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The Vienna Institute for International Economic Studies

Research Reports | 377 | April 2012

Robert Stehrer et al.

Convergence of Knowledge-intensive Sectors and the EU's External Competitiveness

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The European Commission, DG Enterprise and Industry paid for the study (Framework Service Contract no. ENTR/2009/033) in the amount of EUR 173,029. The opinions expressed are those of the authors only and do not represent the Commission's official position.

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The share of knowledge-intensive services and products in total output and demand and in the production of advanced, but also less advanced or emerging economies, has steadily increased over time and especially so for the knowledge-intensive services. This 'quaternization' of the economies not only points towards the rising shares of services but also stresses the role of knowledge-intensive services and their growing importance as sources of innovation and technology and as inputs into the manufacturing process. First the study documents the important role played by services in the EU as compared to the USA and Japan. Special emphasis is given to the role of knowledge-intensive business services (KIBS). The study then stresses the role of service output of manufacturing firms, a phenomenon also termed 'convergence process' which so far has not received much attention in the existing literature. Further it analyses the role of knowledge-intensive business services (KIBS) with respect to their role of embodied knowledge flows and linkages between KIBS and manufacturing sectors, underpinning that services have been playing an increasing role in boosting the productivity of manufacturing sectors. Finally, the study focuses on the importance of trade in knowledge-intensive manufacturing and services (overall and KIBS in particular) regarding the competitiveness of the EU with respect to trade in services in general and trade in knowledge-intensive business services in particular.

Keywords: *knowledge-intensive sectors, trade in services, service provision of manufacturing firms, inter-sectoral linkages*

JEL codes: *C67, F14, L8, L16, O14, O33, O47*

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1. Introduction

The share of knowledge intensive services and products in total output and demand and in the production of advanced, but also less advanced or emerging economies has steadily increased over time. This is documented in a large number of publications studying 'tertiarization' but pointing towards uneven dynamics within the services sectors (e.g. Peneder et al. 2003, Montresor and Marzetti, 2010), especially emphasising the role of knowledge intensive services. Though this trend of rising shares of services and declining shares of manufacturing (after a long period of declining shares in agriculture and rising shares in manufacturing) is undoubted, some of the authors ask what comes next. For example, Pender et al. (2001) use the term 'quaternisation' stressing the role of knowledge intensive services and their rising importance as sources of innovation, technology and their role as inputs which has increases steadily over time. In essence, in this study we also focus on the role of these knowledge intensive (business) services for a more recent period and covering a larger set of countries. There are however still large cross-country differences in this process which does not allow to conclude that countries have already converged enough in this respect such that one can talk of a general era of 'quaternisation'. This study further stresses the role of service output of manufacturing firms, a phenomenon also baptised 'convergence process' which was so far not so much focused on in the literature. The study also analyses more detailed the role of knowledge intensive business services (KIBS) with respect to their role of embodied knowledge flows and linkages between KIBS and manufacturing sectors. This underpins the further growing evidence in the literature that services have been playing an increasing role in boosting productivity of manufacturing sectors (e.g. Arnold, Javorcik and Mattoo, 2006, and Javorcik, 2004).

A distinct feature of the above trends is the growing importance of knowledge intensive business services (KIBS) for manufacturing industries. Innovation in manufacturing often arises as a result of innovations in producer services such as design and production organisation. Production processes and output in manufacturing are also changed via increasing service inputs. But also the other way round, innovation in services often requires inputs of products from the manufacturing industries. A simple example for this linkage would be a hard-disk drive enabling the production of design services for the automobile industry.

Technology flows as well as product flows between services and manufacturing sectors deepen the inter-industry linkages between them and consequently the boundaries between different firms and industries have become more blurred. Knowledge-intensive service firms have often been developing new services as a part of a product package that includes physical, tangible goods. Firms developing new products also offer additional services as part of a package including both the physical product as well as the services (see Monti, 2010). For example, high-tech products are often sold in combination with maintenance services.

These trends not only reflect changes in relative shares of services and manufacturing, but also point to increasingly stronger linkages between these sectors together with a growing importance of intermediate services trade for production processes. Increased FDI-activities in knowledge intensive services also point to growing interdependence between services and manufacturing industries. The forces driving changes in industrial structures influence external competitiveness of EU knowledge intensive manufacturing industries and services, which is reflected in changing patterns of specialization in services and manufacturing production and exports.

The increasing interest in this part of the economy is also reflected in the growing literature touching a variety of issues. Since the mid 1990s, there is growing interest in knowledge-intensive business services (KIBS) and hence growing research on this topic. This has been due to KIBS' dynamic performance in the economy, growing at more rapid and sustained growth rates than those of other economic sectors. In addition, they are increasingly influential sources of, and channels for, new knowledge, affecting the performance of their clients. Thus, their dynamism impacts the whole economy (see EMCC, 2005). Research on KIBS has focused on these main aspects: their definition, their contribution to growth and structural change, the relationship between KIBS and their clients (in terms of knowledge, innovation and productivity) and especially on various aspects of innovation.

Miles et al. (1995) seem to have proposed the first detailed elaboration of KIBS. They identified three principal characteristics of KIBS:

- They rely heavily upon professional knowledge;
- They either are themselves primary sources of information and knowledge or they use knowledge to produce intermediate services for their clients' production processes;
- They are of competitive importance and supplied primarily to business.

In more precise terms, Miles et al. (1995) defined KIBS as "services that involved economic activities which are intended to result in the creation, accumulation or dissemination of knowledge". In addition, they distinguish between 'traditional professional services (P-KIBS)' and 'new-technology-based services (T-KIBS)'. P-KIBS are "traditional professional services, liable to be intensive users of new technology (business and management services, legal accounting and activities, market research, etc.)". T-KIBS are mainly related to information and communication technologies as well as technical activities (IT related services, engineering, R&D consulting, etc.).

As the *definition of KIBS* is still not standard across the literature, one can find various attempts for a description of KIBS (e.g. den Hertog, 2000; Bettencourt et.al, 2002). On the other hand, classification often follows the NACE classification system (Classification of Economic Activities in the European Community), including the sectors ‘computer and related activities’ (NACE 72), ‘research and development’ (73), and ‘other business services’ (NACE 74). However, the inclusion of sub-sectors of ‘other business services’ is again not uniform across studies (compare e.g. Muller and Doloreux, 2007; European Commission, 2009).

As regards the *role and performance of KIBS in the economy and in structural change*, several studies have dwelled on this subject, including Peneder et al. (2003), European Commission (2004), Cainelli, Evangelista, and Savona (2006) and Kox and Rubalcaba (2007, a and b). While business services are a main source of job creation, they are characterized by a relatively weak productivity growth (Kox and Rubalcaba, 2007, a).

The role of KIBS as *growth drivers* has been investigated in EMCC (2005) and Toivonen (2004). The following growth drivers have been mentioned in EMCC (2005): outsourcing of services, growing demand for different types of technological knowledge (IT), growing demand for specialized forms of knowledge, and the internationalization and globalization of business.

Looking at *innovation*, Muller and Doloreux (2007) provide an overview on literature covering this topic. They state that research concentrated on two questions: (i) do KIBS innovate? And (ii) do KIBS innovate differently from manufacturing? Citing literature based on Community Innovation Survey data (CIS)[1] as well as on large scale surveys directed towards KIBS, they conclude that KIBS are major innovators. Also for the second question, various studies are cited, leading to the conclusion that innovative activities in KIBS are distinctive from those in manufacturing. Finally, the *role of KIBS in client innovation* was emphasized in Hauknes (1998) as well as den Hertog (2000) discerning three different aspects: According to Hauknes (1998) KIBS firms act in three ways: as facilitators of innovation, as carriers of innovation and as sources of innovation.

Based on this background the study addresses the following issues related to the overall and growing importance of knowledge intensive business services, its role as inputs in

1 Muller and Doloreux (2007) cite the following studies based on CIS-data: studies covering patterns of innovation and sources of competitiveness (Camacho, Rodriguez, 2005; Evangelista, 2000; Hollenstein, 2003; Tether, 2003; Tether, Hipp, 2003), innovation and sectoral performance (Cainelli et al, 2004; Cainelli et al, 2006; Evangelista, Savona, 2002) and innovation and inter-firm collaboration (Tether, 2003). “When addressing KIBS, these papers focus essentially on the innovation activities of KIBS within national frameworks only”.

manufacturing, the supply of services by manufacturing industries and the growing importance of services in trade. More specifically, the following issues are discussed in the following sections:

- To which extent have services (both intermediates and final use services) become more important over time and how does Europe differ from other major economies like the US and Japan in this respect? Similarly, to which extent have services gained importance as inputs in manufacturing production processes and are there important differences as compared to the US and Japan? Therein, we address the specific role of knowledge intensive business services (KIBS).
- How important are the direct and indirect flows of knowledge between KIBS and manufacturing industries? How have these developed over time and are there important differences across countries and in relation to the US and Japan in particular?
- To which extent is there a tendency towards an increase in the share of services in the output of manufacturing industries and firms? How does this relate to firms performance and innovation?
- Finally, the study focuses on the importance of trade in knowledge intensive manufacturing and services (overall and KIBS in particular) regarding the competitiveness of the EU with respect to trade in services in general and trade in knowledge intensive business services in particular.

2. The rising importance of service sectors in the economy comparing EU with US and Japan

2.1 Introduction

Services industries have grown in importance over the last decades in advanced but also less advanced economies both in terms of output or value added and employment. This is reflected in the underlying trend towards rising importance of the services sectors in the advanced but also less advanced economies over the last decades as evident from rising shares of services in terms of output, value added and employment for example. Further, trade in services also gained importance in overall trade over the last years. In this section we provide some descriptive evidence on the rising importance of the services sectors within the overall economies in several respects. In particular we pay attention to the question whether the share of services (measured by various variables) has converged across the economies under consideration. Further, underlying the overall increase of services shares and its evolution is an interesting dynamics within the service industries. In particular, the role of knowledge intensive business services attracted particular attention over the last few years. We therefore investigate in details this part of the services sector with again having the same question in mind, whether the shares of these sectors have converged across the economies.

‘Knowledge-intensive business services’ (KIBS) have been the main source of job creation in Europe in the last decade and also contributed substantially to value added growth as pointed out in the literature (see e.g. European Commission, 2009). However, these services not only contribute directly to economic development through their own growth in employment and income, they additionally serve as major inputs in other industries. Thus they could have a positive effect on production and productivity of their clients (Cantuche and Rodriguez, 2007).

The aim of this task is therefore to provide an overview of the relevance and trends in these service activities in a comparative manner across countries and over time. In the cross-country comparison also important advanced non-EU countries (in particular the US and Japan) will be included. The analysis will mainly be based on the EU KLEMS dataset. This section will in particular address the following questions:

- What is the role of service activities and *output* in Europe, the US and Japan and what are these trends over time? Specifically, we address whether there has been some kind of convergence process in structures across countries.
- Within the service categories we shall look at the role of KIBS (or related concepts as noted above) again in a cross-country comparison over time. The particular definition of KIBS applied will be determined by the classification used in the data at hand (which are in most cases at the NACE rev.1 2-digit level, i.e. industries 72, 73 and 74).
- Additional information on the role of services can be derived from the same data set. In particular we will discuss the importance of services in value added growth across countries.
- The use of input-output tables further allows studying the importance of KIBS industries as inputs in the production process of manufacturing industries. This will be addressed in this section as well in a descriptive manner providing also information on linkage indicators.

2.2 KIBS services and classification

Within service industries real estate, renting and business services sector (NACE rev.1 K, 70-74) has the largest share with about 30 percent. This sector also contains those subsectors that are often referred to as ‘knowledge-intensive business services’ (KIBS), though the definition is not fully consistent across the literature. In most cases sectors NACE industries 72, 73 and 74 (NACE rev. 1.1) are included, though in most cases this is dictated by the availability of data and classifications; in some cases only some 3-digit subsectors of the services industries mentioned below are included (for this see e.g. Kox and Rubalcaba, 2007; OECD, 2007; European Commission, 2004).

Thus, the definition of "knowledge-intensive business services" is not consistently used across the literature and is often dictated by the data which are available. The European Commission (2009) is referring to the following economic activities of the NACE rev. 1.1 classification system: computer and related activities (72), research and development (73), legal, accounting, book-keeping and auditing activities (74.1), architectural and engineering activities (74.2), technical testing and analysis (74.3) and advertising (74.4). Other activities of category 74 (74.5 to 74.8) can be subsumed under the term 'operational services' and include industrial cleaning, security services and secretarial services (see OECD, 2007). However, often data are only supplied at the 2-digit level and a distinction between KIBS and operational services is not possible.[2]

2.3 The overall share of services in the economy

Let us first look at the overall tendency with respect to services in the overall economy. Service sectors are classified as sectors in NACE rev. 1.1 G to Q (see Appendix Table A.2.1), i.e. not considering Electricity, gas and waters supply and construction. We do this for a group of advanced EU countries differentiating between EU-25 (i.e. EU-27 without Bulgaria and Romania), the EU-15 and the EU-10 (EU-12 without Cyprus and Malta) in comparison with the US and Japan (JPN). The variables we look at are value added and gross output (both in nominal terms) and employment figures in terms of persons and hours worked. The EU KLEMS database allows going back to 1975 for the EU-15 and Japan; data for the US starts in 1985 only. Data for all groups are available from 1995 on up to 2007 (i.e. the year just before the economic crisis hit most of the countries in the world). We report data for both 2006 and 2007 as for some country groups data for 2007 are missing however. These shares are presented in Table 2.3.1.

With respect to the share of services in value added the share in the EU-15 was already at 60% in 1975, being about 5 percentage points higher than the share in Japan. This share has continuously risen to about 70 percent in 2007. The Japanese share has risen even more and in 2006 has been at the level of the EU-15. This pattern can be compared to the US for which data are available from 1985 on. In this year the US shows a share of almost 70% (i.e. the level the EU-15 reached in the mid of last decade) which has grown to almost 78% in 2007. Thus the distance of about 6-7 percentage points remained over the last 20 years. It is further interesting to note that the share of services in the EU-10 countries has been higher compared to the EU-15 by about 4-5 percentage points. One reason for this might be that the transformational recession in these countries has led to a severed decline of output particularly in the manufacturing industries resulting in a higher share of ser-

[2] This situation improves with the introduction of the NACE rev. 2 classification system where these categories will become 2-digit status.

vices[3]. As one can see this share remained rather stable over the 10 years to follow and in 2006 was at the level of the EU-15. The share of the whole EU-25 is in between these two.

In terms of gross output the developments are very similar though at a different level. The EU-15 started from a share of 48% in 1975 with a rise of about 10 percentage points to 57% in 2007. Similarly, the service share of services in Japan for gross output was about 8 percentage points lower compared to the EU-15 but converged considerably until 2006 to the EU-15 share being only 2.5 percentage points below. Again, there is a striking difference to the US which in 1985 started off with a higher share of about 6 percentage points; this difference became even more pronounced and in 2007 was by about 12 percentage points (57.3% in the EU-15 compared to 69.6% in the US). The EU-10 also showed a somewhat higher share compared to EU-15 in 1995 with facing a decline of it thus that the overall number in 2006 is even below those of the EU-15.

Table 2.3.1

Services shares in the overall economy (in %), 1975-2007

		1975	1985	1995	2005	2006	2007
Value added	EU-25			68.1	71.7	71.1	70.8
	EU-15	59.8	63.6	67.7	71.5	71.1	70.8
	EU-10			72.3	73.1	71.5	
	USA		69.1	73.4	77.3	77.1	77.7
	JPN	55.5	58.5	64.2	69.1	69.2	
Gross output	EU-25			55.6	58.6	57.6	56.9
	EU-15	48	50.8	55.2	58.7	57.9	57.3
	EU-10			58.8	57.6	55.2	
	USA		57.1	63.4	68.6	68.9	69.6
	JPN	39.4	44	52.1	56.2	55.3	
Employment	EU-25			64.8	70.1	70.5	70.7
	EU-15	51.4	59.8	67.2	72.2	72.6	72.8
	EU-10			51.8	57.4	57.7	
	USA		73.3	77.7	81.3	81.4	81.8
	JPN	49.6	56	61.2	68.4	68.5	
Hours worked	EU-25			62.6	67.9	68.2	68.4
	EU-15	49.5	58	65.1	70.2	70.5	70.7
	EU-10			50.6	55.8	56.1	
	USA		69.9	74.3	78.2	78.3	78.7
	JPN	51.1	56.6	60.6	66.1	66.2	

Source: EU KLEMS, Release 2009, own calculations.

Turning to the share of employed persons in total employed the trend for the EU-15 is from 51% in 1975 to about 73% in 2007, thus an increase by more than 20 percentage points which is much more pronounced than the increase in terms of value added or gross output.

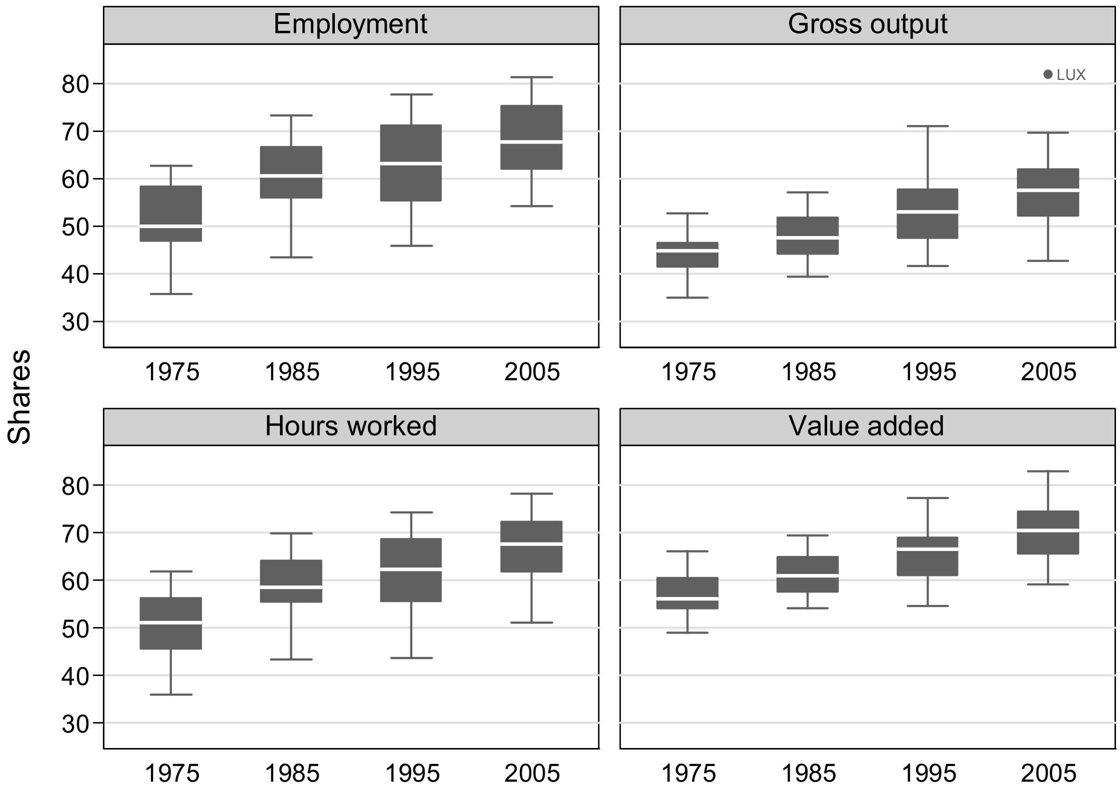
3 Another reason could be higher prices of services in these economies; this is however not supported by the data.

This is largely explained by the higher productivity growth rates in manufacturing and agriculture. Interestingly, the employment share for Japan was only slightly below that of the EU-15 (and in particular the differences is much less compared to value added or gross output) in 1975. Also these shares increased though to a less extent than the one in the EU-15 and is now about 4-5 percentage points below this level. For the US the share in terms of employment was more than 10 percentage points above the EU-15; this difference was rather stable and is still at about 10 percentage points (72.6% compared to 81.4%). Similar patterns and trends can be found when looking at hours worked which also reflect average hours worked in the countries considered.

With respect to the question whether there convergence has been taken place between these economies (with the EU-25 being considered as one economy) is not straightforward to answer. Whereas Japan converged to the EU the difference of the EU to the US remained rather constant, which is generally found for the variables considered.

Figure 2.3.1

Service shares across countries (in %), 1975-2005



Source: EU KLEMS, Release 2009, own calculations.

However, one might find different patterns of convergence when looking at the level of individual countries and in particular considering the EU countries separately. In Figure 2.3.1 we present box plots providing information on the median of the shares across the countries considered and the distribution of the shares. This is again shown for the four variables considered above. The median (the line in the boxes) shows a steady increase of the shares from about 55% to 70% in value added and 50% to 67% for employment which is in line with the results reported above. However, as one can also see the variance (as indicated by the boxes and the whiskers) seems not to have declined over time and in some cases might even have increased. However for 1995 this was mainly due to the inclusion of the EU-10 countries.

Thus from this graph there is no evidence that there is a strong convergence in terms of service shares across countries. This is also confirmed by more formal tests which reject the hypothesis of convergence.

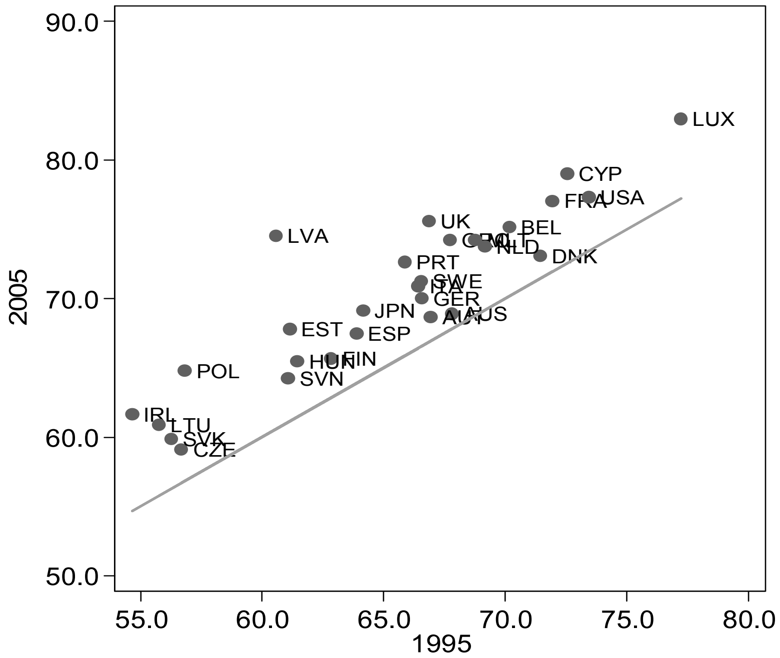
A remaining question evolving from this picture is whether particular countries have shown significant increases in their services shares and other countries might have been fallen back with respect to their service shares. This can be easily looked at when comparing the respective shares in a particular year and compare it to those in another year. Particularly, we present in Figures 2.3.2 and 2.3.3 the shares of services in the countries in 1995 and 2005 for two variables, value added and hours worked, respectively.

Figure 2.3.2 presents the shares of services in value added in 1995 and 2005. The line indicates the 45° line. Thus, if a country would be located at this line the shares in 2005 would be the same as in 1995. As one can see, the shares have increased in all countries and there seems to be only little changes in the ranking across countries. There seem to be slightly larger increases at the lower end of the distribution. This is also confirmed when running a regression which provides a coefficient lower than one (0.93). Testing whether this is significantly different from one is however rejected. This means that the hypothesis that those countries with lower shares in services tend to have a faster increase in these shares does not hold. Spearman's rank correlation provides a coefficient of 0.85; the test whether the ranks of the countries in 1995 and 2005 are different is rejected.

Figure 2.3.3 provides the analogous graph for employment. One can find a similar pattern with respect to changes over time. However, doing a similar exercise the coefficient of the respective regression yields a coefficient of 0.9 which is significantly different from 1 (at the 5% level). This would indicate that in terms of employment there is some convergence in shares taking place. Looking at the graph in more detail one can see that this is mostly the case for the EU-10 countries which are all on the left side of the distribution. A similar pattern is found when looking at hours worked.

Figure 2.3.2

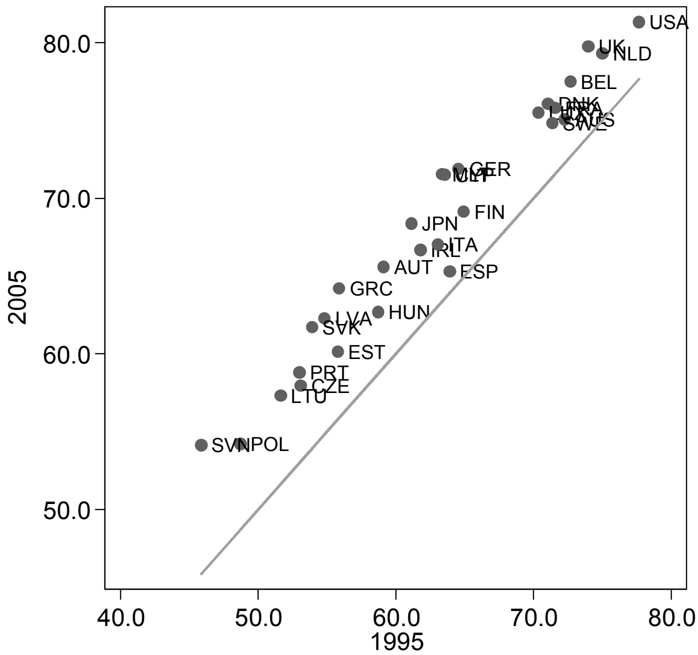
Service shares in value added (in %), 1995 and 2005



Source: EU KLEMS, Release 2009, own calculations.

Figure 2.3.3

Service shares in employment (in %), 1995 and 2005



Source: EU KLEMS, Release 2009, own calculations.

2.4 Changes and structures within the services sector

The service sector plays a large role in the economies under consideration. As shown above, service sectors account now on average for about 65-70 percent of total value added as shown above, whereas manufacturing reached now a share of only about 20 percent (though with differences across countries) with a declining trend. Manufacturing and services' employment shares display similar developments. This however hides the fact that the service sector itself is quite heterogeneous including wholesale and retail trade, finance and public services like public administration and education. Table 2.4.1 provides the shares of various service sectors in total services again for value added and gross output (in nominal terms) and employment and hours worked.

Table 2.4.1

Service sector shares in total services (in %), 2006

		Wholesale and retail trade (G)	Hotels and restaurants (H)	Transport (I)	Business services (JtK)	Public services (LtQ)
Value added	EU-25	13.5	3.2	10.5	39.6	33.1
	EU-15	13.5	3.4	10.7	40.8	31.6
	EU-10	13.7	1.2	9.1	30.3	45.7
	USA	14.5	3.3	7.1	43.5	31.6
	JPN	19.8	4.3	9.1	37.2	29.6
Gross output	EU-25	14.8	3.6	14.1	38.2	29.3
	EU-15	14.8	3.9	14.2	39.0	28.1
	EU-10	14.4	1.5	13.2	32.0	38.9
	USA	14.3	3.9	8.4	41.5	31.9
	JPN	19.5	6.3	11.0	34.2	29.0
Employment	EU-25	21.3	6.7	8.2	21.7	42.1
	EU-15	20.6	6.9	7.8	22.2	42.4
	EU-10	26.6	4.7	11.0	17.2	40.5
	USA	19.8	9.2	5.6	23.3	42.1
	JPN	25.1	10.6	8.4	22.1	33.8
Hours worked	EU-25	22.5	7.1	9.3	22.3	38.8
	EU-15	21.6	7.4	8.9	23.0	39.0
	EU-10	28.6	4.9	11.6	17.6	37.3
	USA	19.8	7.3	6.2	24.9	41.8
	JPN	23.9	10.5	9.9	22.2	33.6

Source: EU KLEMS, Release 2009, own calculations.

In value added terms business services and public services make up the largest part with more than 70% when taken together. The third largest group is wholesale and retail trade with around 14% though much higher share of 20% in Japan. This is followed by transport services for which the shares range from 7% (USA) to about 9 and 10% in Japan and the EU. Hotels and restaurants play a minor role. A very similar pattern can be seen when looking at gross output figures. The patterns however somewhat differ when looking at the figures for employment or hours worked. In this case public services make up an even larger part of more than 40% in the EU and the USA with a remarkably lower share for Japan (34%). Business services account only for around 20% in terms of employment as compared to about 40% in terms of value added (with the EU-10 showing a distinct pattern). On the other hand, wholesale and restaurant services account for a larger share of around 20% with even higher shares in the EU-10 and Japan. In transport services the employment shares range from about 6% in the USA to more than 11% in the EU-10. Of course, these patterns when compared with the value added shares reflect differences in labour productivity across countries.

As the focus of this study is on business services – and more particular on knowledge intensive business services (KIBS) – let us focus in more detail on this category. What is the relative importance of this part of services in the overall economy? Table 2.4.2 provides information on the evolution of the respective shares over time.

Table 2.4.2

Share of business services in total economy (in %), 1975-2007

		1975	1985	1995	2005	2006	2007
Value added	EU-25			25.4	28.1	28.2	28.2
	EU-15	18.3	22.1	25.8	28.9	29.0	29.0
	EU-10			21.9	21.8	21.7	
	USA		24.6	28.3	33.5	33.5	33.9
	JPN	14.7	18.2	22.2	25.6	25.7	
Gross output	EU-25			19.8	22.3	22.0	21.8
	EU-15	13.8	16.8	20.1	22.8	22.6	22.4
	EU-10			17.5	18.2	17.7	
	USA		19.2	22.9	28.3	28.6	28.9
	JPN	10.0	12.8	16.9	19.1	18.9	
Employment	EU-25			11.7	15.0	15.3	15.6
	EU-15	6.9	9.2	12.6	15.9	16.1	16.5
	EU-10			6.6	9.6	9.9	
	USA		13.7	16.4	18.7	19.0	19.0
	JPN	6.4	9.3	11.7	14.8	15.1	
Hours worked	EU-25			11.5	15.0	15.2	15.6
	EU-15	6.7	9.2	12.5	16.0	16.2	16.6
	EU-10			6.6	9.5	9.9	
	USA		14.0	16.5	19.1	19.5	19.6
	JPN	6.1	9.0	11.3	14.2	14.7	

Source: EU KLEMS, Release 2009, own calculations.

Focusing on the longer term trends first one can see that in the EU-15 the value added share has increased from 18% in 1975 to almost 30% in 2007. A similar development is seen in Japan though a somewhat lower level with the differences being about 4 percentage points. The USA shows a slightly larger share of about 2.5 percentage points in 1985 compared to the EU-15 however with a stronger increase as the share in 2007 was 5 percentage points above those found for the EU-15. The EU-10 countries show significantly lower shares having reached about 22% in 2006, thus lying 7 percentage points below the EU-15. Again similar trends and patterns are seen when looking at gross output figures. The same trends also apply when looking at employment where for the EU-15 the share has increased from slightly less than 7% to more than 16%. A similar development has occurred in Japan. The USA shows a somewhat distinct picture with a share of already 14% in 1985 which increased to almost 19% in 2007; thus the increase in terms of employment shares was less strong compared to the EU pointing towards a kind of convergence.

Let us now focus on the share of knowledge intensive business services. Specifically we focus on the NACE rev. 1.1 categories computer and related activities (72), research and development (73) and other business activities (74). In this overview which is based on the EU KLEMS data we also have to include the item renting of machinery and equipment (NACE rev. 1.1 71) as for the comparison across countries we can only use the category 71t74 as provided in the database. Table 2.4.3 provides the respective shares in the total economy whereas Table 2.4.4 provides the shares of this category in business services (JtK).

Table 2.4.3

Share of KIBS (incl. 71) in total economy (in %), 1975-2007

		1975	1985	1995	2005	2006	2007
Value added	EU-25			8.3	11.0	11.1	11.4
	EU-15	4.7	6.7	8.7	11.5	11.7	12.0
	EU-10			4.4	5.9	6.1	
	USA		7.2	9.4	12.9	13.0	13.3
	JPN	2.3	4.3	6.1	7.7	7.8	
Gross output	EU-25			7.1	9.1	9.2	9.3
	EU-15	4.0	5.6	7.4	9.6	9.6	9.8
	EU-10			4.5	5.4	5.4	
	USA		5.4	7.5	11.2	11.3	11.7
	JPN	2.7	4.2	5.8	7.1	7.0	
Employment	EU-25			7.8	11.1	11.4	11.7
	EU-15	4.0	5.6	8.6	11.9	12.2	12.6
	EU-10			3.7	6.3	6.6	
	USA		8.2	11.0	13.2	13.4	13.5
	JPN	2.9	4.9	7.1	10.6	10.9	
Hours worked	EU-25			7.7	11.1	11.3	11.7
	EU-15	3.9	5.6	8.6	12.1	12.2	12.7
	EU-10			3.9	6.4	6.6	
	USA		8.3	10.9	13.3	13.6	13.8
	JPN	2.9	4.9	6.9	10.0	10.5	

Source: EU KLEMS, Release 2009, own calculations.

The share of KIBS increased even more pronounced by about 7 percentage points in the EU-15 from 4.7 to 12% when looking at value added. In relative terms the increase has been even larger in Japan from 2.3 to 8%; remarkably, the shares are still lower than compared to the EU-15. The USA showed only a slightly larger share in 1985 compared to the EU-15 (7.2 compared to 6.7%), however the share increased more in the US reaching a level of 13.3% in 2007, thus being 2 percentage points above the share in the EU-15. The EU-10 shows a remarkably lower share of only 6% in 2006 starting from a share of 4.4% in 1995. In terms of gross output one finds similar trends and structures. Also for employment patterns the figures are similar with Japan showing a stronger increase compared to the share of employment reaching about 11% in 2006. Employment shares in the US are about 2 percentage points above those found for the EU-15. Again the share for the EU-10 is remarkably below the EU-15.

Table 2.4.4 provides the respective shares for KIBS in business services (JtK). The most remarkable result from this is whereas KIBS account for about 40% of value added within this category (with less than 30% in case of the EU-10) the employment shares reach 75% in the EU-15 and 70% in the USA. Again the EU-10 has much lower shares though there seems to be more convergence going on which is studied in more detail below.

Table 2.4.4

Share of KIBS (incl. 71) in business services (in %), 1975-2007

		1975	1985	1995	2005	2006	2007
Value added	EU-25			32.6	38.9	39.4	40.3
	EU-15	25.7	30.4	33.7	40.0	40.4	41.4
	EU-10			20.2	27.2	28.3	
	USA		29.1	33.3	38.5	38.7	39.4
	JPN	15.4	23.8	27.3	30.2	30.2	
Gross output	EU-25			35.9	41.0	41.6	42.8
	EU-15	28.8	33.3	36.8	42.1	42.7	44.0
	EU-10			25.7	29.5	30.4	
	USA		28.0	32.6	39.5	39.6	40.4
	JPN	26.4	32.6	34.3	37.4	37.2	
Employment	EU-25			67.1	74.2	74.4	75.0
	EU-15	58.0	60.6	68.1	75.0	75.3	75.9
	EU-10			56.3	66.0	66.0	
	USA		60.0	67.3	70.3	70.5	70.9
	JPN	44.7	53.0	60.4	71.3	71.9	
Hours worked	EU-25			67.4	74.5	74.7	75.3
	EU-15	58.0	60.7	68.4	75.4	75.6	76.2
	EU-10			58.4	66.8	66.8	
	USA		59.5	66.2	69.6	69.8	70.1
	JPN	46.8	54.6	60.9	70.6	71.3	

Source: EU KLEMS, Release 2009, own calculations.

