than input substitution. Hijzen et al. (2005) also estimate a system of regressions for three different types of labour and materials using data on UK manufacturing industries over the period 1982-1986. Their results indicate a large negative effect of outsourcing on the demand for unskilled labour. Similar results to those of Hijzen et al. (2005) are presented by Strauss-Kahn (2003) for France.

Despite these results the consensus view of empirical economists is that trade was not the major reason for rising wage inequality in the 1980s and early 1990s. This view is based upon a number of factors. Firstly, the share of skilled workers increased within most industries, which contrasts with the predictions of the basic Heckscher-Ohlin theory. Secondly, the demand for skilled workers was closely related to various measures of technology such as R&D, but not with measures of trade (Autor et al., 1998). Thirdly, calibrated general equilibrium models found only a small quantitative role of trade (Borjas et al., 1997). Finally, recent research suggests that skill-biased technological change is still the main determinant of the demand for skilled workers (Michaels et al., 2010). Krugman (2008) however, argues that trade might have become much more important in driving the demand for skilled workers in recent years due to the fast growth in imports from low-skill abundant developing countries, notably China.

In this paper, we extend and update earlier empirical results on the relationship between offshoring and relative skill demand. In particular, we use data from the recently compiled WIOD database to examine the relationship between measures of offshoring and relative labour demand for 40 countries over the period 1995-2009. We develop and test an em-

pirical model linking the cost shares of variable inputs (i.e. materials and different types of labour). The equations for the different cost shares are estimated using Iterated Seemingly Unrelated Regression (ISUR), with the model being estimated separately for six different industry types. The current paper updates some of the earlier papers mentioned above to a more recent time period where relative wages and employment have been shown to behave differently to earlier periods (see Feenstra, 2010, p. 31). The dataset also allows us to consider a panel of data, with data compiled over the period 1995-2009, and allows us to consider a relatively large number of countries when compared with the above mentioned studies that often focus on a single country. Our results indicate that while offshoring has impacted negatively upon all skill-levels the largest impacts have been observed for medium-skilled (and to a lesser extent high-skilled) workers. Such results are consistent with recent evidence indicating that medium-skilled workers have suffered to a greater extent than other skill-types in recent years (see for example Autor et al., 2006).

The remainder of the paper is set out as follows: Section 2 presents a simple model to be empirically implemented and discusses the econometric approach; Section 3 describes the data used in the later analysis and presents some data on trends in labour markets and offshoring activities; Section 4 describes our main results; and Section 5 concludes.

## 2. Model

In this section we sketch a simple model that will be empirically implemented below. The approach relies on the now standard approach to analysing the relative demand for labour, which involves the estimation of a translog cost function (see Berman et al., 1994). For each industry  $i = 1, \dots, I$  in country  $c = 1, \dots, C$  we consider a gross output production function:

$$Y_{ic} = f_{ic}(L_{ic}, M_{ic}, H_{ic}, K_{ic}, IID_{ic}, IIM_{ic}), \quad (1)$$

where  $Y$  is gross output,  $L$  is low-skilled labor,  $M$  is medium-skilled labor,  $H$  is high-skilled labor,  $K$  is the capital stock and  $IID$  and  $IIM$  are domestic and imported intermediate inputs respectively. We assume the production function  $f_{ic}$  is increasing and concave in  $(L_{ic}, M_{ic}, H_{ic}, K_{ic}, IID_{ic}, IIM_{ic})$ .

The short-run cost function, obtained when the levels of capital and output are fixed but labour and intermediate inputs are flexible, is defined as:

$$C_{ic}(w_{Lic}, w_{Mic}, w_{Hic}, w_{IIDic}, w_{IIMic}, K_{ic}, Y_{ic}) \equiv \min_{L, M, H, IID, IIM} w_{Lic}L_{ic} + w_{Mic}M_{ic} + w_{Hic}H_{ic} + w_{IIDic}IID_{ic} + w_{IIMic}IIM_{ic}, \quad (2)$$

subject to equation (1).

We assume that the cost function, equation (2), can be approximated by a second order flexible functional form such as the translog. Cost minimization therefore implies:

$$\ln C_i = \alpha_0 + \sum_{j=1}^N \alpha_j \ln w_{ij} + \sum_{k=1}^K \beta_k \ln x_{ik} + \frac{1}{2} \sum_{j=1}^J \sum_{s=1}^J \gamma_{js} \ln w_{ij} \ln w_{is} + \frac{1}{2} \sum_{k=1}^K \sum_{l=1}^K \delta_{kl} \ln x_{ik} \ln x_{il} + \sum_{j=1}^J \sum_{k=1}^K \theta_{jk} \ln w_{ij} \ln x_{ik}, \quad (3)$$

where  $C_i$  is the variable cost for industry  $i = 1, \dots, I$ ,  $w_j$  denotes wages and the price of intermediate inputs that are optimally chosen,  $j = 1, \dots, N$ . The variables  $x_k$  are shift parameters and denote fixed inputs or outputs (i.e. the quantities of the (quasi-) fixed input capital, gross output, and the two variables capturing domestic and imported intermediate inputs)  $k = 1, \dots, K$ .

If we take first derivatives of the cost function with respect to wages, we obtain  $\frac{\delta \ln C}{\delta \ln w_j} = \left(\frac{\delta C}{\delta w_j}\right) \left(\frac{w_j}{C}\right)$ . Note that  $\left(\frac{\delta C}{\delta w_j}\right)$  equals the demand for input  $j$ . Therefore,  $\left(\frac{\delta C}{\delta w_j}\right) \left(\frac{w_j}{C}\right)$  equals the payments to factor  $j$  relative to total costs, which we denote by the cost shares  $s_j$  (Feenstra, 2004). Differentiating equation (3) with respect to  $\ln w_j$  therefore results in:

$$s_{ij} = \alpha_j + \sum_{s=1}^J \gamma_{js} \ln w_{is} + \sum_{k=1}^K \theta_{jk} \ln x_{ik}, \quad j = 1, \dots, s \dots, J. \quad (4)$$

Taking differences between two periods, the estimating equations become:

$$\Delta s_{ij} = \sum_{s=1}^J \gamma_{js} \Delta \ln w_{is} + \theta_K \Delta \ln K_i + \theta_Y \Delta \ln Y_i + \theta_{IID} \Delta \ln IID_i + \theta_{IIM} \Delta \ln IIM_i + \varepsilon_i, \quad j = 1, \dots, N \quad (5)$$

where  $\Delta \ln IIM_i$  will be our measures of offshoring (or international outsourcing) and  $\Delta \ln IID_i$  is our measure of domestic intermediate (or domestic outsourcing) use.

