The Servitization of European Manufacturing Industries

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Contents

Abstract

This paper provides new evidence for the servitization of European manufacturing – the trend that manufacturing firms increasingly offer services along with their physical products. We employ input-output data as well as data from a company survey to give a comprehensive picture of servitization across countries and industries.

The share of services in the output of manufacturing industries increased in the large majority of European countries between 1995 and 2005 and between 2000 and 2005. Service output of manufacturing, however, is still small compared to the output of physical products. The highest service shares are found in small countries with a high degree of openness and R&D intensity. EU-12 Member States have lower shares of service output compared to the EU-15.

There is a strong link between servitization and technological innovation at different levels. Countries with the highest shares of services on manufacturing output have also the highest R&D intensities at the aggregate level. The service output of these countries consists predominantly of knowledge-intensive services. Highly innovative sectors reveal also the highest share of firms that offer services and the highest turnover generated with services. Examples are electrical and optical equipment, machinery, or the chemical and pharmaceutical industry.

At the firm level, we find a U-shaped relationship between firm size and service output, which indicates that small, but also large manufacturing firms have advantages in servitization. Producers of complex, customized products tend to have a higher share of services in output than producers of simple, mass-produced goods. Moreover, firms which have launched products new to the market during the last two years are more likely to realize higher shares of turnover from services compared to companies which launched no products new to the market.

1 Introduction

The structure of economic output has considerably changed over the last 30 years in all European countries. Manufacturing industries lost shares on total output and employment, while the share of service industries increased, both in absolute and relative terms (Rubalcaba et al. 2008, Gallouj and Dejellal, 2010).

This structural change towards services at the aggregate level, however, is only one aspect of the changing relationship between manufacturing and services industries. Manufacturing firms themselves increasingly produce and provide services along with or instead their traditional physical products (Pilat et al., 2006; Christensen and Drejer, 2007). We will refer to this trend as the servitization of manufacturing. According to Vandermerwe and Rada (1988), servitization is "*the increased offering of fuller market packages or 'bundles' of customer focussed combinations of goods, services, support, self-service and knowledge in order to add value to core corporate offerings"*. Thus, servitization refers to services as one possible output of manufacturing firms, but not to the internal services all manufacturers require to produce goods (accounting, human resource management, marketing and logistics, etc).

The servitization of manufacturing is not a new phenomenon. Already in 1972, Levitt (1972) found that "there are only industries whose service components are greater or less than those of other industries. Everybody is in service business". Nevertheless, most contributions stick to the conventional distinction between manufacturing and service sector, and service innovation is still largely defined as *innovation in the service sector* (e.g. Hipp and Grupp, 2005; Preissl, 2000), neglecting the rise of product-related services in recent decades.

Our contribution to the literature is twofold: First, we provide a comprehensive overview of servicitation across countries and manufacturing sectors with macroeconomic and firm-level data. Second, we investigate the link between servitization, technological product innovation and technology intensity. The literature that examines product-related services in manufacturing is growing (Baines et al., 2009, Tether and Bascavusoglu-Moreau, 2012, Neely, 2008); however, there is scant empirical evidence of the relationship between servitization and technology. We regard servitizaton as a form of inovation and assume that servitization is a complement to technological innovation to some extent. There may be several mechanisms which associate servitization and technological innovation: Technology works as an enabler for some types of services provided by manufacturing (virtual design, remote product servicing etc.). Moreover, complex multi-technological products may be the driving necessity to provide complementary services (installation etc.) Furthermore, servitization is associated with organisational innovation: Neely (2008) states that servitization involves the innovation of an organisations' capabilities and processes in order to create mutual value through a shift from selling products to selling product-service-systems. A product-service-system is an integrated product and service offering that delivers value in use.

The paper is structured as follows: A first section summarises and discusses the literature on servitization. The second section tackles servitization of manufacturing at the macroeconomic level with input-output data. Finally, we go to the firm level and study the servitization of manufacturing firms with data from a pan-European survey.

2 Literature Survey

For the past decade, the phenomenon of manufacturers turning into service providers has gained increasing attention in the literature. Most of this attention came from the management literature. Up to now, a multitude of concepts and terms has been created to describe and research the phenomenon of the convergence between manufacturing and services. Contributions investigated *product-related services* (e.g. Lalonde and Zinszer, 1976; Frambach et al., 1997), *product-service-systems* (e.g. Mont, 2002; Tukker and Tischner, 2006), *integrated solutions* (e.g. Brax and Jonsson, 2009; Davis et al., 2007; Windahl, 2007; Davies, 2004) or, more generally, *servitization* (e.g. Vandermerwe and Rada, 1988; Rothenberg, 2007; Neely, 2008; Baines et al., 2009). The reason for these different concepts and nomenclatures can be found in the motives behind the research activities, but also on their geographic places of origin (Baines et al., 2009). Research communities developed independently and mostly in isolation from each other (e. g. Baines et al., 2009; Tukker and Tischner, 2006).

Lay et al. (2009) identified three basic strands in the management literature addressing convergence: the marketing literature, the literature on sustainability and sector-specific studies dealing with adding services to physical products. In the marketing literature, the convergence of manufacturing and services is discussed on the basis of concepts such as *servitization* (Vandermerwe and Rada, 1988), *servicizing* (Rothenberg, 2007), *full-service contracts* (Stremersch et al., 2001), high-value integrated solutions (Davies et al., 2007; Windahl, 2007), *functional sales* (Markeset and Kumar, 2005) or *operational services* (Oliva and Kallenberg, 2003).

In the literature on sustainability, the terms *product-service systems* (e. g. Tukker and Tischner, 2006; Mont, 2002; Baines et al., 2007) and *industrial product-service systems* (Welp et al., 2008) respectively are mostly used. In sector-specific publications, service concepts in the chemical industry (e. g. Reiskin et al., 1999), services offered by energy providers (e. g. Sorrell, 2007) and services of the aviation industry, such as performance-based contracting (Kim et al., 2007) are very prominent.

A special focus of the literature lies on the drivers of servitization and the rationales for the introduction of product-related services. One of the first comprehensive overviews is provided by Vandermerwe and Rada (1988). Based on interviews with business executives they are listing the following drivers of servitization: (1) Setting up barriers to competitors, customers and third parties; (2) creating dependency; (3) differentiating the market offering; (4) diffusing new innovations; (5) market research. Though for example the maturity of industries is said to require a differentiation of drivers, the overriding motive for servitization is the wish to **gain a competitive edge**.

Frambach et al. (1997) distinguish between three rationales behind servitization:

- First, manufacturers with innovative product related services are regarded to be able to differentiate from competitors and thus to gain competitive advantage. Due to increasingly comparable physical products and the growing demand for turnkey solutions service innovations can create additional value for the customer. Manufacturers offering such a value are supposed to have advantages in competition.

- Second, product services are said to be a means of creating sustainable, long-lasting relationships with customers. The density of contacts between manufacturers and customers over the lifetime of the physical product is intensified by offering services. By that the manufacturers learn more about the needs of the customer and are able to customize their products.

- Third, offering product services enables the suppliers to increase their profitability. Service elements are regarded to have higher margins while physical products have to face reduced margins due to competition. Hence service margins can compensate for falling product margins and stabilize overall margins.

Wise and Baumgartner (1999) directed the attention to the **installed base** as an argument for going downstream. They summarize that manufacturers' traditional role in the value chain– producing and selling goods – has become less and less attractive as the demand for products has stagnated throughout the economy. At the same time, the installed base of products has been expanding steadily due to accumulation of past purchases and longer life times of products. This combination is regarded to push economic value downstream, away from manufacturing and toward providing services required to operate and maintain products. Besides downstream market opportunities as a **source of revenue** Wise and Baumgartner also mention higher margins, the requirement of fewer assets, the steadiness of revenue streams and their countercyclical flow of income – arguments which have been discussed already previously or more in depth in papers which have been published later.

One of these publications has been presented by Mathieu (2001). She distinguishes between three generic benefits from implementing a service strategy in manufacturing companies:

- In the field of *financial benefits* she mentions the option to reduce the vulnerability and volatility of cash flow by offering product related services besides the argument of growth with innovative services. With regard to the margins she points out that there could be a difficulty to realize higher margins due to the fact that the costs of services in manufacturing companies are hardly transparent. She summarizes that services can be worthwhile from a financial viewpoint so long as the manufacturing company not only gets service costs under control, but also implements a consistent pricing strategy.

- In the field of *strategic benefits* Mathieu combines all arguments dealing with building barriers for market entry, differentiating from competitors and hence gaining competitive advantage. She concludes that service innovations in manufacturing may not induce strategic benefits per se but with regard to the specificity and intensity of the service manoeuvre. Even if lack of experience may handicap the manufacturing company, innovativeness in service strategy is regarded as a precondition for building an original competitive positioning.

- In the field of *marketing benefits* several aspects have been mentioned: gaining client satisfaction with superior product related services, improving the adoption of new physical products by offering assistance with product related services, maintaining ongoing relationships with an enhanced service strategy or strengthening the client's confidence and the supplier's credibility with services. All these aspects are said to result in enhanced market shares if the service strategy not only relies on traditional services but is focused on more innovative and advanced service offerings.

This differentiation into the three generic benefit categories "financial", "strategic" and "marketing" has been picked up afterwards e.g. by Baines et al. (2009).

Targeting the rationales for servitization Oliva and Kallenberg (2003) present a modified threefold classification:

- First, they mention economic arguments. Here they subsume revenue generation from the installed base of products with a long lifecycle, the generation of margins due to superior margins in the service business compared to the product business and the stabilization of revenues due to the resistance of service revenues to the economic cycles.

- Second, customers' demand for more services is noted. More flexible customer firms, narrower definitions of their core competencies and increasing technological complexity are highlighted as the main reasons for such a demand.

- Third, competitive arguments are observed. Here especially the increased difficulty to imitate services compared to products is said to induce a superior position.

