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The Increasing Service Intensity of European Manufacturing

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Abstract

This paper investigates the impact of the increase in service output on the demand for different categories of service occupations in the EU manufacturing sector. Furthermore, we investigate the impact of the global sourcing of producer services on the demand for different service occupations. Using fixed-effects models based on the manufacturing sector for 18 EU countries for the period 1995-2008, we find that the employment share of service occupations is significantly and positively related to the output share of producer services in manufacturing. In particular, the increase in the output share of services accounts for an average of 13 percent of the increase in the share of service occupations. When service occupations are disaggregated by different categories, we find that the output share of services is significantly and positively related to the share of managers, professionals, and technicians. In contrast, service occupations involving clerks, administrative support, and other office-related personnel do not benefit from increasing service revenues. Finally, professionals and technicians are complementary to intermediate producer services (either from domestic or foreign suppliers), while clerks do not benefit from the rise in intermediate service inputs in manufacturing.

Keywords: service occupations, servitization, intermediate service inputs, global sourcing, manufacturing sector

JEL Classification: F14, L8, O11.

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1. Introduction

The interaction between manufacturing and services has increased rapidly in recent decades (Bryson & Daniels, 2010; Francois & Woerz, 2008; Pilat & Woelfl, 2005). On the output side, manufacturing firms are increasingly offering services in combination with their products (Neely, 2008). Indeed, data based on EU and OECD input-output tables shows that in the EU-15, the share of producer services in total manufacturing output increased by about one percentage point between 1995-2007. On the input side, we have observed an increase in the share of intermediate service inputs from abroad. This indicates that firms are benefiting increasingly from the global sourcing of producer services. Furthermore, there has been a strong increase in the share of service occupations in the manufacturing sector, showing a widespread shift in the production process towards service functions. Data based on the European Union Labour Force Survey (EU-LFS) for the manufacturing sector in the EU-15 shows that the share of service occupations rose from 37 to 42 per cent between 1993 and 2008. However, this increase was uneven across different categories of service occupations. While there was a strong increase in the employment share of supervisors, professionals, and technicians, the share of clerks and market shop sales workers was almost stable over time. In addition, production-related occupations decreased rapidly during the same period.

This paper investigates the impact of the increase in the output share of services on the demand for different categories of service occupations in the manufacturing sector. Another question researched herein deals with the categories of service occupations (e.g. professionals, technicians, and clerks) that benefit most from the increase in service revenues. Furthermore, we investigate whether purchased services (either from foreign or domestic suppliers) are complements or substitutes to in-house services.

Both anecdotal and case-study evidence suggests that manufacturing firms generate an increasing share of revenues from services (Antioco et al. 2008; Fang et al., 2008; Gebauer, 2007; Howells, 2004). This trend is commonly referred as “servitization”, the servicing of manufacturing (Baines et al., 2009; Bryson & Daniels, 2010; Howells, 2004; Neely, 2008; Vandermerve & Rada, 1988), product-service solutions (Johnstone, Dainty & Wilkinson 2008), or the service infusion of manufacturing (see the special issues of the Journal of Service Management 2011). Manufacturing firms’ service offerings typically include design and development services, (ICT) systems and solutions, maintenance and support services, and installation and implementation services, but also financial services, property and real estate services, and consulting (Neely, 2008). However,

Schmenner (2009) suggests that the integration of manufacturing and services is not a new concept, but one that arose 150 years ago.

Furthermore, there has not only been an increase in the share of service occupations combined with an increase in service offerings in manufacturing; there has also been an increase in the demand for intermediate service inputs from both domestic and foreign suppliers. The rapid diffusion of ICT has made it possible to source services globally. Miroudot, Lanz & Ragoussis (2009) find that the international trade in intermediate services is growing substantially faster than in intermediate goods (Miroduot, Lanz & Ragossis, 2009; Lejour & Smith, 2008; Jensen, 2008). However, the bulk of producer services is still sourced from domestic suppliers. Overall, it seems that the growing share of service workers in manufacturing has been accompanied by a rise in intermediate services inputs and in the output share of services. However, intermediate producer services from abroad and the share of service occupations are growing faster than the share of service revenues in manufacturing. There are several underlying factors that contribute to the rising importance of services in manufacturing. These include increasing product complexity, product differentiation, and access to new and superior services that complement in-house services (Francois, 1990; MacPherson & Vanchan, 2010; Peneder et al., 2003).

While the amount of literature on the extent, characteristics, and determinants of the servitization of manufacturing based on firm-level data (Bascavusoglu-Moreau & Tether 2010; Fang et al., 2008; Howells, 2004; Lay et al. 2010; Leo & Philippe, 2001; Neely, 2008; Neely et al., 2009) is growing at a rapid pace, relatively few studies have examined the consequences of the rising output of services in manufacturing on the occupational structure of the workforce in the manufacturing sector. There is also a large and quickly growing body of literature on the role of intermediate service inputs in manufacturing based on input-output tables (Francois & Woerz, 2008; Peneder et al., 2003) and on survey data (see e.g. Juleff-Tranter, 1996). Furthermore, extensive literature is available on the impact of intermediate producer services on productivity, output, and manufacturing exports (Drejer, 2002; Fixler & Siegel, 1999; Francois & Woerz, 2008; ten Raa & Wolff, 2001). These studies show that producer services play an increasing role as suppliers of intermediate inputs in the manufacturing sector (Peneder et al., 2003; Francois and Woerz, 2008) and in the total economy (O'Mahony and Timmer, 2009). Furthermore, intermediate service inputs have a positive effect on productivity growth in the manufacturing sector (see e.g. ten Raa & Wolff, 2001). More recently, Francois & Woerz (2008) show that intermediate business services are significantly and positively related to manufacturing exports, value added, and employment based on data on 24 OECD countries for the period 1994-2004, but only in technology-intensive manufacturing industries. Furthermore, the effects

depend on the type of service inputs and are not clear-cut with respect to how financial, insurance, and transportation services influence manufacturing exports and output.

Meanwhile, related literature investigates the determinants of the use of internal and external producer services (Abramovsky & Griffith, 2006; Broersma & Van Ark, 2007; Pardos, Gómez- Loscos, & -Morollón, 2007). For instance, based on UK firm-level data, Abramovsky & Griffith (2006) find that the use of ICTs has a positive effect on both the incidence of business service imports and the share of purchased services. Using industry-level data for the Netherlands, Broersma & van Ark (2007) find that industries with a high share of intermediate service inputs also exhibit a high share of IT investment.

In summarising the literature, one can conclude that the growing importance of both internal and external services and the rise of service revenues in manufacturing are well documented. However, a striking feature of the literature is that the phenomenon of service differentiation on the output side and the increased use of internal and external services in the manufacturing sector on the input side have been studied in isolation from each other. As such, the studies neglect the impact of the rising output share of services on the transition in the occupational structure of the workforce towards service-related occupations – in particular, towards professionals and technicians at the expense of clerks, administrative support, and other office-related occupations. It is obvious that the increase in the manufacturing sector's service offerings is leading to a shift in the demand for service occupations. One open question in this context concerns the service occupations that benefit most from the rise of service occupations. The relation between service inputs and the service output of manufacturing firms is also relevant from a policy standpoint. For instance, the Monti report (2010) stresses the importance of service revenues for European manufacturers, stating: "European industry must move further into the provision of services." The question here is, which service occupations stand to benefit most from the expected increase in service output in the manufacturing sector.