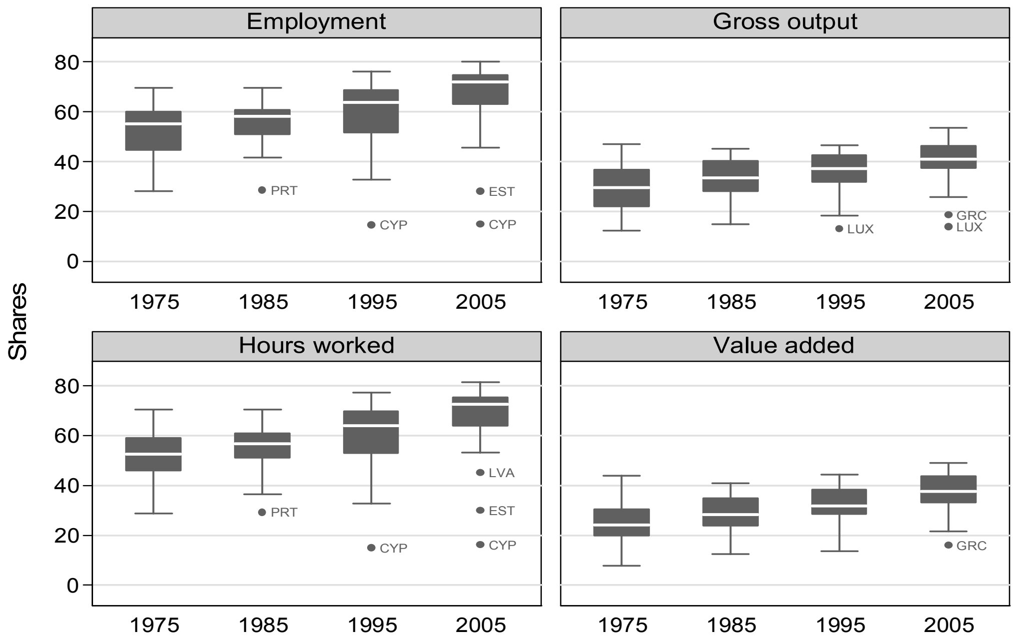
Figure 2.4.1

KIBS shares in total economy across countries (in %), 1975-2005

Source: EU KLEMS, Release 2009, own calculations.

Figure 2.4.2

KIBS shares in business services (in %), 1975-2005

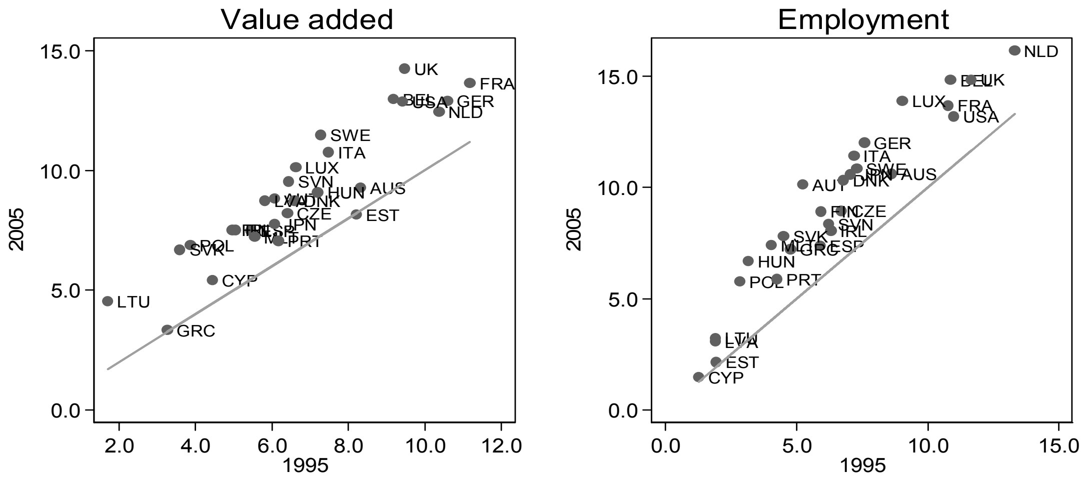


Source: EU KLEMS, Release 2009, own calculations.

This latter conclusion is confirmed when looking at the boxplots provided in Figures 2.4.1 and 2.4.2 respectively. When looking at the share of KIBS in total economy the graphs show a diverging patterns going on in particular for employment but also for value added and gross output. This is again the case when considering only the period 1995-2005; the increase of the variance in 1995 was expected due to the appearance of the EU-10 countries. However, when looking at the patterns within business services there was actual convergence going on between 1995 and 2005 (with the increase in 1995 being caused by the EU-10 countries which have not been in the statistics before). In these cases it is more intriguing to look at the scatter diagrams provided in Figures 2.4.3 and 2.4.4.

Figure 2.4.3

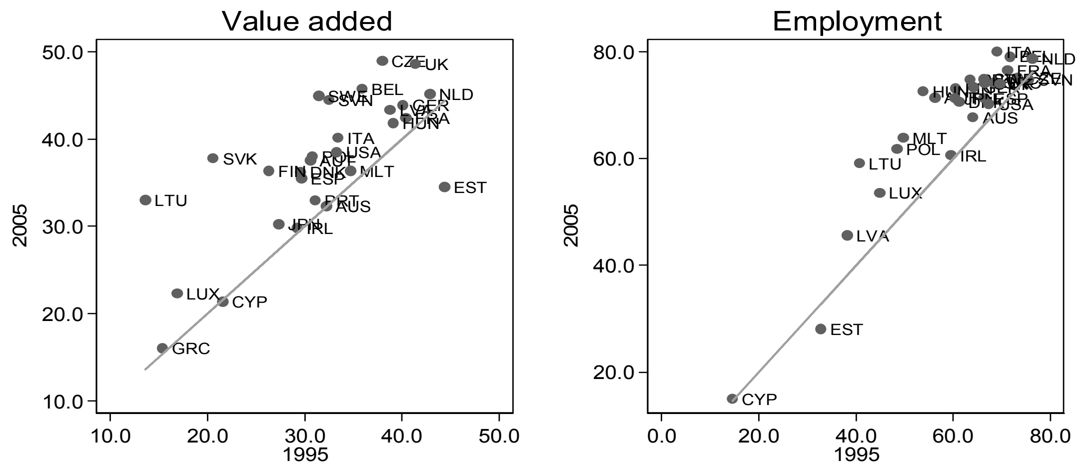
Convergence of KIBS shares in total economy (in %), 1995 and 2005



Source: EU KLEMS, Release 2009, own calculations.

Figure 2.4.4

Convergence of KIBS shares in business services (in %), 1995 and 2005



Source: EU KLEMS, Release 2009, own calculations.

From Figure 2.4.3 which shows the share of KIBS in the total economy that the divergence was driven by some countries at the upper end of the distribution like UK, France, Germany and the Netherlands whereas for the other countries the shares increased less. This is even more evident when looking at employment shares in which case also productivity developments play a particular role especially for the countries at the lower end which are mostly EU-10 countries. This is slightly different from the pattern emerging from the shares of KIBS in business services. Not regarding Cyprus and Estonia (which are classified as outliers in the boxplots) employment shares increased more in those countries having lower shares in 1995 which again are the EU-10 countries. The picture for value added looks a bit more diverse though when not considering some outlying countries (like Lithuania, Slovak Republic and Estonia) there is some divergence going on with the countries at the upper part gaining shares in relative terms.

2.5 Contributions to growth and productivity

Finally, we shortly discuss the contribution of the KIBS sector to overall value added growth. This can be calculated by multiplying the respective growth rates of value added in constant prices (we used 1995 prices) with the share of this sector in the economy (for which we took the average share over the period considered). The results for the groups of countries considered are provided in Table 2.5.1.

Table 2.5.1

Growth contributions of KIBS, 1975-2007

	1975-1985		1986-1995		1996-2007	
	Share	Contribution to growth	Share	Contribution to growth	Share	Contribution to growth
EU-25					9.5	16.8
EU-15	6.4	12.8	8.1	14.9	10.0	18.2
EU-10					5.0	7.6
USA	6.8	14.5	8.9	16.0	11.1	21.9
JPN	4.1	7.1	5.2	8.5	7.7	27.6

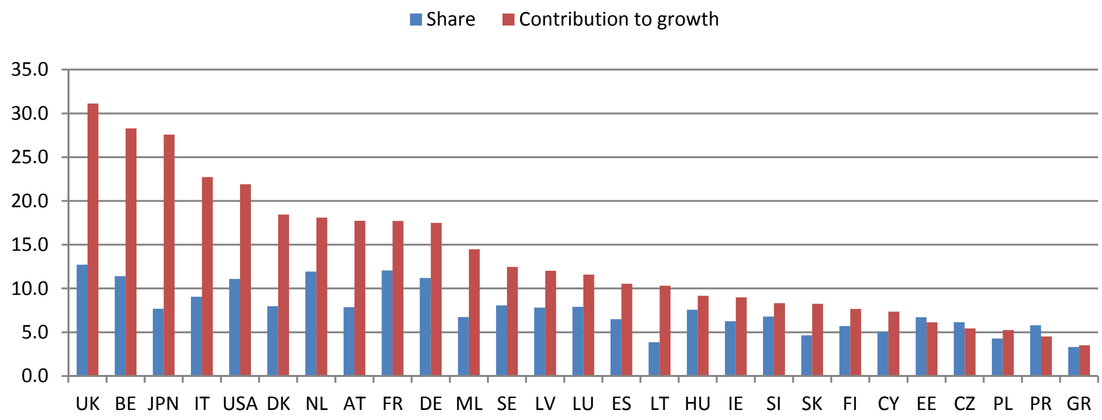
Source: EU KLEMS, Release 2009, own calculations.

First, the contribution to growth of the KIBS in all periods was much larger than its share in value added at constant prices. In the EU-15 the average share over 1975-1985 was 6.4% whereas the contribution to growth was 12.8%. Over the period 1995-2007 the share of KIBS sectors in value added at constant prices was 10% whereas the contribution to growth was 18.2%. Thus, though the KIBS industries account for about a tenth of value added, the contribution to growth accounts for about one fifth. This can be contrasted with the USA where the contribution to growth was almost 22% with an average of 11%, not much larger than the one in the EU-15. Over time, the contribution to growth was relatively larger in the USA compared to the EU-15. The opposite is true for Japan where the contribution to growth was relatively low with 7.1 and 8.5% in the first two periods, respectively. Only in the last period 1995-2007 the contribution peaked to 27.6%. The EU-10 countries are again exceptional in the way that on top of the relatively low share of KIBS the contribution to growth was also relatively low with 7.6% only.

We study this latter period in more detail across countries. Figure 2.5.1 presents the average share of KIBS and the contribution to growth for the EU-25 countries plus USA and Japan.

Figure 2.5.1

Contributions to growth by country, 1995-2007



Source: EU KLEMS, Release 2009, own calculations.

First, the overall shares of KIBS across countries are in the range of about 13% (like in the UK, Netherlands and France) to much lower levels of less than 5% in Greece, Portugal, and Poland. However, the contribution to value added growth in all countries with the exception of Estonia, Czech Republic and Portugal are larger than this share would suggest. In particular in a group of advanced economies (the UK, Belgium, Japan, Italy, and Austria) the contribution to growth was much larger than its share which confirms the finding as presented in Figure 2.5.1. This ratio of the contribution to growth and the share of KIBS is much lower for most of the EU-12 countries together with Ireland and Finland, Portugal and Greece.

Finally, let us shortly look at the growth rates of total factor and labour productivity of the KIBS sector over time and across country groups. In Table 2.5.2 we present the average growth rates of total factor productivity and labour productivity over the periods 1975-1985, 1986-1995, and 1996-2007. In this table we also included a category EU-15ex which includes those countries of EU-15 for which a growth accounting exercise is possible over the longer run.

All countries show negative total factor productivity growth rates in the first two periods though the one of the USA was higher by 0.5 to 1 percentage points compared to the EU-15ex countries. However, whereas in the USA and also in Japan these total factor productivity growth rates turned into positive in the period 1996-2007 it remained negative for the EU countries. Labour productivity was positive however in most country groups (and only negative in the USA in the first and slightly negative for the EU-15 in the second period). In the more recent period there is however a substantial difference between labour productivity growth rates between the EU countries and USA and Japan. Whereas in the latter two countries the growth rates have been at 3.1 and 1.7% respectively, labour productivity growth was almost non-existing in the EU countries. Only in the EU-10 countries the growth rate of labour productivity was little higher at 0.6% due to a catching-up process but well below the growth rate in the USA and Japan. Therefore, this points towards a divergence of productivity levels between the EU countries and the USA and Japan.

Table 2.5.2

Productivity growth (in %)

	Total factor productivity			Labour productivity		
	1975-1985	1986-1995	1996-2007	1975-1985	1986-1995	1996-2007
EU-25						0.09
EU-15				1.09	-0.04	0.07
EU-15ex	-1.56	-1.56	-1.24	1.19	0.14	0.05
EU-10						0.61
USA	-0.97	-0.66	0.71	-0.48	0.54	3.11
JPN	-1.48	-1.19	0.22	1.40	2.10	1.74

Source: EU KLEMS, Release 2009, own calculations.

2.6 The role of KIBS as an intermediate input in the EU, US and Japan

As already mentioned above services and KIBS in particular play also an important and growing role as inputs into manufacturing processes. We therefore focus now on this important aspect of KIBS and examine their role as an intermediate input in the EU and compares it to that in the US and Japan. 'Knowledge-intensive services' can be described by their knowledge-intensity, relative capital intensity and high degree of specialisation (European Commission, 2009, p.19). Business services again cover a wide range of services, which serve as intermediate inputs in value chains of companies. They often complement or substitute in-house service functions of their clients. In this function, they contribute to the competitiveness of companies, stemming from quality and innovation gains coming from the interaction between suppliers and clients (European Commission, 2009, p.15).

Using input-output tables, we look at the importance of KIBS sectors as inputs in the total economy and the manufacturing sector in particular. Input-output data are an appropriate tool for investigating interindustrial relationships and the composition of supply and use of goods and services. For this we use the OECD Stan Input-Output database-2009 edition covering 21 EU countries, the US and Japan. It supplies symmetric industry-by-industry input output tables for the whole economy, for the domestic economy and for imports. We look at the share of KIBS in total intermediate inputs, in manufacturing and in certain high-tech manufacturing sectors for the years 1995, 2000 and 2005. Data are provided only at the 2-digit ISIC rev. 3 (which is compatible to NACE rev.1) level. We subsume the following activities under the term ‘knowledge-intensive business services: computer and related activities (72), research and development (73) and other business services (74).

The questions to be addressed are whether the EU-countries use more or less KIBS in their economy compared to the US and Japan as inputs in other sectors? If this is the case the question is whether there is at least a convergence process taking place between these countries. It is further interesting to study how do KIBS shares vary for the total economy, for manufacturing and for high-tech sectors?

KIBS are important intermediate inputs for the total economy: In 2005, KIBS accounted for almost 15% of total intermediate consumption in the EU-15, but only 9% in the EU-12. In Japan, this share was about 12%, while in the US it reached 14% in that year – slightly below the EU-15 share. Development trends differed between Japan and the other countries over the last 10-years: While in Japan the share increased substantially between 1995 and 2000 (though this might be due to a methodological change) and fell again until 2005 according to the data, in the EU and US shares increased continuously. However, the share expanded slightly more in the US than in the EU-15.

There is however a substantial differentiation across EU economies. When looking at individual EU countries, the share of KIBS ranged from 27% in Ireland at the top end to only 7% in Slovakia at the bottom end in 2005. Figure 2.6.1a presents the countries according to their share of KIBS used in the total intermediates: Countries with high-above average EU KIBS usage are Ireland, the UK, Belgium, Netherlands and France, those with below average usage are mostly new EU member states, but also Greece, Spain, and Portugal. Also Finland and Austria are slightly below the EU-average. Between 1995 and 2005, the KIBS share was expanded remarkably in the following countries: Ireland (+10 pp), the UK, Denmark, Finland, Belgium, and the Netherlands; also Austria increased its share at the same magnitude as the US. Conversely, the KIBS-share fell in Hungary and France or increased only slightly in Portugal, Germany and Spain.

Also when only looking at the manufacturing sector, KIBS prove to be important inputs: In 2005, the share of KIBS used by manufacturing industries amounted to 9% in the EU-15, 5% in the EU-12, roughly 9% in Japan and 10.5% in the US, in this case lying ahead of the EU-15 figure. Development trends between 1995 and 2005 resembled those in the total economy: In Japan, the share of KIBS first increased but then fell again, while in the EU-15, the EU-12 and the US shares increased during the whole period, with the US experiencing a sharp rise between 1995 and 2005 (see Figure 2.6.1b).

At the EU-country level, the share of KIBS was exceptionally high in Ireland in 2005 accounting for 38% of manufacturing intermediates.4 Sweden, Luxembourg, Germany and France followed with shares above 10% (see Figure 2.6.1b). The usage of KIBS in manufacturing was below EU-average in the new EU member states, especially in the Czech Republic (2%) and Slovakia (4%). Among these countries, Hungary showed the relatively largest share of about 7%, ranking before Italy, Austria and the UK with about 6%. Between 1995 and 2005, shares grew most in Ireland and Luxembourg, while shares declined only in France and Portugal (and the Czech Republic between 2000 and 2005).

Knowledge-intensive business services do play a significant role especially in the input structure of high-tech manufacturing industries, under which we subsume NACE rev.1 categories 30-33 (including office machinery, electrical machinery, communication equipment and medical & optical instruments). Indeed, these industries use a larger share of KIBS than manufacturing on average: In the EU-15, KIBS accounted for 14% of all intermediates in high-tech industries, compared to only 5% in the EU-12. However, this share was even lager in Japan and the US with about 16%. Trends between 1995 and 2005 were largely the same as in manufacturing; however, the share in the EU-12 countries slightly decreased between 2000 and 2005 (see Figure 2.6.1c).

Looking again at EU countries in more detail, the share of KIBS was remarkably higher than EU (and US) average in four countries: the Netherlands, Sweden, Finland and Ireland. In these countries, KIBS accounted for more than 25% of intermediates. Belgium, Germany and France held shares of about 15%. On the bottom end, again the new member states but also Portugal and the UK used less KIBS in high-tech industries. Of these countries, Poland held a share similar to Austria, Spain, Greece and Slovenia, all ranging around 7% (see Figure 2.6.2c). Between 1995 and 2005, shares increased by more than 10 percentage points in Finland, the Netherlands, Belgium, Ireland and Sweden on the one hand. On the other, there were also several countries where shares slightly decreased (France -5pp, Czech Republic, Hungary, Spain, Luxembourg and UK -0.1 pp).

Overall, when comparing the KIBS usage between the EU-average (which is almost the same as for EU-15) and the US, is about the same in the total economy, slightly less in manufacturing and somewhat lower in high-tech industries. When compared to Japan, KIBS usage is higher in the EU in the total economy, about the same in manufacturing and somewhat lower in high-tech industries. What is more striking than differences between these three countries/regions are distinct differences within Europe: The gap between EU-15 and EU-12 is pronounced and takes about 5 percentage points difference in the share of KIBS in total intermediates and in manufacturing intermediates and almost 9% in high-tech industries' intermediates. When looking at the individual EU-countries, the wide range

[4] Of these, the chemicals sector accounted for 49% of all KIBS in manufacturing, with 80% stemming from other business services (NACE 74).

of KIBS-usage is even more evident and most striking in high tech manufacturing (compare Netherlands with 29% and Estonia with 2%). While this gap between the EU-15 and the EU-12 seems to have become somewhat smaller for the use of KIBS in the total economy between 2000 and 2005 or at least remained the same in manufacturing, the gap increased in high-tech intermediates according to the data.

Figure 2.6.1a

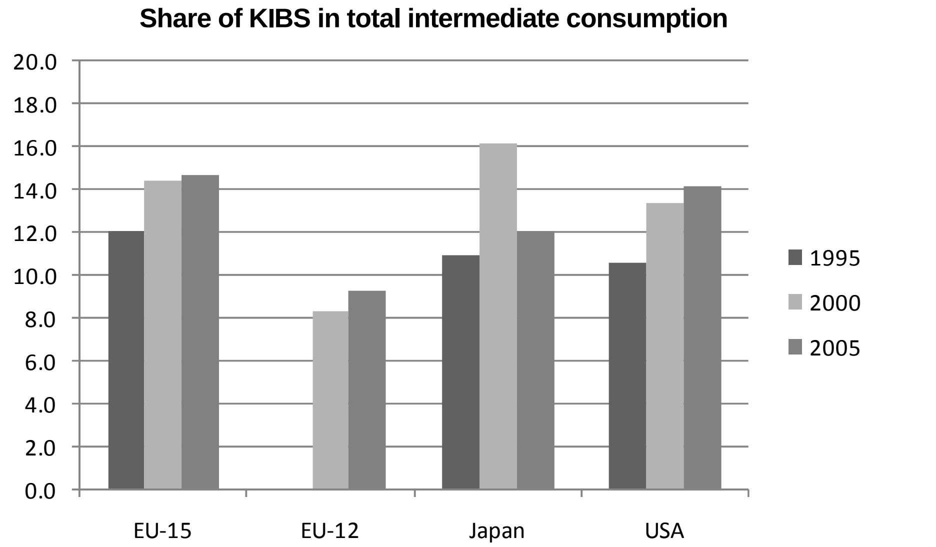


Figure 2.6.1b

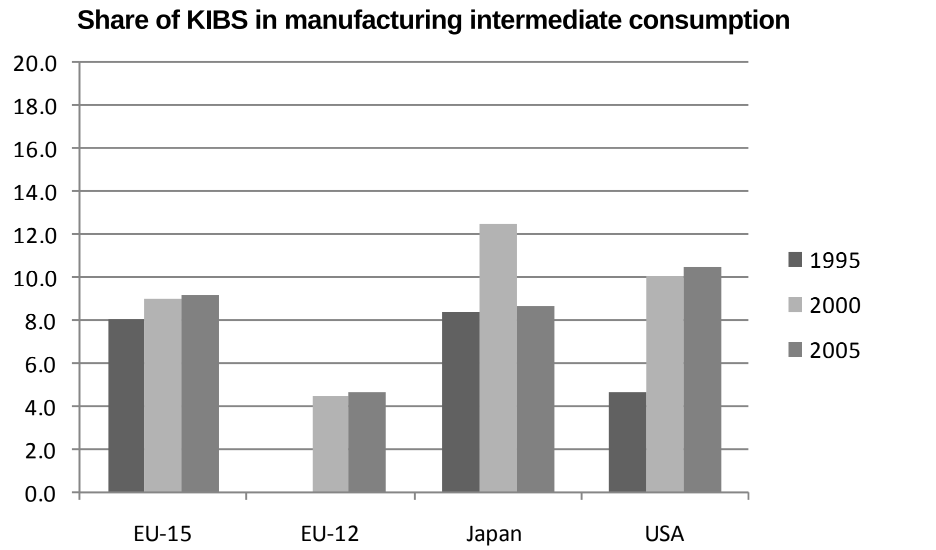


Figure 2.6.1c

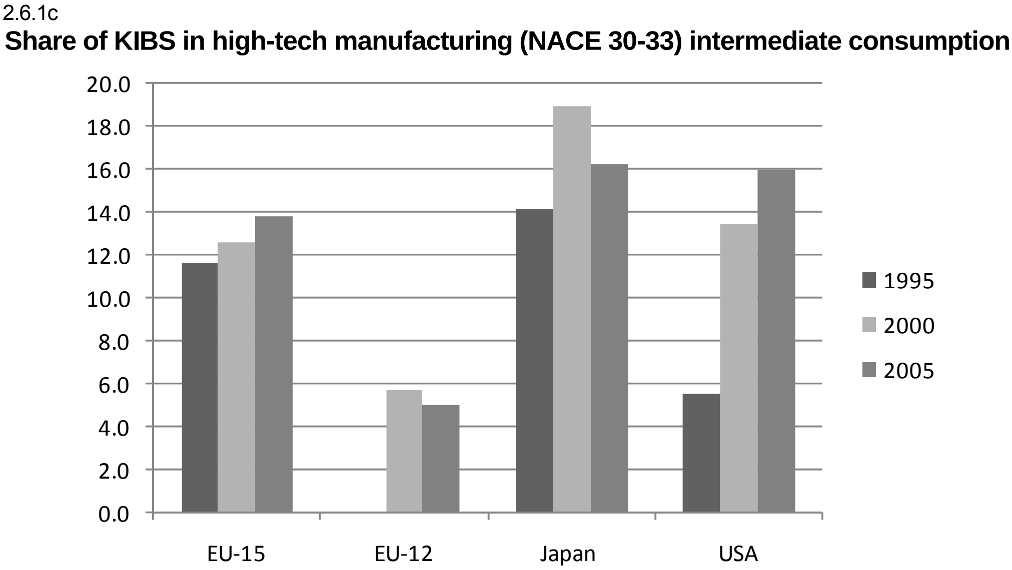


Figure 2.6.2a

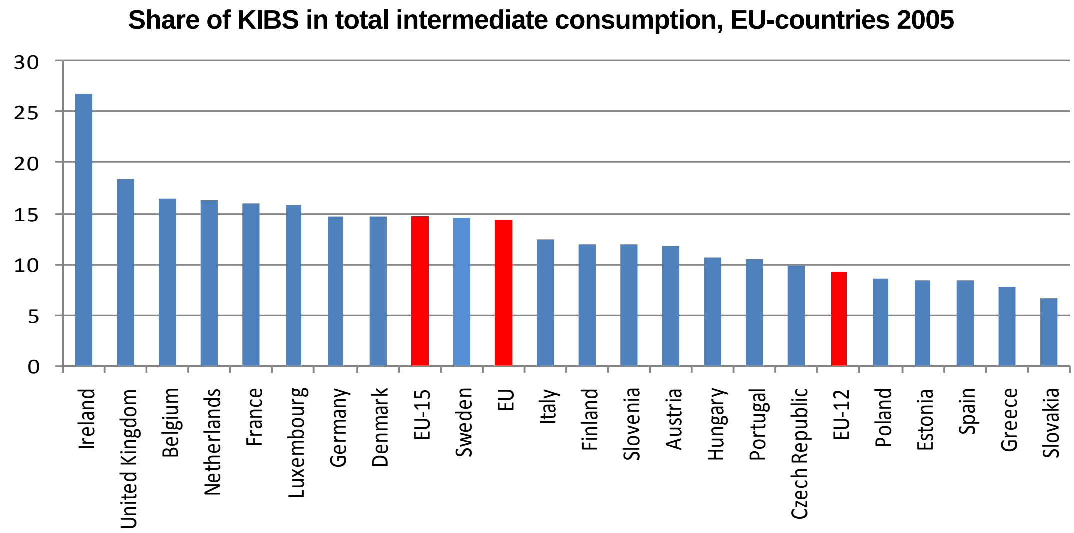


Figure 2.6.2b

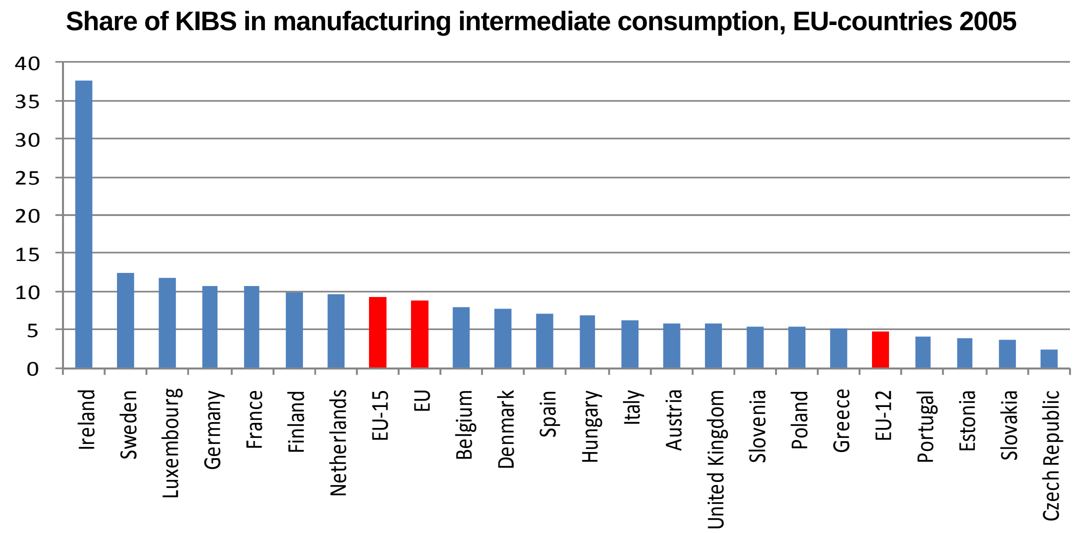
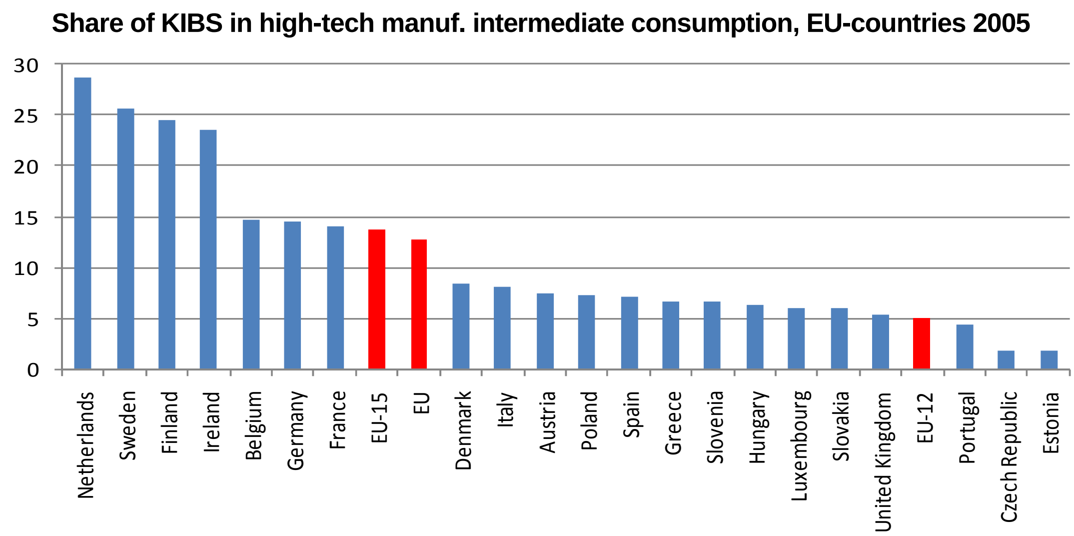


Figure 2.6.2c



2.7 Backward and forward linkages of KIBS in the EU, US and Japan

Linkages, i.e. the interconnectedness of sectors among each other, have increased during the last decades. This is often illustrated by the example of manufacturing industry and services, between which interaction and linkages between have grown over time (Pilat and Wölfl, 2005). Input-output data are an appropriate tool for investigating interindustrial relationships and linkages. Generally, two kinds of linkages occur in the framework of the input-output analysis: On the one hand, a sector needs inputs from other sectors. The interconnection of a particular sector with those "upstream" sectors from which it purchases inputs is termed "backward linkages". The economic effect on other sectors is to be found on the demand side: "If sector j increased its output, this means there will be increased demands from sector j (as a purchaser) on the sectors whose goods are used as inputs to production in j" (Miller and Blair, 2009). On the other hand, a sector sells its output to other sectors. This kind of interconnection of a particular sector with those "upstream" sectors to which it sells its output is called "forward linkages". The economic effect is to be found on the supply side: "If sector j increased its output, this means there will be increased supplies from sector j (as a seller) for the sectors that use good j in their production" (Miller and Blair, 2009). We use the OECD Stan Input-Output database-2009 edition, which covers 21 EU countries, the US and Japan, in order to calculate linkage measures for knowledge-intensive business sectors (NACE 72, 73 and 74). We compare forward and backward linkages over countries and time (1995, 2000 and 2005) based on IO tables for the total economy.

Various measures have been proposed to calculate backward and forward linkages in the literature (see e.g. Miller and Blair, 2009; Drejer, 2002). An early and today still commonly used linkage index was suggested by Rasmussen in 1957, i.e. the 'power of dispersion' (backward linkages) and the 'sensitivity of dispersion' (forward linkage), which we employ in our analysis (see Box 2.7.1). In a next step, one can use these backward and forward linkage measures and select those industries with the highest measures in order to identify "key" sectors in the economy, i.e. those that are most connected and therefore most important in an economy. In the normalized form (as proposed by Rasmussen) these are industries with linkage measures greater than one. We applied the following classification as used widely in the literature:

- Key industries: strong forward and backward linkages
- Lead industries: weak forward and strong backward linkages
- Basic industries: strong forward and weak backward linkages
- Independent industries: weak forward and weak backward linkages

Box 2.7.1

Measurements of backward and forward linkages

The Rasmussen linkage index **'power of dispersion'** describes the relative extent to which an increase in final demand for the products of a given industry is dispersed throughout the total system of industries and is defined as:

$$U_j = \frac{\frac{1}{n}\sum_i B_{ij}}{\frac{1}{n^2}\sum_{ij} B_{ij}}$$

where n is the number of industries and Σ_i $\mathbf{B}_{ij}$ is the sum of the column elements in the Leontief inverse matrix $\mathbf{B} = (\mathbf{I}\text{-}\mathbf{A})^{-1}$. It can be interpreted as the total increase in output from the entire system of industries needed to cope with an increase in final demand for the products of industry j by one unit. This index describes the "backward linkage effects".

Rasmussen also presented a supplementary index describing the extent to which the system of industries draws upon a given industry – an index of the **'sensitivity of dispersion'**. The sensitivity of dispersion index measures the increase in the production of industry i, driven by a unit increase in the final demand for all industries in the system. The index is defined as:

$$U_i = \frac{\frac{1}{n}\sum_j B_{ij}}{\frac{1}{n^2}\sum_{ij} B_{ij}}$$

where Σ_j $\mathbf{B}_{ij}$ is the sum of the row elements in the Leontief inverse matrix, which is interpreted as the increase in output in industry i needed in order to cope with a unit increase in the final demand for the product of each industry. This index may be labelled as "forward linkage effects".

See Drejer, 2002, p.5.

Overall, backward linkages of knowledge-intensive business services to the rest of the economy are rather weak and do not differ much across EU-countries, the US and Japan: the relevant linkage indices are rather small and mostly below one for all three KIB-sectors. They ranged between 0.7 and 1 for computer services, 0.6 and 1 for R&D and 0.7 and 0.9 for other business services in 2005 (see Figure 2.7.1). In computer services (NACE 72), Ireland and Luxembourg showed the largest backward linkages in 2005, with indices slightly above one, all other countries had values below. On the other end, Germany, Spain and Japan exhibited the smallest linkage indices, while the USA lay in the middle field. In R&D (NACE 73), Ireland was the only country with a linkage index above one in 2005, followed by the USA (0.9). Portugal, Estonia and the Czech Republic were the countries with the smallest backward linkages in R&D, Japan lay in the middle field. In other business services (NACE 74), Ireland and Greece exhibited the largest backward indices; Estonia, Germany and Hungary the smallest. Both, the USA and Japan were in the lower middle-field. Backward linkages were rather stable between 1995 and 2005. However, a slight tendency to decline could be observed for this period.

Forward linkages to the rest of the economy do differ across individual KIBS and are extremely strong for other business services, while they are weak for computer services and especially for R&D. They ranged between 0.5 and 1 in computer services, 0.3 and 1.8 in R&D and 1.4 and 4 in other business services in 2005 (see Figure 2.7.2). In computer services (NACE 72), only Ireland and Sweden showed forward linkages above one in 2005, all other countries held values below. On the bottom end were Portugal, Spain and Estonia; Japan lay before the USA in the upper middle field. In R&D (NACE 73), the USA and Japan held the largest forward linkages. For the EU countries, forward linkages indices were below one, a relatively higher linkage index was only found for the Netherlands. In other business services (NACE 74), forward linkages are pronounced in all countries and range above one. In 2005, the highest linkages indices were found for Ireland, Luxembourg and Belgium; the lowest for the USA, Slovakia and Japan. Forward linkages mostly increased between 1995 and 2005.

Classification of industries according to their backward and forward linkages into key, leading, basic and independent industries reveals again major differences among the individual KIBS (see Figure 2.7.3): other business services is a basic industry in all countries with pronounced forward linkages and weak backward linkages, while computer services and R&D are mostly independent industries, having weak forward and backward linkages (with only some exceptions). In more detail, computer services (NACE 72) is mostly classified as a independent industry, except in Sweden, where it s a basic industry (strong forward linkages), Luxembourg, where it is a leading industry (strong backward linkages) and Ireland, where it turned out to be a key industry with both backward and forward linkages being strong (indeed the Irish computer service industry is the only industry classified as key among all KIBS). The R&D (NACE 73) industry is also classified as an independent industry in most counties, except in the USA and Japan, where it is a basic industry and Ireland, where it is a leading industry. Other business services (NACE 74) are basic industries in all countries, with an especially pronounced position in Ireland, Luxembourg and Belgium. Between 1995 and 2005, only a few cases of reclassification occurred (the most important one being the shift of computer services in Ireland from an independent to a key industry). Overall computer services shifted slightly left (denoting a decline in backward linkages), while other business services shifted upward (denoting an increase in forward linkages). No change is visible for R&D.

