Patterns of Knowledge-Intensive Business Services Use Across Europe

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Abstract

This paper examines the structure and the relevance of knowledge-intensive business services (KIBS) consumption for different industries. The research is based upon the analysis of national input-output tables for European countries presented in the last release of the World Input-Output Database (WIOD). The dataset allows for the identification of both the largest and the most intensive sectoral users of KIBS among different manufacturing, market services, and all other industries. The results confirm that the KIBS subsectors are very heterogeneous; patterns of consumption substantially differ across the six different types of KIBS that the data distinguish. It is suggested that these differences may be explained by the existence of specific synergies between each type of KIBS and some of the consuming industries.

Keywords: knowledge-intensive business services; input-output tables; European countries; patterns of consumption

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Introduction

The direct contribution of knowledge-intensive business services (KIBS) to value added and employment is still growing in both advanced and emerging economies (Miles et al., 2018; Chichkanov et al., 2021). This continuing growth of KIBS is fueled by the increasing demand for these services resulting from increasing technological complexity and outsourcing opportunities (Heirati et al., 2016). KIBS are important sources of knowledge for other companies which makes them important actors in national and regional innovation systems (Muller, Zenker, 2001; Doloreux, Gomez, 2017; Shearmur, Doloreux, 2019).

KIBS industries have been empirically found to be highly innovative. Gotsch et al. (2011) reported that KIBS outperform manufacturing and the economy as a whole in terms of both the share of innovative firms and the share of firms engaged in research and development (R&D) activities. Similarly, Behrens et al. (2017) found that knowledge-intensive services have a higher share of innovation-active firms than most other industries except for some R&D-intensive manufacturing sectors. KIBS firms are characterized by a wide range of innovation patterns and strategies in terms of external knowledge sourcing approaches (Rodriguez et al., 2017), appropriability mechanisms (Miozzo et al., 2016), obstacles being faced (Amara et al., 2016), etc. However, KIBS may also have an impact upon the innovation-related behavior of their clients by acting as facilitators (supporting the innovation processes of the client firm while the solution is not being originated from KIBS or transferred from other sources), carriers (transferring the existing innovative solution from other firms or industries) and sources (playing a key role in initiating and developing an innovative solution) of innovation (den Hertog, 2000).

As KIBS consumption is related to the innovativeness of their clients, patterns of such consumption are quite widely explored at the firm level (Shearmur, Doloreux, 2013; D'Antone, Santos, 2016). However, much less is known about patterns of KIBS consumption at the industry level although their use of KIBS may be expected to vary significantly as different industries confront various business problems to different degrees. An existing lack of research in this area may also restrict the effectiveness of the supportive initiatives aimed at stimulating innovation activities through the consumption of KIBS as they may not reach the targeted industries. Trying to fill this gap, this paper aims to explore how KIBS are consumed at the industry level and map out the existing distinctive patterns of KIBS use across the economy. To do so it employs the most recent release of the World Input-Output Database, focusing on European Union (EU) countries which allows for the examination of business services in a more disaggregated way than possible in most of earlier studies (Stehrer et al., 2012).

The next section briefly reviews relevant studies dealing with KIBS consumption at the industry level. After describing data and methods, the research results are presented and discussed. The final part summarizes key findings and outlines implications for further work.

Literature Review

Research interest in the examination of the sectoral patterns of services consumption was fueled mostly by the exploration of the dramatic rise of service industries (and business services (BS[1]) in particular) that occurred in recent decades. For example, Savona & Lorenz (2006) provided an empirical analysis of the structural changes in advanced OECD economies from the end of the 1960s to the end of the 1990s, finding the key growth drivers of services to be quite different from those of manufacturing. While the real growth of output in manufacturing was driven mainly by increases in final demand, this rapid development of services was fueled by the significant changes in both final and intermediate demand and in KIBS this contribution from the intermediary users was found to be among the highest compared to other industries.

Kox (2002) has analyzed Dutch data, finding that the growth of labor specialization and production 'roundaboutedness' significantly contributed to the growth of BS industries. This study suggested that while in the early 1990s, outsourcing of BS was aimed at the simple replacement of in-house activities, in the late 1990s it became more 'service-upgrading' (especially in the case of more client-specific BS) related to the consumption of high-skilled external inputs. The structure of BS consumption also significantly changed: at the end of the 1970s, more than 40% of such services were consumed by manufacturing, while at the end of the 1990s the largest values were found in BS themselves (more than 20%). In addition, the share of BS in total intermediary inputs was found to reach 50% in BS, 30% in distributive services, 25% in both transportation and storage and communication, exceed 20% in financial services and reach about 17%-18% in manufacturing.