In this classification of rationales, which can in a similar way be found in Auramo and Ala-Risku (2005), actively pursued objectives and more passive needs are mingled. While economic and competitive arguments for servicizing are stimuli to gain advantages for manufacturers, customers' demands seem to be a trend which manufacturers have to cope with.

Malleret (2006) related the expected benefits of developing innovative services in manufacturing companies to four major themes: Building customer loyalty, differentiation, increasing or stabilizing turnover and corporate image. This arrangement in groups seems to be only a slight modification against the earlier classification attempts mentioned above. More valuable and important for measuring the impact of servitization seems to be the observation that contradictions might occur between objectives from the lists of previous scholars. Malleret observed that many of the expected benefits described in earlier work relates to corporate competitiveness, i.e. the company's capacity to win or keep customers. Understood strictly in the sense of winning market shares, competitiveness however does not always go hand-in-hand with profitability. To achieve competitive edge that is profitable, the services concerned would have to be charged to customers and produced at lower costs than competitors.

This observation leads to the necessity not to measure the achievement of the financial objectives of servitization with one indicator. At least growth in sales and growth in profitability are worth to be differentiated.

An additional differentiation has been introduced by Gebauer (2007). He explains the rationales for extending service businesses of manufacturers along five lines: Three of these arguments are familiar from previous scholarly work mentioned above like strategic benefits from differentiation, margins from the more profitable business with services and more stable revenues due to contra-cyclical flow of income from services. The two other arguments however are slightly modified from previous lists: Gebauer mentions on the one hand **growth opportunities with physical products** augmented with and hence induced by services, on the other hand **growth options by selling additionally services** it selves and creating revenues from these innovative offerings. This differentiation clearly indicates that servitization should not be measured only by monitoring service sales.

In recent literature one more aspect of servitization benefits is highlighted severally: Product related services are recognized as an important **feedback-loop to product development** of manufacturers (Brax and Jonson, 2009). The feedback-loop advantage picks up relationship-benefits coming from an increased contact between manufacturer and customer induced by product related services, which have been mentioned before (e.g. Frambach et al., 1997). These benefits are specified in the direction of stimulating new products and services instead of only customizing existing products to individual customer needs. Goh and McMahon (2009) found that companies can use insights gained from use and in-service to adapt their support activities and also to feed-forward this knowledge into new design projects.

The move from goods producers to providers of complex solutions is a complicated task. Case studies indicate that manufacturers find it extremely difficult to successfully exploit the potential of an extended service business (Gebauer et al., 2005). Companies which invest heavily in extending their service activities incur higher costs, but often do not yield the expected correspondingly higher returns. Because of increasing costs and a lack of corresponding returns, the growth in service revenue fails to meet its intended objective. Gebauer et al. (2005) term this phenomenon the "service paradox in manufacturing companies". Recently Neely (2008) found some large scale empirical evidence for this paradox of servitization. He reports that servitized firms generate higher revenues, but tend to generate lower net profits (as a percent of revenues) than pure manufacturing firms. Brax (2005) as well identified a paradox as her findings show that engaging in service business also entails risks for the providing companies. Although services are regarded as a safe source of revenue, turning into a service provider brings about considerable challenges and threats to business, especially if they are considered as secondary to the product business in manufacturing companies.

3 Macroeconomic Evidence

The aim of this section is to draw the 'big picture' of the servitization of manufacturing. Based on the results of the literature survey, we assume that there is a general trend towards a higher share of service products in manufacturing output across countries and over time. We will examine similarities and differences regarding the service output of the manufacturing sectors at the country level, with a focus on the developments having in the last ten years up to 2005. We examine which sectors offer services, as well as what types of services are offered.

The analysis is based on input-output data. We employ supply tables for 23 EU Member States and the US, provided by Eurostat and the US Bureau of Economic Analysis (BEA). These tables give a detailed account of the supply of goods in an economy broken down into industries and goods. They indicate which industry produces what good in what quantity. Thus, supply tables give a detailed picture of the structure of production in a particular country.

The supply tables have been compiled according to the 'European System of National Accounts 1995' (ESA 95) for the EU Member States, and according to the 'North American Industry Classification System 1997 (NAICS) for the US. For a detailed outline of the compilation of the supply tables, see Eurostat (2008) and Bureau of Economic Analysis (2009). The EU Member States included are, in alphabetical order, Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Lithuania, Luxembourg, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and the United Kingdom[1].

The supply tables are organised as product by sector matrices. Industries are classified in NACE Rev. 1.1[2], the corresponding classification scheme for products is CPA[3]. NACE and CPA correspond at the two-digit level. The study concentrates on domestic production. Therefore, we exclude imports as well as trade and transport margins. The classification of the supply tables covers sectors and products, ranging from NACE/CPA 1 to 95.

The manufacturing sectors are grouped into larger aggregates by using the NACE classification at section level from A to P[4], as suggested by Hanzl-Weiss and Stehrer (2010). Moreover, we applied an aggregation of manufacturing sectors according to their innovation intensity at two-digit level (see Peneder, 2010). Table A2 in the appendix reports these aggregates in detail.

1 For most countries, data is available for the years 1995, 2000 and 2005. In the case of Greece, Lithuania, Poland and Romania the latest available data is from 2000. Not earlier than 1996 are sup-ply tables available for Slovenia. Supply tables for Estonia are available for 1997 and data for Hun-gary as well as Ireland has been recorded since 1998. The newest data for the USA and the UK is from 2002 and 2003, respectively. Table A1 in the appendix gives a detailed overview of the data availability. The analysis reflects values at current prices in terms of millions of national currency.

2 NACE – Nomenclature générale des activités économiques dans les communautés européennes, Classification of Economic Activities in the European Community, Rev. 1.1.

3 CPA – Classification of Products by Activity.

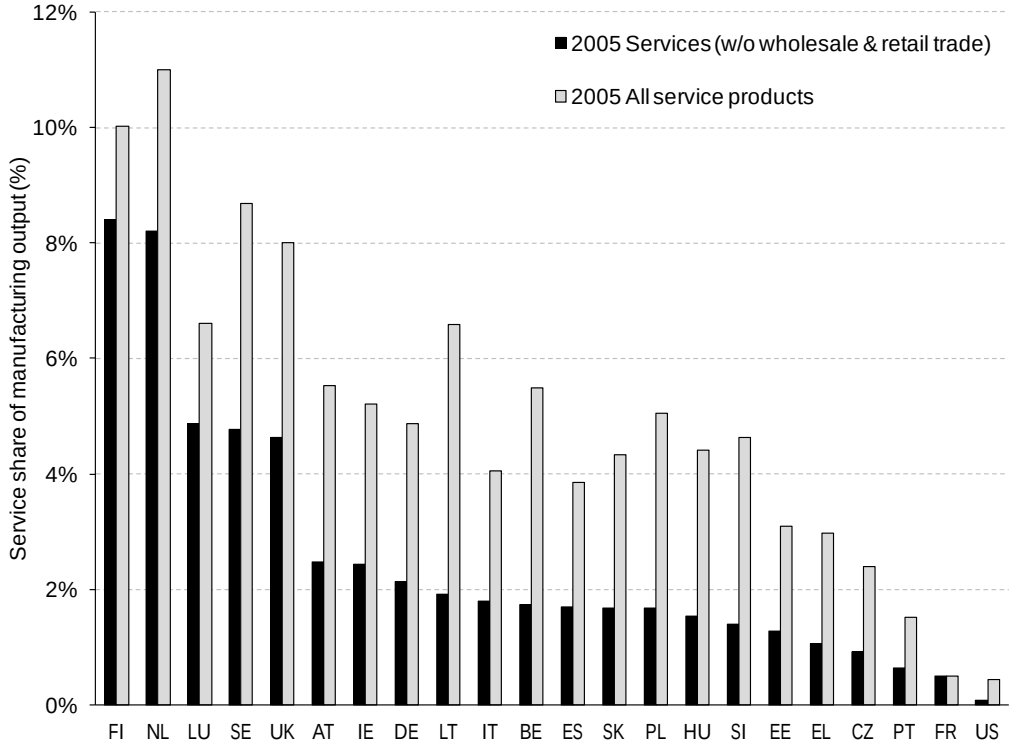
4 D for the manufacturing sectors and G (Wholesale and retail trade), H (Hotels and restaurants), I (Transport, storage and communication), J (Financial intermediation), K (Real estate, renting and business activities), L (Public administration and defence; compulsory social security), M (Education), N (Health and social work), O (Other community, social and personal service activities) and P (Activities of households) for services.

3.1 Service Output across Countries and Changes over Time

We calculate the service share of manufacturing output as service output divided by total output for each manufacturing sector (see Box 1 in the appendix). We distinguish two types of service output. The first type includes the the whole range of services from CPA 50 to 95 and NAICS 42 to 92. In the second type we define services more narrowly and exclude wholesale and retail trade[5] (CPA 50, 51 and 52 for the EU Member States, and NAICS 42-45 for the US).

Supply table data indicates that the output of manufacturing still consists to a great extent of manufactured products. As Figure 1 illustrates, services (excluding trade) do not represent more than 9% in any country. Obviously, the process of servitization is not in an advanced stage as far as the EU Member States and the US are concerned. However, as discussed below in section 4.1, the majority of services offered by manufacturing firms is not charged directly but indirectly as part of a product-service bundle and hence difficult to see in input-output tables. It is therefore reasonable to assume that the real share of service output in manufacturing is considerably higher.

Figure 1: Service share of manufacturing output (%), various countries, 2005



Note: Latest available data: the US and the UK until 2002 and 2003, respectively. The values for all service products include CPA 50 to 95 for the EU Member States and NAICS 42 to 92 for the US. The values for services excluding wholesale and retail trade cover CPA 55 to 95 for the EU Member States and NAICS 48 to 92 for the US. Data for France covers only service products CPA 72 to 95.
Source: Eurostat and US Bureau of Economic Analysis supply tables; own calculations.

