World Input-Output Database

Offshoring and the Skill Structure of Labour Demand

Working Paper Number: 6

Authors: Neil Foster, Robert Stehrer, Marcel Timmer, Gaaitzen de Vries

Working Paper Series

Offshoring and the Skill Structure of Labour Demand

Neil Foster[♦]

Robert Stehrer[*]

Marcel Timmer[⊗]

Gaaitzen de Vries[#]

April 2012

Abstract

In this paper we examine the link between international outsourcing – or offshoring – and the skill-structure of labour demand for a sample of 18 countries over the period 1995-2007. The paper uses data from the recently compiled World-Input-Output-Database (WIOD) to estimate a system of variable factor demand equations. 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

[♦] Neil Foster, Vienna Institute for International Economic Studies (wiiw), Rahlgasse 3, A1060, Vienna, Austria. Email: Neil.Foster@wiiw.ac.at

[*] Robert Stehrer, Vienna Institute for International Economic Studies (wiiw), Rahlgasse 3, A1060, Vienna, Austria. Email: Robert.Stehrer@wiiw.ac.at

[⊗] Marcel Timmer, Groningen Growth and Development Centre, University of Groningen, P.O. Box 800, 9700 AV Groningen, The Netherlands. Email: M.Timmer@rug.nl

[#] Gaaitzen de Vries, Groningen Growth and Development Centre, University of Groningen, P.O. Box 800, 9700 AV Groningen, The Netherlands. Email: G.J.de.Vries@rug.nl

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. Production offshoring has lead to the fear in developed countries especially that outsourcing 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 (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 EU-KLEMS database and the recently compiled WIOD database to examine the relationship between measures of offshoring and relative labour demand for 18 countries over the period 1995-2007. We develop and test an empirical 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 1995-2007[1], and allows us to consider a relatively large number of countries when compared with the above mentioned studies that tend to 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.

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:

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

where GO 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:

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

subject to equation (1).

[1] The WIOD dataset has data up to 2009, but the data on ICT and non-ICT capital that we also require is only available up to 2007.

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:

$$\ln C_{ic} = \propto_0 + \sum_{i=1}^{N} \propto_i w_i + \sum_{k=1}^{K} \beta_k \ln x_k + \frac{1}{2}\sum_{i=1}^{N}\sum_{j=1}^{N} \gamma_{ij} \ln w_i \ln w_j + \frac{1}{2}\sum_{k=1}^{K}\sum_{l=1}^{K} \delta_{kl} \ln x_k \ln x_l + \sum_{i=1}^{N}\sum_{k=1}^{K} \theta_{ik} \ln w_i \ln x_k, \quad (3)$$

where w_i denotes wages and the price of intermediate inputs that are optimally chosen, $i = 1, \dots, N$. The variables x_k are shift parameters and denote either the quantities of the (quasi-) fixed input capital or gross output, $k = 1, \dots, K$.

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

$$s_i = \alpha_i + \sum_{j=1}^{N} \gamma_{ij} \ln w_j + \sum_{k=1}^{K} \theta_{ij} \ln x_k , \qquad i = 1, \dots, N. \quad (4)$$

Here the cost share for high-skilled is $s_{Hi} = \frac{w_{Hi}H_i}{w_{Li}L_i + w_{Mi}M_i + w_{Hi}H_i + w_{IIDi}IID_i + w_{IIMi}IIM_i}$, and the cost share for the other inputs is obtained in a similar manner.

Taking differences between two periods, the estimating equations become:

$$\Delta s_i = \sum_{j=1}^{N} \gamma_{ij} \Delta \ln w_j + \theta_K \Delta \ln K_i + \theta_{GO} \Delta \ln GO_i + \theta_{IID} \Delta \ln IID_i + \theta_{IIM} \Delta \ln IIM_i + \varepsilon_i, \quad i = 1, \dots, N \quad (5)$$

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:

$$\epsilon_{js} = \frac{\partial \ln v_j}{\partial \ln w_s} = \frac{\gamma_{js}}{s_j} + s_s - \phi_{js}, \qquad \sum_{j=1}^{N} \epsilon_{js} = 0 \quad (6)$$

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:

$$\epsilon_{jk} = \frac{\partial \ln v_j}{\partial \ln x_k} = \frac{\theta_{jk}}{s_j}, \qquad \sum_{l=1}^{M} \epsilon_{jl} = 1 \quad (7)$$

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, 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. These tables 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. These tables 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.