Figure 2.7.1

Backward linkages, Computer and related services (NACE 72), 1995 and 2005

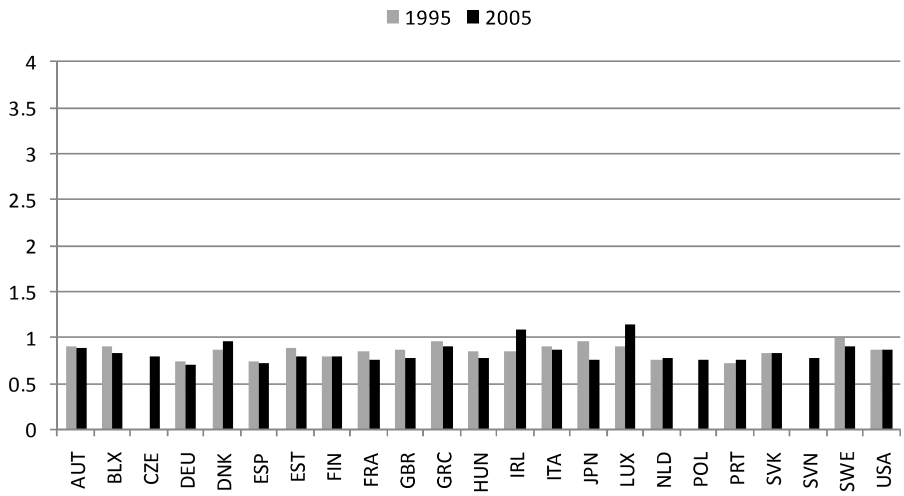


Figure 2.7.1b

Backward linkages, R&D (NACE 73), 1995 and 2005

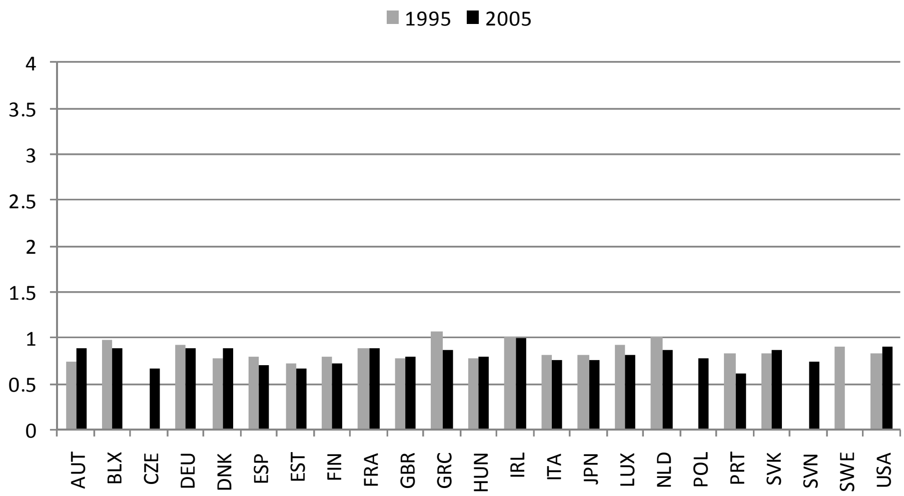


Figure 2.7.1c

Backward linkages, Other business services (NACE 74), 1995 and 2005

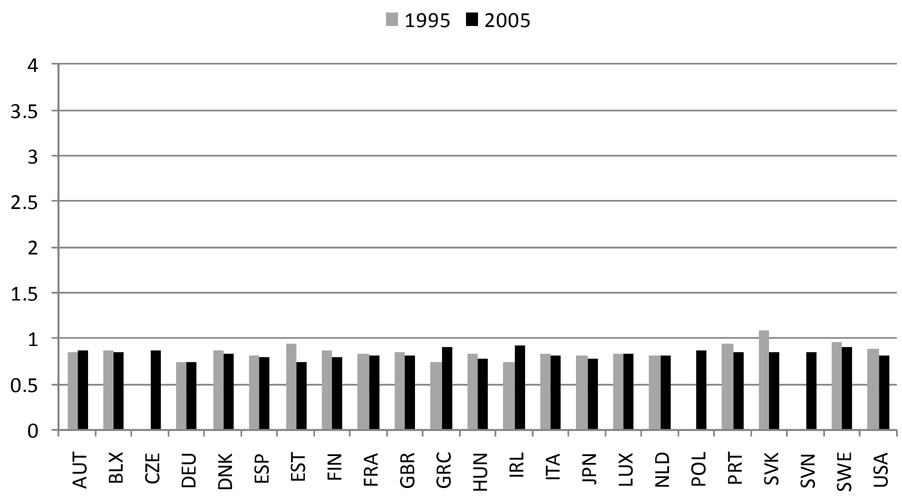


Figure 2.7.2a

Forward linkages, Computer and related services (NACE 72), 1995 and 2005

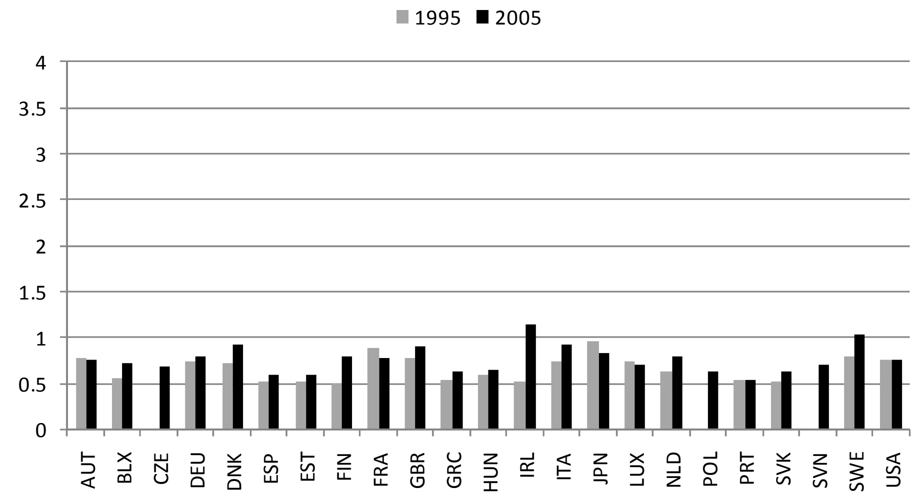


Figure 2.7.2b

Forward linkages, R&D (NACE 73), 1995 and 2005

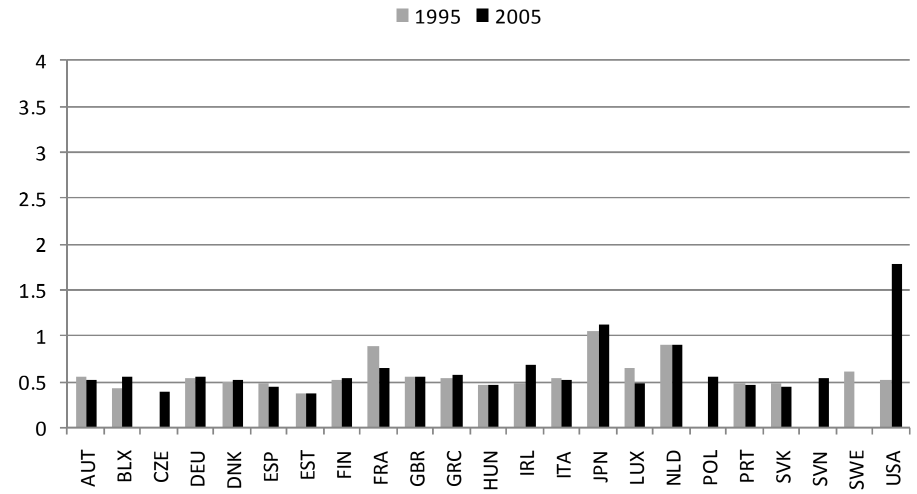


Figure 2.7.2c

Forward linkages, Other business services (NACE 74), 1995 and 2005

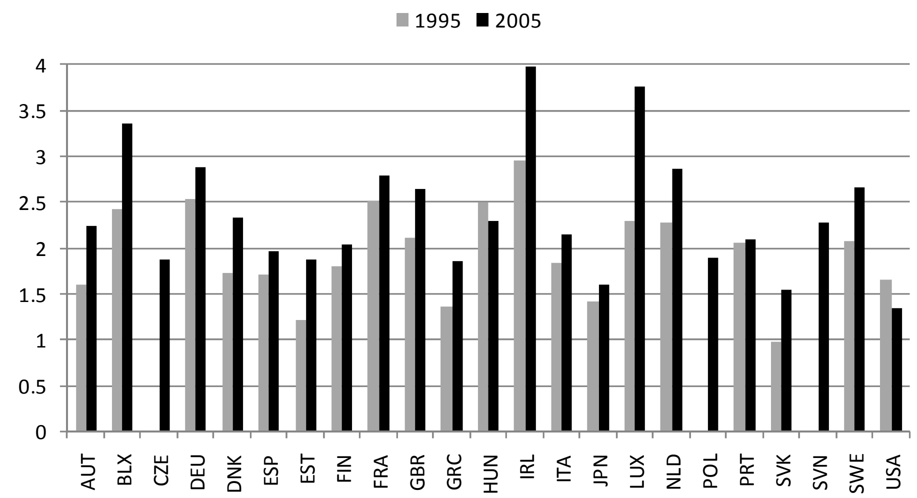


Figure 2.7.3a

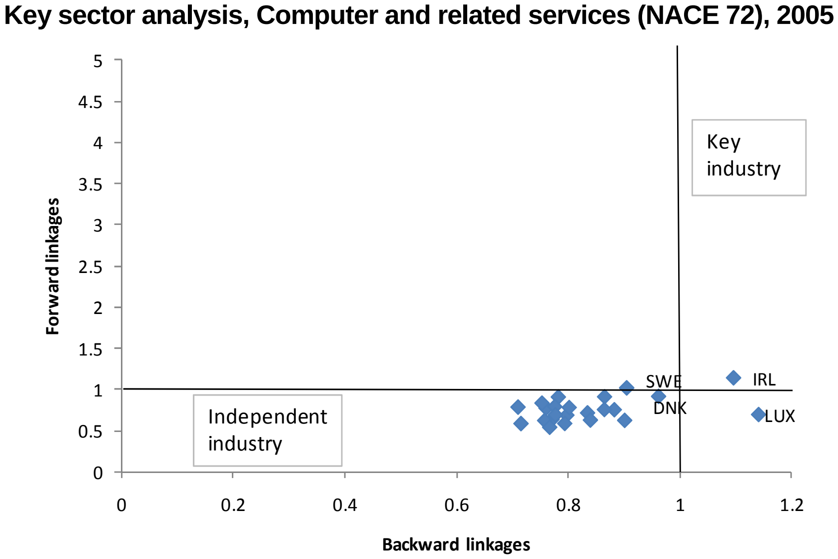


Figure 2.7.3b

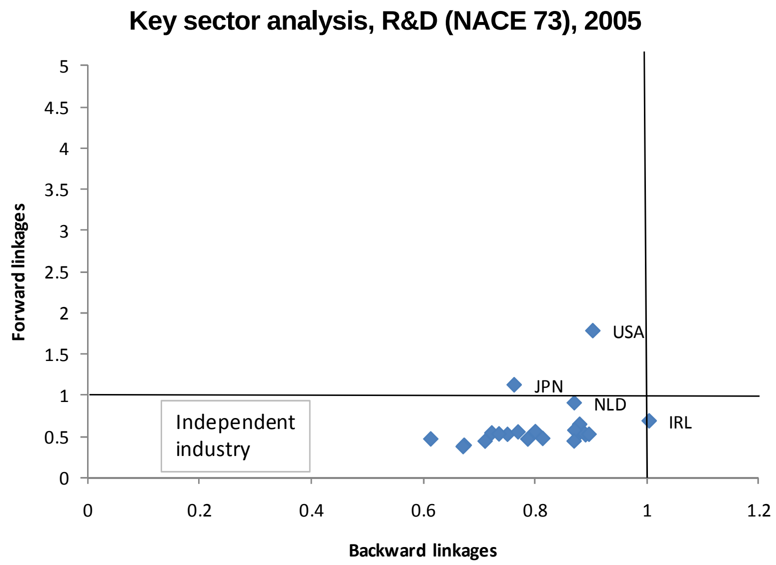
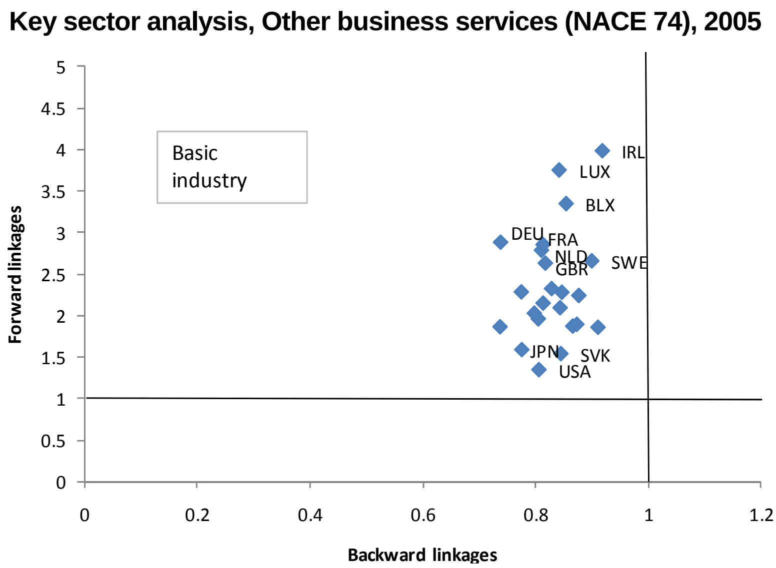


Figure 2.7.3c



2.8 Conclusions

In this section we pointed towards the increasing importance of KIBS in the EU economies and compared these to Japan and the US. Though the increasing importance of KIBS for all economies considered here is clearly seen in terms of rising shares in employment and value added the concerning question on whether there has been a tendency of convergence in the sectoral structures and the share of KIBS in particular cannot be answered in a confirmative way. There is no overall convincing statistically significant tendency of such a convergence process. The evidence found here is though the shares are growing in most countries, the countries having lower shares do not have increased them in a particularly faster way. In some cases we even find evidence for more specialisation into KIBS services, i.e. those countries having already large shares tended to increase these faster than those will lower shares initially. The second issue covered in this section was on the role of KIBS as inputs into the total economy and into high-tech manufacturing in particular. Here we first find some evidence on the growing importance of KIBS as inputs in the total economy and particular subsectors, but also a not too large but significant gap between the EU and the US with the EU lagging behind in high-tech manufacturing. The mean over EU countries however hides important cross country differences. Looking in more detail at these figures at the country level one can find that the most advanced European economies like Germany do have similar shares as the US whereas for example the EU-10 lag far behind. Finally, using input-output techniques we studied the forward and backward linkages of KIBS industries in more detail. The backward linkages of KIBS to the rest of the economy (i.e. the interconnection of a particular sector with “upstream” sectors from which it purchases) turned out to be rather weak and further do not differ much across EU-countries, the US and Japan. In particular, the relevant linkage indices are rather small and mostly below one for all three KIB-sectors. On the other hand, the forward linkages (i.e. interconnections of a particular sector with those “upstream” sectors from which it purchases) turn out to be rather strong for business services and astonishingly weak for the other KIBS sectors considered (R&D and computer). Whereas for the business sectors there was a tendency of the linkage indicator to increase over time the evidence on this is rather mixed over countries for the other sectors. Considering the forward and backward linkages together it turns out that other business services can be classified as basic industry in all countries with pronounced forward linkages and weak backward linkages, while computer services and R&D are mostly independent industries characterised by weak forward and backward linkages (with a few exceptions). This pattern remained further rather stable across countries over the period 1995-2005.

Appendix

Table A.2.1

NACE rev. 1.1 classification

NACE rev. 1.1	Description
A	Agriculture, hunting and forestry
B	Fishing
C	Mining and quarrying
D	Manufacturing
E	Electricity, gas and water supply
F	Construction
G	Wholesale and retail trade; repair of motor vehicles, motorcycles and personal and household goods
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
P	Private households with employed persons
Q	Extra-territorial organizations and bodies

3. Embodied and sectoral linkages between manufacturing and the knowledge-intensive services

This section considers the direct and indirect flows of knowledge between the manufacturing industries and knowledge-intensive business services (KIBS). Flows of knowledge between these two sectors represent a bilateral learning process or what might be called a coproduction of capabilities. KIBS often facilitates the innovation process in the manufacturing industries and they have considerable potential in creating new knowledge and transforming firms into learning organisations (Hauknes, 1998). Statistical evidence, particularly from input-output tables, shows that global technological and organisational capacity is a function of its use of software and other business services.

While manufacturing appears to be an engine of productivity growth, this growth depends to a great extent on services in general and KIBS in particular. Kaldor (1966) and later Cornwall (1977) suggested that manufacturing is the main source of new technical knowledge and that this knowledge diffuses from there into other sectors, including into the service sector. This argument presumes that backward and forward linkages from manufacturing to services are particularly strong. While the Kaldor-Cornwall argument might still be valid for catching-up economies, Hauknes (1998) and Fagerberg and Verspagen (2002) suggest that manufacturing may no longer be the ‘engine of growth’ of high productivity economies, but that services, and especially knowledge intensive business services (KIBS) have become much more important. They show that in the advanced economies, the role of services has become much more important, thus confirming the conclusions of the European SI4S (Services in Innovation, Innovations in Services) project (Hauknes, 1998). This argument would imply that the direction of the linkage between manufacturing and KIBS services would be the other way around.

3.1 Inter-industry technology flows

Input-output analysis provides a way to measure the interdependence of the manufacturing industries and the knowledge intensive services in the national production system, as well as its interdependence in the global economy. Developed in the 1930s by Wassily Leontief (1936, 1937), the framework makes it possible to describe an economy on the basis of domestic and international knowledge and technology flows contained in intermediate and capital goods. Smookler (1966) later showed that technical change could result from R&D performed within an industry as well as also from R&D performed in other industries and “embodied” in intermediate purchases. Picking up on this idea, Terleckjy (1974) and Scherer (1982) measure inter-industry technology flows and their impact on productivity growth by combining business expenditures on R&D activity with input-output tables. They show that purchased inputs, whether intermediate or capital goods and services, and whether domestic or international, contain technology and knowledge created by another industry. This analysis made it possible to show that R&D activity within an industry comprised only a fraction of the knowledge and technology actually appropriated by any firm within the industry.

Papaconstantinou, Sakurai and Wyckoff (1998) and Hauknes and Knell (2009) developed a higher level of precision to estimate these flows. While the common methodology in these two works does not adequately account for the industry-to-industry interaction within technology flows, due to double counting, it does provide a way to see patterns that appear within an industry relatively to other industries across many different countries. Hauknes and Knell (2009) develops this methodology further to correct for this. This section extends this methodology.

To measure the total R&D content of manufacturing and the knowledge-intensive services and the embodied flows between these two sectors, this section makes extensive use of the OECD Input-Output Database and the OECD Analytical Business Enterprise Research and Development (ANBERD) Database, covering the year 2005. These databases are part of the OECD Structural Analysis (STAN) family of databases, which strives to provide a consistent data set that overcomes the problems of international comparability. The analysis covers twenty-two Member States of the European Union plus Norway, the United States, Canada, Japan, Korea and China. The input-output table and R&D expenditure data for Lithuania was obtained from Eurostat and the R&D data are based on estimates based on the 2000 table and recent statistics on manufacturing data obtained from the OECD. Since community, social and personal services were aggregated into one group in the ANBERD database; the input-output tables were aggregated in the same way, resulting in 33 industries defined according to the two-digit NACE rev 1 and ISIC rev. 3 classification system.

There are some caveats concerning the data used in the analysis. The first concerns the nature of the services itself. In some service industries the process of production is often confused with the output of that process, whereas they can be easily distinguished in the manufacturing industries (Hill, 1977; Hauknes, 1996). Hill (1977: 318) stressed that “the process of producing a service is the activity which affects the person or goods belonging to some economic unit, whereas the output itself is the change in the condition of person or good affected”, or as he phrased it in the early 1960s, “consumers don’t demand quarter-inch drill bits, they demand quarter-inch holes”. This makes it difficult to measure the output and productivity of many services. Finally R&D activity itself is a service.

The second concerns the quality of the R&D statistics for the services industry and its comparability to the input-output statistics. R&D statistics are collected at the enterprise level whereas national income statistics are collected at the plant level, with adjustments being made to the composition of the output of the plant. Many of the large firms that engage in R&D activity do these activities at a particular location, often close to the global headquarters. For this reason, R&D intensity can appear exceedingly high in one country and low in another because of the location of certain activities. There is also one particular problem associated with the KIBS industries. It is not always clear what goes into the market based 'research and development' (R&D) industry (NACE 73). In some cases this industry includes governmental R&D labs and contract research agencies, serving the business sector. The ANBERD database was conceived to better match R&D activities with industrial performance. This increases the international comparability and consistency data with the STAN family of databases.

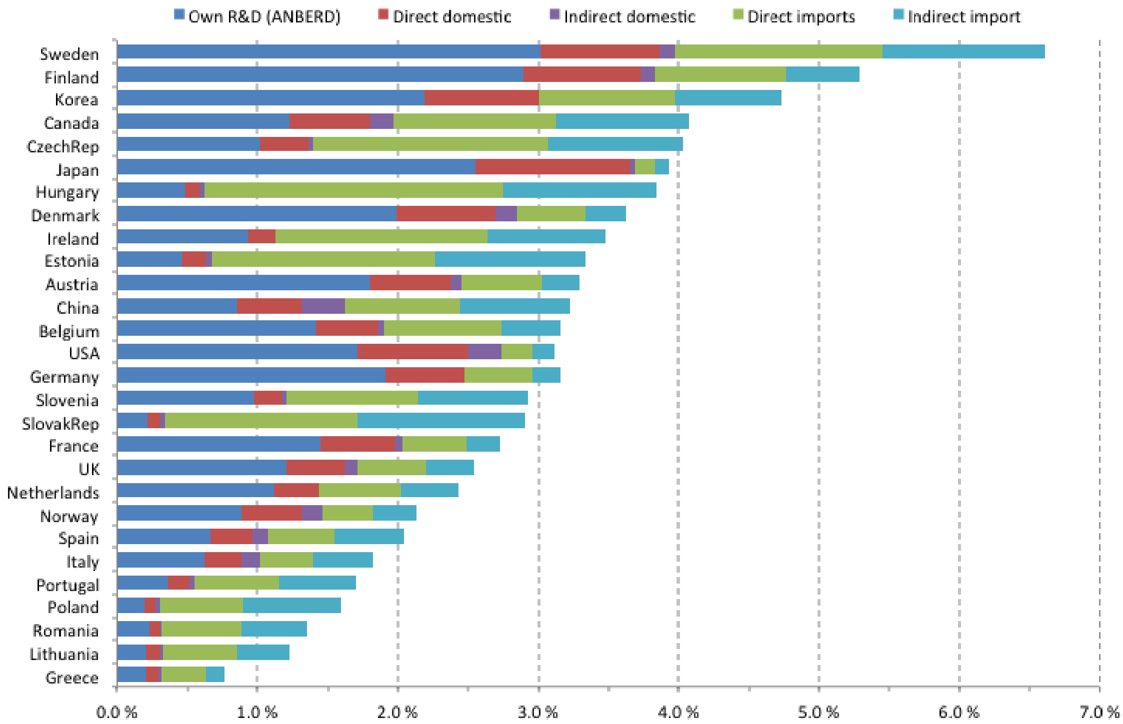
To calculate the technology intensity at sectoral level we use the input-output tables of intersectoral and imported intermediate traded inputs. R&D performed in a source sector is assumed to be embodied in the products produced here as knowledge, characteristics that enter into the production of knowledge and turnover of the users of these products. The integration of input-output data and R&D data gives us a tool for estimating all these intersectoral flows, and thus also the total amount of embodied technology deposited into any domestic sector. Summing over all the 33 sectors we get an estimate of the economy-wide technology intensity, relative to value added.

Product-embodied knowledge resides in intermediate inputs that originate from both domestic and foreign sources, and it can flow both directly and indirectly though the production of all other commodities. The total technology intensity therefore contains five components: 1) sectoral R&D as described by the ANBERD data (own R&D (ANBERD)); 2) direct R&D flows from all other domestic source sectors into any recipient industry, such as flows of R&D from any KIBS-sector directly into manufacturing sectors and embodied in the outputs of the KIBS-sector (Direct domestic); 3) indirect R&D flows from domestic source sectors that enter one or more intermediate sectors before arriving in the recipient industry, such as computer service products used in the production of electronic equipment, ending in food production (Indirect domestic); 4) direct R&D flows from foreign source sectors into any recipient industry (Direct imports); and 5) indirect R&D flows from international source sectors (Indirect imports). Figure 3.1.1 ranks the countries according to total technology intensity and shows that the share of own R&D activity of business enterprises is about one-half of the total R&D content in countries with a relatively high level of GDP per capita and below this share in countries with lower level of income.[5] Box A.3.1 provides an outline of the simple mathematics behind the analysis.

[5] Papaconstantinou et al. (1998), Knell (2008) and Hauknes and Knell (2009) confirm these findings. But unlike these studies, figure 3.1.1 distinguishes between R&D activity located within the industry and the direct and indirect domestic and international product-embodied knowledge flows contained in intermediate inputs.

Figure 3.1.1

Technology intensity relative to total value added by source, 2005.



The direct R&D flows from all other domestic source sectors into any recipient industry are positively (and highly) correlated with R&D performed within an industry. Countries with a high share of R&D activity performed within the sector are generally considered to be knowledge creators. More than 60% of the total technology intensity in Japan and Germany has its origin in the own R&D performance of the industry, and Denmark, USA, Austria, Finland and France depend on own R&D performance for more than half its technical knowledge. Countries with a low share of R&D activity performed within the sector are generally considered to be knowledge users. Estonia, Hungary, Lithuania, Poland, Romania and Slovakia depend on knowledge embodied in inter-industry trade for more than 80% of the total technology intensity, whereas Japan and the USA relied on imported knowledge for only 6% and 12% of total knowledge inputs, respectively.

Table 3.1.1 shows the share of embodied technology flows in total knowledge inputs. Countries that are typically above the European Union average income per capita appear as a knowledge generating countries in that they are largely self-sufficient in knowledge inputs. Countries below this average, including several New Member States, in addition to Ireland and Portugal, appear similarly as technology importers. In the table we have defined knowledge suppliers by an import share less than one-third, and knowledge users by a share larger than two thirds.

The size of the country also matters as to whether the embodied technology comes from domestic or international sources. Germany, Japan and the USA depend more on domestic flows of embodied knowledge, whereas Ireland, Estonia and Slovenia depend more on international flows. In general, smaller countries depend more on international sources of knowledge than larger ones. Countries where assembly production looms high in the national economic structure, such as most of the east European countries and Ireland, have a very high share of knowledge sourced from abroad. Finally, differences in the industrial structure and in the way each country create and use technical knowledge can also be an important factor behind the patterns observed.

Table 3.1.1

Share of imported technology flows in total knowledge inputs

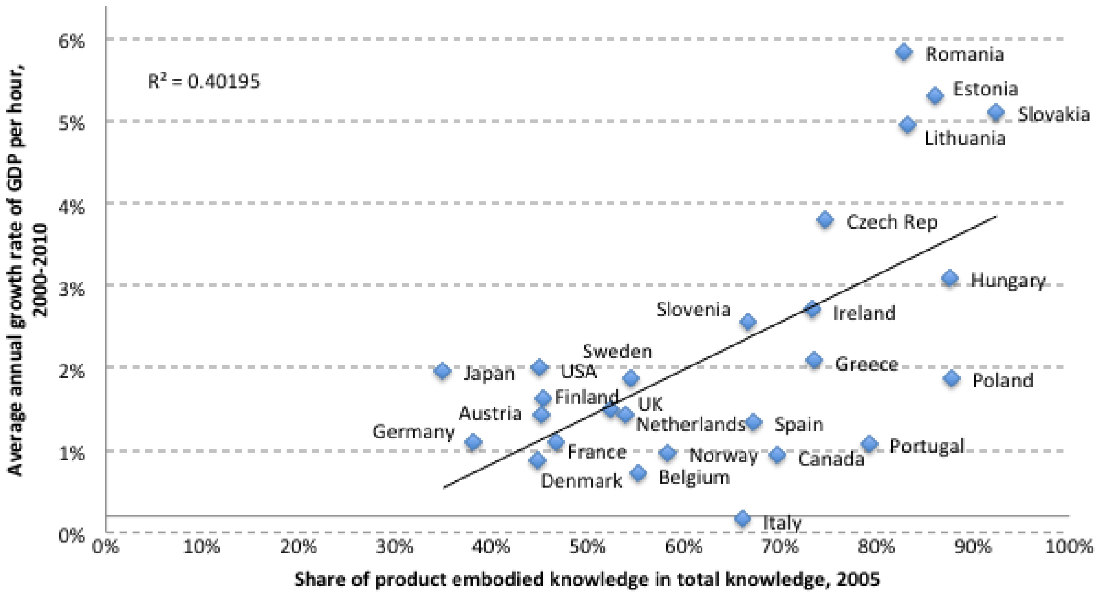
	Embodied technology flows of total knowledge inputs	Imported technology flows of total knowledge inputs
Knowledge suppliers		
Japan	35.0 %	6.2 %
USA	45.0 %	11.9 %
Denmark	44.8 %	21.3 %
Germany	38.1 %	22.0 %
Austria	45.1 %	25.4 %
France	46.6 %	25.5 %
Finland	45.3 %	27.6 %
Norway	58.3 %	31.3 %
UK	52.4 %	32.4 %
Knowledge users		
Ireland	73.3 %	67.4 %
Portugal	79.1 %	67.7 %
Lithuania	83.1 %	73.4 %
Romania	82.9 %	76.4 %
Estonia	86.1 %	79.7 %
Poland	87.7 %	80.9 %
Hungary	87.6 %	83.8 %
Slovakia	92.4 %	88.5 %

Knowledge users rely more on technical knowledge embodied in the inputs into the production process, and especially on technical knowledge embodied in goods and services that are imported. Catching-up, in the form of beta-convergence, occurs when countries with relatively low GDP per capita experience higher rates of productivity growth than those countries with relatively high income levels. Figure 3.1.2 shows a positive statistical relationship between productivity growth, measured in terms of GDP per hour worked and the use of technology embodied in products. This suggests that beta-convergence is taking place between the knowledge suppliers and knowledge users within the European "club".[6]

[6] China was left out of Figure 3.1.2 because the average annual growth rate per worker exceeded ten per cent, whereas the technology embodied in products explains about three-quarters of the total Chinese technology intensity.

Figure 3.1.2

Product embodied knowledge relative to productivity growth, 2000-2010.



The ratio of total technology intensity to R&D intensity, or the technology multiplier, can be calculated for any industry or groups of industries. Figure 3.1.3 shows the embodied technology flows into manufacturing, relative to national R&D expenditures in manufacturing, or the technology multiplier for manufacturing. Note that the technology multipliers of the ten countries at the top of the figure are a factor 15 higher than those in the bottom part. Hence, the scale of the horizontal axis at the top is about 15 times the scale of the lower horizontal axis.

Except for Japan and the US at the bottom of the figure, imported knowledge to domestic manufacturing sectors dominates (the sum of Import MFG, Import KIBS and Import non-KIBS/non-MFG), rather than domestic transfers. For most countries the main source of imported knowledge inputs is from foreign manufacturing sectors (cf. the variable Import MFG). The main exception to this is Ireland, where imports of KIBS products to intermediate use in Irish manufacturing sectors are a major source of these inputs. The underlying data shows that almost all of this is through imports of R&D services from abroad, with Irish chemical industries as the major recipient, and Irish printing and publishing, including software publishing, as the second main recipient.

The vast differences between countries observed in Figure 3.1.3 are mostly driven by knowledge generated in other manufacturing industries and sourced abroad denoted ‘Import MFG’ (the light blue part of the columns). As in Figure 3.1.1, the order of the countries in the figure is driven mainly by their level of development and the extent to which countries carry out their own R&D. Perhaps most significant is that relatively little knowledge appears to flow from the KIBS sector (sum of Domestic KIBS and Import KIBS) to the manufacturing industries, except in Ireland where there appears to be a significant flow from abroad. Size also matters as to whether the embodied technology comes from domestic or international sources. Domestic sources appear dominantly important in Japan and the United States. In all other countries imported flows dominate over domestic flows, though domestic flows are more important in China than in other countries. International sources of knowledge into the manufacturing industries are much more important for the New Member States, along with Portugal and Greece.

The resulting pattern in Figure 3.1.3 seems to reflect two underlying factors. The difference between Japan, the US, and to some extent China, and the rest, suggests that the size of the economy is a determining factor; large economies tend to be more closed to international trade than smaller and more open economies. Secondly, with the exception of Ireland, the distribution in Figure 3.1.3 is correlated to the distribution of national income levels, as measured in terms of GDP per capita. Low income countries tend to be clustered at the top, while high income countries clusters at the bottom.

Figure 3.1.4 illustrates the embodied technology flows into KIBS, relative to national R&D expenditures in KIBS, which has a similar pattern as observed in Figure 3.1.3. However, this time Finland appears as an outlier; the Finnish KIBS-sector's knowledge inputs are almost completely dominated by imported technology flows from manufacturing (Import MFG) and from other sectors outside of KIBS and manufacturing (Import non-KIBS/non-MFG).

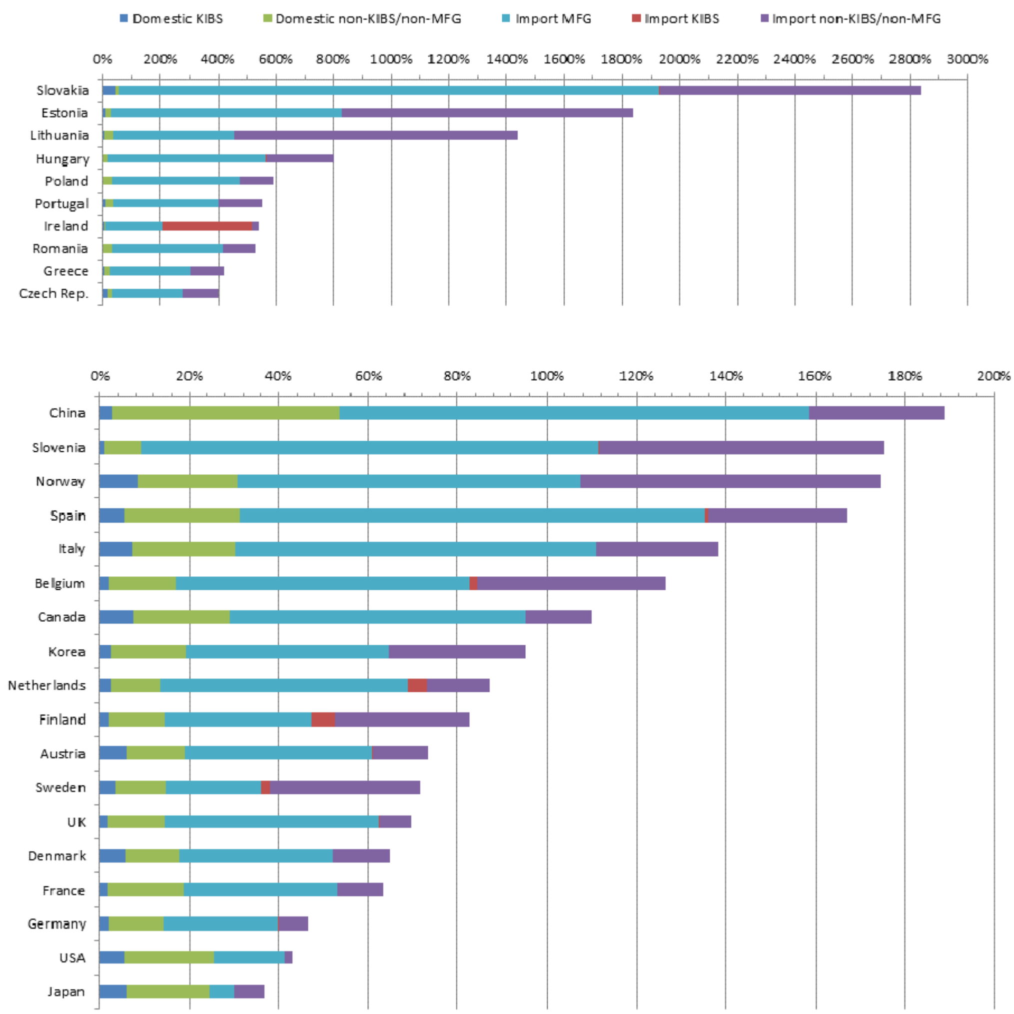
Measurement problems may have an important influence on this indicator. As one potential problem with this figure is that sectoral R&D is in the denominator, the indicator will be highly sensitive to the size and the extent to which the R&D survey covers these service sectors. Moreover, while the KIBS sector is knowledge intensive, there is some controversy over what is research and development in this context. If the coverage is weak, or R&D is interpreted in a too narrow sense, relative to the characteristics of the sector itself, then the denominator will be small.