We can clearly distinguish various groups of countries according to their levels of service output. A first group comprises of Finland and the Netherlands with service shares above 8 %. Another group of countries includes Luxembourg, Sweden, and the UK with above-average levels of service shares

5 CPA 50 includes sale, maintenance and repair of motor vehicles and motorcycles as well as retail sale services of automotive fuel; CPA 51 covers wholesale trade and commission trade, except of motor vehicles and motorcycles; CPA 52 comprises retail trade, except of motor vehicles and motorcycles as well as repair of personal and household goods.

above 4 %. The last group of countries exhibits levels of service shares up to 2 %. There are more gradual differences among this group, approximately half of the countries being around 2%.

Two characteristics of Figure 1 are worth highlighting at this stage, though they ought to be interpreted with caution. First, countries with higher service content tend to be small, export oriented, open economies. These countries are Finland, the Netherlands, Luxembourg, Sweden, Austria, and Ireland, with the UK being the only large country in this group. Second, the service content of manufacturing industries tends to be lower in EU-12 countries, with values invariably below 2%. This is consistent with Neely (2007) who finds that manufacturing firms in countries with a high GDP per capita tend to offer services more frequently than firms from catching-up economies

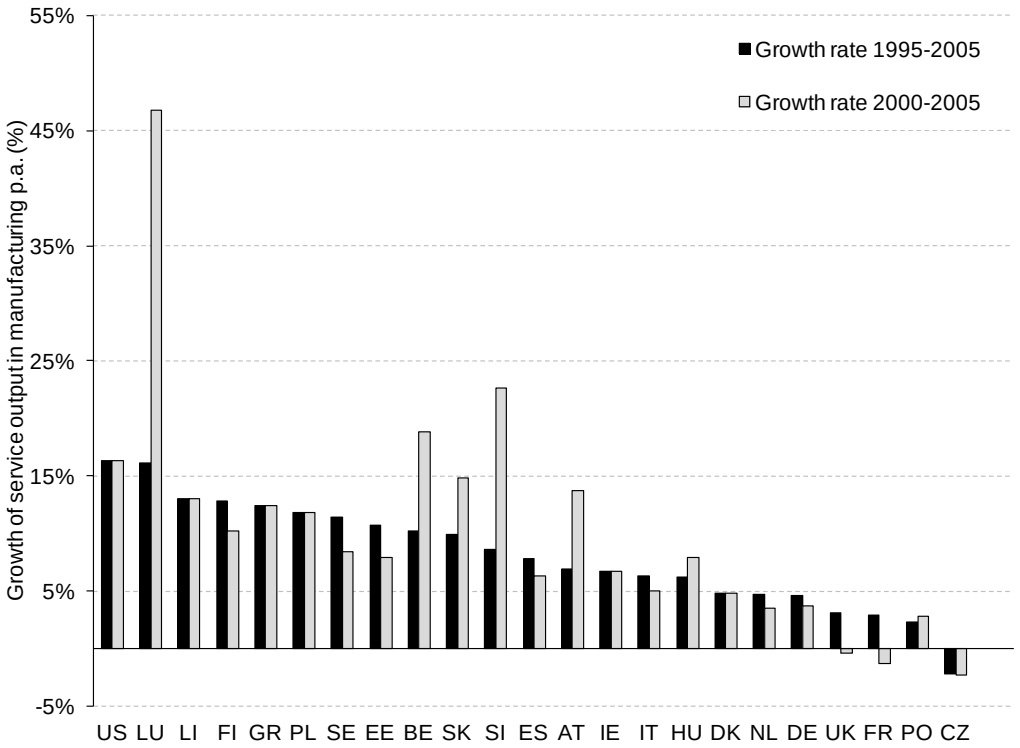
There are also differences between countries which may be the result of differences in data collection and treatment rather than in industrial structure. It has already been mentioned that services which are charged directly may only be the tip of the iceberg, because most turnover is generated by services which are charged indirectly, as part of a product-service bundle. Input-output data does not account for these services. Moreover, in some cases we cannot tell if differences between countries are due to differences in production structures or different data collection procedures. There is no output in wholesale and retail trade in the Danish manufacturing sector. In some other countries, the output for some other service products is very low, which may also indicate that statistical agencies collect data on sectoral production not in a uniform manner.

The cross-country comparison of the output structure for 2005 reveals the latest available picture of the service specialisation of the manufacturing sector. To gain an insight on the developments leading to this picture we have calculated the average annual growth rate of manufacturing service output for the period 1995-2005 and the period 2000-2005 (Figure 2). Figure 2 and the following figures do not include wholesale and retail trade (CPA 50, 51 and 52).

The share of services in manufacturing output has been growing in all countries under study, the only exception being the Czech Republic. We therefore assume that servitization is a uniform development across the countries.

In most countries growth rates for the period 2000-2005 are similar or lower than for the period 1995-2000. In other words, there was no acceleration of growth of the service share compared to 1995-2000. This result is striking since it contrasts to the view of an accelerating ‘tertiarisation’ process in developed countries. Only Luxembourg, Belgium, Slovakia, Hungaria and Slovenia have shown a more dynamic growth recently. Obviously, in these countries the manufacturing sector seems to have experienced a more pronounced development process in terms of servitization in the years before 2005. Yet another group of countries, notably Austria, Greece, Ireland, Lithuania, and Poland, has shown more or less a similar growth in the subperiod 2000-2005 as in the whole period looked upon. Interestingly, the data shows that Luxembourg and Finland both have high service shares and a strong growth of these shares.

Figure 2: Annual growth rate of the service share of manufacturing output (%), various countries, 1995-2005 and 2000-2005



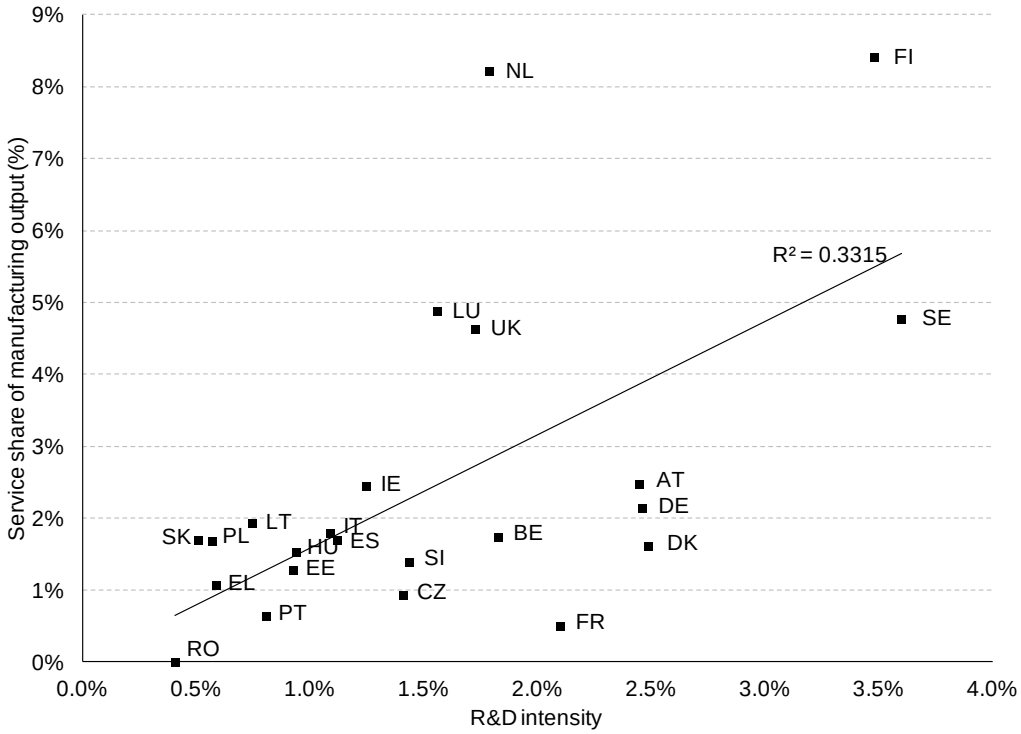
Note : Latest available data: Estonia (1997), Lithuania (2000), Hungary (1998), Greece (2000), Poland (2000), Ireland (1998) and Slovenia (1996). Data for the US and the UK were available until 2002 and 2003, respectively. The values for all service products include CPA 55 to 95 for the EU Member States and NAICS 48 to 92 for the US. Data for France covers only service products CPA 72 to 95.
Source: Eurostat and US Bureau of Economic Analysis supply tables; own calculations.

Countries with high share of service output in manufacturing - Finland, the Netherlands, Luxembourg, Sweden, and the UK - are also top-performing in terms of research and development (R&D) intensity[6]. Based on this observation, we explore in the following whether the countries with a higher R&D intensity also exhibit higher shares of service products in their manufacturing sector's output.

In Figure 3 we have plotted the service share on manufacturing output against R&D intensity for each country for the year 2005. We see only a weak relationship between R&D intensity and the service content of manufacturing. The data reveals to a lesser degree that the countries with lower shares of R&D intensities tend to have lower service shares as well. On the contrary, countries with R&D intensities above average may be divided into two groups. On the one hand, Austria, Belgium, Denmark, France, and Germany, perform better than average regarding their values for R&D intensity, while the service content of manufacturing does not exceed average values around 2.5%. On the other hand, we observe a group of countries, where a positive relationship between R&D intensity and service share seems to exist, notably for Finland, Luxembourg, the Netherlands, Sweden, and the UK. We cannot deny or accept a possible positive relationship between R&D intensity and service share of manufacturing output at country level. The relationship between service output of manufacturing and innovative intensity will further investigated at the sectoral level in the next section.

6 Insofar as their R&D expenditure as a share of GDP exceeds average values for OECD countries.

Figure 3: Service share of manufacturing output (%) and R&D intensity (%), various countries, 2005



Note : Latest available data for the UK is 2003.. The values for all service products include CPA 55 to 95 for the EU Member States and NAICS 48 to 92 for the US. Data for France includes only service products CPA 72 to 95. R&D intensity measures gross expenditure on R&D (GERD) as a share of GDP.

Source: Eurostat; author's calculations.