In addition to reporting the results from estimating the variable cost function, the elasticities of factor demand will also be reported. The elasticity of factor demand for factor  $j$  with respect to a change in factor prices will be given by:

$$\epsilon_{js} = \frac{\gamma_{js}}{s_j} + s_s - \phi_{js} \quad (6)$$

where  $\phi_{js} = 1$  if  $j = s$ . Similarly, the elasticity of factor demand with respect to a change in the capital stock, output, and domestic and imported intermediates will be given by:

$$\epsilon_{jk} = \frac{\theta_{jk}}{s_j} \quad (7)$$

### 3. Trends in labour markets and offshoring

The basic data source for our analysis is the recently completed World-Input-Output-Database (WIOD), which reports data on socio-economic accounts, international input-output tables and bilateral trade data across 35 industries and 40 countries over the period 1995-2009. These data result from an effort to bring together information from national

accounts statistics, supply and use tables, data on trade in goods and services and corresponding data on factors of production (capital and labour by educational attainment categories). The starting point for the WIOD data are national supply and use tables (SUTs) which have been collected, harmonized and standardized for 40 countries (the 27 EU countries, Australia, Brazil, Canada, China, India, Indonesia, Japan, Korea, Mexico, Russia, Taiwan, Turkey and the US) over the period 1995-2009. These tables contain information on the supply and use of 59 products in 35 industries together with information on final use (consumption, investment) by product, value added and gross output by industry and have been benchmarked to time series of national accounts data on value added and gross output to allow for consistency over time and across countries. This approach allows to provide information on supply and use of product by industry for each country. Using detailed trade data the use tables are then split up into domestic and imported sourcing components, with the latter further split by country of origin. Data on goods trade were collected from the UN COMTRADE database at the HS 6-digit level. These detailed bilateral trade data allow one to differentiate imports by use categories (intermediates, consumption and investment goods) by applying a modified categorisation based on broad end-use categories at the product classification. Bilateral trade in services data were collected from various sources. Services trade data are only available from Balance of Payments (BoP) statistics providing information at a detailed level only in BoP categories. Using a correspondence these data were merged to the product level data provided in the supply and use tables. The differentiation into use categories of services imports was based on information from existing import use or import input-output tables. Combining this information from the bilateral trade data by product and use categories with the supply and use tables resulted in a set of 40 international use tables for each year. This set of international supply and use tables was then transformed into an international input-output table using standard procedures (model D in the Eurostat manual (Eurostat, 2008)). A rest-of-world was also estimated using available statistics from the UN and included in this table to account for world trade and production. This results in a world input-output database for 41 countries (including the rest-of-world) and 35 industries. Additional data allow for the splitting up of value added into capital and labour income and the latter into low, medium and high educated workers. These data are available both in factor income and physical input terms (for a detailed presentation of the database see Timmer, 2012).

In our analysis we use data on all 40 WIOD countries, but make one or two departures from the full WIOD. While the offshoring measures defined below are calculated using intermediate inputs from all 35 we include only 29 industries in the regression analysis below.<sup>1</sup> The industries that are dropped are the services industries L to P (see Table A1 in the Appendix). These industries are largely non-market services where offshoring is less likely to be a significant activity. We further drop industry 23 (i.e. Coke, Refined Petroleum and Nuclear Fuel) from our analysis. For a number of countries this industry shows very low

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<sup>1</sup> The 35 industries are listed in Table A1 of the Appendix.

levels of value-added, which often leads to very large values for the offshoring measures. To avoid these outliers affecting our results we drop these industries from the analysis.<sup>2</sup>

When measuring offshoring the majority of existing studies focus on some measure of trade in intermediates, though as Hijzen and Swaim (2007) note this ignores the offshoring of assembly activities. In our analysis we use data from input-output tables, which allow one to measure the intermediate input purchases by each industry from each industry. In terms of the measures of offshoring Feenstra and Hanson (1999) distinguish between narrow and broad offshoring, where the former considers imported intermediates in a given industry from the same industry only, while the latter considers imported intermediates from all industries. Feenstra and Hanson (1999) prefer the narrow definition as it is thought to be closer to the essence of fragmentation, which necessarily takes place within the industry.<sup>3</sup> In our analysis we will consider both measures of offshoring. Following Hijzen and Swaim (2007) a measure of narrow offshoring (or intra-industry offshoring) for industry  $i$ ,  $IIM_i^N$ , can be calculated as:

$$IIM_i^N = \frac{O_{j=i}}{V_i} \quad (8)$$

where  $O$  refers to imported intermediate purchases from industry  $j = i$  by industry  $i$ , and  $V$  refers to value-added. Similarly, we can define broad offshoring (or inter-industry offshoring) for industry  $i$ ,  $IIM_i^B$ , as:

$$IIM_i^B = \frac{\sum_{j=1}^J O_{j \neq i}}{V_i} \quad (9)$$

Measures of domestic intermediate use are constructed in an analogous manner for both domestic intermediate use from the same industry (a narrow measure) and from all industries (a broad measure). These variables are termed  $IID^N$  and  $IID^B$  in the analysis below respectively.

Figure 1 plots the average level of narrow offshoring across industries for each country for the 1995 and the change between 1995 and 2009. The figure indicates that imported intermediates are a significant feature of production in our sample of countries, but that there exists a great deal of heterogeneity in the extent of intra-industry offshoring across countries, being relatively low in Brazil, India, Australia, Japan, Turkey and the USA in 1995 and relatively high in Belgium, Czech Republic, Estonia, Luxembourg, Ireland, Malta and Slovenia in that year. The figure also reveals that narrow offshoring has shown a tendency to increase across countries over the period, increasing in 31 of the 40 countries considered. The increase in offshoring has been particularly large in a number of CEECs, most notably the

<sup>2</sup> As it turns out including this industry (and the excluded service industries) doesn't affect our results qualitatively. These results are available upon request.

<sup>3</sup> Hijzen et al. (2005) note that this distinction is not without problems, most notably due to the way industries are defined in the data. They consider the example of two industries in which outsourcing is important, namely 'motor vehicles and parts' and 'textiles', noting that while 'motor vehicles and parts' is a single industry in the UK IO table, 'textiles' consists of up to ten industries.

