Are KIBS more than intermediate inputs? An examination into their R&D diffuser role in Europe

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Abstract

It is widely accepted that knowledge-intensive business services (KIBS) are key agents in knowledge diffusion. Thanks in part to information technologies, an increasing internationalisation process has been taking place in this type of services in recent years.
Starting from these two facts, the objective of this paper is to evaluate and compare the R&D diffuser role of a group of KIBS, those called high-tech services, both within domestic economies and among countries. To do so an input-output model that estimates the domestic and the imported product-embodied R&D diffused by intermediate consumptions of high-tech services is applied in eleven European countries. The results obtained point out the existence of a potential "compensatory" role of imported high-tech services in some countries, a role that deserves further study.

Keywords: high-tech services, input-output, innovation, R&D, diffusion, internationalisation
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1. Introduction

Services began to be taken into consideration in innovation studies during the eighties with the pioneer works of Richard Barras, Jonathan Gershuny and Ian Miles, after decades of having been virtually ignored. But it was not until the nineties that services captured the attention they deserved. Among the different types of service activities analysed, a group of industries stood out because of their 'special' characteristics— those called knowledge-intensive business services (KIBS). In a widely cited paper Miles et al (1995) summarised these characteristics in terms of the three features they have in common, that is, they rely greatly on professional knowledge, are themselves sources of knowledge and are of competitive importance for their clients.

In addition to the relatively recent recognition of the key role of services and more concretely of KIBS in innovation, we have been witnessing a great increase in international trade in services. Far from the traditional belief that services are, by nature, non-tradable, the fact is that the provision of services is becoming more and more global, with the result that foreign direct investment (FDI) in services is nowadays more relevant than FDI in manufacturing. Many factors can be highlighted as drivers of the upsurge in the internationalisation of service activities (changes in business strategies, higher competition…), but one stands out above all: the impact that information technologies (IT) have had on services. Services are not only the main users of IT but they are also, thanks to advances in technology, more divisible than ever, in the sense that many service functions can be separated, and, as a result, traded, such as in the case of software development. Consequently, within this global context it becomes essential to adopt an 'international perspective'.

Starting from these premises, in this paper we try to analyse the impact that the increasing role of KIBS in production processes, in combination with the growing internationalisation of this type of activities, has on the diffusion of product-embodied R&D across national borders. To do so, we estimate the product-embodied R&D diffusion that takes place in eleven European countries by means of the use of some KIBS as intermediate consumptions. In this diffusion we differentiate between domestic flows and flows coming from imports. Given the limited amount of statistical information available, we centre on a group of KIBS called by Eurostat 'knowledge-intensive high-tech services' or 'high-tech services', composed of the three following industries of the ISIC revision 3: 64 post and telecommunications, 72 computer and related activities and 73 research and development.

The structure of the paper is the following. In the first section we briefly review recent theories about the role of services in innovation and in international trade. In particular, we show how considerably interest in innovation in services has risen during recent years. An important consequence of this growing attention is that KIBS are regarded nowadays as essential elements in the innovation processes of their client firms. Different perspectives can be identified in the analyses that support this general vision. For example, some studies, based on knowledge creation theories, such as the one elaborated by Nonaka and Takeuchi (1995), adopt an 'organisational' perspective (Strambach, 2001; Glücker, 1999). Others take the national innovation system concept to characterise the functions of KIBS (Fischer, 2001).

Furthermore, the fact that KIBS are ever more easily provided from long distances makes their 'innovation supporting' role more global. The papers on the internationalisation of business service firms highlight the following of clients abroad as the major incentive for going international. This fact reinforces the above-mentioned hypotheses regarding the positive impact of the use of KIBS on knowledge diffusion and ultimately on innovation.

In the second section we examine the increasing importance of high-tech services as intermediate consumptions within the different production systems, paying special attention to growth in the imports of intermediate consumptions of these services. We also highlight the increasing R&D efforts carried out by high-tech services.

We study the diffuser role of high-tech services within the production systems in the third section. In particular we analyse whether the diffusion of product-embodied R&D carried out by high-tech services is mainly developed through the use of domestic or imported intermediate consumptions. The methodology employed (Camacho and Rodriguez, 2006) is a modified

version of the input-output model introduced by Papaconstantinou et al (1998). The novel element is the attempt to estimate, for the first time, the product-embodied R&D diffused by imported intermediate consumptions of high-tech services. In this way it is possible to 'go beyond' traditional analyses which commonly centre on domestic economies by demonstrating that the functions of KIBS surpass national borders. The empirical analysis is developed for eleven of the EU-15 countries: Belgium, Denmark, Finland, France, Germany, Ireland, Italy, the Netherlands, Spain, Sweden and the United Kingdom, in the year 2000. Four databases are employed: the OECD input-output database 2006, the ANBERD database, the STAN database and the Eurostat International Trade in Services Database.

The main results of the analysis and future lines of research are summarised in the conclusions.