As with the previous figure, Figure 3.1.4 depicts a technology multiplier, the multiplier of domestic KIBS-sectors. Thus, again the denominator of the ratio is national R&D expenditures, this time of the KIBS-sectors. In the Finnish case, the total embodied technology flows into Finnish KIBS sectors more than eight times larger than technology generation through own R&D in these sectors. Given that the Finnish economy is among the most R&D intensive, this result is surprisingly large. However, the Finnish ANBERD data show that R&D expenditures in the market-based R&D sector itself, NACE 73, are zero, in spite of a significant production in this sector. In addition the R&D intensity of other business services, NACE 74, is low, relative to other countries. This suggests that these two sectors are weakly covered in the national R&D surveys, something that would come some way in explaining the enormous multiplier value of the KIBS sectors.

The Austrian case, at the bottom of the figure, appears as the very opposite of Finland. In the Austrian case, nearly 50 per cent of R&D expenditures in the KIBS sectors are accounted for by the R&D sector. While the 2005 R&D intensity of NACE 73 in Austria is more than 60 per cent, the corresponding Finnish intensity is zero. For NACE 72, the corresponding intensities are 2.7 and 4.3 per cent, while the intensities of NACE 74 are 1.1 and 0.3 per cent, respectively in the Austrian and Finnish cases. We conclude that Figure 3.1.4 seriously depend on the coverage of KIBS sectors in national R&D surveys.

Figure 3.1.3

Embodied technology flows into manufacturing, relative to national R&D expenditures in manufacturing (ANBERD), 2005

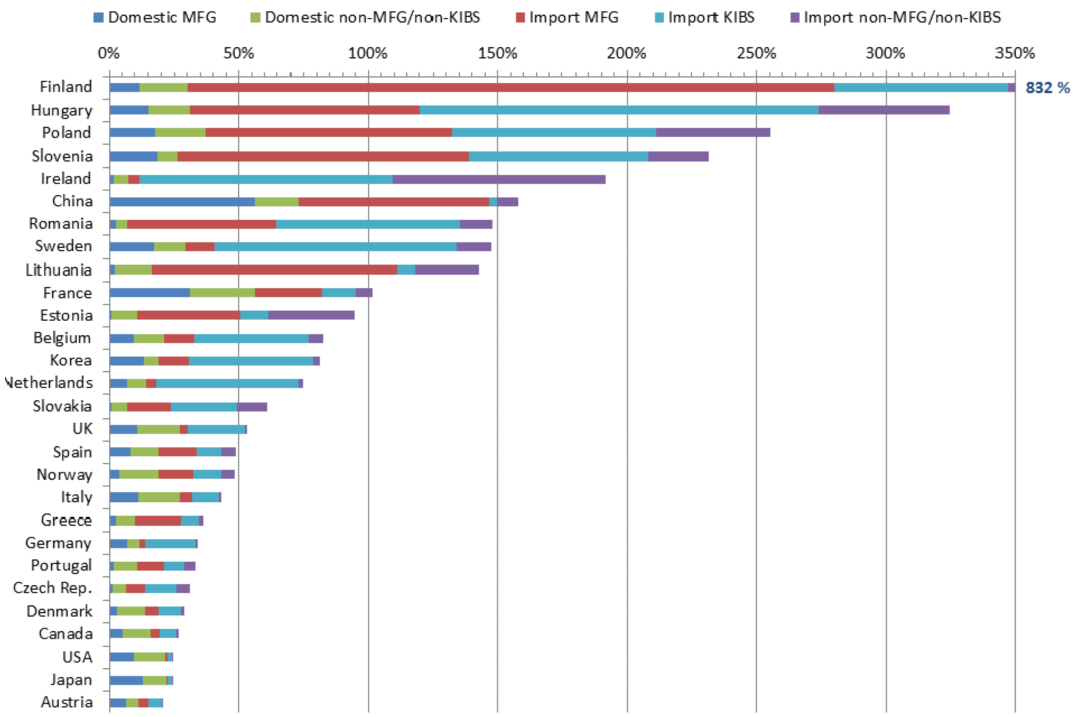


Apart from this, we note the following features of Figure 3.1.4. The Eastern European States, EU-12, depend heavily on manufacturing knowledge imported from abroad (Import MFG, Import KIBS and Import non-KIBS/non-MFG). The KIBS sector in China not only depends on imported knowledge from manufacturing (Import MFG), but also domestic knowledge from the sector (Domestic MFG). Ireland and Sweden, and perhaps Belgium and the Netherlands appear different in that they depend relatively more on knowledge imported through the KIBS sectors (Import KIBS).

For almost all countries, except a few countries at the bottom of the figure, imported knowledge inputs to KIBS dominates over technology flows from other domestic sectors. Estonia, Slovakia, Romania and Ireland are almost completely dominated by imported knowledge inputs. For most countries imports from manufacturing (Import MFG) and KIBS (Import KIBS) abroad are the largest source of knowledge inputs.

Figure 3.1.4

Embodied technology flows into KIBS, relative to national R&D expenditures in KIBS (ANBERD), 2005.



3.2. Backward and forward linkages between manufacturing and KIBS

This section focuses on the strength of the linkages from manufacturing sectors into domestic KIBS sectors and from KIBS sectors into domestic manufacturing sectors, which Rasmussen (1956) described as backward and forward linkages. Flows within the domestic economy are thus distinguished from total flows, including technology flows from foreign sources. Rasmussen's forward and backward linkage measures, however, do not adequately take into account the industry-to-industry interaction within technology flows as it may lead to double accounting. Box A.3.2 describes how to modify the technology flow measure described in Box A.3.1.

The backward linkages used here are the intersectoral technology flows as the share of technology flows into the recipient sector, while forward linkages are the intersectoral technology flows as the share of total technology flows out of the source sector. These measures are constructed for domestic and total flows, where total flows are the sum of domestic and import flows. Hence, the backward technology linkage may be described as:

$$t_i^j(domestic) = \frac{p_i^j(domestic)}{\sum_{k\neq j} p_k^j(domestic) + R^j} = \frac{p_i^j(domestic)}{\sum_k p_k^j(domestic)}$$

where p_i^j (*domestic*) is the embodied R&D flows from domestic sector *i* to domestic sector *j*, and R^j is the R&D performed in the domestic sector *j*, and

$$t_i^j(total) = \frac{p_i^j(domestic) + p_i^j(imports)}{\sum_k\left[p_k^j(domestic) + p_k^j(imports)\right]} = \frac{p_i^j(total)}{\sum_k p_k^j(total)}$$

where p_k^j (*imports*) is the embodied R&D flows from all foreign sectors *k* to domestic sector *j*. The backward linkages for the 28 countries are shown in figures 3.2.1 and 3.2.2. In these figures we consider the two cases of *i* being manufacturing (figure 3.2.1), thus *j* being KIBS, and *i* being KIBS, and *j* manufacturing (figure 3.2.2).
The *forward technology linkages* are described as:

$$t_i^j(domestic) = \frac{p_i^j(domestic)}{\sum_{k\neq i} p_i^k(domestic) + R^i} = \frac{p_i^j(domestic)}{\sum_k p_i^k(domestic)}$$

where p_i^j (*domestic*) is the embodied R&D flows from domestic sector *i* to domestic sector *j,* and R_i is the R&D performed in the domestic source sector *i*, and

$$t_i^j(total) = \frac{p_i^j(domestic) + p_i^j(imports)}{\sum_k\left[p_i^k(domestic) + p_i^k(imports)\right]} = \frac{p_i^j(total)}{\sum_k p_i^k(total)}$$

where p_i^k (*imports*) is the embodied R&D flows from foreign and domestic sectors *i* to all domestic sectors *k*.

Figures 3.2.1 and 3.2.2 show the backward linkages for the 28 countries, where *i* is manufacturing and *j* is KIBS, and figures 3.2.3 and 3.2.4 show the forward linkages, where *j* is manufacturing and *i* is KIBS. The backward technology linkage measures the technology flows from sector *i* into sector *j,* relative to total knowledge inputs into sector *j.* In other words, it gives the relative size of knowledge inputs from sector *i*, as measured from the perspective of recipient sector *j*. And the forward technology linkage on the other hand measures the technology flows from sector *i* into sector *j,* relative to total knowledge inputs from sector *i* to all other sectors. In other words, it gives the relative size of knowledge inputs into sector *j*, as measured from the perspective of source sector *i*.

The backward linkages shown in figure 3.2.1, measured in terms of the total technology content of KIBS, are rather small in countries on the technology frontier; 10% or less, and with domestic and total backward linkages being more or less of the same size. There is substantially larger variance between the technology using economies, reflecting the higher dependence on imported technology flows. The variance between domestic and total flow strengths appears to be driven by the size of the economy, reflecting the negative correlation between size and openness of countries on the technology frontier. This suggests that size and national income levels are two main underlying variables.

Domestic sources of KIBS embodied inputs into manufacturing dominate over imported KIBS inputs in most countries, as figure 3.2.2 illustrates. Ireland is a notable exception as they source almost everything internationally, most probably from other English speaking countries. These linkages, measured in terms of the total technology content of manufacturing, is rather small in almost all countries, and to the lowest order do not appear to be dependent on the size of the economy. In virtually every country, except Ireland, the total linkage is less than 5%. In countries at the global technology frontier, including Sweden, the United States, and Japan the domestic linkages are also marginal, and are more evenly distributed between domestic and total backward linkages. The only countries showing a notable technology linkage of domestic KIBS are Estonia, Slovakia and the Czech Republic.

Forward linkages from manufacturing into KIBS are relatively small, when compared with the other three linkage measures. Figure 3.2.3 shows that the linkage never exceeds the 3% level for any country, except in Finland, whether in terms of domestic or total linkages. This suggests that KIBS are knowledge supplying and upstream industry flowing, relative to most manufacturing industries. Hauknes and Knell (2009) shows that it applies to manufacturing except for the science-based industries. There is a general tendency for the forward linkages between domestic manufacturing to KIBS to be small in the new Member States, but it also appears to be the case for the Nordic countries. The reason for this may be that some of these countries, especially Sweden and Finland, rely heavily on the science-based industries. Most countries on the technology frontier have a fairly even distribution of forward linkages.

Figure 3.2.4 shows that the forward linkages from KIBS to manufacturing appear rather large when compared to the opposite forward linkage. The domestic and total forward linkages are also more evenly distributed across all countries. Ireland, Finland, and the Netherlands, and possibly Belgium and Hungary, are notable exceptions to this pattern, alongside with Poland and Romania. Ireland becomes an outlier because of foreign KIBS inputs into domestic manufacturing, and Finland becomes an outlier because of foreign manufacturing inputs into KIBS sectors. R&D performed in the R&D sector that was not distributed to the other industries may result in an overestimation of the impact of KIBS on manufacturing. These problems appear mostly in east Europe, which still rely heavily on the government for performing and funding R&D activity. Remnants of the old science and technology system of Soviet times remain in these countries and appear as active research organizations in the R&D sector. The reason for the different pattern in Ireland is that embodied knowledge from the KIBS sector NACE 73 (R&D) sourced abroad into Irish chemical industries is particularly high.

The strength of the backward linkage from KIBS to manufacturing appears small, and the backward linkage from manufacturing to KIBS appears to be substantially stronger. Conversely, the strength of the forward linkage from manufacturing into KIBS is substantially weaker than the forward linkage from KIBS into manufacturing. The reason is that the size of the KIBS sector is substantially smaller than the manufacturing sector as a whole. The measures of linkage strengths reflect this size difference. When this is taken this consideration, domestic KIBS inputs into manufacturing dominate domestic manufacturing inputs into KIBS in virtually every country, except France. Total linkages of manufacturing into KIBS are, by far, the dominant linkage in Lithuania, Slovenia, Poland and Estonia. Romania, China, Hungary and Greece are also dominated by manufacturing to KIBS inputs. France remains an exception among the high-income economies, but the balance of total flows suggests that the UK, Finland and Norway may also be exceptions. The most KIBS intensive economies are Ireland, Japan and the Netherlands.

3.3. Concluding remarks

This section outlined the structure and strengths of domestic and international inter-industry knowledge flows. R&D performed within the sector determines only part of the total technology flows the economy. Technical knowledge embedded in intermediate goods, sourced both domestically and abroad, make up an important part of the total technology flows, especially in those countries attempting to catch-up with the technological leaders. It is equally important for countries on the global technology frontier and considerably more important for those countries below it.

Product embodied knowledge plays an important role in the catching-up, or convergence, process of economies below the global technology frontier. At the frontier, economies rely more on domestic R&D performance than on inter industry, domestic or international, technology flows, while for the countries behind the frontier, international embodied technology flows provide important into the convergence process. Two dimensions determine the structure of embodied technology flows and their relative importance to intra-industrial R&D performance. The first is the openness of the national economy to international trade, having a strong co-linearity with the size of the economy, and the second is the national position vis á vis the global technology frontier, proxied by the level of GDP per capita and the intensity of R&D activity.

For almost all countries, except a few countries at the bottom of the figure, imported knowledge inputs to KIBS dominates over technology flows from other domestic sectors. Estonia, Slovakia, Romania and Ireland are almost completely dominated by imported knowledge inputs. For most countries imports from manufacturing (Import MFG) and KIBS (Import KIBS) abroad are the largest source of knowledge inputs.

Figure 3.2.1

Backward linkage of manufacturing embodied inputs into KIBS sectors, domestic and imported supply. Ranked by total linkage, 2005

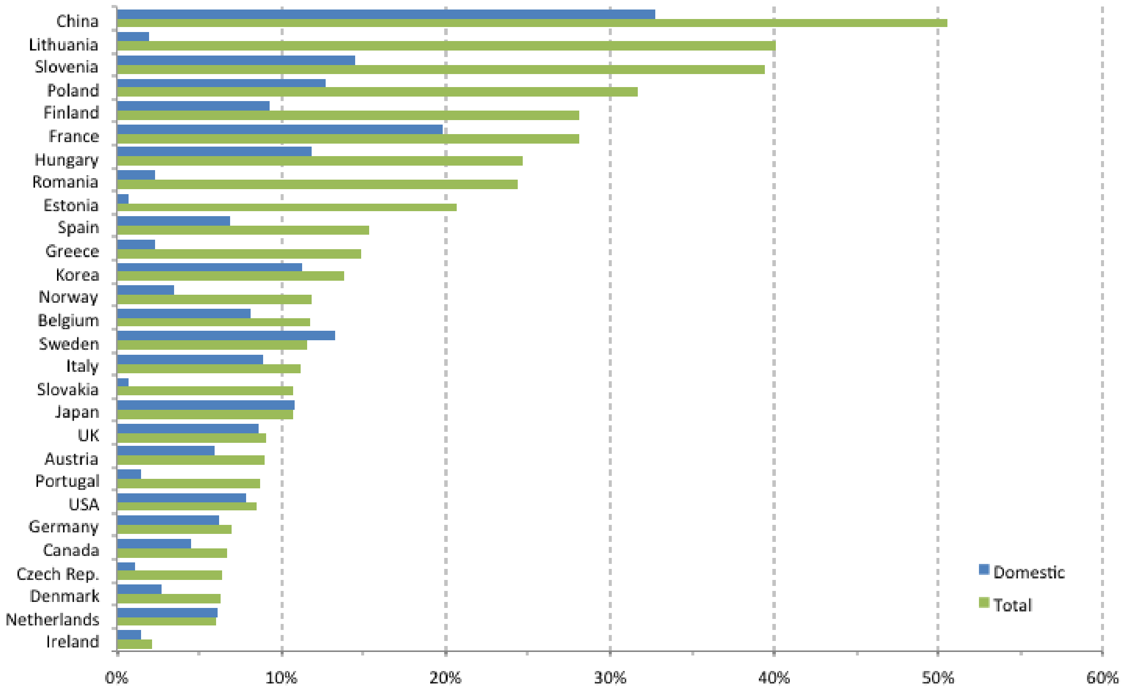


Figure 3.2.2

Backward linkage of KIBS embodied inputs into manufacturing sectors, domestic and total supply. Ranked by total linkage, 2005

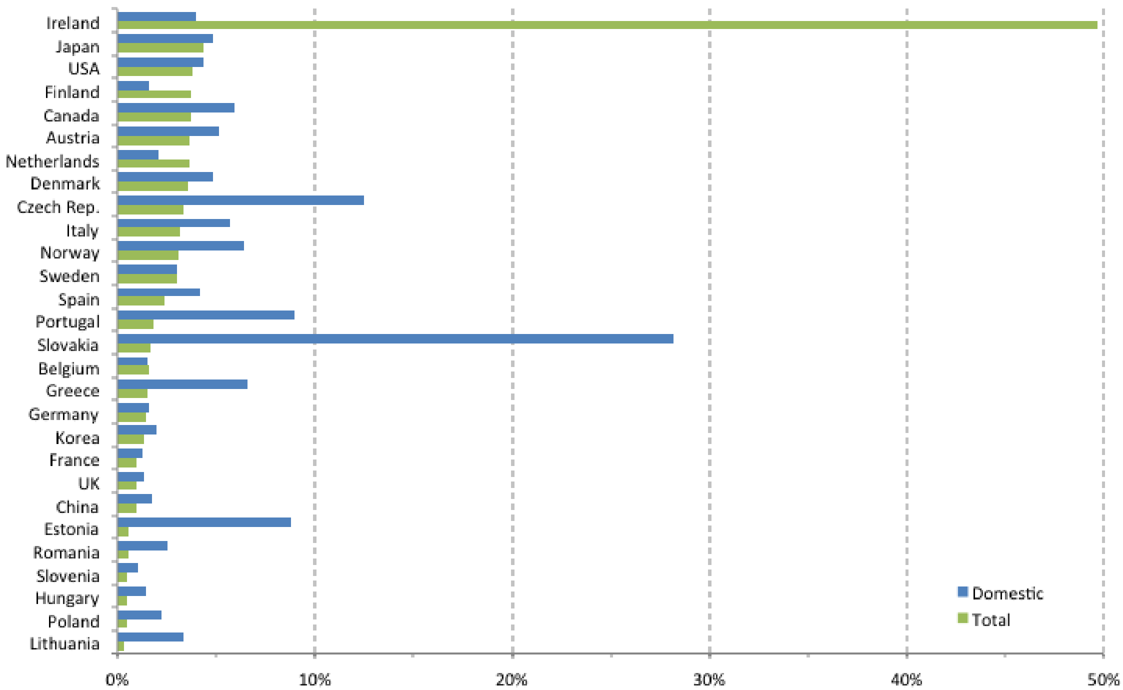


Figure 3.2.3

Forward linkage of manufacturing embodied inputs into KIBS sectors, domestic and imported supply. Ranked by total linkage, 2005

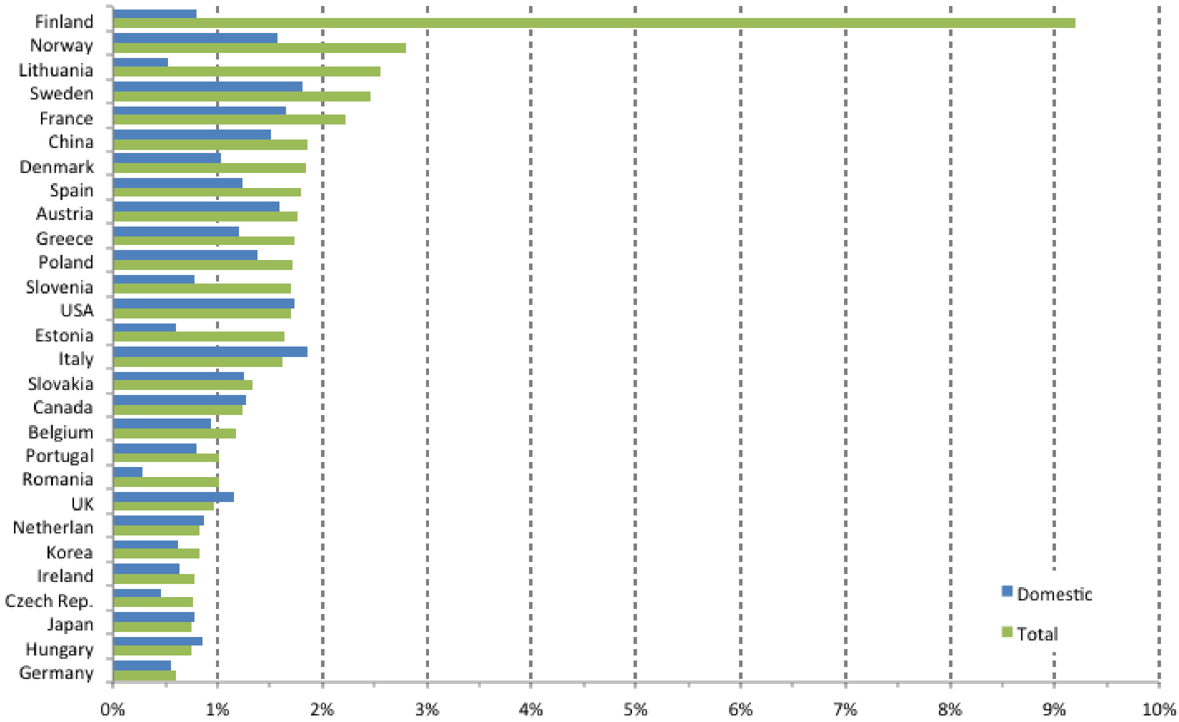
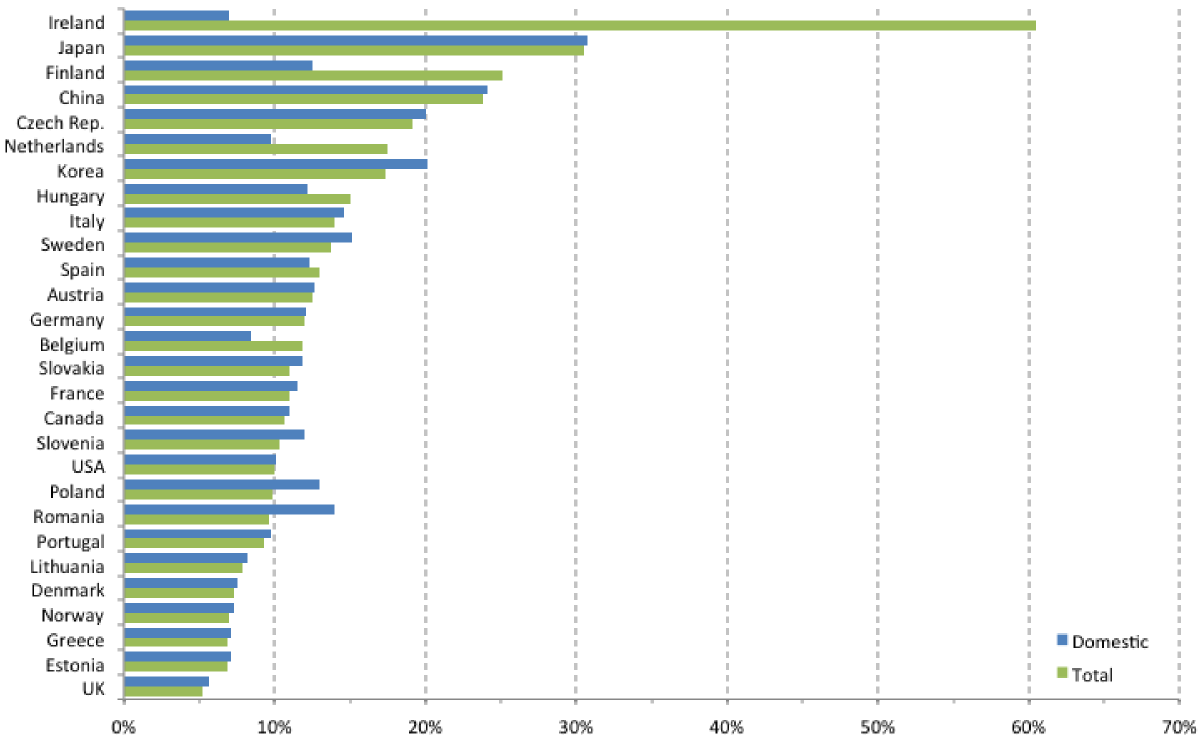


Figure 3.2.4

Forward linkages of KIBS embodied inputs into manufacturing sectors, domestic and total supply. Ranked by total linkage, 2005.



Appendix

Box A.3.1

Measuring direct and indirect flows of R&D activity in the Input-Output framework

Input-Output analysis is ideal for measuring the diffusion of product-embodied R&D. The open Leontief model is best suited for the task as it considers technology and final demand separately. Assume that the economy is composed of *n* industries, the output vector *x* of which is either consumed as final demand *y* or used by other industries. In matrix notation, it appears as:

$x = \mathbf{A}x + y,$

where **A** is known as the technical coefficients matrix. If **A** is non-singular, it is possible to obtain the Leontief inverse or total requirements matrix **B** through matrix algebra:

$x = (\mathbf{1} - \mathbf{A})^{-1}y \equiv \mathbf{B}y,$

which shows the input requirements, both direct and indirect, on all other producers, generated by one unit of output.

Assume that the R&D intensity is the vector with the components r_i in each industry *i* measuring gross R&D expenditures over gross output. The intensity vector of *direct* and *indirect* flows of R&D activity t_i into each industry *i* are obtained as:

$t = r\mathbf{B},$

This relationship, however, measures intensity relative to final demand, and not to total output. The expression thus implies a double-counting when we want to estimate the technology intensity of the sector as a whole. Both the backward linkages to industry *j* and the forward linkages from industry *j* determine the intensity of product-embodied R&D, before ending up in the exogenous final demand categories of industry *j* in this expression. Hauknes and Knell (2009), following Miller and Blair (1985), get around this problem by using a modified input-output matrix $\mathbf{B}^*$:

$t^* = r\mathbf{B}^*,$

which measures the technology intensity per unit of total output rather than per unit of final demand of the recipient sector *j*. The elements of **B*** are given directly by the elements of the ordinary Leontief inverse **B**, but scaled by the diagonal elements of the **B** matrix (Hauknes (2011)).

Total knowledge flows k_j into industry *j*, measured relative to total output, are in this study composed of the domestic R&D intensity within the industry r_j^d, the intensity of domestically generated embodied technical knowledge t_j^d from other sectors, and the intensity of embodied technical knowledge t_j^m contained in imported commodities:

$$k_j = r_j^d + t_j^d + t_j^m = \sum_{i=1}^{n}\left(r_i^d b^*{}_{ij} + r_i^f m_{ij}\right) = \sum_{i=1}^{n}\left(r_i^d \frac{b_{ij}}{b_{jj}} + r_i^f m_{ij}\right)$$

Where b^*_{ij} and b_{ij} are the elements of **B*** and **B**, resp., r_i^f represents the global technology frontier for industry *i*, defined as the average R&D intensity of the OECD, and m_{ij} is based on the imports of inputs from industry *i* going into industry *j*. This formulation of the global technology frontier contains a small upward bias in the estimates of international R&D flows as about one-fourth of total trade is with countries below the frontier. Value-added intensities can be obtained by dividing the individual components to R&D in industry *j* through by y_i.

The formulation of the import vector is not obvious. We have chosen in this study to let the imports be multiplied in the importing country, i.e. imported R&D flows in the transnational context are treated as similar to own R&D in the domestic context. More explicitly

$\boldsymbol{t}^m = r^f\,(\mathbf{A}_m\mathbf{B}_d{}^*\boldsymbol{x} + \mathbf{A}_m\mathbf{B}_d{}^*\,\mathbf{A}_m\mathbf{B}_d{}^*\,\mathbf{A}_m\mathbf{B}_d{}^*\boldsymbol{x} + \ldots)$

where $\boldsymbol{A}_m$ is the matrix of import coefficients relative to domestic total output, and $\mathbf{B}_d{}^*$ is the domestic **B*** matrix for the importing country. This series expansion is rapidly converging, here we have retained just the stated two terms.

The analysis also distinguishes between *direct* and *indirect* flows of knowledge. Embodied knowledge can flow directly from industry i to industry j, or indirectly through other intermediate sectors. Direct knowledge flows from domestic sources are identified as $t_j^d(direct) = r_i^d\,\frac{a_{ij}}{b_{jj}}$ and indirect linkages as the residual: $t_j^d(indirect) = t_j^d - t_j^d(direct)$. Similarly, direct knowledge flows from international sources are identified as $\boldsymbol{t}^m(\text{direct}) = r^f\mathbf{A}_m\boldsymbol{x}$. Indirect linkages appear as a residual: $\boldsymbol{t}^m(\text{indirect}) = \boldsymbol{t}^m - \boldsymbol{t}^m(\text{direct})$. The total knowledge or technology intensity of any domestic sector j, relative to total domestic output of this sector, can therefore be written as:

$$k_j = r_j^d + t_j^d(direct) + t_j^d(indirect) + t_j^m(direct) + t_j^m(indirect)$$

Box A.3.2

Measuring intersectoral forward and backward linkages

Rasmussen (1957) and Hirschman (1958) focus on the 'use' of inputs in a single downstream sector j to measure backward linkages. They measure the total technology intensity of sector j, but do not consider the originating sector. The backward linkage measure of sector j, described in Box 1, overestimates the pairwise inter-linkages between a source sector i and a different recipient sector j of the economy. The measure $t^* = r\mathbf{B}^*$ gives the total technology intensity of the downstream recipient sector j, across all originating upstream sectors i. **B*** incurs a double-counting, when the analysis focuses on the intersectoral linkage between i and j. This suggests that it is necessary to extract the impact of paths that include upstream sectors relative to sector i to capture the true total inter-linkage of a pair of sectors i and j. Given the inter-industrial network structure the Leontief matrix, the task becomes to sum up all direct and indirect paths between the two sectors that start in the source sector and end in the recipient sector, and never pass through any of them along the way. From the perspective of the upstream industry i, this is the *forward linkage* (in the sense of *along the flows of traded goods*) of this sector into sector j, while from the perspective of the (relative) downstream sector j, the same measure describes the *backward linkage* – in the *opposite direction* of trade flows – of j into sector i.

Similar to **B*** there is a very similar matrix $\mathbf{B}^+$ measuring the downstream impact of R&D performed in any industry i. The i-component of the total downstream impact t^+ in units of total output of sector i is:

$$\boldsymbol{t^+}_{\boldsymbol{i}} = \frac{\boldsymbol{r_i}}{\boldsymbol{x_i}}\sum_{\boldsymbol{k}} \boldsymbol{b^+}_{\boldsymbol{i}}^{\boldsymbol{k}}\boldsymbol{x_k} = \frac{\boldsymbol{r_i}}{\boldsymbol{x_i}}\sum_{\boldsymbol{k}} \frac{\boldsymbol{b_i^k}}{\boldsymbol{b_i^i}}\boldsymbol{x_k}$$

The full *intersectoral linkage matrix* of the economy, given the basic input-output matrix **A**, is described by a matrix **L**, whose matrix elements l_{ij} measure the aggregate linkage amplitude l between any two industries i and j:

$$l_{ij} = \frac{b_{ij}}{b_{ii}b_{jj} - b_{ij}b_{ji}}$$

with b_{ij} being as before the matrix elements of the Leontief inverse **B** of **A** (see Hauknes, 2011, for derivation). The denominator is the determinant of the (*i*, *j*) 2 x 2 submatrix of **B**:

$$\mathbf{B_2}(i, j) = \begin{pmatrix} b_{ii} & b_{ij} \\ b_{ji} & b_{jj} \end{pmatrix}$$

Scaling the components of the **B** matrix eliminates the double-counting that results from the interaction between sectors *i* and *j*. The components of the matrix **B*,** (see Box 1), make mathematical sense, but do not make economic sense because a sum over rows is always assumed to produce a measure of economy-wide impacts on sector *j.* The linkage matrix **L** above, however, is economically meaningful at the component level, measuring the strength of interaction of the link $i \rightarrow j$, but not when summed. Sums along rows or columns of **L** have no direct economic meaning.

Import flows need to be included to close the economy. Adding the domestic and import flows together does this, which creates a Leontief **A** matrix of 'total' flows. Standard procedure generates a total Leontief inverse **B**, which is then used to calculate the total **L** matrix. Producer or backward linkages are calculated on the basis of the total connections. Following Jones (1976), the analysis used the domestic linkages for calculating the user or forward linkages. This procedure implies that imports are treated on the same level as domestic inputs; that is, we mimic the input-output flow structure and its accumulation of the exporting country by the same structures in the importing country. The implicit assumption is that all countries are structurally similar in a certain sense. Though conventional and valuable, this is a rough first-order approximation. However, an extension along these lines quickly runs into large data and estimation challenges, even though it is a fairly straightforward extension.

With this we create the following modified Rasmussen measures to describe the strength of intersectoral technology linkages. The relative forward linkages p_a^b and backward linkages u_a^b between the two industry groups *a* and *b* (with the sense of trade flow direction $a \rightarrow b$) can be constructed as:

$$\boldsymbol{p_a^b} = \frac{\sum_{\substack{i\in a \\ j\in b}} \boldsymbol{r_i l_i^j x_j}}{\sum_{\substack{i\in a \\ \forall k}} \boldsymbol{r_i {b^+}_i^k x_k}}$$

and

$$\boldsymbol{u_a^b} = \frac{\sum_{\substack{i\in a \\ j\in b}} \boldsymbol{r_i l_i^j x_j}}{\sum_{\substack{j\in b \\ \forall k}} \boldsymbol{r_k {b^*}_k^j x_j}}$$

The forward linkage *p* measures the accumulated technology volume from *a* to *b* as a share of the total technology deposits emanating from source sector *a.* The backward linkage *u* measures the same nominator as a share of the total economy wide deposits into the recipient sector *u.*

4. The Service output of manufacturing Industries

4.1. Introduction

The analysis of the previous chapter suggests that services, in particular knowledge-intensive services, have become and important input for manufacturing. Based on Input-Output tables, we could demonstrate in the previous chapter that KIBS are important carriers of research and development done in upstream sectors that diffuse into manufacturing.

This is, however, only one aspect of the changing relationship between manufacturing and services industries. There is evidence that manufacturing firms themselves produce and provide more and more services along with their traditional physical products (Pilat et al., 2006; Christensen and Drejer, 2007). We will label this trend “convergence between manufacturing and services”.

There are various reasons for this convergence, as discussed in the literature survey below. It is, however, clear that offering complementary services are a strategy by manufacturing firms to maintain and increase competitiveness. This point has already been recognized by European politics. The Monti Report states that:

“European industry must move further into the provision of services in order to remain competitive at the global level. Companies operating in industry sectors and manufacturing need to develop new business opportunities by spurring related services such as maintenance, support, training and financing. In general, the growth potential of these services is much higher than that of the product business itself.” (Monti 2010, p. 54)

The aim of this chapter is to examine this convergence from various points of view. A first section summarises and discusses the management and economics literature on convergence. The second section tackles convergence between manufacturing and services at the macroeconomic level with input-output data. Finally, we go to the firm level and study service offerings by manufacturing firms with data from a pan-European survey.

4.2. Literature Survey

For the past decade, the phenomenon of manufacturers turning into service providers has gained increasing attention. Most of this attention came from business administration and management studies. The managerial perspective mainly deals with questions such as what rationales are behind such service offers and why customer companies make use of them. Furthermore, the challenges involved with such a service offer as well as prerequisites for service provision are objects of academic exploration.

4.2.1. Convergence between Manufacturing and Services

Over the past decades, services have considerably gained importance in European economies, both in terms of value added and employment (Rubalcaba et al. 2008). However, we also see a growing relevance of services within the manufacturing sector. Consequently, the boundaries between the production of physical goods in this sector and the provision of product-related services are increasingly blurring. A large share of the staff in the manufacturing sector is not employed with production-oriented activities. They rather deliver services to internal and external customers. Between 65 and 75 per cent of personnel in the manufacturing sector deliver services such as research and development, logistics or maintenance. Additionally, in cross-functional areas of manufacturing companies supporting services such as finance and accounting or human resource management are provided (Mont 2002).