Czech Republic, Hungary and Slovenia, as well as India, Japan and Turkey. The figures for broad offshoring reported in Figure 2 also reveal large differences in the extent of broad offshoring across countries. The overall tendency for broad offshoring to increase is even stronger than that for the narrow measure however, increasing in 37 of the 40 countries. For completeness, Figures 3 and 4 report similar statistics for the narrow and broad measures of domestic intermediate use. In general, we observe less heterogeneity in the extent of domestic outsourcing across countries, though smaller countries (e.g. Denmark, Luxembourg, Netherlands and Sweden) tend to have lower shares of domestic outsourcing as may be expected. There also appear to be fewer large changes in the extent of domestic outsourcing over time (with the exceptions of China and Korea when considering the narrow measure).

Data on the labour market is split into three different skill categories (i.e. low-skill, medium-skill and high-skill) by ISCED categories in a manner similar to Gregory et al. (2001) and Hijzen et al. (2005). As dependent variables in the econometric analysis below we will consider the shares of each labour type in total variable costs, where it is assumed that the variable inputs are labour and intermediate inputs. Table 1 reports the shares of low, medium and high skilled labour in total variable costs for 1995 and the change between 1995 and 2009. While there are large differences in the shares of these three types of labour across countries, the most notable thing from these figures is the tendency for the cost shares of low and medium skilled labour to decline and that of high skilled labour to increase. In all but three of the countries we observe a decline in the cost share of low skilled labour, while in half of countries the share of medium skilled labour also decreases. In the case of high skilled labour however, we observe an increase in the cost share in all but three of the countries.

For our analysis we further require data on average wages by skill-level, which are calculated directly from the WIOD dataset. We also require a measure of gross output and the capital stock, which are also available directly from the WIOD. It is common in the literature to split the capital stock into an ICT and a non-ICT component, with the ICT component capturing the effects of skill-biased technological change. Unfortunately, the WIOD doesn't include information on the split between ICT and non-ICT capital for emerging economies and so it is not possible to do this while including all WIOD countries in the analysis. To control for skill-biased technological change however we include a set of country-sector time trends (i.e. for each sector within each country we include a separate time trend).



