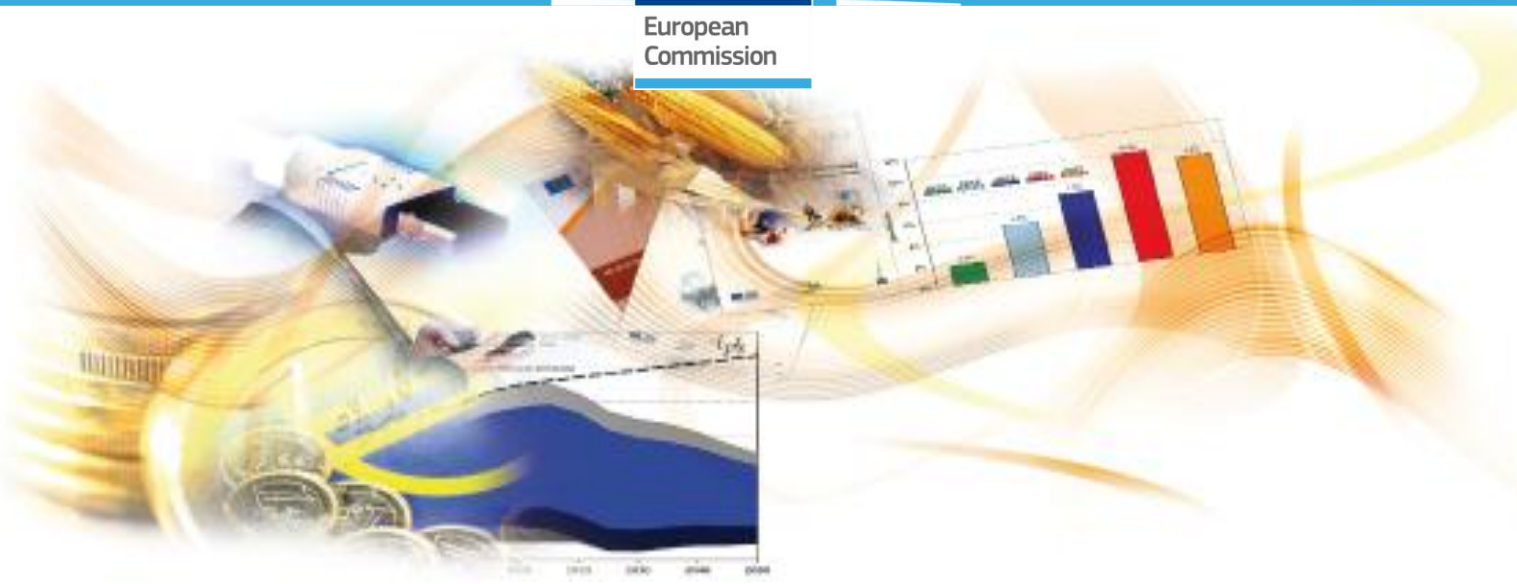

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To what extent are knowledge-intensive business services contributing to manufacturing? A subsystem analysis

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Abstract

The rise of knowledge-intensive business services (KIBS) may be considered as one of the decisive trends of economic evolution of industrialised countries in recent decades. This paper uses the concept of vertical integrated sectors and the subsystem approach to input-output matrix analysis to study the vertical integration of knowledge-based business services into manufacturing sectors. To date, companies increasingly rely on outside innovation for new products and processes and have become more active in licensing and selling results of their innovation to third parties. At the same time, they may rely on the marketing and financial consulting offered by third parties. As a consequence, considering manufacturing and KIBS as vertically inter-related sectors, the hypothesis of a virtuous circle can be expressed in the following way: the higher the degree of integration between KIBS and manufacturing sectors along what we could define as a 'knowledge-based value chain', the easier the knowledge diffusion and the competitiveness of the economic system as a whole. The study covers Germany, France, Italy, and the United Kingdom over the period 1995-2005. Results decisively support both the existence of structural differences among the countries considered, and a significant heterogeneity to the extent to which manufacturing outsources to knowledge-intensive business services.

Keywords: Knowledge-intensive business services; subsystem approach; input-output analysis; knowledge diffusion.

JEL Classification: L60, L84, 033, 032, P00

1 Introduction

The rise of services in industrialised countries, particularly of knowledge-intensive business services (KIBS),[1] may be considered one of the main characteristics of the establishment of the knowledge economy over recent decades. Nowadays, to bring new products, processes and services to the market, firms have to mobilise a broad set of skills, which are often beyond their internal capabilities and which include not only technical skills, but also market analysis, logistics and behavioural sciences (OECD, 2007). Co-operation with other firms and outsourcing enable enterprises to use their own internal knowledge resources optimally, to combine them with specific competencies of their partners, to further specialise and enhance their competitive advantage (Coffey and Bailly, 1991; Porter, 1990; Abramovsky et al., 2004; OECD, 2007). In this framework, a product can be represented as the association of various constituent services and technical characteristics (material and immaterial; Gallouj and Weinstein, 1997), and be considered the output of a vertical-integrated production process, along an integrated knowledge-based value chain (Gallouj and Savona, 2009) that cuts across industries (Schettkat and Yocarini, 2006). Not surprisingly, along with this process of knowledge diffusion, the boundaries between manufacturing and services, especially KIBS are becoming blurred. This process of convergence between manufacturing and services may be interpreted as a sign of the transition of advanced countries from service economies to economies based on service relationships (De Bandt and Gadrey, 1994).

At the present time, KIBS are increasingly recognised as important carriers of new knowledge developed in upstream sectors and then diffused into manufacturing industries, which increasingly rely on them as inputs to their production process (European Commission, 2011). As such, their significance goes beyond their large and growing share of GDP, and is deeply rooted in their solid forward linkages with the rest of the economy. Nevertheless, the extent to which KIBS contribute to the economy is generally underestimated as it is usually measured adopting a sectoral approach which cannot account for the shifting boundaries between market and in-house firms' activities.

The aim of this paper is threefold. First of all, we analyse whether a knowledge-intensive tertiarisation process has occurred over time (1995-2005) in France, Germany, Italy, and the United Kingdom.[2] Secondly, we aim at verifying whether the degree of vertical integration between knowledge-intensive business services and the manufacturing sectors differs according to the technological intensity of the latter. Finally, through the analysis of the evolution of KIBS vertical integration, we have attempted to measure whether a phenomenon of manufacturing outsourcing to KIBS has occurred over time (1995-2005). Thus, the paper reaches beyond the question of manufacturing outsourcing to KIBS to deepen our understanding of the evolution of industry in the countries analysed. To this end, we applied a subsystem approach (Momigliano and Siniscalco, 1982) to the OECD STAN Input-Output database 2010 edition.[3]

The methodology proposed cannot be used to — and it is not intended to — establish a causality relationship between KIBS diffusion within an economic system and the economic system's

[1] The definition of KIBS generally includes computer and related services (NACE 72), research and development services (NACE 73), and other business services (NACE 74), which include legal, marketing and advertisement, business consulting and human resource development services, and other more *operational* services.