Later Kox & Rubalcaba (2007a, 2007b) extended the analysis to other countries and confirmed that from the mid-1990s the increasing complexity and spe-

[1] In early studies, it was often difficult to distinguish between different types of business services due to the data limitation, so all of them were explored jointly. Although, most business services are typically considered KIBS, it also includes some other services like renting or industrial cleaning.

cialization of labor tend to be more important in explaining BS growth than was the simple transfer of activities from other industries (i.e., outsourcing of services that users would previously have obtained internally). Thus, at the end of the 1990s, the BS industry was itself ranked the first destination sector for BS in the UK and Netherlands, the second in France, Germany and the US, and the third in Italy and Spain. As for other industries consuming BS, the largest shares were found in the manufacturing, public sector and trade, hotel, and catering industry.

Baker (2007) explored the consumption of BS in nine EU countries in the mid-1990s and reported that BS were consumed mainly by manufacturing (28.2%) followed by BS themselves (20.4%), public sector (12.3%), trade and hotels (10.8%), and finance and insurance (8.9%). However, adjusting for the differences in the size of the consuming industries it was found that the largest consumers of BS by far are business services themselves, followed by the finance and insurance sector. The same was found in relation to the share of BS in sectoral intermediate consumption – the most intensive users were BS themselves, finance and insurance, and real estate industries. Although manufacturing industries were found to be the largest consumers of BS in absolute terms, these were also reported to be among the least intensive users.

Di Berardino & Onesti (2018, 2020) employed Pasinetti's "subsystem" approach (Pasinetti, 1988) for the analysis of structural changes in European countries. In an earlier paper, the authors compared the contribution of services to six main different subsystems representing agriculture, manufacturing, public utilities, construction, market and non-market services, respectively. The results indicated that market services (including KIBS) are characterized by the most intensive forward linkages, confirming that these services are mostly 'producer inputs', making important contributions to the production of the other products and services. Regarding the intersectoral linkages, the results confirmed that the highest shares of KIBS were in the market services subsystem (of which KIBS form part), in manufacturing and in construction; the lowest ones were in agriculture and non-market services. In the more recent paper, the authors did not focus on KIBS per se, but the examination of the composition of intermediate services demanded by manufacturing subsystems showed that renting and other business activities (including KIBS) tended to be the most vertically integrated service industry (i.e., KIBS inputs are mostly used for the satisfaction of final demand for different types of manufactured products).

Stehrer et al. (2012) compared the role of KIBS inputs for the high-tech (HT) manufacturing industries, for manufacturing industries in general, and for the total economy in 1995, 2000, and 2005 and reported increasing KIBS shares in intermediate consumption in European countries and the US. In addition, the share of KIBS inputs in HT manufacturing was reported to be higher than in manufacturing in general. This result is in line with Ciriaci & Palma (2016) who employed the subsystem approach to explore the level of KIBS vertical integration into manufacturing industries. The authors confirmed that this level significantly increased between 1995 and 2005 and is also affected by the technological intensity of manufacturing industries, tending to be higher in medium-high-tech and high-tech versus low-tech and medium-low-tech manufacturing industries.

Antonioli et al. (2020) examine changes in the productive structures of the European Monetary Union members' economies in the 2000s and applied the subsystem approach specifically to the analysis of KIBS' role in the economy. They paid special attention to the integration of KIBS in the manufacturing industries in these countries, highlighting the frequent underestimation of their indirect role in satisfying the final demand for other products and services. The authors also compared the integration of KIBS in two different types of manufacturing subsystems regarding their technological intensity – low- and medium low-tech (LMLT) and high- and medium high-tech (HMHT) manufacturing respectively. They found that HMHT manufacturing industries tend to better integrate KIBS while the level of KIBS integration in LMLT manufacturing is lower, but here it was much more stable during the financial crisis.

Although KIBS are often described as a quite heterogeneous industry, not all of the studies discussed above consider this issue. One of the rare exceptions is the study by Baker (2007) who identified six clusters, representing six main types of business services consumers - those who are low (1) and average (2) users of all types of business services; and those who are intensive users of a only specific type of business services – renting (3), computing (4), R&D (5) and other BS (6) respectively. While a possible limitation of this work is that the data employed dealt with different time points for different countries, these results show that the consumption of specific KIBS may significantly differ across industries.