Figure 1

**Narrow offshoring by country, 1995 and change between 1995 and 2007**

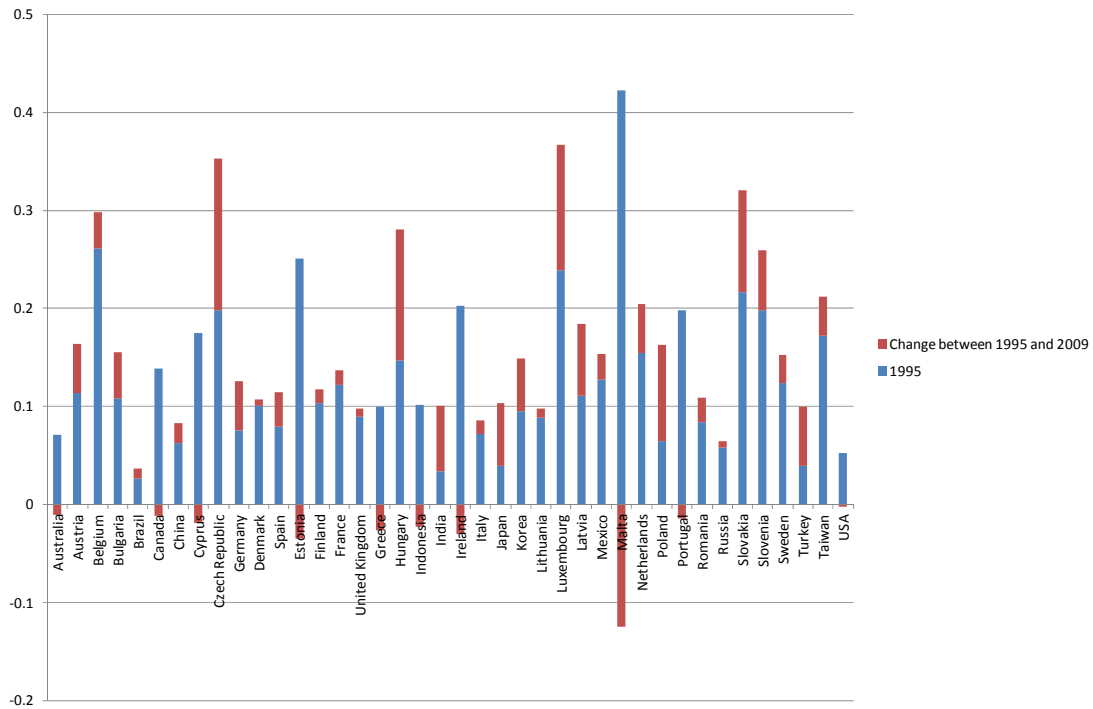


Figure 2

**Broad offshoring by country, 1995 and change between 1995 and 2007**

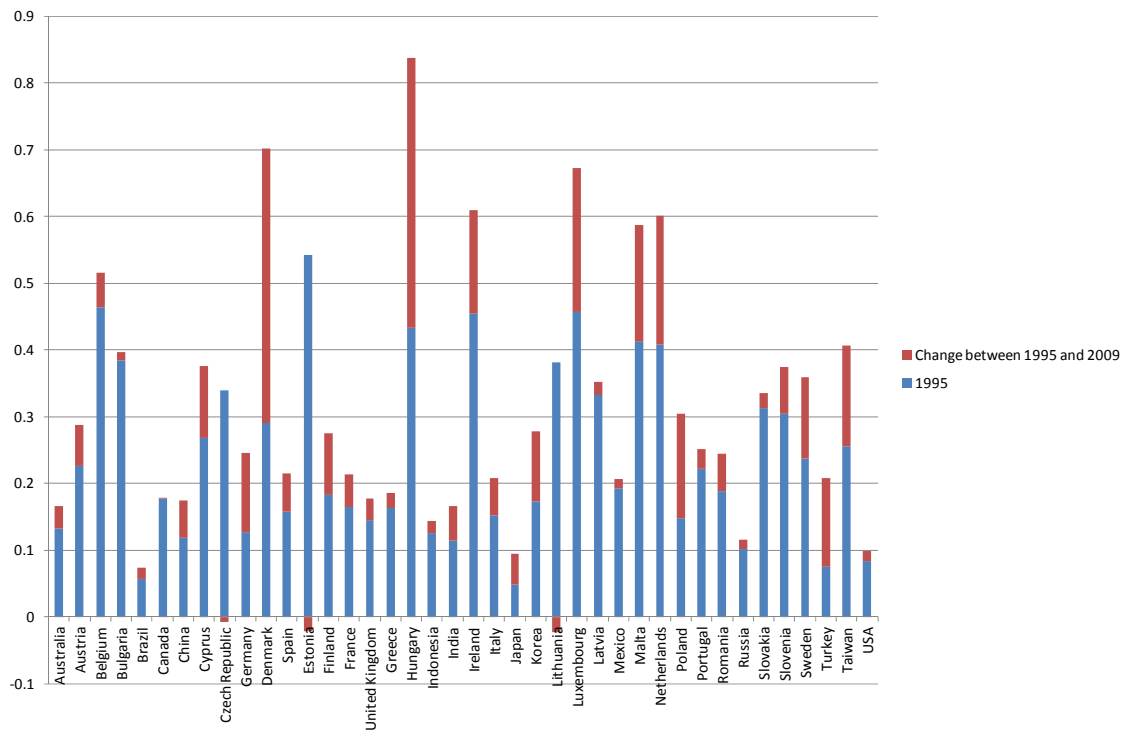


Figure 3

**Domestic intermediate use in 1995 and change between 1995 and 2007 – Narrow measure**

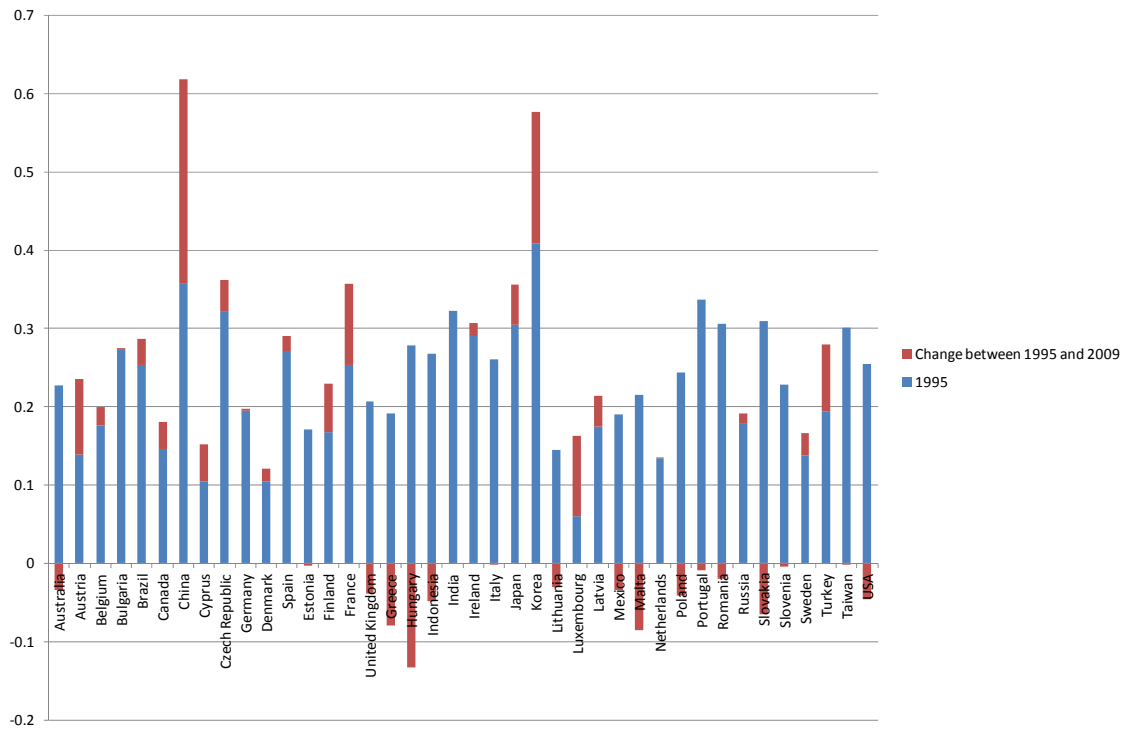


Figure 4

**Domestic intermediate use in 1995 and change between 1995 and 2007 – Broad measure**

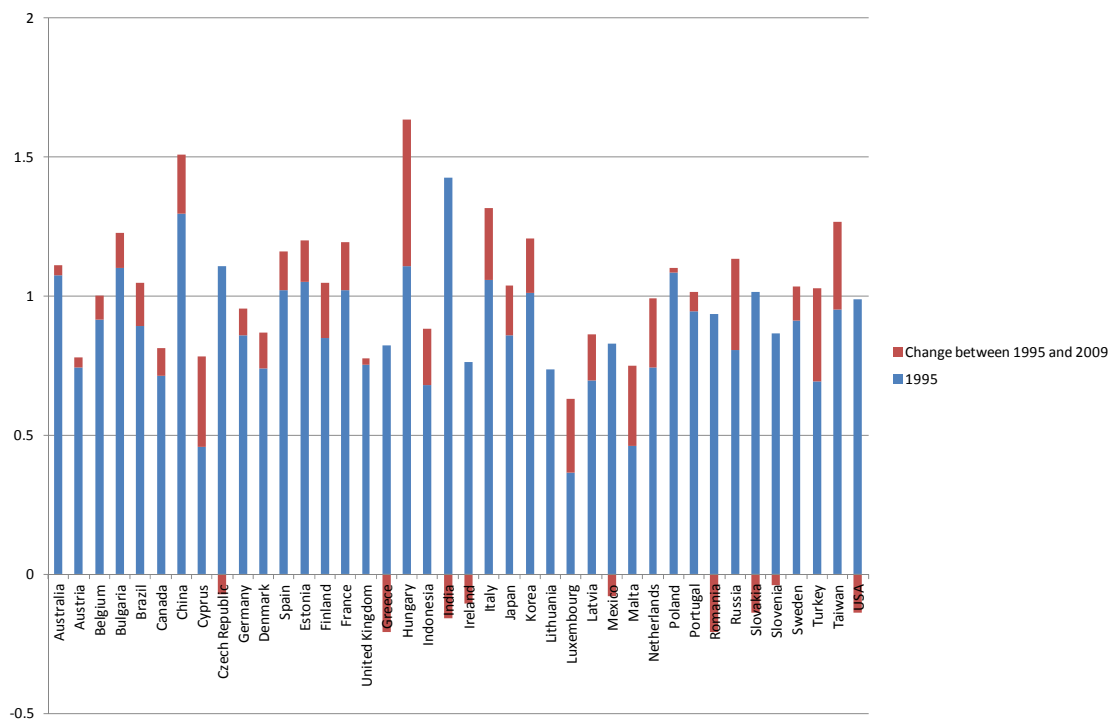


Table 1

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**Change between 1995 and 2009**