2. Innovation, internationalisation and KIBS: recent trends

The traditional vision of services as non-innovative and non-tradable activities has radically changed in recent years.

In relation to the non-innovative character of services, the long-time predominance of manufacturing within the economies established a 'technologically-biased' vision of innovation. Given the 'supplier-dominated' nature of services (Pavitt, 1984) and their scant contribution to technological change, services were not included in innovation studies. One of the first attempts to break with this trend was the work of Gershuny and Miles. In their book *The New Service Economy: The Transformation of Employment in Industrial Societies* (1983), they recognised the potential impact of information technologies (IT) on services. This laid the foundation for the elaboration of the first model of innovation in services by Barras in 1986. Starting from the famous 'product cycle' described by Abernathy and Utterback (1978), Barras observed that, despite information technologies being implemented in order to improve efficiency, the use of IT brought about learning processes, which led, in a first phase, to improvements in quality and other aspects, and, in a second phase, to the emergence of new services (innovation). Nonetheless, it was not until the latter half of the nineties that in-depth works on services and innovation came to light, in which new theories were developed (Gadrey et al., 1995; Gallouj and Weinstein, 1997; Miles, 1996) and empirical analyses were carried out (Hipp et al. 1996; Sundbo, 1998).

Despite this 'belated' interest in innovation activities of services, some studies that called attention to the potential role of services as knowledge diffusers appeared earlier. During the sixties, economists such as Machlup (1962) or Greenfield (1966) described the role of certain services, specifically business services, as creators and diffusers of knowledge.

In the last decade, we have witnessed a dramatic upsurge of interest in these functions of services in the innovation domain, and specifically of those called knowledge-intensive services (KIBS). KIBS are 'special' due to their close relationship with knowledge as well as being innovative in their own right. One of their main capacities is the provision of knowledge to other industries. Antonelli (2000, p.171) states that KIBS function as '*holders of proprietary 'quasi-generic' knowledge, from interactions with customers and the scientific community, and operate as an interface between such knowledge and its tacit counterpart, located within the daily practices of the firm*'. In other words, they can act as 'bridges' for knowledge (Czarnitzki and Spielkamp, 2000) or, to quote Den Hertog and Bilderbeek (1998), 'as a second knowledge infrastructure', even substituting for functions traditionally ascribed to the public sector.

Among the various analyses on the functions of KIBS, some studies adopt what can be described as a 'management' or 'organisational' perspective to describe the activities of KIBS in transmitting knowledge to their clients. This is the case of the papers by Strambach (2001), Glücker (1999) and Schulz (2000), where the emphasis is placed on the generation, diffusion and creation of knowledge by the interactions between KIBS and their clients.

Another approach consists in starting from the concept of a national innovation system. In this case KIBS are considered to carry out three major functions: they are *facilitators*, *carriers* and *sources* of innovation for their client firms (Fischer, 2001; Den Hertog and Bilderbeek, 1998; Hipp, 2000). Concretely, they act as *facilitators* of innovation when they collaborate in

the innovation process of their client firms, but they do not directly generate innovations or transfer them from other firms. They function as *carriers* of innovation when they directly participate in the innovations developed by their client firms. Finally, KIBS are *sources* of innovation when they generate innovations for their client firms.

More recent papers centre on the behaviour of KIBS firms in order to clarify how they innovate and collaborate in innovation (Freel, 2006; Leiponen 2005, 2006, Wong and He, 2005).

Concerning the internationalisation of KIBS, during recent times international trade in services has increased as never before. One of the main explanatory factors of the growing internationalisation of services is the impact that technological change has had on services. Miozzo and Soete (2001) point out two major aspects modified by information technologies (IT): non storability and intangibility. IT make it possible for many services to eliminate the need for physical proximity, and, as a consequence, they become more tradable.

Given the chance to go international offered by IT, the motives that currently drive the internationalisation of service firms are various and varied. In their revision of the existing literature, Lommelen and Matthyssens (2005) differentiate eight main reactive motives in driving service companies to expand internationally: the request of clients for service companies to follow them, the reception of unsolicited foreign orders, the existence of competitive pressures by competitors and partners, the opportunities offered by formal and informal networks, the presence of small and/or saturated home markets, the development of export promotion programs by governmental and trade organisations, the proximity of attractive foreign markets and the availability of excess production capacity.

Nevertheless, among all these reasons, client following is assumed to have the most crucial influence, more so for service industries than for manufacturing (Bryson, 2001). This assumption acquires special relevance in the case of business services. The majority of the studies on internationalisation of business services firms highlight the following of clients abroad as the major motive for going international (Léo and Philippe, 2001; Fernández-Fernández, 2001). As a result, the choice of the foreign markets to enter is also mainly prompted by the location of clients (O'Farrell and Wood, 1998; O'Farrell et al.; 1996). So, we can infer that the links established with their clients are a very relevant variable to take into consideration by KIBS when they decide to internationalise.