This paper contributes to the literature on the increasing integration of manufacturing and services in a number of ways. To our knowledge, this is the first paper that investigates the link between the increase in manufacturing sector's service offerings and the demand for different in-house service functions, which are measured as occupations. In addition, we use different sources of input-output tables – namely from the OECD and EU – to construct different measures of the output share of producer services in manufacturing. We also construct several different measures of intermediate producer services, such as the ratio of domestically purchased services and those purchased abroad to total output. Since purchased services include activities that add varying amounts of value, we use

both total producer services (transportation, financial, and business services) and the sub-group of business services only. The empirical analysis concentrates on the manufacturing sector because this is the only sector in which the trend towards service occupations can be observed (except for construction and mining with similar tendencies). The employment share equations are estimated using the fixed-effects model with robust standard errors.

The structure of this paper is as follows. Section 2 introduces the empirical model and the hypotheses. Section 3 presents the data used, while the empirical results are discussed in section 4. Some concluding remarks are provided in section 5.

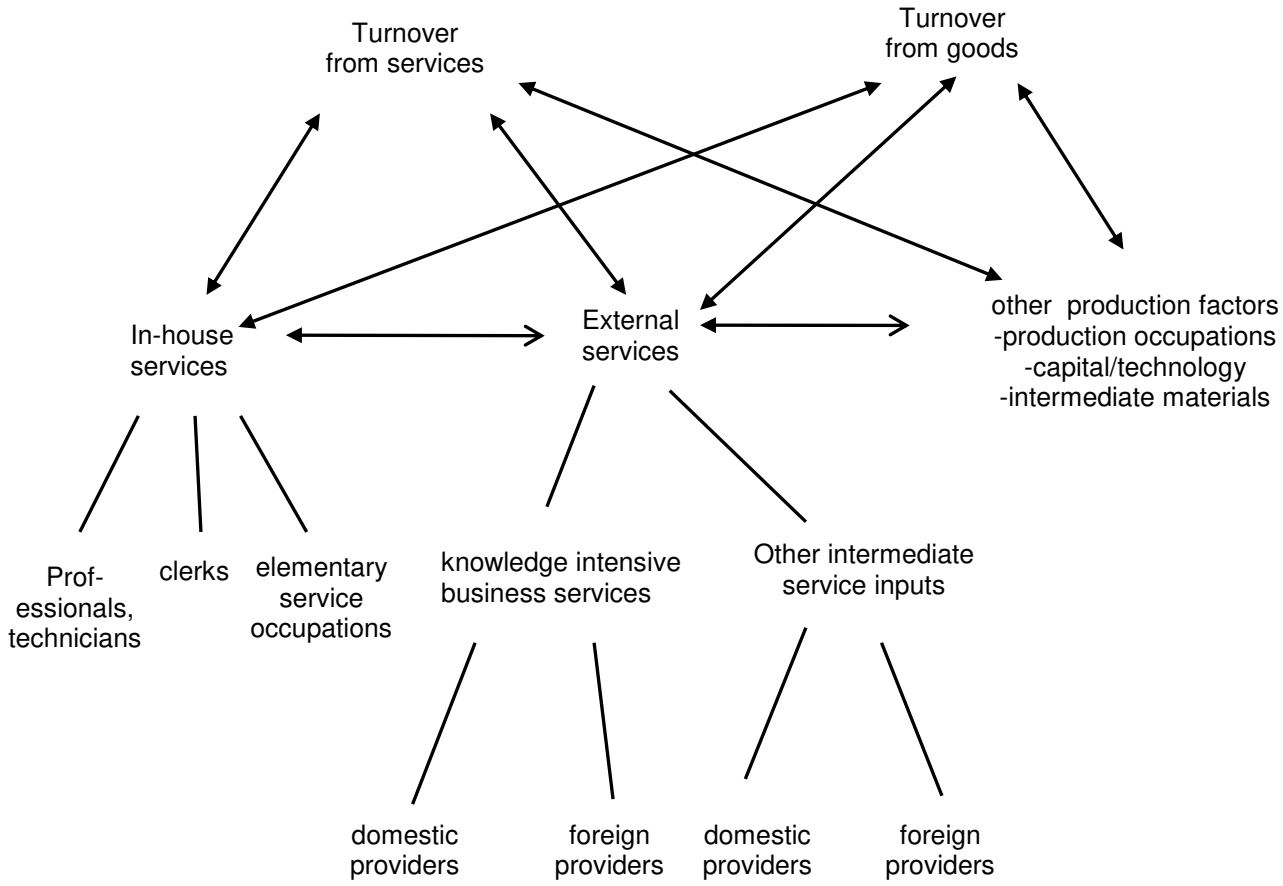
2. Empirical model and theoretical background

Figure 1 illustrates the linkages between the output of producer services, external services, and in-house services in the manufacturing sector. It is assumed that the typical manufacturing firm offers services in combination with its products. In general, both service occupations and intermediate service inputs are important production factors in modern manufacturing. Greenfield (1966) and Francois (1990) suggest that producer services also play an important role in the coordination and control of operations within the manufacturing production process. Other production factors include production occupations, capital and material inputs, and the technological level at hand.

An increase in the output of services will directly increase the demand for specific service occupations involved in preparing and delivering services. Manufacturing firms increasing their service offerings is also likely to lead to an increase in the demand for external services. The increase in service revenues also has an indirect effect on in-house service occupations when internal and external services complement each other. In this case, an increase in external services due to an increase in service output will lead to an increase in the demand for service occupations. The complementary relationship between internal and external service inputs is consistent with the resource-based theory of the firm (Barney, 1991; Yasuda, 2005). Following the resource-based view of the firm introduced by Barney (1991), external services are often used as an instrument to access knowledge and skills. Beyers (2005) suggests that external service suppliers often deliver superior knowledge because of their high levels of specialization and new types of business solutions that are unlikely to be found or generated in-house. Bryson and Daniels (2010) also suggest that intermediate business services support services produced in-house. Using survey data on 50 manufacturing firms in the US, MacPherson and Vanchan (2010) find that the purchase of industrial design services is complementary to in-house core competences. The outsourcing of industrial design services is often related to the acquisition of superior services or totally new services, which is unlikely to reduce in-house services (see also

MacPherson, 2008). Francois (1990) also finds that producer services and in-house service functions are complementary based on a theoretical model.

Figure 1: Inputs and outputs of manufacturing firms offering services related to their products



However, intermediate services and in-house services can be substitutes. It can be the case that firms outsource service activities they previously performed in-house; the gains from contracting depend on the transaction costs. This is often related to a strategy in which firms focus on their core competencies by outsourcing their non-core service activities (Hamel and Prahalad, 1990). Such activities can then be sourced from external suppliers. An increase in intermediate service inputs can therefore be regarded as an indicator of service outsourcing. The degree of substitutability between external and internal service functions is likely to depend on the type of service activity at hand. Blinder (2009) suggests that service tasks are quite heterogeneous and differ with respect to their potential offshorability, whereas jobs that require face-to-face contact with customers are least vulnerable. Similarly, Moncarz, Wolf, and Wright (2008) suggest that administrative support occupations, such as clerks and data-entry positions that require relatively little training, are most likely to be outsourced.

An increase in intermediate service inputs may change the structure of service occupations. Increased use of external services may lead to a rise in in-house activities, particularly in coordinating, monitoring, and controlling the quality and performance of external suppliers (Williamson, 1975). This will likely raise the demand for professional occupations rather than for elementary or intermediate service qualifications, such as clerks and administrative support personnel.

Another explanation for the expansion of in-house services relates to the rise of multinational enterprise activities in industrialised countries. When firms relocate parts of their services abroad, headquarter service activities expand and the parent companies in question begin importing and exporting more services than before (Lodefalk, 2010).

It is important to distinguish between knowledge-intensive business services (KIBS) and other intermediate service inputs, such as transportation and financial services. KIBS consist of computer services, research and development, legal activities, accountancy services, market research, management consultancy, architectural activities, technical consulting, and advertising. The importance of KIBS as source of innovation, output, and productivity is widely acknowledged (Boden & Miles, 2000).

