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OFFSHORING OF SERVICES FUNCTIONS AND LABOUR MARKET ADJUSTMENTS

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About 40% of employment in manufacturing is in services functions. This paper develops a measure of narrow outsourcing, matching services functions performed by workers inside manufacturing firms to the same services functions provided by outside suppliers. The measure allows us to analyse the competition that, say, workers at the IT services desk in manufacturing firms face from outside IT suppliers. Narrow outsourcing is entered into labour demand functions where labour is broken down on business functions using OECD data combined with the 2016 releases of the World Input Output Database (WIOD). On average, a one percentage point increase in narrow local outsourcing of services reduces manufacturing employment in the same services function by between 1.5% (R&D) and 3% (transport). The impact of offshoring on manufacturing labour demand is small on average, but depends strongly on the complexity of the value chain, the policy environment and technology. Manufacturing employment is more services intensive the longer the value chain. In-house IT functions complement and support offshored IT functions, while offshored R&D functions tend to replace in-house R&D. Tentatively, technology as measured by IT maturity and the length of the value chain is more important for employment in services functions in manufacturing than is offshoring.

Keywords: outsourcing, offshoring, labour demand, technology, regulation, structural changes

JEL Codes: F16

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Key findings

This report develops a new measure of narrow local outsourcing and offshoring, matching services functions performed by workers inside manufacturing firms to the same services functions provided by outside suppliers. The measure allows us to analyse the competition that, say, workers at the IT services desk in manufacturing firms face from outside IT suppliers.

Services workers inside manufacturing support and complement shop-floor workers. A rise in the wage rate for shop-floor workers has only a small effect on demand for shop-floor workers. Instead, demand for services workers, particularly in administrative functions go down somewhat. Thus, employment in services functions in manufacturing is more sensitive to costs than employment of core shop-floor workers.

Manufacturers source most of their services inputs from domestic suppliers (local outsourcing). Offshoring of services accounted for about 18% of total expenditure on services inputs in manufacturing in 2014, up from 13% in 2000.

On average, a one percentage point increase in narrow local outsourcing of services reduces manufacturing employment in the same services function by between 1.5% (R&D) and 3% (transport). Employment in IT functions are unaffected by local outsourcing, suggesting that in-house and outside suppliers perform different IT tasks.

On average, a one percentage point increase in narrow offshoring of marketing services reduces manufacturing employment in marketing by 2%. Employment in other services functions are unaffected by offshoring, suggesting that offshored services complement the services functions performed inside manufacturing.

Although there is no discernible impact of offshoring on employment on average, looking into the details reveals that the impact depends on the length and complexity of the value chain; the regulatory environment and the ICT maturity of the sector:

- In long and complex value chains, narrow offshoring complements manufacturing employment in IT functions, but replaces in-house employment in R&D functions.
- Manufacturing employment is more services intensive the longer the value chain.
- In countries where infrastructure services are heavily regulated, narrow offshoring complements manufacturing employment in IT functions, other services functions and transport; but substitutes for in-house employment in R&D functions.
- In sectors with a high score on ICT maturity, narrow offshoring is associated with more in-house employment in the services functions being offshored. In such sectors it appears that in-house workers and foreign services suppliers perform different and complementary tasks.

Tentatively, technology as measured by IT maturity and the length of the value chain is more important for employment in services functions in manufacturing than is offshoring.

Executive summary

This study analyses the relationship between services inputs and employment patterns in manufacturing. Between 25% and 60% of employment in manufacturing is in services functions performing tasks such as transport, marketing, IT, R&D, management, maintenance, repair, cleaning and training. The best-paying jobs in manufacturing are in services functions.

Intermediate services sourced from local and foreign services suppliers account for about 20% of gross output in manufacturing. The foreign share of services inputs is small, but it has increased from an average of 13% in 2000 to 18% in 2014. Some intermediate services complement and support the services functions performed by manufacturing employees while others replace services jobs in manufacturing. Whether to make or buy services is both a strategic and operational decision facing manufacturers.

To study the outcome of the make-or-buy decision, it is crucial to compare like for like; that is, the functions performed by manufacturing workers versus the services sourced from outside. For this purpose, we construct a new measure of narrow local outsourcing and offshoring that matches business functions to ISIC rev4 services sectors for the period 2000-2014. With the new measure in hand, we set out to study the interface between services employment inside the manufacturing sector, and the services market outside manufacturing.

When the make-or-buy decision falls on "buy", manufacturers typically source a *function* rather than an individual task from outside suppliers. For this reason, statistical agencies around the world have started to gather and publish information on manufacturing employment, local outsourcing and offshoring by business function. Our measure of narrow local outsourcing and offshoring corresponds to these business function categories.

Starting with identifying stylised facts from descriptive analysis, we find that services intensity and the composition of services jobs by function vary considerably across manufacturing sectors within and across countries, but services intensity is surprisingly stable over time. Interestingly and unexpectedly, the outcome of the make-or-buy decision has shifted slightly towards "make" over time for services. When the outcome is "buy", imports have gained ground. Local services suppliers have thus seen their market share being eroded from both ends.

A higher intensity of offshored services goes together with better export performance in manufacturing industries. Although causality cannot be inferred, access to competitive services is a necessary but not sufficient condition for manufacturing exports.

Having mapped the interface between services functions inside manufacturing and the outside services market and established a set of stylised facts, the study explores the following questions: What determines whether manufacturers make or buy services? When manufacturing industries source business functions from outside suppliers, does this support or replace the workers providing similar functions inside the manufacturing sector? Is there a difference between local and imported services in this respect? The driving forces determining the level and composition of services employment in manufacturing that we study are local outsourcing and offshoring, technology, the complexity of the production process and the policy environment.

We find that the functional composition as well as the overall level of employment in manufacturing is quite resilient to all these factors. Thus, at the industry level studied here, structural changes are gradual and take time.

Offshoring, technology, the length of the value chain and policy shape employment patterns in manufacturing in complex ways. The four factors are related such that the impact of one often depends on the level of the others. Bearing this caveat in mind, our analysis suggest that the complexity (the length of the value chain) is by far the most important.

A longer and more complex value chain is associated with less manufacturing employment in all functions. The core manufacturing operations decline more than the services operations and manufacturing employment becomes more services intensive the longer the value chain. The composition of services employment in manufacturing also change somewhat. A clear result is that the R&D function becomes relatively less important inside the manufacturing sector, while IT functions are less affected. The results also point to higher labour productivity in manufacturing the longer the value chain.

Services sourced from local suppliers are more likely to replace services jobs inside manufacturing than are imported services. The services functions most likely to face cuts following offshoring are management and marketing functions. This result is modified somewhat in long value chains, however. Additional management inside manufacturing may be needed to complement and govern offshored management functions when value chains become long and complex.

Technology is measured by ICT intensity and internet use. Our findings suggest that more ICT-intensive sectors employ less workers in core operations functions and more workers in services functions. In particular, ICT-intensity goes together with strengthening of the R&D function and a broad category of other services functions including maintenance, repair and training.

Our policy measure is the OECD product market regulation (PMR), which measures burdensome services market regulation. Regulation is not strongly related to employment in manufacturing, but to the extent that it is, a high score on the PMR is associated with more employment in core operations and administration, and less in IT functions. In high-technology sectors, a high level of regulation is strongly and negatively associated with in-house employment in most functions, particularly core operations, R&D and other services functions.

The policy lessons are first, that regulation in services has implications for employment in manufacturing through tilting the make-or-buy decision towards “make”, also when “buy” would yield higher labour productivity and better export performance. Reforms in key infrastructure services are thus associated with a structural shift in manufacturing employment from core operations and management to IT-related services. Second, the shift towards services employment is largely technology-driven. Offshoring is in many cases a response to and support of technical changes and the lengthening of value chains.

1. Introduction

Firms can be seen as a bundle of functions such as R&D; purchasing and storing inputs, processing inputs into parts, components, modules or final products; marketing, sales and after sales services. Vertical disintegration is part of the growth process where firms outsource non-core functions to external suppliers, which specialise in providing the function. Thus, what is non-core activities for one firm becomes the core of another as the size of the market expands and sustains deeper specialisation (Stigler, 1951[1]).[1]

The view of the firm as a bundle of functions has support in reality. That is why recent surveys on local outsourcing and offshoring activities in the European Union, the US and Canada focus on business functions as the unit being outsourced or offshored.[2] These surveys confirm that firms tend to outsource services functions rather than individual tasks. Perhaps surprisingly, the surveys also reveal that most firms outsource locally. When they buy services from abroad, the source is most often countries in the same region with similar production costs as in their own country. Multinationals are more likely to offshore than local firms and they often offshore from their own subsidiaries. Nevertheless, China and India are the most important non-European destinations of offshoring relationships for EU firms (see footnote 2).

Services functions account for between 25% and 60% of total employment in manufacturing (Miroudot and Cadestin, 2017[2]). This study exploits new information on employment by business functions in manufacturing and explores the following questions: When manufacturers source business functions from outside suppliers, does this support or replace the workers providing similar functions inside the manufacturing firm? What determines whether manufacturers make or buy services? How does policy and technology interact to shape the patterns of employment across business functions within and across sectors and countries? An examination of these dynamics aims to provide insight into both the effectiveness and the limitations of policy interventions, in particular with respect to employment.

To address the first question, one needs a tool for comparing the functions provided inside manufacturing and the functions sourced from outside. Such a tool is the first contribution of this study. We create a new measure of narrow local outsourcing and offshoring that matches business functions provided inside manufacturing to services produced by special services providers outside the sector. An example illustrates the point. Consider a computer engineer employed in the IT department of a car manufacturer. The market for her skills is IT departments in any sector, including special computer services firms. Similarly, she and her colleagues in the IT department face direct competition from computer services firms that may offer to take over the IT functions of the car manufacturer on a contractual basis. To capture this, we match IT functions inside the firm to computer services (ISIC rev 4, J62-63) from external suppliers. This brings a new approach and dimension to the offshoring literature, which is better aligned with the actual decisions facing businesses, shedding new light on the drivers and implications of offshoring.

[1] In contrast, declining industries tend to integrate vertically as for instance observed by Michael Porter in his path breaking work on competitiveness. (Porter, 1979[31]).

[2] The National Organization Survey in the US and similar surveys in Canada and the European Union. See https://ec.europa.eu/eurostat/statistics-explained/index.php/International_sourcing_and_relocation_of_business_functions and http://irle.berkeley.edu/files/2013/The-2010-National-Organizations-Survey.pdf.

With this new tool in hand the second contribution of the study is to relate patterns of employment to local outsourcing and offshoring of business functions and explore to what extent and under which circumstances outsourcing supports or replaces services functions inside manufacturing. Ours is the first study to analyse the relationship between services outsourcing and offshoring using the 2016 release of the World Input Output Database (WIOD) together with information on employment and earnings by business function (Miroudot and Cadestin, 2017[2]).

The third contribution from the study is to analyse how policy and technology interact to shape patterns of employment. The most relevant and available policy indicator is the OECD product market regulation (PMR) indicator. It is available for key services sectors for most of the countries covered by WIOD for the entire period of the 2016 release. A drawback is that it is quite general and covers only a few sectors, although the sectors covered provide key inputs to manufacturing.[3] The technology indicators used are related to ICT. Our contribution is to create manufacturing sector-specific policy and technology indicators and explore to what extent the employment effect of outsourcing and offshoring is conditioned on the policy and technology framework.

We find that the aggregate share of services inputs in manufacturing has not changed much during the period 2000-2014. There is however substantial variation across manufacturing sectors and countries. Furthermore, a small change in sourcing of services is observed as the share offshored and the share produced inside manufacturing have both increased at the expense of local services suppliers.

Tentatively our results suggest that the most important driver of both the level and composition of employment by function in manufacturing is complexity as measured by the length of the value chain. A longer value chain is associated with less employment in all business functions and a significant reduction in the cost share of the core operations function. The second most important factor appears to be technology, while offshoring ranks third in relative importance. The extent to which offshoring replaces or supports manufacturing employment depends, however, on the policy framework, technology and length of the value chain in complex ways that are traced out in the report.

The rest of the paper is organised as follows: Section 2 takes stock of what we already know about the labour market impacts of services offshoring, and positions the study in the literature. Section 3 presents the data and extracts some stylised facts. The econometric analysis are reported in Section 4, while Section 5 discusses policy implications, future work and concludes. Statistical and technical annexes lay out the details.

[3] The OECD Services Trade Restrictiveness Indices are the preferred policy measures for future analysis. The problem with using them in this study is that they overlap with the WIOD data only in 2014. Robust econometric analysis of these questions require a time series. Nevertheless, some indicative mappings are made using the STRI (see Box 3).

2. How are offshoring of services and employment related?

The fundamental question that determines the relationship between local outsourcing, offshoring and internal provision of business functions is firms' make-or-buy decision. This question has been central to the field of economics since its inception with the work of Adam Smith in the 18th century. The classical work looked at the question from a growth and development perspective. Growing industries create space for deeper specialisation allowing firms to hive off non-core activities to outside suppliers. In the process, firms become more productive and new sectors emerge from taking up the hived-off functions.