[2] The choice of these countries was determined by the fact that they are the four 'largest' European countries in terms of gross domestic product - representing almost 63% of the UE27 GDP.

[3] The database supplies symmetric industry-by-industry input-output tables for the whole economy, for the domestic economy and for imports at 2-digit ISIC rev. 3 (compatible with NACE rev. 1).

competitiveness. However on the basis of the vast economic literature in the field, it can be argued that structural differences in the direct and indirect use of KIBS between high, medium and low technology manufacturing sectors among countries would likely be reflected in disparities in the generation and diffusion of knowledge by firms between countries. This, in turn, would induce inequalities in competitiveness. Stated simply, the strength of interactions among suppliers, producers and users of advanced technologies and the existence of established and well-functioning sets of vertical linkages may be considered as a major source of competitive advantage (Porter, 1990; Lundvall, 1992; Castellacci, 2008). As a consequence, the hypothesis of a virtuous circle can be expressed in the following way: as new technologies and know-how are generated through the interaction of companies and their environment and are further developed internally, the higher the degree of integration between KIBS and manufacturing sectors along what we could define as a 'knowledge-based value chain', the easier the knowledge diffusion and the success of the economic system as a whole.

The paper is organised as follows. The following section briefly explains the reasons why to focus on the integration of KIBS within national economic systems. Section 3 clarifies why a subsystem approach to input-output has to be preferred to a traditional input-output analysis of inter-industry links. To make this clear, it explains the methodology and shows — by means of an applied example — the main differences in terms of results between the two approaches. Section 4 shows the results obtained at an increasing level of disaggregation, starting from considering KIBS as an aggregate sector, and then disaggregating them into (1) computer and related services, (2) research and development services, and (3) other business services. Finally, Section 5 sums up the empirical findings and discusses them, concluding the paper.

2 Which KIBS and when?

The increasing economic importance of KIBS has been interpreted as being the counterpart of the establishment of the so-called "ecosystem of innovation", an innovation paradigm in which firms depend in various ways on the expertise of their different partners. That is to say, the extent to which KIBS are integrated with the other sectors of economy reflects not only a general increased demand for knowledge, but also an increasing division of labour due to firms' decisions about making or buying (Coase, 1937; Riordan and Williamson, 1985), a choice which reconfigures the sectoral structure of an economic system (Montresor and Vittucci Marzetti, 2010 and 2007). Among the different types of service activities, the knowledge-intensive business services stood out because of their 'special' characteristics, summarised in a widely cited paper by Miles et al. (1995): they rely greatly on professional knowledge and are sources of knowledge and are of competitive importance for their clients. Knowledge-intensive business services are generally defined as 'consultancy' or intermediary firms in a broad sense. These companies are specialised in knowledge screening, assessment and evaluation and the trading of professional consultancy services (Consoli and Elche-Hortelano, 2010), and perform, mainly for other companies, 'services encompassing a high intellectual value-added' (Muller, 2001) providing customised problem solving assistance for their clients, through tacit and codified knowledge exchange. As such, KIBS play a twofold role, acting as an external knowledge source for their client firms and introducing internal innovations (Den Hertog, 2000; Miles, 2005; Toivonen, 2004; Muller and Zenker, 2001; Wood, 2005). Consequently, KIBS are responsible for the combination of knowledge from different sources, and for the distribution of knowledge itself (David and Fouray, 1995), a procedure which - far away from being automatic - requires specific supporting functions (Hipp and Grupp, 2005).

In the innovation-oriented economic literature there are two prevailing approaches to the study of these business services. The first approach points out their function as 'bridges' for knowledge (Czarnitzki and Spielkamp, 2000) and as 'holders' of proprietary 'quasi-generic' knowledge, which is generated from interactions with customers and the scientific community. This is the case of the papers by Strambach (2001) andGlücker (1999), where the emphasis is placed on the generation, diffusion and creation of knowledge by the interactions between KIBS and their clients. The second approach, on the other hand, starts from the concept of a 'national innovation system' (Nelson, 1993) and ascribes to KIBS three major functions: they are facilitators', 'carriers' and 'sources' of innovation for their client firms (Den Hertog and Bilderbeek, 1998; Hipp et al., 2000). As KIBS provide services and knowledge to the rest of the economy and deliver knowledge or services which are complementary to the manufacturing industry's products or to other services, their use and integration within manufacturing and other services within a country is the result of the country's established industrial structure and specialization. Clearly, the existence and the extent to which knowledge networks operate translate themselves into support for firms at different stages of the production as each stage of the product and business life cycle needs different knowledge intensive services. R&D services are generally provided in the early stages of the process, while intellectual property rights, commercialization, marketing and production process development tend to be more important at the end of it. All in all, the use of externally sourced services typically increase at more mature stages of the product life cycle: many software firms specify, design and implement new product using internal resources, and require outside assistant for business strategy formulation and finance, followed by legal services.

In addition, the demand for KIBS (and the ability to make use of them) changes according to several dimensions such as firms' size and division of labour, business model, knowledge base, sector specialisation and the degree of internationalisation (OECD, 2007). All these factors will likely lead to a high level of country heterogeneity in KIBS use and impact. For instance, a start-up firm may not be able to afford to pay for an external service, so it provides it by itself. Consequently, a country (and/or a sector) that is 'rich' in start-ups and micro/small firms may be characterised by a lower level of KIBS vertical integration into manufacturing than a country (and/or sector) where large firms prevail. In fact, as the business grows, a firm can pay for outsourcing the service, and, eventually, the firm is large enough to hire a specialist to perform the service internally. At the same time, the demand for KIBS varies according to the firm's business model. If a firm aims at becoming vertically integrated, it will always tend to learn enough to incorporate the service and even if it is small, perhaps focused on a particular technology, it may decide to adopt a strategy of outsourcing everything possible. Marketing and design support are essential to enter (and stay) in markets for highly differentiated products, and are fundamental activities for matching consumers' needs and expectations. Business service providers and research technology organisations appear to be especially important for firms that are expanding into international markets as they are often used to support business management and development. Legal services may be extremely useful if a firm decides to grow through mergers and acquisitions (in this case backing and financial assistance are fundamental too). Finally, a firm that is seeking to develop a new product or services has distinctively different profile needs in terms of KIBS from the one trying to break into an international market with a more established product.

To conclude, KIBS contribute in a unique and essential way to knowledge dynamics in firms, sectors and territorial contexts through the attributes and production of their products (Strambach, 2008). Within this context, the knowledge created by these industries is not only an object, i.e. a public or private good that can be exchanged; it is, as Antonelli (2005) underlines, a collective and complex path-dependent activity.

3 Methodological Approach

Over the years 1995-2005, KIBS employment share measured in terms of total employment in market services is found to converge across the four countries analysed: in 2005 the range was close to 30%. This last finding supports the need to investigate the extent to which KIBS are integrated within manufacturing subsystems along with the structural change that took place in the market services sector, as their development required the KIBS contribution to be sized at a specific cut-off threshold.