This brief literature review clearly shows that the intermediate demand for business services and KIBS, in particular, has grown dramatically. Subsystem analyses that evaluate the importance of KIBS for different industries' final output show that this is a topic that deserves a more detailed analysis of the differences between patterns of KIBS consumption at the sectoral level. As data with a lower level of aggregation becomes available, there is scope for further investigation of KIBS heterogeneity.

Data & Methods

This research is based on the analysis of the input-output tables and the basics for such an analytical framework emerges from the model developed by Leontief (1936) which has become one of the most widely used tools among economists with the increase of the speed and capacity of computer-based calculations (Miller, Blair, 2009). Nowadays, such an analysis and its extensions are used for various types of research – e.g., evaluation of industrial resilience (Giannakis, Bruggeman, 2015), tracking the value-added trade (Johnson, Noguera, 2017), decomposing the structure of carbon emissions (Su et al., 2017), etc.

The data employed for this paper is taken from the World Input-Output Database (WIOD) (Timmer et al., 2015) and include national input-output tables for 28 EU countries[2] in the industry-by-industry format. The last available version of WIOD, released in 2016, covers each year from 2000 to 2014. The methodology of the database construction was close to that used for the previous version of WIOD, released in 2013 (Timmer et al., 2016).[3] From the point of the current research, the most important extension was the change of the aggregation level from 35 to 56 industries, increasing opportunities to explore the consumption of KIBS not only as a whole but also of the six different types of KIBS separately identified.

The empirical results presented in this research were achieved during the two main stages of the analysis. The first stage was devoted to the exploration of the structure of *direct* KIBS consumption among individual industries. First, for each of the 54 individual industries in each country the share of this particular industry in the total intermediate consumption of KIBS was calculated based on the following formula:

$$\text{Industry share}_i = \frac{\text{Intermediate consumption of KIBS by industry}_i}{\text{Total intermediate consumption of KIBS by all industries in a country}} \quad (1)$$

Then, for each of these industries a simple mean across 28 EU countries was calculated. Finally, following the arguments by Antonioli et al. (2020) on the necessity for the time partition in such analysis and taking into consideration their findings regarding the changes in the integration of KIBS into manufacturing subsystems after the Great Recession, the calculated mean values were averaged across 2011-2014. The whole procedure was replicated for both KIBS as a whole and for each of the six types of KIBS being separately considered.

The second stage of analysis was devoted to the examination of the relative importance of KIBS in the cost structure of different industries by calculating the ratio of total (both domestic and imported) intermediate consumption of KIBS per 100 units of other intermediate consumption for each individual industry in each country:

$$\text{KIBS/other inputs}_i = \frac{\text{Total intermediate consumption of KIBS by industry}_i}{\text{Total intermediate consumption by industry}_i / 100} \quad (2)$$

These ratios apply at a national level, and to get a picture of typical patterns of industrial use of KIBS for the EU as a whole, each country's data was weighted according to the share of each industry in the total output of the same industries across all European countries. Following the same logic as for the first stage of the analysis, these values were averaged across the years 2011-2014. This procedure was again replicated for both KIBS as a whole and for each of the six types of KIBS being separately considered.

Results & Discussion

The main units of analysis were the individual industrial sectors that were divided into three subsets to facilitate the presentation of results[4]. The first one covers 19 manufacturing industries, including two high-tech (HT), five medium-high-tech (MHT), six medium-low-tech (MLT) and six low-tech (LT) industries.[5] The second subset includes market services (except KIBS themselves[6]) and includes 17 sectors: three trade-related, five specializing in transportation and storage, three financial industries, three information- and communication-related industries, three service sectors covering real estate, accommodation and food, and administrative and support activities. The third subset unites all other industries not included in the first two groups and covers such industries as agriculture, mining, construction, utilities, education, health, etc.

[2] As the used dataset covers the time span from 2000 to 2014 and data for the UK (no longer a EU member) could also be included in the analysis.

[3] The basic principles and the methodology of WIOD development are presented in Dietzenbacher et al. (2013), while the key benefits of WIOD compared with the other similar databases are discussed in Timmer et al. (2015).