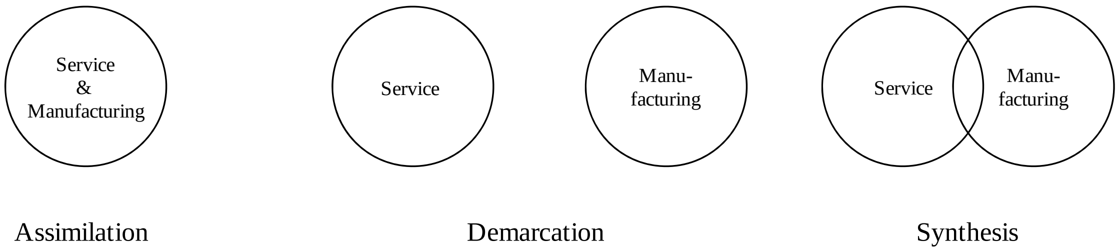
In a study on future trends of labour in the manufacturing sector, Kinkel et al. (2008) found out that the shares of personnel working in production-oriented jobs and of those working in service-oriented jobs do not remain on a constant level. Whilst the share of persons employed in production continuously decreases, the share of service-oriented persons employed increases by exactly this loss. For the time period from 1998 to 2005, the authors could demonstrate for the German manufacturing sector that the share of production-oriented personnel decreased by 3.4 per cent whereas the share of persons employed with service delivery in this sector increased by 3.5 per cent.

The convergence of manufacturing and services becomes manifest in the discussion of service innovations. Studies on innovation were for a long time largely associated with gaining new insights in research and development (R&D) focused on creating technologically advanced physical products (Tether, 2004). Only in recent years the dominance of services for employment and sales in most developed countries has induced scholarly attention to the phenomenon of services and service innovation: there is, for example, an intense discussion if there are fundamental differences between innovation in manufacturing and services (e.g. Miles, 2008; Pires et al., 2008, Nijssen et al., 2006); if R&D is a prerequisite for service innovation (e.g. Gallego and Rubalcaba, 2008; Miles, 2007); or if customers have to be regarded as co-creators of service innovation (e.g. Sundbo, 2008; Fuglsang, 2008).

Service sector companies have been studied and compared to manufacturing companies in terms of innovation. Coombs and Miles (2000) propose three alternative approaches for defining and measuring service innovations by linking them to innovations in manufacturing (see Figure 4.2.1). In the assimilation approach, service innovation is seen as very similar to innovation in manufacturing; consequently the same methods and concepts for exploring them can be used by merely implementing minor changes to the methodologies. This approach is the basis for most scientific work dealing with service innovations. The second alternative is called the demarcation approach and is based on the assumption that there are no similarities between service innovations and innovations in manufacturing since service innovation is highly distinctive and follows a different logic. Hence, novel ways of researching and measuring are needed. The last approach puts emphasis on aspects that have been neglected so far in innovation processes but, however, are present in the economy. The linkage between service innovations and innovations in manufacturing in seen as a symbiotic one; consequently this approach is called synthesis. Hipp (2008) puts it like this: “The worlds of manufacturing and service are not parallel and independent, but mutually dependent”.

Figure 4.2.1

Overview of the different basic approaches of service innovation analysis



Source: Hipp 2008, following Coombs and Miles 2000.

Nevertheless, most of these research activities have defined service innovation as *innovation in the service sector* (e.g. Hipp and Grupp, 2005; Preissl, 2000). Such an approach neglects the finding that the sector boundaries are increasingly blurring (Coombs and Miles, 2000): service sector companies are not any longer restricted to offering services and manufacturing companies are servicizing. Coombs and Miles (2000) title this phenomenon the “rainbow economy” and postulate to forego drawing a gross distinction between manufacturing and service innovations, due to the fact that most companies, “whether statistically defined as manufacturers or as service firms, are thus predominantly service providers”. Already in 1972, Levitt drew the conclusion that “there are only industries whose service components are greater or less than those of other industries. Everybody is in service business”.

4.2.2 Strands of management literature dealing with convergence of manufacturing and services

Convergence found most attention in the management literature. Research 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). Up to now, in the literature neither a common term nor a standard definition has been agreed upon. 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: marketing literature, literature on sustainability and sector-specific publications 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. As can be derived from this short overview, a multitude of concepts and terms has been created up to now to research the phenomenon of the convergence between manufacturing and services. The most common ones are shortly depicted below.

The term “servitization” was coined by Vandermerwe and Rada (1988) and describes a process of creating value by adding services to products. Servitization can be defined as a “customer proposition that includes a [physical] product and a range of associated services” (Johnson and Mena, 2008). Servicizing is regarded as a reaction of manufacturing companies to changes in the business environment. The rising market power of global rivals has worsened the conditions for formerly well-established goods producers. As a result, these producers are increasingly revising their business model towards offering additional value-added services in the form of service-based business concepts to tap into new business opportunities (Davies, 2004; Oliva and Kallenberg, 2003; Stremersch et al., 2001; Wise and Baumgartner, 1999).

The term “product-service systems” has its origin in the sustainability-oriented management literature of Scandinavia (Baines et al., 2009). Even in this field, several diverging definitions do exist. In a review of the relevant literature on product-service systems, Baines et al. (2007) distilled the following definition: A product-service system “is an integrated product and service offering that delivers value in use”. Whilst sustainability and the ecological effects involved in integrating products and services or even replacing products with services were in the focus this strand of research, environmental effects today are no longer the sole motive. Rather, sustainability effects have become one target variable besides economic benefits, customer loyalty and competitiveness. In today's literature, a distinction is made between product-service systems (PSS) and industrial product-service systems (IPSS). Whilst PSS encompass all kinds of integrated concepts of products and services, the focus of IPSS is on product-service combinations which are delivered in a B2B context. Hence, IPSS are a subcategory of PSS and represent B2B solutions e. g. in machinery.

A widely used categorization scheme for product-service systems was compiled by Tukker and Tischner (2004). In this approach, these are divided into three subcategories sorted by decreasing product content and increasing service content:

- *Product-oriented services* are strongly connected with the product. The property rights of the physical assets are transferred to the customer while extra value is added to the offer by arranging services around this product. Especially technical services have a strong product relationship (Aurich et al., 2006), yet the interdependencies between the product and the related service are generally weak (Welp et al., 2008). Examples for product-oriented product-service systems in the capital goods industry are maintenance or training services.
- In *use-oriented product-service systems*, the property rights of the physical product remain at the manufacturing company which sells the use of this equipment via concepts like pooling, leasing or sharing, making the physical product available for the production of one or several users. Supplying manufacturing capacity instead of selling a capital good can be taken as an example here.
- *Result-oriented product-service systems* focus on the result of production or services whilst disregarding the underlying product. As in use-oriented product-service systems, the property rights of the product the concept is based on are retained by the manufacturing company. The provider of the result can freely decide on how the result is produced. For instance a production service can be quoted here.

"Solutions" (e. g. Foote et al. 2001), "customer solutions" (e. g. Tuli et al., 2007) or "integrated solutions" (Davies et al., 2006; Windahl et al., 2004) are terms mainly used by authors from the US for a combination of physical goods and services aiming at fulfilling a customer's business needs. In particular, the term "integrated solutions" is used to describe product-service combinations offered to companies by organisational entities (Windahl et al., 2004). Tuli et al. identify three commonalities across several definitions of solutions. (1) A solution involves a combination of goods and services. (2) Solutions are customized, i. e. the goods and the services of these combination are adapted to the specific needs of a customer. (3) All elements of a solution need to be in harmony with the other solution components, i. e. "a solution consists of an integrated set of goods and services". Solutions are the most advanced type of external procurement as entire business processes are outsourced to internal or external providers. The customer purchases a performance outcome; the provider is remunerated on a success-oriented or output-oriented basis.

4.2.3. *Rationales for the convergence of manufacturing and services*

The importance of innovative product related services for manufacturers has been discussed in literature frequently. 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.

In 1999, Wise and Baumgartner directed the attention to the **installed base** as an argument for going downstream. They summarize that manufacturers' traditional value-chain role – 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.

4.2.4. Prerequisites for service provision in manufacturing companies

Related to the process of servitization manufacturers have to develop service innovations in order to move from goods producers to providers of complex solutions for their customers. Now literature reports case study findings 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 business, increase their service offerings and incur higher costs, but this does not result in 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.

4.3. The Service Output of Manufacturing Industries in Input-Output Tables

The aim of this section is to draw the ‘big picture’ of convergence between manufacturing and services. In other words, we investigate how the composition of output of manufacturing industries has changed over time. 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 services are offered.

Moreover, the study examines a possible link between the service content of manufacturing at country level and R&D intensity or innovation intensity. In order to do so, data on research and development from the Eurostat database[7] is used.

[7] See http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database

Finally, we explore which services are provided by different manufacturing industries. The structure of the supply of services should shed light on the specialisation patterns of manufacturing. Moreover, we seek to find similarities or differences regarding the services provided at the country level.

4.3.1. Data

Supply tables taken from input-output statistics compiled by national statistical offices provide the empirical basis for this section. These tables give a detailed account of the supply of goods in each industry in an economy. 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. Input-output tables as used in the previous section are derived from the system of supply and use tables and provide information on intersectoral linkages.

We employ supply tables for 23 EU Member States and the US, provided by Eurostat and the US Bureau of Economic Analysis (BEA). 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.

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 supply tables available for Slovenia. Supply tables for Estonia are available for 1997 and data for Hungary 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 A.4.1 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.

The supply tables are organised as product by sector matrices. Industries are classified in NACE Rev. 1.1[8], the corresponding classification scheme for products is CPA[9]. 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.

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

9 CPA – Classification of Products by Activity.

The manufacturing sectors are grouped into larger aggregates by using the NACE classification at section level from A to P[10], 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). Tables A.4.2 and A.4.3 in the appendix report these aggregates in detail

4.3.2. 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 the appendix). We distinguish two cases. In the first case, we include the whole range of services as indicated by the CPA and the NAICS, that is CPA 50 to 95 and NAICS 42 to 92. In the second case we define services more narrowly and exclude wholesale and retail trade[11] (CPA 50, 51 and 52 for the EU Member States, and NAICS 42-45 for the US). We consider trade as the most basic type of convergence between manufacturing and services. It is simply an extension of the firm's product range by offering third-party products.

Supply table data indicates that the output of manufacturing still consists to a great extent of manufactured products. As figure 4.3.1 illustrates, services (without trade) do not represent more than 9% in any country under study. Obviously, the process of 'tertiarisation' is not in an advanced stage as far as the EU Member States and the US are concerned.

There is a considerable degree of heterogeneity in service output with respect to the sector of origin, technology intensity, growth rates, etc. We can clearly distinguish various groups of countries according to service shares. A first group comprises of Finland and the Netherlands with a service share of 8.4% and 8.2%, respectively. Another group of countries with above average service shares includes Luxembourg, Sweden, and the UK. There are more gradual differences among the other countries, such that a single group can be identified. It's composed of approximately half of the countries under study with shares around 2%. It is important to note that the data for France includes only service products ranging from CPA 72 to 95, thus a direct comparison with the other countries is not recommended.

The picture gets less clear when we include wholesale and retail trade (see light blue bars in figure 4.3.1). The data for service output as a share of total manufacturing output reveals that the two countries with the highest shares, Netherlands and Finland, still rank at the top

[10] 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.

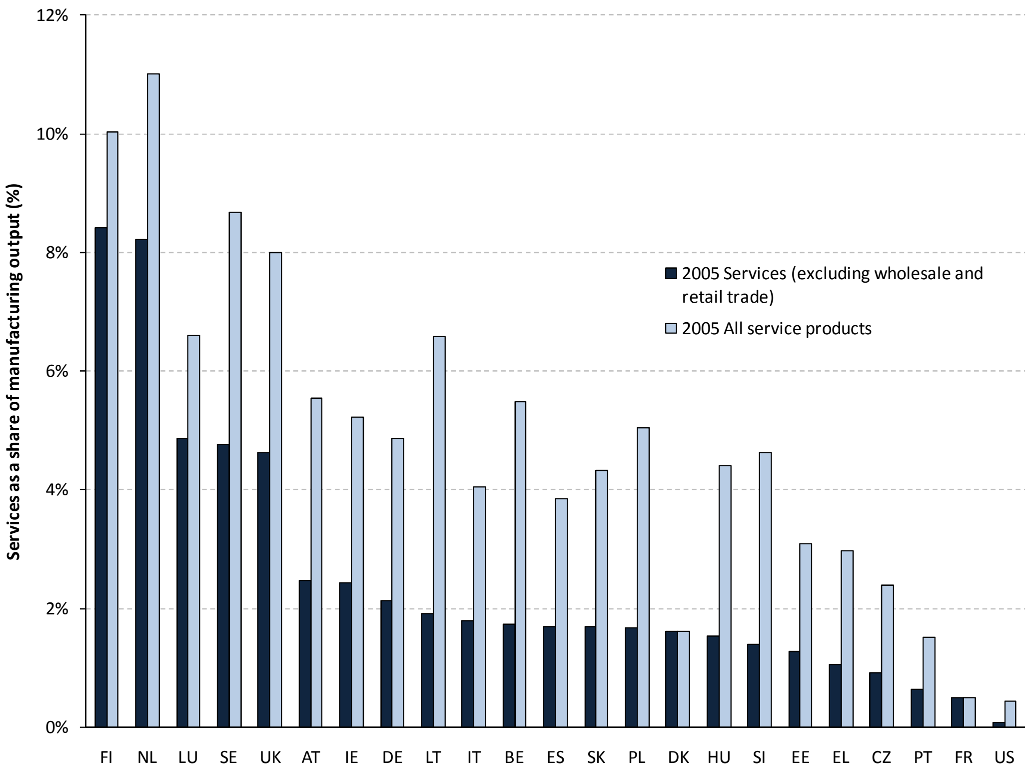
[11] CPA 50 includes sale, maintenance and repair of motor vehicles and motorcycles as well as retail sale services of automotive fuel; CPA 51 covers wholesale trade and commission trade, except of motor vehicles and motorcycles; CPA 52 comprises retail trade, except of motor vehicles and motorcycles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

positions. Another group of countries, namely Sweden, the UK, and Luxembourg, show above average values for their service output, as in the case of services without wholesale and retail trade. Including wholesale and retail trade apparently leads to changes in the positions of countries. Belgium, Poland, Slovenia, Hungary, and to a lesser degree Slovakia, now have a higher relative service share of their manufacturing output. Strikingly, the results for Denmark are the same with and without wholesale and retail trade. As before, the data for France covers only service products CPA 72 to 95. This allows no direct comparison between France and other countries.

Two characteristics of figure 4.3.1 are worth highlighting at this stage, though they ought to be interpreted with caution. First, countries with higher service content tend to be small, open economies. These countries are Finland, the Netherlands, Luxembourg, Sweden, Austria, and Ireland, with the UK being the only exception. Second, the service content of manufacturing industries tends to be lower in EU-12 countries, with values invariably below 2%. Hence, we may relate a high service content to openness to trade, high income or a high R&D intensity of the country.

Figure 4.3.1

Services as a share of total manufacturing output, various countries, 2005



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.

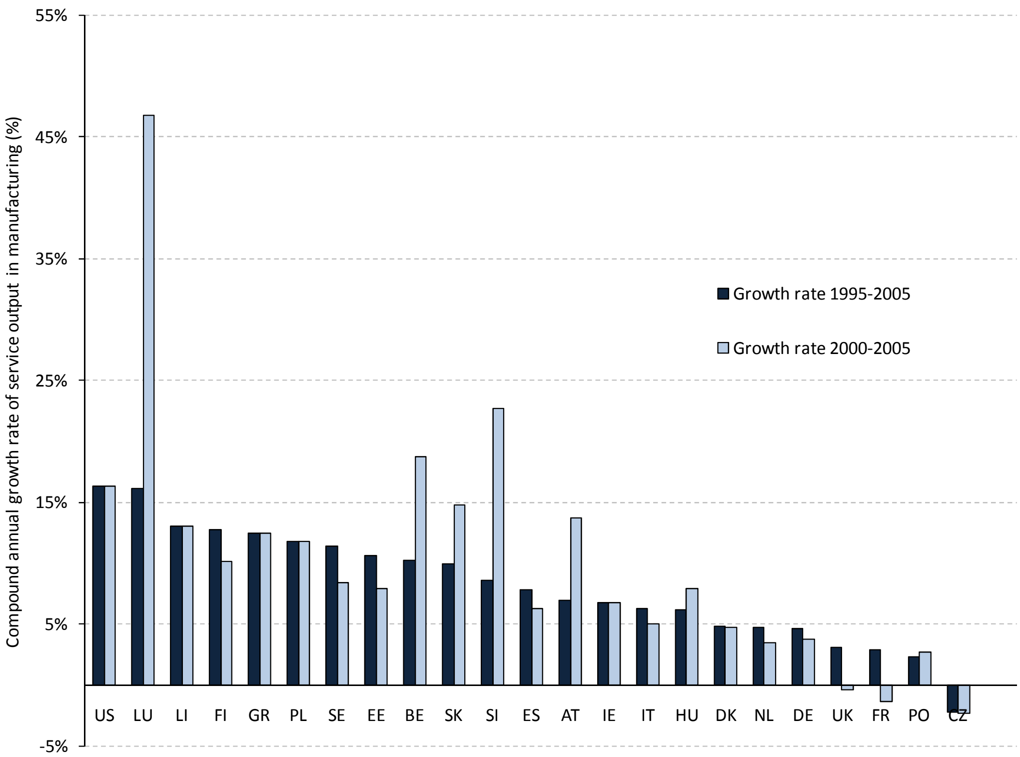
Source: Eurostat and US Bureau of Economic Analysis supply tables; author's calculations.

However, there are also differences between countries which may be the result of differences in data collection and treatment rather than in industrial structure. In some cases we cannot tell if differences between countries are due to differences in production structures or different data collection procedures. For example, French data for services produced by the manufacturing sector is not completely available, and the results obtained for France are somewhat distorting. 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 indicate that statistical agencies collect data on sectoral production not in an 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 4.3.2). This and the following figures do not include wholesale and retail trade (CPA 50, 51 and 52).

Figure 4.3.2

Annual growth rate of the service share of manufacturing output among countries: Periods 1995-2005 and 2000-2005



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; author's calculations.

In the case of Estonia, Hungary, Ireland, and Slovenia, we start with the years 1997, 1998, 1998, and 1996, respectively, due to lack of data for the year 1995. Owing to missing supply tables for the years before 2000, the whole period analysed for Lithuania, Greece and Poland coincides with the subperiod 2000-2005. The service output refers to the entire CPA service class except wholesale and retail trade (CPA 55 to 95).

The service content of manufacturing output has been growing in all countries under study. The only exception is the Czech Republic. We therefore assume a uniform development across the countries and a growing importance of service products for the manufacturing sector.

Further, the comparison for the entire period 1995-2005 indicates major differences in the growth rate of the service content of manufacturing (see figure 4.3.2). A group of countries including Finland, Luxembourg and Sweden with high service shares in 2005 has is growing fast in the ten years up to 2005. Yet another group of countries has shown a dynamic growth rate, though these countries reported average or below average values for their service content in 2005: Estonia, Belgium, Slovakia, Slovenia, the US, and Spain, more than doubled their service share within ten years.

In most countries growth rates for the period 2000-2005 are not higher 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 of its service content 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.

Countries with a high service content - Finland, the Netherlands, Luxembourg, Sweden, and the UK - have also a high research and development (R&D) intensity[12]. Based on our observation we explore in the following whether the countries with a higher R&D intensity exhibit higher shares of service products in their manufacturing sector's output.

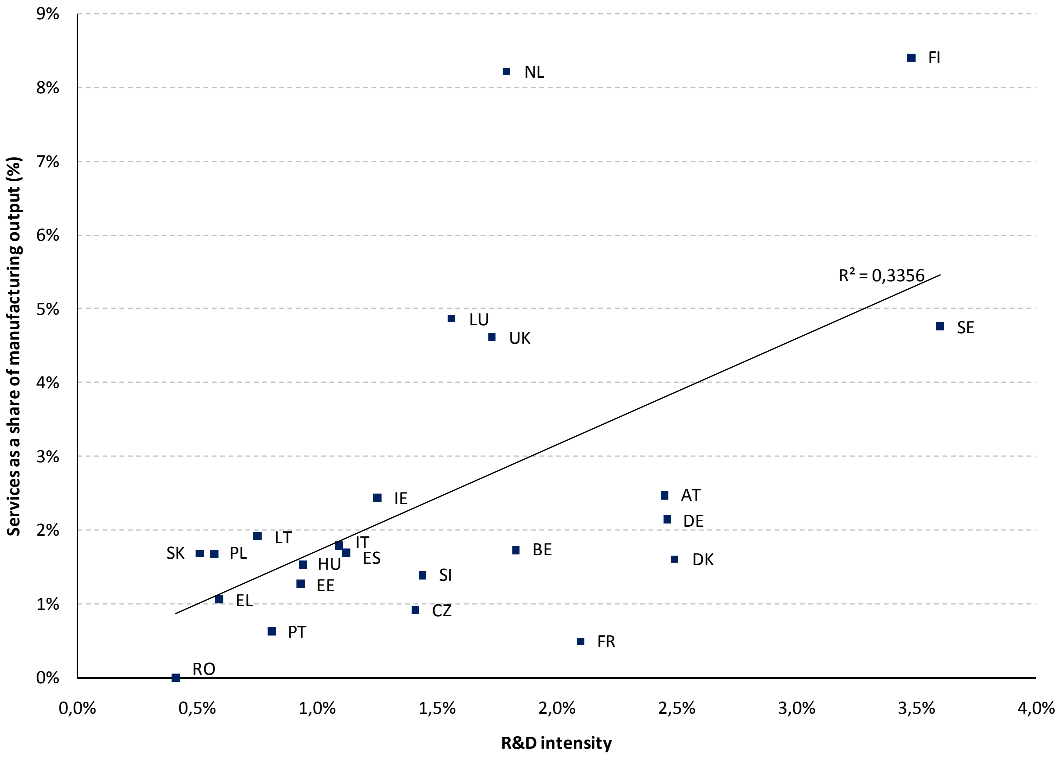
In figure 4.3.4 we have plotted the service share as a percentage of manufacturing output against R&D intensity for each country for the year 2005. We see only a weak relationship between R&D intensity and the service content of manufacturing. The data reveals to a lesser degree that the countries with lower shares of R&D intensities tend to have lower

[12] Insofar as their expenditures on R&D as a share of GDP exceeds average values for OECD countries.

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.

Figure 4.3.3

Services as a share of total manufacturing output and R&D intensity, 2005



Latest available data: the UK until 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 covers only service products CPA 72 to 95. R&D intensity measures expenditures or investments in R&D (GERD) as a proportion of GDP.

Source: Eurostat; author's calculations.

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.

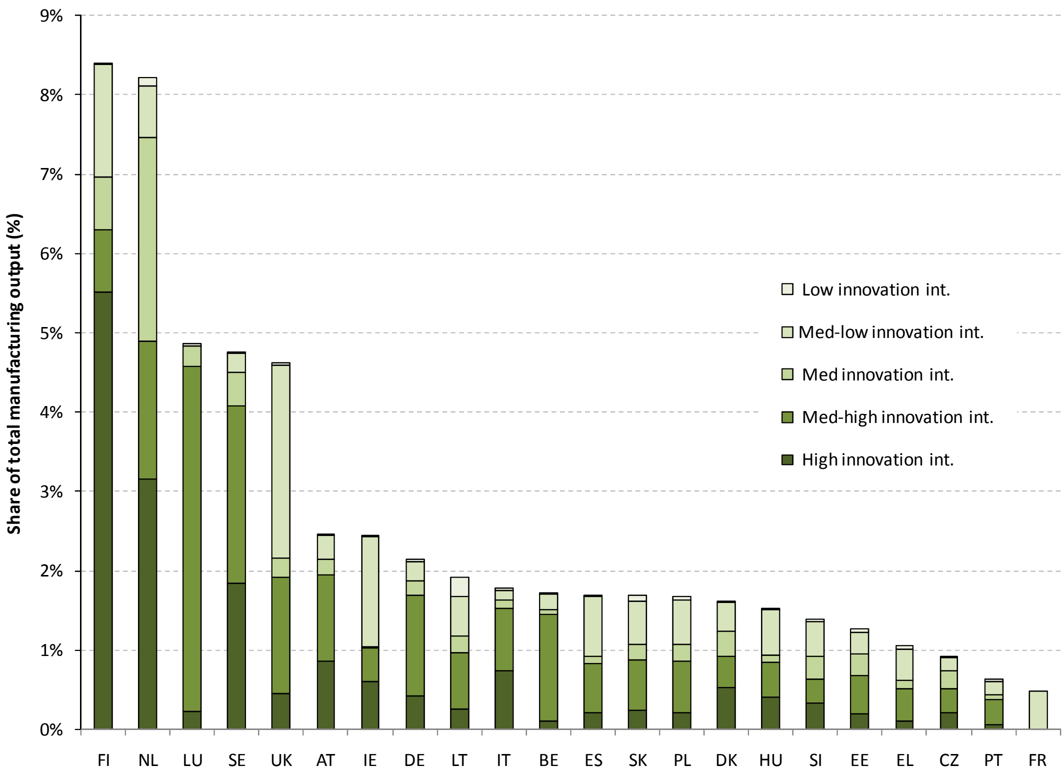
4.3.3. Which Manufacturing Industries provide Services?

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.

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.

Figure 4.3.4

Services as a share of total manufacturing output broken down according to innovation intensity, 2005



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

Source: Eurostat; author's calculations.

The results show a clear pattern, as detailed in Figure 4.3.4: 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.

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.

4.3.4. What Services are offered by Manufacturing Firms?

Services are predominantly offered by innovation-intensive sectors. But what types of services are offered by manufacturing firms? 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). To allow comparisons, the definition of KIBS is identical to the definition used in the section on service exports in this report.

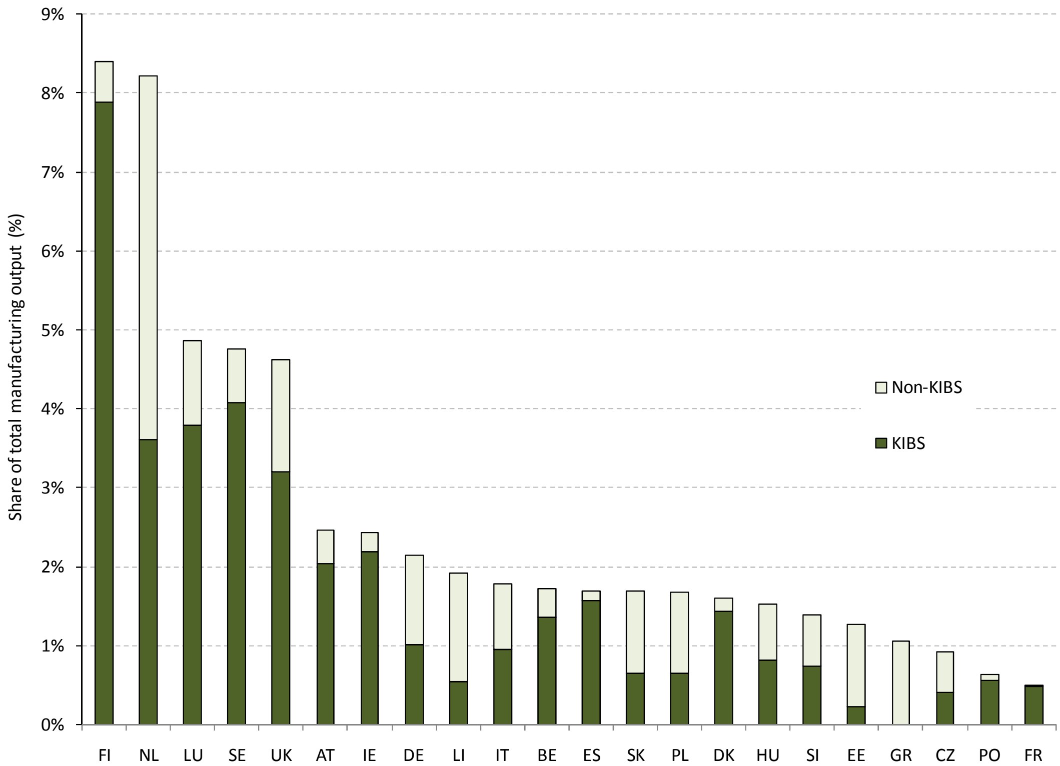
The results reveal that the service output of manufacturing predominantly consists of knowledge-intensive business services. The KIBS share on total service high in countries with a higher service content in particular (see figure 4.3.5). The only exception in these service-intensive countries is the Netherlands.

In half of the countries, KIBS constitute at least two Thirds of the service output of manufacturing. In Sweden for instance, high innovation intensive services account for 85% of the entire service content. As figure 4.3.5 shows, a specialisation in innovation intensive services is characteristic for countries with an above average service content.

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 on service output of manufacturing is considerably higher in the EU-15 than in the EU-12.

Figure 4.3.5

KIBS and non-KIBS services as a share of total manufacturing output, 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.

Box 4.3.1

Service exports by manufacturing firms

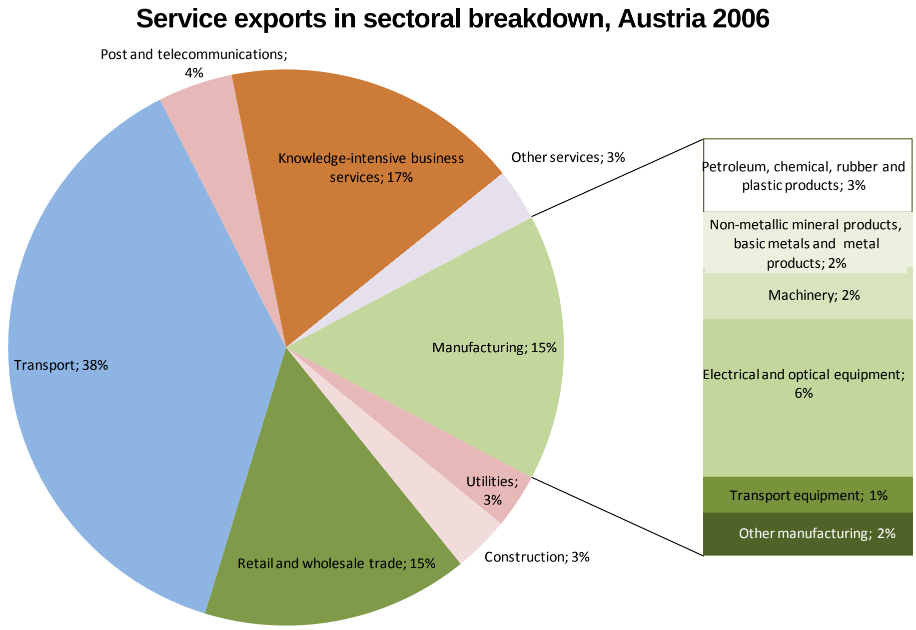
Input-output data can reveal the share of services on total output of manufacturing industries, but we are not able to trace the usage of these services in the economy with this data. We do not know from input-output data if the services provided by manufacturing firms are used as inputs in manufacturing or service industries, if they are consumed or exported.

Data from a pilot study investigated Austrian foreign trade in services conducted by the Austrian Central Bank (Walter and Dell'mour, 2009) sheds light on the linkages between service output of manufacturing firms and total service exports. Some of the results can also be generalized for other countries.

First, the study reveals that manufacturing firms have a considerable share on total service exports. In 2006, manufacturing accounted for 15% of total Austrian service exports, which is about the size of service exports of wholesale and retail trade and only slightly less than service exports by knowledge-intensive business services (see Figure 4.3.6 below).

Electrical and optical equipment (NACE 30-33) has the highest service exports in manufacturing. This sector exports more services than the post and communications sector. Based on the results of this chapter, we assume that most of these service exports are KIBS.

Figure 4.3.6

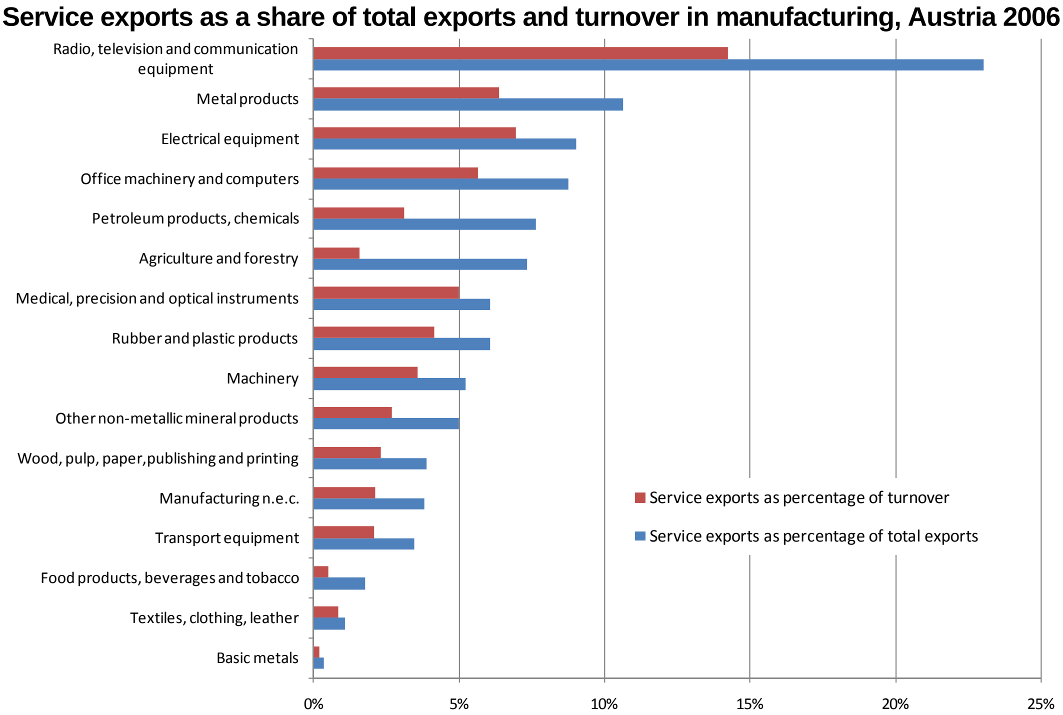


Source: Oesterreichische Nationalbank; author's calculations.

We examine the relationship between service output and service exports in more detail in the following Figure 4.3.7. Here, we relates service exports of manufacturing firms to total turnover and to total exports of physical (manufactured) goods.

Service exports have the highest share in sectors which are also characterized by a high share of services on total output. The best example is radio, television and communication equipment (NACE 32), which yields 14% of its turnover and 23% of total exports from services exports.

Figure 4.3.7



Source: Oesterreichische Nationalbank; author's calculations.

The results clearly point to the strong linkages between service exports and service output of manufacturing at the industry level. Export-oriented industries such as electrical and optical equipment or machinery and also service-oriented industries, and generate a considerable share of their turnover by service exports. This complements the previous observation that service output is highest in small, export-oriented countries. Hence, the growth of service exports is not only associated with the service sector: the manufacturing is an important driver in the current growth in international trade in services, and service exports are a considerable source of revenue for manufacturing firms.

4.4. Evidence on Service Output of Manufacturing Industries from Firm-Level Data

In the following section we analyse the distribution and content of product-related services in European countries with firm-level data from the *European Manufacturing Survey (EMS)*. The European Manufacturing Survey (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. 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.

Box 4.4.1

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.

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 data set used in this report was compiled by using data based on the surveys conducted in 10 European countries and includes the Austrian, Croatian, Danish, Finnish, French, German, Dutch, Slovenian and Swiss data sets collected in 2009. The respondents were however asked to fill in information on their activities in the year 2008. Whilst most partners sent out their questionnaire by mail, the Finnish and Danish data was collected using an online questionnaire. The persons contacted to fill in the questionnaires include the production manager or the CEO of contacted manufacturing firms.

In table 4.1.1 an overview is given about the number of firms contacted in each country, the number of valid cases and the return rates achieved. In total, 3,693 cases can be used for the analysis on product-related services in this report.

Table 4.1.1

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 %

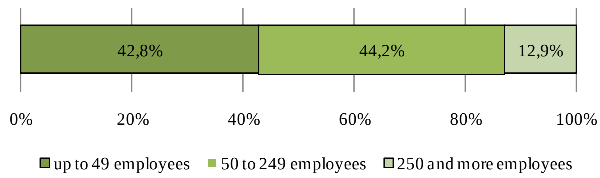
The return rates in Spain, the Netherlands and France are relatively low compared to the other participating countries. Furthermore, the French data set has a regional focus on the Alsace region. In relation to the other data sets, the number of Croatian and Slovenian cases is relatively low.