Given the theoretical and empirical literature discussed, we derive the following hypotheses:

H1: A rising output share of services is significantly and positively related to the share of service occupations.

H2: The magnitude of the employment effects of the output share of services is likely to be different across different types of service occupations, and is expected to increase with the skill level of the service occupations.

H3: The substitutability between intermediate service inputs and service occupations is heterogeneous between different categories of service functions and also differs with respect to the origin of the service provider (domestic or foreign).

The regression equation can be derived from a flexible cost function in which total costs depend on two types of labour, namely service occupations and non-service occupations. The resulting factor share equation relates the wage bill share of service occupations to output, relative wages, capital, and measures of external services. However, consistent time series for occupational wages are not available and can therefore not be controlled for.[1] Following the related literature, the wage bill share

[1] In principle, one can include wages for the different occupations. However, occupational wages from the European Community Household Panel are only available for the period 1994 -2001 and based on the EU SILC (2004-2008).

is approximated by the employment share. The determinants of the employment share of service occupations in the manufacturing sector can be described as:

$$\frac{LSCVS_{it}}{L_{it}} = \beta_{1j}\frac{MSCVS_{ijt}^{DOM}}{Y_{it}} + \beta_{2j}\frac{MSCVS_{ijt}^{FOR}}{Y_{it}} + \beta_{3j}\frac{YSCVS_{ijt}}{Y_{it}} + \theta_t + \mu_i + \varepsilon_{it},$$

where t denotes time and i denotes country. $LSCVS_{it}$ is the number of service occupations and L_{ti} is the total number of occupations (service and production occupations). $MSCVS_{ijt}^{DOM}$ denotes services purchased from domestic providers by the manufacturing sector, and $MSCVS_{ijt}^{FOR}$ denotes services purchased from abroad by the manufacturing sector; both input factors are measured in relation to manufacturing output, Y_{it}, where j=1 denotes total producer services and j=2 represents knowledge-intensive business services. $YSCVS_{ijt}$ denotes the output of producer services, and Y represents total output in manufacturing in basic prices. μ_i is the country effect, θ_t denotes a set of time dummy variables, and ε_{it} is the error term. A positive sign of β_3 indicates that an increase in the output share of services will lead to an increase in the demand for service occupations relative to total occupations. Positive signs of β_1 and β_2 indicate that in-house services and external sources either from domestic or foreign providers are complementary to each other.

Services purchased from abroad are an indicator of the extent of global sourcing, while services purchased from domestic suppliers are an indicator of domestic outsourcing. Alternatively, we replace external services with the ratio of economy-wide service imports to output, $IMSCVS / Y$, which leads to the following regression equation:

$$\frac{LSCVS_{it}}{L_{it}} = \tilde{\beta}_1\frac{IMSCVS_{it}}{Y_{it}} + \tilde{\beta}_2\frac{YSCVS_{it}}{Y_{it}} + \tilde{\theta}_t + \tilde{\mu}_i + \tilde{\varepsilon}_{it}.$$

Note that this measure includes both intermediate and final service imports. As the share of service output and purchased services may have different effects on different service occupations, we also investigate the demand for three different categories of service occupations: (i) supervisors, professionals, and technicians; (ii) clerks; and (iii) other elementary service occupations. The equations will be estimated by the fixed-effects model using cluster-robust standard errors. In addition, we use standard errors that are robust to serial correlation and cross-sectional correlation – as well as

arbitrary heteroscedasticity – as demonstrated by Driscoll and Kraay (1998). Since all variables are input-output ratios or shares, stationarity of the time series is a plausible assumption.

3. Data and descriptive statistics

In order to investigate the determinants of service occupations, we use manufacturing industry data for several EU countries, matching aggregate data from the EU-LFS with manufacturing industry data based on input-output tables. We use product-by-product I-O tables for the EU that contain information on the use of intermediate services as inputs in the manufacturing sector. We use the symmetric input-output table at basic prices (including both domestic and imported use) and the symmetric input-output table for imports that are available at five-year intervals for most of the EU countries. For some EU countries, annual symmetric input-output tables are available. These SIOT are supplemented with national input-output tables for which data is available (DE, DK, IT, UK). The share of purchased (producer) services measures the output of the service industry that is used as an input in manufacturing. We distinguish between total purchased producer services (NACE rev 1.1 55 to 74) and purchased business-service inputs, which are also referred to as knowledge-intensive service inputs (KIBS, NACE rev.1.1 72-74). As mentioned above, the latter comprises computer services, management and consulting services, research and development, accounting, and architectural services, as well as a number of low-skilled services, such as cleaning, security services, and call centres. However, the latter only represents a tiny proportion.

One problem in measuring services purchased from abroad is that in some countries (e.g. UK, US), the tables of imports used are generally compiled using the import proportionality assumption. This assumes that the import share of a product is the same for both intermediate and final users (Feenstra et al. 2010). For most EU countries, however, the assumption is not imposed and direct information is available.

We also use the supply tables that include information on the supply of goods and services by product and type of supplier. Note that EU supply tables are not internationally comparable across countries. For Denmark and France, for instance, these tables only contain information on the output of business services. Therefore, we also employ the OECD industry-by-industry I-O tables, which by their nature are more comparable across countries than product-by-product tables.

Service occupations are calculated using the anonymised EU-LFS and population weights. In addition, we use tabulated data provided by EUROSTAT. The service occupations include self-employed individuals and employees, and we apply the definition used by Pilat and Woelfl (2005). In addition,

service occupations are aggregated into three broad groups: (i) legislators, senior officials and managers, professionals and technicians, and associate professionals (ISCO-88 100-348); (ii) clerks, administrative service personnel, and other office-related staff (ISCO-88 400-522), and other service occupations (ISCO-88 830-916+933); and (iii) remaining occupations related to production (such as skilled agricultural and fishery workers, workers in crafts and related trades, plant and machine operators, and those in assembly and basic employment).

Descriptive statistics on the change in the output share of services, intermediate service inputs, and the different service occupations for the manufacturing sector by country can be found in the appendix (see Tables 4-8 and Figures 2-4). We find that the share of service occupations has increased in all EU-15 countries at the expense of production workers (Table 4 in the appendix). In particular, the share of service occupations has increased rapidly since the year 2000. Note that the shift in the occupational structure towards service occupations is not a new phenomenon: In the US, for instance, the increase in service occupations began back in the 1950s (Francois, 1990; Kenessey, 1987). In the EU-10 (central and eastern EU countries) for which data is available, the share of service occupations is quoted as stable over time.

Furthermore, there is has been an increase in the share of producer services in total manufacturing output in almost all of the EU-15 countries (see Table 5 in the appendix). Similar findings can be observed based on OECD input-output tables. Not surprisingly, we find that the output share of producer services is considerably higher when based on OECD industry-by-industry I-O tables. Note that it is difficult to compare the results for the output share of services based on input-output tables with the findings based on firm-level data. Using Compustat data on large US manufacturing firms, Fang et al. (2008) find a share of service sales in manufacturing of about 42 per cent. Using data from Sweden's statistical office, Lodefalk (2010) finds that manufacturers' revenues from services increased from 13.6 to 20.3 per cent between 1997 and 2006. Neely (2008) analyses the business descriptions of large manufacturing firms and finds that 30 per cent of those with manufacturing SIC codes – some 10,000 firms in 25 countries – are offering services based on the OSIRIS database. However, the sample is restricted to firms with at least 100 employees, which may lead to overestimation of the share of manufacturing firms offering services. After updating the survey to include about 50,000 firms, Neely et al. (2009) find that the US has the largest share of manufacturing firms offering services. Among the EU countries, Finland has the highest share of service revenues, followed by the Netherlands, Belgium, Germany, Sweden, Spain, and the UK. Based on survey data for eight European countries, Lay et al. (2010) find that 87.5 per cent of the manufacturing firms are offering services, with a corresponding mean share of turnover of about 15 per cent. Using the UK's

Business Structure Database, Bascavusoglu-Moreau and Tether (2010) find that the share of manufacturing firms offering services is about 3.5 per cent, with a share of 4 per cent for the microfirms with nine or fewer employees and 90 per cent for the very large firms with 10,000 and more employees.