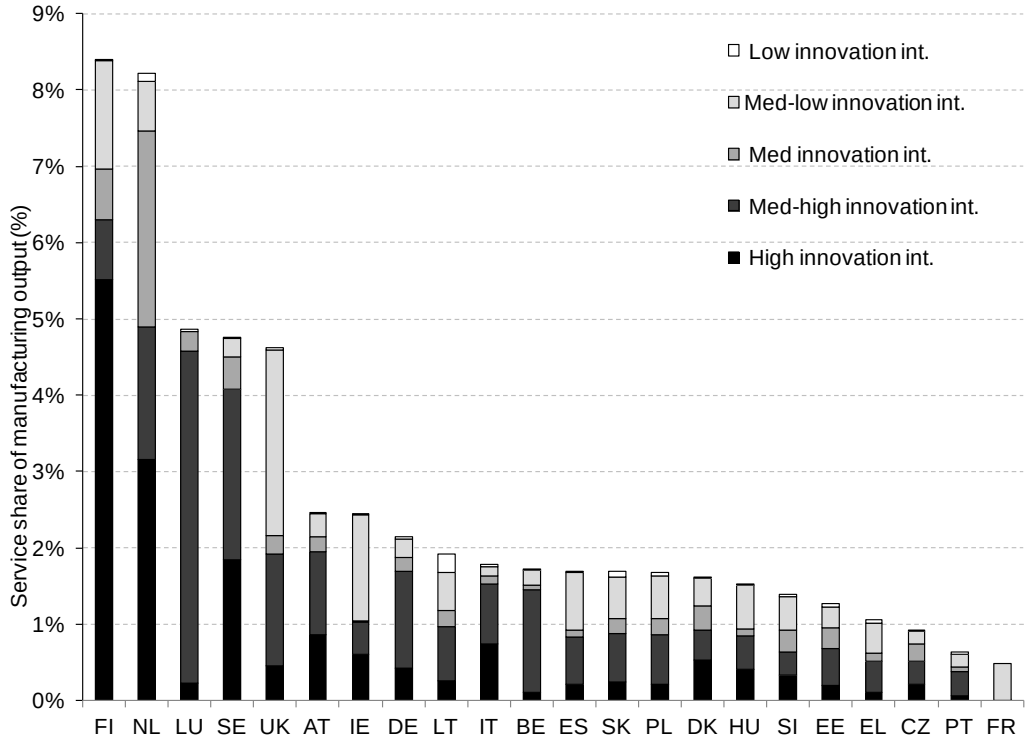
3.2 Which Manufacturing Industries provide Services?

In this section we will have a look at the service content of manufacturing at the level of sectors. In order to explore possible similarities and differences at the sectoral level between the EU Member States, we apply a sectoral taxonomy based innovation intensity proposed by Peneder (2010). Peneder (2010) characterises sectors by the distribution of diverse innovation modes at the firm level. The empirical identification of those modes is based on the micro-data of the Community Innovation Survey (CIS) for 22 European countries by applying statistical cluster analysis. Sectors with high innovation intensity have i) a high share of creative firms (i.e. firms with product innovations new to the market or process innovations developed internally), ii) a high share of firms with innovation expenditures in total turnover of above 5 per cent, iii) a high share of firms with strategic and formal methods of appropriation (e.g. patents) and iv) a high share of firms which value their own sources of knowledge generation more than external sources of knowledge generation (Peneder, 2010).

In a first step, we aggregate manufacturing industries at the two-digit level (NACE 15-37) according to this taxonomy. As a result, we get five classes, ranging from manufacturing industries with low innovation intensity to industries with high innovation intensity. In a second step, we split total service output for each country according to these industry aggregates.

The results show a clear pattern, as detailed in Figure 4: service output is associated with high and medium-high innovation intensive industries. In Austria, Belgium, Denmark, Finland, Germany, Italy, Luxembourg, and Sweden, more than two thirds of the service output comes from high or medium-high innovation intensive industries. Here, the sector ‘Manufacture of electrical and optical equipment’ prevails. We can relate this to complementary software and business services, that are offered along with information and communication technologies.

Figure 4: Service share of manufacturing output (%) by innovation intensity, various countries, 2005



Note : Latest available data for the UK is 2003. The values for all service products include CPA 55 to. Data for France includes only service products CPA 72 to 95.

Source: Eurostat; author's calculations.

Further, in a second group of countries, including the Czech Republic, Estonia, Greece, Hungary, Lithuania, the Netherlands, Poland, Portugal, Slovakia, Slovenia, and Spain, high and medium-high innovation intense sectors still play an important role, with a share of approximately 50% on the service output. A strong contributor to service output in many of these countries are the manufactures of coke, refined petroleum products, chemicals and chemical products, or rubber and plastic products.

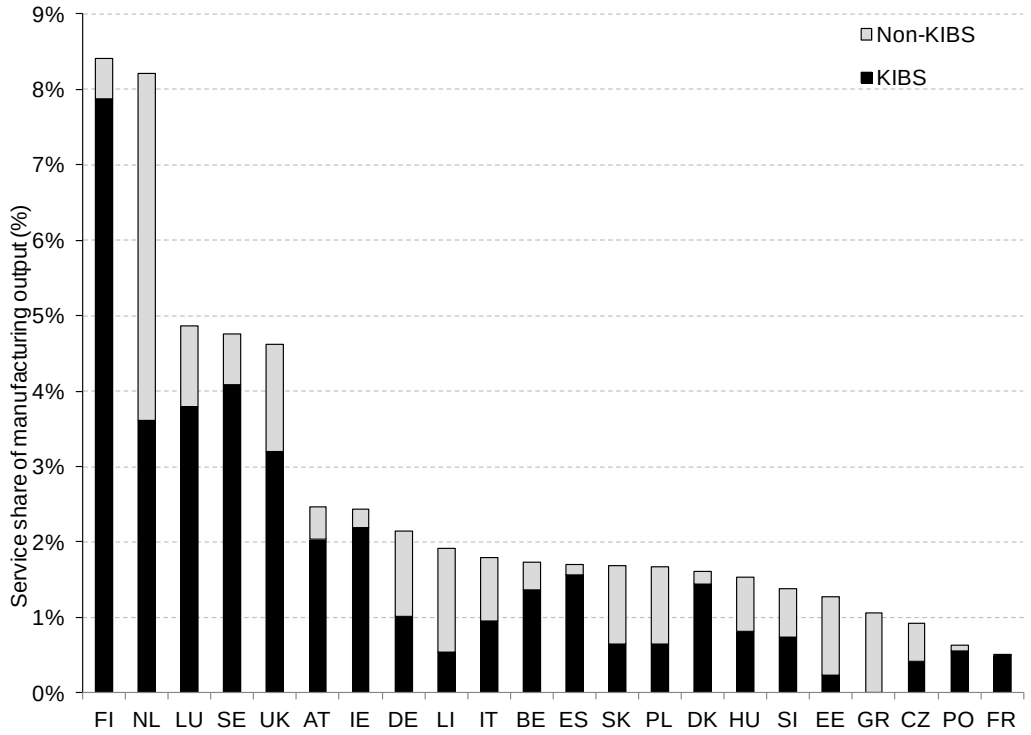
Manufacturing sectors with medium-low innovation intensity explain more than 50% of the service content in the UK and Ireland. In these two countries, the industry 'Publishing, printing and reproduction of recorded media' (NACE 22) has a considerable output of 'Other business services' (NACE 74) which explains half of the total service output of UK manufacturing and more than 20% of service output in Irish manufacturing, respectively. We assume that this is largely due to new 'creative industries' that have grown out of traditional printing and publishing firms. The manufactures of wood and wood products, pulp, paper, paper products and publishing and printing have also high shares on service output in Slovenia, France, and the US.

3.3 Which Services are offered by Manufacturing Firms?

We now turn to the types of services offered by manufacturing industries. To investigate the composition of service output of manufacturing firms in more detail, we have aggregated the service output into knowledge-intensive business services (KIBS, CPA product classes 72-74) and non-KIBS services (CPA 55 to 95 excluding CPA 72-74). KIBS include, for example, computer services, consultancy and accounting services, engineering and R&D services, advertising and public relations services, or services of corporate headquarters.

The results reveal that the service output of manufacturing predominantly consists of knowledge-intensive business services. In half of the countries, KIBS constitute at least two thirds of the service output of manufacturing. In Sweden for instance, KIBS account for 85% of the entire service output of manufacturing. Moreover, the share of KIBS on total service output is high in countries with a higher degree of servitization in manufacturing (see Figure 5), the only exception being the Netherlands. In other words, the supply of KIBS is a main driver for the servitization of manufacturing.

Figure 5: Service share of manufacturing output split into knowledge-intensive business service sectors (KIBS) and non-KIBS services, various countries, 2005



Latest available data: the UK until 2003. The values for all service products include CPA 55 to 95. Data for France covers only service products CPA 72 to 95.
Source: Eurostat; author's calculations.

The results indicate that there is a difference in the specialisation patterns of manufacturing between EU-15 and EU-12 Member States. The share of KIBS in the service output of manufacturing is considerably higher in the EU-15 than in the EU-12.

4 Evidence from Firm-Level Data

Macroeconomic data gives detailed insight into the share of service output in different countries, its development over time as well as into sectoral patterns in a cross-country perspective. However, the macroeconomic perspective can tell very little about differences between various groups of firms, in particular small and large firms, and the factors that determine the service output of manufacturing firms. In the following section we will therefore use firm-level data from the *European Manufacturing Survey (EMS)*.

EMS is organized by a consortium of research institutes and universities co-ordinated by the Fraunhofer Institute for Systems and Innovation Research (ISI) and takes place every three years. This section presents results from the last round of EMS conducted in 2009. EMS investigates product, process, service and organisational innovation in the European manufacturing sectors. In contrast to CIS, EMS is more focused on technology diffusion and organisational innovation than on product innovation.