The data set includes small (up to 49 employees), medium-sized (50 to 249 employees) and large (250 and more employees) manufacturing establishments. A breakdown of the data set into these size classes can be found in figure 4.4.1.

The target group of the EMS survey are manufacturing establishments with more than 20 employees in 2008. Yet, a small percentage of responding firms has less than 20 employees due to labour turnover effects in the time period between selecting firms for the sample and their response. Whilst in most national data sets this percentage of manufacturing establishments with less than 20 employees is between 1 and 5 per cent, in the Dutch data set 28 per cent of respondents employed less than 20 persons when filling in the questionnaire. In total, manufacturing establishments with less than 20 employees account for 5 per cent (184 cases) of the entire data set.

Figure 4.4.1

Firm size

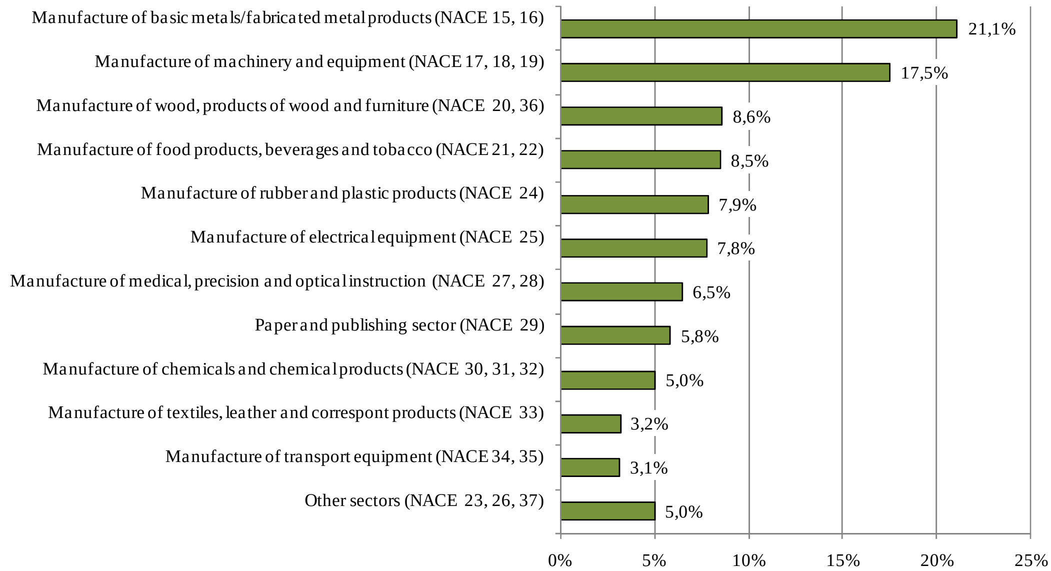


Source: EMS 2009, N=3,518.

The firms surveyed belong to sectors 15 to 37 of the NACE (Rev. 1.1). The sectoral distribution of the data set can be found in figure 4.4.2.

Figure 4.4.2

Sectoral distribution of firms surveyed



Source: EMS 2009, N=3,506.

In the following sections of the report, we define product-related services in a narrow sense as services which are closely associated with manufactured goods so that the consumption of a product incorporates a goods as well as service content. The purpose of the next section is to analyse the proportion and characteristics of the service content of products in the manufacturing sector.

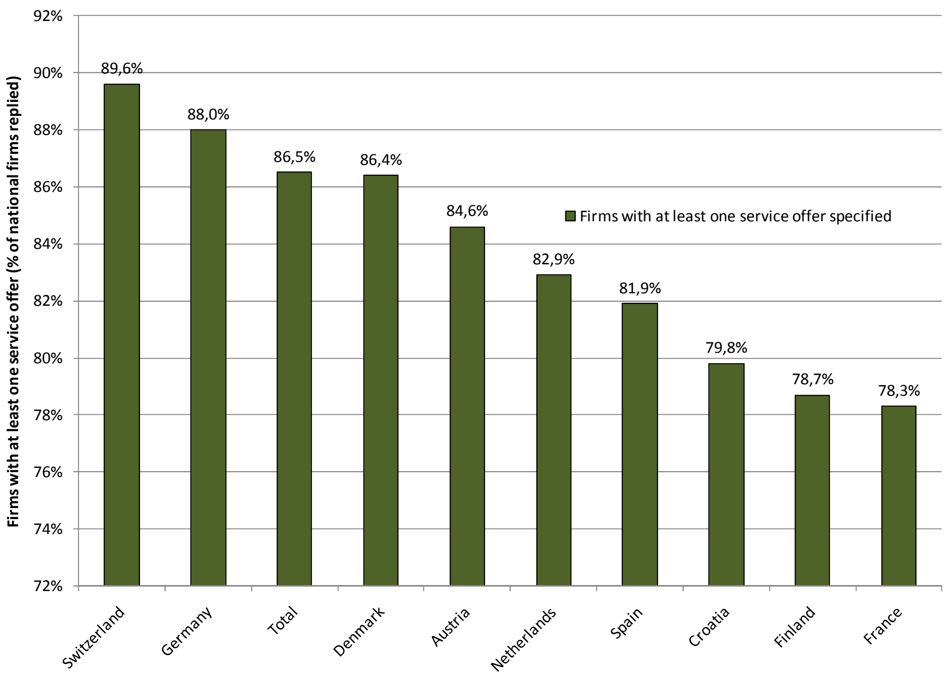
4.4.1. The scope of service offerings

Figure 4.4.1 shows the spread of services in the European manufacturing sectors, i.e. the proportion of firms offering at least one (out of 10) different types of services surveyed in the EMS questionnaire (see also Figure 4.4.3 for list of service types). 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 in manufacturing firms.

In contrast to the analysis on the basis of input-output-tables (see previous section), no pattern is distinguishable in the countries figured: Switzerland as a small open economy is on top, closely followed by Germany, as a large leading industrial nation. They are the two countries which exceed the total average of 86.5 per cent. Finland, another small open economy, figures among the last, however all countries perform within a span of 10 percentage points. This rather small span – in all countries the proportion of manufacturing firms offering services is about 80 to 90 per cent - leads to the conclusion the supply of services by manufacturing firms is a competitive necessity rather than providing a competitive advantage.

Figure 4.4.3

The spread of services in the European manufacturing sectors, 2008



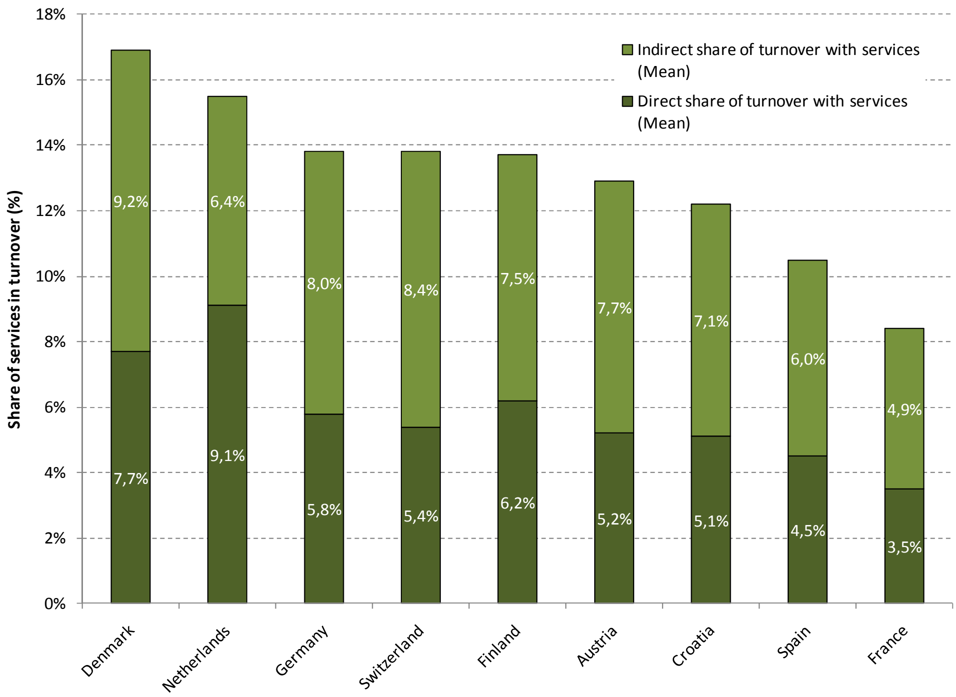
Source: EMS 2009. Question: Which of the following product-related services do you offer to your customers? N=3,693.

Figure 4.4.4 illustrates the shares of turnover with services at the country level. Like in the analysis of service output with input-output data, small open economies like Denmark, the Netherlands, Switzerland, etc. have the highest service shares. Germany as a large leading industrial nation is also among the top performers.

Figure 4.4.4 also distinguishes between two types of service turnover. Firms invoice services directly or indirectly, by offering a product-service package that includes the cost of the product and the service. It becomes apparent that in almost all countries a higher proportion of firms charge prices for their service indirectly via their product prices and do not directly calculate product-related services in their price strategy. This may indicate 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 4.4.4

Direct and indirect turnover with services as a share of total turnover, 2008



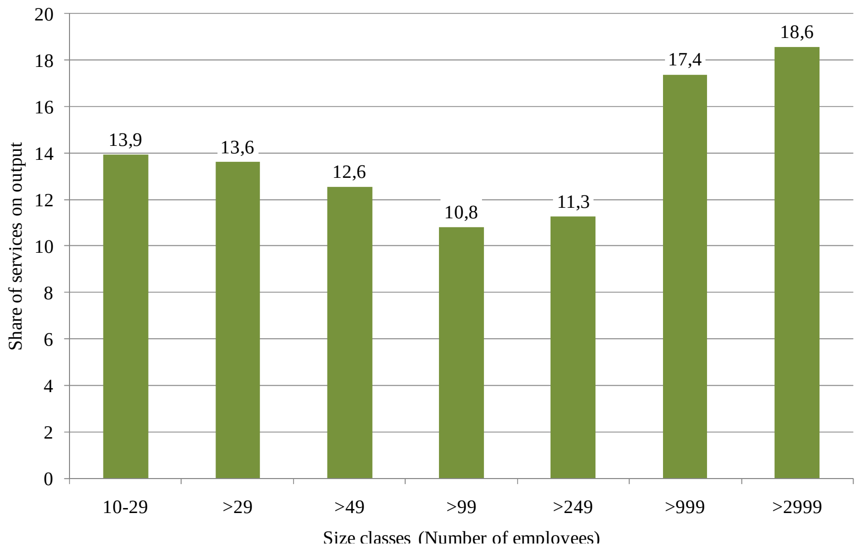
Source: EMS 2009. Question: If you offer product-related services to your customers – what was the percentage of turnover you charged directly (and indirectly)? N=3,693.

A further argument in the literature that may explain the high share of indirect pricing 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).

In figure 4.4.5 we relate the share of turnover generated with services to firm size. The overall service turnover, invoiced directly and indirectly, generated in small manufacturing enterprises is between 13.6 and 13.9 per cent. This share of turnover is lower in medium-sized firms, with 12.6 and 10.8 per cent respectively. The share of turnover generated in manufacturing establishments with more than 250 employees in contrast is higher. Companies with up to 999 employees generate a share of 17.4 per cent of their turnover with product-related services whilst this share is even higher in large companies with more than 1.000 persons employed.

Figure 4.4.5

Turnover with services as a share of total turnover and firm size, 2008



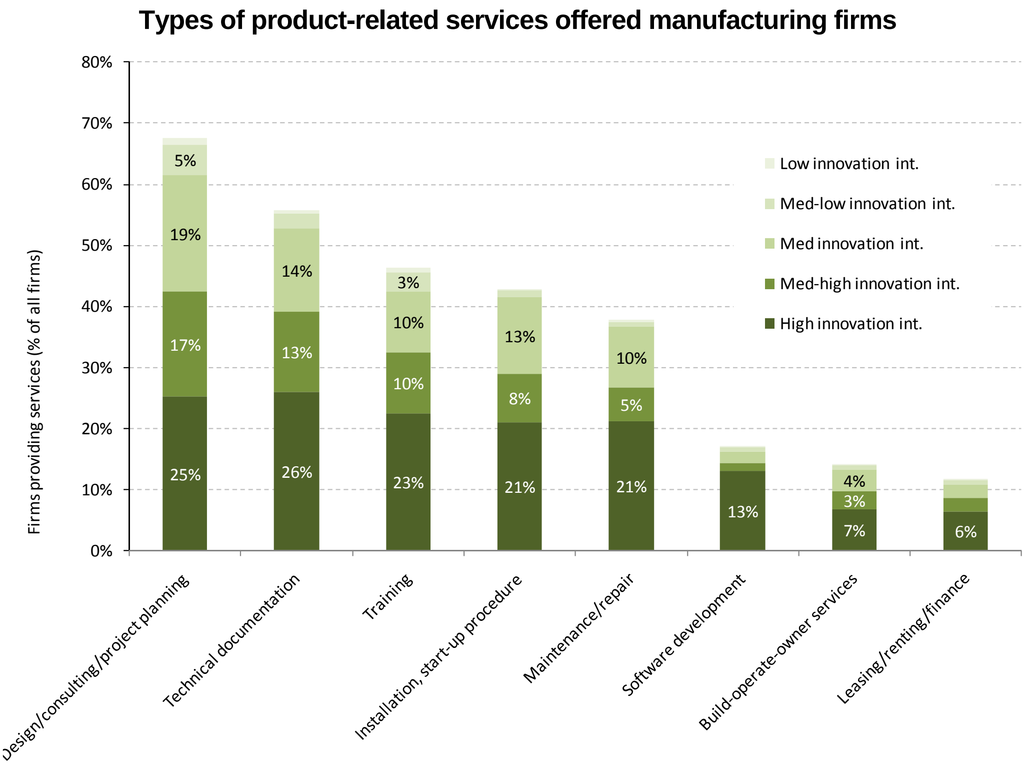
Source: EMS 2009. N=3,693.

4.4.2. Service output, innovation and technology intensity

Results from input-output tables suggest a relationship between service output and innovation intensity at the sectoral: innovation-intensive sectors have a higher share of services on output. In addition, services provided by manufacturing firms are predominantly knowledge-intensive.

We reassess this relationship in figure 4.4.7 with firm level data. The figure shows the share of firms with a certain innovation intensity that offer a particular type of service. We employed the taxonomy of Peneder explained in the previous section.

Figure 4.4.6



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

The figure reveals that the supply of product-related services depends on the innovation intensity of the firm. For all kinds of product-related services, the proportion of firms offering the service is highest among high innovation-intensive firms. 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 4.4.6 also provides evidence for the distribution of various types of product-related services in the manufacturing sector. Apparently, distribution varies widely according to the type of product-related service. We can distinguish between three broad categories:

- *Engineering services*: These are services which accrue in the design phase of the product, like consulting and other forms of user interaction in the design and planning of the product. Included here are engineering services which adapt products to the requirements of customers as well as those engineering services which facilitate handling and operation of the product. Research and development for customer needs falls under this category as well as the technical documentation of technical product characteristics, setup, operation and maintenance of the product. It incorporates also the presentation of the technical documentation in a format which is comprehensible for (different kinds of) users. Figure 3 shows that these are performed by over 75 per cent (Design, consulting, project planning) and over 55 per cent (Technical documentation) of firms.

- *Customization services*: These are services to implement and maintain the product in the customers' processes of operation. Technical services of assembling and installing the product on-site, the set-up process, training of users and maintenance and repair. For the customer, these constitute basic complements to the product – this entails that the supply of these services is often not an option, but a necessity for the firm to remain in business. Without these services the product often cannot be used by the customer. Figure 4.4.3 provides evidence that these services – training, installation and start-up, and maintenance and repair - are offered by around 40 per cent of the firms in the countries considered.
- *Business services*: These are services which allow a deviation from the traditional investment in capital goods and offer renting, leasing, licensing, partnership models in the construction and operation of devices and products etc. (Lay and Jung Erceg, 2002: 7). The financial models and related services often entail advantages for producers as well as users of manufactured goods. The various business services allow producers to establish long-term partnerships with customers and users, and hence gain insight in their spectrum of needs. For the customer, business services may also be associated with numerous advantages. They need not make any costly financial investments. E.g. Renting equipment entails that it is always up-to-date and reliable and it allows customers a trial phase before making a purchase decision. Figure 4.4.3 shows that business services are offered by 10 to 15 per cent of the manufacturing firms in the countries considered.

Software development services may fall under engineering services as well as under customization services. They account for around 17 per cent of service turnover of manufacturing firms in the countries considered. Their provision is even more dependent on the characteristics of the product – three quarters of the firms offering software development services produce high-tech products.

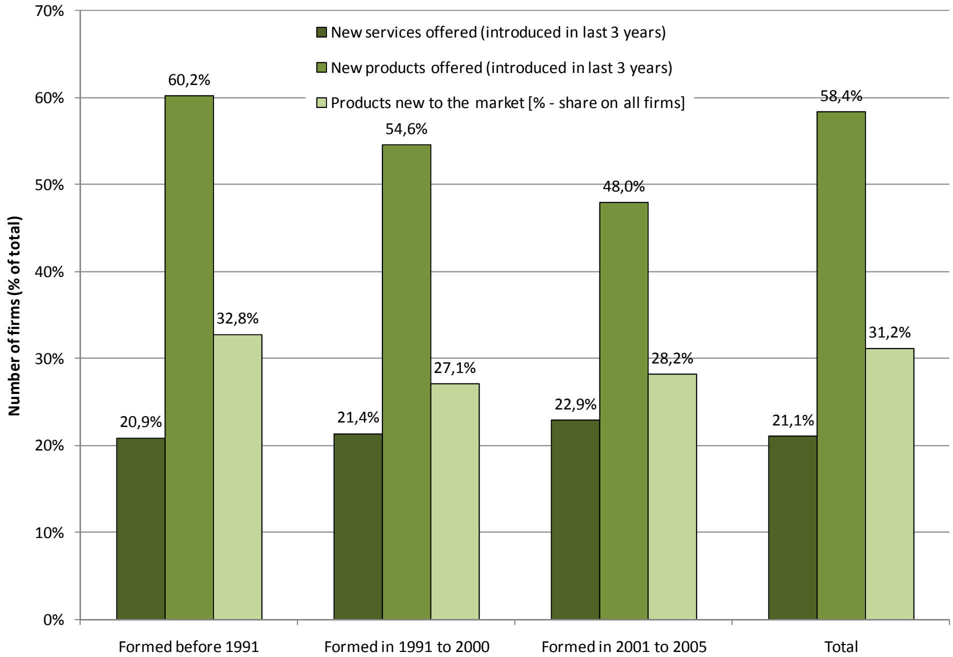
Further information on the linkage between technology, innovation and service offerings of firms is given in Figure 4.4.7. It reveals that around 20 per cent of firms in manufacturing have introduced new services in the last three years, regardless of the age of the firm. Yet there seems to be the tendency that younger firms are more likely to introduce new services to the market. Whilst 21 per cent of the companies which were formed before 2000 stated that they had brought new services to the market, the share of firms founded after 2000 is slightly higher with 23 per cent with innovative services.

Firms founded before 1991, as well as the two other age classes, are found to have a high share of innovative products: Around 60 per cent of the firms which were formed before

1991 introduced new products during the last three years. The younger the firms are, the smaller is the share of those who stated that they had launched new products. 55 per cont of the companies which were founded between 1991 and 2000 had done so, while only 48 per cent of the companies founded after 2000 had brought new products onto the market. Around 30 per cent of firms have introduced products that were not only new to the firm, but also new to the market. This reveals that there is not only a vast spread of services supplied by the manufacturing sector *per se* in the various countries, but there is also a steady proportion of firms which introduce new products and services regardless of the maturity of the firm. The maturity of the product is likely to play a role, however it cannot be easily inferred that mature firms also offer mature products, as such a high proportion of firms founded before 1991 has introduced innovative products over the last three years.

Figure 4.4.7

Service and product innovation in European manufacturing according to firm age



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

4.4.3. The Determinants of Service Output in a Multivariate Analysis

This chapter 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 chapter 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 (cf. figure 4.4.5). 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 4.4.6), 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 firm 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, to customize service offers for them and to promote and sell these service concepts to their customers.

As this report deals with the EU's competitiveness with regard to services, one of the research interests is to identify **European regions** which can serve as best practice examples for the convergence of manufacturing and services. It must, however, be assumed that servitization has up to now been realized with different intensity in the European regions. 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 (cf. figure 4.4.3 and 4.4.4) seem to 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** (cf. figure 4.4.7) 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, cf. figure 4.4.4. 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 offerings.

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).

One more product characteristic we include into our regression model refers to the **volume of production**. It shows whether the main product of the firm is produced in single part 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 4.4.2 below reports the results of this regression.

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.

Table 4.4.2

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

The relationship between service output and innovation intensity of the sector is confirmed by the regression analysis. When holding all other factors constant, firms in innovation-intensive sectors are more likely to realize a higher share of turnover with services than firms in less innovation-intensive sectors. This finding is also supported by the significant influence of product innovativeness. Firms which have launched new products during the last two years are more likely to realize higher shares of turnover generated with services compared to companies who stated to not have introduced new products. Product innovativeness seems to reinforce service delivery.

The service intensity 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, and 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 not significant at a level of at least 95%, except for France and Slovenia. Most country variations seem to better explained by sector, size or the other variables included.

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.

Appendix

Box 4.4.1

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 A.4.1

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 A.4.2

NACE Rev. 1.1 alphabetical code for subsections of manufacturing

NACE Rev. 1.1 alphabetical code	Manufacturing industry subsections
DA	Food products, beverages and tobacco
DB+DC	Textiles and textile products; leather and leather products
DD+DE	Wood and wood products; pulp, paper and paper products; publishing and printing
DF-DH	Coke, refined petroleum products and nuclear fuel; chemicals, chemical products and man-made fibres; rubber and plastic products
DI+DJ	Other non-metallic mineral products; basic metals and fabricated metal products
DK	Machinery and equipment n.e.c.
DL	Electrical and optical equipment
DM	Transport equipment
DN	Manufacturing n.e.c.

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

Table A.4.3

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, -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, -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 A.4.4

Classification of innovation intensity of service sectors

NACE Rev. 1.1	Manufacturing industry	Innovation intensity
50	Sale & repair of vehicles, fuel	None
51	Wholesale trade and commission trade	Medium-low and low
52	Retail trade, repair of personal and household goods	None
55	Hotel and restaurant services	None
60	Land transport; transport via pipeline services	Medium-low and low
61	Water transport services	Medium-low and low
62	Air transport services	Medium
63	Supporting and auxiliary transport services; travel agency services	Medium-low and low
64	Post and telecommunication servicesfuels	Medium-high and high
65	Financial intermediation services fundingservices	Medium
66	Insurance and pension funding services, except compulsory social security services	Medium-low and low
67	Services auxiliary to financial intermediation	Medium-low and low
70	Real estate services	None
71	Renting services of machinery and equipment	None
72	Computer and related services	Medium-high and high
73	Research and development services	Medium-high and high
74	Other business services	Medium-high and high
75	Public administration and defence services; compulsory social security services	None
80	Education services	None
85	Health and social work services	None
90	Sewage and refuse disposal services, sanitation and similar services	None
91	Membership organisation services n.e.c.	None
92	Recreational, cultural and sporting services	None
93	Other services	None
95	Private households with employed persons	None

Classification of innovation intensity of service 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

5. Europe's position in trade in goods and services and EU's external competitiveness

5.1. Introduction

In this chapter we take a closer look at the EU's external competitiveness with respect to technology-intensive goods and particularly knowledge-intensive business services (KIBS) trade.

- First, we describe trends in KIBS and technology-intensive merchandise trade over 1996-2007 including cross-country comparisons.
- Second, we examine specialization patterns in EU merchandise and services trade where we apply common measures of specialization and revealed comparative advantages.
- Third, using information from input-output tables we assess the imported service intensity of manufacturing sectors. We compare imported service intensities of different sectors across countries and analyze their changes over time, and also consider the role of imported versus domestically produced KIBS.

Before analyzing services trade, we need to stress that services have unique characteristics that greatly affect their tradability as compared with goods. The two most obvious characteristics include intangibility and non-storability. These characteristics mean that services typically require joint production, with customers having to participate in the production process.[13] In order to capture these aspects and to allow for trade in services that also require joint production, the WTO classifies trade in services under four modes of supply:

- Mode 1 – Cross-border: services supplied from the territory of one country into the territory of another.
- Mode 2 – Consumption abroad: services supplied in the territory of a nation to the consumers of another.
- Mode 3 – Commercial presence: services supplied through any type of business or professional establishment of one country in the territory of another (i.e., FDI).
- Mode 4 – Presence of natural persons: services supplied by nationals of a country in the territory of another.

In the analysis of trade in knowledge-intensive business services (KIBS) in this chapter, we focus on modes 1 and 2 of services trade. The data come from the TSD dataset[14], which contains data on annual bilateral services trade flows for 244 reporting countries and 244 partners, for the period of 1995-2008. The dataset is compiled from the OECD, Eurostat,

[13] Francois, J. and B. Hoekman (2010), Trade and Policy in Services, Journal of Economic Literature, 48 (September 2010): 642–692.

[14] See Francois, J., Pindyuk, O., and Woerz, J. (2009) for more details on the dataset.

UN, and IMF data (the latter data are only on trade with the World as a partner). OECD, Eurostat and UN provide data on bilateral services trade flows on dual breakdown, by partners and sectors (24 sectors and subsectors). The most comprehensive coverage of reporting countries among the three sources is the UN, which provides data on 190 reporters. Eurostat and OECD provide data for a limited number of reporters: Eurostat covers 27 EU members plus Croatia, Iceland, Japan, Norway, Turkey, Switzerland, and US; while OECD covers 28 countries (all the OECD members apart from Chile, Iceland, Israel, Slovenia, and Switzerland). Time coverage is the biggest in EUROSTAT, which reports data starting from 1995. IMF data cover 166 reporters and 28 sectors for the period 1995-2008. Data are annual for 1995-2008, with earlier data and 2008 data available for individual countries. In total we have 1,379,363 observations, 8% of observations are missing values, and 36% of observations are zero flows.

We work with the following definition of knowledge intensive business services: computer and information services, research and development, and other business services (in NACE classification). In order to be able to use trade statistics we use the following concordance between NACE and EBOPS classifications:

Table 5.1.1

NACE-EBOPS concordance

NACE sector description	**NACE code**	**EBOPS code**
Computer and information services	72	262
Research and development	73	279
Other business services	74	268-269-279 (other business services – trade and repairs –research and development)[15]

We draw comparisons between old EU member states (EU-15) and new EU member states (EU-12), and between both of these and other markets (in particular Japan and the US). When talking about EU foreign trade, we distinguish between extra- and intra-EU trade. However for the general analysis of trade we consider total EU trade (meaning both extra- and intra- trade). Though the treaty establishing the European Community guarantees freedom of establishment of service companies and freedom to provide services on the territory of another EU Member State, discriminatory barriers to services trade remained quite significant (as it was shown in the report of the European Commission “Internal Market: barriers to the free movement of services mean businesses and consumers still get a raw deal” written in 2002). Indeed, Kox and Lejour (2007) show that the EU

[15] Other business services are mainly comprised of legal, accounting and management consulting, architectural, engineering and other technical services, market research and advertising.

members have quite heterogeneous regulation, and heterogeneity of regulations has significant impact on services trade.

5.2. Trends in KIBS and technology-intensive manufacturing trade

We start with recent trends in the structure of trade in KIBS. The period of analysis here is 1996-2007.

As Figures 5.2.1 and 5.2.2 show, in 2007, exports of KIBS in all the regions analyzed were dominated by other business services, which account for about 70% of EU-12 and EU-15 exports, and more than 80% of US and Japan exports. The common trend, though, is decline of the share of other business services in exports, the biggest decline occurred in EU-12 – by 23 p.p., the smallest – in the US (5 p.p.). This is mirrored by increased export shares for computer and information services (apart from US) and R&D (apart from EU-15). The EU-12 had the highest increase in the share of R&D services in KIBS exports – by 10 p.p. As a result, in 2007, EU-12 had the highest share of R&D in their KIBS exports – 10.3%, the lowest share was in Japan – 1.7%.

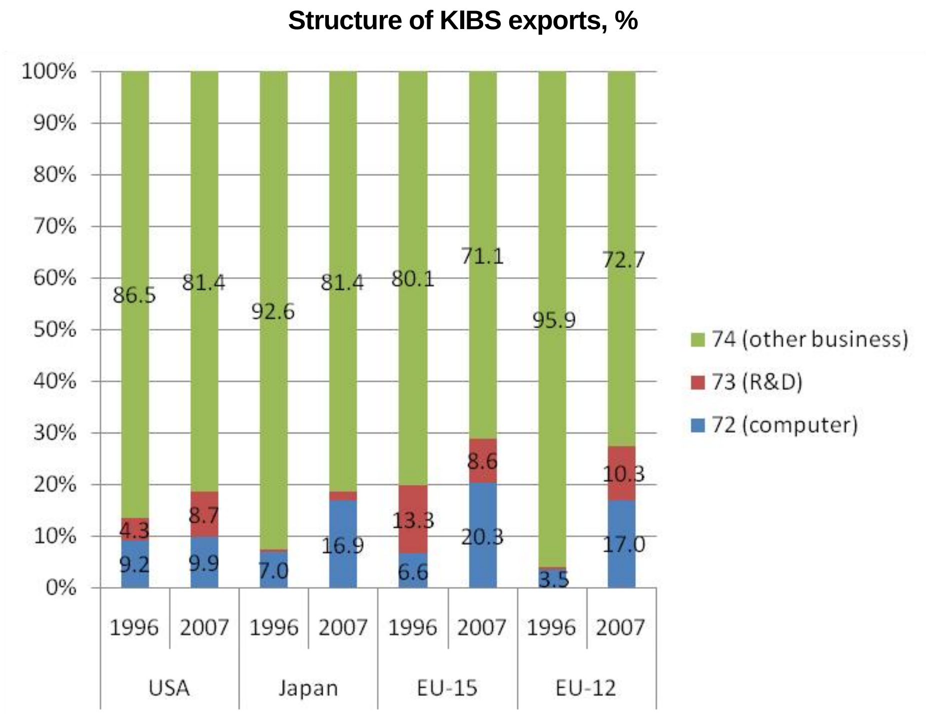
The structure of KIBS imports for the EU-12 and EU-15 in 2007 was similar to the export exports structure, and has gone through similar transformations. The US, however, has a very different imports structure. The share of other business services in imports for the US is only 49%, 31% belong to computer and information services, and 20% - to R&D. In addition, for the US the share of other business services decreased by about 41 p.p. during the period 1996-2007. Japan, in contrast, had a decrease in the share of computer and information services in its KIBS imports – by 4 p.p. Shares of both R&D and other business services increased.

As can be seen from Figure 5.2.3, the value of KIBS trade is relatively low compared to technology-intensive merchandise trade in all the regions (sectors 29-35 in ISIC 3 classification are considered to be technology-intensive). In 2007, share of KIBS in global exports of knowledge-intensive business services and technology-intensive goods was only 14% - which is about 7 p.p. lower than the share of total services trade in cross-border trade.

EU-15 is the major player at the KIBS market – its share in global KIBS exports is around 50%. In global imports the share is slightly lower, but the region still is the key importer. The US have the second biggest share in KIBS exports (15%), while India is a number three player with 6% share.

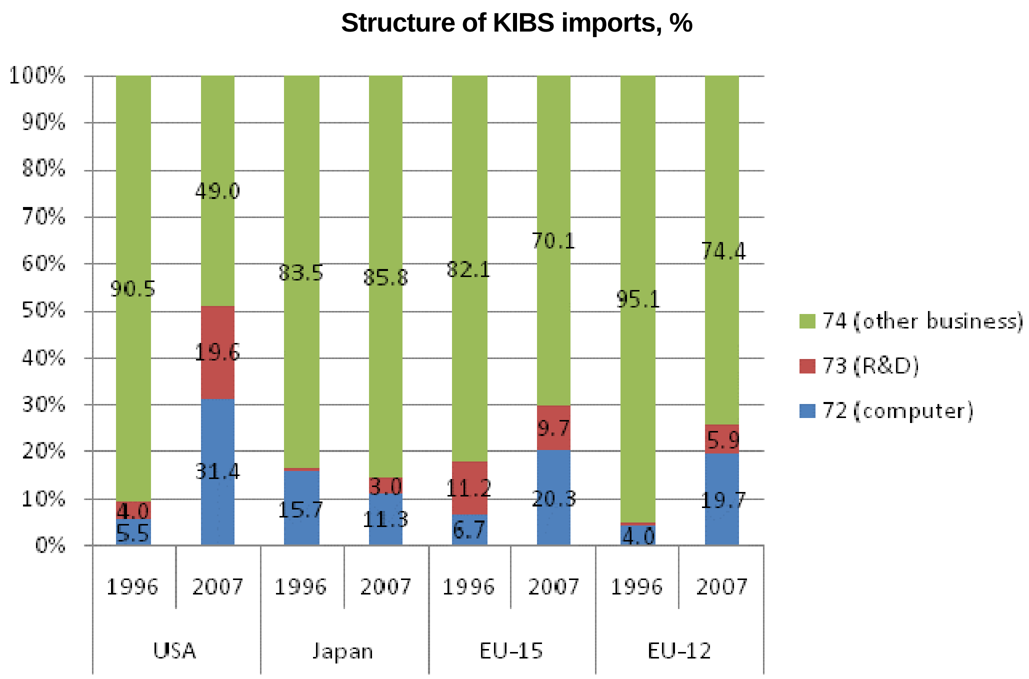
EU-15 is also the biggest player at the market of technology-intensive goods. However, its share is much smaller compared to the KIBS market – 35% in 2007. The second biggest exporter at this market is China, the share of which was 12% in 2007. The US is the third biggest exporter with an 11% share. EU-12, though having a small share at the market of technology-intensive goods, has been increasing it quite fast – from 1% in 1996 to 3.6% in 2007.

Figure 5.2.1



Source: TSD

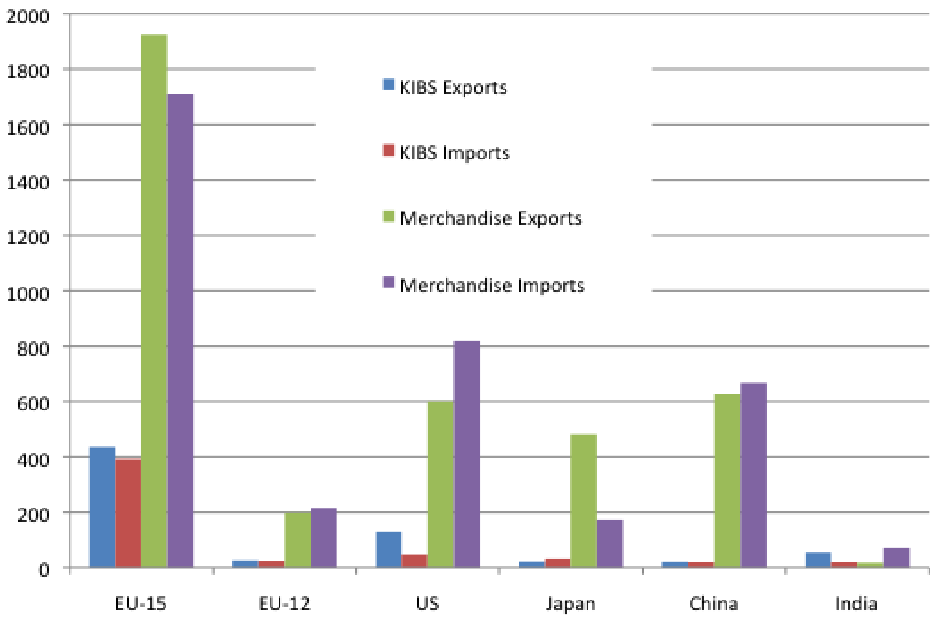
Figure 5.2.2



Source: TSD

Figure 5.2.3

Value of KIBS and technology intensive merchandise exports in 2007, USD bn



Source: TSD, UN COMTRADE

As Figure 5.2.3 shows, EU-15, US and India are net exporters of KIBS, while Japan is a net importer. EU-12 and China have approximately equal volumes of exports and imports of KIBS. On the market of technology-intensive merchandise goods, EU-15 preserves its status of a net exporter, Japan is a net exporter as well, while the US, China and India are net importers.