Tables 7 and 8 show the change in the ratio of purchased producer services to gross output for the manufacturing sector based on EU and OECD input-output tables, distinguishing between services purchased from domestic and foreign suppliers. In addition, we include the share of knowledge-intensive business services purchased. As expected, there has been an increase in purchased services in almost all countries. The purchasing of producer services from domestic suppliers has risen faster than that of services purchased from abroad. In order to provide some initial evidence of the relationship between the output share of purchased services and the share of professionals and technicians, we present a simple scatter plot (see Figure 5 in the appendix). We find that both variables are positively correlated, but generally only marginally significant.

4. Empirical results

Table 1 shows the results of the fixed-effects model of the impact of the service output share on the employment share of service occupations, and that of three groups of service occupations. It also displays the results of a regression including only a set of time dummy variables and the output share of services in percentages. The first column shows the results for the employment share of all service occupations. The second column includes the results for the employment of supervisors, professionals, and technicians (also referred to as highly skilled, white-collar workers). The third and fourth columns contain the results for the employment share of clerks, administrative service personnel, and other office-related workers, as well as other service occupations. We use both the output share of producer services and the output share of knowledge-intensive industries (NACE rev. 1.1 72-74). In addition, the share of service output is based on two data sources: EU I-O tables and OECD I-O tables, the latter of which are based on data collected every five years. T-values are based on standard errors according to Driscoll and Kraay's (1998) method, which usually produce higher t-values in absolute terms. In addition, we display standard t-values based cluster-robust standard errors.

We find that the output share of producer services has a positive and significant impact on the employment share of service occupations. The coefficient is 0.8, indicating that an increase in the output share of producer services by one percentage point will lead to an increase in the share of service occupations by 0.8 percentage points. However, the coefficient is only weakly significant,

exhibiting a t-value of 1.91 (indicating significance at the 7 per cent level). Based on Driscoll-Kraay standard errors, the output share of services is significant at the 1 per cent level. In order to provide an indication of the magnitude of the relation between the output share of services and service occupations, one can calculate the contribution of the change in the service output share to the change in the share of service occupations. The calculations suggest that the rising service output share explains 13 per cent of the increase in the share of service occupations between 1995 and 2005 based on the countries for which data is available for the entire sample period.[2] This indicates that while the servitization of manufacturing does shift the structure of employment towards service occupations, the magnitude of the effect is quite modest.

Table 1: Fixed-effects model of the impact of the service output share on the share of service occupations (by different categories)

	Total svcs occupations			Supervisors, professionals, technicians			Clerks, sales workers		Other service occupations			
Output share of	co (t)		R^2	co (t)		R^2	co (t)	R^2	co (t)	R^2	#obs	#co
services (NACE 55-95)	0.81	*	.39	0.64	***	.60	-0.08	.60	0.31	.08	197	19
based on EU supply	(1.91)			(2.98)			(-0.61)		(0.89)			
IOT (in %)	[4.82]			[3.30]			[-1.32]		[2.29]			
Output share of	co (t)		R^2	co (t)		R^2	co (t)	R^2	co (t)	R^2	#obs	#co
producer services	0.80	*	.40	0.60	***	.60	-0.07	.60	0.33	.07	197	19
(NACE 55-74), EU	(1.86)			(2.73)			(-0.49)		(0.92)			
supply IOT (%)	[4.69]			[2.88]			[-0.95]		[2.47]			
Output share of	co (t)		R^2	co (t)		R^2	co (t)	R^2	co (t)	R^2	#obs	#co
knowledge-intensive	0.70		.40	0.66	***	.59	-0.12	.59	0.21	.08	189	18
services (NACE 72-74), based on EU	(1.49)			(3.26)			(-0.82)		(0.61)			
supply IOT	[4.07]			[3.99]			[-1.44]		[1.89]			
Output share of	co (t)		R^2	co (t)		R^2	Co (t)	R^2	Co (t)	R^2	#obs	#co
producer services	0.44	*	.70	0.44		.70	0.17	.19	-0.15	.12	46	18
(NACE 55-74) (OECD	(1.77)			(1.26)			(0.69)		(-0.59)			
SIOT) (in %)	[3.51]			[6.28]			[3.34]		[-1.32]			
Output share of	co (t)		R^2	co (t)		R^2	Co (t)	R^2	Co (t)	R^2	#obs	#co
knowledge-intensive	1.47	*	.71	0.15		.71	0.22	.18	-0.24	.11	46	18
services (NACE 72-74), OCED SIOT (%)	(1.66)			-0.16			(0.42)		(-0.37)			
	[2.87]			[0.48]			[1.20]		[-2.24]			

Notes: ***, **, and * denote significance at the 1 per cent, 5 per cent, and 10 per cent levels, respectively. The dependent variable is the employment share of service occupations (following the definition of Pilat and Woelfl (2005) and the employment share of three subgroups: (i): supervisors, professionals, and technicians (ISCO 88 100-348); (ii) clerks and sales shop workers (ISCO 88 400-523); and (iii) other service workers (basic employment, drivers, etc) (ISCO 88 830-916, 933). Time dummies are jointly significant at the 1 per cent level, but not reported. T-values are based on robust standard errors (in parentheses) and based on Driscoll-Kraay (1998) standard errors (in brackets). The sample includes the EU-15 countries except LU, CZ, HU, PL, SI, and SK (AT and BE: 1995, 1997, 1999-2007; CZ: 1997-2007; DE, EE, IE, and LT: 2000-2007; ES, IT, and NL: 1995-2007; GR: 2000-2008; HU and SK: 1998-2007; LT: 2000-2007; PL: 2000-2006; PT: 1995-2006; SE: 1997-2007; SI: 1996, 2000-2007; and UK: 2000-2008).

[2] The output share of services increased from 2.1 to 3.1 per cent in the period 1995-2006 based on 10 EU countries that remain in the sample for the entire period. The corresponding increase in the employment share is six percentage points (from 41 per cent to 47 per cent), resulting in a contribution of 0.8 percentage points, or 13.4 per cent.

Furthermore, we find that the output share of services has a positive and significant impact on the employment share of professionals and technicians. Here the coefficient is highly significant at the 1 percent level based on both robust standard errors and Driscoll-Kraay standard errors that are robust to heteroscedasticity, serial correlation, and cross-sectional correlation. However, for the employment share of clerks, administrative support, and other office-related occupations, the coefficient is not significantly different from zero, indicating that this category of service occupations does not benefit from the servitization of manufacturing. For the remaining group of service occupations, the results are not clear-cut depending on how the output share of services is measured and which data source is used. However, the group of other service occupations – including drivers of trucks and other vehicles, as well as sales service occupations – represents only a tiny part of the service occupations as a whole. Furthermore, we find that the impact is robust to the measurement of service outputs (based on two different data sources). When the output share of knowledge-intensive services is considered, we find that the impact on total service occupations decreases slightly in size and significance. As expected, we find that the impact of the share of service revenues on the employment share of supervisors, professionals, and technicians increases in magnitude and significance when only knowledge-intensive services are considered. This is not surprising because an increase in the knowledge-intensive service activities on offer raises the demand for in-house services in related tasks and functions.

In order to test the robustness of the basic regression results, we conduct a number of sensitivity and robustness checks. First, we include interaction terms for the service output share multiplied by country dummy variables in order to investigate whether the coefficient varies across the countries. However, the coefficients on the interaction terms are not significantly different from zero. Second, we experiment with interaction terms between time dummy variables and the output share of services. Here, the coefficients are once again not significantly different from zero.