From all the above we can conclude that the close relationships that tie KIBS with their clients influence both innovation and internationalisation processes. KIBS collaborate with innovation in other firms and besides, thanks to IT, they can easily be provided at long distances. This poses various questions about the different effects brought about by the increasing international sourcing of KIBS. For instance, how the international provision of KIBS contributes to knowledge diffusion?

Given the scant availability of internationally comparable data on knowledge, in this paper we take as a proxy R&D expenditures[1]. In particular, the objective is to evaluate the product-embodied R&D diffuser role of certain KIBS (the high-tech services) from a double perspective: domestic and imported.

3. An analysis of the role of high-tech services within the production systems using input-output tables

As has been mentioned, in our paper we focus on a specific group of KIBS, the 'high-tech services'[2], namely, post and telecommunications, computer and related activities and research and development. In the statistical domain the definition of knowledge-intensive business services has been very complex because of the commonly insufficient level of detail. In the case of the OECD *business services* include three categories of the ISIC rev.3: computer and related services (72), research and development (73) and other business services (74) and they are divided into two subgroups. For one part, those called *knowledge-intensive business services*, which are professional services, including IT-consulting (72), R&D services (73), legal (74), accounting (74), marketing and advertising (74), business consulting and human resource

development (74). For the other part, a second subgroup composed of *operational services,* including industrial cleaning (74), security services (74) and secretarial services (74).
Eurostat defines *business services* as composed of the industries included in NACE K72 and K74.1 to K74.5, namely, computer & related activities (K72.00), legal, accounting, bookkeeping & auditing activities, tax consultancy, market research & public opinion polling, business & management consultancy, holdings (K74.10), architectural & engineering activities & related technical consultancy (74.20), technical testing & analysis (74.30), advertising (74.40) and labour recruitment & provision of personnel (74.50). As Miles et al. (1995) did in their characterisation of KIBS, it employs several classifications that try to capture the higher or lower knowledge intensity of service activities. Within these categories are included in most of the cases one or more types of business services. It describes *Knowledge-intensive services* according to technological intensity and based on the NACE Rev. 1.1 classification at a 3-digit level as follows: water transport (61), air transport (62), post and telecommunications (64); financial intermediation, except insurance and pension funding (65), insurance and pension funding, except compulsory social security (66), activities auxiliary to financial intermediation (67), real estate activities (70), renting of machinery and equipment without operator, and of personal and household goods (71), computer and related activities (72), research and development (73), other business activities (74), education (80), health and social work (85), and recreational, cultural and sporting activities (92). This wide group of *Knowledge-intensive services* is divided into five subgroups:

- *Knowledge-intensive high-tech services*: post and telecommunications (64); computer and related activities (72); research and development (73)
- *Knowledge-intensive market services*: (excl. financial intermediation and high-tech services): water transport (61); air transport (62); real estate activities (70); renting of machinery and equipment without operator, and of personal and household goods (71); other business activities (74)
- *Knowledge-intensive financial services*: financial intermediation, except insurance and pension funding (65); insurance and pension funding, except compulsory social security (66); activities auxiliary to financial intermediation (67)
- *Other knowledge-intensive services*: education (80); health and social work (85); recreational, cultural and sporting activities (92)

Despite a more detailed level of detail would be desirable, in this paper we employ the definition of Eurostat of "knowledge-intensive high-tech services"[3].

Before entering into the estimation of their product-embodied R&D diffuser role, in this section we examine two aspects.

Firstly, we evaluate whether high-tech services are acquiring greater importance as intermediate consumptions within the production systems. In line with what theories described above point out, KIBS are becoming key sources of value added, and as a result, they account for a growing share of the cost of products. Therefore, it is reasonable to suppose that their participation in intermediate consumptions is growing as well.

Secondly, we analyse whether economies domestically produce the high-tech services they use as intermediate consumptions or if they are increasingly acquiring them from abroad. That is to say, we differentiate between domestic and imported intermediate consumptions of high-tech services.

In order to examine the relevance of high-tech services within the production systems, the shares of high-tech services in intermediate consumptions in the 11 European countries previously listed as well as the US, Canada and Japan, in the years 1995 and 2000, are shown in Table 1. The annual average growth rate of intermediate consumptions of high-tech services and the percentages of imported intermediate consumptions are also reported for each country. As can be observed, the share of high-tech services in total intermediate consumptions has increased considerably during the period studied. Thus, whereas in 1995 there were noticeable differences between the EU countries and Japan and the US, these differentials have decreased significantly in only five years. In 1995 high-tech services accounted for more than 6 percent of

total intermediate consumptions in Japan and the US while only one European country, France, showed a similar participation. In contrast to this situation, in the year 2000 the participation of high-tech services in intermediate consumptions was above 7 percent not only in Japan and the U.S., but also in four European countries: the United Kingdom, France, Sweden and Denmark.