[4] Although some of KIBS may be also consumed by households (e.g. legal services), the share of KIBS output being dedicated to final consumption is quite low so it can be neglected for the current analysis.

[5] This classification is based on the technological intensity and is taken from Eurostat (2021). See: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:High-tech_classification_of_manufacturing_industries), accessed 21.08.2021.

[6] Self-consumption of KIBS which represent from 17% (for creative KIBS) to 28% (for IT-related KIBS) consumption of KIBS is not analyzed as its inclusion in the analysis will significantly bias the interpretation of the results.

Table 1. **Share of Manufacturing Industries in the Intermediate Consumption of Different Types of KIBS (ordered by the share of industry in total KIBS intermediate consumption, %)**

Consuming industry (NACE Rev.2 Code)	KIBS total	KIBS types					
		J62-63	M69-70	M71	M72	M73	M74-75
Manufacture of food & beverages (C10-12)	3.30	1.66	3.11	1.61	2.31	9.61	2.35
Manufacture of motor vehicles & trailers (C29)	1.46	1.16	1.28	2.13	2.80	1.14	1.56
Manufacture of machinery & equipment nec (C28)	1.29	0.98	1.34	1.46	2.78	0.86	1.44
Manufacture of pharmaceuticals (C21)	1.24	0.77	1.07	0.80	4.91	2.61	0.74
Manufacture of computer & electronic products (C26)	1.17	1.42	1.03	0.63	4.52	1.19	1.12
Manufacture of fabricated metal products (C25)	1.04	0.71	1.13	1.85	0.92	0.59	0.73
Manufacture of coke & refined petroleum products (C19)	0.86	0.40	1.15	0.80	0.57	0.36	1.49
Manufacture of chemicals & chemical products (C20)	0.84	0.57	0.92	0.81	1.49	1.30	0.57
Manufacture of electrical equipment (C27)	0.72	0.58	0.79	0.76	0.88	0.62	0.70
Manufacture of rubber & plastic products (C22)	0.55	0.35	0.77	0.54	0.89	0.47	0.46
Manufacture of other non-metallic mineral products (C23)	0.54	0.37	0.74	0.60	0.49	0.41	0.36
Manufacture of textiles, wearing apparel, leather & related products (C13-15)	0.54	0.37	0.62	0.39	0.64	0.74	0.66
Manufacture of furniture & other manufacturing (C31-32)	0.54	0.39	0.58	0.32	0.72	0.72	0.78
Repair and installation of machinery & equipment (C33)	0.53	0.48	0.54	0.72	0.59	0.23	0.82
Manufacture of basic metals (C24)	0.50	0.41	0.66	0.44	0.61	0.27	0.53
Manufacture of other transport equipment (C30)	0.34	0.28	0.34	0.49	0.50	0.22	0.28
Manufacture of wood & wood-based products (C16)	0.33	0.19	0.49	0.28	0.32	0.26	0.26
Manufacture of paper & paper products (C17)	0.32	0.29	0.35	0.30	0.33	0.36	0.27
Printing & reproduction of recorded media (C18)	0.30	0.33	0.32	0.18	0.28	0.37	0.30
Total Manufacturing	**16.39**	**11.71**	**17.23**	**15.10**	**26.55**	**22.31**	**15.43**

Legend: J62-63 — IT-related KIBS; M69-70 — Professional KIBS; M71 — Architecture and engineering; M72 — R&D services; M73 — Creative KIBS; M74-75 — OPST activities.

Source: own calculations based on WIOD, transposed tables.

As was mentioned above, the first stage of the analysis was devoted to the exploration of the distribution of direct KIBS consumption in absolute terms across different industries while the second part of the analysis was devoted to the exploration of the relevance of KIBS consumption for different industries. In both cases, the analysis was done as for KIBS as a whole and for six different types of KIBS separately: IT-related KIBS (computer programming, consultancy and information service activities, J62-63 NACE Rev. 2 codes); professional KIBS (legal, accounting and management consultancy activities, M69-70); architecture and engineering (including technical testing, M71); R&D services (M72), creative KIBS (advertising and market research, M73), other professional, scientific and technical (OPST) activities including design (M74-75)[7].