One shortcoming of the WIOD database is that it doesn't split up the capital stock into an ICT and non-ICT component. This is a disadvantage in terms of our analysis since the ICT share of

capital is often used as a measure of skill-biased technological change. To get around this problem we use data from the EU KLEMS database which does report this information for a subsample of the WIOD countries over the period 1995-2007. In our analysis therefore we are left with data on 18 countries over the period 1995-2007.[2]

A further departure from the WIOD is that we drop some industries from our analysis. While the offshoring measures defined below are calculated using intermediate inputs from all 35 in the regression analysis below we include only 29 industries.[3] The industries that are dropped are the services industries L to P. These industries are largely public 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 levels of value-added, which often leads to very large values for the offshoring measures. To avoid these outliers affecting our results we drop this industry from the analysis.[4]

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.[5] 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:

$$IIM_i^N = \frac{O_{j=i}}{V_i} \tag{8}$$

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:

[2] The countries included in the analysis are Australia, Austria, Belgium, Czech Republic, Germany, Denmark, Spain, Finland, France, United Kingdom, Hungary, Ireland, Italy, Japan, Netherlands, Slovenia, Sweden, and the USA.
[3] The 35 industries are listed in Table A1 of the Appendix.
[4] As it turns out including this industry (and the excluded service industries) doesn't affect our results qualitatively. These results are available upon request.
[5] 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.

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

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 years 1995 and 2007. 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 Australia, Japan and the USA in 1995 and relatively high in Belgium, Czech Republic, Ireland 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 16 of the 18 countries considered. The increase in offshoring has been particularly large in a number of CEECs, most notably the Czech Republic, Hungary and Slovenia, as well as Austria, Germany and Spain. 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 all of the 18 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, Netherlands and Sweden) tend to have lower shares of domestic outsourcing. There also appear to be fewer large changes in the extent of domestic outsourcing over time, though in 12 and 13 countries we observe an increase in the extent of narrow and broad domestic outsourcing across time respectively.