Table 1 Evolution of the participation of high-tech services in intermediate consumptions, 1995-2000

	Share in total intermediate consumptions		**Annual average growth rate**	**Percentage of intermediate consumptions Imported**	
	1995	**2000**	**1995-2000**	**1995**	**2000**
Belgium	2.53	4.23	18.34	21.07	21.62
Denmark	4.16	7.02	16.68	9.11	12.26
Finland	3.19	4.61	16.94	9.12	6.66
France	6.44	7.43	8.93	2.05	2.49
Germany	3.54	4.83	10.90	11.31	15.37
Ireland	n.a.	3.04	n.a.	n.a.	7.38
Italy	3.04	3.79	10.16	4.43	9.60
Netherlands	4.13	5.61	13.11	16.61	18.87
Spain	2.33	3.32	15.45	5.29	6.54
Sweden	5.40	7.18	11.98	7.78	14.39
United Kingdom	5.56	8.04	14.00	8.60	5.10
US	6.00	7.12	9.77	0.16	0.16
Canada	n.a.	4.09	n.a.	n.a.	7.10
Japan	6.43	7.49	4.33	1.10	1.50

In the case of Ireland the most recent year available is 1998 and information on the origin of intermediate consumptions is available only for post and telecommunications

Source: OECD Input-Output Database 2006.

However, we have to highlight substantial differences among the various EU countries: e.g., in the group of four countries mentioned above the share of high-tech services in intermediate consumptions in 2000 was more than double the participation in other EU countries, such as Ireland or Spain.

In any case, a trend towards reduction of these differences is observed. If we take the annual average growth rates of high-tech services, excepting the US, France and Japan, all the countries analysed have experienced annual average growth rates in the intermediate consumption of high-tech services above 10 percent. The growth in four European countries, Belgium, Finland, Denmark and Spain, deserve special attention, since their annual average rates were higher than 15 percent.

In the two last columns of Table 1 we show the percentage of intermediate consumptions of high-tech services from abroad, in order to study the origin (domestic or imported) of the intermediate consumptions of high-tech services. We notice that the imported intermediate consumptions of these services grew during the period analysed in all countries except Finland and the United Kingdom. The countries that imported the greatest volume of high-tech services in 2000 were respectively Belgium, the Netherlands, Germany, Sweden and Denmark, where more than 10 percent of the high-tech services employed as intermediate consumptions were imported. The percentages are especially remarkable in Belgium (21.62 percent) and the Netherlands (18.87 percent). At the opposite end of the scale we find such countries as the US, Japan and, within Europe, France and to a lesser extent, the United Kingdom that domestically produce the major part of the high-tech services employed as intermediate consumptions.

As was mentioned in the previous section, high-tech services are highly innovative activities. So as to evaluate the innovation efforts carried out by high-tech services, in Table 2 we report their R&D intensities in 2000 (defined as business expenditures on R&D divided by production) and the annual average growth rates of their business expenditures on R&D during

the period 1995-2000. Both the intensities and the growth rates are calculated for each of the three industries included within high-tech services.

Table 2 Evolution of R&D expenditures in high-tech services, 1995-2000

	R&D intensity			Annual average growth rate		
	Post	**Computer**	**Research**	**Post**	**Computer**	**Research**
Belgium	0.81	2.20	0.55	32.97	14.10	-1.55
Denmark	n.a	6.39	3.60	n.a	20.53	40.46
Finland	3.33	3.79	n.a.	33.15	17.17	n.a
France	n.a.	1.04	n.a.	n.a	4.17	n.a
Germany	n.a.	1.99	5.74	n.a	46.37	38.15
Ireland	2.25	4.45	34.17	16.04	46.60	55.06
Italy	0.01	0.65	12.94	-41.62	18.41	18.88
Netherlands	0.47	2.10	3.45	-1.12	52.12	32.34
Spain	0.98	3.07	7.75	31.91	33.34	44.67
Sweden	1.83	2.97	9.82	10.64	36.51	4.86
United Kingdom	1.37	1.55	6.99	9.91	-2.26	11.29
US	0.43	4.18	16.53	-12.11	13.60	25.05
Canada	0.17	4.02	n.a.	-21.66	12.34	5.90
Japan	n.a.	1.37	n.a.	n.a	n.a	n.a

In Denmark the R&D intensities are for 2001 and the annual average growth rate refers to the period 1995-99.
In Germany and Japan the intensities for computer services are for 2001.
In the US the intensity for post and telecommunications refers to 1998 and the growth is for the period 1996-98.
In Spain the intensity for research and development is for 1999.
Source: OECD Input-Output Database 2006, STAN and ANBERD.

With respect to the industry of post and telecommunications we observe quite varied evolutions. One the one hand, we find those countries with the highest R&D intensities and where the R&D expenditures carried out in this industry grew at a fast pace: Finland and Ireland. On the other hand, we note those countries with the lowest R&D intensities that, in addition, have experienced a considerable reduction in R&D expenditures: Italy, Canada and the US. In the rest of the countries the annual average growth rates of the R&D expenditures were relatively high, except in the Netherlands, where the expenditures decreased slightly.