The data set used here consists of EMS data from 10 European countries and includes the Austrian, Croatian, Danish, Finnish, French, German, Dutch, Slovenian and Swiss data sets collected in 2009. Table A3 in the appendix gives an overview about the number of firms included in each country, the number of valid cases and the return rates achieved. In total, 3,693 cases can be used for the analysis of this paper. Most firms are from Germany, followed by Switzerland and Denmark. The French data set has a regional focus on the Alsace region. The return rates in Spain, the Netherlands and France are relatively low compared to the other participating countries.

The European Manufacturing Survey

The European Manufacturing Survey (EMS) covers a core of indicators on the innovation fields "technical modernisation of value adding processes", "introduction of innovative organisational concepts and processes" and "new business models for complementing the product portfolio with innovative services". The questions on these indicators have been agreed upon in the EMS consortium and are surveyed in all the participating countries. Additionally, some countries ask questions on specific topics. The underlying idea of the question design is to have a common part of questions constantly over several survey rounds, to modify other common questions in the respective survey round corresponding to current problems and topics from the area of innovations in production and to thirdly give space for some country or project specific topics.

The EMS adressed the production manager or the CEO of contacted manufacturing firms. The respondents were however asked to fill in information on their activities in the year 2008. In most countries, EMS is carried out as a written survey on company level. For preparing multinational analyses the national data undergo a joint validation/harmonisation procedure.

The latest survey EMS 2009 was carried out successfully in 13 countries. Due to the cooperation of the EMS partners, information on the utilisation of innovative organisation and technology concepts in the generation of products and services as well as performance indicators such as productivity, flexibility and quality of more than 3,500 companies of the manufacturing service in these countries could be surveyed.

Source: Fraunhofer-ISI (2011)

The target group of the EMS survey were manufacturing firm with more than 20 employees in 2008. 42.8% of the firms in the sample are small firms up to 49 employees, another 44.2% of the firms have between 50 and 249 employees. 12.9% of the firms have more than 250 employees.

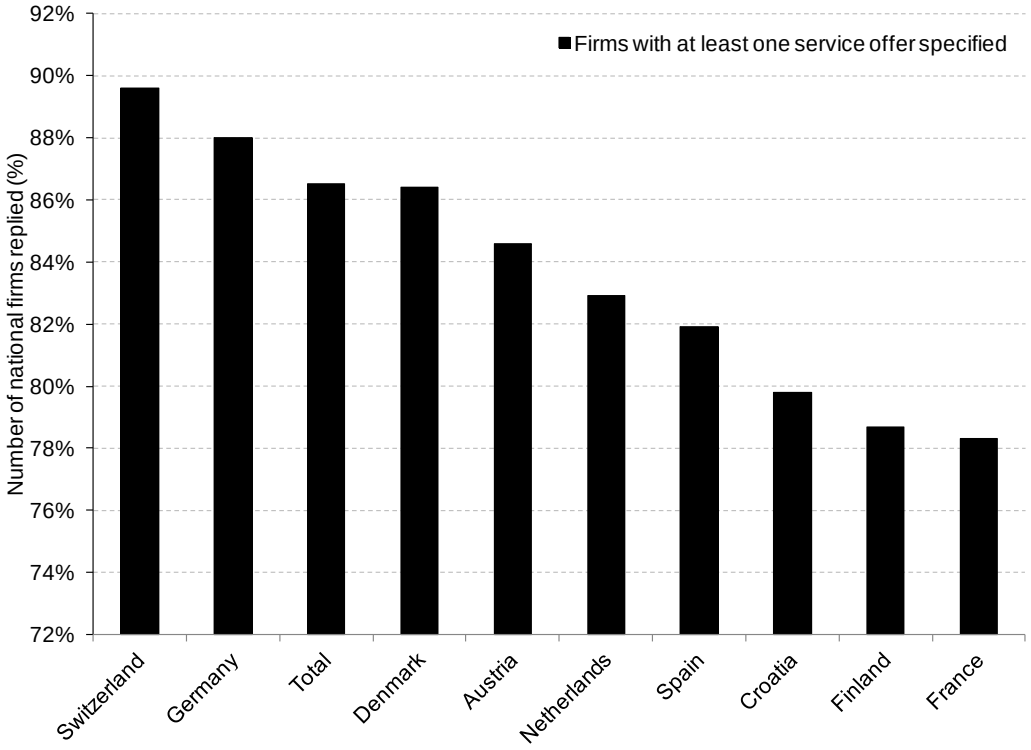
The analysis only considers manufacturing industries NACE 15 to 37. The largest sector in the sample are the producers of metal products, followed by machinery and the producers of wood products and furniture. The sectoral distribution of the data set can be found in Table A4 in the annex.

4.1 The Scope of Service Output in Manufacturing

The EMS defines service offerings of manufacturing firms in a narrower sense than input-output data. It only considers product-related services which are closely associated with manufactured goods so that the consumption of a product incorporates a goods as well as service content. The following eight types of services are included: design/consulting/project planning, technical documentation, software development, leasing/renting/finance, installation, start-up procedure, training, maintenance/repair, and build-operate-owner services.

Figure 6 shows the spread of product-related services in European manufacturing, i.e. the proportion of firms offering at least one out of the eight types of services listed above. It reveals that in all countries the proportion of manufacturing firms supplying at least one type of service is extremely high, starting from around 80 per cent in the countries with the least spread and about 90 per cent in Switzerland, which is the country with the highest spread of services as an output in manufacturing firms.

Figure 6: Firms with service offers in the European manufacturing (%), various countries, 2008



Source: EMS 2009. Question: Which of the following product-related services do you offer to your customers? N=3,693.

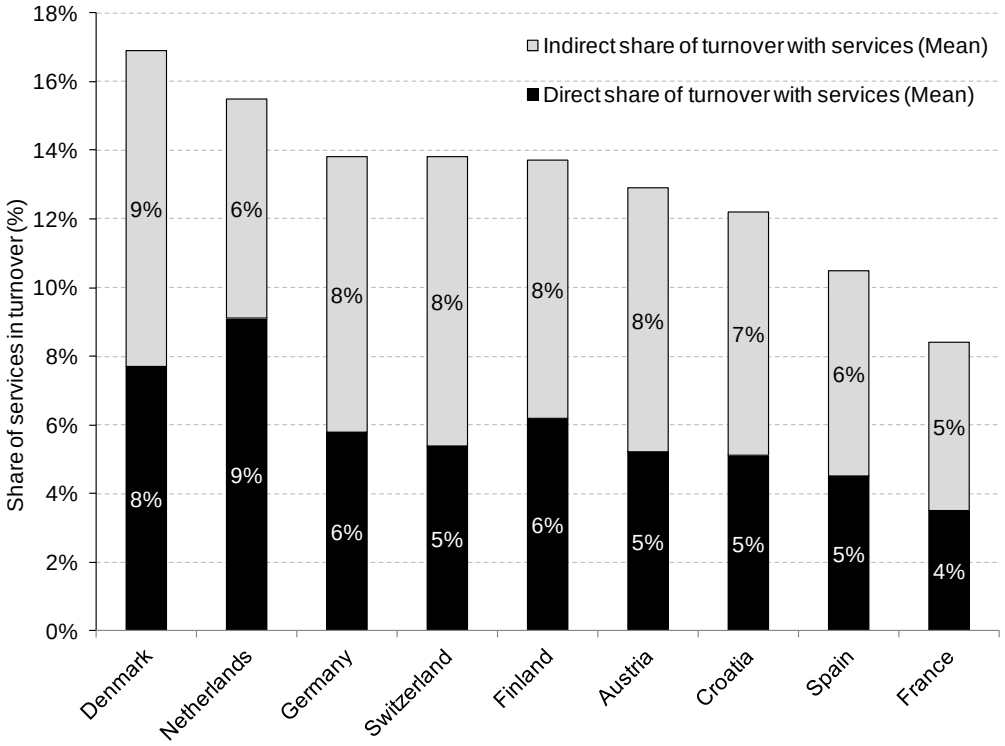
The literature indicates that firms invoice services in two different ways to their customers: directly, by invoicing the service seperately, and indirectly, by offering a product-service package that covers the cost of the product and the service. Figure 7 distinguishes between these two types of service turnover.

The data show that the indirect turnover from services is higher than the turnover from invoicing services in almost all countries. Hence, the share of services in manufacturing output as measured by

input-output data is rather the tip of the iceberg, and services have a much higher relevance for manufacturing performance than indicated by value added.

We may interpret this preference for indirect invoicing of services by the fact that the sales processes of manufactured products are mostly focused on attributes embedded in the physical design of the products, as Lenfle and Midler (2009: 167) suggest. Often the sales process is not the suitable situation to sell also services in a direct form, as the willingness to pay for product-related services seems underdeveloped. This may be even more the case for innovative producer-related services: In purchasing physical goods, attractive physical features of the good prevail, explaining in detail an innovative service is likely to be a second-order goal, both from the salesperson's as well as the buyer's point of view. Still, this does not contradict the proposition that product-related services represent a competitive advantage which is very well perceived by the customer and provides a differentiation between otherwise competing products in saturated and rapidly changing markets (Furrer, 1999). First, a considerable share of turnover from product-related services is achieved via direct service prices, although it is less than indirect pricing. Second, customers seem to accept higher product prices which incorporate services.

Figure 7: Direct and indirect turnover with services as a share of total turnover in manufacturing, various countries, 2008



Source: EMS 2009. Question: If you offer product-related services to your customers – what was the percentage of turnover you charged directly (and indirectly)? N=3,693.