Figure 1: Narrow Offshoring by Country, 1995 and Change between 1995 and 2007

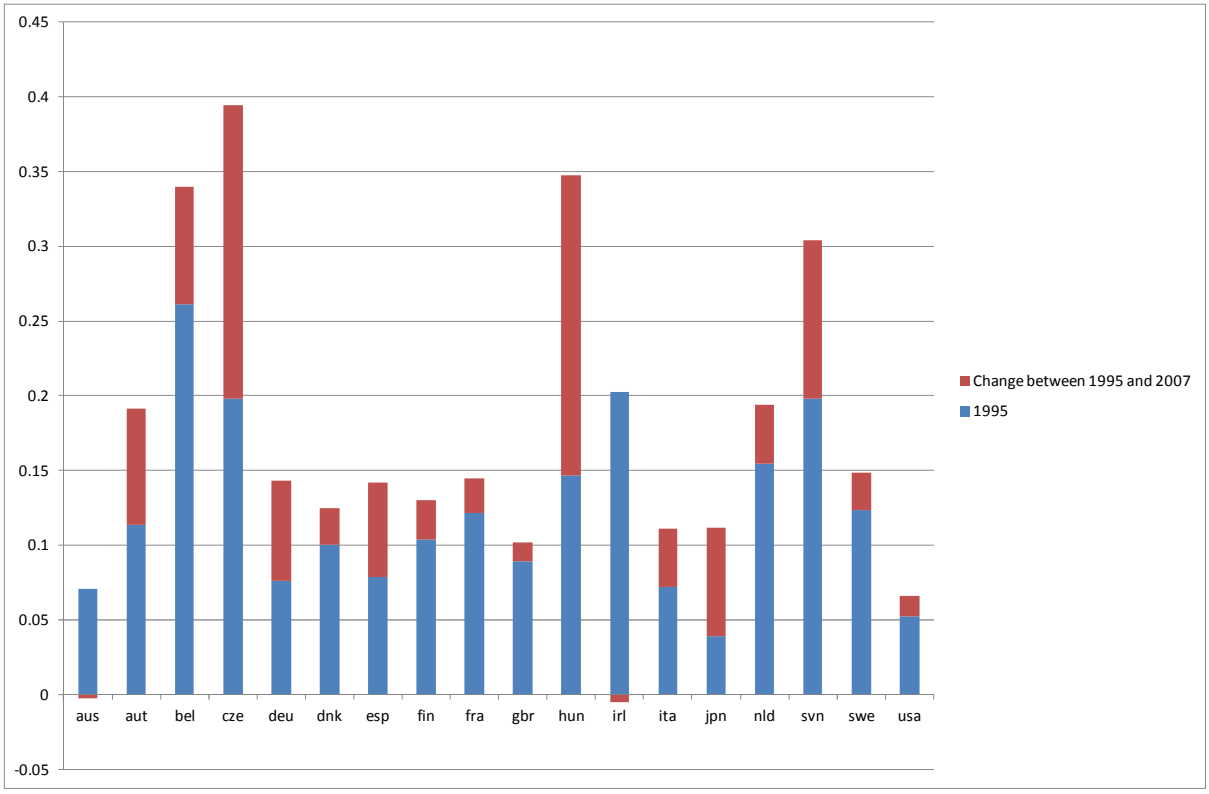


Figure 2: Broad Offshoring by Country, 1995 and Change between 1995 and 2007

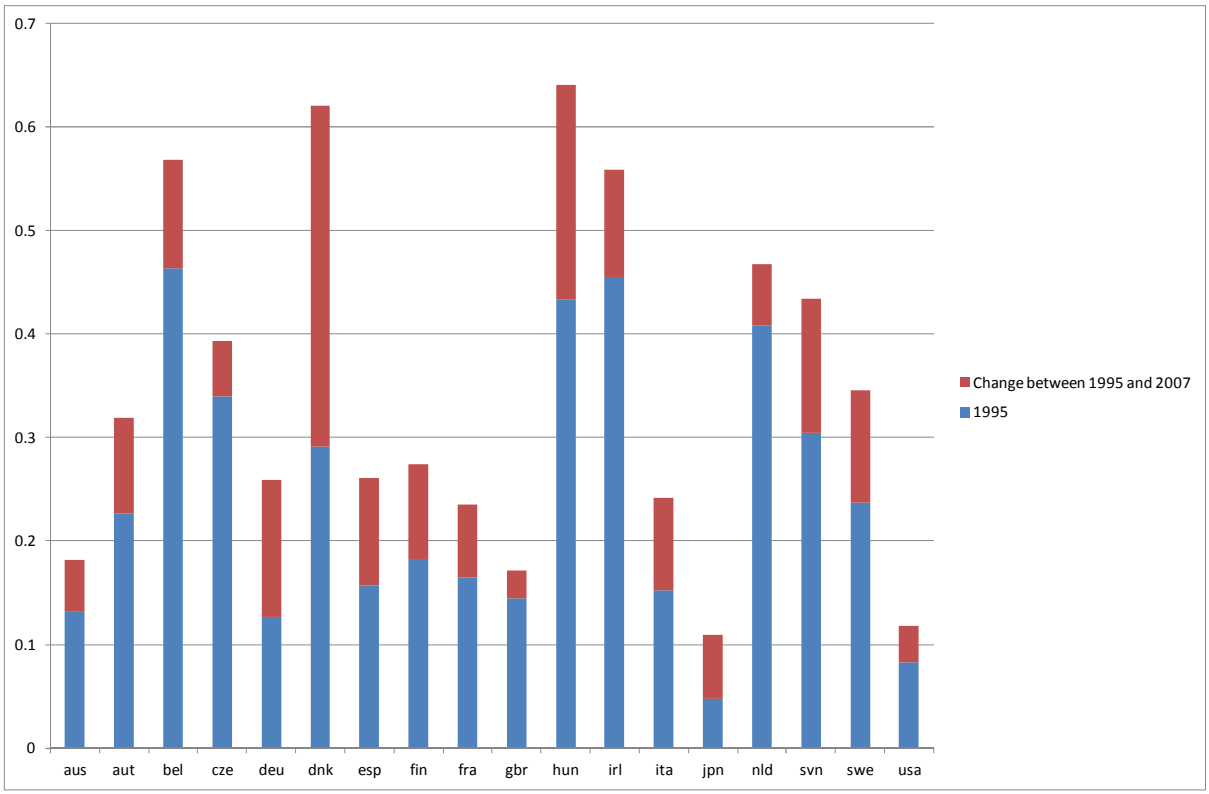


Figure 3: Domestic Intermediate Use in 1995 and the Change between 1995 and 2007 – Narrow Measure