Table 2 shows the results of the fixed-effects model when both measures of external services (services purchased domestically and from abroad) are included in the regression equation (Table 9 in the appendix displays the results with only the share of services purchased from abroad included). Again, we provide results for service occupations overall and for the three subgroups: (i) supervisors, professionals, and technicians; (ii) clerks and shop sales personnel; and (iii) other basic service occupations. In addition, results are available for two types of external services: one broad measure including total services purchased and one narrow measure including only knowledge-intensive business services. The results show that services purchased from both domestic and foreign sources are significantly and positively related to the employment share of service occupations. This indicates that intermediate service inputs and service occupations are complements independent from the

location of the service provider. The coefficient of the ratio of services purchased from abroad to total manufacturing output is 0.55, indicating that an increase in the output share of services by one percentage point will cause the share of service occupations to increase by 0.55 percentage points. For the ratio of services purchased from domestic suppliers, we find an even higher coefficient of 0.72. Turning to the three subgroups of service occupations, we find that the most highly skilled group of service occupations is complementary to services purchased from abroad, while the other groups of service occupations do not benefit from the use of external services from abroad.

Table 2: Fixed-effects estimates of the impact of external services and service output on the employment share of service occupations (by different categories)

	Total scvs occ	Professionals Technicians	Clerks	Other scvs. Occ
	Specification with total purchased services			
	Coef. (t)	Coef. (t)	Coef. (t)	Coef. (t)
Output share of producer services (excl. wh. & re. trade, public & personnel scvs) (%)	-0.23	1.14 ***	-0.65 ***	-0.29
	(-0.56)	(3.52)	(-2.81)	(-0.66)
	[-1.06]	[11.79]	[-1.65]	[-1.39]
Ratio of producer services purchased from abroad to output (in %)	0.55 ***	0.32 ***	0.11	0.08
	(2.35)	(2.82)	(0.77)	(0.53)
	[5.46]	[4.06]	[3.19]	[0.94]
Ratio of domestic producer services to output (in %)	0.72 ***	0.03	0.23	0.16
	(2.32)	(0.10)	(1.62)	(1.05)
	[4.60]	[5.05]	[0.22]	[1.35]
# of obs	69	69	69	69
# of countries	18	18	18	18
R 2 within	0.67	0.73	0.30	0.16
	Specifications with knowledge intensive purchased services			
	Coef. (t)	Coef. (t)	Coef. (t)	Coef. (t)
Output share of producer services (excl. wh. & re. trade, public & personnel scvs)	1.12	1.23 **	-0.19	0.74
	(1.50)	(2.24)	(-0.71)	(0.93)
	[1.85]	[2.91]	[-1.42]	[1.78]
Ratio of KIBS services from abroad to output	0.40 **	0.22 **	0.12 *	0.05
	(2.37)	(2.40)	(1.69)	(0.57)
	[5.76]	[2.92]	[3.74]	[1.65]
Ratio of domestic KIBS to output, in %	0.35	0.82	-0.75	-0.41
	(0.38)	(1.51)	(-1.53)	(-0.74)
	[0.56]	[2.08]	[-4.00]	[-1.19]
# of obs	66	66	66	66
# of countries	18	18	18	18
R 2 within	0.58	0.70	0.30	0.20

Notes: ***, **, and * denote significance at the 1 per cent, 5 per cent, and 10 per cent levels, respectively; see Table 1. The sample includes data for AT, BE, IT, PT, and UK: 1995, 2000, 2005; DE: 2000-2007; EE: 1997, 2000, and 2005; FI: 1997-2007; HU: 1998, 2000, and 2005; IE, LT: 2000 and 2005; NL: 1995-2007; PL, SE, SI, and SK: 2000 and 2005).

Concerning the impact of knowledge-intensive business services, we find that the group of professionals, technicians, and supervisors are complements to business services purchased from domestic providers, while clerks do not benefit. Furthermore, we again find that professionals, technicians, and supervisors benefit from the rising output share of services, while clerks do not benefit from the servitization of manufacturing even when controlling for external services. Overall,

the results are consistent with earlier studies. Van Welsum and Reif (2009) find that the share of clerical occupations potentially affected by offshoring is the highest of all service occupations, ranging between 27 per cent in Finland and 63 per cent in Portugal. For service occupations as a whole, however, the positive impact of the output share of services disappears when controlling for external services.

We again conduct a number of robustness checks, including interaction terms between groups of countries (eastern, high-income, and low-income countries). We find that the interaction terms are not significant. However, the results become slightly more significant when the four eastern European countries (CZ, SK, SI, and PL) are excluded or interaction terms are included. Second, we use an instrumental variable method in which imported intermediate services are instrumented with lagged changes and the US price index of information and communication technologies converted to euros. However, the results are almost similar and are available upon request.

Table 3 shows the results of the fixed-effects model with the ratio of service imports to GDP as an alternative measure of external services purchased from abroad. Here, service imports include both final and intermediate imports and also refer to imports into the economy at large rather than into manufacturing alone. We find that both service occupations as a whole and highly skilled service occupations benefit from imports of services. However, the effect is only marginally significant when t-values are based on clustered standard errors. The coefficient of service imports becomes more significant based on the Driscoll-Kraay standard errors. In contrast, we find a negative impact of service imports on clerks and shop sales personnel, but the coefficient is not significant at the 10 per cent level. Furthermore, there is a positive and marginally significant relationship between the share of basic service occupations and the ratio of service imports. This is not surprising, as basic service occupations include truck drivers and cleaning and shop sales personnel, who cannot be traded.

Table 3: Fixed-effects estimates of the impact of service imports on the share of service occupations in manufacturing (by different categories)

	Total scvs occ Coeff (t)	Professionals Technicians Coeff (t)	Clerks Coeff (t)	Other scvs. Occ Coeff (t)
Output share of producer services (excl. wh. & re. trade, public & personnel scvs) (in %)	0.63 (1.64) [4.04]	0.52** (2.38) [3.37]	-0.05 (-0.39) [-0.62]	0.28 (0.81) [1.80]
Ratio of economy-wide service imports to GDP (in %)	0.76* (1.75) [3.23]	0.36 (1.63) [2.18]	-0.09 (-0.73) [-1.43]	0.23 (1.66) [4.15]
# of obs	198	198	198	198
# of countries	19	19	19	19
R-sq: within	0.44	0.62	0.15	0.11

Notes: ***, **, and * denote significance at the 1 per cent, 5 per cent and 10 per cent levels, respectively; see Table 1.

5. Conclusions

This paper provides new empirical evidence of the level of integration between services and manufacturing. In particular, we investigate the extent to which changes in the employment share of service occupations can be explained by the increase in the output share of services in manufacturing. In addition, we analyse whether service occupations are a complement of or substitute for services purchased from either domestic or foreign suppliers. Here, we place special emphasis on the role of knowledge-intensive business services either as output or externally sourced input. In addition, we distinguish between different types of service occupations, such as professionals, technicians, clerks, and basic service occupations. The data is drawn from the EU Labour Force Survey and EU and OECD input-output tables for the period 1995-2007.

The results show that the EU manufacturing sector's service offerings are increasing. Between 1995 and 2005, the output share of producer services rose from 7 to 8.5 per cent (unweighted across EU-15 countries). In addition, manufacturing is relying increasingly on external and internal services, particularly business services from external providers and skilled service occupations such as professionals and technicians. Overall, these trends show that the boundaries between manufacturing and services are becoming increasingly vague.

The results clearly show that labour demand is shifting away from production occupations to skilled service occupations. Service occupations have generally been growing faster than both external services from domestic suppliers and the output share of manufacturing, indicating that other factors – such as (information) technology and R&D activities – are also important in the shift towards services in the occupational structure .