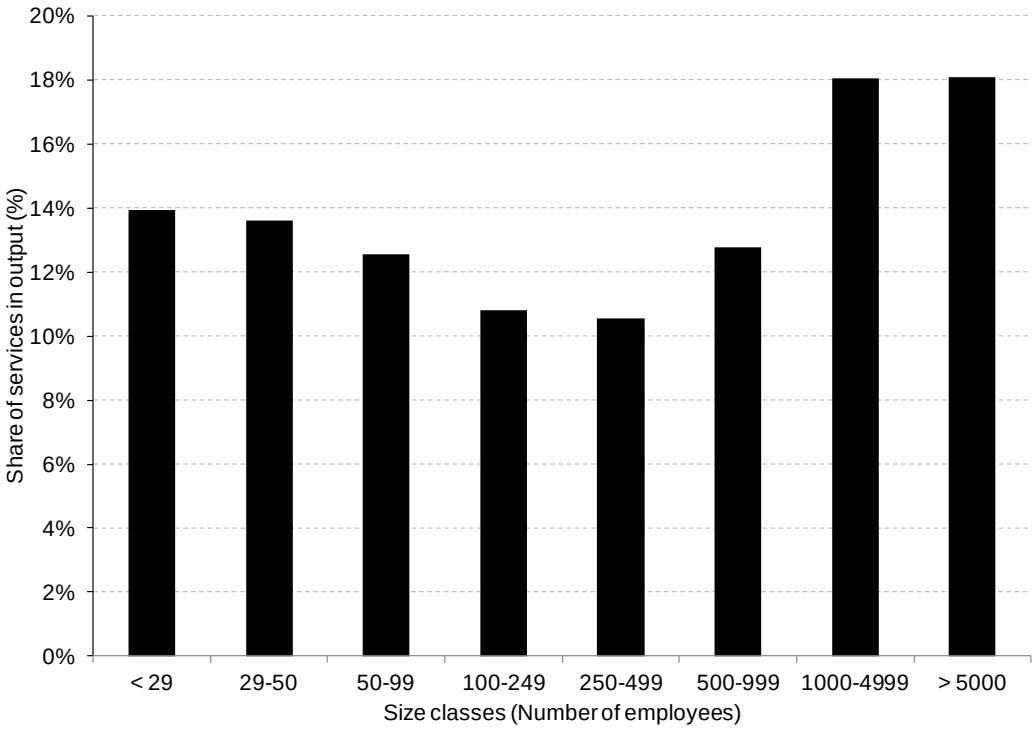
Another argument from the literature that may explain the high share of indirect invoicing in product-related services is that firms in manufacturing do not deliberately tailor their service offerings in order to attract new customers or minimize customer turnover. Instead, they add services bit by bit, layer upon layer, and do not dispose of the necessary controlling mechanisms to provide full cost transparency which is necessary for direct pricing. (Furrer, 2010: 717, Lay and Jung Erceg, 2002: 6).

Empirical research on innovation in firms found a U-shaped relationship between innovation intensity and firm size (Cohen 2010 provides a review of the evidence). This finding has been explained by the specific advantages and disadvantages of small and large firms in the innovation process.

We find a very similar relationship between firm size and the turnover generated with services (Figure 8). The overall service turnover including direct and indirect turnover, of small manufacturing enterprises is between 13.6 and 13.9 per cent. The share decreases in medium-sized firms to 12.6 and 10.8 per cent respectively, reaches the minimum in firms with 250-499 employees, and then rises again. Companies with 1,000 and more employees generate 18 per cent of their turnover with product-related services.

The explanation for this size distribution is very similar to the explanation for the U-shaped relationship between innovation intensity and firm size: small firms enjoy the advantages of flexibility and easy internal communication which allows them to react very flexible to new market opportunities. Moreover, many small firms operate in small niche markets, are very specialized and often only supply a handful of customers. Such a niche strategy also includes product-related services. Large firms, on contrary, can benefit from scale advantages such as benefits from a more intensive division of labour, fixed cost degression and the spread of risk over a larger number of products and countries. This allows them to offer product-related services at a much larger scale and build up specialized service departments which may be not economical for smaller firms. Medium-sized firms are cought between the advantages of small-sized and large firms.

Figure 8: Turnover with services as a share of total turnover by firm size, manufacturing, 2008



Source: EMS 2009. N=3,693.

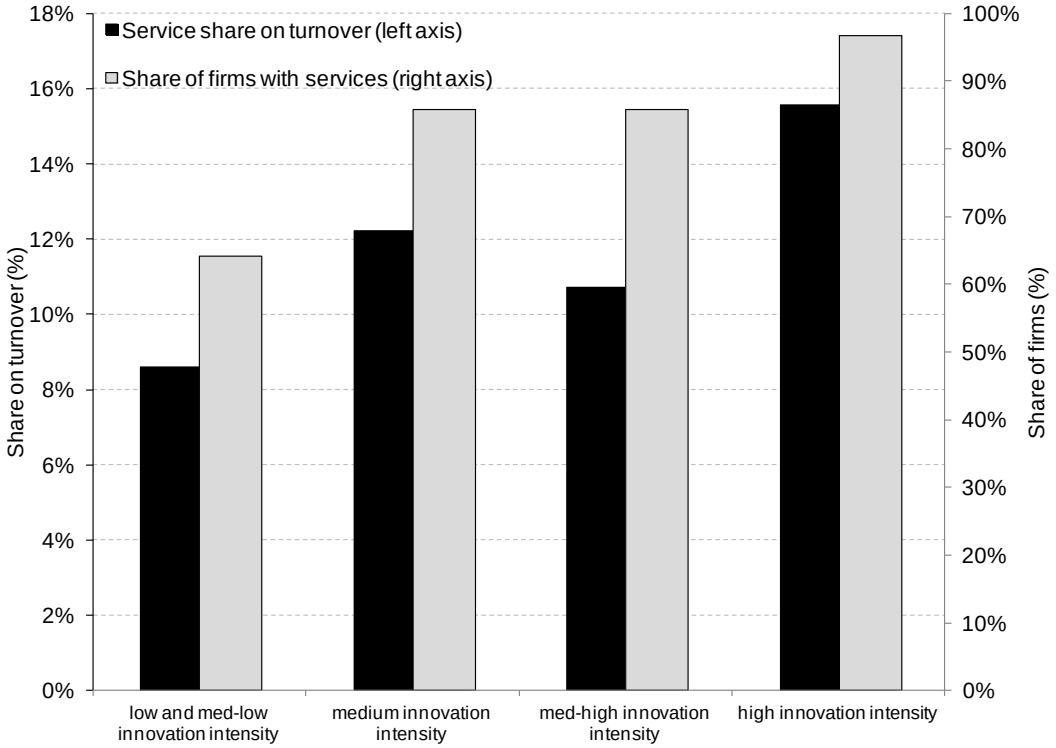
4.2 Service Output and Innovation at the Firm Level

Results from input-output tables suggest a positive relationship between the service output of manufacturing industries and innovation intensity at the sectoral level: highly innovative manufacturing sectors have a higher share of services on output. We reassess this relationship in Figure 9 with firm level data from EMS. Again we employed the taxonomy of innovation intensity by Peneder (2010). Figure 9 shows the share of firms in different classes of innovation intensity that offer product-related services and the share of product-related services on turnover. Firms in sectors with low and medium-low innovation intensities have been merged into one group due to the low number of observations in low innovation intensity sectors.

Descriptive statistics confirms the result that the supply of product-related services is related to the innovation intensity of the sector. The share of firms offering services as well as the service share on turnover is highest among firms in sectors with high innovation intensity and lowest among firms in sectors with low and med-low innovation intensity. Moreover, we also find that the number of different services offered by the average firm increases with the innovation intensity of its sector (not shown in the figure). Firms in sectors with high innovation intensity on average offer 4.6 out of the 8 service types included in the survey, while firms in sectors with low and medium-low innovation intensity only offer 1.4 services on average.

Hence, the supply of these kinds of services is likely to be also strongly dependent on the characteristics of the tangible product. High-tech products are characterised by complexity, rapid development and innovativeness. Complex products necessitate customer information and training, quickly developing products need upgrades and updates, radically innovative products require customers to realize the utility. Furthermore, they may require maintenance and repair (Furrer, 2010: 718).

Figure 9: Relevance of product-related services in manufacturing by innovation intensity, 2008



Source: EMS 2009. Question: Which of the following product-related services do you offer to your customers? N=3693.

Terms such as product-service systems or integrated product-service solutions suggest a close relationship between product and service offerings of a firm. Such a relationship may also assume between innovation in products and innovation in services. Firms operating in sectors where new products are introduced frequently to the market may also feel a stronger pressure to bring new accompanying services more often.

We test this hypothesis first with a simple cross-tabulation. Between 2006 and 2008, out of the 3,550 manufacturing firms in the sample,

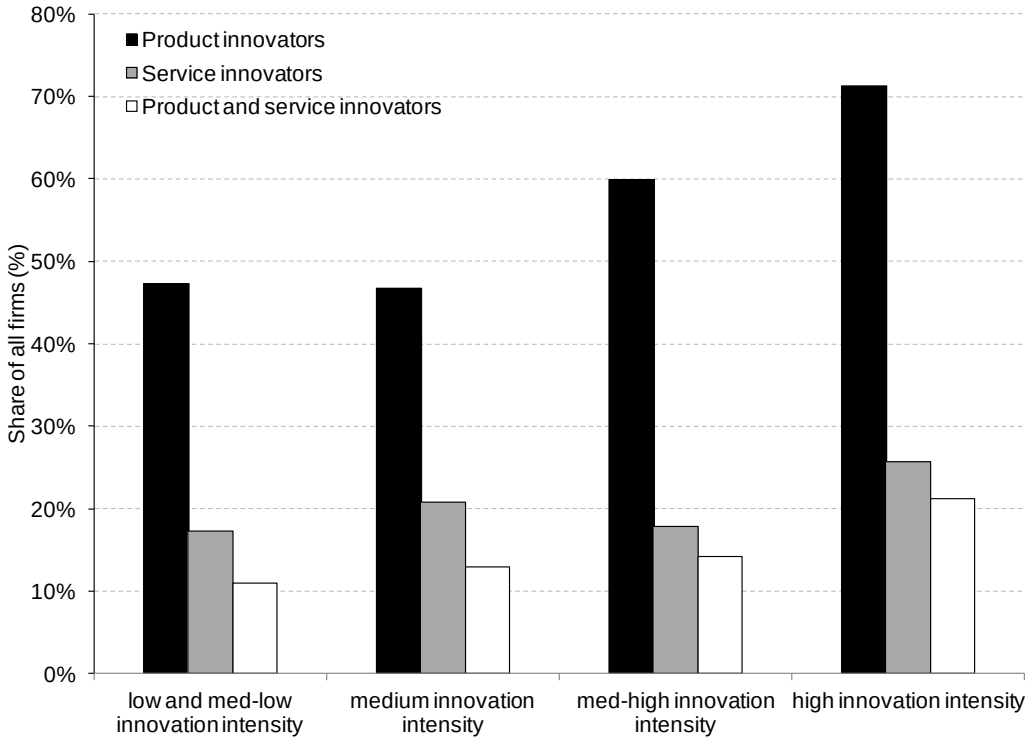
- 37% have not introducted any product or service innovation
- 42% have introduced at least one product innovation
- 5% have introduced at least one service innovation, but no product innovation

- 16% have introduced at least one product innovation and one service innovation

Introducing both, new products and new services to the market is not common in European manufacturing; only one out of four product innovators also introduced new services. However, product innovation seems to be a precondition for service innovation; Firms which introduced new or significantly inproved products to the market between 2006 and 2008 have also a significantly higher probability to introduce new services as well. So, there is indeed a strong linkage between product and service innovation in European manufacturing firms, which goes from product to service innovation.