In the case of computer and related activities the picture is clearer: the R&D expenditures carried out in this industry grew significantly in all countries with the sole exception of the United Kingdom, where there was a minor decline. Denmark is the country with the highest R&D intensity in computer services, followed by Ireland, the US, Canada and Finland. Again Italy is the country that shows the lowest R&D intensity.

The situation in the industry of research and development is very similar to that of computer services. The R&D expenditures carried out in this industry increased a lot in all the countries analysed except in Belgium, where the expenditures diminished a little. The countries with higher R&D intensities are Ireland, the US, and Italy, whereas Belgium is the country with the lowest R&D intensity.

In brief, we can confirm that high-tech services are, in fact, services that carry out important efforts in R&D. Thus, they not only show high R&D intensities, but they also spend more and more on R&D. Within this general trend we can only exclude the industry of post and telecommunications, because of the disparate evolution presented in the countries analysed.

4. Domestic versus imported R&D diffusion by high-tech services: an evaluation

In the previous section we corroborated the key role that high-tech services play as intermediate consumptions within the European production systems as well as the general growth in their R&D efforts. The objective now is to evaluate the product-embodied R&D diffuser activity carried out by high-tech services, both domestically and by means of imports.

We define the R&D intensity in industry *i* as the Business Expenditure on R&D (R_i) divided by value added (W_i)[4]:

$$r_i = \frac{R_i}{W_i} \qquad \text{(i = 1,2, ..., n)} \qquad [1]$$

The methodology employed starts from the model elaborated by Papaconstantinou et al (1998) and applied to service activities by Amable and Palombarini (1998). Nonetheless our objective is substantially different from that of these previous studies. Whereas they centred on the incorporation of product-embodied R&D, our aim is to approximate the diffusion of product-embodied R&D that takes place by means of the acquisition of intermediate consumptions.

Using the output inverse matrix introduced by Ghosh (1958), the equilibrium in the domestic supply model can be expressed as follows:

$$X = W(I - B)^{-1} \qquad [2]$$

where X is the vector of domestic gross outputs, W is the vector of value added and $(I - B)^{-1}$ is the domestic output inverse (Ghosh) matrix. We can define the matrix of domestic embodied R&D diffusion, D, by introducing a diagonalised matrix of R&D intensities in equation [2] as follows:

$$D = W\hat{r}(I - B)^{-1} \qquad [3]$$

where r-hat ($\hat{r}$) indicates a diagonal matrix whose elements are those of vector r.

Equation [3] relates domestic product-embodied R&D diffusion to the value added components (compensation of employees and gross operating surplus).

Thus, the domestic product-embodied R&D diffusion per unit of value added of industry *i*, DUD_i, can be obtained from the sum of the *i*th row of matrix $\hat{r}(I - B)^{-1}$:

$$DUD_i = \sum_{j=1}^{n} r_i q_{ij} \qquad \text{(i = 1,2, ..., n)} \qquad [4]$$

where r_i is the R&D intensity for industry *i* and q_{ij} are the elements of the Ghosh inverse.

Since the *i*th row of the Ghosh inverse measures the impact on domestic production when the utilisation of primary inputs (valued added) of the *i*th industry varies by one unit, equation [4] provides the amount of domestic product-embodied R&D diffused per unit of value added of industry *i*.

We can obtain the total domestic product-embodied R&D diffused through the domestic intermediate consumptions, DTD, by pre-multiplying equation [4] by the value added:

$$DTD_i = w_i \sum_{j=1}^{n} r_i q_{ij} \qquad [5]$$

where w_i is the value added of industry *i*.

Similarly, the imported product-embodied R&D diffused per unit of value added, IUD, can be defined as follows:

$$IUD_i = \sum_{j=1}^{n} \sum_{k=1}^{l} \alpha_k r_{ik} q_{ij} \qquad \text{(i = 1,2, ..., n)} \qquad [6]$$

where α_k is the import share of country k, r_{ik} is the R&D intensity for industry *i* in country k and q_{ij} are the elements of the Ghosh inverse.

Again, the total product-embodied R&D diffused through the imported intermediate consumptions, ITD, can be obtained by pre-multiplying equation [6] by the value added:

$$ITD_i = w_i \sum_{j=1}^{n} \sum_{k=1}^{l} \alpha_k r_{ik} q_{ij} \qquad \text{(i = 1,2, ..., n)} \qquad [7]$$

The calculation of the domestic flows is a way of approximating the relevance of high-tech services as transmitters of their own R&D efforts within the production systems. The comparison of the diffusion carried out by domestic and imported intermediate consumptions allows us to evaluate to what extent the countries benefit from the R&D efforts carried out by high-tech services in other countries.

In Table 3 the product-embodied R&D diffused per unit of value added through domestic and imported intermediate consumptions of high-tech services is shown[5]. We independently report the flows for each industry.