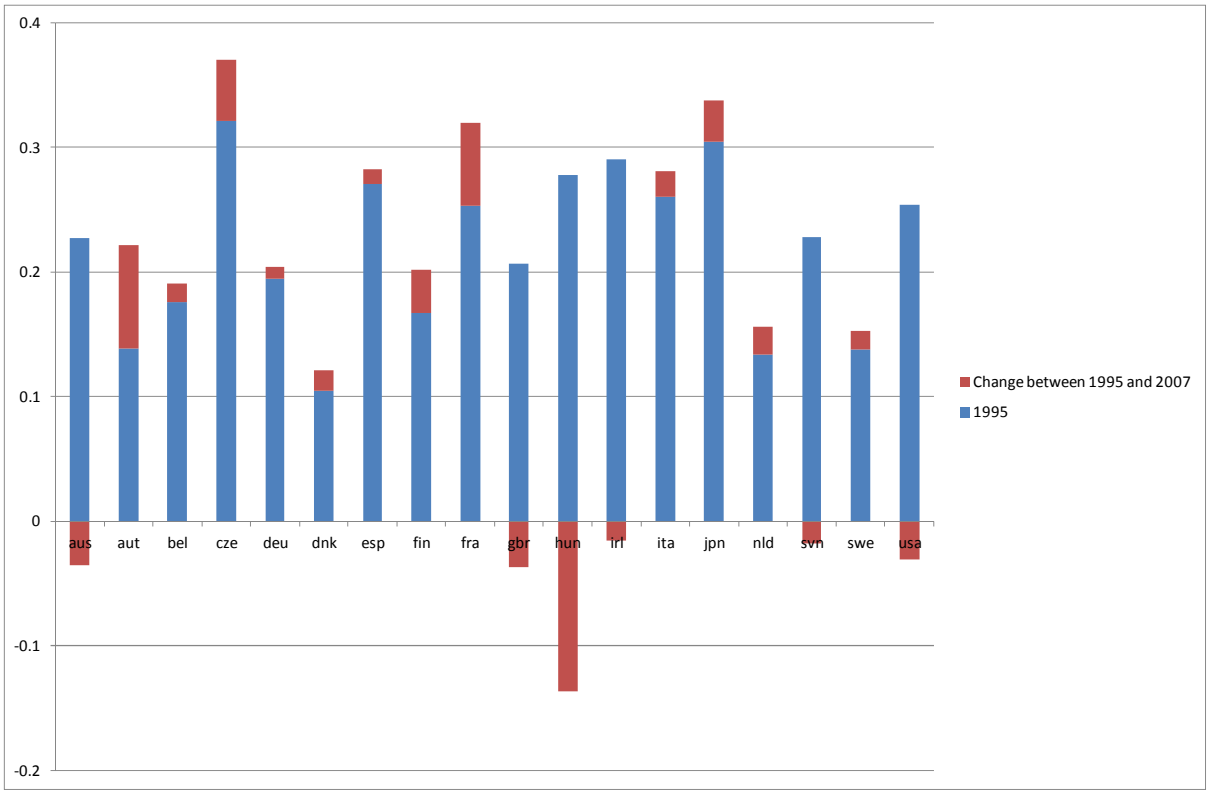
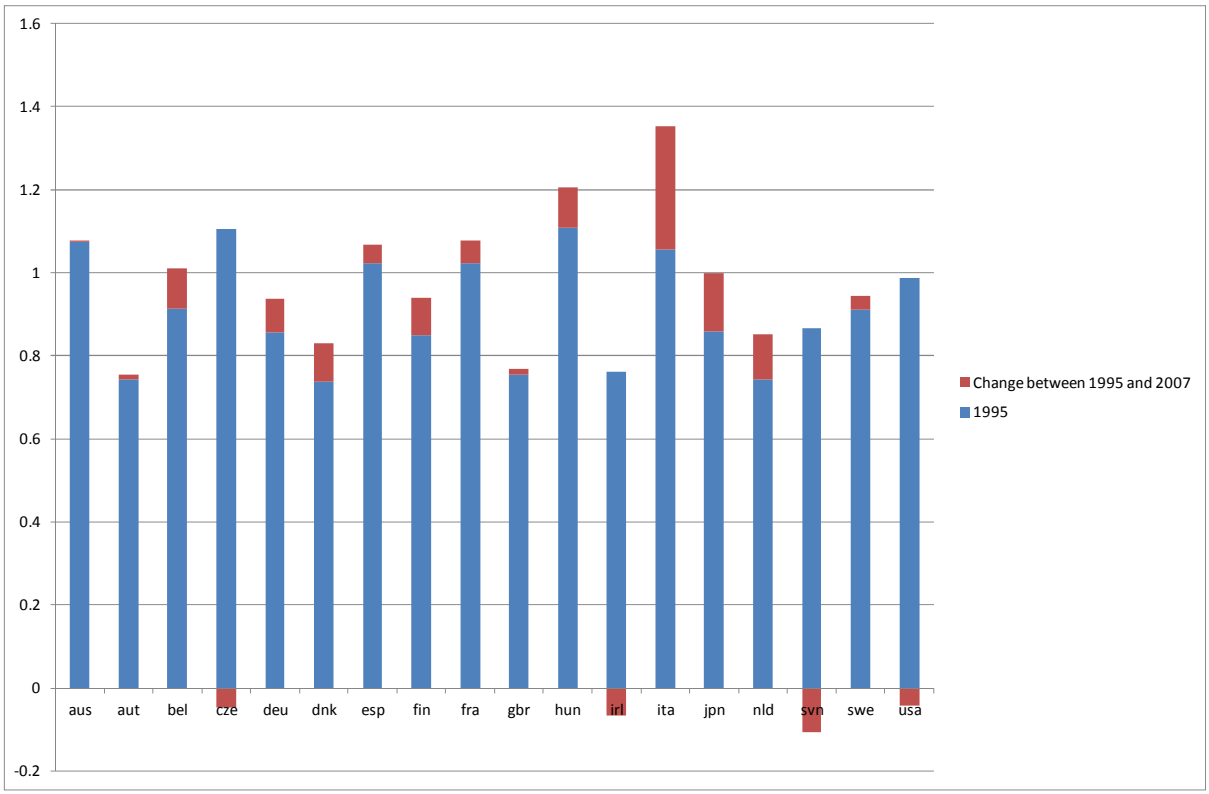