However, this paper does not focus on KIBS sectors per se, but on their function as carriers and sources of knowledge which influence the performance of firms, value chains and clusters across industries and within countries. Differently from previous studies, we are concerned with the contribution of KIBS to the final demand of manufacturing sectors and with how this 'contribute' changes, according to the manufacturing sector's technological intensity among countries, whose evolution is part of the overall process of structural change that would interest an economy over time. Therefore, data on intersectoral flows and input-output analysis are needed. However, in a standard approach[4] to input-output analysis, the economy is disaggregated into sectors which are conceived of as if they were vertically integrated models of production, but in reality they are not, i.e. they are not complete production systems, as they are still inter-linked with the rest of the economy. In fact, an intermediate good is a composite product and it is likely that the sector buying the intermediate product contributed directly or indirectly to its production. Besides, a traditional approach cannot give any insight into the use of intermediate inputs by a specific production as a consequence of a re-organisation of manufacturing value chains. That is to say, if some business activities previously performed 'in house' by manufacturing companies are outsourced to specialist subcontractors, this reorganisation of the value chain will not be captured by such an input-output analysis. We would observe an increase in the share of the services sector and a decrease in manufacturing though these activities were still satisfying the final demand of manufacturing. Consequently, a sector approach is extremely sensitive to changes in the way firms organise their production processes, which could be erroneously thought of as a 'sign' of structural change. This approach is unable to capture the effects of outsourcing on the whole set of relationships within an economic system (Montresor and Vittucci Marzetti, 2010).

Differently from the Leontief approach, the subsystem approach (Momigliano and Siniscalco, 1982) enables the classification of each industry to obtain a well-defined, independent and complete production system, with no other exchange with the rest of the economic sectors. That is to say, the economy is disaggregated into sectors 'which are vertically integrated models of production' (Sraffa, 1960; Pasinetti, 1973). The logic behind this is to classify each industry on the basis of its final product to identify each industry's contribution to each production process.[5] As such, a 'vertically integrated sector' is defined as the overall activities directly 'and indirectly' used in the economic system to satisfy the final demand for a certain product.

[4] For instance, Petit (1986), Russo and Schettkat (1999, 2001), and Gregory and Russo (2007) have performed input-output analysis to determine the inter-industry division of labour and the extent of outsourcing from the manufacturing to the services sectors (for a review see Schettkat et al., 2006). Within the literature on service innovation (Drejer, 2004; Miles, 2005), the growing interdependence between the manufacturing and services branches of the economy has been analysed by Guerrieri and Meliciani (2005), Miozzo and Soete (2001) and Evangelista (2000).

[5] Here any *flow input - flow output* process is broken down into as many *point input- point output* processes as there are stages of production. Thus all processes constituting a system of production can be represented by matrices of input and output respectively.

The first step of the subsystem approach to input-output matrices consists of reorganising the input-output matrices expressed at current prices (for each year and each country) through an operator (B) which re-classify any variable from a sector base to a subsystem one. Once this operator has been applied, we obtain a table (for each year and each country) in which all the links among the subsystems considered and the different branches that contribute to them are shown. Momigliano and Siniscalco (1982) referred to the concept of a subsystem by constructing the following matrix (the circumflex symbol is used to denote diagonalisation):

$$B = \hat{q}^{-1}(I - A)^{-1}\hat{y} \qquad (1)$$

in which $\hat{q}$ is the diagonalised vector of gross production, A is the matrix of domestic flow-based input-output coefficients and $\hat{y}$ is the diagonalised vector of final demand.

Each row of B adds up to one and shows the proportion of the activity of each branch which comes under the different subsystems. As such, the analysis of B has been generally used to detect whether a process of tertiarisation or de-industrialisation occurred over time. As far as its characteristics are concerned, B is influenced neither by relative prices6 — the results are the same no matter whether B is calculated starting from matrices expressed at current or constant price, or in quantities 7 — nor by decentralization of production phases across industries. In fact, every subsystem represents all the activities used to satisfy the final demand for a particular product, whose total value does not depend on the geographical distribution of the production process whose total value does not depend on the sectoral distribution of the production process (Momigliano and Siniscalco, 1982).

On the basis of B, the matrix C is derived as follows:

$$C = \hat{l}\,B\left(\hat{l}'B\right)^{-1} \qquad (2)$$

in which $\hat{l}$ is the diagonalised vector of labour input (source: OECD STAN database, various years). The generic element of C (cij) measures the share accounted for by sector i in total labour required by subsystem j in order to satisfy final demand. As such, it can be used to detect to what extent the different subsystems (the columns of C) rely on extra-sectoral labour contributions. In particular, each of the cells cjj on the main diagonal inform us about the proportion of total labour, directly and indirectly required to produce the output of a certain branch j, accounted for by branch j itself. Therefore, the closer the value of cjj is to 1 (0) the higher (lower) the level of vertical integration of the branch (i.e. the production process took place entirely within the branch itself and, if close to 0, the more outsourcing processes are relevant to it). At the same time, if we look at each of the C columns (namely at each subsystem) and we add the

[6] As demonstrated by Rampa (1982).

[7] Therefore, service employment is attributed to the subsystems considered without the need to evaluate services in real terms, avoiding the theoretical and empirical problems associated with service deflation (Momigliano and Siniscalco, 1982).

rows corresponding to the knowledge-intensive business sectors, we obtain a second indicator of outsourcing (Montresor and Vittucci Marzetti, 2007). The lower this sum, the less the knowledge-intensive business services are integrated into the subsystem considered.8

The large differences in results obtained through a traditional and a subsystem approach to input-output analysis can be easily grasped by means of an applied example. Table 1 reports the employment share of Services[9], KIBS and Manufacturing sectors (both at aggregate level and disaggregated by technology intensity) in Germany in 1995 and 2005, calculated with a traditional input-output approach and with a subsystem one.

Table 1. Differences in terms of employment share between a tradional and a sub-system approach to I-O analysis.

			Services	KIBS	Manufacturing				
					Total	L	ML	MHT	HT
Germany	Traditional approach	1995	64.6	7.4	22.5	7.2	5.3	8.4	1.6
		2005	71.9	11.8	19.4	5.7	4.6	7.8	1.4
	Sub-system approach	1995	59,0	2.3	27.8	9.4	4.0	12.6	1.8
		2005	62.8	3.6	28.5	8.4	4.5	13.6	2.0

Source : Authors' elaboration on OECD input-output matrices, 1995 and 2005.