The share of manufacturing industries in the total direct consumption of KIBS was found to be about 16% (Table 1). The largest consuming sector was represented by companies specializing in the production of food and beverages (C10-12) who significantly exceed all other manufacturing industries (consumed 3.3% of KIBS versus less than 1.5% consumed by any other industry from the top five KIBS users among manufacturing - motor vehicles & trailers production (C29), production of machinery and equipment not being elsewhere classified (C28) or HT industries represented by the production of pharmaceuticals (C21) and computer and electronic products (26) respectively). The lowest amounts of KIBS are consumed by such industries as manufacturing of wood and wood-based products (C16), manufacturing of paper and paper-based products (C17) and printing and reproduction of recorded media (C19), each of those consumes just about 0.3% of KIBS.

However, when different types of KIBS are being considered separately, the share of manufacturing in their consumption varies from 11.7% for IT-related KIBS (J62-63) to 22.3% for creative KIBS (M73) and 26.5% for R&D services (M72). This relative 'overconsumption' of these types of KIBS by manufacturing as a whole seems to be driven by the large disparities in their consumption by individual industries. Thus, while the gaps between the most and the least consuming industries for other types of KIBS tend to be less substantial, these gaps

[7] Due to the data limitation, veterinary services that are often not treated as KIBS are included in this category. More details on the classification of KIBS may be found in Schnabl & Zenker (2013) and Miles et al. (2018).

Table 2. **Share of Market Services Industries in the Intermediate Consumption of Different Types of KIBS (ordered by the share of industry in total KIBS intermediate consumption, %)**

Consuming industry (NACE Rev.2 Code)	KIBS total	KIBS types					
		J62-63	M69-70	M71	M72	M73	M74-75
Wholesale trade (G46)	7.96	6.13	8.69	4.43	3.48	12.83	6.38
Financial services (K64)	6.37	8.44	9.15	3.08	3.77	3.96	3.41
Retail trade (G47)	4.73	3.30	5.26	2.31	2.09	9.96	4.26
Administrative & support service activities (N)	3.81	3.24	4.49	2.88	2.25	3.04	5.68
Activities auxiliary to finance & insurance (K66)	2.69	2.18	3.44	0.77	0.77	1.00	1.32
Telecommunications (J61)	2.33	4.15	1.75	1.40	1.13	2.93	2.00
Real estate activities (L68)	2.07	1.06	2.82	3.05	2.92	1.41	1.35
Warehousing & support activities for transportation (H52)	1.77	1.74	1.82	2.43	1.88	1.60	1.56
Accommodation & food service activities (I)	1.36	0.99	1.73	0.88	0.90	1.73	1.45
Insurance, reinsurance & pension funding (K65)	1.36	2.46	1.22	0.74	0.67	1.43	1.81
Trade & repair of motor vehicles and motorcycles (G45)	1.28	0.98	1.28	0.64	0.58	3.08	1.00
Land transport & transport via pipelines (H49)	1.24	1.57	1.34	1.34	1.22	0.75	1.08
Publishing activities (J58)	0.92	1.20	0.68	0.49	0.93	1.48	1.73
Motion picture, video & TV programme production, sound recording & music publishing, broadcasting (J59-60)	0.76	1.20	0.65	0.39	0.34	1.19	1.25
Air transport (H51)	0.46	0.69	0.38	0.25	0.39	0.40	0.82
Water transport (H50)	0.45	0.34	0.53	0.17	0.44	0.65	0.32
Postal & courier activities (H53)	0.34	0.73	0.25	0.28	0.17	0.34	0.24
Total market services	**39.94**	**40.40**	**45.48**	**25.53**	**23.92**	**47.79**	**35.64**

Legend: J62-63 — IT-related KIBS; M69-70 — Professional KIBS; M71 — Architecture and engineering; M72 — R&D services; M73 — Creative KIBS; M74-75 — OPST activities.

Source: own calculations based on WIOD, transposed tables.

tend to be quite high in the case of both creative KIBS (M73) and R&D services (M72). The former is much more consumed by the industry producing food and beverages (C10-12) which consume about 9.6% of the total amount of these services, while all other manufacturing industries together consume just only 12.7%. The latter is much more consumed by two high-tech manufacturing industries: those related to the production of pharmaceuticals (C21) and computer and electronic products (26) who consume 4.9% and 4.5% of R&D services, respectively, which is more than 1.5 times higher than the next large R&D-consuming industry which is manufacturing of motor vehicles and trailers (C29).