Figure 4: Domestic Intermediate Use in 1995 and the Change between 1995 and 2007 – Broad Measure



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 2007. 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 of the 18 countries we observe a decline in the cost share of low skilled labour, while in the case of medium skilled labour the number is 12. In the case of high skilled labour however, we observe an increase in the cost share in all but one of the countries.

For our analysis we further require data on average wages by skill-level, which can also be calculated directly from the WIOD dataset. We also require a measure of gross output, which are also available from the WIOD database. Finally, we include a measure of ICT capital in our analysis. To do this we split the capital stock data from the EU-KLEMS database into an ICT and a non-ICT component and include both in our regression analysis, the former capturing skill-biased technological change.

Table 1: Change between 1995 and 2007

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	-0.025	0.266	-0.067	0.046	0.016
Belgium	0.121	-0.064	0.130	0.013	0.043	0.004
Czech Republic	0.013	-0.002	0.151	0.019	0.029	0.013
Germany	0.045	-0.009	0.236	-0.057	0.099	-0.005
Denmark	0.079	-0.003	0.199	-0.050	0.063	0.014
Spain	0.189	-0.082	0.056	0.010	0.075	0.024
Finland	0.101	-0.047	0.137	-0.010	0.097	0.007
France	0.110	-0.044	0.144	-0.010	0.082	0.015
Great Britain	0.116	-0.042	0.153	0.006	0.091	0.038
Hungary	0.040	-0.014	0.188	-0.027	0.064	0.012
Ireland	0.113	-0.048	0.125	-0.022	0.057	0.036
Italy	0.183	-0.078	0.107	0.024	0.029	0.005
Japan	0.059	-0.032	0.219	-0.024	0.080	0.011
Netherlands	0.116	-0.039	0.160	-0.028	0.049	0.030
Slovenia	0.052	-0.019	0.226	-0.051	0.070	0.012
Sweden	0.087	-0.034	0.191	-0.015	0.047	0.020
USA	0.033	-0.006	0.216	-0.016	0.103	0.017

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 iterated seemingly unrelated regression (ISUR) 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. We also include a full set of year dummies in all regressions.

One issue in estimating equation (5) on the full sample of countries and industries is that the approach assumes that that the same cost function applies across industries. While this is a common assumption to make in the literature (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 1 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.[6] All regressions include a full set of time dummies. The results in Table 2 indicate that the cost shares of all three types of labour are increasing in output, with the capital stock (both ICT and non-ICT) only having a significant (and positive) effect on the medium-skilled cost share, a result consistent with the existence of a capital-medium skill complementarity. The results on ICT capital also provide little evidence of a negative effect of this measure of skill-biased technological change on labour demand. The coefficients on the wage variables are mixed. The coefficients on the low-skilled wage are found to be insignificant in the low-skilled cost share equation, negative in the medium-skilled equation and positive in the high-skilled equation. Negative coefficients are found on the wages of medium-skilled workers when considering the low- and high-skilled cost shares, with a positive effect found for the medium-skilled share. The coefficients on high-skilled wages are positive for the low-skilled cost shares and negative for the medium- and high-skilled cost shares. The price of intermediates has a positive impact on the cost shares of low-skilled labour suggesting that materials are substitutes for low-skilled labour, but has an insignificant impact on medium- and high-skilled 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 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

[6] OLS results for the all four variable input cost shares are reported in Table A2 of the Appendix.

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. Results for the services sectors are found to be less strong, with negative and significant coefficients on narrow offshoring found only for low- and medium-skilled workers in medium-tech services.