Recent work has focussed on individual firms' decision-making and the parameters affecting their choices. The offshoring dimension was brought into the analysis by embedding the make-or-buy decision into a suitable trade model (Antràs and Helpman, 2004[3]). There are four possible outcomes of the make-or-buy decision: i) make at home; ii) make in a subsidiary established abroad; iii) buy from a local supplier; iv) buy from a foreign supplier. Each outcome is associated with a set of fixed and variable costs and the decision minimises the total production and transaction costs. Setting up a subsidiary abroad is the highest fixed cost alternative, but the higher cost of establishment may be compensated by lower cost of operations. The cost of governing production is lower when performed inside the firm, but lack of scale may still favour outside suppliers. In addition, compliance costs with foreign regulation as well as outright trade and investment barriers add to the costs of engaging in offshoring.

The cost of governing outside suppliers also depends on the characteristics of the product and the production process. Complex processes begets complex contracts that may be difficult to draw up and monitor, raising the relative transaction cost of outsourcing (Tadelis, 2002[4]; Bashir and Thomson, 1999[5]; Novak and Eppinger, 2001[6]).

The relative costs of the different outcomes are only one dimension governing the make-or-buy decision. Another important aspect is the firms' ability to absorb fixed costs. Obviously, the size of the market matters as fixed costs can be spread more thinly over units sold the larger the market. Indeed, a dynamic version of this argument is behind the insight that non-core functions are hived off in growing markets where the supplier base becomes larger and more diversified.

Firms that are more productive can also more easily absorb trade and investment costs. Not only are they more likely to buy inputs from outside suppliers, they are also more likely to export (Melitz and Ottaviano, 2008[7]).[4] A simple regression linking services offshoring to export performance at the industry level reported in Box 1 supports this finding.

Finally, the nature of the tasks performed is an important factor determining the relative cost of making or buying a particular input. The literature offers a host of measures of "offshorability" of tasks and jobs, and explicitly brings the employment perspective into the analysis. They capture ICT intensity and the extent to which the job function is routine and could be digitised. As the popular press drew attention to the new phenomenon of offshoring ICT-enabled services e.g. to India and other countries with low labour costs, a number of studies set out to measure how many jobs were at risk of being offshored. The OECD made an influential early contribution suggesting that 20% of employees in OECD

[4] The evidence on whether firms become more productive because they engage in trade or trade because they are more productive is mixed. However, the prediction that offshoring of intermediate inputs improves productivity is supported by empirical evidence (Amiti and Wei, 2009[34]).

countries were at risk of being offshored (van Welsum and Vickery, 2006[8]). Similar analysis of US data found that 28-42 million services jobs were at risk of being offshored (Blinder, 2006[9]). Naturally, workers and policy makers were worried.[5]

Revisiting the debate on offshoring of jobs from 10-20 years back is interesting in the light of the current debate on automation and jobs. The current discourse follows a similar pattern starting with an in depth analysis of the nature of work performed in different occupations. To what extent do jobs consist of routine tasks? To what extent can jobs be automated? To what extent is face-to-face interaction with customers or co-workers essential? In both strands of literature, the number of jobs susceptible to offshoring or automation is calculated by adding up the number of workers currently holding a job in an occupation, which scores above a given threshold on an offshorability or automation scale.

There is a big difference between the number of jobs that conceptually could be automated, offshored or both and jobs that are actually automated or offshored. Studies relating offshoring to changes in overall employment found no or limited effects (Liu and Trefler, 2008[10]; Hijzen et al., 2011[11]). Nevertheless, evidence of quite significant effects on the skills composition of employment and relative wages were identified (Hijzen, Görg and Hine, 2005[12]; Geishecker and Görgy, 2013[13]).[6] Little is known about the impact of offshoring on the functional composition of employment, but there is some evidence that offshoring of material inputs from the US to China is associated with a net decline in low-skilled production workers, which has been more than offset with a net increase in employment of non-production workers (Wright, 2014[14]).

Analysis of micro data is suitable for gaining insights on job creation and job separation across firms within sectors and sometimes even within firms, distinguishing between firm and worker characteristics. It is, however, difficult to study trade and regulatory policy drivers of labour market outcomes in country-specific microanalysis, since firms and workers within a country face the same policy environment. Furthermore, it is well known from the classical work of Hecksher, Ohlin, Vanek and others that trade leads to changes in relative prices, which drive a reallocation of resources to their most efficient use. These changes affect all firms and workers in the economy, not only those directly engaged in trade. Therefore, cross-country analysis may be more suitable for policy analysis and studies on the overall impact of trade.

The WIOD and the TiVA databases have been instrumental for cross-country analysis of trade and jobs at the industry level. They confirm that overall employment is mostly determined by factors other than trade and trade policy. There is evidence that services offshoring has contributed to making hiring and firing more sensitive to changes in wages and other market conditions (Foster-McGregor, Stehrer and de Vries, 2013[15]; Hijzen and Swaim, 2010[16]), and thus may have had an impact on job security.[7] Finally, cross-country analysis support the finding that offshoring may have contributed to polarisation of earnings where the medium skilled workers have seen their share of the total wage bill decline to the benefit of high-skilled workers and, to a less extent to low-skilled workers (Foster-McGregor, Poeschl and Stehrer, 2016[17]).

[5] There were also a number of studies that focussed on the gains from offshoring, such as (Jensen, 2012[39]) and nuanced studies looking at both the upsides and downsides (Robert-Nicoud, 2008[35]).

[6] These studies analyse UK micro data.

[7] Technically speaking the studies find that offshoring is associated with higher labour demand elasticities.

To summarise what we already know from the literature, trade in intermediate goods and services is governed by comparative advantage and gains from specialisation at the macro and sector level; and by the make-or-buy decision at the firm level. The literature documents a rising offshoring trend over many decades, which appears to have levelled off over the past decade or so. Offshoring has had no discernible impact on overall employment, but has contributed significantly to a higher level of productivity in firms that offshore. Furthermore, a shift in labour demand towards skilled workers has been observed together with a rising skills premium. It is beyond reasonable doubt that trade in general and offshoring in particular has contributed to this, but skills-biased technical progress is also a major driver behind structural changes. The jury is still out on the relative importance of technology and trade in this respect.[8]

This study takes a different approach. While the literature often portrays deepening international division of labour in terms of slicing up the production process into ever-thinner slivers, which are traded as tasks, this study focuses on business functions.[9] The fact that statistical agencies have started to focus on business functions as a unit of measurement for analysing offshoring underscores its relevance. Clusters of complementary inputs form business functions that cannot easily be unbundled and the cost of doing so is often overlooked in both the current debate and the offshoring debate 10-20 years back (Lanz, Miroudot and Nordås, 2013[18]). This study contributes to bringing the business function dimension into rigorous policy-oriented analysis beyond descriptive statistics. For this purpose, we study the most recent release of the WIOD table; develop a new measure of narrow offshoring and introduce policy, technology, complexity and bring the interaction between policy, technology and offshoring into the analysis.

[8] See (Fort, Pierce and Schott, 2018[38]) for a recent discussion using US data.

[9] The number of suppliers to large manufacturing firms indeed runs into their thousands, generating very complex value chains, giving rise to new services coined supply chain aggregators. Nevertheless consolidation of the number of suppliers is the new mantra of cost saving and not least making sure that suppliers comply with standards, be they technical, environmental or social (Aral, Bakos and Brynjolfsson, 2018[32]; Dedrick, Xu and Zhu, 2008[33])

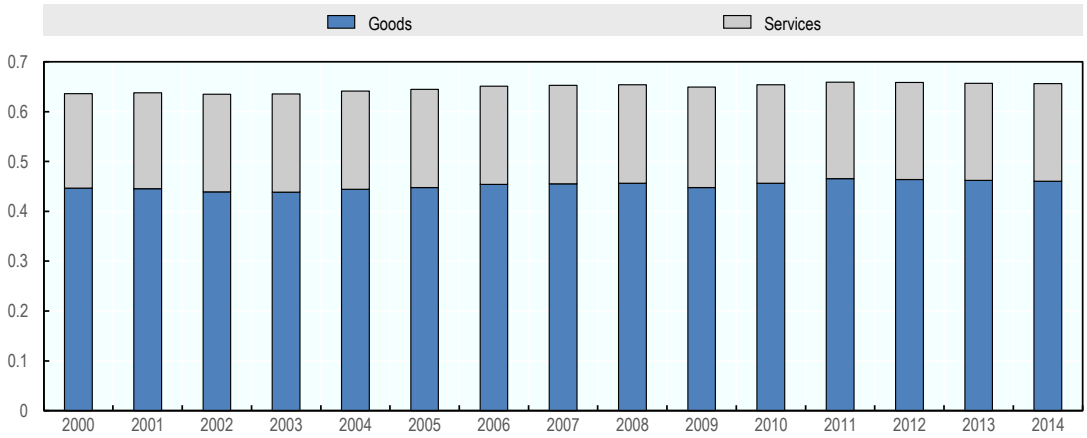
3. Data and stylised facts

The main sources of data for this study are the 2016 release of the World Input Output Tables (WIOD), the associated Socio Economic Accounts (Timmer et al., 2015[19]) and OECD estimates of employment by business function (Miroudot and Cadestin, 2017[2]).[10] The WIOD input output tables provide information on intermediate inputs by sector and source for 43 countries plus "rest of the world" from 2000 to 2014, while the socio-economic accounts contain information on key macro-economic variables including employment and earnings. As opposed to earlier releases of WIOD, the 2016 release does not provide information on employment by skill level.

Figure 1 depicts the average share of intermediate inputs in manufacturing for all countries included in the WIOD database by year. The most striking takeaway from this chart is the stability of the share of intermediate inputs, accounting for about two thirds of gross output throughout the period. Bearing in mind the popular debate about the increasing fragmentation of production this may be surprising.[11] The share of intermediate services in gross output has also been stable hovering around 20% and peaking at 21.1% in 2009.

Figure 1. Average share of intermediate goods and services in gross output

Manufacturing, all countries



Source: WIOD.

Services are also produced inside the manufacturing sector and on average internal services provision raises the contribution of services to manufacturing gross output by 16% (Miroudot and Cadestin, 2017[2]). Figure 2 breaks down intermediate services inputs into locally sourced and imported and adds services produced internally in the manufacturing sector. It shows that externally sourced services from the local market is the most important, followed by internal services production. Services imported directly account for a relatively

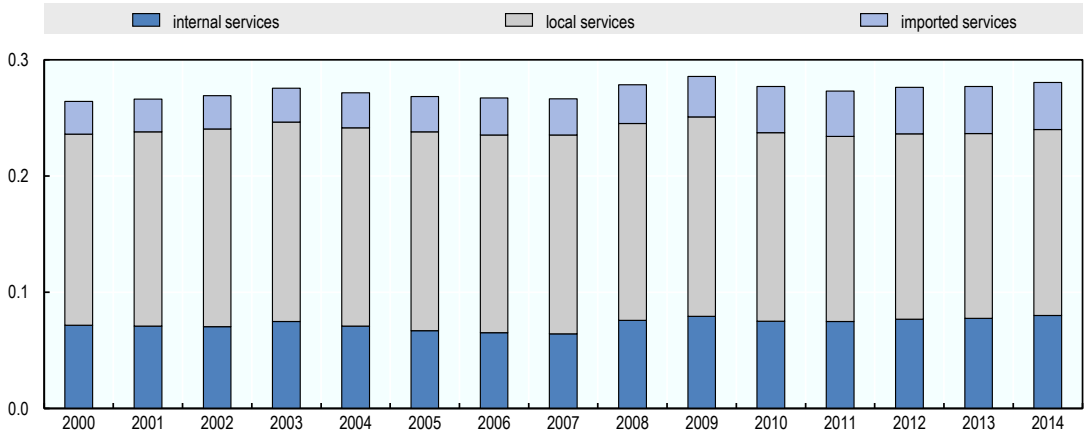
[10] Alternatively, the OECD/WTO Trade in Value Added database could have been used. However, for this study, WIOD is better suited since it provides information on all inputs, including labour and capital, employed in the creation of value added and gross output by sector. Information on employment by function is available for the EU countries plus Brazil, Canada, India, Korea, Mexico and the United States.

[11] This may be partly, but far from entirely a statistical artefact since input-output coefficients may not be frequently updated in the underlying data.

small share.[12] We also observe that although the overall share of services in gross output has been relatively stable over the past decade and a half, there has been a shift in the composition from locally sourced to internal and imported services. Thus, the import share of intermediate services has increased from 13% in 2000 to 18% in 2014.

Figure 2. Services inputs in manufacturing

Internal, local and imported



Source: WIOD; Miroudot and Cadestin (2017).