The largest users of KIBS, consuming about 40% of these services, are market services industries, such as transport, telecommunications or administrative support services (Table 2). In general, most (but not all) of these industries tend to be bigger consumers of KIBS than manufacturing ones, and this group includes four of the five largest users of KIBS in the whole economy - wholesale (G46) and retail (G47) trade, financial services (K64) and administrative and support services (N). The lowest shares of KIBS consumption among market services are observed in transportation and storage industries – air (H51) and water transport (H50), postal and courier activities (H53).

However, the patterns of KIBS consumption by market services vary across different types of KIBS. Thus, all together market services industries consumed about a half of professional (M69-70) and creative (M73) KIBS, but only a quarter of technological ones like architecture and engineering (M71) and R&D services (M72) - being even smaller absolute consumers of R&D services than manufacturing. As was observed in manufacturing, the KIBS in most demand from the market services tend to display much higher gaps between the largest and the smallest users than do those types that are less demanded. For instance, the two largest user industries account for about 18% of the total consumption of professional KIBS (M69-70) (compared to 28% being contributed by all other market services industries), and about 23% (vs 25%) of creative KIBS (M73). In contrast, the consumption of R&D services (M72) or architecture & engineering (M71) is not so significantly skewed towards the most consuming industries.

About 21% of KIBS is consumed by all other industries like construction, utilities or agriculture (Table 3). Among these industries, the largest KIBS user is construction (F) which consumes about 6.9% of KIBS, followed by public administration and defense (O84, 3.4%) arts, entertainment and recreation (R-S, 3.4%) and human health (Q, 1.9%)

Table 3. **Share of Other Industries in the Intermediate Consumption of Different Types of KIBS (ordered by the share of industry in total KIBS intermediate consumption, %)**

Consuming industry (NACE Rev.2 Code)	KIBS total	KIBS types					
		J62-63	M69-70	M71	M72	M73	M74-75
Construction (F)	6.85	2.09	3.61	23.76	4.33	1.61	3.39
Public administration & defence (O84)	3.43	5.16	3.55	3.05	3.27	1.68	5.12
Arts, entertainment, recreation & other activities (R-S)	3.38	4.18	2.51	1.59	3.55	4.96	6.20
Human health & social work activities (Q)	1.93	1.88	2.06	1.50	6.60	1.42	2.38
Electricity, gas, steam & air conditioning supply (D35)	1.75	1.73	2.31	2.15	1.10	0.67	1.57
Education (P85)	1.15	1.47	0.97	0.82	2.14	0.76	3.05
Crop, animal production, hunting & related services (A01)	0.93	0.46	0.44	0.72	1.78	0.27	6.32
Sewerage, waste collection, treatment & disposal activities, materials recovery & remediation activities, etc. (E37-39)	0.78	0.57	0.78	1.33	0.61	0.42	1.02
Mining & quarrying (B)	0.43	0.27	0.42	0.84	0.31	0.21	0.59
Water collection, treatment & supply (E36)	0.24	0.26	0.22	0.37	0.19	0.11	0.41
Forestry & logging (A02)	0.18	0.15	0.25	0.16	0.12	0.09	0.21
Fishing & aquaculture (A03)	0.02	0.01	0.04	0.01	0.04	0.01	0.03
Total other industries	21.09	18.23	17.15	36.28	24.04	12.21	30.28

Legend: J62-63 — IT-related KIBS; M69-70 — Professional KIBS; M71 — Architecture and engineering; M72 — R&D services; M73 — Creative KIBS; M74-75 — OPST activities.

Source: own calculations based on WIOD, transposed tables.

industries. The smallest users include such industries like water collection, treatment and supply (E36), forestry and logging (A02) and fishing and aquaculture (A03) that are not only the smallest KIBS users among the considered set of 'other' industries but also among all industries included in the two other subsets.

Each of the four largest users of KIBS among 'other' industries tends to be ranked among the largest users of each of the individual types of KIBS; but each of them also has one or two specific types of KIBS that it is outstanding compared to other industries in this group. Thus, construction (F) is the very much largest user of architecture and engineering services (M71) - not only among the 'other industries' group but also among all other industries of the economy. Public administration and defense (O84) is one of the largest users of IT-related KIBS (J62-63), while the arts, entertainment and recreation industry (R-S) consumes quite a high share of creative KIBS (M73), as well as of OPST services (M74-75). The human health industry (Q) is the largest user of R&D services (M72), while crop, animal production and hunting (A01) is found to be a large user of OPST services (M74-75). This result could well reflect data limitations: it is impossible to differentiate between KIBS activities (i.e. design services) and activities that are only arguably KIBS (i.e. veterinary services - extremely relevant for agriculture) that are included in the M74-75 category.