Table 2: SUR Results for the Full Sample of Countries and Industries

VARIABLES	(1) Δs_{LS}	(2) Δs_{MS}	(3) Δs_{HS}
Δw_{LS}	0.00190	-0.00613**	0.0482***
	(0.00191)	(0.00245)	(0.00198)
Δw_{MS}	-0.0143***	0.0932***	-0.0178***
	(0.00271)	(0.00349)	(0.00282)
Δw_{HS}	0.0387***	-0.00482***	-0.0135***
	(0.00126)	(0.00163)	(0.00132)
Δw_{II}	0.00636***	0.000415	-0.00263
	(0.00215)	(0.00277)	(0.00224)
ΔICT	0.000432	0.00135*	0.000700
	(0.000568)	(0.000730)	(0.000591)
$\Delta NONICT$	1.70e-05	0.00147**	0.000479
	(0.000456)	(0.000586)	(0.000474)
ΔGO	-0.0292***	-0.0739***	-0.0305***
	(0.00167)	(0.00214)	(0.00173)
ΔIIM^N	-0.00265***	-0.00495***	-0.00170***
	(0.000406)	(0.000522)	(0.000422)
ΔIID^N	-0.00146***	-0.00464***	-0.00195***
	(0.000360)	(0.000463)	(0.000374)
Observations	4,773	4,773	4,773
R-squared	0.367	0.398	0.252

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) Δs_{LS}	(2) Δs_{MS}	(3) Δs_{HS}
Manufacturing – Low	-0.00192	-0.00934***	-0.00408***
	(0.00174)	(0.00202)	(0.00141)
Manufacturing - Medium	-0.00375***	-0.00620***	-0.00348**
	(0.00133)	(0.00173)	(0.00156)
Manufacturing - High	-0.00418***	-0.0142***	-0.00690***
	(0.00129)	(0.00156)	(0.00131)
Services - Low	-0.00109	-0.000825	0.00106
	(0.00110)	(0.00126)	(0.000885)
Services – Medium	-0.00229***	-0.00213**	-0.000491
	(0.000692)	(0.000898)	(0.000649)
Services - High	0.000714	0.000199	-0.000526
	(0.000975)	(0.00148)	(0.00184)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

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-skilled labour reported above the elasticities reported in Table 4 are mixed, due to the larger shares of medium-skilled labour in total variable costs. When considering all industries therefore we find that the elasticity of the cost shares to a change in narrow offshoring are largest (in absolute value) for low-skilled labour and smallest for high-skilled labour. Such results hide differences across industries however, with the elasticity being largest for high- and medium-skilled labour in low-tech and high-tech manufacturing, and for low- and high-skilled labour in medium-tech manufacturing. That the elasticities in high-tech manufacturing are found to be relatively large is interesting, since it is these industries in which the majority of parts and components trade takes place. In the case of services industries the elasticities are found to be small, but in the case of low- and medium-tech services the elasticities tend to be largest for low-skilled workers.

Table 4: Own Elasticities of Narrow Offshoring Measure

VARIABLES	(1) Δs_{LS}	(2) Δs_{MS}	(3) Δs_{HS}
All Industries	-0.03753	-0.03089	-0.0217
Manufacturing – Low	-0.02204	-0.06299	-0.07129
Manufacturing - Medium	-0.05382	-0.04311	-0.05378
Manufacturing - High	-0.0773	-0.12301	-0.12573
Services - Low	-0.01049	-0.0037	0.016168
Services – Medium	-0.03514	-0.01262	-0.00635
Services - High	0.016847	0.001056	-0.00248

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, with one or two exceptions. In particular, the coefficient on the price of intermediate inputs is now found to be negative and significant in the case of the high-skilled cost share, while the coefficients on non-ICT capital are negative and significant for all three labour cost shares. 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, and in the case of the high-skilled cost share the coefficient is no longer significant. 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-skilled cost share, with the coefficient in this case being between 1.5 and 5 times bigger than that for the low- and high-skilled 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 tend to be negative and significant for medium-skilled workers across all industry types (except high-tech services), with the coefficients for low- and high-skilled workers being more mixed. In the case of low-skilled labour we find negative and significant coefficients in the case of medium-skilled services only. Results for the narrow offshoring measure in Table 6 are somewhat weaker than those reported in Table 3. In most cases where negative effects are found however results indicate that offshoring has a stronger effect on the cost shares of medium-skilled workers, the main exception being medium-tech services.