The rather underwhelming dynamics gleaned from the averages conceal large differences across manufacturing sectors and across countries within the same sector. Starting with variation across sectors, Figure 3 shows the average services share of gross output by ISIC rev 4 manufacturing sector in 2014 for all WIOD countries. Sectors are ranked by the share of gross output provided by internal services functions. Unsurprisingly, the sector that uses services the most intensively is repair and installation of manufacturing equipment (C33), a sector at the borderline between goods and services. Manufacture of other transport equipment (C30) and pharmaceuticals (C21) follow as the second and third most services intensive manufacturing sectors. Pharmaceuticals have the highest share of locally outsourced services, while the highest share of imported services are found in manufacture of coke and petroleum products (C19).[13]

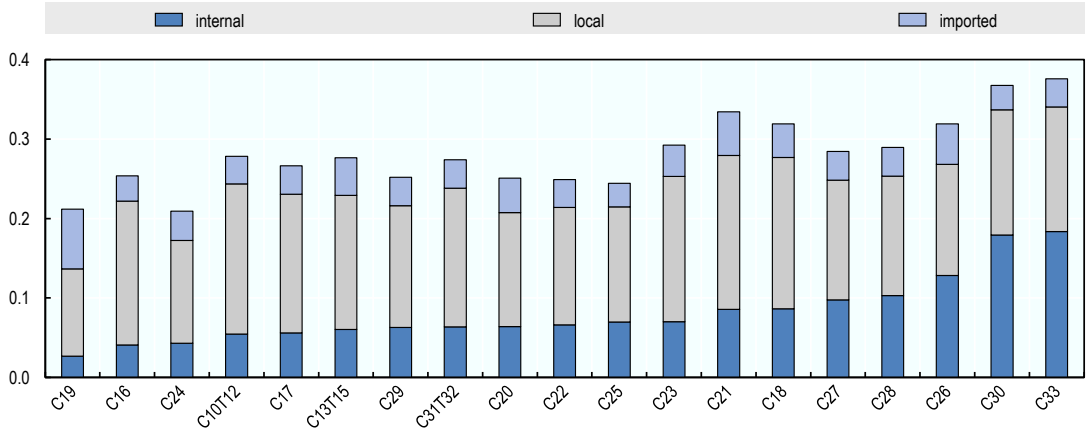
Finally, we highlight differences in services intensity across countries. Such differences can be due to variation in industrial structure across countries, or due to a more services intensive production technology within a sector. Here we are interested in the latter, and we choose manufacture of computer, electronic and optical products (C26) to illustrate the point. The sector is characterised by a large number of products ranging from simple cables and switches to the most sophisticated computers and optical instruments. Internationally dispersed value chains in which there are large variations in the positioning of countries also distinguish it. Figure 4 ranks countries by intensity of internal services functions.

[12] A major insight from the work on trade in value added is that services play a much stronger role in international trade when measured in value added terms, which also takes into account indirect trade in services.

[13] We follow the practice in previous work and omit this sector from the econometric analysis in Section 4 due to measurement problems related to sharp fluctuations in oil prices (Foster-McGregor, Poeschl and Stehrer, 2016[17]).

Figure 3. Services inputs in manufacturing by sector, 2014

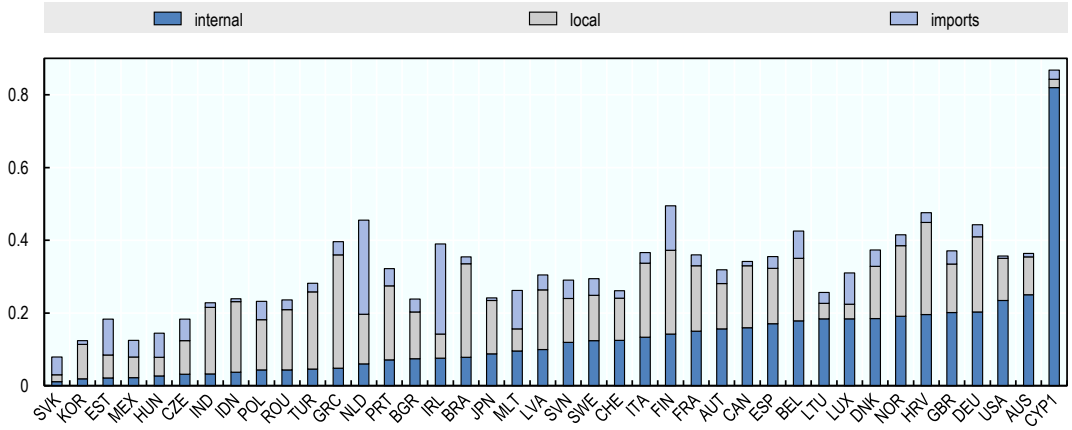
Internal, local and imported



Notes: C19: Coke and refined petroleum products; C16: Wood and of products of wood and cork, except furniture; articles of straw and plaiting materials; C24: Basic metals; C10T12: Food, beverages and tobacco; C17: Paper and paper products; C13T15: Textiles, wearing apparel and leather products; C29: Motor vehicles, trailers and semi-trailers; C31T32: Furniture; other manufacturing; C20: Chemicals and chemical products; C22: Rubber and plastic products; C25: Fabricated metal products, except machinery and equipment; C23: Other non-metallic mineral products; C21: Basic pharmaceutical products and pharmaceutical preparations; C18: Printing and reproduction of recorded media; C27: Electrical equipment; C28: Machinery and equipment n.e.c.; C26: Computer, electronic and optical products; C30: Other transport equipment; C33: Repair and installation of machinery and equipment
Source: WIOD; Miroudot and Cadestin (2017).

Figure 4. Services inputs in manufacture of computer, electronic and optical products, 2014

Internal, local and imported



Notes: 1. *Note by Turkey*: The information in this document with reference to "Cyprus" relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Turkey shall preserve its position concerning the "Cyprus issue."
Note by all the European Union Member States of the OECD and the European Union: The Republic of Cyprus is recognised by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.
Source: WIOD; Miroudot and Cadestin (2017).

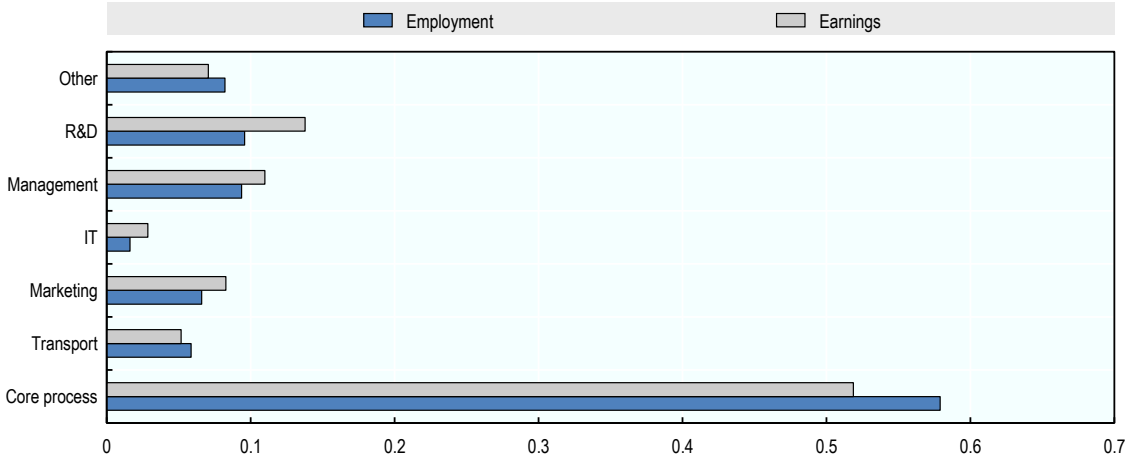
The figure depicts substantial variation in both services intensities and the sourcing of services. At the one extreme, manufacturers in Cyprus appear to engage mainly in the services stages of the production process while in the Slovak Republic services account for less than 10% of gross output, of which more than half is imported.

Figure 5 exhibits the composition of employment by business function in manufacturing in 2014. On average almost 60% of employment and about half of earnings ensue in the core function, which is fabrication of products at the shop floor. Conversely more than 40% of employment and half of the wage earnings go to services workers in the manufacturing sector. R&D, which also includes engineering and other technical services, figures most prominently, followed by management and marketing.

It is worth noticing the difference in the earnings and employment shares. Jobs in functions with a higher earnings than employment share are better paid than average and conversely for the functions with a lower earnings than employment share. From this metrics, it appears that the best-paid jobs in the manufacturing sector are the ones providing services functions, particularly R&D and other technical support functions.

Figure 5. Employment and earnings in manufacturing by business function, 2014

Average shares of total employment and earnings in manufacturing, 31 countries



Source: WIOD; Miroudot and Cadestin (2017).

To summarise the stylised facts, services functions account for about 30% manufacturing gross output and about 40% of employment in manufacturing. These aggregates have not changed much over time, but a slight shift from local outsourcing towards both imports and internal provision has been observed. Most importantly, there is substantial variation in both the services intensity and the sourcing of services across manufacturing industries and across countries within the same industry. The next sections of the study aims at explaining this variation.

Box 1. Services offshoring and export performance in manufacturing

Export performance in manufacturing is related to offshoring of services in two ways. First, as previous studies have shown, services offshoring may improve productivity in manufacturing, making manufactures more competitive (Debaere, Görg and Raff, 2013[20]; Francois and Woerz, 2008[21]). There is also growing evidence that services intensity is related to competitiveness in more sophisticated products (Ariu, 2018[22]; Ciriaci, Montresor and Palma, 2015[23]). Second, services sourced from the destination country, such as transport, distribution, marketing, technical testing and legal services, directly support the exporting activity. A set of simple regressions using the 2016 issue of the WIOD data indicates a positive relationship between services offshoring and export performance in manufacturing. Table 1 reports the results. The first column relates the level of exports to offshoring of services by service category. The second column relates change in exports to change in services offshoring while the last two columns show how exports as a share of value added and gross output respectively relate to services offshoring.

Table 1. Services offshoring and manufacturing export performance

	Level	One year difference	Intensity VA	Intensity GO
G, Wholesale and retail trade	0.660***	0.304***	2.638***	11.124***
	(0.018)	(0.021)	(0.503)	(1.758)
H, Transport and storage	0.385***	0.204***	6.123***	19.159***
	(0.019)	(0.017)	(0.780)	(2.436)
J, Information and communication	0.085***	0.102***	6.875***	24.144***
	(0.022)	(0.017)	(1.810)	(4.800)
K, Finance and insurance activities	0.108***	0.069***	8.385***	35.393***
	(0.027)	(0.014)	(2.130)	(7.855)
M, Professional, scientific and technical activities	0.175***	0.069***	3.295***	9.044***
	(0.016)	(0.016)	(0.704)	(1.879)
N, Administrative and support activities	-0.117***	0.021*	3.251***	16.594***
	(0.023)	(0.012)	(0.949)	(1.597)
R^2	0.901	0.32	0.782	0.782
N	11 880	11 088	11 640	11 640

Note: OLS regression with country, sector and year fixed effects. The left hand side variable is the log of exports and the right hand side variable the log of imported intermediate services in the sector indicated. ***, **, and * signify statistical significance at a 1%, 5% and 10% level respectively.
Source: Own estimates.

We observe that all services inputs are simultaneously statistically significant with the largest coefficients on finance, transport, and information and communications. A strong correlation does not mean that services offshoring *causes* more exports. It may very well be that demand from goods exporters drives services offshoring. Nevertheless, whichever way causality runs, it is important for export performance that demand for supporting services is met through access to competitive services.

4. Labour demand, and cost shares of labour by business function: econometric estimates

Given that offshoring is one of several possible outcomes of the make-or-buy decision, one would expect that offshored services are substitutes to internal production of services, and that offshoring reduces demand for labour performing the same functions inside the firm. However, offshoring may also replace local outsourcing, leaving in-house provision of the function un-affected. Finally, the productivity effect of offshoring may reduce cost and raise total output, fully or partly compensating the substitution effect. The impact of offshoring on local manufacturing employment is therefore ambiguous and an empirical question to which we now turn. The first step is to match business functions performed inside the industry to business functions produced by specialised services providers. Table 2 presents the matching. Bold italics highlights the label to be used for each function in the rest of the paper.

Table 2. Matching business functions to sectors

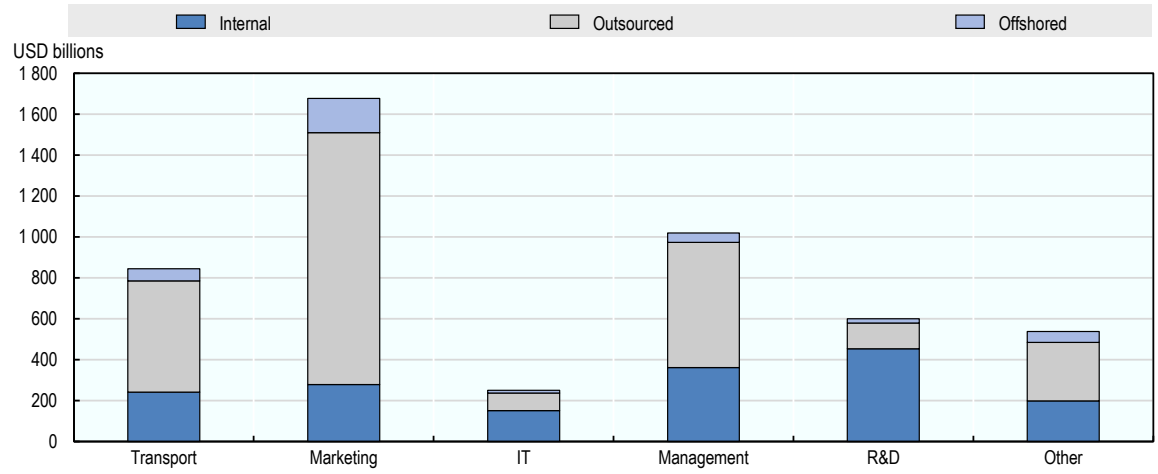
	Business function	Definition	Related sector (WIOD)
1	***Operations***/core business functions	The core/primary business function of the firm.	Materials
2	***Transport***, logistics and distribution support functions	A support function related to procurement, transportation, warehousing and the delivery of goods and services to customers.	H49-H53
3	***Marketing***, sales, after sales services	A support function related to market analysis, advertising, selling, retail management and customer services.	G45-47, M73
4	***IT*** services and software support	Activities related to data processing, software development and the provision of ICT services	J62-63
5	***Management***, administration and back-office support functions	Activities associated with the administration of the firm, including legal, finance, accounting and human resource management.	K64-66, M69-70
6	***R&D***, engineering and related technical services and R&D support functions	Activities related to experimental development, research, design, engineering and related technical consultancy, technical testing, analysis and certification.	M71-72
7	***Other*** business functions	Maintenance, repair, security, education and training.	N

Note: The definition of the seven business functions corresponds to those used in Eurostat and NOS surveys and applied by (Miroudot and Cadestin, 2017[2]) in their estimate of services functions performed inside manufacturing firms. The matching to ISIC Rev 4 sectors at the WIOD level of aggregation is our own.