As can be easily noted, the industry structures of employment obtained by applying the two methods are highly different (this is confirmed for all countries in the analysis; the results are available on request). For instance, in 2005 Services accounted for 71.9% of total employment if a traditional approach is used and for 62.8% if a subsystem approach is preferred. Overestimation appears even larger if we look at KIBS, suggesting that their indirect contribution to satisfying the final demand of other sectors is generally strongly underestimated. The opposite trend is observed for Manufacturing: if we use a subsystem approach (i.e. if we consider the whole re-organization of production across the economic system) these industries accounted for 27.8% of total employment in 1995 and for 28.5% in 2005 (instead of, respectively, 22.5% and 19.4%). That is to say, the data confirms a substantial underestimation of the manufacturing employment share and, at the same time that in Germany the employment weight of Manufacturing increased over the years considered. If we consider the manufacturing industries according to their global technological intensity, a traditional approach especially underestimates the employment share of the medium/high -tech sectors. In 2005 they accounted for 13.6% of total employment when considered as a vertical integrated sector, while only for 7.8% if a traditional approach is used. This might suggest that among German manufacturing industries, medium/high-tech ones are those more reliant on other sectors to satisfy the final demand for their products, and that an approach which cannot tackle the reorganisation of the production process across sectors tends to underestimate the employment creation

8 Furthermore, **B** and **C** measure shares do not depend, respectively, on sectoral labour productivities or on the final demand structure (Montresor and Vittucci Marzetti, 2010). In fact, on the one hand **B** calculates the shares of each subsystem in each relevant sector, for example in terms of employees. Therefore, changes in total employment in a certain sector, with gross production constant, do not affect these shares. On the other side, if constant returns to scale are assumed (or if we assume that all sectors share the same patterns of returns to scale, either increasing or decreasing), C is not affected by changes in the composition of final demand. If, instead, "returns to scale are increasing in the manufacturing sector only, an increase in industrial demand might lead to a decrease in the manufacturing elements of **C**" (Montresor and Vittucci Marzetti, 2010, p. 6). This would actually imply that even if a subsystem approach is used, manufacturing capacity of activating employment might continue to be underestimated, although to a lesser extent than in the case of a traditional I-O approach.

9 The Service aggregate is based on the two-digit ISIC REV 3 classification used in the OECD I-O tables including Market services (in which KIBS are comprised) and Non market services.

capacity of manufacturing sectors, especially of those which increasingly rely on outsourcing. More importantly, the lack of consideration of both the 'direct' and 'indirect' uses of intermediate input may lead even to misleading results. If we consider the classification of manufacturing in low, medium/low, medium/high and high-tech sectors, a traditional I-O approach shows that from 1995 to 2005 their relative weight in terms of employment decreased. Instead, a subsystem approach suggests that their weight has increased. The employment share of the medium/low tech sectors increased from 3.95% to 4.53% (vs a decrease from 5.3% to 4.6%), that of the medium/high-tech sectors from 12.56% to 13.61% (vs 8.4% to 7.8%), and that of the high-tech sectors from 1.85% to 2% (vs 1.6% to 1.4%). Overall, the differences in results obtained by applying a traditional and a subsystem approach are due to the fact that the former does not properly account for those employees formally employed in services but who are working to satisfy the final demand for non-service sectors.10 Clearly, these findings do not imply that the increase in the employment share of German services sectors is an effect of an increase in the final demand for manufacturing sectors, but only that in order to obtain a reliable picture of the structure of an economy these indirect links must be properly accounted for.

Finally, a last disclaimer is needed. The matching between the sectoral level and the firm level of analysis of outsourcing, although reasonable, is not trivial as input-output tables are built using the 'establishment', and not the firm, as the unit of analysis. However, as pointed out by Montresor and Vittucci Marzetti (2007), given the particular nature of service output (neither storable nor transportable), firms rarely set up separate establishments for the 'in-house' provision of services, especially in the case of knowledge-intensive services. It follows that in the case of KIBS outsourcing, the focus of this paper, the bias due to dealing with establishments and not with firms is likely to be limited.

4 Results and Discussion

As KIBS provide services and knowledge for the rest of the economy and deliver knowledge or services which are complementary to the manufacturing industry's products or to other services, their use and integration within manufacturing and other services within a country is the result of the country's established industrial structure and specialisation.

Hereinafter, with the term 'KIBS vertical integration' into low, medium/low, medium/high and high-tech manufacturing subsystems we will refer to the input of KIBS to low, medium/low, medium/high and high-tech final demand of manufacturing in terms of subsystems' total employment11. Namely, in the case of KIBS vertical integration we will look at the columns of matrix C, at each subsystem separately (i.e. if total employment to satisfy the subsystem j final demand is 100, how much of this amount is accounted for — directly and indirectly — by KIBS employees?). As such, the focus is on the extent to which manufacturing sectors rely on KIBS to satisfy the final demand for their products, while in the latter (KIBS contribution) the focus is on the extent to which KIBS contribution is spread throughout the economic sectors. As the term 'outsourcing' usually defines a process through which a certain firm switches from making a certain activity in-house to buying its outcome from an external provider, by using input-output tables, an outsourcing process can be only identified (with the caveats previously stressed) if — comparing the C

[10] At this stage we cannot know whether this demand comes from manufacturing (and from which manufacturing sectors) and/or from the rest of the economy.

[11] The aggregation of the manufacturing sectors by technology intensity has been carried out following the Eurostat criteria while considering the ISIC REV. 3 sectoral breakdown of the Oecd Input-Output Tables.

matrix of country i over time by subsystem — we observe an increase of KIBS contribution to the j subsystem final demand. In fact, only looking at a C matrix in one specific year does not give us any information about outsourcing, as we do not know if the service that is 'bought' by subsystem j from KIBS at time t, was provided internally at time t-1. Having clarified this, we will firstly consider KIBS as an aggregate sector, and then we will disaggregate it into: (1) other business services (2) computer and related services, (3) research and development services.[12]

4.1 Manufacturing vertical integration and the use of KIBS: 1995-2005

Overall, the results of the subsystem IO analysis show that in the period 1995-2005 KIBS vertical integration into manufacturing remarkably increased in three out the four countries analysed (Table 2). The empirical evidence shows that KIBS are generally more integrated with the medium/high-tech subsystems than with the other manufacturing ones, and that the extent of this integration varies significantly among countries. In 1995, France was the country in which manufacturing relied more on extra-labour input from KIBS, followed by the United Kingdom, and by Germany and Italy with the lowest level of vertical integration into manufacturing. At the end of the period, although France was still the best ranking country in terms of vertical integration into manufacturing with KIBS, Germany caught up, followed — at a large distance — by the United Kingdom and Italy. On the base of the results, the four countries can be clustered into two distinct groups bearing similar patterns of KIBS integration: on the one hand France and Germany, and on the other hand, Italy and the United Kingdom.