| Country        | Low-Skilled |        | Medium-Skilled |        | High-Skilled |        |
|----------------|-------------|--------|----------------|--------|--------------|--------|
|                | 1995        | Change | 1995           | Change | 1995         | Change |
| Australia      | 0.141       | -0.021 | 0.116          | 0.009  | 0.038        | 0.018  |
| Austria        | 0.064       | -0.030 | 0.266          | -0.052 | 0.046        | 0.022  |
| Belgium        | 0.121       | -0.065 | 0.130          | 0.022  | 0.043        | 0.012  |
| Bulgaria       | 0.201       | -0.074 | 0.049          | 0.002  | 0.036        | 0.011  |
| Brazil         | 0.135       | -0.041 | 0.105          | 0.038  | 0.083        | 0.024  |
| Canada         | 0.020       | -0.011 | 0.284          | -0.030 | 0.051        | 0.027  |
| China          | 0.113       | -0.043 | 0.099          | -0.026 | 0.011        | 0.012  |
| Cyprus         | 0.116       | -0.033 | 0.135          | 0.008  | 0.162        | -0.042 |
| Czech Republic | 0.013       | -0.002 | 0.151          | 0.032  | 0.029        | 0.021  |
| Germany        | 0.045       | -0.010 | 0.236          | -0.042 | 0.099        | 0.0123 |
| Denmark        | 0.079       | 0.003  | 0.120          | -0.039 | 0.063        | 0.028  |
| Spain          | 0.189       | -0.084 | 0.056          | 0.010  | 0.075        | 0.0285 |
| Estonia        | 0.020       | 0.006  | 0.141          | 0.014  | 0.118        | -0.016 |
| Finland        | 0.101       | -0.050 | 0.137          | -0.006 | 0.097        | 0.018  |
| France         | 0.110       | -0.047 | 0.144          | -0.012 | 0.082        | 0.028  |
| United Kingdom | 0.116       | -0.043 | 0.153          | 0.015  | 0.091        | 0.048  |
| Greece         | 0.177       | -0.038 | 0.112          | 0.055  | 0.066        | 0.026  |
| Hungary        | 0.040       | -0.018 | 0.188          | -0.030 | 0.064        | 0.019  |
| Indonesia      | 0.193       | -0.048 | 0.088          | 0.016  | 0.040        | 0.015  |
| India          | 0.114       | -0.013 | 0.138          | -0.009 | 0.076        | 0.018  |
| Ireland        | 0.113       | -0.049 | 0.123          | -0.013 | 0.057        | 0.057  |
| Italy          | 0.183       | -0.071 | 0.107          | 0.034  | 0.029        | 0.014  |
| Japan          | 0.059       | -0.032 | 0.219          | -0.023 | 0.080        | 0.010  |
| Korea          | 0.079       | -0.054 | 0.164          | -0.049 | 0.108        | 0.035  |
| Lithuania      | 0.019       | 0.005  | 0.159          | 0.032  | 0.112        | 0.016  |
| Luxembourg     | 0.176       | -0.114 | 0.114          | 0.007  | 0.062        | 0.030  |
| Latvia         | 0.037       | -0.009 | 0.158          | -0.003 | 0.086        | 0.012  |
| Mexico         | 0.066       | -0.021 | 0.136          | 0.017  | 0.065        | -0.010 |
| Malta          | 0.227       | -0.048 | 0.058          | 0.010  | 0.039        | 0.014  |
| Netherlands    | 0.116       | -0.031 | 0.160          | -0.028 | 0.049        | 0.041  |
| Poland         | 0.025       | -0.011 | 0.217          | -0.054 | 0.049        | 0.023  |
| Portugal       | 0.209       | -0.037 | 0.054          | 0.011  | 0.037        | 0.017  |
| Romania        | 0.209       | -0.038 | 0.051          | 0.009  | 0.036        | 0.012  |
| Russia         | 0.023       | -0.010 | 0.268          | -0.043 | 0.061        | 0.010  |
| Slovakia       | 0.013       | -0.007 | 0.143          | 0.016  | 0.029        | 0.015  |
| Slovenia       | 0.052       | -0.020 | 0.226          | -0.043 | 0.070        | 0.025  |
| Sweden         | 0.087       | -0.030 | 0.191          | -0.023 | 0.047        | 0.030  |
| Turkey         | 0.150       | -0.051 | 0.054          | 0.005  | 0.037        | 0.006  |
| Taiwan         | 0.136       | -0.060 | 0.113          | -0.009 | 0.091        | 0.028  |
| USA            | 0.033       | -0.006 | 0.216          | -0.004 | 0.103        | 0.127  |

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#### 4. Results

To investigate the relationship between international outsourcing and the skill structure of labour demand we adopt a fairly standard approach by analysing the relative demand for skilled labour based on the estimation of a translog cost function (introduced by Berman et al., 1994) as described above. The cost functions are estimated as a system of demand equations for all variable factors (i.e. high, medium and low skilled labour and materials) as

in Hijzen et al. (2005). The complete system of equations is estimated using seemingly unrelated regression (SUR) methods. Given that the sum of shares adds up to one we are forced to drop one of the regressions. In our analysis, we choose to drop the equation for the share of materials in total variable costs.

One issue in estimating equation (5) on the full sample of countries and industries is that the approach assumes that the same cost function applies across industries. While it is common in empirical applications to pool data across industries, thereby assuming that the same cost function applies across industries (see for example Feenstra and Hanson, 1999; Michaels et al., 2011) it is somewhat restrictive. To relax this assumption we report in addition to results for the full sample results for a number of different industry types, and in particular low-, medium- and high-tech manufacturing and low-, medium- and high-tech services industries. The allocation of industries into these categories is provided in Table A1 of the Appendix.

The discussion of the results is split into two sections. In the first subsection we report results when just including the narrow measure of offshoring. We then proceed in the second subsection to include both the narrow and broad measure of offshoring.