The results presented in Tables 1-3 provide an overview of the structure of the direct consumption of KIBS as well as of different types of KIBS. First, the results indicate that the largest users of KIBS (in absolute terms) in the EU countries are market services industries that include four of the five largest KIBS consumers among the individual industries (except for the KIBS themselves). Second, in most cases, the absolute consumption of KIBS seems to be associated either with overall industry size (larger industries consume more of each type of KIBS compared to smaller ones) or with the overall propensity toward KIBS consumption (those industries that consume more (less) of one type of KIBS also consume more (less) of other types of KIBS). Thus, those industries being classified as large (small) absolute consumers of one type of KIBS tend to occupy fairly close positions in the same ranking for other types of KIBS.

However, some strong disparities in the distribution of the individual industries' shares in KIBS consumption emerge when different types of KIBS are separately considered. These disparities are probably driven by the existence of specific synergies between some types of KIBS and some specific industries. For example:

- financial services are the largest users of both IT-related and professional KIBS. The latter may reflect the high relevance of accounting, auditing and legal services for the financial industry, while the former – the rapid development of financial technologies.
- architecture and engineering services are highly relevant for the construction industry – this outstrips all other industries (including engineering and architectural services themselves) in terms of the absolute amount of consumption

Table 4. **KIBS/Other Inputs Ratio in Manufacturing Industries (per 100 units of other inputs, ordered by ratio for KIBS in total)**

Consuming industry (NACE Rev.2 Code)	KIBS total	KIBS types					
		J62-63	M69-70	M71	M72	M73	M74-75
Manufacture of pharmaceuticals (C21)	13.07	1.98	4.04	1.79	1.48	3.24	0.54
Manufacture of computer & electronic products (C26)	8.70	2.05	2.78	1.70	0.61	0.96	0.60
Printing & reproduction of recorded media (C18)	7.55	1.47	3.24	0.84	0.20	1.26	0.54
Manufacture of other transport equipment (C30)	7.46	1.34	2.51	2.56	0.21	0.45	0.39
Manufacture of electrical equipment (C27)	6.78	1.13	2.78	1.76	0.10	0.61	0.40
Manufacture of machinery & equipment nec (C28)	6.74	1.11	3.23	1.36	0.21	0.43	0.40
Manufacture of furniture & other manufacturing (C31-32)	6.59	1.00	2.28	0.65	0.28	1.46	0.91
Repair and installation of machinery & equipment (C33)	6.50	1.10	2.86	1.65	0.11	0.43	0.36
Manufacture of other non-metallic mineral products (C23)	6.43	0.72	3.11	1.61	0.10	0.57	0.31
Manufacture of textiles, wearing apparel, leather & related products (C13-15)	5.82	0.88	2.18	0.74	0.07	1.06	0.89
Manufacture of food & beverages (C10-12)	5.43	0.52	2.09	0.48	0.07	2.02	0.25
Manufacture of chemicals & chemical products (C20)	5.33	0.78	2.05	0.95	0.19	1.12	0.24
Manufacture of rubber & plastic products (C22)	5.14	0.64	2.38	1.19	0.09	0.56	0.28
Manufacture of motor vehicles & trailers (C29)	5.05	0.77	2.06	1.00	0.17	0.72	0.33
Manufacture of fabricated metal products (C25)	4.86	0.82	2.12	1.13	0.06	0.40	0.33
Manufacture of coke & refined petroleum products (C19)	4.17	0.27	3.14	0.43	0.03	0.19	0.10
Manufacture of paper & paper products (C17)	3.88	0.63	1.71	0.73	0.05	0.54	0.23
Manufacture of wood & wood-based products (C16)	3.49	0.47	1.64	0.77	0.05	0.35	0.23
Manufacture of basic metals (C24)	2.96	0.46	1.68	0.50	0.04	0.14	0.14

Legend: J62-63 — IT-related KIBS; M69-70 — Professional KIBS; M71 — Architecture and engineering; M72 — R&D services; M73 — Creative KIBS; M74-75 — OPST activities.