The input from each services business function by source, i.e. internal, outsourced locally or offshored is depicted in Figure 6. It adds up earnings by internal employees and payments to local and foreign suppliers for each function for total manufacturing in all countries covered. As also depicted in Figure 2, local outsourcing is clearly the most important source of services functions. There are interesting differences across functions. Transport and marketing appear to be the furthest from the core, while R&D is the function most often provided in-house. Offshoring does not feature prominently for any of the services business functions, although as discussed in Section 2, offshoring is important in some sectors and some countries. In this section, we explore econometrically how a change in offshoring affects the level and composition of employment by business function in manufacturing.

Figure 6. Business functions by source

Total manufacturing 2014



Source: Own estimates based on WIOD (2016) and Miroudot and Cadestin (2017[2]).

The matching of business functions forms the basis for our measure of narrow offshoring. It is defined as the purchase from foreign suppliers of intermediate services that correspond to the in-house functions defined in Table 2 and illustrated in Figure 6. Two empirical strategies are frequently used for analysing the impact of offshoring on local labour market outcomes. The first focuses on the level of employment by worker category, for instance skills, while the second approach looks at the cost shares of different categories of labour inputs. The former is used for analysis of the impact of offshoring on the overall level of employment and labour productivity, while the latter is used for analysing structural changes in employment patterns. We employ both approaches in this study. The novelty we bring to the table is to analyse structural changes by business function, which we think reflects the real choices that businesses make. The technical details of our empirical strategy are explained in Box 2.

Box 2. Empirical strategy

To explore the labour market impact of services outsourcing and offshoring, we use standard trade and labour market analysis tools from the literature (Hijzen, Görg and Hine, 2005[12]; Foster-McGregor, Stehrer and de Vries, 2013[15]; Foster-McGregor, Poeschl and Stehrer, 2016[17]), but differs from theirs by breaking down labour into in-house business functions, rather than skill levels. Conditional labour demand controls for output, and thus scale effects and is the most frequently used in such analysis. It is a function of factor prices and output and derived from minimising costs subject to production technology. Offshoring enters the equation as a shift parameter, which means that for a given level of factor prices and output, offshoring may shift labour demand up or down, but it does not affect the elasticity of labour demand to factor prices or output. The conditional labour demand for function *f* in sector *i*, country *c* at time *t* can be written as follows:

$$lnl_{fict} = \alpha_0 + \sum_f \alpha_j lnw_{fict} + \beta_k lnk_{ict} + \beta_y lny_{ict} + \sum_l \gamma_l lnz_{ilct}$$

The first term is a constant while the second term contains the unit prices of the seven business functions presented in Table 1. The next two terms represent capital and output respectively. The last term denotes a set of demand shifters. These are local and foreign sourced intermediate services, the length of the value chain, technology indicators (ICT maturity and internet use) and policy variables (the OECD Product Market Regulation (PMR) indices for infrastructure-related services). To explore the possibility that offshoring may have a different marginal impact on labour demand depending on the policy and technology environment, we introduce interaction terms as shift parameters in a second set of regressions. The interaction terms are offshoring times the length of the value chain; offshoring times the weighted PMR; and offshoring times ICT maturity. Finally, an interaction term between ICT maturity and the PMR explores whether regulation has a different marginal effect on ICT mature sectors. Labour demand functions are estimated in five-year differences to reduce the sensitivity to measurement error as follows:

$$\Delta lnl_{fict} = \alpha_0 + \sum_f \alpha_j \Delta lnw_{fict} + \beta_k \Delta lnk_{ict} + \beta_y \Delta lny_{ict} + \sum_l \gamma_l \Delta lnz_{ilct} + \varepsilon_{fict}$$

However, the second set of regressions containing interaction terms is estimated in levels with country, year and industry fixed effects to control for unobserved country, sector or time-specific factors that could influence labour demand. This is necessary since interaction terms are not compatible with difference equations.

The cost share approach is particularly suitable for analysing structural changes in the labour market. Similar to the conditional labour demand functions it is derived from the cost function, which is assumed to take a trans-log form. This is convenient as differentiating a trans-log cost function with respect to factor prices applying Shepherd's lemma yields factor shares. The independent variables are the same as for the conditional labour demand function and the regression function now reads:

$$\Delta s_{fict} = \alpha_0 + \sum_f \varphi_j \Delta lnw_{fict} + \delta_k \Delta lnk_{ict} + \delta_y \Delta lny_{ict} + \sum_l \vartheta_l \Delta lnz_{ilct} + \varepsilon_{fict}$$

The dependent variable is the cost share in total variable costs of business function *f* in industry *i* country *c* at time *t*. We consider labour costs plus the cost of intermediate inputs as variable costs. Cost shares of each variable input are determined simultaneously and they must add up to unity. It is therefore natural to run the regressions simultaneously, using seemingly unrelated regressions (SUR) and drop one input function from the regressions to avoid over-identification. We have chosen to omit local intermediate inputs, so that we can study explicitly the shifts in cost shares among the seven business functions. Note that the narrow offshoring shift variables are specific to each business function. The make-or-buy decision can be studied within this framework as changes in "make" is reflected in the coefficients on the shift parameters, while the "buy" locally can be inferred from the outcome on the omitted variable cost component.

4.1. Results, conditional labour demand

We start our analysis by examining the relationship between local outsourcing and offshoring on conditional labour demand to assess their relative importance.[14] As one might expect from Figure 6, local outsourcing has a stronger impact on manufacturing employment than offshoring. Thus, 10% increase in local outsourcing over a five-year period is associated with 1% lower unit labour demand in manufacturing while a similar increase in offshoring reduces unit labour demand by 0.7%.[15] This result is similar to (Foster-McGregor, Stehrer and de Vries, 2013[15]) who found that domestic broad outsourcing has a larger impact on jobs than broad offshoring using the 2013 issue of WIOD.

The next step is to study the impact of broad local outsourcing and offshoring by business function. The results are depicted in Figure 7. Only offshoring has made an impact on manufacturing employment in marketing and IT functions, while only local outsourcing has diverted labour away from the transport, management and R&D functions. Interestingly, broad local outsourcing and offshoring appear to affect different business functions. Perhaps surprisingly, neither local outsourcing nor offshoring appear to affect manufacturing employment in other services functions. These are largely non-core services that are typically provided by outside suppliers. However, as we shall see below, other services functions are strongly impacted by narrow local outsourcing.

The results also point to interesting relationships between the seven business functions. For the most part, they are complementary to each other. The core operations function, for example, is complementary to all other functions.[16] If the wage rate for operations workers increases by 10% over a five-year period, unit demand for core operations workers declines by about 1%. All else equal, it also leads to a shift in the composition of services functions provided inside the manufacturing sector. Labour performing administrative functions bear the brunt of the cost rise, while R&D also suffer somewhat lower demand. In contrast, labour demand in transport and other services functions increase.

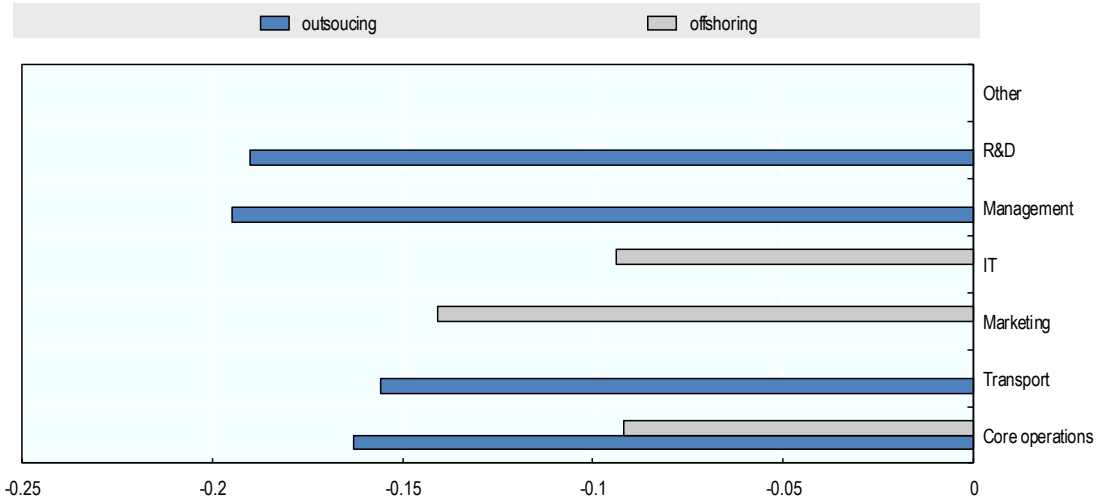
[14] By local services outsourcing we mean total services inputs from domestic suppliers as a share of value added in the sector, and similar for total services offshoring.

[15] See Annex Table B.1 for regression results. It is useful to start with basic analysis to make sure that that established results from the literature holds also for the 2016 release of WIOD. However, since this release does not have information on employment by skills, it is not possible to make more detailed comparison.

[16] Functions are gross substitutes when the cross price elasticity is positive and statistically significant, while they are gross complements when the cross price elasticity is negative and statistically significant. See Annex Table B.2.

Figure 7. Change in manufacturing employment by business function and broad outsourcing

Percentage point change over five years, 1 percentage point increase in offshoring or local outsourcing



Note: The figure depicts the statistically significant parameters from a SUR regression of employment by business function. The full regression results are reported in Annex Table B.2.

A possible story behind these results is that as operations workers become more expensive, manufacturing firms absorb the higher costs by local outsourcing, offshoring or scale back non-core functions such as management, IT and R&D.[17] Core operations workers, however, may not be easily substituted for. Instead, firms may save costs by narrowing the range of tasks that they perform. Operations workers often perform auxiliary tasks such as moving raw materials, parts and components between workstations, routine maintenance and repair. Such tasks being taken over by special transport and maintenance functions inside the manufacturing firms is consistent with the results reported in Annex Table B.2.[18]

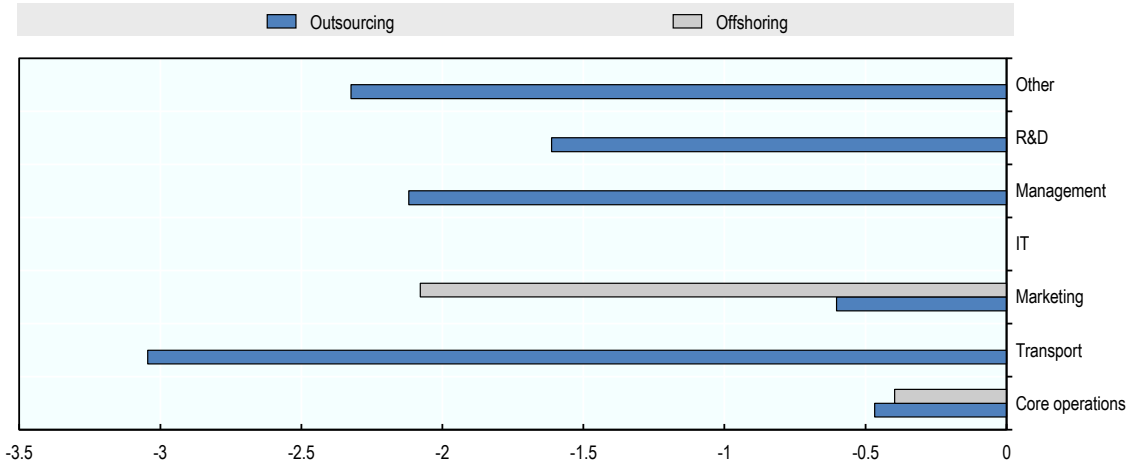
We now turn to the main econometric contribution of this paper, which is the study of narrow offshoring by business function. By narrow local outsourcing and offshoring, we mean matching the in-house functions to the corresponding services sectors as depicted in Table 2. The marginal impact of narrow local outsourcing is an order of magnitude larger than that of broad local outsourcing as can be seen by comparing Figure 7 and Figure 8.

[17] What is core and non-core depends on the manufacturing sector. R&D, for instance is close to the core in high-technology industries.

[18] It can also be more efficient and effective to have core production workers do auxiliary tasks as experience from quality circles suggests.

Figure 8. Change in manufacturing employment by business function and narrow outsourcing

Percentage point change over five years, 1 percentage point increase in offshoring or local outsourcing



Note: The figure depicts the statistically significant parameters from a SUR regression of employment by business function. The full regression results are reported in Annex Table B.3.