#### ***4.1. Narrow offshoring and the skill structure of labour demand***

We begin our discussion of the results by including the narrow measure of offshoring only, which Feenstra and Hanson (1999) argue is closer to the essence of fragmentation. Table 2 reports results from estimating equation (5) for each of the labour cost shares using ISUR techniques on the full sample of countries and industries, while Table 3 reports the coefficients on the narrow offshoring measures for the six different industry types.<sup>4</sup> All regressions include a set of country-sector time trends, the coefficients of which are not reported. The results in Table 2 indicate that the cost shares of all three types of labour are decreasing in output and the capital stock. The coefficients on the wage variables are mixed. The own-wage coefficients are found to be negative and significant for low- and high-educated labour, but positive and significant for medium-educated labour. The medium-educated wage impacts negatively upon the cost shares of low- and high-educated labour, while the low- and high-educated wage impacts negatively upon the medium-educated cost share. The high-educated (low-educated) wage impacts positively upon the low-educated (high-educated) cost shares however. The price of intermediates has a positive impact on the cost shares of low- and medium-educated labour suggesting that materials are substitutes for these types of labour, but has an insignificant impact on high-educated labour. Turning to the outsourcing and offshoring measures we observe a negative coefficient on domestic outsourcing for all three types of labour, as we do for the

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<sup>4</sup> OLS results for the all four variable input cost shares are reported in Table A2 of the Appendix.

measure of international offshoring. Interestingly, the coefficients are largest in absolute value for medium-skilled labour in both cases, with the coefficients being nearly twice as large as those for low-skilled labour. Such results – if confirmed in the later analysis - would tend to suggest that it is the medium-skilled that have been squeezed by both domestic outsourcing and international offshoring in the recent past.

Results for the different industry types (Table 3) largely confirm the findings on international offshoring, particularly in manufacturing industries. When considering the manufacturing sectors we observe coefficients on the narrow offshoring measure that are negative (and usually significant) for all cost shares across the different industry types. For all manufacturing industries the coefficients are also found to be larger in absolute value for the medium skilled cost share. These coefficients are particularly large for high-tech manufacturing industries (for example electronics, transport equipment), which tend to have high shares of offshoring and trade in parts and components. When considering the services sector we find insignificant coefficients on the narrow offshoring variable for low- and high-educated labour in low- and high-tech sectors. Coefficients for medium-educated workers are always negative however and in all cases are larger in absolute value than the corresponding coefficients for low- and high-educated labour.

Table 2

**SUR results for the full sample of countries and industries**

| VARIABLES       | (1)<br>$\Delta S_{LS}$    | (2)<br>$\Delta S_{MS}$    | (3)<br>$\Delta S_{HS}$     |
|-----------------|---------------------------|---------------------------|----------------------------|
| $\Delta w_{LS}$ | -0.00747***<br>(0.00109)  | -0.0114***<br>(0.00127)   | 0.0609***<br>(0.00106)     |
| $\Delta w_{MS}$ | -0.00956***<br>(0.00142)  | 0.0550***<br>(0.00165)    | -0.0377***<br>(0.00137)    |
| $\Delta w_{HS}$ | 0.0421***<br>(0.000851)   | -0.00473***<br>(0.000989) | -0.00788***<br>(0.000824)  |
| $\Delta w_{II}$ | 0.00309***<br>(0.000854)  | 0.00319***<br>(0.000993)  | -0.000587<br>(0.000827)    |
| $\Delta K$      | -0.00253***<br>(0.000290) | -0.00105***<br>(0.000337) | -0.000850***<br>(0.000281) |
| $\Delta GO$     | -0.0259***<br>(0.000990)  | -0.0452***<br>(0.00115)   | -0.0189***<br>(0.000958)   |
| $\Delta IIM^N$  | -0.00249***<br>(0.000247) | -0.00467***<br>(0.000287) | -0.00185***<br>(0.000239)  |
| $\Delta IID^N$  | -0.00146***<br>(0.000179) | -0.00297***<br>(0.000208) | -0.00116***<br>(0.000173)  |
| Observations    | 15,270                    | 15,270                    | 15,270                     |
| R-squared       | 0.338                     | 0.339                     | 0.319                      |

Standard errors in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Table 3

**SUR results on narrow offshoring measure by industry type**

| VARIABLES              | (1)<br>$\Delta S_{LS}$    | (2)<br>$\Delta S_{MS}$    | (3)<br>$\Delta S_{HS}$    |
|------------------------|---------------------------|---------------------------|---------------------------|
| Manufacturing – Low    | -0.00251***<br>(0.000579) | -0.00351***<br>(0.000589) | -0.00140***<br>(0.000335) |
| Manufacturing - Medium | -0.00378***<br>(0.00108)  | -0.00522***<br>(0.00119)  | -0.00406***<br>(0.00100)  |
| Manufacturing - High   | -0.00898***<br>(0.000922) | -0.0166***<br>(0.00105)   | -0.00719***<br>(0.000676) |
| Services - Low         | -0.000795<br>(0.000748)   | -0.00415***<br>(0.000888) | 0.000126<br>(0.000647)    |
| Services – Medium      | -0.00262***<br>(0.000391) | -0.00406***<br>(0.000452) | -0.00143***<br>(0.000362) |
| Services - High        | 0.000473<br>(0.000643)    | -0.00252**<br>(0.00101)   | -0.000478<br>(0.00119)    |

Standard errors in parentheses

\*\*\* p&lt;0.01, \*\* p&lt;0.05, \* p&lt;0.1

Table 4

**Own elasticities of narrow offshoring measure**

| VARIABLES              | (1)<br>$\Delta S_{LS}$ | (2)<br>$\Delta S_{MS}$ | (3)<br>$\Delta S_{HS}$ |
|------------------------|------------------------|------------------------|------------------------|
| All Industries         | -0.02993               | -0.03247               | -0.02568               |
| Manufacturing – Low    | -0.02352               | -0.02782               | -0.02963               |
| Manufacturing - Medium | -0.04447               | -0.04012               | -0.07225               |
| Manufacturing - High   | -0.13795               | -0.16174               | -0.15653               |
| Services - Low         | -0.00701               | -0.02122               | 0.001874               |
| Services – Medium      | -0.03288               | -0.02594               | -0.01917               |
| Services - High        | 0.009878               | -0.01646               | -0.00289               |

Table 4 reports the estimated elasticities of the cost shares with respect to narrow offshoring. Despite the larger coefficients on the narrow offshoring measure for medium-educated labour there are some differences when considering the elasticities due to the larger shares of medium-educated labour in total variable costs. Despite this, when considering all industries we find that the elasticity of the cost shares to a change in narrow offshoring are largest (in absolute value) for medium-educated labour, followed by low- and high-educated labour. This is also true for the services industries (with the exception of medium-tech industries, where the elasticity is largest for the low-educated). For manufacturing industries however we find that the elasticities are largest for high-educated labour in low- and medium-tech industries, and largest for medium-educated labour in high-tech industries. In general, elasticities are much larger in high-tech (and to a lesser extent medium-tech) manufacturing than in other industries, with a one percent increase in narrow offshor-

ing in high-tech manufacturing lowering labour cost shares by between 0.14 percent (for low-educated) and 0.16 percent (for medium-educated). That the elasticities in high-tech manufacturing are found to be relatively large may reflect the fact that it is in these industries in which the majority of parts and components trade takes place. By considering different industry types the current paper allows for heterogeneous effects of offshoring on different industries. Interestingly, by doing this we observe that the elasticities of offshoring on skill demand differ across industries, and in some cases high-educated workers are also strongly affected by offshoring. This is something that is hidden when considering all industries together and suggests that is important to allow for an industry dimension to overcome some kind of aggregation problem.