The empirical results based on fixed-effects models for countries show that part of the shift away from production towards service occupations can be attributed to the shift from goods production to service production. Based on 18 EU countries for the period 1997-2007, an average of 13 per cent of the increase in the employment share of service occupations in the manufacturing sector can be attributed to the increase of the output share of services.

Furthermore, we find that external services and highly skilled service occupations are complements, which supports the resource-based theory of external linkages with suppliers. However, we do not find clerical occupations to be negatively affected by the global sourcing of producer services. If anything, one can conclude that clerical occupations are rather affected by intermediate services purchased from domestic providers. Furthermore, service imports tend to have a positive impact on professionals, technicians, and supervisors, but not on clerks and other basic service occupations.

Possible future work in this area may employ two-digit industry data. Nordas (2010) shows that the service intensity of manufacturing (measured as purchased services) differs widely across two-digit industries, finding a higher service intensity in the computer and office machinery, chemical, and food industries. Similarly, there is a higher output share of services in skill-intensive manufacturing industries. Two-digit data would also make it possible to provide separate empirical results for each EU country. Finally, another line of future research might use firm-level data from the structural business statistics for manufacturing, which include data on revenues by services, wholesale and retail trade, and goods production.

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Appendix

Table 4: Change in the share of service occupations in manufacturing (total and by different categories) (in per cent)

	Share of service occupations in per cent			Share of supervisors, professionals, technicians in per cent			Share of clerks, office and administrative service occupations			Share of elementary service occupations		
	1995	2000	2008	1995	2000	2008	1995	2000	2008	1995	2000	2008
AT	45	44	47	27	27	28	13	12	11	7	6	7
BE	49	58	55	26	28	34	13	12	12	10	8	9
CY		33	39		14	15		9	14		10	10
CZ		36	38		22	26		7	6		7	5
DE		47	50		28	30		14	14		5	6
DK	45	48	56	24	30	36	13	9	11	8	9	9
EE		39	39		23	26		4	4		13	9
ES	30	33	41	16	19	27	8	8	8	6	5	6
FI		46	48		33	39		5	4		7	5
FR	44	44	50	27	27	35	12	11	10	6	6	5
GR	29	31	39	13	15	21	10	10	11	6	6	7
HU		31	35		17	21		8	7		6	6
IE	41	42	48	22	26	32	12	11	10	6	5	6
IT	31	35	41	18	21	26	10	11	12	3	3	4
LT		37	42		20	25		8	5		9	11
NL	55	58	60	31	32	32	16	12	15	8	13	13
PL		36	33		22	20		8	6		7	6
PT	31	27	29	15	13	14	11	10	10	5	4	5
RO		29	28		16	17		4	5		8	7
SE		44	44		31	31		8	9		5	5
SI		37	39		23	27		10	9		4	4
SK		35	32		20	21		6	5		8	6
UK	48	50	58	30	33	39	12	12	10	5	5	8

Source: EU-LFS, Weighted percentages.

Table 5: Change in the output share of services in manufacturing by data source and by type of service (in per cent)

	Output share of producer services EU I/O tables			Output share of KIBS EU I/O tables			Output share of producer services OECD I/O tables			Output share of KIBS OECD I/O tables		
	1995	2000	2005	1995	2000	2005	1995	2000	2005	1995	2000	2005
AT	1.9	1.5	2.4	0.9	0.9	2.0	6.0	7.2	7.6	1.0	1.3	2.1
BE	0.9	0.7	1.6	0.7	0.5	1.4	6.9	7.4	6.8	2.1	2.6	1.7
CY												
CZ		1.4	0.9		0.5	0.4		6.3	5.7		1.4	1.3
DE	1.6	1.8	2.0	0.7	0.9	1.0	3.9	3.9	3.8	0.9	1.0	0.9
DK							6.9	9.6	11.3	2.6	3.1	2.9
EE		1.5	1.3		0.2	0.2		9.6	10.1		1.6	1.8
ES	1.5	1.6	1.7	1.2	1.5	1.6	8.5	10.5	11.1	1.1	2.5	2.5
FI	4.0	7.2	8.4	3.2	6.3	7.9	5.8	5.8	6.9	1.5	1.8	1.7
FR							6.6	7.3	8.0	2.6	2.8	3.1
GR		0.7	1.1				9.5	14.4	14.4	0.4	1.0	1.2
HU		1.3	1.4		0.5	0.8		6.1	6.1		1.5	1.6
IE		2.0	2.4		1.8	2.2		3.9	7.0		0.6	1.3
IT	1.3	1.5	1.7	0.8	0.8	1.0	6.8	7.1	8.2	1.5	1.2	1.7
LT		1.7	1.6		0.5	0.5						
NL	3.1	3.5	3.9	2.7	3.2	3.6	6.1	7.4	7.3	1.8	2.3	1.8
PL		1.2	1.5		0.4	0.6	7.0	7.6	8.3		2.0	2.1
PT	0.7	0.6	0.6	0.7	0.5	0.6	7.0	7.8	8.7	1.5	1.4	1.6
RO												
SE	2.4	3.6	4.8	1.9	3.1	4.2	8.6	9.1	9.2	3.0	3.8	3.5
SI		0.7	1.3		0.3	0.7	6.8	6.3	5.9	2.4	2.3	1.8
SK	1.3	1.2	1.5	0.5	0.3	0.7	5.4	5.1	5.5	1.6	1.5	1.7
UK	3.6	4.6	4.7	2.2	3.0	3.3	8.7	10.9	9.5	2.2	2.0	1.7

Source: EU and OECD supply tables.

Table 6: Change in the ratio of purchased producer services to output in manufacturing (distinguished between domestic and foreign suppliers based on EU input-output tables) (in per cent)

	Share of producer services from domestic providers			Share of knowledge intensive business services from domestic providers			Share of producer services from abroad			Share of knowledge intensive business services from abroad		
	1995	2000	2005	1995	2000	2005	1995	2000	2005	1995	2000	2005
AT	14.5	14.7	16.4	3.2	3.5	3.1	0.9	1.4	2.4	0.3	0.4	0.9
BE	13.3	16.6	16.2	3.2	4.4	4.0	2.2	2.6	2.6	0.5	0.9	1.0
CY												
CZ												
DE	16.8	19.1	18.3	6.2	7.0	6.9	0.6	1.1	1.1	0.2	0.5	0.5
DK	13.6	13.5	14.6	2.5	3.2	4.0	0.5	1.9	2.9	0.4	0.6	1.2
EE		11.9	12.4		1.5	1.9		1.2	1.5		0.6	1.0
ES	14.0	14.4	16.4	3.6	4.2	4.8	1.1	2.2	2.1	0.7	1.3	1.3
FI	10.5	15.1	14.9	3.6	3.4	3.6	2.6	3.0	3.6	1.5	2.7	3.2
FR	18.2	19.5	21.7	7.4	8.4	9.1	0.8	0.9	1.1	0.3	0.4	0.5
GR		14.6	18.5		3.4	3.7		0.5	0.6		0.2	0.2
HU		8.6	11.7		1.9	3.3		2.6	3.2		2.3	2.5
IE		6.9	8.6		1.4	2.6		23.3	30.6		15.3	23.9
IT	17.0	19.2	20.1	3.5	4.2	4.3	1.4	1.7	1.9	0.4	0.5	0.7
LT		15.5	14.5		0.5	0.6		1.5	0.6		0.1	0.1
NL	11.7	12.5	15.5	4.1	5.5	5.1	1.7	2.1	3.2	0.7	1.4	2.0
PL		20.0	18.9		3.4	4.0		0.5	0.5		0.2	0.3
PT	13.5	14.7	13.7	3.9	4.5	3.5	0.5	0.5	0.6	0.2	0.2	0.2
RO		13.1	13.9		0.3	0.5		1.1	0.6		0.1	0.1
SE	17.4	19.7	19.0	5.2	7.4	6.7	1.9	3.7	4.1	0.8	2.5	2.6
SI	12.6	12.1	13.7	1.8	2.4	2.9	1.3	1.7	1.4	0.2	0.4	0.7
SK		9.9	9.4		1.0	1.6		2.8	2.3		1.3	1.2
UK	15.2	18.1	18.5	3.4	3.9	4.0	0.7	0.8	0.9	0.3	0.4	0.4

Source: EU input-output tables.