Narrow local outsourcing reduces unit labour demand in the corresponding services function inside the manufacturing sector for all functions except IT. Furthermore, it appears that offshoring of these functions reduces unit costs and improves labour productivity.[19] Local outsourcing of materials, on the other hand has a relatively small impact on employment in core operations. Finally, narrow offshoring only affects manufacturing employment in marketing and the core operations function.[20]

A preliminary answer to the question in the introduction would be that local outsourcing has a much more economically significant impact on employment in the manufacturing sector than has offshoring. Both local outsourcing and offshoring replace rather than support employment in manufacturing. The business functions most sensitive to narrow local outsourcing are transport and other business functions. These are also the only functions that are gross substitutes to core operations.[21] A reasonable interpretation consistent with the story above is that the border between transport and other business functions such as maintenance, repair, security and training and core processing is blurred. With rising wages in core operations, the border may become more distinct and auxiliary activities can be sliced off to specialised in-house functions, and next outsourced to outside suppliers.

We now turn to estimating the impact of narrow offshoring on the cost shares of each business function. Such estimates shed more light on structural changes in employment

[19] This can be seen from the regression results reported in Annex Table B.3. Unit labour demand goes down more than proportionally to additional expenditure on inputs purchased from external suppliers.

[20] The results are presented in Annex Table B.3.

[21] This can be seen from Annex Table B.2 where the elasticity of labour demand for transport (F2) and other business functions (F7) are positively related to the wage rate in core operations.

within manufacturing. Local outsourcing is not explicitly studied here because local intermediate inputs are included in variable costs (see Box 2 for a technical explanation).

4.2. Outsourcing, offshoring and cost shares of business functions

The first thing to notice when analysing the determinants of the cost share of different business functions in manufacturing is their resilience (see Annex Table B.4). Costs shares are relatively inelastic to changes in wages and to offshoring. This suggests that for the bulk of manufacturers, structural change evolves slowly.

The second observation is that the cost share of five out of seven business functions decline with rising output. In that case, the cost share of local intermediate inputs (the omitted variable input) must rise with growing output, consistent with the story of vertical disintegration in growing industries, and conversely vertical integration in contracting industries. Interestingly, the two exceptions are marketing and IT. Marketing is unaffected by scale, while the cost share of the IT function grows slightly with output.

The impact of offshoring on the structure of employment in manufacturing is modest. A statistically significant impact could only be identified for core operations, management and other services functions. Offshoring reduces the cost share of internal provision of these functions. For operations, the cost share declines less than employment (see previous section and compare Annex Table B.3 and Annex Table B.4), which suggests that manufactures keep their better skilled and experienced shop floor workers. For management, in contrast, offshoring has no significant impact on the level of employment, but reduces the cost share of the internal management function, which may suggest that offshoring tilt employment towards lower skilled workers or put downward pressure on wages in this function. As discussed in the introduction, firms typically keep a front desk to manage outside suppliers when they outsource a function. Our empirical finding is consistent with this story.

The modest average effect of offshoring on cost shares conceal some interesting patterns when drilling down into the details. In the following we look at the role of the length of the value chain, technology and policy in shaping the structural composition of business functions performed in manufacturing. In particular, we are interested in how the complexity of production, the regulatory environment and technology affect the sensitivity employment in manufacturing to offshoring of services functions.[22]

Costs shares and the length of the value chain

The length of the value chain is defined as the number of production stages therein. We use a measure of the length, which is calculated from input-output data in a similar way as backward linkages.[23] The length of the value chain turns out to be strongly related to the sourcing of intermediate inputs from outside suppliers as illustrated in Figure 9. This is not surprising, since it makes intuitively sense that a long value chain with many processing steps is associated with sourcing of inputs from outside the sector.

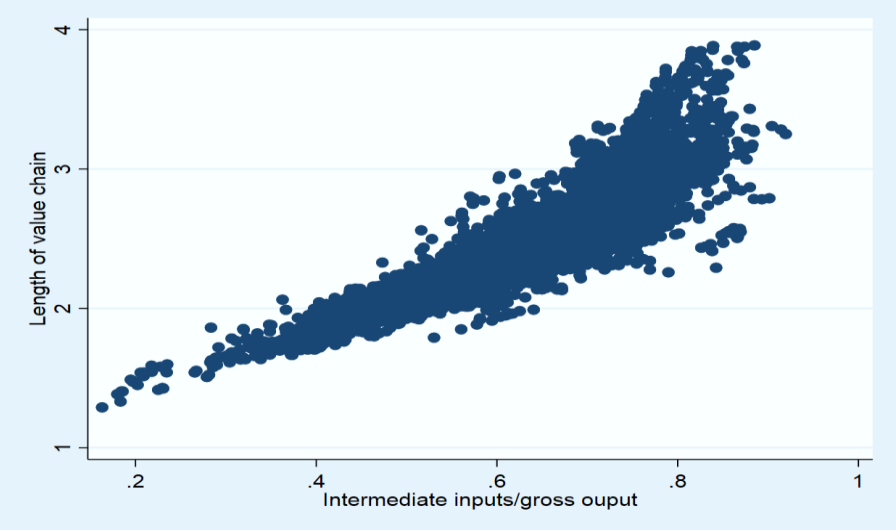
Nevertheless, the strong correlation is not a fundamental technical feature. One could think of a number of examples of short value chains with a high intermediate input content. Food

[22] Recall that previous studies have found that offshoring is associated with more elastic labour demand (Foster-McGregor, Poeschl and Stehrer, 2016[17]). The interaction terms capture this possibility in our analysis.

[23] See (De Backer and Miroudot, 2013[37]) for details.

processing, basic metals and 3-D printing comes to mind. Conversely, there are multi-stage sequential processing within a sector or a firm, resulting in a long value chain with a low share of intermediate inputs in gross output. Examples are some chemicals and pharmaceuticals.

Figure 9. Intermediate inputs and length of value chain, manufacturing



Note: All countries, all years
Source: WIOD; Mirodout and Cadestin (2017); own estimates

Given the pattern depicted in Figure 9, one would expect that the length of the value chain may not only affect the value added share in gross output, but also its composition. For instance, long value chains may require more coordination and could be associated with more use of services functions such as management, IT and logistics.

To explore this, we first introduce the length of the value chain as an additional shift parameter in the cost function.[24] The detailed results are reported in the Annex Table B.5. Here we note that longer value chains tilt the make-or-buy decision towards "buy" for all business functions, with the strongest effect on core operations and R&D.[25] The impact is nevertheless moderate. Thus, a 10% lengthening of the value chain over a five-year period is associated with between 2.6% (operations) and 0.2% (transport) reduction in the cost shares of internally provided functions over the same period.

We also note that the length of the value chain has a more widespread impact on the cost share of internal services functions than has offshoring. In fact, introducing the length of the value chain in the regressions changes the sign of the impact of offshoring from negative

[24] As depicted in Figure 9, there may be problems of multicollinearity between the length of the value chain and offshoring. However, although statistically significant at a 1% level, the correlation coefficient between services offshoring and the length of the value chain in manufacturing is only about 0.2.

[25] We notice that the direct impact is not statistically significant for management functions, but when introducing an interaction term with offshoring, reported in Annex Table B.6, also the direct effect turns statistically significant.

to positive for core operations (see Annex Table B.5).[26] Such a result suggest that the sensitivity of manufacturing employment to offshoring may depend on the length of the value chain. Interacting offshoring and the length of the value chain in the regression can test this. Table 3 reports the marginal effect of narrow offshoring on the cost share of the seven business functions in manufacturing at different lengths of the value chain.

Table 3. The marginal effect of narrow offshoring on the cost share of business functions

Conditioned on the length of the value chain

	Operations	Transport	Marketing	IT	Management	R&D	Other
Mean-0.5 standard deviation	0.20	-0.04		0.85	-0.15	0.03	-0.08
Mean	0.17	-0.02		0.85	-0.10	-0.12	-0.08
Mean + 0.5 standard deviation	0.15	0.01		0.85	-0.04	-0.27	-0.08

Note: The table reports the marginal effect of narrow offshoring at the mean, the mean less half of a standard deviation and the mean plus half a standard deviation of the length of the value chain. All coefficients are statistically significant at least at a 10% level. The underlying regression is a SUR trans-log costs functions with country, year and industry fixed effects, where offshoring and the length of the value chain are shift parameters alone and interacted reported in Annex Table B.6.
Source: Own estimates.

The results show quite interesting and complex patterns. First, as predicted, the sensitivity of local employment to offshoring indeed depends on the length of the value chain for most functions. Controlling for length, offshoring is significantly associated with the level of internal employment in all business functions except marketing, with a particularly strong effect for IT functions. The marginal effect of offshoring declines with the length of the value chain in core operations, transport and management, although the effect is small. Furthermore, the marginal effects on transport and management are small and negative in short value chains, but turn positive as the value chain becomes longer.[27] Employment in the R&D function in contrast is positively related to offshoring when value chains are short, but quickly turns negative as the value chain lengthens. Particularly the finding on the management and IT functions is interesting and supports the intuition that long and complex value chains require more in-house management and IT resources. The result appears to contradict the prediction from the literature that processes that are more complex are done in-house. It is however possible that complexity at the firm level does not correspond to the length of the value chain at the industry level. More research is needed to explore this.

Cost shares and regulation

The outcome of the make-or-buy decision depends on the relative importance of fixed and variable costs of each alternative. The literature, including previous OECD work, has demonstrated that the policy environment and regulation affect firms' cost of entry and operations (Sutherland et al., 2011[24]) and may have an impact on the relative costs and benefits of each outcome (Ariu et al., 2017[25]). It would be useful to explore all regulation that may have an impact on the fixed and variable cost of in-house provision of business functions versus the cost of offshoring them. Comparable policy indicators that covers the

[26] If introducing an additional variable to a regression changes the parameters of other regressors, the first regression could suffer from an omitted variable bias or the new regressor could be related to the variable for which the parameter change. As noted, the length of the value chain is not strongly correlated with offshoring, so we explore the possibility that the impact of offshoring on internal provision of business functions depends on the length of the value chain.

[27] The effect turns positive when the length of the value chain is 2.82 for management.

WIOD countries for the period 2000 to 2014 are not readily available. One of the few is the OECD Product Market Regulation (PMR) indicators. They are available for infrastructure-related services (electricity, gas, transport, post and telecommunications) for the entire period for most of the countries included in the WIOD database. The PMR takes values between zero and six with higher scores reflecting regulation that is more burdensome. They cover information on entry regulation, public ownership, vertical integration and market structure (Koske et al., 2015[26]). A drawback for the purpose of this study is that the PMR varies across countries and over time, but not across manufacturing sectors, which makes it hard to identify its impact. Another problem is that the PMR combines information on policies and outcomes and may pose endogeneity problems when used in regressions.[28]

We solve the first problem by creating sector-specific policy indices exploiting sector variation in the intensity of use of infrastructure services within and across countries. We first calculate the weight of infrastructure services in each manufacturing sector in a benchmark country and year (United States for 2000) based on the WIOD input-output tables and then multiply the sector-specific weights with the country-year specific PMR index to obtain a country-year-sector specific policy measure. The second problem is mitigated by using the entry regulation sub-indicator, which does not contain outcome measures (see the statistical annex for details).

Burdensome regulation is associated with a higher cost share of the core operations and management functions, and a lower cost share of the IT function inside manufacturing (see Annex Table B.7). Thus, the higher the score on the PMR, the more likely the outcome of the make-or-buy decision is to fall on "make". To put it differently, less burdensome regulation in infrastructure services is related to more local outsourcing and offshoring of production and administration from manufacturing, which is supported by strengthening the IT functions inside manufacturing. A possible channel through which policy affects the organisation of manufacturing is better performance in infrastructure services (Nordås and Kim, 2013[27]) such that more manufacturers are able to use the Internet for supporting and rationalising in-house functions and coordinating a more complex supply chain.

It is also interesting to explore whether offshoring has a different impact on manufacturing employment depending on the level of regulation. The result of this exercise is reported in Table 4.

Table 4. The marginal effect of narrow offshoring on the cost share of business functions

Conditioned on the PMR

Marginal effect at PMR	Operations	Transport	Marketing	IT	Management	R&D	Other
Mean - 0.5 std dev	0.132	-0.013	0.083	0.106		0.040	
Mean	0.129	0.010	0.069	0.168		-0.037	
Mean + 0.5 std dev	0.125	0.033	0.055	0.229		-0.114	

Note: The table reports the marginal effect of narrow offshoring at the mean, the mean less half of a standard deviation and the mean plus half a standard deviation of the PMR. All coefficients are statistically significant at least at a 10% level. The underlying regressions are SUR trans-log costs functions with country, year and industry fixed effects where offshoring and the PMR are shift parameters alone and interacted as reported in annex Table B.8.
Source: Own estimates.

[28] The outcome measures included in the PMR for network services that may create endogeneity problems are the number of firms that has entered the market and the market share of new entrants.

In absolute magnitude, the effects are quite small, but the pattern is interesting. Offshoring of core operations and marketing complements internal employment in the same functions, particularly at low levels of regulation. Offshoring also complements internal employment in IT and transport functions, in this case the more so the higher the PMR score. Offshoring of R&D services, on the other hand, substitutes for internal employment in R&D functions for most values of the PMR, and the effect increases with the level of the PMR. A possible explanation is that sourcing inputs from abroad requires in-house capacity to manage contracts with foreign suppliers. Moreover, the complexity and cost of integrating offshored functions into the local manufacturing process may be larger the poorer the quality of infrastructure services, particularly telecommunications. Box 3 reports the matching of business functions to STRI sectors. Since coverage of the STRIs only overlaps with WIOD for one year (2014), robust results could not be obtained. A more in depth policy analysis using the STRIs is therefore left to future research.