#### ***4.2. Narrow and broad offshoring and the skill structure of labour demand***

In this subsection we add the measure of broad offshoring to the previous regression specification, including both the measure of broad domestic outsourcing and broad international offshoring alongside the two narrow measures. ISUR results for the full sample and for the different industry types are reported in Tables 5 and 6. Results on the additional explanatory variables in Table 5 are largely consistent with those in Table 2. Turning to the offshoring measures, the first thing that we note is that while the pattern of coefficients on the narrow measure of offshoring is similar to that in Table 2, the size of the coefficients is somewhat smaller. This is also the case for the narrow domestic outsourcing variable, though the coefficients are significant for all three labour types and still largest (in absolute value) for medium skilled workers. When considering the broad measure of offshoring we find coefficients that are consistently negative and significant. As with the case of the narrow measure however the coefficients tend to be larger in absolute value in the case of the medium-educated cost share, with the coefficients again being roughly twice as large as those for the low- and high-educated cost shares. Results for the broad domestic outsourcing variable also show a similar pattern.

These results for the broad measure of offshoring are broadly confirmed when we consider industry types separately (Table 6). Coefficients are negative and significant for all types of labour, and in all cases the coefficients are larger in absolute value for medium-educated workers. Results for the narrow offshoring measure in Table 6 tend to give coefficients that are somewhat smaller than those in Table 3, but are otherwise similar with offshoring having a stronger effect on the cost shares of medium-educated workers in all industry types.

Table 7 reports the elasticities and here we find a mixed set of results. When considering the narrow measure we obtain a pattern that is fairly similar to that reported in Table 4, though the size of the elasticities is somewhat lower due to the lower coefficients. When considering all industries the elasticities for low- and medium-educated labour are very similar, with the elasticities found to be largest (in absolute value) for medium-educated

workers in low-tech manufacturing and in low- and high-tech services. In the remaining industry types the elasticities are found to be largest for low-educated workers in medium-tech manufacturing and services, and for high-educated in high-tech manufacturing. Elasticities for the broad measure are found to be largest for medium-educated labour when considering all industries and when considering low- and medium-tech manufacturing and low-tech services. Elasticities are largest for low-educated labour in the case of medium- and high-tech services and once again for high-educated workers in the case of high-tech manufacturing.

Table 5

**SUR results for narrow and broad measure of offshoring**

| VARIABLES       | (1)<br>$\Delta S_{LS}$    | (2)<br>$\Delta S_{MS}$    | (3)<br>$\Delta S_{HS}$     |
|-----------------|---------------------------|---------------------------|----------------------------|
| $\Delta w_{LS}$ | -0.00870***<br>(0.00106)  | -0.0140***<br>(0.00116)   | 0.0597***<br>(0.00103)     |
| $\Delta w_{MS}$ | -0.00954***<br>(0.00138)  | 0.0550***<br>(0.00151)    | -0.0375***<br>(0.00134)    |
| $\Delta w_{HS}$ | 0.0408***<br>(0.000831)   | -0.00736***<br>(0.000908) | -0.00917***<br>(0.000805)  |
| $\Delta w_{II}$ | 0.00335***<br>(0.000832)  | 0.00372***<br>(0.000909)  | -0.000364<br>(0.000806)    |
| $\Delta K$      | -0.00614***<br>(0.000309) | -0.00843***<br>(0.000337) | -0.00427***<br>(0.000299)  |
| $\Delta GO$     | -0.0205***<br>(0.000983)  | -0.0342***<br>(0.00107)   | -0.0139***<br>(0.000952)   |
| $\Delta IIM^N$  | -0.00134***<br>(0.000247) | -0.00231***<br>(0.000270) | -0.000842***<br>(0.000239) |
| $\Delta IID^N$  | -0.00121***<br>(0.000176) | -0.00246***<br>(0.000192) | -0.000886***<br>(0.000170) |
| $\Delta IIM^B$  | -0.00529***<br>(0.000582) | -0.0110***<br>(0.000636)  | -0.00393***<br>(0.000564)  |
| $\Delta IID^B$  | -0.0141***<br>(0.000738)  | -0.0286***<br>(0.000806)  | -0.0144***<br>(0.000715)   |
| Observations    | 15,270                    | 15,270                    | 15,270                     |
| R-squared       | 0.372                     | 0.446                     | 0.353                      |

Standard errors in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1



Table 6

**SUR results for narrow and broad measure by industry type**

| VARIABLES                | (1)<br>$\Delta S_{LS}$    | (2)<br>$\Delta S_{MS}$    | (3)<br>$\Delta S_{HS}$    |
|--------------------------|---------------------------|---------------------------|---------------------------|
| <i>NARROW OFFSHORING</i> |                           |                           |                           |
| Manufacturing – Low      | -0.00163***<br>(0.000449) | -0.00290***<br>(0.000457) | -0.000355<br>(0.000326)   |
| Manufacturing - Medium   | -0.00147***<br>(0.000367) | -0.00185***<br>(0.000394) | -0.000887**<br>(0.000345) |
| Manufacturing - High     | -0.000647<br>(0.000463)   | -0.00279***<br>(0.000601) | -0.00136**<br>(0.000643)  |
| Services - Low           | -0.00163***<br>(0.000449) | -0.00290***<br>(0.000457) | -0.000355<br>(0.000326)   |
| Services – Medium        | -0.00147***<br>(0.000367) | -0.00185***<br>(0.000394) | -0.000887**<br>(0.000345) |
| Services - High          | -0.000647<br>(0.000463)   | -0.00279***<br>(0.000601) | -0.00136**<br>(0.000643)  |
| <i>BROAD OFFSHORING</i>  |                           |                           |                           |
| Manufacturing – Low      | -0.00284**<br>(0.00118)   | -0.00844***<br>(0.00120)  | -0.00195**<br>(0.000853)  |
| Manufacturing - Medium   | -0.00694***<br>(0.000867) | -0.0118***<br>(0.000930)  | -0.00386***<br>(0.000813) |
| Manufacturing - High     | -0.00408***<br>(0.000949) | -0.0119***<br>(0.00123)   | -0.00630***<br>(0.00132)  |
| Services - Low           | -0.00284**<br>(0.00118)   | -0.00844***<br>(0.00120)  | -0.00195**<br>(0.000853)  |
| Services – Medium        | -0.00694***<br>(0.000867) | -0.0118***<br>(0.000930)  | -0.00386***<br>(0.000813) |
| Services - High          | -0.00408***<br>(0.000949) | -0.0119***<br>(0.00123)   | -0.00630***<br>(0.00132)  |