Table 5: SUR Results for Narrow and Broad Measure of Offshoring

VARIABLES	(1) Δs_{LS}	(2) Δs_{MS}	(3) Δs_{HS}
Δw_{LS}	0.000189	-0.00541**	0.0477***
	(0.00189)	(0.00230)	(0.00193)
Δws_{MS}	-0.0216***	0.0918***	-0.0205***
	(0.00262)	(0.00317)	(0.00267)
Δw_{HS}	0.0451***	-0.00648***	-0.0121***
	(0.00103)	(0.00125)	(0.00105)
Δw_{II}	0.00649***	-6.99e-05	-0.00402*
	(0.00215)	(0.00260)	(0.00219)
ΔICT	-0.000216	0.00230***	0.000850
	(0.000558)	(0.000676)	(0.000569)
$\Delta NONICT$	-0.00178***	-0.00339***	-0.00189***
	(0.000477)	(0.000578)	(0.000486)
ΔGO	-0.0271***	-0.0690***	-0.0289***
	(0.00164)	(0.00199)	(0.00167)
ΔIIM^N	-0.00146***	-0.00212***	-0.000380
	(0.000412)	(0.000499)	(0.000419)
ΔIID^N	-0.000599*	-0.00273***	-0.00107***
	(0.000364)	(0.000441)	(0.000371)
ΔIIM^B	-0.00148	-0.00695***	-0.00443***
	(0.000991)	(0.00120)	(0.00101)
ΔIID^B	-0.0146***	-0.0296***	-0.0148***
	(0.00139)	(0.00168)	(0.00141)
Observations	4,773	4,773	4,773
R-squared	0.366	0.465	0.282

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) Δs_{LS}	(2) Δs_{MS}	(3) Δs_{HS}
NARROW OFFSHORING			
Manufacturing – Low	0.000501	-0.00603***	-0.00226*
	(0.00166)	(0.00191)	(0.00135)
Manufacturing - Medium	-0.00108	-0.00238	-0.00149
	(0.00130)	(0.00165)	(0.00155)
Manufacturing - High	-0.00134	-0.00760***	-0.00274**
	(0.00133)	(0.00161)	(0.00133)
Services - Low	-0.00215*	-0.000485	0.00182**
	(0.00113)	(0.00122)	(0.000894)
Services – Medium	-0.00149**	-0.000819	-0.000129
	(0.000704)	(0.000835)	(0.000637)
Services - High	0.000388	0.00108	-0.000841
	(0.000988)	(0.00146)	(0.00175)
BROAD OFFSHORING			
Manufacturing – Low	-0.00221	-0.00615**	-0.00468**
	(0.00252)	(0.00292)	(0.00206)
Manufacturing - Medium	-0.00183	-0.00672**	-0.00475
	(0.00258)	(0.00326)	(0.00307)
Manufacturing - High	0.00219	-0.00456*	-0.00387*
	(0.00199)	(0.00240)	(0.00198)
Services - Low	0.00685	-0.0104**	-0.00717**
	(0.00430)	(0.00465)	(0.00341)
Services – Medium	-0.00481***	-0.00713***	-0.00194
	(0.00166)	(0.00197)	(0.00150)
Services - High	0.00391	-0.00551	-0.00186
	(0.00279)	(0.00411)	(0.00495)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 7 reports the elasticities and here we again 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, with the elasticities being largest for medium- and high-skilled labour in most manufacturing industries. In the case of broad offshoring we find elasticities that tend to be largest in absolute value for high-skilled labour for the full sample of observations and for the three manufacturing industries. In the case of services industries elasticities are found to be largest for high-skilled in the low-tech sector, low-skilled in the medium-tech sector and medium-skilled in the high-tech sector.

Table 7: Elasticities for Narrow and Broad Measure

VARIABLES	(1) Δs_{LS}	(2) Δs_{MS}	(3) Δs_{HS}
NARROW OFFSHORING			
All Industries	-0.02068	-0.01323	-0.00485
Manufacturing – Low	0.00575	-0.04066	-0.03949
Manufacturing - Medium	-0.0155	-0.01655	-0.02303
Manufacturing - High	-0.02478	-0.06584	-0.04993
Services - Low	-0.02069	-0.00218	0.027761
Services – Medium	-0.02287	-0.00485	-0.00167
Services - High	0.009155	0.005731	-0.00396
BROAD OFFSHORING			
All Industries	-0.02096	-0.04336	-0.05654
Manufacturing – Low	-0.02536	-0.04147	-0.08177
Manufacturing - Medium	-0.02626	-0.04673	-0.0734
Manufacturing - High	0.040498	-0.0395	-0.07052
Services - Low	0.065918	-0.04666	-0.10937
Services – Medium	-0.07382	-0.04223	-0.02509
Services - High	0.092256	-0.02924	-0.00876