Table 7: Change in the ratio of purchased producer services from abroad to output in manufacturing based on OECD input-output tables)

	Share of producer services from abroad in per cent			Share of knowledge intensive business services from abroad in per cent		
	1995	2000	2005	1995	2000	2005
AT	1.0	1.5	2.5	0.3	0.4	1.0
BE	2.3	2.6	2.8	0.5	0.9	1.1
CY						
CZ		4.5	3.2		3.0	1.3
DE	0.6	1.2	1.3	0.2	0.5	0.5
DK	0.5	1.9	2.9	0.4	0.6	1.2
EE		1.3	1.6		0.6	1.0
ES	1.1	2.2	2.1	0.7	1.3	1.3
FI	2.6	2.2	3.6	1.6	1.6	3.2
FR	0.8	0.9	1.1	0.5	0.4	0.5
GR	0.4	0.5	0.6	0.3	0.2	0.2
HU		2.6	3.7		2.3	2.2
IE		23.1	29.6		15.3	23.1
IT	1.4	2.3	2.8	0.4	0.6	0.9
LT						
NL	1.7	2.1	3.2	0.7	1.4	2.0
PL	0.5	0.6	0.6	0.2	0.2	0.3
PT	0.6	0.8	0.6	0.3	0.2	0.2
RO						
SE	2.7	3.0	4.1	1.2	2.2	2.7
SI	1.0	0.9	1.5	0.2	0.5	0.7
SK	1.9	2.8	2.3	0.8	1.3	1.2
UK	0.8	0.9	1.0	0.3	0.4	0.4

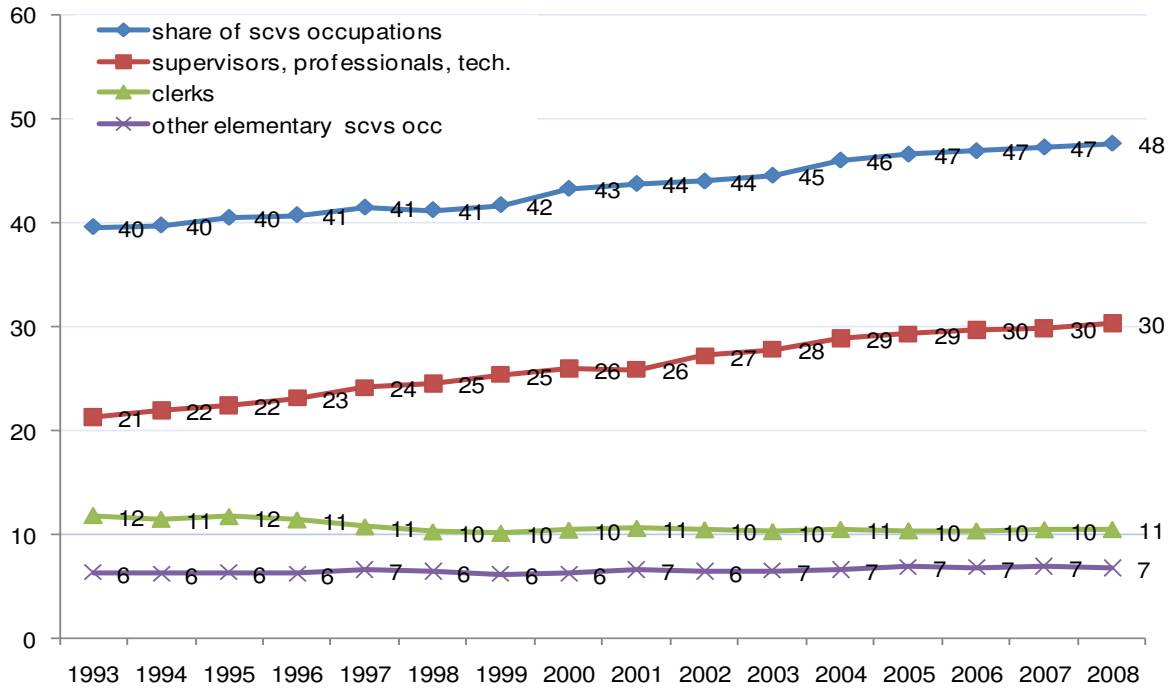
Source: OECD input-output tables.

Table 8: Change in the ratio of imported (economy wide) services to GDP (in per cent)

	1995	2000	2007
AT	8.2	8.8	10.3
BE	11	14.5	14.4
CY	14.3	17.4	17.7
CZ	9.9	9.7	8.4
DE	5.2	7.2	7.6
DK	9.3	13.3	17.7
EE	13.2	16.1	14.1
ES	3.7	5.9	6.7
FI	7.4	7.9	9.2
FR	4.4	4.9	5
GR		8.5	5.6
HU	9.4	10.1	11.5
IE	16.1	34.2	37.5
IT	4.5	5.1	5.8
LT	7.5	5.9	8.7
NL	12.1	14.6	13.7
PL	2.7	5.4	5.7
PT	5.2	5	5.5
RO	5	5.4	5.2
SE	7.5	10.5	11.5
SI	7.2	7.3	9.1
SK	9.3	8.7	8.8
UK	5.8	6.8	7.6

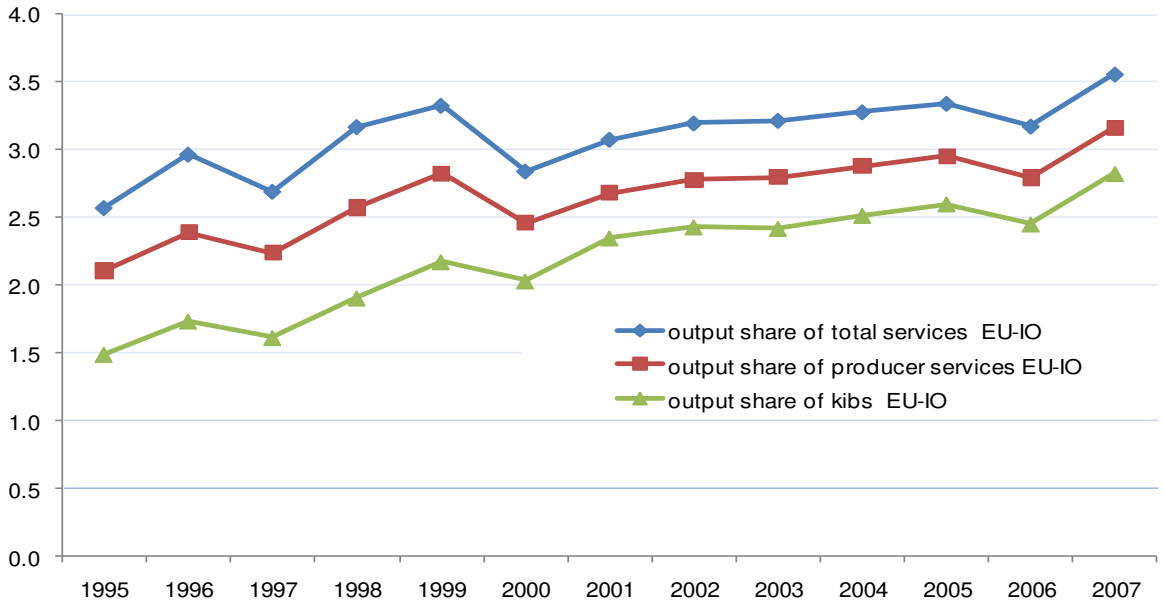
Source: Eurostat, New Cronos.