Table 3 Product-embodied R&D per unit of value added diffused through domestic and imported intermediate consumptions of high-tech services, 2000

	Domestic			**Imported**	
	Post	**Computer**	**Research**	**Computer**	**Research**
Belgium	0.034	0.113	0.015	0.053	0.380
Denmark	n.a.	0.280	0.096	0.059	0.209
Finland	0.116	0.129	n.a.	0.059	n.a.
France	n.a.	0.047	n.a.	0.045	n.a.
Germany	n.a.	0.052	0.167	0.053	0.274
Ireland	0.065	0.091	1.788	0.051	0.174
Italy	0.0004	0.026	0.331	0.042	0.187
Netherlands	0.017	0.070	0.117	0.047	0.326
Spain	0.037	0.061	0.277	0.040	0.374
Sweden	0.077	0.127	0.317	0.062	0.268
United Kingdom	0.060	0.073	0.255	0.053	0.217

In Ireland the data refer to 1998.

Source: OECD Input-Output Database 2006, STAN and ANBERD.

As can be expected, on a general basis, the industry that diffuses more product-embodied R&D in most of the countries is research and development and the industry that diffuses less product-embodied R&D is post and telecommunications. The high domestic diffusion that this latter industry carries out in Finland, probably due to the great importance of the telecommunications industry within its production system, can be noted.

Concerning the industry of computer services we observe a high correspondence between the R&D intensity (Table 2) and the product-embodied R&D diffused per unit of value added. Thus, Denmark, Finland and Sweden, which were the countries with higher R&D intensities, are also the countries where the diffusion of both domestic and imported product-embodied R&D is greater. On the contrary, Italy and France, the countries with lower R&D intensities, are the ones where less product-embodied R&D per unit of value added is diffused.

The exception to be highlighted is Ireland, since it occupies a modest position in terms of product-embodied R&D diffusion per unit of value added, despite being the second country with the highest R&D intensity in computer services. In a midway position, the industry of computer services in the United Kingdom and the Netherlands carries out medium R&D efforts, the diffusion of product-embodied R&D being moderate too.

Two cases should be pointed out: Germany and Spain. Germany can be classified as the country that benefits the most from imports (in terms of product-embodied R&D). While its R&D intensity is not very high (and in consequence the domestic product-embodied R&D diffused per unit of value added is not very high either), it is the fourth highest ranking country that incorporates more product-embodied R&D through imports of intermediate consumptions. The opposite phenomenon is found in Spain. Although its R&D intensity is quite high, it is the country that diffuses the least product-embodied R&D via imported intermediate consumptions of computer services.

If we turn to the industry of research and development, the panorama changes greatly. Ireland and Italy, the countries with higher R&D intensities, are also the countries that diffuse more domestic product-embodied R&D. Yet they are the countries that diffuse less R&D through imported intermediate consumptions[6]. The country that benefits the most from the product-embodied R&D diffused by imported intermediate consumptions is Belgium: it shows the lowest R&D intensity, but is the country where more product-embodied R&D per unit of value added is diffused via imports. To a lesser extent, Spain and the Netherlands also benefit from the R&D incorporated in their imported intermediate consumptions of research and development services.

The rest of the countries, that is, Sweden, Germany, the United Kingdom and Denmark show unitary flows of product-embodied R&D in line with their own R&D efforts. We have to note, however, that the product-embodied R&D diffused per unit of value added is higher for imported intermediate consumptions than for domestic intermediate consumptions in Denmark and Germany.

As was pointed out earlier, we can easily obtain the total product-embodied R&D diffused by multiplying the unitary flows by the value added of each industry. In Table 4 we report the total product-embodied R&D diffused, expressed as a percentage of the total business expenditure on R&D[7].

Table 4 Total product-embodied R&D diffused through domestic and imported intermediate consumptions of high-tech services, 2000
(percentage of total BERD)

	Domestic			Imported	
	Post	**Computer**	**Research**	**Computer**	**Research**
Belgium	5.29	7.86	0.17	3.69	4.38
Denmark	n.a.	20.64	1.64	4.35	3.57
Finland	13.36	7.27	n.a.	3.31	n.a.
France	n.a.	6.11	n.a.	5.87	n.a.
Germany	n.a.	4.64	3.45	4.78	5.69
Ireland	19.48	9.79	4.95	5.45	0.48
Italy	0.17	6.18	20.01	9.75	11.32
Netherlands	3.54	10.71	3.97	7.20	11.04
Spain	16.82	10.19	1.78	6.63	2.41
Sweden	5.72	8.52	6.81	4.17	5.77
United Kingdom	13.58	13.06	7.93	9.51	6.73

In Ireland the data refer to 1998.
Source: OECD Input-Output Database 2006, STAN and ANBERD.

By taking into account the extent of these industries within the production system of each country, we can note the considerable increase of the role played by post and telecommunications, its diffusion being especially noticeable in Ireland and Spain.