Cost shares and technology

We know from the literature that technology, particularly ICT, has had a large impact on both trade and employment. Most studies find that ICT is skills-biased, pushing up demand and relative wages for skilled workers. There are several indicators of ICT that could be used to explore the relationship between technology, offshoring and employment. Indicators available from the World Development Indicators (WDI) are telecommunications density, internet use and secure server density. Another available ICT technology indicator is the OECD ICT-maturity indicators (Calvino et al., 2018[28]). They characterise sectors by their investment in tangible ICT, software and the share of on-line sale in total sale. The indicators are available at the ISIC rev4 2-digit level and can thus be matched directly with the WIOD sectors. However, the indicators do not vary across countries and over time.[29] The advantage of the ICT maturity indicators over the WDI indicators is that the former build on surveys of firms in a number of countries and better capture differences across industries. We therefore use ICT maturity as our first choice and complement with robustness checks using the WDI indicators. We find that industries with a high score on the ICT-maturity index have a higher share of employment in services functions. Among the services functions, R&D and other services functions, which include training and education, stand out (see Annex Tables B.10-B.12 for details).

Table 5. Marginal effect of offshoring on manufacturing employment by business function

Conditioned on ICT maturity

	Operations	Transport	Marketing	IT	Management	R&D	Other
Mean - 0.5 standard deviations	0.086	0.048	0.061	1.107	0.051		
Mean	0.094	0.065	0.061	1.107	0.027		
Mean + 0.5 standard deviations	0.101	0.082	0.061	1.107	0.002		

Note: The table reports the marginal effect of narrow offshoring at the mean, mean less half of a standard deviation and the mean plus half a standard deviation of ICT maturity. All coefficients are statistically significant at least at a 10% level. The underlying regressions are SUR trans-log costs functions with country and year fixed effects where offshoring and ICT maturity are shift parameters, alone and interacted as reported in Annex Table B.11.
Source: Own estimates.

[29] Therefore, one cannot run difference regressions or use sector fixed effects when including the ICT maturity indictors as a shift parameter in conditional labour demand or trans-log cost functions.

Conditioned on ICT maturity, narrow offshoring supports core operations, transport, marketing, IT and management but has no discernible impact on R&D and other services functions. Core operations and transport are more sensitive to offshoring in more ICT mature industries, while management is less sensitive to offshoring in ICT mature sectors.

Policy and technology

We finally explore how policy and technology interact in shaping employment responses to offshoring. Does burdensome regulation have a stronger or weaker effect in more ICT-intensive sectors? The result of this exercise is reported in Table 6.

Table 6. Marginal effect of regulation on manufacturing cost shares by business function

Conditioned on ICT-maturity

	Operations	Transport	Marketing	IT	Management	R&D	Other
mean less 0.5 std. dev	0.041	-0.033	0.084	0.062	0.040	0.171	-0.019
Mean	-0.045	-0.033	0.092	0.057	0.028	0.124	-0.049
mean plus 0.5 std. dev	-0.130	-0.033	0.099	0.051	0.017	0.078	-0.080

Note: The table reports the marginal effect of the PMR at the mean, mean less half of a standard deviation and the mean plus half a standard deviation of ICT maturity. All coefficients are statistically significant at least at a 10% level. The underlying regressions are SUR trans-log costs functions with country and year fixed effects. The PMR and ICT maturity are shift parameters, alone and interacted as reported in Annex Table B.12.
Source: Own estimates.

Starting with the core operations functions, burdensome regulation appears to protect core operations in low-ICT mature industries, but turns negative with a larger marginal impact in more ICT-mature industries. Services functions in contrast, are protected by burdensome regulation and more so at low ICT maturity. The exceptions are transport and other services functions that are negatively affected at any level of ICT maturity, and marketing that is more sensitive to regulation at high ICT levels.

Box 3. Offshoring, employment and regulation measured by the STRI

The Services Trade Restrictiveness Indices (STRIs) are available for most of the countries included in the WIOD database and for all countries for which we have information on employment by function. Their strength as a policy shifter of labour demand by function is that the STRIs capture function-specific trade costs and thus a direct measure of the relative transaction costs of sourcing locally and offshoring. The mapping of STRIs, business functions and ISIC rev4 services categories are displayed in Table 7. They also have the advantage that endogeneity is much less of a problem than for the PMR, since the STRIs only include policy measures based on legislation in force.

Table 7. Matching business functions to services sectors and services sector regulation

	Business function	Related sector (WIOD)	Related sector (STRI)
1	***Operations***/core business functions	Materials	
2	***Transport***, logistics and distribution support functions	H49-H53	Transport and logistics
3	***Marketing***, sales, after sales services	G45-47, M73	Distribution services
4	***IT*** services and software support	J62-63	Computer services
5	***Management***, administration and back-office support functions	K64-66, M69-70	Professional services, accounting and legal
6	***R&D***, engineering and related technical services and R&D support functions	M71-72	Professional services, architecture and engineering
7	***Other*** business functions	N	

Note: The STRIs for transport and logistics are calculated as the simple average of air, maritime, rail, road and logistics.

The limitation of using the STRIs in the current analyses is that the time series of STRI starts in 2014, so there is only one year of overlap with the WIOD data. This makes it difficult to identify the effect.

4.3. Policy, technology, complexity and trade – which is it?

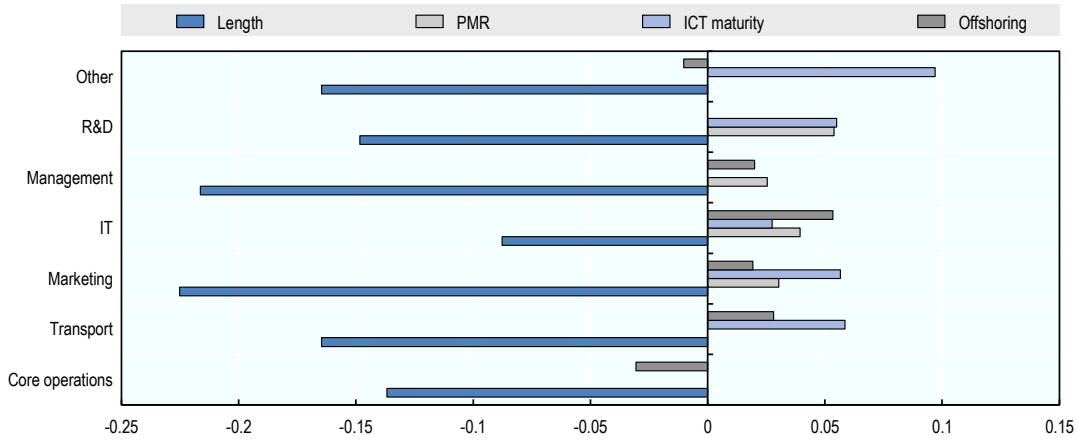
This section offers some preliminary estimates of the relative importance of technology, trade, complexity and policy in shaping employment patterns in manufacturing. The technology measure applied is the OECD ICT maturity indicators. We continue to use the PMR as our policy measure, and the length of the value chain as measure of complexity. Finally, sector and function-specific narrow offshoring as defined in Table 2 are used as the trade measure. The relative importance of these measures are studied by introducing all four of them as shift parameters, first in the conditional labour demand function and second in the trans-log cost function as described in Box 2.[30]

The four indicators are not measured at the same scale and cannot be compared directly. We therefore normalise them by their standard deviation and compare the impact of a change in half a standard deviation on conditional labour demand, and cost shares respectively. The results are presented in Figures 10 and 11. Bearing in mind that the impact of one of these may depend on the level of the others as illustrated in the previous sections, the results are not meant to pin down exactly how much each variable contributes to structural changes in manufacturing employment. Rather, the results indicate the direction, order of magnitude and relative importance of the indicators.

[30] Due to absence of time variation in the technology variable, the dependent variable is the log of employment by function in the conditional labour demand functions and the log of the cost share by function in the trans-log regressions.

Figure 10. Conditional labour demand by business function and changes in technology, complexity, offshoring and policy

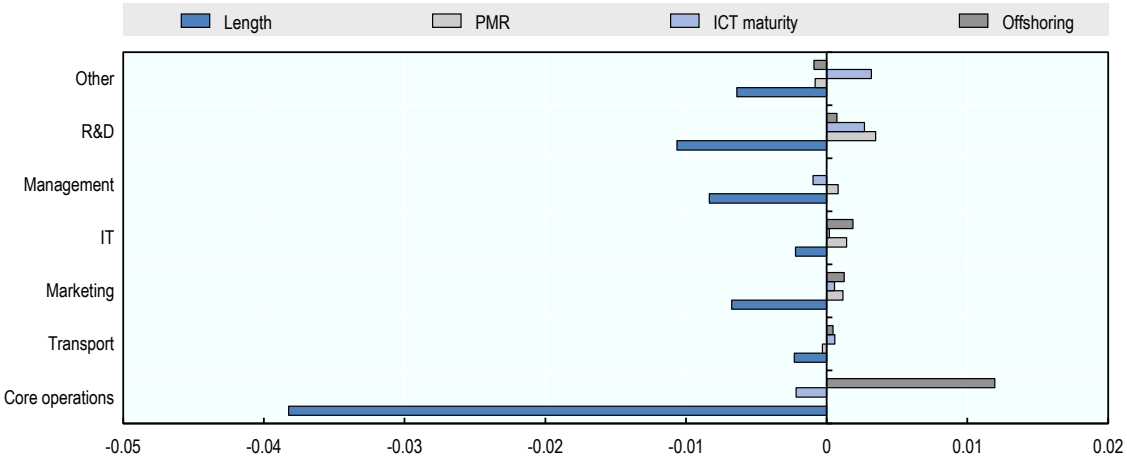
Changes following a 0.5 standard deviation increase in the shift parameter



Note: Based on the coefficients that are statistically significant at least at a 10% level. The chart shows the change in employment, keeping output constant, in percentages from a 0.5 standard deviation increase in each of the shift parameters.
Source: Own estimates.

Figure 11. Cost shares by business function and changes in technology, complexity, offshoring and policy

Changes following a 0.5 standard deviation increase in the shift parameter



Note: Based on the coefficients that are statistically significant at least at a 10% level. The chart shows the change in cost shares (of variable inputs), in percentages from a 0.5 standard deviation increase in each of the shift parameters.
Source: Own estimates.

With these caveats in mind, we can draw the following tentative conclusions:

- The functional composition as well as the overall level of employment in manufacturing are not strongly affected by offshoring, regulation, technology or complexity.
- Complexity (the length of the value chain) is by far the most important factor affecting the structure as well as the level of employment in manufacturing. A longer and more complex value chain is associated with less manufacturing employment in all functions. The largest effect in terms of workers per unit of output is in marketing and management functions, while the strongest effect in terms of cost shares is on the core operations function. Together these results point to higher labour productivity the longer the value chain.
- After having controlled for the length of the value chain, offshoring only has a small effect on employment. Interestingly, the impact on workers per unit of output is negative but the cost share is positive in the core operations function, suggesting a shift to higher-skilled tasks following material offshoring.
- Burdensome product market regulation in services may protect jobs in some services functions, and contribute to keeping the R&D function inside the manufacturing sector.
- Offshoring of IT functions seems to go together with more jobs in IT functions inside manufacturing, suggesting that offshored services complements the IT function in manufacturing.
- ICT-mature sectors are characterised by a lower cost and employment share in core operations and management, and a higher cost and employment share of R&D and other services functions, which presumably are related to training.[31]

From these conclusions, one can also infer that the main driver of employment in manufacturing is demand factors. To the extent that the four indicators analysed here can be distinguished from each other the answer to the "which is it" question is complexity, followed by technology and offshoring as a third.

[31] Information on the composition of business function 7 is not available, but education and training is part of it together with maintenance, repair, cleaning etc. Intuitively one would expect that education and training go together with ICT maturity.

5. Concluding remarks

This study has, for the first time, analysed offshoring and local outsourcing of services from manufacturing matching services functions inside manufacturing to services outsourced or offshored. Previous studies have defined narrow offshoring as imports of materials from the same sector, which does not capture the competition facing services workers inside manufacturing from outside suppliers. Given that on average about 40% of employment in manufacturing is in services functions with a slightly increasing trend over time, we have shed light on an important issue. The fact that our measure of narrow offshoring has a more significant effect on structural changes in manufacturing employment than the traditional measures, underscores the importance of this aspect.

Offshoring is associated with structural changes in manufacturing employment, but it appears that technology is a more important factor. Furthermore, the sensitivity of manufacturing jobs to offshoring depends strongly and in complex ways on the level of ICT-maturity in the sector, internet use, the complexity of the value chain and on policy. When taking policy, technology and complexity into account, offshoring support and complement some services functions in manufacturing, particularly IT services, but may substitute for management and other services functions. Offshoring is complementary to manufacturing employment particularly when value chains are long and complex.