As far as France and Germany are concerned, the extent to which manufacturing relies on KIBS employees to satisfy its final demand has been continuously growing across all the subsystems analysed since 1995. In addition, the extent to which employees formally employed in KIBS directly and indirectly contribute to manufacturing is higher as we move from low-tech to high-tech subsystems. However, a clear-cut evolution of the sectoral patterns of KIBS vertical integration emerges over time. In fact, while in 1995 KIBS vertical integration appears to be much higher in the medium and high-tech industries than in the medium and low-tech ones in both countries, at the end of the period a more even pattern of the KIBS share is singled out across all manufacturing subsytems in France, but not in Germany. At the same time, the sectoral patterns of KIBS vertical integration observed in 2005 for the two economies appear to be more similar than at the beginning of the period, due to the accelerated growth of KIBS vertical integration into manufacturing subsystems in Germany. All in all, these results show that between 1995 and 2005 Germany caught up with France, although the former held a lower degree of KIBS vertical integration across all four manufacturing subsystems than France. In addition, the development of German advanced services turned out to be more concentrated in the medium and high-tech manufacturing subsystems.

[12] Data are always obtained from matrices of different sizes; however, calculus have been carried out at the highest disaggregated level available, and then aggregated at the chosen level of analysis to avoid distortions, which are usually encountered when aggregated input-output tables are used.

Table 2 KIBS vertical integration within manufacturing subsystems, 1995-2005.

		L	ML	MHT	HT
1995	France	10.69	10.51	17.42	18.73
	Germany	7.14	7.52	9.40	8.91
	Italy	5.01	7.56	8.42	7.74
	United Kingdom	8.68	8.38	10.64	9.51
2005	France	12.45	15.02	20.33	19.92
	Germany	12.32	13.10	16.98	16.33
	Italy	7.93	11.27	11.87	7.20
	United Kingdom	8.76	8.19	10.60	8.20

Source: Authors' elaboration on OECD input-output matrices, 2005.

On the other hand, in the United Kingdom and Italy we generally observe a lower contribution of KIBS sectors' employment to the final demand of the four manufacturing subsystems analysed, with marked specificities at both subsystem and country level. In fact, although in 1995 the United Kingdom was ranked second in terms of KIBS vertical integration into the manufacturing subsystems (immediately after France), in the following decade quite a slow growth of the direct and indirect contribution of the KIBS sector to the final demand of manufacturing is noted. Moreover, unlike France and Germany, in the United Kingdom this does not show a continuous growth across all the manufacturing subsystems, as in three out of four (low, medium/high and high-tech), an initial increase of the direct and indirect 'use' of KIBS employees by the manufacturing subsystems during the period 1995-2000 is followed by a contraction between 2000 and 2005, which is quite dramatic in the case of the high-tech subsystem. As a result, in 2005 United Kingdom KIBS vertical integration into the high-tech subsystem is found to be almost the same as that of the medium/low-tech ones, and nearly a flat subsystem pattern of the contribution of KIBS emerged. This result shows that the service integration in the United Kingdom manufacturing subsystem increased initially, whilst it decreased from 2000 on, when a significant process of tertiarisation was experienced. This is in line with other empirical studies sharing the same subsystem approach (Montresor and Vittucci Marzetti, 2010 and 2007) that showed a significant overestimation of the United Kingdom's tertiarisation process in the 1980s and 1990s, stressing how their integration with manufacturing (namely manufacturing outsourcing to services) has actually increased. As far as Italy is concerned, over the same decade a high growth of the KIBS direct and indirect employment contribution to the manufacturing subsystems' final demand is observed for the low, medium/low and medium/high-tech subsystems, whereas an overall contraction is recorded for the high-tech subsystems. That is to say, compared to the other manufacturing subsystems, the Italian high-tech manufacturing subsystem is the one that relies least on KIBS. In any case, notwithstanding the increased contribution of KIBS to the final demand of low, medium/low and medium/high-tech manufacturing subsystems observed during the 1995-2005 period (which can be partly interpreted as a sign of increasing outsourcing to KIBS), at the end of the period Italy still held the lowest degree of KIBS vertical integration into manufacturing in the low-tech subsystems and the last position in KIBS vertical integration into high-tech subsystems. Besides, in 2005 the lag vis-à-vis France and Germany is larger than that observed in 1995. In the case of the high-tech subsystem, the degree to which KIBS employees are used to satisfy its final demand turns out to be even lower than that observed in the United Kingdom.

Summing up, in the four main European economies over the period 1995-2005 not only has the increase of KIBS vertical integration into manufacturing proven to be concentrated in the most technologically advanced subsystems (which increasingly rely on outsourcing activities to KIBS), but the sectoral pattern

of KIBS vertical integration has also turned out to be increasingly country specific. To a large extent this process reveals the essential role played by tertiarisation in the dynamics of structural change in the four countries analysed. On the one hand, our analysis suggests the emergence of services as an independent driving force for growth, i.e. KIBS are increasingly used by the Services sector itself (quite in line with previous empirical evidence, for instance Montresor and Vittucci Marzetti, 2010). At the same time, however, along with this general structural trend, the analysis shows that KIBS employees are increasingly directly and indirectly used by the manufacturing subsystems, though to different extents according to the technological intensity of the subsystem and the country considered (given its industrial structure and specialisation). Stated simply, the subsystem analysis of the vertical relationships between KIBS and manufacturing subsystems has shown that the extent to which these categories of services contribute to the final demand of manufacturing has developed according to a subsystem specific pattern of tertiarisation in each country. While it is clear that all the four countries have undergone a process of tertiarisation, differences in the rate of growth of KIBS and in the share of KIBS in total employment have to be considered the result of the adjustment of the economic systems to a knowledge-based production structure where the services sectors, mainly through the KIBS, have played an essential role.

4.2. A disaggregate view of KIBS: 1995-2005

As stressed by many authors in the field, KIBS are characterised by a significant level of heterogeneity which profoundly modifies the way they interact with the manufacturing system. In fact, the way single firms co-operate with other firms and combine different sources of knowledge will differ according to the kind of knowledge-intensive business services used as input. As extensively documented (for instance Consoli and Elche-Hortelano, 2010), though 'the core competences of combining different forms of knowledge to produce a tradable output'[13] is common to all KIBS, these are characterised by a high degree of heterogeneity not only in terms of output but also in terms of educational requirements, occupational structures and skill base. On the one hand, there are knowledge-intensive business services that do not involve changes in the content of information which is trading and amenable to standardisation (computer and related services). On the other hand, R&D and 'other business services' rely more on the ability to formulate client-specific problem-solving strategies, and make up the fields of discretion and cognitive ability. Therefore, knowledge-intensive business services which imply extensive customer contact and client-specific solutions and professional discretion are characterised by a high degree of 'intangibility' and the extent to which they contribute to satisfying the final demand of manufacturing may be considered a proxy of manufacturing firms' need to acquire external intangible resources. Besides, the existence and the extent to which knowledge networks operate is translated into support for firms at different stages in the production and/or the innovation process as each stage of the product and business life cycle needs different knowledge-intensive services. R&D services are generally provided in the early stages of the process, while intellectual property rights, commercialisation, marketing and production process development tend to be more important at the end. All in all, the use of externally sourced services typically increases at more mature stages of the product's life cycle. Many software firms specify, design and implement new products using internal resources, and require outside assistance for business strategy formulation and finance, followed by legal services. To take these sectoral specificities into account, the study of KIBS integration within an economic system must necessarily be conducted at the highest available level of disaggregation.