In the case of computer services, Denmark, the United Kingdom, the Netherlands and Spain are the countries where the diffusion of product-embodied R&D has greater importance. The case of Italy draws our attention. Here the major part of the product-embodied R&D is obtained from imports because of the low R&D effort of the industry. Again, and in line with previous comments with reference to the unitary flows, Germany is, along with Italy, the only country where the product-embodied R&D diffused by imported intermediate consumptions is superior to the domestic product-embodied R&D diffused.

With reference to the industry of research and development, Italy, the Netherlands, the United Kingdom and Sweden are the countries where the diffusion carried out has higher relevance.
As in the case of computer services in Italy, in Belgium because of the low R&D intensity of the industry, the product-embodied R&D diffused through imported intermediate consumptions is higher than the product-embodied R&D diffused domestically. The same phenomenon occurs in Germany, the Netherlands and Spain, where more product-embodied R&D is diffused via imported intermediate consumptions than through domestic intermediate consumptions.

In the previous section a general upsurge in imported intermediate consumptions of high-tech services was shown. In light of the diffuser role carried out both by domestic and imported intermediate consumptions of high-tech services, a question emerges: Do imported intermediate consumptions of high-tech services contribute to raising the volume of product-embodied R&D diffused in countries with low R&D intensities in these services? To try to answer this question, in Table 5 we compare the shares of imported intermediate consumptions with the domestic R&D intensities and with the imported product-embodied R&D flows per unit of value added.

Table 5 Imported intermediate consumptions, R&D intensities and product-embodied R&D diffused through imports, 2000

	Computer services			Research and development		
	Share	**Intensity**	**Diffusion**	**Share**	**Intensity**	**Diffusion**
Belgium	28.47	5.69	0.053	81.87	1.20	0.380
Denmark	15.34	15.03	0.059	28.98	6.31	0.209
Finland	4.50	6.75	0.059	n.a.	n.a.	n.a.
France	1.54	1.97	0.045	n.a.	n.a.	n.a.
Germany	13.90	2.67	0.053	49.17	11.92	0.274
Italy	5.16	1.05	0.042	15.93	20.92	0.187
Netherlands	10.66	3.53	0.047	57.99	7.27	0.326
Spain	7.91	4.51	0.040	51.19	11.60	0.374
Sweden	8.36	6.92	0.062	49.65	19.89	0.268
United Kingdom	4.70	2.96	0.053	14.52	11.98	0.217

As there are no data on the origin of intermediate consumptions in Ireland, it is not included in this table
Source: OECD Input-Output Database 2006, STAN and ANBERD.

As can be observed, the imports of intermediate consumptions perform an important compensatory role in some countries where the domestic R&D efforts are not very high. The clearest examples are Germany, in the case of computer services, and Belgium, in the case of research and development. Germany is the third highest ranking country in its share of intermediate consumptions of computer services imported, and at the same, shows a relatively low R&D intensity. Nevertheless, it is the fourth highest ranking country in terms of product-embodied R&D diffused per unit of value added through imported intermediate consumptions. Belgium is the country where the participation of imported intermediate consumptions of research and development is the highest: more than 80 percent. This high dependence on imports compensates for its low R&D intensity: Belgium is the country where more product-embodied R&D per unit of value added is diffused through imported intermediate consumptions of research and development services.

These results are in line with Papaconstantinou et al. (1998) findings about the growing acquisition of technology[8] via imports. In their analysis of the product-embodied R&D diffusion in 10 OECD countries[9], they reported an increase in the acquisition of technology via imports in all countries except Japan. They observe that larger countries are more self-reliant. In particular the US and Germany are considered to be the most relevant sources of technology for many countries. Nevertheless, even for the US the technology acquired via imports more than tripled in two decades. This confirms that imports are assuming an increasingly important diffuser role even for high R&D developers.

Following their results, in this paper the analysis of the sourcing of embodied R&D from manufacturing is translated to services: as the Knowledge-based Economy develops, services,

and more concretely KIBS, assume part of this diffuser role traditionally carried out by manufacturing.

5. Conclusions

The essential functions that KIBS perform in the innovation domain have been highlighted by many scholars. Currently, as our economies are ever more knowledge-based, KIBS are acquiring greater relevance in the production processes of the different industries. In addition to their growing 'domestic' importance, we note the significant rise in internationalisation of KIBS, mainly due to the changes in transportability introduced by IT.

In this paper we have tried to show the contribution of KIBS to knowledge diffusion processes expands beyond national borders. To do so, we have calculated the product-embodied R&D diffused both by domestic and by imported intermediate consumptions of a group of KIBS, the high-tech services.

Using data from the input-output tables, we have confirmed the growing relevance of high-tech services as intermediate consumptions within production processes. In only five years the differentials between the European countries and the US and Japan have lessened considerably, thanks to the fast pace of growth experienced by these services. Intermediate consumptions of high-tech services grew at an annual average rate higher than 10 percent in all the European countries analysed except France (which was the only European country with a share of high-tech services in intermediate consumptions above 6 percent in 1995).