Burdensome regulation in key services sectors comes at the expense of lower labour productivity in manufacturing. To the extent that burdensome regulation appears to mitigate labour market adjustment in some core operations, it is to the detriment of employment in higher earning business functions. This finding demonstrates a regulatory spillover from services to manufacturing, an important area for future analysis matching the STRIs with recent data on trade and production.

Insights from this study with policy implications are, first, regulation in services has implications for employment in manufacturing through tilting the make-or-buy decision towards “make”, also when “buy” would yield higher labour productivity and better export performance. Burdensome product market regulations in services are unlikely to halt or reverse the rise of services, although a modest regulatory burden might hold back structural transformation from core operations to services in sectors with a low degree of ICT maturity. Second, the shift towards services employment not only in services sectors, but also inside the manufacturing sector, is largely technology-driven in a broad sense counting both ICT and the length of value chains as technology-related.

The econometric analysis in this study applies the WIOD database and the PMR indicators for regulation. Future work could study the linkages between manufacturing, service inputs and employment using the TiVA database, which provides information on more countries and the STRIs as policy shifters. This would be particularly useful for a more detailed analysis of which policies protect which jobs at what costs in terms of productivity and competitiveness of manufacturing. Firm level analysis linking imports of services to innovation, exports and jobs in manufacturing is also a promising avenue for gaining better understanding of how goods and services complement each other and how policy targeting one affects the other. Further work would also address possible endogeneity and identification problems.

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Annex A. Summary statistics

Table A.1. Summary statistics, jobs and earnings by function

Employment, Thousands					
	Observations	Mean	Std. dev	Min	Max
Operations	10 530	109.6	377.3	0	10 195.8
Transport	10 530	9.7	27.2	0	433.4
Marketing	10 530	7.6	23.4	0	659.4
IT	10 530	1.6	6.2	0	156.0
Management	10 530	16.9	53.7	0	1 560.5
R&D	10 530	7.9	20.9	0	320.1
Other	10 530	10.1	26.3	0	607.3
Average hourly wages, USD					
Operations	8 366	18.5	18.2	0.0	537.0
Transport	7 848	16.5	14.4	0.1	381.3
Marketing	7 603	31.1	31.6	0	748.7
IT	6 219	52.3	211.4	0	10 806.4
Management	8 104	25.5	21.5	0.02	387.0
R&D	7 794	41.0	262.4	0	19 048.7
Other	7 993	17.5	19.3	0	669.4

Note: The descriptive statistics refer to manufacturing employment all years 2000-2014. Extreme values on hourly wages are due to poor information on earnings and are dropped in the regressions.

Table A.2. Summary statistics, outsourcing and offshoring, shares of value added

Outsourcing	Observations	Mean	Std. dev	Min	Max
Operations	11 385	0.793	0.606	0.000	4.914
Transport	11 385	0.083	0.071	0.000	0.806
Marketing	11 385	0.222	0.168	0.000	4.502
IT	11 385	0.008	0.010	0.000	0.159
Management	11 385	0.068	0.048	0.000	0.728
R&D	11 385	0.015	0.026	0.000	0.422
Other	11 385	0.032	0.032	0.000	0.345
Offshoring					
Operations	11 385	0.603	0.488	0.019	7.403
Transport	11 385	0.017	0.021	0.000	0.324
Marketing	11 385	0.036	0.043	0.001	0.646
IT	11 385	0.002	0.004	0.000	0.117
Management	11 385	0.012	0.018	0.000	0.254
R&D	11 385	0.004	0.011	0.000	0.232
Other	11 385	0.009	0.042	0.000	1.423

Note: The descriptive statistics cover manufacturing for all years 2000-2014.

Table A.3. Weights of the PMR for infrastructure services

Industry	PMR infrastructure
C10T12	0.134
C13T15	0.034
C16	0.028
C17	0.070
C18	0.051
C19	0.460
C20	0.103
C21	0.041
C22	0.071
C23	0.038
C24	0.091
C25	0.166
C26	0.136
C27	0.041
C28	0.084
C29	0.114
C30	0.073
C31T32	0.026
C33	0.007

The PMR for infrastructure services are aggregated from individual indices for transport, electricity, post and telecommunications. The weights to obtain sector-specific PMRs for each WIOD manufacturing sector is derived from the sum of the coefficient for transport, electricity, gas, post and telecommunications in the inverse Leontief matrix for the United States in the year 2000. These weights reflect the direct and indirect importance of infrastructure services in each sector. The weights from the US inverse Leontief matrix in the first year of the analysis is used to mitigate possible endogeneity problems. Ideally, we should use the Leontief matrix from 1999, but this is not readily available at a comparable format to the 2016 issue of WIOD.

Annex B. Regression results

Table B.1. Conditional labour demand, total employment

5-year differences, manufacturing, broad services local outsourcing and offshoring

	Δ ln wage	Δ ln price int.	Δ ln capital	Δ ln gross output	Δ ln price final output	Δ ln outsourcing	Δ ln offshoring
coefficient	-0.641***	-0.089**	-0.040***	0.539***	-0.073	-0.113***	-0.075***
std. dev.	(0.008)	(0.045)	(0.003)	(0.009)	(0.048)	(0.008)	(0.009)
R^2	0.531						
N	7540						

Note: A Five-year difference regressions. Robust standard errors are reported in parentheses and ***, ** and * represent statistical significance at 1%, 5% and 10% level respectively. Dependent variable is labour demand measured in total hours worked and wages are hourly wages.

Table B.2. Labour demand by function and broad outsourcing and offshoring

	F1	F2	F3	F4	F5	F6	F7
Δ ln wage 1	-0.105***	0.361***	0.007	-0.124	-0.462***	-0.124*	0.169**
	(0.030)	(0.064)	(0.080)	(0.087)	(0.057)	(0.064)	(0.066)
Δ ln wage 2	-0.035**	-0.363***	-0.026	0.058	0.026	-0.02	-0.037
	(0.018)	(0.038)	(0.048)	(0.051)	(0.034)	(0.038)	(0.039)
Δ ln wage 3	-0.040***	0.008	-0.223***	-0.036	0.028*	-0.01	-0.065***
	(0.009)	(0.019)	(0.023)	(0.025)	(0.017)	(0.019)	(0.019)
Δ ln wage 4	-0.034***	-0.040***	-0.044**	-0.344***	-0.012	-0.027*	-0.027*
	(0.007)	(0.015)	(0.018)	(0.020)	(0.013)	(0.015)	(0.015)
Δ ln wage 5	-0.093***	-0.069**	-0.090**	-0.080**	-0.245***	-0.124***	0.007
	(0.014)	(0.030)	(0.037)	(0.040)	(0.027)	(0.030)	(0.031)
Δ ln wage 6	-0.021***	-0.017	-0.042*	-0.034	-0.011	-0.250***	-0.004
	(0.008)	(0.018)	(0.022)	(0.024)	(0.016)	(0.018)	(0.018)
Δ ln wage 7	-0.064***	-0.076***	0.019	-0.058	0.013	-0.050*	-0.293***
	(0.012)	(0.026)	(0.033)	(0.036)	(0.024)	(0.026)	(0.027)
Δ ln price intermediate inputs	0.272***	0.167	-0.840***	0.178	0.471**	0.208	0.025
	(0.104)	(0.223)	(0.282)	(0.305)	(0.201)	(0.224)	(0.232)
Δ ln Capital	-0.026***	0.016	0.023	-0.068***	-0.012	-0.025	0.030*
	(0.008)	(0.017)	(0.022)	(0.023)	(0.015)	(0.017)	(0.018)
Δ ln Gross output	0.458***	0.239***	0.379***	0.481***	0.284***	0.378***	0.238***
	(0.025)	(0.054)	(0.069)	(0.074)	(0.049)	(0.054)	(0.056)
Δ ln final output price	-0.456***	-0.564**	0.37	-0.445	-0.746***	-0.491**	-0.543**
	(0.111)	(0.238)	(0.300)	(0.324)	(0.213)	(0.238)	(0.246)
Δ ln services outsourcing	-0.163***	-0.156***	0.042	-0.097	-0.195***	-0.190***	-0.006
	(0.023)	(0.050)	(0.063)	(0.068)	(0.045)	(0.050)	(0.052)
Δ ln services offshoring	-0.092***	-0.051	-0.141***	-0.094*	-0.052	-0.02	-0.067
	(0.019)	(0.041)	(0.052)	(0.056)	(0.037)	(0.041)	(0.043)
R^2	0.18	0.061	0.052	0.107	0.089	0.094	0.063
N	2829	2829	2829	2829	2829	2829	2829

Note: A Five-year difference regressions. Robust standard errors are reported in parentheses and ***, ** and * represent statistical significance at 1%, 5% and 10% level respectively. Dependent variable is labour demand by function measured in total hours worked and wages are hourly wages by function.

Table B.3. Labour demand by function, narrow outsourcing and offshoring

	F1	F2	F3	F4	F5	F6	F7
Δ ln outsourcing	-0.468***	-3.045***	-0.603*	3.359	-2.119***	-1.613**	-2.324**
	(0.04)	(0.43)	(0.25)	(2.68)	(0.32)	(0.59)	(0.78)
Δ ln offshoring	-0.397***	0.073	-2.078***	-6.628	-0.547	-0.788	-0.444
	(0.05)	(0.91)	(0.59)	(6.79)	(1.04)	(1.20)	(0.56)
R^2	0.217	0.074	0.056	0.105	0.097	0.090	0.066
N	2829	2829	2829	2829	2829	2829	2829

Note: Five-year difference regressions. Robust standard errors are reported in parentheses and ***, ** and * represent statistical significance at 1%, 5% and 10% level respectively. Dependent variable is labour demand by function measured in total hours worked and wages are hourly wages by function.

Table B.4. Trans-log cost functions and narrow offshoring by business function, manufacturing

	F 1	F 2	F 3	F 4	F 5	F 6	F 7
Δ.ln wage 1	0.077***	-0.002	-0.010***	0.002	-0.031***	-0.006	0.009***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Δ.ln wage 2	0	0.020***	-0.002	-0.002*	0	0.001	-0.003**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Δ.ln wage 3	-0.004**	-0.001	0.012***	-0.004***	0.001	0	-0.002***
	(0.00)	0.00	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Δ.ln wage 4	0	-0.001***	-0.002**	0.009***	0	-0.001	-0.001
	(0.00)	0.00	(0.00)	0.00	(0.00)	(0.00)	0.00
Δ.ln wage 5	-0.005*	-0.004***	-0.001	-0.003***	0.030***	-0.005***	0
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Δ.ln wage 6	0	-0.001**	-0.002*	-0.006***	-0.001	0.014***	-0.001
	(0.00)	0.00	(0.00)	(0.00)	(0.00)	(0.00)	0.00
Δ.ln wage 7	-0.004*	-0.003***	0.003**	-0.005***	0.001	-0.006***	0.011***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Δ.ln price intermediate inputs	0.003	0.006	-0.032**	-0.005	-0.006	0.012	-0.003
	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Δ.ln capital	-0.001	0.001**	0	0	0	0.001	0.002***
	(0.00)	0.00	(0.00)	0.00	(0.00)	(0.00)	0.00
Δ.ln gross output	-0.042***	-0.009***	-0.003	0.005***	-0.017***	-0.013***	-0.011***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Δ.ln price final output	0.008	-0.008	0.023*	0.001	-0.003	-0.015	-0.003
	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Δ.ln offshoring	-0.021**	-0.01	-0.033	0.024	-0.893***	-0.055	-0.038**
	(0.01)	(0.02)	(0.02)	(0.12)	(0.05)	(0.06)	(0.01)
R^2	0.150	0.158	0.086	0.223	0.215	0.105	0.119
N	2829	2829	2829	2829	2829	2829	2829

Note: Five-year difference regressions. Robust standard errors are reported in parentheses and ***, ** and * represent statistical significance at 1%, 5% and 10% level respectively. Dependent variable is cost share of labour by business function in variable costs.
Source: Own estimates.

Table B.5. The length of the value chain and the structure of employment in manufacturing.

	F 1	F2	F3	F4	F5	F6	F7
Δ ln Length	-0.264***	-0.018**	-0.038***	-0.038***	0.004	-0.090***	-0.020**
	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Δ ln narrow offshoring	0.058***	-0.002	-0.023	0.214	-0.908***	0.019	-0.032*
	(0.01)	(0.02)	(0.02)	(0.12)	(0.05)	(0.06)	(0.01)
R^2	0.188	0.161	0.090	0.230	0.215	0.122	0.122
N	2829	2829	2829	2829	2829	2829	2829

Note: SUR five-year difference regressions. Robust standard errors are reported in parentheses and ***, ** and * represent statistical significance at 1%, 5% and 10% level respectively. Dependent variable is cost share of labour by business function in variable costs. The other regressors are omitted for brevity, but the coefficients are very similar to those reported in Table B.4.

Table B.6. Length interacted with offshoring

	F1	F2	F3	F4	F5	F6	F7
ln length	-0.394***	-0.029***	-0.077***	-0.033***	-0.091***	-0.128***	-0.043***
	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)
ln narrow offshoring	0.406***	-0.272***	0.088	0.850**	-0.662***	1.404***	-0.075*
	(0.02)	(0.06)	(0.05)	(0.32)	(0.15)	(0.20)	(0.03)
ln length * ln offshoring	-0.263***	0.284***	-0.02	-0.608	0.635***	-1.714***	0.056
	(0.02)	(0.06)	(0.05)	(0.33)	(0.14)	(0.23)	(0.03)
R^2	0.797	0.493	0.566	0.624	0.678	0.721	0.689
N	5887	5887	5887	5887	5887	5887	5887

Note: SUR regressions with country, sector and year fixed effects. Robust standard errors are reported in parentheses and ***, ** and * represent statistical significance at 1%, 5% and 10% level respectively. Dependent variable is cost share of labour by business function in variable costs. The other regressors are omitted for brevity.