The fastest average annual growth of KIBS exports was recorded in India – 56%. China had the second highest growth rate (20% on average year-on-year). EU-15, US, and EU-12 have been increasing their exports of KIBS at approximately the same average speed during 1996-2007 (around 13% on average year-on-year), while Japan has lagged behind, showing 2% average annual growth (see Figure 5.2.4 and Tables A1.1 and A1.2).

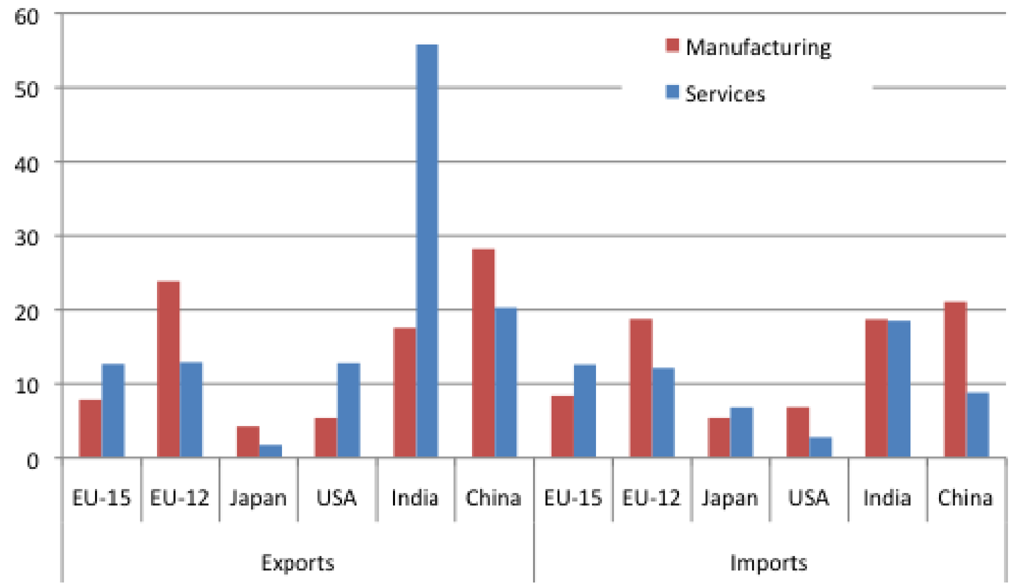
In technology-intensive merchandise exports trends were different – here China and EU-12 are the leaders by growth rate (28% and 24% on average year-on-year respectively), while India was the third in terms of growth rate (18%). EU-15 increased its exports on average by 8% per year. Japan was again the laggard with 4% average annual growth, while the US performed only slightly better with 5% average annual growth.

The fastest growth of KIBS imports during that period was in India (19% on average per annum), EU-15 and EU-12 (at rates similar to exports). The US was increasing KIBS imports the slowest among six regions – at only 3% per year. Japan was more active in the KIBS import market as compared to the export market, with average annual growth of KIBS imports at 7%.

In technology-intensive merchandise imports China, India and EU-12 are again the leaders in terms of growth with 19%-21% average annual growth rate. In other regions imports were increasing at 5%-8% average annual rate.

Figure 5.2.4

Average annual growth of exports and imports of KIBS and technology-intensive manufacturing trade, 1996-2007, %



Source: TSD, UN COMTRADE

Comparison of KIBS and technology-intensive merchandise exports dynamics during 1996-2007 shows, that in the old member states it was KIBS exports, which grew more dynamically than merchandise trade, while in EU-12 the situation was reverse. Similar trends took place in imports: EU-15's imports of KIBS grew much faster than merchandise technology-intensive imports, while in the case of EU-12 the opposite was true. This reflects increased specialization by the EU-12 in merchandise technology-intensive goods trade relative to KIBS trade.

However, when we later look at individual KIBS, we will see that there has been quite heterogeneous dynamics among three KIBS sectors, with EU-12 significantly outpacing EU-15 in terms of growth of computer and information services and R&D exports.

In the US exports of KIBS were increasing faster than both technology-intensive merchandise exports and KIBS imports, while US imports of KIBS have been growing slower than technology-intensive merchandise imports. This suggests that the US has been increasing its specialization in KIBS exports and also its dependency on technology-intensive merchandise imports. For Japan the contrary is true – the country seems to have been increasing its dependency on KIBS imports, instead raising specialization in technology-intensive merchandise exports rather than KIBS.

Next we switch to developments in trade of individual KIBS. As Figure 5.2.6 shows, EU-15 is the biggest exporter in all the KIBS sectors. It accounts for around 50% of global exports of other business services and computer and information services in 2007, and for more than 60% of global R&D exports. EU-12 has a very low share in the global KIBS trade, but it has been experiencing very fast exports growth in computer and information services and R&D. In other business services EU-15 outperformed the EU-12 in terms of exports growth rate (Figure 5.2.7). This is consistent with the EU-12 emphasis on merchandise rather than services trade in the knowledge intensive sectors. (For more details refer to Tables A1.3-A1.5)

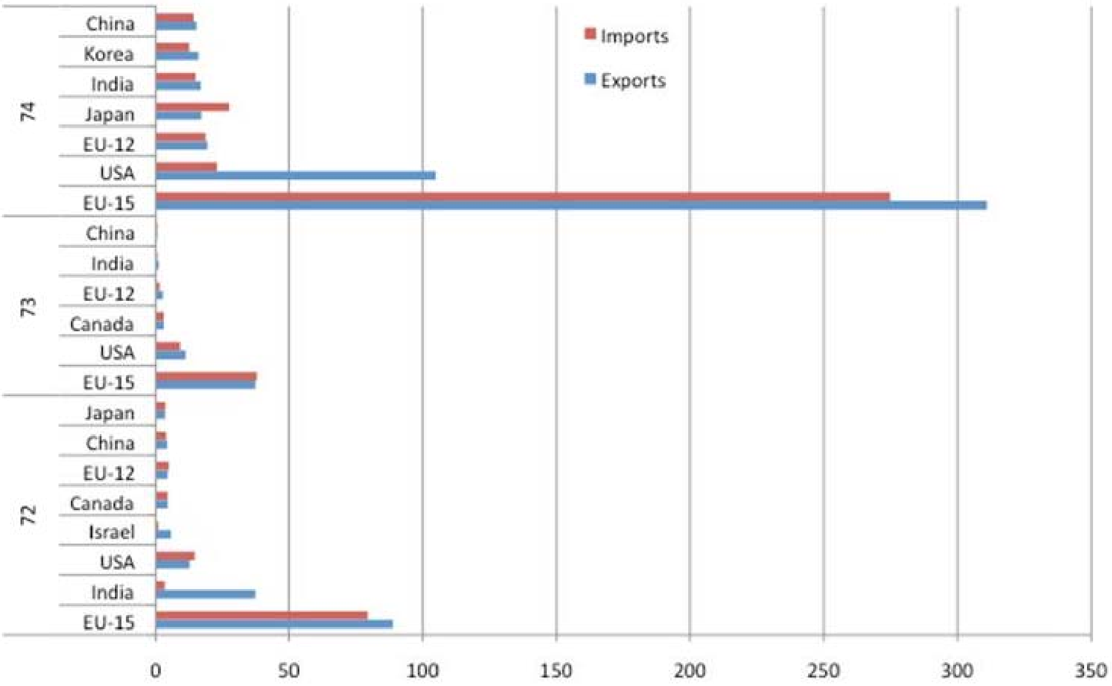
In computer and information services (72), the second biggest player at the global market is India, with a 21% share in 2007 (Figure 5.2.6). India also increased its exports the fastest – on average by 92% year-on-year (Figure 5.2.7). China, though currently a small player at this market (3% market share), has been increasing its exports of computer and information services at the second highest rate after India (48% average annual growth). EU-12 was number three in terms of exports growth speed with 31% average annual growth. Average annual growth of computer and information services of EU-15 was at par with the average world one (25%), while other advanced economies – US, Canada, Japan – had much slower growth.

The R&D (73) market is dominated by EU-15 and US (the latter had 18% share of the global exports in 2007) (Figure 5.2.6). It is worth noting that EU-12 has been demonstrating the fastest growth of exports in this sector (Figure 5.2.7) – on average 46% per annum. On the one hand, this can be partially explained by the low starting base. On the other hand, currently the share of EU-12 in the global R&D market is almost at par with Canada, which makes it an important player in the world market. EU-15, on the contrary to EU-12, has been experiencing relatively sluggish growth of R&D exports – on average 8% per annum, which is lower than the world average. US outperformed EU-15 by this indicator.

At the market of other business services (74), the US is again the second biggest player after EU-15 (16% market share in 2007) (Figure 5.2.6). The market share of EU-12 (around 3%) is comparable to those of India, Korea, and China. China has been establishing itself as a serious player at the market, demonstrating the fastest export growth – during 1996-2007, its annual exports of other business services increased at the annual average rate of 52% (Figure 5.2.7). India had the second highest growth rate – 27%. EU-12, as well as advanced economies of EU-15 and US, showed moderate growth of exports in this sector – around 10%-12% per annum. Japan had the most sluggish dynamics of other business services exports – less than 1% average growth per annum.

Figure 5.2.6

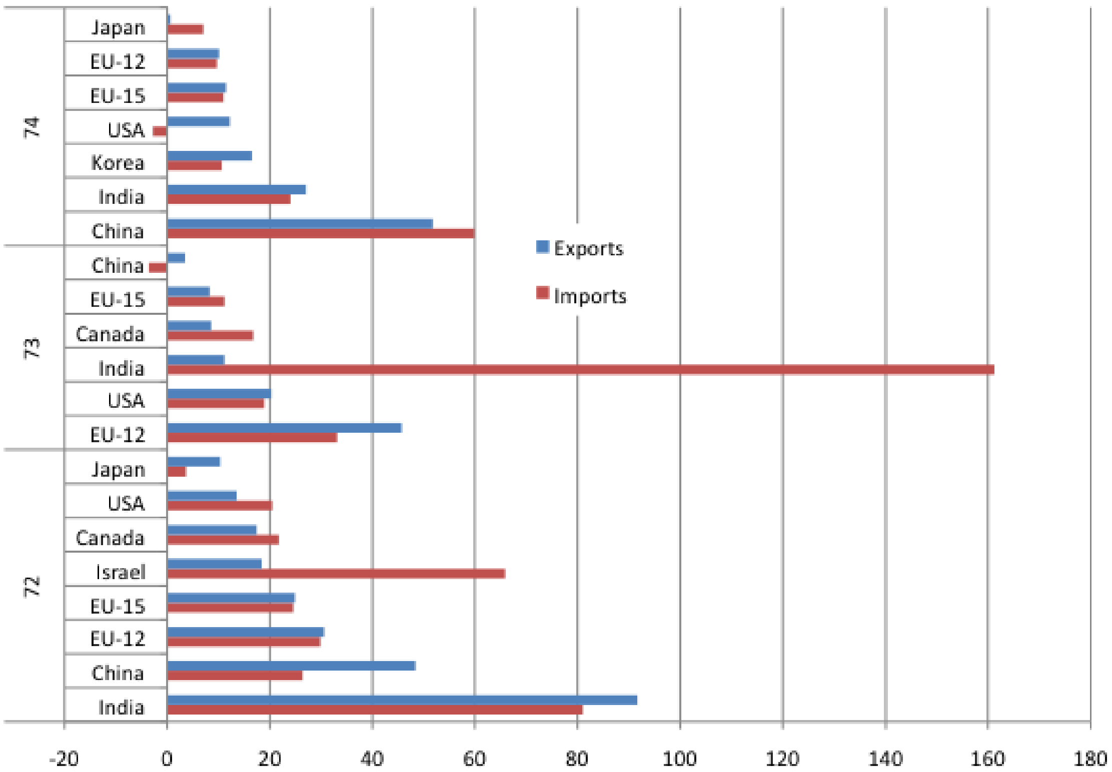
Exports and imports of KIBS in 2007, USD bn



Source: TSD

Figure 5.2.7

Average annual growth of exports and imports of KIBS, 1996-2007, %



Source: TSD

There is growing evidence in the literature that services have been playing an increasingly important role in boosting productivity of manufacturing sectors (e.g., Arnold, Javorcik, and Mattoo (2006), Javorcik (2004). Therefore we are also interested in the dynamics of KIBS imports and its impact on manufacturing which is analyzed in Section 5.4 in more detail.

As can be seen from Figure 5.2.6, EU-15 is the major importer in all the KIBS markets. The US is the second biggest importer of computer and information services, while Japan holds the second position as an importer of other business services.

India has had the fastest growth of imports of computer and information services (72) during 1996-2007 – on average 81% year on year (Figure 5.2.7). This trend together with extremely fast growth of exports of this sector reflects the importance of off-shoring of computer and information services to India. EU-12 also increased imports of computer and information services rather fast – at 30% average annual growth. The US and EU-15 had similar average annual rates of growth for imports – 21% and 25% respectively, while Japan significantly lagged behind by this indicator with 4% average annual growth.

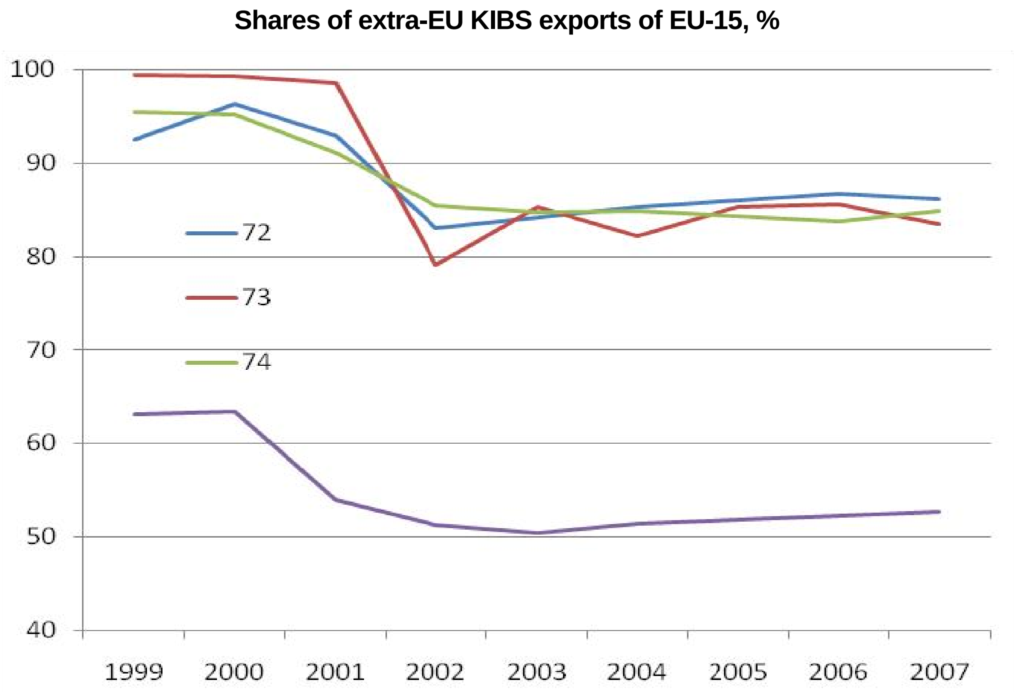
Similar trends prevailed at the R&D (73) market – India, though having a tiny share as an importer, increased imports of these services the fastest (on average at 170% year-on-year). EU-12 was second in terms of imports growth (33%). EU-15 was increasing R&D imports much slower than Japan or the US – 11% average annual growth versus 20% and 19% respectively (Figures 5.2.17-5.2.18).

In the market of other business services (74), it was China and India that increased their imports the fastest with 60% and 24% average annual growth respectively (Figure 5.2.20). EU-15 and EU-12 had similar rates of the sector imports growth – 11% and 10% respectively. Japan had slower imports growth – at 7% on average per annum, while the US had negative growth of 3% on average per annum.

When we break down EU exports into extra- and intra-EU KIBS exports, it appears that the bulk of trade in KIBS occurs with the third countries (80%-90% of trade in KIBS) – in contrast to total services exports, where extra-EU share has been steadily decreasing and was less than 50% in 2007 (see Figures 5.2.7 and 5.2.8).

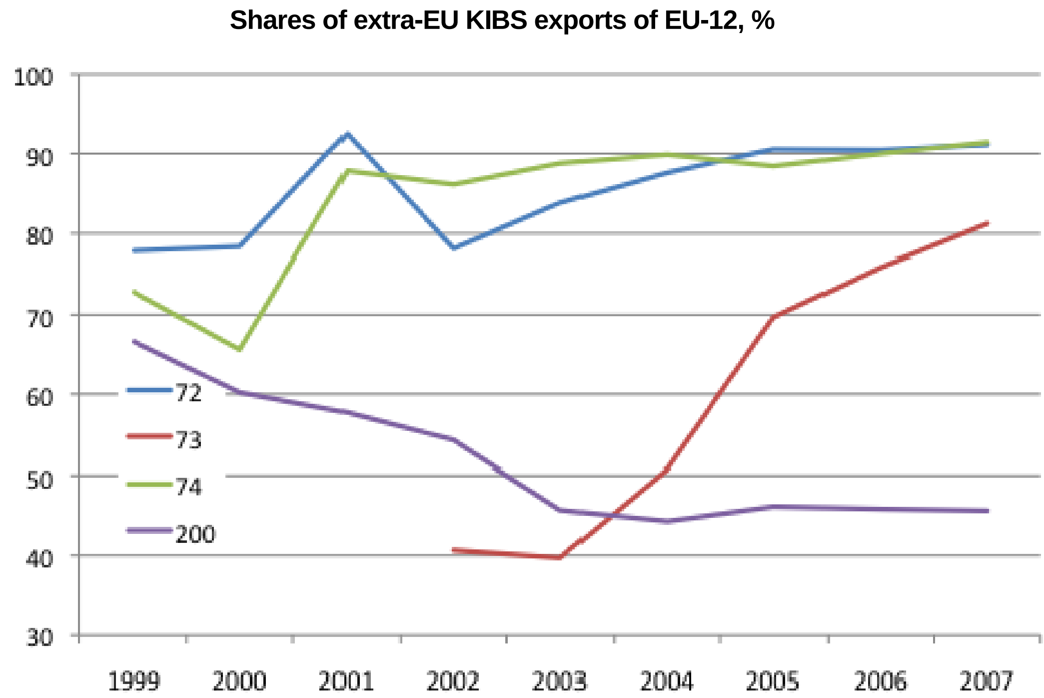
EU-15 and EU-12 experienced slightly different dynamics in terms of extra-EU share of KIBS exports. In EU-15, after initial decline, extra-EU exports shares for all three KIBS services stabilized at the level of about 85%. In EU-12, on the contrary, shares of the third countries have been increasing over the last years, the increase being most profound in the case of R&D, where the share of extra-EU in exports doubled over 2002-2007.

Figure 5.2.7



Source: TSD

Figure 5.2.8



Source: TSD

5.3. Specialization patterns in KIBS and technology-intensive merchandise exports

In this section we examine patterns of specialization in the EU technology-intensive merchandise and KIBS trade. We apply a common measure of Balassa's Revealed Comparative Advantage (RCA) index, also known as 'export specialization index'. The index for country *i* good *j* is $RCA_{ij} = (X_{ij} / X_{it})/(X_{wj} / X_{wt})$, where *w*=world and *t*=total for all services. The RCA simply compares the composition of exports of one country to a certain market with the composition of total exports that are absorbed by the market. A region is considered to have a revealed comparative advantage in a certain type of services or goods, if a value of the RCA index for this sector is higher than 1.

According to the calculated revealed comparative advantages indices (see Figure 5.3.1 and Table A5.1.13), EU-15 has specialization in all three KIBS sectors; the strongest comparative advantage is revealed for R&D (73). Comparative advantages in R&D gradually declined during 1996-2003, but have picked up after 2004, which might be related to efficiency gains brought by the EU enlargement. Also, EU-15 appears to increase specialization in other business services – after 2000, the value of RCA index for this sector started to exceed 1. EU-15 is the only region among the four, which appears to specialize in computer and information services exports.

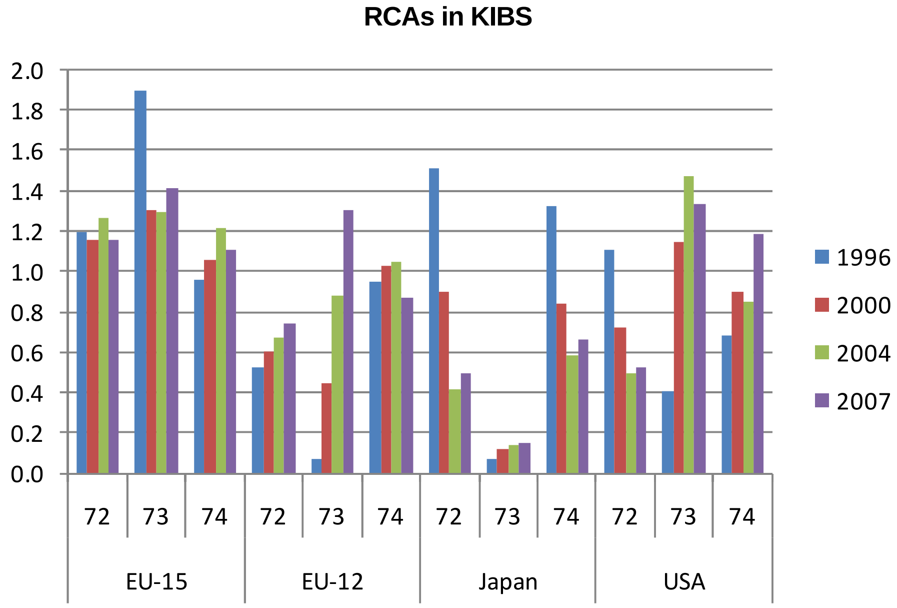
EU-12 has revealed comparative advantages only in R&D. This is a new specialization pattern that has developed since 2004. This result is in line with the findings of the European Competitiveness Report 2010, which shows that recently internationalization of R&D has increased considerably in the EU. Developing of specialization in R&D after 2004 may be linked to increased opportunities for foreign companies to exploit Single Market, brought about by the EU enlargement.

Japan has no RCAs in KIBS exports. Though the country tended to specialize in exports of computer and information services and other business services at the beginning of the period, this revealed comparative advantages fell away over the period.

While the US has increasingly specialization in R&D since 1998, specialization in computer and information services exports has faded away.

Figure 5.3.2 presents RCAs for technology-intensive manufacturing exports (for more details refer to Table A1.14). EU-15 have more diverse specialization pattern than EU-12. The former specializes in all the sectors apart from office machinery (30) and radio, television and communication equipment (32), while EU-12 has revealed comparative advantages only in three sectors, namely, motor vehicles (34), electrical machinery (31), and machinery and equipment n.e.c. (29). At the same time, EU-15 has the weakest comparative advantages in all the sectors as compared with the US and Japan. Only in machinery n.e.c. (29) and motor vehicles (34) RCAs appear to significantly exceed 1.

Figure 5.3.1



Source: TSD, authors' calculations

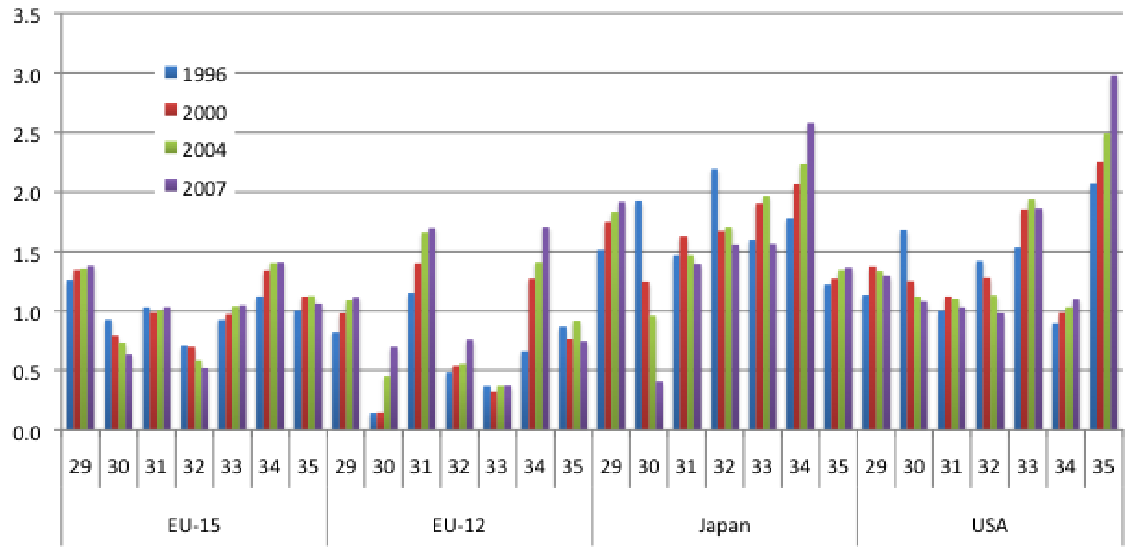
In EU-15 specialization patterns remained fairly stable during 1996-2007. An increase in specialization is only apparent in motor vehicles (34) and medical equipment (33). In EU-12, specialization indices have been increasing in all the sectors apart from medical instruments (33) and other transport equipment (35). Specialization in motor vehicles (34) and machinery and equipment n.e.c. (29) is a relatively recent phenomenon. (RCAs exceeded 1 in 1999 in case of motor vehicles, and in 2001 in case of machinery and equipment n.e.c.). The motor vehicles sector trend is possibly explained by increase of FDI in motor vehicle plants in the region.

Japan has the strongest specialization among 4 regions in motor vehicles (34) and radio and television equipment (32). Overall the country tends to specialize in all the technology-intensive goods sectors, apart from office and computing machinery (30), where it lost export specialization after 2003 – this apparently reflects re-location of computer equipment production to other Asian countries.

The US has the strongest specialization among all the regions analyzed in other transport equipment (35). The RCA index is close to 3. Another sector with relatively strong revealed comparative advantages is medical instruments (33). The country also appears to have recently developed a stronger export specialization in motor vehicles (34). Revealed comparative advantages in office and computing equipment (30) and radio and television equipment (32) seem to be gradually fading away. In electrical machinery and machinery n.e.c. (29) the US tends to have stable though relatively weak export specialization.

Figure 5.3.2

RCAs in technology-intensive goods



Source: UN COMTRADE, authors' calculations

5.4. *KIBS intensity in manufacturing*

In this section we examine linkages between KIBS and other sectors of the European economy. This includes both direct shares of total cost, as well as the import intensity of KIBS demand in the manufacturing sector. It also includes the contribution of KIBS to total European exports. When we focus on exports, we take advantage of input-output data to highlight the impact of KIBS on the value added content of European exports. We also compare imported KIBS intensities of the EU-15 and EU-12 with those in the US and Japan.

The source of data for our analysis is the GTAP database. We work with version 8 (with 2007 and 2004 as a benchmark year) and Version 6 (with 2001 as a benchmark year). The database provides internally consistent data on production, consumption and international trade by country and sector.[16] Our trade and production data are all valued at current prices. Trade data are based on UNCTAD COMTRADE data as reported (in the case of the EU) by Eurostat and as integrated into the GTAP database. In the GTAP nomenclature, KIBS correspond to GTAP other business services sector (which comprises computer and information services, R&D, and other business services). The GTAP sector aggregation used in our analysis is presented in Annex 5.2. [17]

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16 For more information, please refer to Dimaran and McDougall (2007).

17 It should be noted that for the discussion in this section, we have grouped petrochemicals production within the energy sector. Because of adjustments to national production data in GTAP which is done for consistency with independent

We start with the KIBS intensity of manufacturing. Figure 5.4.1 and 5.4.2 provide a comparison of the KIBS share of total production costs in manufacturing, as well as a more detailed breakdown across sectors within manufacturing. For the EU-27 as a whole, the KIBS intensity of manufacturing is comparable to that of Japan, and greater than that of the United States (measured on a cost basis). However, there is a significant variation between the EU-15 and EU-12. Manufacturing in the EU-15 is highly KIBS intensive, while in the EU-12 the KIBS intensity of manufacturing is below that of the EU-15, and Japan, and closer to that of the United States. From Figure 2, the KIBS intensity of manufacturing in both the EU-15 and EU-12 has risen across a wide range of manufacturing sectors since 2001. Hence, while the EU-12 is still below the EU-15, manufacturing in the EU-12 has become increasingly KIBS intensive since enlargement of the EU, in terms of cost shares.

From Figure 5.4.2 and Table A5.1.10, there has been a reinforcement of forward linkages (higher cost shares) in a wide range of industries. This increase includes high technology sectors (like electrical machinery) but this is actually a rather broad based trend. While we interpret this as a shift toward more KIBS intensive inputs, this could technically be a result of rising prices rather than a shift in input structures. However, evidence points to productivity gains and a shift toward more reliance on KIBS inputs. For example, Jorgenson (2005) argues that “despite differences in methodology and data sources, a consensus has emerged that the remarkable behaviour of IT prices provides the key to the surge in U.S. economic growth after 1995. The relentless decline in the prices of information technology equipment and software has steadily enhanced the role of IT investment. The surge of IT investment in the United States after 1995 has counterparts in all other industrialized countries.”[18] This process has driven falling costs and rising output in KIBS, and on this basis we feel justified for interpreting these changes in cost shares as reflecting a mix of productivity gains and shifting input structures.

Figure 5.4.3 highlights the importance of imported KIBS inputs as a share of total KIBS demand in manufacturing. Here we can see that cross-border KIBS trade is important in both the EU-15 and EU-12 in terms of the impact of manufacturing costs. From Figure 5.4.1, we have cost shares of 9.8 percent and 4.5 percent in the EU-15 and EU-12. As noted earlier, the EU stands as more KIBS intensive than the US or Japan. From Figure 5.4.3, imports account for between 5.3 percent (EU-12) and 5.5 percent (EU-15) of these total costs. Together, Figures 5.4.1-5.4.3 (and the underlying data in the annex tables) point to the importance of KIBS in the competitiveness of European manufacturing, especially in comparison to the US and Japan. This is particularly true for electrical machinery and equipment in the EU-15, though across manufacturing KIBS represents an important

IEA and IPCC data on energy production to allow mapping to CO2 emissions data, this means aggregate manufacturing sector data may vary from aggregates of manufacturing elsewhere in this report.

18 Dale W. Jorgenson, *Accounting for Growth in the Information Age,* Chapter 10 in Handbook of Economic Growth, 2005, vol. 1, Part A, pp 743-815 from Elsevier.

aspect of the cost structure of industry. From Table A5.1.1, there has been rapid growth in imports in KIBS intensive service categories. Indeed, this growth in the EU has been in the range of 12.2 to 12.6 percent per year from 1996 to 2007. This is far greater than the KIBS import growth rate in Japan and the US, which was only 6.8 percent and 2.8 percent respectively. This means the EU has become increasingly dependent on imported service inputs for the cost competitiveness of KIBS intensive industry, in comparison to both the US and Japan.

We turn next to the trade intensity of KIBS. In this regard, we focus on the contribution of KIBS to the value added contained in European exports. By focusing on value added, we are highlighting the direct contribution exports makes to demand for labour and capital in Europe, rather than counting the value of imported (extra-EU) inputs to production costs. Also, by focusing on value added, we can better trace the indirect linkages between KIBS demand in manufacturing, and the value added contained in exports.

In Figure 5.4.4 we present the share of KIBS in total EU value added contained in exports. Two sets of figures are presented. The first set of figures presents, as defined in the box above, KIBS as a share of direct exports, measured in terms of sector value added. This is the share of direct value added, following from the value added (capital and labour) needed to produce direct EU exports in KIBS sectors and ignoring EU value added in intermediates that feed into the sector. However, this is not a complete picture. Because, as we have seen above, KIBS are also important inputs to manufacturing, this means that the value added in KIBS activities that feed into manufacturing are also reflected in sales of exports in the manufacturing sector. (See the Box 5.1 for a technical definition). Therefore, the second measure presented in the table, which reflects forward linkages from KIBS production into other downstream sectors, includes not only value added from direct exports, but also the KIBS value added that is embodied in other European exports, such as heavy machinery, motor vehicles, and electrical machinery and office equipment.

Box 5.1

Measuring KIBS Intensities

In this chapter we work with several measures of the KIBS intensity of the European economy. This includes direct shares of KIBS in total costs in manufacturing, as well as the trade intensity of KIBS demand. We also examine the contribution of KIBS to European exports, measured in terms of the value added content of European exports. This last measure reflects indirect KIBS exports embodied in manufacturing because of intermediate linkages.

Our intensity indexes are defined below. Notation is as follows: $e_{j,i}$ represents expenditure in sector *i* on inputs bought from sectors indexed by *j*, including both value added or primary inputs (capital, labour, land), KIBS inputs, and other intermediate inputs; v_i represents value added as a share of gross output value (i.e. expenditure on primary inputs as a share of total costs of production in sector *i*); and x_i represents the gross value of exports from sector *i*. Note that by definition v_i equals the value added per € of gross value of output, and so is used to calculate the value added content of gross exports in the last equation below. The last two terms can also be calculated for other (non-KIBS) sectors.

Direct cost shares of KIBS in a given sector *i* as a share of all inputs:

$$\theta_{KIBS,i} = \frac{e_{KIBS,i}}{\sum_j e_{j,i}} \times 100$$

KIBS Imports as a share of total KIBS costs in sector *i*:

$$\phi_{KIBS,i} = \frac{m_{KIBS,i}}{e_{KIBS,i}} \times 100$$

Direct share of value added in KIBS in total direct value added in exports:

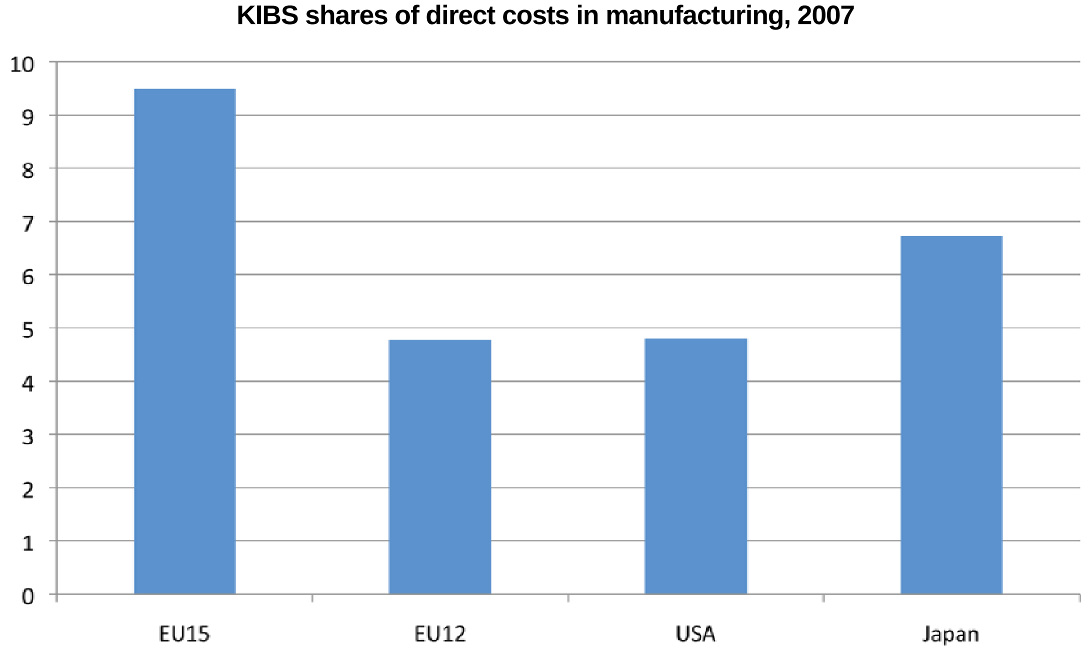
$$\alpha_{KIBS} = \frac{v_{KIBS} x_{KIBS}}{\sum_j v_j x_j}$$

Total (direct and indirect) share of KIBS value added in total exports:

$$\beta_{KIBS} = \frac{v_{KIBS} x_{KIBS} + \sum_{i \neq KIBS} \theta_{KIBS,i} v_{KIBS} x_i}{\sum_j \left(v_j x_j + \sum_{z \neq j} \theta_{z,j} v_z x_j \right)} \times 100$$

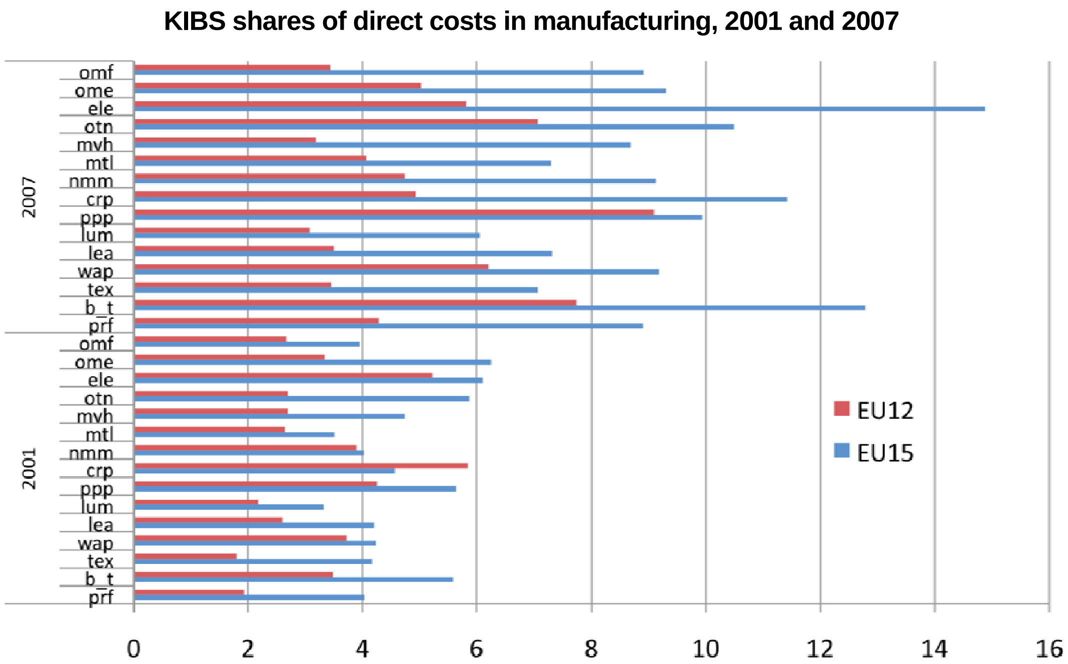
On a direct basis, KIBS activities accounted for between 4.4 percent (EU-12) and 10.9 percent (EU-15) of EU exports on a value added basis in 2007. This differs from gross export shares, because gross exports also reflect the cost of intermediate inputs. For both the EU-12 and EU-15, these value added shares of direct KIBS exports have risen from 2001 levels. On a value added basis, when we account for indirect exports, where KIBS value added is embodied in manufacturing exports, the KIBS intensity of EU exports is even greater, ranging from 8.8 (EU-12) to 18 percent (EU-15) of the value added contained in European exports in 2007. Like the direct shares, these values are up from 2001 levels. Like the data in cost shares in Figures 5.4.1-5.4.3, the data in Figure 5.4.4 (and the underlying data in the annex) underscore the importance of KIBS activities to the competitiveness of the European economy, in this case measured on an export basis. In terms of the value added contained in European exports, the strong linkages between services and manufacturing means that KIBS activities are important for the cost structure of European industry and the support of EU value added activities (jobs and investment) linked directly and indirectly to trade. From Figure 5.4.2 and Table A5.1.10, strong forward linkages can be seen in electrical machinery (ele), chemicals (crp) (which is inclusive of pharmaceuticals and cosmetics), beverages and tobacco (b_t), and publishing (ppp).