Figure 2: Change in the share of service occupations and by different categories in the EU-15 (unweighted means across countries in per cent)



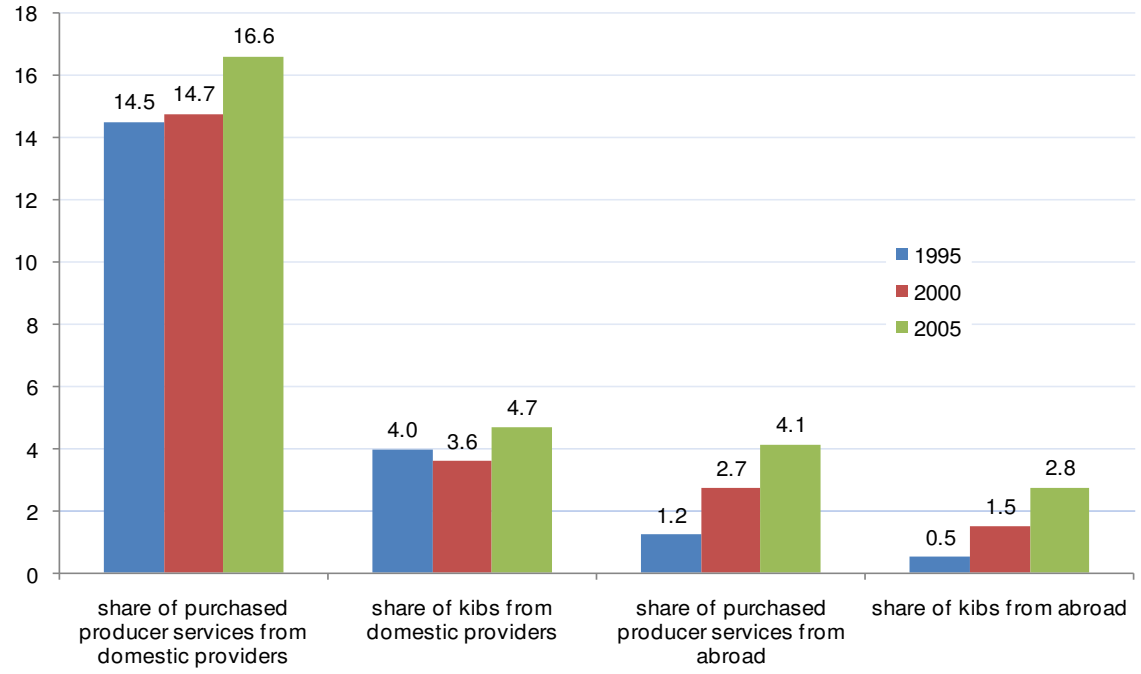
Source: EU-LFS, Weighted percentages. This figure includes EU countries for which data is continuously available since 1993.

Figure 3: Change in the output share of producer services in the EU-15 countries for which data is continuously available (unweighted means across countries in per cent)



Source: EU input-output tables.

Figure 4: Change in the output share of producer services in the EU-15 countries for which data is continuously available (unweighted means across countries in per cent)



Source: EU input-output tables.

Figure 5: Relationship between the change in the output share of KIBS and change in employment share of supervisors, professionals and technicians

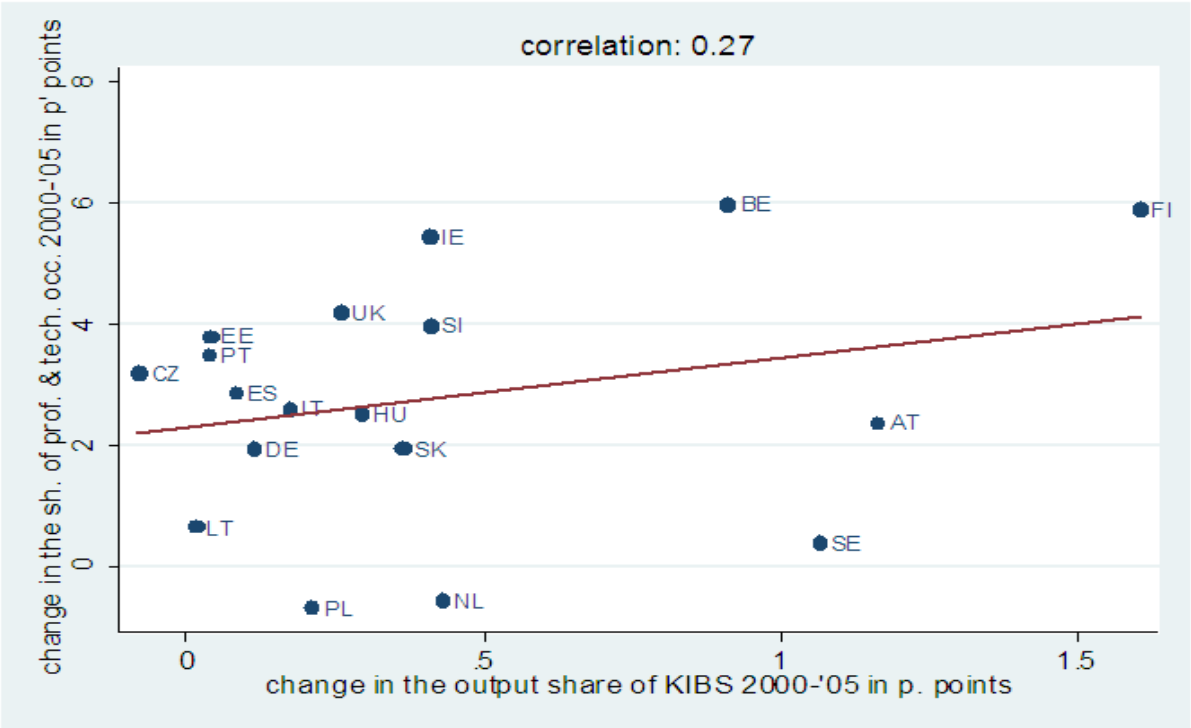


Table 9: Fixed effects estimates of the impact of purchased services from abroad on the employment share of different types of service occupations

	Total scvs occ	Professionals Technicians	Clerks	Other scvs. Occ
		Impact of purchased services from abroad		
	Coef.	Coef.	Coef.	Coef.
output share of producer services (excl. wh. & re. trade, public & personnel scvs)	-0.12	0.76**	-0.59***	-0.16
	(-0.25)	(2.36)	(-4.02)	(-0.54)
	[-0.60]	[6.77]	[-7.15]	[-0.92]
Ratio of purchased services from abroad to output	0.60**	0.22	0.13	0.14
	(2.68)	(0.95)	(0.98)	(0.72)
	[17.08]	[2.42]	[5.13]	[1.30]
# of obs	79	79	79	79
# of co	18	18	18	18
R2 within	0.62	0.70	0.28	0.13
		Impact of KIBS from abroad		
	Coef.	Coef.	Coef.	Coef.
output share of producer services (excl. wh. & re. trade, public & personnel scvs)	0.84	0.89	-0.27	0.79
	(1.03)	(1.41)	(-0.89)	(0.95)
	[1.26]	[2.56]	[-1.17]	[1.73]
Ratio of KIBS from abroad to gross output	0.39***	0.26**	0.01	0.01
	(3.19)	(2.14)	(0.15)	(0.14)
	[8.32]	[4.21]	[0.30]	[0.21]
# of obs	76	76	0.27	76
# of co	18	18	18	18
R2 within	0.62	0.65	0.65	0.17