In addition to the rise in the use of these services, the percentage of intermediate consumptions of high-tech services imported has also substantially increased. Finland and the United Kingdom are the only two countries where this did not occur. The share of imported intermediate consumptions is specially striking in some cases. In research and development 82 percent of the intermediate consumptions were imported in Belgium and 58 percent in the Netherlands in the year 2000. The share was around 50 percent in Spain, Sweden and Germany. In relation to computer services the share of intermediate consumptions imported was 28 percent in Belgium and more than 10 percent in Denmark, Germany and the Netherlands.

In terms of R&D intensities, the trend is quite similar. R&D expenditures in high-tech services rose in almost all the European countries examined during the period 1995-2000. This growth was especially noteworthy in computer services and research and development.

The combination of a rising use of high-tech services as intermediate consumptions and their increasing R&D intensity translates into what we observe as a key role for product-embodied R&D diffusion. Given their rising internationalisation, it is of significant interest to differentiate between the diffusion carried out by domestic and by imported intermediate consumptions of high-tech services.

By comparing domestic and imported product-embodied R&D diffused through intermediate consumptions of high-tech services, we have corroborated that imported intermediate consumptions are very relevant diffusers. In some cases, these diffusions, per unit of value added, are higher than those carried out by domestic intermediate consumptions. This is the case of Germany and Italy in computer services and Belgium, the Netherlands, Germany, Denmark and Spain in research and development. Among those countries that diffuse more product-embodied R&D by means of imports two cases stand out: Germany and Belgium. In these countries the relatively low domestic R&D intensity is 'compensated' by imported intermediate consumptions. Thus, Germany is the third highest ranking country in product-embodied R&D diffused by imported intermediate consumptions of computer services, and Belgium is first in terms of product-embodied R&D diffused per unit of value added via imported intermediate consumptions of research and development services.

In conclusion, we feel that this study is a small step in the understanding of knowledge flows generated through international provision of KIBS. We have obtained evidence concerning a potential compensation of low domestic R&D intensities via imports. A next stage in this line of analysis could be an in-depth examination of the specialisation patterns of each economy to better link specialisation, innovation and international flows of knowledge. This

analysis, in combination with statistical information for various years, could shed more light on the international diffusion of knowledge through KIBS— a diffusion that seems to be acquiring growing importance within our ever more global ‘Knowledge-based Economies’.

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Notes

[1] KIBS are considered quite similar to innovative manufacturing industries in terms of their R&D efforts. In this line, the study by Wong and He (2005) highlights that there are no differences in the propensity to carry out R&D activities between KIBS and manufacturing firms.

[2] Since the establishment of the pioneer distinction between "traditional professional services" or p-KIBS and "new technology-based services" or t-KIBS by Miles et al in 1995, the number of studies that seek a correspondence between "theoretical" and "statistical" classifications of KIBS has increased considerably (an excellent revision is provided by Nählinder, 2002). In our case, the combination of four different databases makes it difficult to employ an "accurate" classification of KIBS. We have preferred to analyse a smaller number of KIBS industries in order to facilitate the interpretation of the results obtained.

[3] Despite the fact that the post industry cannot be regarded as "knowledge-intensive", the unavailability of data for the post industry at on an international level makes it impossible to separate both activities. Nevertheless, it seems to be reasonable to assume that the share of post is considerably lower than that of telecommunications. Moreover, telecommunications is considered to play a key role in terms of knowledge diffusion, by facilitating the introduction of new technology. This innovation-supporting role is assumed in many analyses of the impact of the use of KIBS on productivity (see for example Windrum and Tomlinson, Katsoulacos and Tsounis).

[4] We choose to compute R&D intensities with respect to output instead of employment because, as Amable and Palombarini (1998) point out in their paper, the use of employment entails two problems when comparing the growth of R&D intensities among countries: firstly, differences can hide variations in capital and labour ratios, and, secondly, increases in R&D intensities can be explained by labour productivity gains. In reference to the output indicator, we consider value added a better measure of output than production or turnover. Since production includes intermediates, any output of intermediate goods consumed within the same sector is also recorded as output. As a result, the impact of such intra-sector flows depends on the coverage of the sector. Turnover, for its part, refers to the actual sales in the year and can be greater than production in a given year if all products are sold together with stock from previous years. Consequently, the turnover can be higher or lower in an industry, depending on how perishable the stock is.

[5] The product-embodied R&D diffused by imported intermediate consumptions cannot be calculated in the case of the industry of post and telecommunications because of the scant statistical information available.

[6] This fact can be explained by the scarce international trade in services between these two countries. Thus, the reciprocal share of imports between Ireland and Italy is less than 4 percent of the total imports in other services from the EU-15.

[7] We report the total flows as percentages of total business expenditure on R&D in order to control for the size of the different countries when comparing the total amount of product-embodied R&D diffused.

[8] They define new technology as the R&D embodied in intermediate consumptions and capital equipment produced by the manufacturing sector.

[9] The countries analysed are: the US, Japan, Germany, France, United Kingdom, Italy, Canada, Australia, Denmark and the Netherlands.