Table B.7. Policy and the structure of employment in manufacturing

	F1	F2	F3	F4	F5	F6	F7
Δ ln Length	-0.259***	-0.018**	-0.048***	-0.047***	0.014	-0.085***	-0.018*
	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Δ PMR infrastructure	0.189*	0.014	0.079	-0.160***	0.127*	0.044	-0.009
	(0.08)	(0.03)	(0.05)	(0.03)	(0.05)	(0.06)	(0.03)
Δ ln narrow offshoring	0.058***	-0.004	-0.047*	0.343	-1.074***	-0.049	-0.033*
	(0.01)	(0.02)	(0.02)	(0.19)	(0.05)	(0.06)	(0.01)
R^2	0.175	0.091	0.092	0.189	0.209	0.098	0.092
N	2262	2262	2262	2262	2262	2262	2262

Note: SUR five-year difference regressions. Robust standard errors are reported in parentheses and ***, ** and * represent statistical significance at 1%, 5% and 10% level respectively. Dependent variable is cost share of labour by business function in variable costs. The other regressors are omitted for brevity.

Table B.8. Policy interacted with offshoring

	F1	F2	F3	F4	F5	F6	F7
ln Length	-0.429***	-0.025***	-0.074***	-0.032***	-0.076***	-0.154***	-0.048***
	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)
PMR	-0.046	-0.007	0.004	-0.035***	0.003	0.001	-0.053***
	(0.04)	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)
ln offshoring	0.138***	-0.053***	0.108***	-0.024	-0.027	0.175**	-0.009
	(0.01)	(0.02)	(0.02)	(0.12)	(0.04)	(0.06)	(0.01)
PMR infrastructure * ln offshoring	-0.142**	0.978***	-0.604***	2.597**	-0.094	-3.282***	-0.257
	(0.05)	(0.20)	(0.15)	(1.00)	(0.38)	(0.60)	(0.15)
R2	0.788	0.470	0.572	0.645	0.704	0.742	0.691
N	4698	4698	4698	4698	4698	4698	4698

Note: SUR regressions with country, sector and year fixed effects. Robust standard errors are reported in parentheses and ***, ** and * represent statistical significance at 1%, 5% and 10% level respectively. Dependent variable is cost share of labour by business function in variable costs. The other regressors are omitted for brevity.

Table B.9. Technology and the structure of employment in manufacturing, ICT maturity

	F1	F2	F3	F4	F5	F6	F7
ln Length	-0.429***	-0.030***	-0.074***	-0.022***	-0.094***	-0.095***	-0.076***
	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)
ln offshoring	0.091***	0.043***	0.068***	0.915***	0.042	0.169***	-0.050***
	(0.01)	(0.01)	(0.01)	(0.05)	(0.03)	(0.03)	(0.01)
ICT maturity	-0.249***	0.067***	0.065***	0.034***	-0.086***	0.280***	0.311***
	(0.04)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)
R2	0.610	0.420	0.513	0.412	0.603	0.459	0.268
N	5887	5887	5887	5887	5887	5887	5887

Note: SUR regressions with country and year fixed effects. Robust standard errors are reported in parentheses and ***, ** and * represent statistical significance at 1%, 5% and 10% level respectively. Dependent variable is cost share of labour by business function in variable costs. The other regressors are omitted for brevity.

Table B.10. Technology and the structure of employment in manufacturing, internet use

	F1	F2	F3	F4	F5	F6	F7
Δ ln Length	-0.264***	-0.018**	-0.038***	-0.038***	0.005	-0.089***	-0.020**
	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Δ ln internet use	-0.163**	0.003	-0.044	0.071**	-0.064	-0.111*	0.036
	(0.06)	(0.02)	(0.04)	(0.03)	(0.04)	(0.04)	(0.02)
Δ ln narrow offshoring	0.059***	-0.002	-0.023	0.214	-0.912***	0.024	-0.032*
	(0.01)	(0.02)	(0.02)	(0.12)	(0.05)	(0.06)	(0.01)
R^2	0.190	0.161	0.090	0.232	0.215	0.124	0.123
N	2829	2829	2829	2829	2829	2829	2829

Note: SUR five-year difference regressions. Robust standard errors are reported in parentheses and ***, ** and * represent statistical significance at 1%, 5% and 10% level respectively. Dependent variable is cost share of labour by business function in variable costs. The other regressors are omitted for brevity.

Table B.11. Technology interacted with offshoring

	F1	F2	F3	F4	F5	F6	F7
Ln Length	-0.416***	-0.030***	-0.074***	-0.022***	-0.094***	-0.095***	-0.075***
	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)
Ln offshoring	-0.008	-0.135**	0.061*	1.107**	0.316**	0.289	0.009
	(0.02)	(0.04)	(0.03)	(0.34)	(0.10)	(0.25)	(0.06)
ICT maturity	-0.638***	0.043***	0.063***	0.037***	-0.061***	0.285***	0.316***
	(0.07)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)
ICT maturity * ln offshoring	0.804***	1.721***	0.065	-1.664	-2.488**	-1.059	-0.544
	(0.12)	(0.41)	(0.25)	(2.93)	(0.83)	(2.27)	(0.53)
R2	0.614	0.423	0.513	0.412	0.604	0.459	0.268
N	5887	5887	5887	5887	5887	5887	5887

Note: SUR regressions with country and year fixed effects. Robust standard errors are reported in parentheses and ***, ** and * represent statistical significance at 1%, 5% and 10% level respectively. Dependent variable is cost share of labour by business function in variable costs. The standard regressors are omitted for brevity.

Table B.12. Technology interacted with policy

	F1	F2	F3	F4	F5	F6	F7
ln Length	-0.431***	-0.026***	-0.075***	-0.025***	-0.095***	-0.122***	-0.074***
	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)
ICT maturity	0.542***	0.045**	-0.013	0.066***	0.002	0.690***	0.596***
	(0.08)	(0.01)	(0.03)	(0.02)	(0.02)	(0.04)	(0.04)
PMR	0.979***	-0.033*	-0.039	0.120***	0.163***	0.677***	0.311***
	(0.09)	(0.02)	(0.03)	(0.02)	(0.03)	(0.05)	(0.04)
ICT maturity * PMR	-8.801***	0.173	0.788**	-0.544***	-1.158***	-4.752***	-3.099***
	(0.76)	(0.14)	(0.25)	(0.16)	(0.24)	(0.41)	(0.36)
Ln offshoring	0.095***	0.045***	0.064***	0.934***	0.044	0.133***	-0.055***
	(0.01)	(0.01)	(0.01)	(0.05)	(0.03)	(0.03)	(0.01)
R2	0.603	0.401	0.520	0.430	0.627	0.522	0.288
N	4698	4698	4698	4698	4698	4698	4698

Note: SUR regressions with country and year fixed effects. Robust standard errors are reported in parentheses and ***, ** and * represent statistical significance at 1%, 5% and 10% level respectively. Dependent variable is cost share of labour by business function in variable costs. The standard regressors are omitted for brevity.

Table B.13. Combining all the shift parameters in one regressions

Conditional labour demand

	lnL1	lnL2	lnL3	lnL4	lnL5	lnL6	lnL7
Ln wage 1	-1.614***	-0.549***	0.004	0.326***	-0.536***	0.775***	-0.004
	(0.04)	(0.05)	(0.05)	(0.05)	(0.04)	(0.05)	(0.06)
Ln wage 2	0.311***	-0.269***	0.071	-0.242***	-0.059	-0.563***	-0.370***
	(0.04)	(0.04)	(0.05)	(0.04)	(0.03)	(0.05)	(0.06)
Ln wage 3	-0.068***	-0.140***	-0.588***	0.120***	-0.090***	0.352***	0.240***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)
Ln wage 4	-0.047*	0.095***	-0.045	-0.324***	-0.118***	-0.204***	-0.007
	(0.02)	(0.03)	(0.03)	(0.03)	(0.02)	(0.03)	(0.03)
Ln wage 5	-0.024	0.135***	0.065	-0.096*	-0.001	-0.241***	-0.321***
	(0.03)	(0.04)	(0.04)	(0.04)	(0.03)	(0.04)	(0.05)
Ln wage 6	0.234***	0.072**	0.167***	0.067*	0.055**	-0.449***	-0.015
	(0.02)	(0.03)	(0.03)	(0.03)	(0.02)	(0.03)	(0.03)
Ln wage 7	-0.259***	-0.183***	-0.328***	0.094**	-0.109***	0.318***	-0.036
	(0.03)	(0.03)	(0.04)	(0.04)	(0.03)	(0.04)	(0.04)
Ln price intermediate inputs	-0.209	-0.175	-0.396**	0.02	0.222*	0.320*	0.476**
	(0.11)	(0.13)	(0.15)	(0.13)	(0.11)	(0.15)	(0.17)
Ln Capital	-0.324***	-0.182***	-0.118***	-0.037*	-0.178***	-0.040*	-0.248***
	(0.01)	(0.01)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)
Ln gross output	1.108***	0.782***	0.666***	0.308***	0.768***	0.594***	0.810***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Ln price final goods	-0.143	-0.081	0.192	0.263*	-0.340**	-0.189	-0.245
	(0.11)	(0.13)	(0.15)	(0.13)	(0.10)	(0.15)	(0.17)
Ln Length	-1.541***	-1.855***	-2.538***	-0.988***	-2.438***	-1.672***	-1.855***
	(0.10)	(0.09)	(0.11)	(0.09)	(0.07)	(0.10)	(0.12)
PMR	-0.271	-0.014	1.286***	1.666***	1.076***	2.283***	0.132
	(0.14)	(0.17)	(0.20)	(0.18)	(0.14)	(0.19)	(0.22)
ICT maturity	-0.076	6.008***	5.814***	2.820***	0.362	5.642***	9.955***
	(0.27)	(0.32)	(0.36)	(0.32)	(0.25)	(0.36)	(0.41)
Ln offshoring	-0.248***	2.823***	0.991***	26.850***	2.361***	0.635	-0.631**
	(0.03)	(0.37)	(0.25)	(1.85)	(0.51)	(0.48)	(0.20)
R2	0.936	0.884	0.823	0.640	0.918	0.820	0.801
N	4698	4698	4698	4698	4698	4698	4698

Note: SUR regressions with country and year fixed effects. Robust standard errors are reported in parentheses and ***, ** and * signify statistical significance at 1%, 5% and 10% level respectively.

Table B.14. Combining all the shift parameters in one regressions

SUR trans-log cost functions.

	F1	F2	F3	F4	F5	F6	F7
Ln wage 1	-0.081***	-0.012***	0.003	0.004**	-0.018***	0.027***	0.012***
	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Ln wage 2	0.041***	0.017***	0.003	-0.002*	-0.010***	-0.031***	-0.018***
	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Ln wage 3	-0.008**	-0.002***	0.005***	-0.001	-0.002**	0.023***	0.007***
	(0.00)	0.00	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Ln wage 4	-0.006	0.001	-0.003**	0.008***	-0.008***	-0.007***	-0.003*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Ln wage 5	0.024***	-0.004***	-0.005**	-0.007***	0.037***	-0.016***	-0.011***
	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Ln wage 6	-0.010***	0	0.005***	0.001	0.002	0.012***	-0.002
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Ln wage 7	-0.026***	-0.001	-0.005***	0.003**	-0.002	0.020***	0.029***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Ln price intermediate inputs	-0.022	-0.001	-0.009	0.009**	0.009	0.036***	0.019**
	(0.02)	(0.00)	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)
Ln capital	-0.039***	-0.002***	0	0.002***	-0.003***	0.005***	-0.009***
	(0.00)	0.00	(0.00)	0.00	(0.00)	(0.00)	(0.00)
Ln gross output	0.025***	0.001	-0.002**	-0.004***	-0.002**	-0.010***	0.005***
	(0.00)	0.00	(0.00)	0.00	(0.00)	(0.00)	(0.00)
Ln price final output	-0.015	-0.001	0.003	-0.002	-0.011*	-0.031***	-0.005
	(0.02)	(0.00)	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)
Ln Length	-0.431***	-0.026***	-0.076***	-0.025***	-0.094***	-0.120***	-0.072***
	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)
PMR	-0.002	-0.013***	0.049***	0.060***	0.034***	0.147***	-0.035***
	(0.02)	(0.00)	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)
ICT maturity	-0.224***	0.060***	0.056***	0.019*	-0.099***	0.276***	0.326***
	(0.04)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)
Ln offshoring	0.097***	0.045***	0.064***	0.935***	0.045	0.141***	-0.056***
	(0.01)	(0.01)	(0.01)	(0.05)	(0.03)	(0.03)	(0.01)
R^2	0.591	0.401	0.519	0.429	0.625	0.508	0.277
N	4698	4698	4698	4698	4698	4698	4698

Note: SUR regressions with country and year fixed effects. Robust standard errors are reported in parentheses and ***, ** and * signify statistical significance at 1%, 5% and 10% level respectively.