5. Conclusions

In this paper we examine the impact of offshoring on the cost shares of low-, medium- and high-skilled workers in 18 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 in to 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. Results further indicate that while offshoring has had a limited effect on cost shares in services industries, the effects on the manufacturing industries has been relatively large, and that they have tended to impact on medium-skilled workers to a greater extent than low- and high-skilled workers. Results on the elasticities of the cost shares with respect to offshoring are found to be somewhat more mixed – reflecting the fact that medium-skilled workers tend to make up the largest shares in total variable costs – but in the majority of cases the elasitcities are found to be largest in the case of medium- and high-skilled labour. Overall, the results would seem to suggest that in recent years offshoring has impacted upon all types of labour, with medium- and to a lesser extent high-skilled labour being squeezed to a greater extent than low-skilled labour by offshoring.

References

Autor, D. and D. Dorn, 2009. This job is "getting old": Measuring changes in job opportunities using occupational age structure. *American Economic Review*, 99, 45-51.

Autor, D.H., Katz, L.F. and A.B. Krueger, 1998. Computing inequality: Have computers changed the labor market? *Quarterly Journal of Economics*, 113, 1169-1213.

Berman, E., Bound, J. and Z. Griliches, 1994. Changes in the demand for skilled labor within U.S. manufacturing: Evidence from the annual survey of manufacturers. *Quarterly Journal of Economics*, 109, 367-397.

Borjas, G.J., Freeman, R.B. and L.F. Katz, 1997. How much do immigration and trade affect labor market outcomes? *Brookings Papers on Economic Activity*, 1-90.

Campa, J. and L.S. Goldberg, 1997. The evolving external orientation of manufacturing: A profile of four countries. *Economic Policy Review*, Federal Reserve Bank of New York, 53-81.

Eurostat, 2008. *Eurostat Manual of Supply, Use and Input-Output Tables*. European Commission, Brussels.

Falk, M. and B.M. Koebel, 2002. Outsourcing, imports and labour demand. *Scandinavian Journal of Economics*, 104(4), 567-586.

Feenstra, R.C., 2010. *Offshoring in the Global Economy: Microeconomic Structure and Marcoeconomic Implications*. Cambridge: MA, The MIT Press.

Feenstra, R.C. and G.H. Hanson, 1996. Foreign investment outsourcing and relative wages. In R.C. Feenstra, G.M. Grossman and D.A. Irwin (eds.), *The Political Economy of Trade Policy: Papers in Honor of Jagdish Bhagwati*, Cambridge: MA, The MIT Press, pp. 89-127.

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. *Quarterly Journal of Economics*, 114, 907-941.

Goos, M., Manning, A. and A. Salomons, 2011. Explaining job polarization: The role of technology, offshoring and institutions. Mimeo, Department of Economics, The University of Leuven.

Gregory, M., Zissimos, B. and C. Greenhalgh, 2001. Jobs for the skilled: How technology, trade, and domestic demand changed the structure of UK employment, 1979-1990. *Oxford Economic Papers*, 53, 20-41.

Hijzen. A., Görg, H. and R.C. Hine, 2005. International outsourcing and the skill structure of labour demand in the United Kingdom. *Economic Journal*, 115, 860-878.

Hijzen, A. and P. Swaim, 2007. Does offshoring reduce industry employment? GEP Research Paper no. 2007/24, The Leverhulme Centre for Research on Globalisation and Economic Policy, the University of Nottingham.

Hummels, D., Ishii, J and K-M. Yi, 2001. The nature and growth of vertical specialization in world trade. *Journal of International Economics*, 51, 75-96.

Jones, R. and H. Kierzkowski, 2001. Globalization and the consequences of international fragmentation. In R. Dornbusch (ed.), *Money, Capital Mobility and Trade: Essays in Honor of Robert A. Mundell*, Cambridge: MA, The MIT Press.

Kohler, W., 2004. International outsourcing and factor prices with multistage production. *Economic Journal*, 114, 166-185.

Krugman, P.R., 2008. Trade and wages, reconsidered. *Brookings Panel on Economic Activity*, Spring, 103-137.

Michaels, G., Natraj, A. and J. van Reenen, 2010. Has ICT polarized skill demand? Evidence from eleven countries over 25 years. Mimeo, London School of Economics.

Strauss-Kahn, V., 2003. The role of globalization in the within-industry shift away from unskilled workers in France. NBER Working Paper no. 9716, National Bureau of Economic Research.

Timmer, M.P., Inklaar, R., O'Mahony, M. and B. van Ark, 2011. Productivity and economic growth in Europe: A comparative industry perspective. *International Productivity Monitor*, Centre for the Study of Living Standards, 21, 3-23.

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