Figure 5.4.1



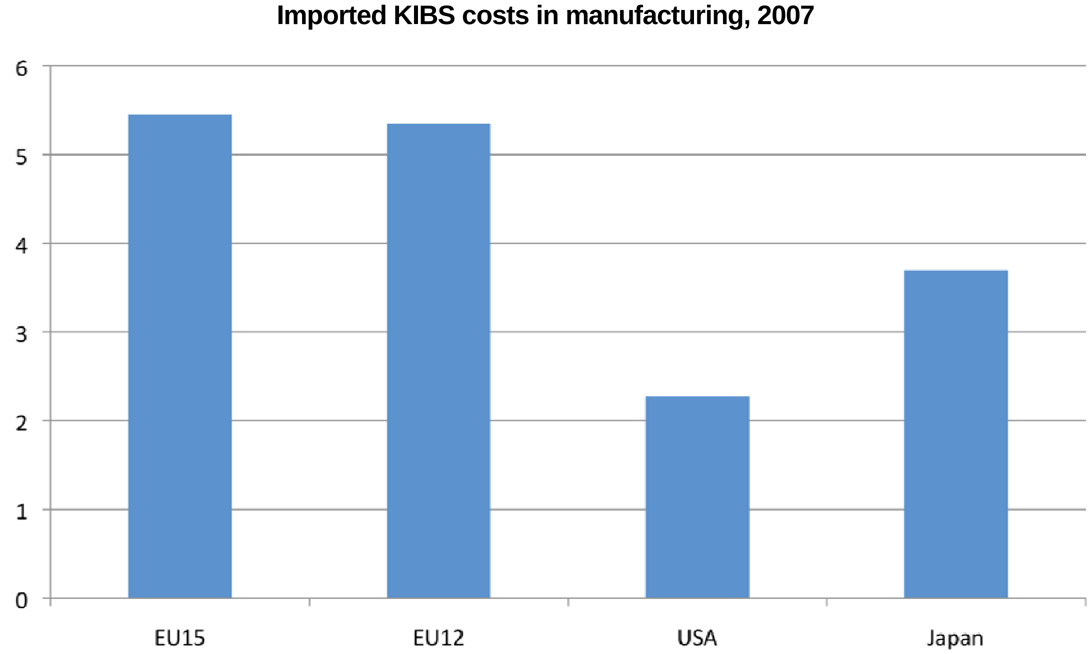
Source: GTAP

Figure 5.4.2



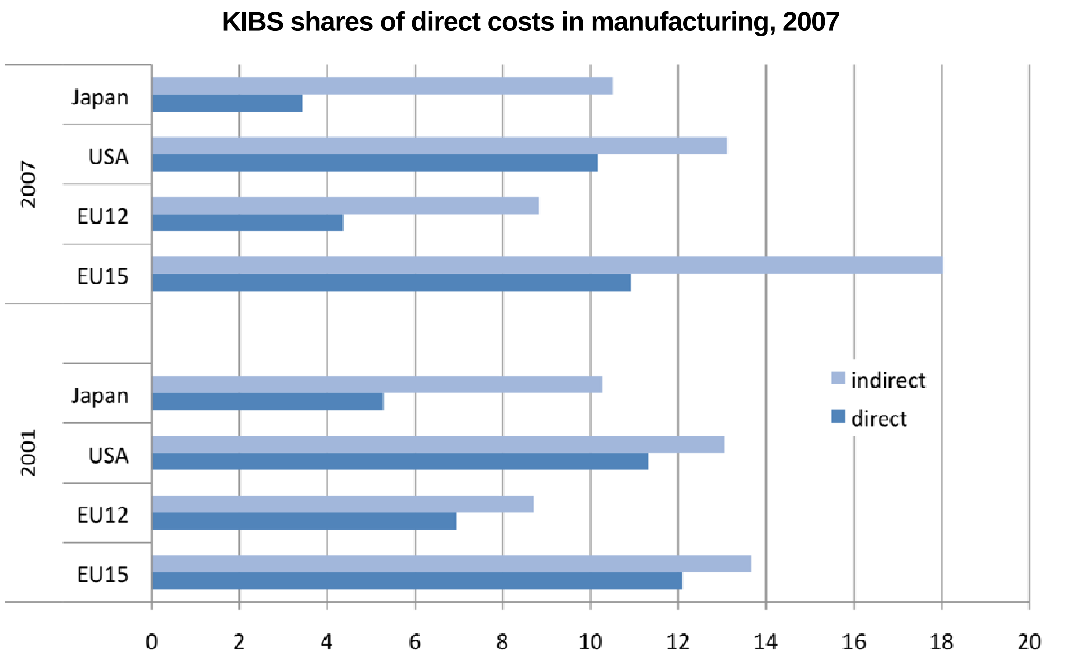
Source: GTAP

Figure 5.4.3



Source: GTAP

Figure 5.4.4



Source: GTAP

5.5. Summary

KIBS shares of gross production costs account for between 5% and 15% of total direct costs in manufacturing in EU-15 in 2007, and from 3% to 9% of total direct costs in manufacturing EU-12 in 2007. On this basis, they are particularly important for EU competitiveness in electrical machinery in EU-15, and other transport equipment and paper and printing in EU-12. Notable is that KIBS intensity increased in all the industries of both regions as compared with 2001.

EU-15 is the major player at the KIBS market – its share in global KIBS exports is around 50%. The US has the second biggest share (15%), while India is a number three player with 6% share. EU-15 is also the biggest player at the market of technology-intensive goods; however, its share there is much smaller than at the KIBS market – 35% in 2007. The second biggest exporter at this market is China, the share of which was 12% in 2007. The US is the third biggest exporter with an 11% share. EU-12, though having a small share at the market of technology-intensive goods, has been increasing it quite fast – from 1% in 1996 to 3.6% in 2007.

EU-15, US and India are net exporters of KIBS, while Japan is a net importer. EU-12 and China have approximately equal volumes of exports and imports of KIBS. On the market of technology-intensive merchandise goods, EU-15 preserves its status of a net exporter, Japan is a net exporter as well, while the US, China and India are net importers.

When we break down EU KIBS exports into extra- and intra-EU exports, it appears that the bulk of trade in KIBS occurs with the third countries (80%-90% of trade in KIBS) – in contrast to total services exports, where extra-EU share has been steadily decreasing and was less than 50% in 2007

The fastest average annual growth of KIBS exports was recorded in India – 56%. China had the second highest growth rate (20% on average year-on-year). EU-15, US, and EU-12 have been increasing their exports of KIBS at approximately the same average speed during 1996-2007 (around 13% on average year-on-year), while Japan has lagged behind, showing 2% average annual growth.

The fastest growth of KIBS imports during that period was also in India (19% on average per annum), EU-15 and EU-12 (at rates similar to exports). The US was increasing KIBS imports the slowest among six regions – at only 3% per year. Japan was more active in terms of KIBS imports rather than exports – average annual growth of Japanese KIBS imports was 7%.

Direct exports of KIBS in all the regions analyzed are dominated by other business services, which account for about 70% of EU-12 and EU-15 exports, and more than 80% of

US and Japan exports. The common trend, though, is decline of the share of other business services in exports.

EU-15 has on average stronger revealed comparative advantages in direct KIBS exports, than in technology-intensive merchandise exports. The strongest comparative advantage for the EU-15 is found for R&D. Comparative advantages in R&D gradually declined during 1996-2003, but have picked up after 2004, which might be related to efficiency gains brought by the EU enlargement. Also, EU-15 appears to increase specialization in other business services. EU-15 has also increasingly specialized in computer and information services exports, in contrast to the US, which has lost this specialization. At the same time EU-15 has the weakest comparative advantages in all the technology-intensive merchandise sectors as compared with the US and Japan. Only in machinery n.e.c. and motor vehicles we see strong RCAs.

The EU-12, on the other hand, seems to have more comparative advantages in technology-intensive merchandise trade rather than in KIBS. It has revealed comparative advantages only in R&D among KIBS sectors; this is a new specialization pattern that has developed since 2004. The conclusion about bigger specialization in manufacturing rather than services is also confirmed by comparison of KIBS and technology-intensive merchandise exports dynamics during 1996-2007, which shows that in the old member states it was KIBS exports, which grew more dynamically than merchandise trade, while in EU-12 the situation was reverse.

When we examine KIBS trade, it is noteworthy that the value of KIBS trade is relatively low compared to technology-intensive merchandise trade in all the regions. However, it is important to recognize that KIBS activities represent a major share of the total cost of production in manufacturing. Indeed, in this chapter we have shown that, on a value added basis, KIBS is highly important to the competitiveness of European manufacturing, and to the overall value added embodied in European exports. KIBS intensity of both EU-15 and EU-12 exports has risen substantially on a value added basis, once we recognize that KIBS are inputs into manufacturing and so are not only exported directly, but also indirectly through goods.

Annex 5.1 – Tables

Table A5.1.1

KIBS and technology-intensive merchandise exports, USD bn

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Average growth rate in 1996-2007, %
EU-15-KIBS	117.2	117.1	133.5	144.2	153.8	172.2	209.9	252.1	300.8	321.3	356.6	437.3	12.7
EU-12-KIBS	7.0	5.7	5.9	7.5	8.1	8.3	9.3	11.3	15.1	16.6	21.9	26.8	13.0
US-KIBS	34.1	40.3	41.3	46.8	57.3	61.7	60.5	64.6	70.9	74.6	109.6	128.8	12.8
Japan-KIBS	17.6	14.2	11.9	23.2	19.7	19.4	18.6	16.3	15.0	14.7	14.4	21.3	1.8
India-KIBS	2.1	2.2	3.9	6.2	9.0	8.8	10.7	12.9	15.7	24.0	33.8	48.4	55.8
China-KIBS	3.7	6.9	0.7	0.9	0.8	1.4	2.6	3.8	5.7	6.2	9.7	13.5	20.3
EU-15-merchandise	834.8	845.2	916.8	976.0	998.0	1007.2	1052.3	1222.7	1445.4	1548.7	1733.4	1925.9	7.9
EU-12-merchandise	18.9	16.5	33.6	32.7	39.5	45.3	56.8	72.6	98.5	116.4	148.8	198.5	23.8
US-merchandise	336.8	386.2	392.2	405.3	455.0	416.9	388.9	393.2	442.4	486.1	553.5	601.2	5.4
Japan-merchandise	304.1	310.0	284.7	306.3	355.7	291.7	299.9	339.6	403.5	413.0	443.6	480.9	4.3
India-merchandise	69.2	70.3	67.7	81.6	101.8	88.0	100.9	123.9	165.2	184.7	210.1	240.3	17.6
China-merchandise	79.6	86.6	90.1	104.8	115.8	102.8	99.5	101.6	113.9	123.4	128.8	133.6	28.2

Source: TSD, UN COMTRADE

Table A5.1.2

KIBS and technology-intensive merchandise imports, USD bn

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Average growth rate in 1996-2007, %
EU-15-KIBS	106.0	109.1	124.8	153.6	162.1	181.5	208.6	253.1	264.8	285.8	316.1	392.4	12.6
EU-12-KIBS	7.1	6.4	7.6	7.2	7.6	7.7	8.7	10.3	13.4	16.3	19.7	25.3	12.2
US-KIBS	34.8	33.9	30.1	28.7	28.8	28.4	29.4	28.3	31.5	34.5	41.2	47.2	2.8
Japan-KIBS	15.6	15.6	12.4	21.5	21.1	20.4	20.8	19.4	21.5	25.2	26.6	32.3	6.8
India-KIBS	2.9	3.3	4.6	7.2	4.8	4.8	5.2	8.3	11.6	13.8	18.5	19.0	18.5
China-KIBS	7.5	0.9	1.3	1.1	2.6	4.4	7.3	9.7	8.2	10.9	13.9	19.1	8.8
EU-15-merchandise	702.3	704.7	803.1	903.1	919.0	902.2	911.1	1079.5	1287.0	1368.9	1523.6	1710.7	8.4
EU-12-merchandise	32.5	34.6	53.2	50.0	54.7	59.4	68.7	87.7	114.4	126.5	161.5	215.2	18.7
US-merchandise	393.8	430.2	462.0	523.7	605.7	548.3	555.1	579.5	661.6	718.5	784.1	817.9	6.9
Japan-merchandise	96.8	95.5	86.0	97.4	120.4	109.2	108.0	121.5	143.1	153.2	165.9	172.8	5.4
India-merchandise	84.1	75.4	48.3	67.4	91.3	74.0	82.4	98.2	119.5	132.2	147.6	84.1	18.7
China-merchandise	128.5	150.7	155.8	170.3	185.6	164.4	163.5	171.1	190.4	212.9	233.5	250.4	21.1

Source: TSD, UN COMTRADE

Table A5.1.3

Exports of computer and information services, USD bn

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Average growth rate in 1996-2007, %
USA	3.1	4.1	4.5	6.8	6.5	6.4	6.9	7.0	7.8	8.3	10.3	12.7	13.6
Japan	1.2	1.4	1.3	3.0	3.1	2.6	2.1	2.1	2.2	2.4	3.1	3.6	10.3
EU-15	7.7	9.5	17.4	20.9	23.0	27.4	34.0	45.2	57.1	62.1	71.5	88.8	24.9
EU-12	0.2	0.2	0.3	0.6	0.7	0.9	1.1	1.3	2.0	2.8	3.6	4.6	30.5
India	0.0	0.1	0.1	0.1	4.7	7.4	8.9	11.9	16.3	21.9	29.1	37.5	91.7
Canada	0.8	1.1	1.4	2.0	2.4	2.3	2.3	3.1	3.0	3.6	4.3	4.6	17.4
China	0.0	0.1	0.1	0.3	0.4	0.5	0.6	1.1	1.6	1.8	3.0	4.3	48.4

Source: TSD

Table A5.1.4

Exports of R&D, USD bn

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Average growth rate in 1996-2007, %
USA	1.5	1.7	2.0	3.6	4.0	3.5	5.5	7.4	9.2	10.0	10.4	11.2	20.3
Japan	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.6	0.4	0.4	16.1
EU-15	15.6	12.8	13.7	9.5	10.1	7.2	18.0	25.3	23.2	29.4	32.9	37.5	8.3
EU-12	0.0	0.0	0.1	0.1	0.2	0.3	0.4	0.6	1.0	2.1	2.3	2.8	45.7
India*	0.0	0.0	0.0	0.0	0.0	0.6	0.8	0.9	0.1	0.3	0.7	1.2	11.2
Canada	1.2	1.3	1.8	2.2	2.9	2.3	1.6	2.6	2.5	2.6	2.9	3.1	8.6
China	0.0	0.3	0.5	0.3	0.4	0.9	1.3	1.9	0.0	0.1	0.2	0.5	3.5

* Average growth rate calculated for 2000-2007

Source : TSD

Table A5.1.5

Exports of other business services, USD bn

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Average growth rate in 1996-2007, %
USA	29	35	35	36	47	52	48	50	54	56	89	105	12.2
Japan	16	13	10	20	16	17	16	14	13	12	11	17	0.6
EU-15	94	95	102	114	121	138	158	181	220	230	252	311	11.5
EU-12	7	5	5	7	7	7	8	9	12	12	16	19	10.1
India	2	4	6	9	4	3	3	3	8	12	19	17	20.8
Korea	5	5	4	5	7	6	7	7	9	10	12	16	12.0
China	7	0	0	0	1	1	2	3	5	8	10	15	7.7

Source : TSD

Table A5.1.6

Imports of computer and information services, USD bn

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Average growth rate in 1996-2007, %
USA	1.9	2.1	2.5	3.8	5.8	5.5	5.7	6.8	8.4	9.4	13.6	14.8	20.5
Japan	2.4	3.5	3.5	3.0	3.1	2.7	2.2	2.1	2.5	2.7	3.5	3.6	3.7
EU-15	7.1	8.1	10.3	21.9	22.3	28.8	33.7	44.9	49.1	54.9	63.5	79.5	24.6
EU-12	0.3	0.3	0.5	0.6	0.7	0.8	0.9	1.2	2.8	3.0	3.9	5.0	29.8
India	0.0	0.0	0.0	0.0	0.6	0.9	0.9	0.7	0.9	1.3	2.0	3.5	81.0
Canada	0.5	0.7	0.7	2.0	2.4	2.3	2.3	2.8	3.0	3.6	4.3	4.6	21.7
China	0.3	0.2	0.3	0.3	1.1	1.0	1.3	1.6	1.7	2.2	3.2	4.3	26.3

Source : TSD

Table A5.1.7

Imports of R&D, USD bn

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Average growth rate in 1996-2007, %
USA	1.4	2.6	2.2	3.7	5.5	3.6	4.8	5.2	5.9	7.0	7.4	9.2	18.9
Japan	0.1	0.1	0.2	0.3	0.2	0.3	0.4	0.6	0.6	0.8	0.9	1.0	19.8
EU-15	11.8	8.1	9.5	9.7	10.3	10.4	19.3	28.2	26.5	30.4	32.0	38.1	11.2
EU-12	0.1	0.1	0.1	0.1	0.2	0.4	0.4	0.4	0.9	2.1	1.3	1.5	33.2
Canada	0.6	0.7	0.9	2.2	2.8	2.0	1.6	2.3	2.5	2.6	2.9	3.1	16.7

Source : TSD

Table A5.1.8

Imports of other business services, USD bn

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Average growth rate in 1996-2007, %
USA	31.5	29.1	25.3	21.2	17.6	19.2	18.9	16.2	17.2	18.2	20.1	23.2	-2.8
Japan	13.0	11.9	8.7	18.3	17.8	17.4	18.2	16.7	18.3	21.8	22.3	27.7	7.1
EU-15	87.1	92.9	105.0	122.0	129.6	142.3	155.7	180.0	189.3	200.6	220.6	274.9	11.0
EU-12	6.8	6.0	7.1	6.5	6.7	6.5	7.5	8.8	9.8	11.2	14.5	18.8	9.7
India	2.9	3.3	4.6	7.1	4.2	3.9	4.3	7.6	10.6	12.5	16.4	15.2	16.1
Korea	6.5	6.5	6.4	5.7	6.9	6.6	6.6	6.8	7.5	8.6	9.1	12.6	6.2
China	7.2	0.2	0.3	0.2	0.9	1.8	3.4	4.6	6.3	8.6	10.5	14.4	50.6

Source : TSD

Table A5.1.9

KIBS cost shares in manufacturing, 2007

	cost shares
EU15	9.5
EU12	4.8
USA	4.8
Japan	6.7

Source: GTAP

Table A5.1.10

KIBS cost shares in EU manufacturing by sector

	2001		2007	
	EU15	EU12	EU15	EU12
Processed food	4.0	1.9	8.9	4.3
Beverages and tobacco	5.6	3.5	12.8	7.7
Textiles	4.2	1.8	7.1	3.5
Wearing apparel	4.2	3.7	9.2	6.2
Leather products	4.2	2.6	7.3	3.5
Wood products	3.3	2.2	6.1	3.1
Paper products, publishing	5.6	4.3	9.9	9.1
Chemical, rubber, plastic products	4.6	5.9	11.4	4.9
Non-metallic mineral products	4.0	3.9	9.1	4.7
Metals	3.5	2.6	7.3	4.1
Motor vehicles	4.7	2.7	8.7	3.2
Transport equipment n.e.c.	5.9	2.7	10.5	7.1
Electronic equipment	6.1	5.2	14.9	5.8
Machinery and equipment n.e.c.	6.3	3.4	9.3	5.0
Manufactures n.e.c.	4.0	2.7	8.9	3.4

Source: GTAP

Table A5.1.11

Imported KIBS shares of KIBS costs in manufacturing, 2007

	cost shares
EU15	5.5
EU12	5.3
USA	2.3
Japan	3.7

Source: GTAP

Table A5.12

Direct and indirect KIBS shares of value added in exports

		direct export shares	indirect export shares
2001	EU15	12.1	13.7
	EU12	7.0	8.7
	USA	11.3	13.0
	Japan	5.3	10.3
2007	EU15	10.9	18.0
	EU12	4.4	8.8
	USA	10.2	13.1
	Japan	3.4	10.5

Source: GTAP

Table A5.1.13

RCAs in KIBS

Sector code	Sector description	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
	EU-15												
72	Computer & information	1.20	1.13	1.39	1.25	1.15	1.18	1.21	1.26	1.26	1.22	1.16	1.15
73	R&D	1.90	1.78	1.69	1.20	1.30	0.93	1.39	1.35	1.29	1.41	1.43	1.41
74	Other business services	0.96	0.96	0.98	0.97	1.05	1.11	1.15	1.14	1.21	1.17	1.10	1.11
	EU-12												
72	Computer & information	0.53	0.43	0.33	0.70	0.60	0.65	0.65	0.63	0.68	0.77	0.78	0.74
73	R&D	0.07	0.09	0.14	0.26	0.45	0.69	0.53	0.53	0.88	1.37	1.31	1.30
74	Other business services	0.95	0.81	0.75	1.03	1.03	0.94	0.99	1.03	1.05	0.83	0.92	0.87
	Japan												
72	Computer & information	1.51	1.34	0.99	1.04	0.89	0.75	0.56	0.51	0.41	0.43	0.50	0.50
73	R&D	0.07	0.07	0.08	0.10	0.12	0.14	0.12	0.14	0.14	0.25	0.17	0.14
74	Other business services	1.33	1.02	0.93	1.01	0.84	0.88	0.87	0.76	0.58	0.53	0.47	0.66
	US												
72	Computer & information	1.11	1.07	0.80	0.97	0.72	0.65	0.66	0.55	0.49	0.48	0.50	0.52
73	R&D	0.41	0.50	0.56	1.09	1.15	1.07	1.12	1.12	1.47	1.40	1.33	1.34
74	Other business services	0.68	0.76	0.74	0.73	0.90	1.00	0.93	0.90	0.85	0.84	1.14	1.18

Source: TSD, authors' calculations

Table A5.1.14

RCAs in technology-intensive goods

Sector code	Sector description	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
							EU-15						
29	Machinery and equipment n.e.c.	1.26	1.34	1.34	1.33	1.34	1.35	1.35	1.36	1.35	1.37	1.41	1.38
30	Office, accounting and computing machinery	0.93	0.86	0.88	0.83	0.79	0.82	0.75	0.73	0.73	0.75	0.76	0.64
31	Electrical machinery and apparatus	1.03	1.09	1.05	1.00	0.99	1.00	0.98	1.00	1.01	1.00	1.02	1.03
32	Radio, television and communication equipment and apparatus	0.71	0.70	0.72	0.70	0.70	0.70	0.65	0.59	0.58	0.62	0.65	0.52
33	Medical, precision and optical instruments, watches and clocks	0.92	0.98	0.96	0.95	0.97	0.99	1.02	1.04	1.04	1.06	1.08	1.05
34	Motor vehicles, trailers and semi-trailers	1.12	1.21	1.20	1.24	1.34	1.34	1.33	1.38	1.40	1.40	1.41	1.41
35	Other transport equipment	1.00	1.10	0.99	1.02	1.12	1.09	1.08	1.12	1.12	1.11	1.13	1.06
							EU-12						
29	Machinery and equipment n.e.c.	0.82	0.73	0.91	0.96	0.98	1.01	0.98	1.06	1.09	1.17	1.20	1.12
30	Office, accounting and computing machinery	0.14	0.06	0.12	0.14	0.15	0.21	0.49	0.41	0.45	0.50	0.61	0.70
31	Electrical machinery and apparatus	1.15	0.99	1.37	1.41	1.40	1.50	1.52	1.66	1.66	1.64	1.69	1.70
32	Radio, television and communication equipment and apparatus	0.48	0.44	0.50	0.47	0.54	0.60	0.54	0.54	0.56	0.55	0.63	0.76
33	Medical, precision and optical instruments, watches and clocks	0.37	0.31	0.34	0.33	0.32	0.32	0.32	0.35	0.37	0.37	0.36	0.37
34	Motor vehicles, trailers and semi-trailers	0.66	0.63	0.93	1.01	1.27	1.24	1.31	1.36	1.41	1.50	1.67	1.71
35	Other transport equipment	0.87	0.50	0.77	0.82	0.76	0.87	0.91	0.99	0.92	0.87	0.78	0.74
							Japan						
29	Machinery and equipment n.e.c.	1.51	1.57	1.46	1.53	1.75	1.66	1.61	1.73	1.83	1.86	1.89	1.92
30	Office, accounting and computing machinery	1.92	1.70	1.65	1.44	1.24	1.28	1.19	1.03	0.96	0.89	0.86	0.40
31	Electrical machinery and apparatus	1.46	1.52	1.49	1.54	1.63	1.55	1.45	1.45	1.47	1.49	1.47	1.40
32	Radio, television and communication equipment and apparatus	2.19	1.86	1.86	1.81	1.67	1.68	1.68	1.80	1.71	1.59	1.51	1.55
33	Medical, precision and optical instruments, watches and clocks	1.60	1.64	1.57	1.65	1.90	1.82	1.73	1.82	1.97	1.89	1.80	1.56
34	Motor vehicles, trailers and semi-trailers	1.78	1.96	1.96	1.97	2.06	2.20	2.34	2.32	2.23	2.35	2.58	2.58
35	Other transport equipment	1.22	1.22	1.17	1.16	1.27	1.24	1.24	1.27	1.34	1.42	1.40	1.36
							US						
29	Machinery and equipment n.e.c.	1.13	1.27	1.22	1.24	1.37	1.34	1.33	1.27	1.33	1.40	1.41	1.29
30	Office, accounting and computing machinery	1.68	1.43	1.35	1.28	1.25	1.21	1.10	1.14	1.12	1.11	1.08	1.08
31	Electrical machinery and apparatus	1.00	1.07	1.04	1.06	1.12	1.12	1.11	1.08	1.10	1.09	1.12	1.03
32	Radio, television and communication equipment and apparatus	1.42	1.30	1.30	1.38	1.28	1.25	1.19	1.21	1.13	1.05	1.01	0.98
33	Medical, precision and optical instruments, watches and clocks	1.53	1.64	1.66	1.73	1.85	1.91	1.94	1.94	1.94	1.90	1.90	1.86
34	Motor vehicles, trailers and semi-trailers	0.89	0.96	0.91	0.93	0.99	0.97	1.03	1.03	1.03	1.10	1.12	1.10
35	Other transport equipment	2.07	2.25	2.43	2.45	2.25	2.38	2.49	2.44	2.49	2.76	2.94	2.98

Source: UN COMTRADE, authors' calculations

Annex 5.2 – Sectoral aggregation used in GTAP

1 aff	Agriculture, forestry, fisheries
2 egy	Energy
3 omn	Minerals n.e.c.
4 prf	Processed food
5 b_t	Beverages and tobacco products
6 tex	Textiles
7 wap	Wearing apparel
8 lea	Leather products
9 lum	Wood products
10 ppp	Paper products, publishing
11 crp	Chemical, rubber, plastic prods
12 nmm	Non-metallic mineral products
13 mtl	Metals
14 mvh	Motor vehicles and parts
15 otn	Transport equipment n.e.c.
16 ele	Electronic equipment
17 ome	Machinery and equipment n.e.c.
18 omf	Manufactures n.e.c.
19 wtr	Water
20 cns	Construction
21 trd	Trade
22 otp	Transport n.e.c.
23 wtp	Sea transport
24 atp	Air transport
25 cmn	Communication
26 ofi	Financial services n.e.c.
27 isr	Insurance
28 obs	Business services n.e.c. **(KIBS)**
29 ros	Recreation and other services
30 osg	PubAdmin/ Defense/ Health/ Education
31 dwe	Dwellings

6. Conclusions

This chapter considered the role of knowledge intensive service sectors in the EU economies as compared to other major economies like the US and Japan. This was done from different perspectives pointing towards the various trajectories the phenomenon of 'quarternisation' (Peneder et al. 2003) might take. Particularly, it was outlined that, first, this 'quarternisation' process is not to be seen as a mere increase of the shares of services in the overall economy but that these services play an increasingly important role of intermediate inputs into manufacturing and into high-tech manufacturing in particular. This was documented by studying the overall shares of intermediate inputs, the respective backward and forward linkages between KIBS and manufacturing and their role in carrying product embodied knowledge flows. Second, there is also in important role of manufacturing industries and firms in the process of an increase of the general share of services as there is evidence that more and more manufacturing firms (in particular firms in high-tech innovation intensive sectors) provide more and more service outputs along their manufacturing goods. Finally, we pointed towards the increasing role of service trade in overall trade, related it to the patterns of trade in high-tech manufacturing goods and the relative importance of imported KIBS services in production costs and the increasing share of KIBS shares in value added exports. However, the sections also pointed towards important and persistent differences across countries with respect to the issues just outlined; in particular within the EU there are large gaps across countries with respect to the shares of services as outputs, the use of services as inputs and the traded services.

In more detail, in Section 2 we pointed towards the increasing importance of KIBS in the EU economies and compared these to Japan and the US. Though the increasing importance of KIBS for all economies considered here is clearly seen in terms of rising shares in employment and value added the concerning question on whether there has been a tendency of convergence in the sectoral structures and the share of KIBS in particular cannot be answered in a confirmative way. There is no overall convincing statistically significant tendency of such a convergence process. The evidence found here is though the shares are growing in most countries, the countries having lower shares do not have increased them in a particularly faster way. The second issue covered in this section was on the role of KIBS as inputs into the total economy and into high-tech manufacturing in particular. Here we first find some evidence on the growing importance of KIBS as inputs in the total economy and particular subsectors, but also a gap between the EU and the US with the EU lagging behind in high-tech manufacturing when only looking at the simple arithmetic mean across countries. The mean over EU countries however hides important cross country differences. Looking in more detail at these figures at the country level one can find that the most advanced European economies like Germany do have similar shares as the US whereas for example the EU-10 lag far behind. Finally, using input-output techniques we studied the forward and backward linkages of KIBS industries in more detail.

Section 3 outlined the structure and strengths of domestic and international inter-industry knowledge flows. R&D performed within the sector determines only part of the total technology flows the economy. Technical knowledge embedded in intermediate goods, sourced both domestically and abroad, make up an important part of the total technology flows, especially in those countries attempting to catch-up with the technological leaders. It is equally important for countries on the global technology frontier and considerably more important for those countries below it. Product embodied knowledge plays an important role in the catching-up, or convergence, process of economies below the global technology frontier. At the frontier, economies rely more on domestic R&D performance than on inter industry, domestic or international, technology flows, while for the countries behind the frontier, international embodied technology flows provide important into the convergence process. Two dimensions determine the structure of embodied technology flows and their relative importance to intra-industrial R&D performance. The first is the openness of the national economy to international trade, having a strong co-linearity with the size of the economy, and the second is the national position vis á vis the global technology frontier. For the catching-up knowledge users, Kaldor's argument that manufacturing is the engine of productivity growth remains valid, as shown by downstream links from manufacturing to KIBS sectors. Inter-industry technology flows from abroad are particularly important. However, for the knowledge supplying economies at the technology frontier, the forward impact of manufacturing on KIBS is substantially diminished relative to the catching-up economies. KIBS have a stronger forward, downstream impact on manufacturing. In these economies KIBS appears to be a significant source of knowledge into the manufacturing industries, alongside the technology generation within these manufacturing industries along with their own R&D performance.

The next section, Section 4, then provided evidence that European manufacturing firms increasingly offer services along with their physical products. The share of services in the output of manufacturing industries increased in the large majority of countries over time. However, service output is still small compared to the output of physical products. The service share tends to be larger in smaller countries and higher in countries with a higher R&D-intensity. EU-12 Member States have lower shares of service output compared to the EU-15. At the sectoral level, we see a higher service share in innovation-intensive sectors, such as the manufacturers of electrical and optical equipment, machinery, or the chemical and pharmaceutical industry. Service output is highest among small and among large firms. Producers of complex, customized products tend to have a higher share of services in output than producers of simple, mass-produced goods. The results clearly show the manifold interactions between KIBS and manufacturing. KIBS are not only an important input for manufacturing, but are also offered by manufacturing firms to gain competitiveness, increase profitability, and generate additional value for customers by offering product-service combinations. KIBS produced by manufacturing firms have a considerable share on total KIBS exports and contribute to trade in services.

Finally, in Section 5 we pointed towards the increasing importance of trade in services and the particular role EU countries play in this field. In particular, the EU-15 has on average stronger revealed comparative advantages in KIBS exports, than in technology-intensive merchandise exports. Further we pointed towards the increasing importance of imported KIBS in the costs structures of manufacturing and the KIBS shares of European and other countries value added exports. The latter show an increasing tendency which points to the particular role KIBS play in EU's external competitiveness.

From a policy perspective this study therefore pointed towards the increasing importance of KIBS in various respects and that, overall, the EU and particularly the EU-15 does not underperform to other major economies like the US and Japan. However, the study also pointed towards the significant differences across EU member states and the lack of any kind of convergence process which might be expected to take place. Thus, the investigated structures and relationships seem to be quite persistent thus that one might be allowed to speak of a general 'quaternisation' process across countries. With respect to the EU countries there have been however achievements with respect to the Service Directive which has been implemented in many countries over the last years though to a varying extent.[19] As, however, the implantation process is still not completed and the persistency seems to be quite strong in some respect it is too early to do an evaluation of these efforts with respect to whether, in which respect and to what extent there has been 'convergence' took place across countries due to the implementation process. This study however pointed towards the potential gains which can be quite large for some countries with respect to potential efficiency gains.

[19] See e.g. documents at http://ec.europa.eu/internal_market/services/docs/ and http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=SEC:2011:0102:FIN:EN:PDF

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