Table 3 shows that in all four countries and across manufacturing subsystems the most directly and indirectly used category of knowledge-intensive business sectors is 'other business services', and that

[13] Consoli and Elche-Hortelano (2010), p. 6.

their use increases over time. This increased diffusion might be due to two different kinds of considerations. First of all, within this category several services are comprised, and secondly, these are also activities which are relatively easier to outsource given the lower level of tacit knowledge which characterises them. Moreover, the empirical evidence suggests that as we move from the low-tech to the medium/high-tech manufacturing subsystems, the contribution increases, while only a slight decrease is observed in the high-tech subsystems, compared to the medium/high-tech ones.

Tab. 3 KIBS integration into manufacturing subsystems by technological intensity, 1995-2005

		France				Germany			
		L	ML	MHT	HT	L	ML	MHT	HT
1995	Computer and related services	1.27	1.30	1.90	2.03	0.27	0.40	0.38	0.57
	Research and development services	0.32	0.84	2.52	4.17	0.01	0.06	0.09	0.03
	Other business services	9.10	8.37	13.00	12.53	6.85	7.05	8.93	8.31
2005	Computer and related services	1.08	1.14	1.41	1.70	0.34	0.66	0.75	1.04
	Research and development services	0.43	0.92	3.24	5.87	0.02	0.09	0.16	0.14
	Other business services	10.94	12.95	15.67	12.34	11.96	12.35	16.07	15.15

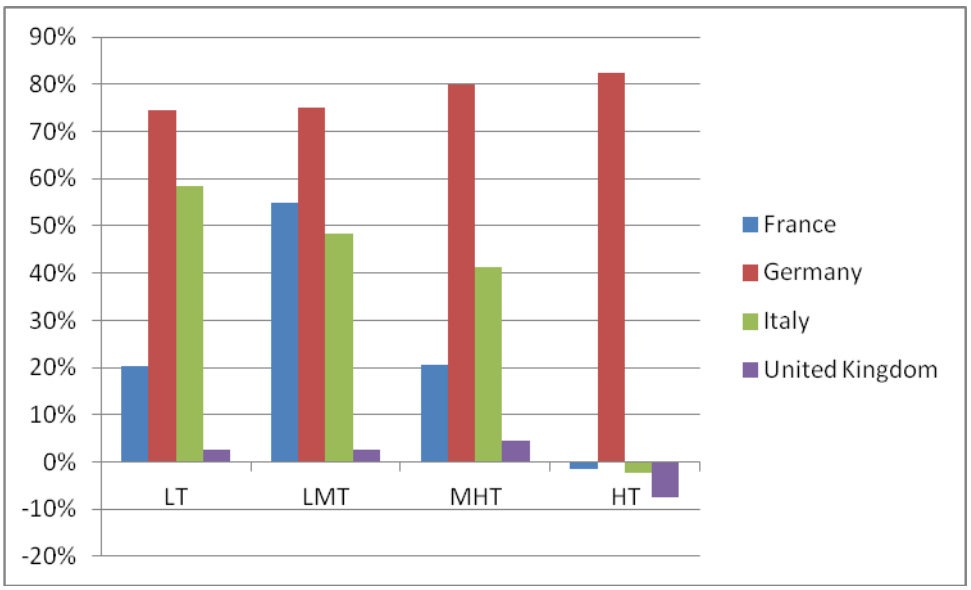
		Italy				United Kingdom			
		L	ML	MHT	HT	L	ML	MHT	HT
1995	Computer and related services	0.54	0.89	0.98	1.37	0.93	1.25	1.62	1.85
	Research and development services	0.23	0.37	0.50	0.51	0.17	0.20	0.26	0.15
	Other business services	4.24	6.31	6.94	5.86	7.57	6.94	8.76	7.51
2005	Computer and related services	0.90	1.48	1.49	0.93	0.86	0.92	1.23	1.06
	Research and development services	0.31	0.44	0.58	0.55	0.14	0.16	0.21	0.19
	Other business services	6.72	9.36	9.80	5.72	7.77	7.11	9.16	6.95

Source: Authors' elaboration on OECD input-output matrices, 2005.

If we compare the 'other business services'contribution to manufacturing demand among the countries considered, highly differentiated 'pictures' emerge. The share of employees of 'other business services' which are directly and indirectly used to satisfy the final demand of the four manufacturing subsystems are always higher in France and Germany compared to those in Italy and the United Kingdom. At the end of the period, in France 'other business services' account for 10.9% and 13% of the employment needed to satisfy the final demand for low and medium/low-tech subsystems, respectively. The share is significantly higher in the case of medium/high-tech manufacturing subsystems (15.7%), while a more similar contribution to the final demand is observed for the high-tech subsystem (12.3%). A similar pattern characterises manufacturing tertiarisation of 'other business services' in Germany: the share of employees which are formally employed in 'other business services' but which satisfy the final demand of low and medium/low subsystems is in line with that of France (12% and 12.4% respectively), but higher than in France in the case of the medium-high and high-tech subsystem (16.1% versus 15.7% and 15.2% versus 12.3% respectively), suggesting that German firms in medium-high and high-tech sectors rely on external legal, marketing and advertising, business consulting and human resource development services more than their French competitors do. If we consider Italy and the United Kingdom, what is initially evident is that in the case of 'other business services', the share of employees who contribute to the final demand of manufacturing is always lower than in France and Germany, more than half in the case of high-tech sectors.

Anyway, remarkable country differences are found in the pace at which manufacturing outsourcing to 'other business services' has grown (Graph 1).

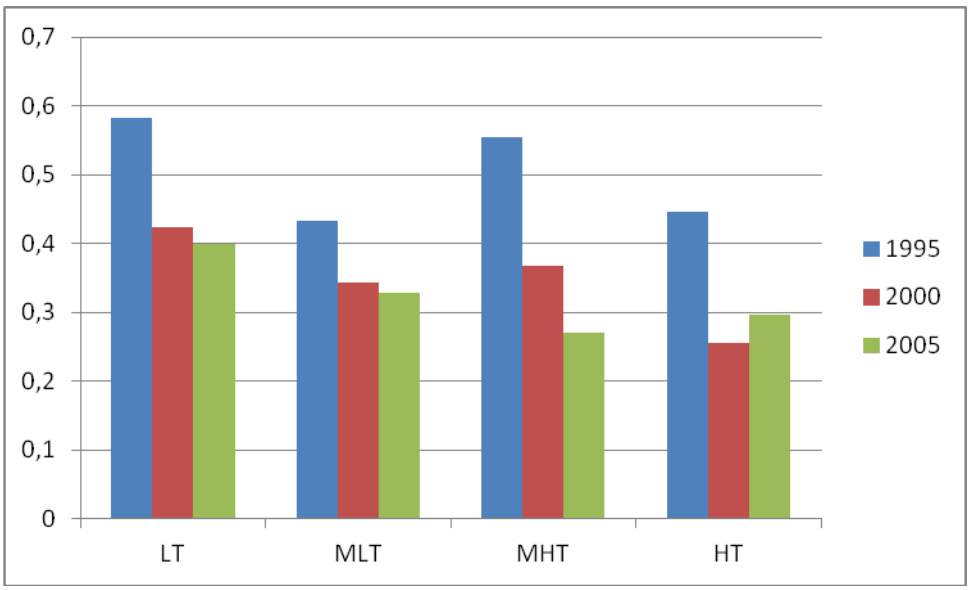
Graph 1. Dynamics of the 'Other business services' vertical integration into low, medium/low, medium/high and high-tech subsystems (1995 - 2005)