Standard errors in parentheses

\*\*\* p&lt;0.01, \*\* p&lt;0.05, \* p&lt;0.1

Table 7

**Elasticities for narrow and broad measure**

| VARIABLES                | (1)<br>$\Delta S_{LS}$ | (2)<br>$\Delta S_{MS}$ | (3)<br>$\Delta S_{HS}$ |
|--------------------------|------------------------|------------------------|------------------------|
| <i>NARROW OFFSHORING</i> |                        |                        |                        |
| All Industries           | -0.016107              | -0.01606               | -0.011688              |
| Manufacturing – Low      | -0.015277              | -0.022985              | -0.007513              |
| Manufacturing - Medium   | -0.017293              | -0.01422               | -0.015786              |
| Manufacturing - High     | -0.009939              | -0.027184              | -0.029607              |
| Services - Low           | -0.014364              | -0.014827              | -0.005279              |
| Services – Medium        | -0.018448              | -0.011818              | -0.011893              |
| Services - High          | -0.013512              | -0.018222              | -0.008229              |
| <i>BROAD OFFSHORING</i>  |                        |                        |                        |
| All Industries           | -0.063587              | -0.076476              | -0.054555              |
| Manufacturing – Low      | -0.026618              | -0.066895              | -0.041267              |
| Manufacturing - Medium   | -0.081643              | -0.0907                | -0.068695              |
| Manufacturing - High     | -0.062678              | -0.115945              | -0.13715               |
| Services - Low           | -0.025027              | -0.043151              | -0.029                 |
| Services – Medium        | -0.087096              | -0.075379              | -0.051756              |
| Services - High          | -0.085208              | -0.07772               | -0.038117              |

**5. Conclusions**

In this paper we examine the impact of offshoring on the cost shares of low-, medium- and high-skilled workers in 40 countries. Estimating a system of cost share equations by ISUR and allowing for differences in the cost share equations across industry types we examine the impact of both narrow and broad measures of offshoring, and further split our offshoring measures into a manufacturing and services component. Our results indicate that both narrow and broad offshoring have tended to reduce the cost shares of all types of employment in total variable costs. When we consider the regression coefficients a clear pattern tends to emerge, with medium-educated workers being hit hardest by both types of offshoring. Concentrating on the elasticities however and distinguishing between different industry types leads to more nuanced results however. While it remains true that offshoring (both narrow and broad) impacts upon the medium-educated to a greater extent than other labour types in the majority of industry types, there are a number of exceptions to this general rule. In particular, high- and medium-educated labour tends to be hit hardest in high-tech manufacturing industries, while low-educated labour is found to be squeezed to a greater extent by offshoring in many of the services industries. Overall, the results would seem to suggest that in recent years offshoring has impacted upon all types of labour, with medium-educated labour being squeezed to a greater extent than low- and high-educated labour by offshoring.

The issue of the impact of offshoring on labour markets remains highly relevant as more and more countries integrate into international production networks. The current paper differs from much of the existing literature by considering a fairly heterogeneous sample of developed and developing offshoring countries. Future work in this area may take advantage of this heterogeneity by examining differences in the response of labour to offshoring in different subsets of countries. It may also be interesting to examine whether similar effects of offshoring are being observed in the sourcing countries. A further avenue for research in this area would be to split the offshoring measures by sourcing countries to examine whether the labour market effects of offshoring differ by sourcing country.

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## Appendix

Table A1

### Industries and industry classification

| Code  | Industry  | Type   |
|-------|---|--------|
| AtB   | Agriculture, Hunting, Forestry and Fishing  | M/Low  |
| C     | Mining and Quarrying  | M/Med  |
| 15t16 | Food, Beverages and Tobacco   | M/Low  |
| 17t18 | Textiles and Textile Products   | M/Low  |
| 19    | Leather, Leather and Footwear   | M/Low  |
| 20    | Wood and Products of Wood and Cork  | M/Low  |
| 21t22 | Pulp, Paper, Paper , Printing and Publishing  | M/Med  |
| 23    | Coke, Refined Petroleum and Nuclear Fuel  | M/Med  |
| 24    | Chemicals and Chemical Products   | M/High |
| 25    | Rubber and Plastics   | M/Med  |
| 26    | Other Non-Metallic Mineral  | M/Low  |
| 27t28 | Basic Metals and Fabricated Metal   | M/Low  |
| 29    | Machinery, Nec  | M/High |
| 30t33 | Electrical and Optical Equipment  | M/High |
| 34t35 | Transport Equipment   | M/High |
| 36t37 | Manufacturing, Nec; Recycling   | M/Med  |
| E     | Electricity, Gas and Water Supply   | S/Med  |
| F     | Construction  | S/Low  |
| 50    | Sale, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sale of Fuel | S/Low  |
| 51    | Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles      | S/Med  |
| 52    | Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods   | S/Med  |
| H     | Hotels and Restaurants  | S/Low  |
| 60    | Inland Transport  | S/Med  |
| 61    | Water Transport   | S/Med  |
| 62    | Air Transport   | S/High |
| 63    | Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies  | S/Med  |
| 64    | Post and Telecommunications   | S/Med  |
| J     | Financial Intermediation  | S/High |
| 70    | Real Estate Activities  | S/Med  |
| 71t74 | Renting of M&Eq and Other Business Activities                                       | S/High |
| L     | Public Admin and Defence; Compulsory Social Security                                | S/High |
| M     | Education   | S/High |
| N     | Health and Social Work  | S/High |
| O     | Other Community, Social and Personal Services                                       | S/High |
| P     | Private Households with Employed Persons  | S/High |

*Notes:* M/Low – Low-tech manufacturing; M/Med – Medium-tech manufacturing; M/High – High-tech manufacturing; S/Low – Low-tech services; S/Med – Medium-tech services; S/High – High-tech services



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