Figure 10 examines this relationship for different classes of manufacturing sectors grouped according to Peneder's taxonomy of innovation intensity (Peneder 2010). The share of product innovators, service innovators and firms which introduced both, new services and new products is highest in sectors with high innovation intensity. This is not surprising and confirms the hypothesis that product innovation and service innovation are often complements in the competitive strategy of highly creative firms.

Figure 10: Share of product innovators and service innovators in manufacturing by innovation intensity, 2008



Source: EMS 2009. Question: Did you introduce new or considerably improved products to the market between 2006 and 2008? Did you introduce new or considerably improved services to the market between 2006 and 2008 N=3693.

What is surprising, however, is the high share of service innovators compared to product innovators in low and medium innovation intensity sectors. Here, one service innovator comes on 2.75 product innovators which is exactly the ratio we find in high innovation intensitve sectors. The highest relative share can be found in sectors with medium innovation intensity. Industries in this class include the producers of wood, wood products and cork, of pulp, paper and paper products, and of fabricated metal products. The high share of service innovators may be explained by the long product cycles in these sectors ; faced with long product cycles and slow technological change, service innovation may be a good way for a firm to distinguish itself from competitiors which may not be possible with product innovation. The opposite is true for high innovation intensity sectors – here, service innovation is needed to complement products, master technological complexity and keep pace with techno-

logical change. This result does not necessarily contradict the taxonomy. It is, however, a sign that existing taxonomies may not capture all aspects of innovation.

4.3 The Determinants of Service Output in a Multivariate Analysis

This paper has presented evidence for service offerings by manufacturing firms and brought forward various assumptions how service offerings relate to sector or innovation intensity. In this final section of the paper we want to reassess these assumptions in a multivariate framework that relates service output to sector, size, country, and a number of firm characteristics.

To identify the determinants of the service output of manufacturing, we use a regression model which is based on several basic assumptions concerning firm and product characteristics and their association with service output of manufacturing firms.

First of all, we assume that **firm size** has a relevant influence on the service output of manufacturing firms. The literature on product innovation points out that there are different advantages and disadvantages of small and large firms in the innovation process, leading to a U-shaped relationship between size and innovativeness (Kleinknecht 1989; Cohen 1995). Small firms can react very quickly to changes in demand and are often very focussed on the needs of their clients, while large firms can benefit from diversification and economics of scope and often have specialized departments for continuous innovation and product development. We assume a similar relationship for service output which is also a type of innovation. We also observe this U-shaped relationship between company size and the share of turnover generation with services in the bivariate analysis (Figure 8). Surprisingly enough, the literature has up to now not given many hints on the relationship between company size and the share of service output. Findings in previously published work were mainly derived from qualitative research in large companies who are in funds to invest in human resources dedicated to service delivery. Neely (2008) found out that company size has a positive impact on the service output of manufacturing. Larger companies seem to servitize more than smaller firms and they will be more likely to profit from the capital spent for introduction of services. However, due to the fact that the structure of European industry is mainly composed of small and medium sized companies, size seems one of the most important characteristics to analyze.

Based on the bivariate analysis of the type of services offered by sectors of different innovativeness (cf. figure 10), we furthermore assume that there is a positive relationship between the **innovativeness** of the companies and service output. Innovative goods, which incorporate new technologies, and service innovations are not independent from each other. Novel products become more complex and require explanation which can be provided via accompanying service concepts as customers cannot have all necessary knowledge available and require additional service inputs, such as training or consulting services.

Innovativeness of products is however not the only firm characteristic we assume to have an influence on the servitization of manufacturing companies. The **type of products** offered is generally seen as a potential determinant of service output and servitization. Concerning product complexity, it can be argued that a customer – a firm or a final consumer - that buys a complex product which incorporates many parts and offers various functionalities may need more training, consulting, maintenance or operation services than a buyer of simple parts (e. g. Oliva and Kallenberg, 2003).

Buyers of bespoke, customized products which are manufactured in **small batches** or even as single products may be more open to complementary services than buyers of mass-produced goods. The reason for this can be seen in the distribution channels and consequently in the customer-producer-relationship. Whilst high-volume producers often sell their products anonymously to end customers, the producers of single units are in closer contact to their customers and are consequently able to, first, identify service needs of their customers and to customize service offers for them and, second, to promote and sell these service concepts to their customers.

In a regional perspective, the adoption of product-service combinations entails significant cultural changes (Baines et al. 2007). This is not only the case on the provider side but also on the customer side. The acceptance of services which are being offered as an add-on or even as a replacement for products depends on the customers' willingness to have their needs fulfilled instead of acquiring the ownership of a physical good, which is not least based in the culture. According to Wong (2004), Scandinavian, Swiss and Dutch consumers' acceptance of product-service combinations has reached a relatively high degree. The bivariate analyses depicted above (Figure 6 and 7) support this finding. Hence, including a geographical variable into the multivariate analysis might contribute to explaining the convergence of manufacturing and service in Europe.

In the bivariate analysis on **firm age** we observed that younger firms seem to be slightly more innovative in terms of services than firms formed before 2000, although these younger firms are less product innovative. A potential explanation for this finding might lie in the innovativeness of younger companies mindset and hence their open-mindedness towards innovative service offerings. Consequently, last not least we want to identify the impact of the firms' age on their degree of servitization.

We operationalized the assumptions lined out above as follows. To measure the **service output** of the manufacturing companies with our survey data, we follow Gebauer et al. (2005) and Lay et al. (2010) and choose the share of turnover generated with services. As discussed above, manufacturing companies not only charge their customers directly for the services they deliver. A large share of the turnover generated with services is included in the product's price which the services relate to, see Figure 7. This price bundling strategy of manufacturing companies is owing to the fact that customers are often not willing to pay for services or that company accounting of the provider companies does not support controlling for costs of service delivery. Consequently, we take the share of turnover generated directly and indirectly by services as the dependent variable.

To operationalize the **size** of the companies, we chose the number of employees (emp) and the number of employees squared (emp2), both in logarithmic form, to allow a non-linear relationship between employment and service output in manufacturing firms.

The **innovativeness** of companies is operationalized by two variables. We use sectoral dummies that represent **sectoral innovation intensity** according to Peneder (2010). For this, the base case is the high-innovation intensity sector. However, there is also evidence that firms within a sector differ considerably with respect to innovativeness. We therefore include a variable which shows the innovativeness on a firm level. This **additional variable for innovativeness at the firm level** indicates if a company has introduced a new product to the market within the last two years (inmar).

Product complexity (complex), which is the second product characteristic we use as independent input variable for the regression analysis, opposes simple products such as mechanical components and complex products which consist of many parts (such as machinery).

Another product characteristic we include into the regression model is the **volume of production**. It shows whether the main product of the firm is produced in single parts or small batch size opposed to large batch production (sbatch).

However, as it is not possible to identify the products' **target group** merely based on the batch size, we also include a variable that indicates if the firm is a supplier for other industries or a producer of consumer goods (supply).

For each **country** covered in the survey, we used country dummies; the base case is Germany. The **age of the firms** was inserted into the regression analysis by using a variable that indicates if the firm has been established after 2005 (newfirm).

The dependent variable (share of service turnover) can only take values between 0 and 100. We employ a generalized linear model (see Papke and Wooldridge 1996). Table 2 below reports the results of this regression.

Table 2: Determinants of the share of services on turnover of manufacturing firms, results from a Generalized Linear Model

Variable	Coefficent	Standard Error	Significance
lemp	-0.636	0.109	***
lemp2	0.058	0.010	***
at	-0.108	0.088	
ch	0.002	0.064	
nl	0.043	0.115	
fr	-0.551	0.129	***
dk	0.170	0.108	
hr	-0.005	0.165	
es	-0.351	0.182	*
si	0.459	0.192	**
se_low	-0.425	0.295	
se_medlow	-0.610	0.120	***
se_med	-0.221	0.063	***
se_medhigh	-0.327	0.067	***
sbatch	0.266	0.056	***
supply	-0.035	0.051	
complex	0.158	0.054	***
newfirm	0.015	0.354	
inmar	0.132	0.052	**
_cons	-0.321	0.282	
No. of obs	2264		
Residual df	2244		
AIC	.583887		
BIC	-17025.24		

Source: EMS 2009, own calculations

Company size had a great explanatory value in the regression analysis. We see a U-shaped relationship between firm size and service share on turnover. As discussed above, this points to different advantages of small and large firms in offering services. It also indicates that, all other things equal, service output decreases first with rising firm size and then increases again. The small coefficient of lemp2, however, indicates that increases can only be seen beyond a very high threshold.