The most dynamic growth in 'other business services' contribution to the final demand of manufacturing is observed in Germany and Italy. In addition, from 1995 to 2005, as we move from the medium/high to the high-tech subsystems, the pace of growth of the share of employees in other business services which satisfy the final demand of manufacturing increases in Germany, although it decreases in Italy. Unsurprisingly, these findings are mostly in line with the results obtained when KIBS are aggregated, given the extremely high share of other business services in total KIBS employment and their similarity among countries. Moreover, if we compare France and Germany in 2005, the contribution of the other business services to final manufacturing demand across subsystems is higher in the latter.

A more clear-cut structural relationship between KIBS and the manufacturing subsystems is singled out in the case of information services. In fact, the contribution of information services to final manufacturing demand always increases as we move from the low-tech to the high-tech subsystems in all four countries. However, in 2000 and 2005, in the case of Italy and the United Kingdom we observe slightly lower values for the information services share in the high-tech subsystems than in the medium/high-tech ones. Furthermore, quite a remarkable convergence of the information services subsystem share emerges among countries for the medium/high and high-tech subsystems (Graph 2).

Graph 2. 'Information services' vertical integration into low, medium-low, medium-high, and high-tech subsystems: variability across country subsystem shares (coefficient of variation)



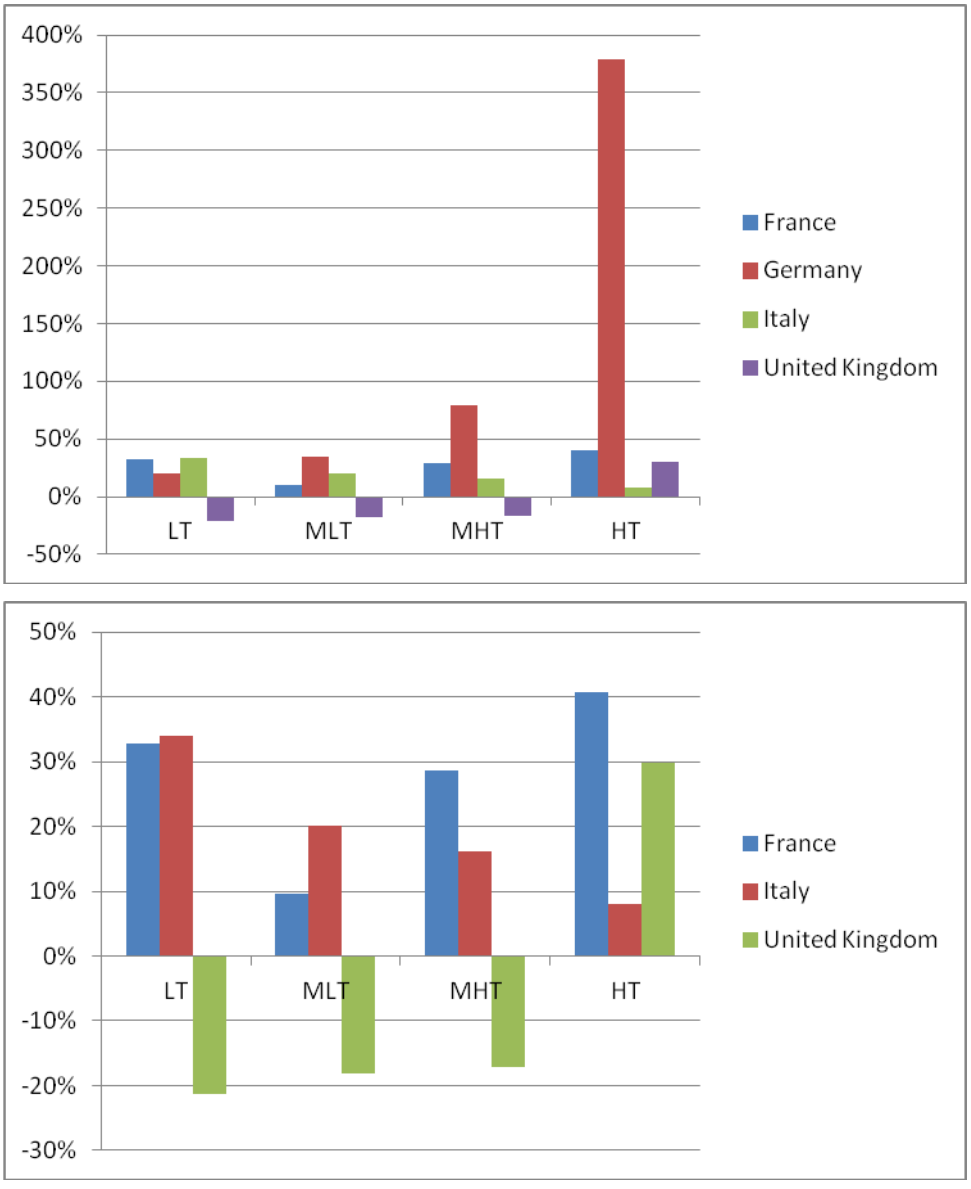
Hence this seems to suggest that the development of ICT and related services was quite widespread across all the four countries involving the most advanced manufacturing sectors. As a consequence, in 2005 the degree to which the KIBS contributed to the final demand of the manufacturing subsystems is almost the same in France, Italy and the United Kingdom. In the case of Germany, however, it is significantly lower in all four subsystems. The explanation is that contrary to what is observed in the other three countries, in Germany these services contribute to a greater extent to satisfying the final demand of the computer and related subsystem (85.8% vs 70.5% in France, 67.7% in Italy and 61.7% in the United Kingdom) suggesting that German firms developed ICT service internally more than their competitors in the other three countries.

Finally, as far as research services are concerned, an increasing contribution to the final demand of manufacturing emerges as we move from the low to the high-tech subsystems in all the countries analysed. Furthermore, the share of research service employees used directly and indirectly by the four manufacturing subsystems to satisfy their final demand increases over time in all four manufacturing subsystems in France, Germany and Italy. In the case of the United Kingdom, on the contrary, this is found to be true only in the case of the high-tech subsystem, while the research service employment contribution decreases in the other three manufacturing subsystems.