The relationship between service output and innovation intensity of the sector is confirmed by the regression analysis. When holding all other factors constant, manufacturing firms in sectors with high innovation-intensity are more likely to realize a higher share of turnover with services than firms in sectors with lower innovation-intensity. This finding is also supported by the significant relationship between service output and product innovation on the firm level. Firms which have launched prod-

ucts new to the market during the last two years are more likely to realize higher shares of turnover generated with services compared to companies which did not introduce products new to the market. Product innovativeness seems to reinforce service delivery.

The share of services in the turnover of manufacturing firms is also related to the characteristics of the main product. A firm that sells a complex product incorporating many parts and various functionalities has also a higher service share in turnover. The buyer of this product may need more training, consulting, maintenance or may even rely on the operation services of the seller than a buyer of simple parts. Moreover, producers of bespoke products which are manufactured in small batches or even as single products have a higher share of services on turnover than manufacturers of mass-produced goods.

We also find confirmation for our assumption that firms which produce in small batch or/and produce complex products are more likely to make more turnover with services than firms with large batches and/or simple products. Both coefficients are highly significant, the coefficient for single batch production is considerably higher.

Despite the bivariate findings which indicate that the degree of servitization depends on the region of origin of the firms surveyed, we could not substantiate our assumption in the multivariate analysis. The country dummies are mostly not significant at the usual error levels. Hence most variations across countries are better explained by sector, size or other firm-level variables.

The position of the firm in the supply chain as well does not seem to have a significant influence on the service output. Suppliers to industrial users have no higher service output than firms which mainly supply consumers. Furthermore, the regression provides no evidence that newly established firms or firms that are mainly suppliers to industrial clients would have a higher share of services on output.

5 Summary and Conclusions

This paper provides new evidence for the servitization of European manufacturing – the trend that manufacturing firms increasingly offer services along with their physical products. Between 1995 and 2005, as well as between 2000 and 2005, the share of services in the output of manufacturing industries increased in the large majority of European countries. Service output of manufacturing industries, however, is still small compared to the output of physical products. The highest service shares are found in small countries with a high degree of openness and high R&D intensities.

There is a strong link between servitization and technological innovation at different levels. At the *country level*, we find that countries which the highest share of services on manufacturing output have also the highest aggregate R&D intensities. The service output of these countries consists predominantly of knowledge-intensive services.

At the *sector level*, sectors with high innovation intensity have also the highest share of firms that offer services, the highest turnover gained from services and the highest number of different services offered by the average firm. Examples for these industries are electrical and optical equipment, machinery, or the chemical and pharmaceutical industry.

At the *firm level*, we see that firms which have launched products new to the market during the last two years are more likely to realize higher shares of turnover from services compared to companies with no products new to the market.

Offering product-related services is a strategy by manufacturing firms to maintain and increase competitiveness. Still, the paradox of servitization (Neely, 2008) makes clear that many firms do not suc-

ceed in their servitization strategy. Thus, the promotion of service innovation in manufacturing may require changes in the system of public support for innovation. Public innovation support, in the words of Rubalcaba et al (2008), suffers from a double bias, towards manufacturing and towards technological innovation. Service innovation in manufactruing, in contrast, is often non-technological, and consists of organisational change and changes in the way products are advertised, sold, delivered, or priced. Operator models such as the Rolls Royce's 'power by the hour' service model for aircraft engines (Expert Panel on Service Innovation 2011, p. 10) can have a major impact on the economic performance of firms; the support of the development of such an innovation, however, is often outside the scope of innovtion promotion agencies due to its non-technological character. Hence, the promotion of service innovation in manufacturing may also require new funding schemes, or a change in the admission requirements of existing schemes.

Moreover, the non-technological character of many service innovations may also require that firms change the way they manage innovation projects. Management concepts that focus on taking up new technologies and developing them into products ready for market introduction hardly fit the needs of non-technological innovation. Service offerings are usually out of scope of the R&D departments in manufacturing firms. The impetus for new services may rather originate from sales or marketing than from R&D or product development divisions. Hence, service innovation requires innovation management procedures that are able to take up ideas from all parts of the firm. In this perspective, service innovation in manufacturing firms requires a break with linear, technology-push models of innovation which may still exist in some parts of the manufacturing sector.

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8 Appendix

Box 1: Comparing service output of manufacturing across countries

Service output of manufacturing captures the measure of service output as a share of total manufacturing output of an economy, whereas an economy is made up of N sectors j, with j=1,2,…,N. We look now on the service output as a share of total sector's output:

t_j is the total output of sector j and s_j is the service output of sector j in that economy (both measured at current prices and in millions of national currency), we then define:

The service output share or service content of industry j (s_j) is

$$o_j = \frac{s_j}{t_j}$$

And the manufacturing's total service content O is then

$$O = \frac{\sum_j s_j}{\sum_j t_j}$$

All in all, the overall service content of manufacturing in an economy is the sum of the service contents of the individual manufacturing sectors, equally weighted.

We then wish to compare the difference in service content of manufacturing between a country, B, and a selected reference country A. Therefore, we just have to compare the service contents of the two countries' manufacturing output:

$$O_A = \frac{\sum_j s_{jA}}{\sum_j t_{jA}} \text{ and } O_B = \frac{\sum_j s_{jB}}{\sum_j t_{jB}}$$

Table A1: Overview on Data availability

Country	Years	Notes on classification (concerning manufacturing/service sectors/products)
Austria (AT)	1995, 2000 and 2005	
Belgium (BE)	1995, 2000 and 2005	
Czech Rep. (CZ)	1995, 2000 and 2005	
Denmark (DK)	1995, 2000 and 2005	
Estonia (EE)	*1997*, 2000 and 2005	Supply table for 1997 is not integrated with the regular national accounts
Finland (FI)	1995, 2000 and 2005	Tables for the years from 2003 onwards are revised and not immediately comparable with those of preceding years.
France (FR)	1995, 2000 and 2005	
Germany (DE)	1995, 2000 and 2005	Tables for the years from 2000 onwards are revised and not immediately comparable with those of preceding years.
Greece (EL)	2000 and 2005	
Hungary (HU)	*1998*, 2000 and 2005	
Ireland (IE)	*1998*, 2000 and 2005	CPA/NACE 23 incl. 36
Italy (IT)	1995, 2000 and 2005	
Lithuania (LT)	2000 and 2005	CPA/NACE 15 incl. 16, 24 incl. 23
Luxembourg (LU)	1995, 2000 and 2005	Data for CPA/NACE 15, 16 21, 22, 30, 32, 34 and 35 not published due to legal restrictions
Netherlands (NL)	1995, 2000 and 2005	
Poland (PL)	2000 and 2005	CPA/NACE 62 incl. 61
Portugal (PT)	1995, 2000 and 2005	
Romania (RO)	2000 and 2005	
Slovakia (SK)	1995, 2000 and 2005	
Slovenia (SI)	*1996*, 2000 and 2005	
Spain (ES)	1995, 2000 and 2005	
Sweden (SE)	1995, 2000 and 2005	CPA/NACE 50 incl. 51 and 52, 32 incl. 31 and 74 incl. 73; for the years 1995 and 2000 only: CPA/NACE 15 incl. 16
United Kingdom (UK)	1995, 2000 and *2003*	
United States (US)	*1997* and *2002*	NAICS used for sectors/products

Source: Eurostat supply tables available at: http://epp.eurostat.ec.europa.eu/portal/page/portal/esa95_supply_use_input_tables/data/workbooks

Table A2: Classification of innovation intensity of manufacturing sectors

NACE Rev. 1.1	Manufacturing industry	Innovation intensity
15	Food products and beverages	Medium-low
16	Tobacco products	Medium-low
17	Textiles	Medium-high
18	Wearing apparel; furs	Low
19	Leather and leather products	Low
20	Wood, wood products and cork	Medium
21	Pulp, paper and paper products	Medium
22	Printed matter and recorded media	Medium-low
23	Coke, ref. petroleum products and nuclear fuels	Medium-high
24	Chemicals, chemical products and man-made fibres	Medium-high
25	Rubber and plastic products	Medium-high
26	Other non-metallic mineral products	Medium-high
27	Basic metals	Medium-high
28	Fabricated metal products	Medium
29	Machinery and equipment n.e.c.	High
30	Office machinery and computers	High
31	Electrical machinery and apparatus n.e.c.	High
32	Radio, television and communication equipment	High
33	Medical, precision and optical instrument	High
34	Motor vehicles, trailers and semi-trailers	Medium-high
35	Other transport equipment	Medium-high
36	Furniture; other manufactured goods n.e.c.	Medium
37	Secondary raw materials (recycling)	Low

Classification of innovation intensity of manufacturing sectors (NACE 15 to 37) based on Peneder (2010).
Source: Eurostat supply tables available at: http://epp.eurostat.ec.europa.eu/portal/page/portal/esa95_supply_use_input_tables/data/workbooks

Table A3: Population of the EMS data set

Country	Number of firms contacted	Number of valid cases	Return rate
Austria	3,828	309	8.1 %
Croatia	1,658	89	5.4 %
Denmark	3,341	328	9.8 %
Finland	1,741	131	7.0 %
France	5,012	164	3.3 %
Germany	16,108	1,484	9.5 %
Netherlands	9,743	323	3.7 %
Slovenia	665	71	10.7 %
Spain	4,298	116	2.7 %
Switzerland	5,267	678	12.9 %

Source : EMS 2009

Table A4: Sectoral structure of the EMS data set

NACE Rev. 1.1	Number of firms contacted	Share on total
27+28	Man. of basic metals/fabricated metal products	21.1%
29	Man. of machinery and equipment n.e.c.	17.5%
20+36	Man. of wood, products of wood and furniture	8.6%
15+16	Man. of food products, beverages and tobacco	8.5%
25	Man. of rubber and plastic products	7.9%
30-32	Man. of electrical equipment	7.8%
33	Man. of medical, precision, optical instr. etc.	6.5%
21+22	Paper and publishing	5.8%
24	Man. of chemicals, chemical products, etc.	5.0%
23+26+37	Other manufacturing industries	5.0%
17-19	Man. of textiles, leather and corresp. products	3.2%
34+35	Man. of transport equipment	3.1%

Source : EMS 2009

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