At the same time, though these general trends emerged, the pace at which research services' contribution to the different manufacturing subsystems has grown over the period 1995-2005 significantly changes across the countries, confirming the existence of profound structural differences among them (Graph 3). In particular, in Germany and France the pace of growth of the share of employees formally employed in the research services sector but which directly and indirectly satisfy the final demand of manufacturing is increasingly higher in the medium/high and high-tech subsystems (in Germany this increase is striking in the high-tech subsystem as a result of the very low initial share in 1995). The opposite is observed in

Italy, where research services appear to be mainly directly and indirectly used by the low and the medium/low-tech subsystems. To some extent, the same trend can be observed in the United Kingdom, where we observe a contraction (and not an expansion as in Italy) of research services' contribution to the low, medium/low and medium/high-tech manufacturing subsystems over time. However this decrease appears to be comparatively lower as we move from the low-tech to the high-tech subsystems.

Graph 3. Dynamics of the 'Research services' vertical integration into low, medium-low, medium-high, and high-tech subsystems (1995 and 2005)



To sum up, France holds the highest research service employment contribution to the manufacturing subsystems, followed by Italy, the United Kingdom and Germany. However, while in France and Germany a much greater contribution of research services is observed in the case of the medium/high and high-tech subsystems than in the case of low and medium/low-tech ones, a much lower difference is found in the case of Italy and the United Kingdom. In summary, in both France and Germany research services support the medium/high and high-tech subsystems (keeping in mind, however, the more widespread character of

innovation throughout all the manufacturing sectors in Germany). In Italy, a relatively higher effort is made towards low and medium/low-tech subsystems and, in the United Kingdom, quite specific support is devoted to high-tech subsystems. However, as we have already seen for the other two services sectors belonging to KIBS, the weaker role of research services in the United Kingdom can be explained by their growth as a services sector tailored to the innovation of other services sectors, which is not the case in Italy.

All in all, these findings corroborate the idea that the way and the extent to which KIBS are integrated and used as intermediate 'knowledge' inputs is very context (country)-dependent as this is one of the dimensions of a country's system of innovation (Lundvall, 1992). In fact, innovation is generally embedded in specific socio-economic, political and cultural contexts (Muller and Zenker, 2001). It is the systemic nature of the innovation process which implies that the set of input-output relationships in terms of advanced knowledge, material input and demand, constitute a crucial factor to enhancing the competitiveness of the whole national system (Castellacci, 2008) and for this reason the country's production structures are determinant factors in the potential expansion of KIBS. Whilst France and Germany have developed KIBS to support their whole industrial advancement, service specialisation in the United Kingdom has been oriented to creating a solid services sector largely independent on the industry and competitive in its innovative performance (as the high export share clearly point out too). In Italy another different situation is singled out, as the weak KIBS tertiarisation of the four manufacturing subsystems considered and the apparent similarity with the United Kingdom's profile is rather the outcome of its overall awkward innovation performance than a choice concerning developing an advanced services sector. The absence of an innovative services sector is quite evident and the poor degree to which KIBS are vertically integrated into the manufacturing subsystems is essentially related to its high specialisation in traditional sectors, given the fundamental role played by manufacturing.

5 Concluding Remarks

The empirical evidence presented in this study suggests the existence of a significant difference in the depth of the blurring of the boundaries between manufacturing and knowledge-intensive business services among the countries considered. Generally speaking, the extent to which KIBS contribute directly and indirectly to satisfying the final demand of manufacturing subsystems is higher in the case of medium/high and high-tech ones than in the case of medium/low and low-tech ones in the majority of the countries considered. However, though this general trend remains true, remarkable differences between countries emerged when comparing the extent to which KIBS contribute directly and indirectly to these four manufacturing subsystems (low, medium/low, medium/high and high-tech), namely the extent to which the employees formally employed in KIBS do actually work to satisfy the final demand for manufacturing products. This suggests that not only did KIBS contribute differently to the aforementioned manufacturing subsystems according to their technology intensity, but that the extent to which they are directly and indirectly used by the rest of the economy is the result of very country-specific sectoral patterns. In Germany, knowledge-intensive business services act as a support to the development of the manufacturing sector with quite widespread diffusion across the entire industrial structure, confirming the role played by the presence of a thoroughly innovative manufacturing sector for national competitiveness. The United Kingdom has developed a more service-oriented industrial structure, in which knowledge-intensive business services have been determining factors in the development of a highly innovative services sector, while concentrating their contribution to manufacturing in high-tech industries. In France,

an intermediate model emerged, with a solid and increasing use of knowledge-intensive business services by more technologically oriented manufacturing subsystems such as medium/high and high-tech ones. The extent to which knowledge-intensive business services contribute directly and indirectly to the final demand of the manufacturing sectors is much lower in Italy, as a result of the higher specialisation of this country in traditional manufacturing sectors less oriented towards innovation. In this country, the use of knowledge-intensive business services is relatively more prominent in low and medium/low-tech subsystems than in the other three countries analysed, and the contribution to the high-tech subsystems is often lower than in the medium/ high-tech ones.

At the same time, the empirical evidence does confirm the existence of a high degree of heterogeneity among the services sectors belonging to the so-called knowledge-intensive business service aggregation, and the way they shape each country's industrial structure. Generally speaking, German and French firms use other business services more than Italian and United Kingdom firms do. The extent of the use of ICT services is quite standard across countries, while significant and increasing country differences emerged regarding the direct and indirect use of research services. In Germany and France, this category of activities is increasingly used by the medium/high and high-tech subsystems, while in Italy it is mainly and increasingly used to satisfy the final demand of low and medium/low-tech manufacturing. In the United Kingdom, on the contrary, their use decreased in the case of low, medium/low and medium/high-tech manufacturing subsystems — although this decrease appears to be comparatively lower as we move from low to medium/high-tech subsystems — and increased in the case of high-tech subsystems, suggesting that the United Kingdom is developing a specialisation niche in research services and high-tech manufacturing.

All in all, our analysis contains significant policy implications as it confirms the emergence of different 'knowledge-based' value chains, which are specific at both country and subsystem levels. The dynamics of these chains has proven to be fundamental in shaping the industrial structural change in all four countries, but a determining role for the direction and the intensity of these processes has been played by the industrial specialisation of the manufacturing sector and by the different underlying business innovation models. As shown in other studies (Montresor and Vittucci Marzetti, 2010; McCarthy and Anagnostou, 2004), ignoring the existence of these intersectoral value chains leads to an overestimation of the decline of manufacturing with respect to services (and to an overestimation of tertiarisation). As such, industrial development policies should be focused more accurately and recognise the blurring of sectoral boundaries between services and manufacturing. Last but not least, the different outsourcing patterns that emerged from our analysis imply that, ceteris paribus, the same employment policy would have very different impacts in the countries analysed. The direct and indirect relationships between KIBS and the different subsystems analysed should be taken into consideration when evaluating the employment effects of a particular policy or when implementing a particular employment policy.

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