Source: own calculations based on WIOD, transposed tables.

of such services, and indicates the dependence of construction projects upon these inputs.

- R&D services are more demanded by manufacturing (especially by HT manufacturing) than by services. However, its largest user is the human health and social work activities industry which probably reflects the presence of clinical trials and biopharmaceutical R&D in this category of KIBS.
- creative KIBS represented by advertising and marketing services are – not surprisingly - significantly demanded by consumer-facing industries like trade, arts and entertainment, production of food and beverages and finance.

Table 4 presents the results of the analysis of KIBS importance (measured by the KIBS/other inputs ratio) for a subset of manufacturing industries. In general, the higher importance of KIBS for those manufacturing sectors with higher technological intensity was only partially confirmed. On the one hand, the intermediate consumption of KIBS as a whole is significantly more important for HT manufacturing (C21 and C26) and large parts of MHT manufacturing (C27-C28, C30), compared to most LT and MLT manufacturing industries. On the other hand, printing and reproduction of recorded media (C18) typically considered a LT industry and earlier found to be the smallest user of KIBS among manufacturing, was found to be ranked the third most 'KIBS dependent' industry (probably, due to the high relevance of IT-related equipment and design activities). Another industry traditionally considered as LT - the manufacturing of furniture (C31-32) - was also found to rely on KIBS consumption significantly more than such MHT industries such as manufacturing of chemicals (C20) or motor vehicles (C29) (probably, due to the high importance of the design services included in OPST, M74-75).

The main reason for the differences from the analysis of the direct consumption of KIBS in absolute terms earlier presented relates to the higher relevance on one or other specific KIBS input against others, for specific industries. For instance, both IT-related KIBS (J62-63) and R&D services (M72) were found to be relatively much more important for HT manufacturing, including both pharmaceutical (C21) and computer and electronic products manufacturing (C26). In turn, architecture and engineering services (M71) were reported to be especially relevant for the manufacturing of transport equipment other than motor vehicles (C30), while creative KIBS (M73) receive greater attention from those industries producing goods for final consumption - manufacturing of pharmaceuticals (C26) and food and beverages (C10-12).

Table 5. **KIBS/Other Inputs Ratio in Market Services Industries (per 100 units of other inputs, ordered by ratio for KIBS in total)**

Consuming industry (NACE Rev.2 Code)	KIBS total	KIBS types					
		J62-63	M69-70	M71	M72	M73	M74-75
Financial services (K64)	22.18	5.86	11.90	1.17	0.14	1.99	1.12
Administrative & support service activities (N)	19.10	2.80	10.13	2.94	0.19	1.39	1.65
Activities auxiliary to finance & insurance (K66)	18.71	6.21	8.22	1.44	0.12	0.86	1.86
Publishing activities (J58)	18.15	5.69	5.21	1.11	0.57	3.60	1.97
Retail trade (G47)	14.89	2.05	7.24	1.09	0.09	3.46	0.97
Wholesale trade (G46)	14.08	2.24	7.04	1.08	0.12	2.43	1.17
Telecommunications (J61)	13.42	5.16	3.65	1.34	0.11	2.25	0.90
Insurance, reinsurance & pension funding (K65)	13.22	3.23	6.06	1.06	0.09	1.60	1.19
Motion picture, video & TV programme production, sound recording & music publishing, broadcasting (J59-60)	12.92	3.28	4.71	1.41	0.14	2.22	1.16
Trade & repair of motor vehicles and motorcycles (G45)	12.65	2.32	5.02	1.26	0.09	3.13	0.83
Real estate activities (L68)	10.90	0.86	6.97	2.07	0.08	0.35	0.57
Postal & courier activities (H53)	10.82	4.39	3.36	1.09	0.10	1.30	0.57
Warehousing & support activities for transportation (H52)	7.54	1.50	3.51	1.52	0.07	0.51	0.43
Air transport (H51)	6.37	2.26	1.90	0.57	0.15	0.74	0.75
Accommodation & food service activities (I)	6.36	1.21	3.08	0.75	0.06	0.74	0.53
Land transport & transport via pipelines (H49)	5.66	1.48	2.07	1.17	0.10	0.48	0.35
Water transport (H50)	5.18	1.39	2.52	0.57	0.07	0.38	0.25

Legend: J62-63 — IT-related KIBS; M69-70 — Professional KIBS; M71 — Architecture and engineering; M72 — R&D services; M73 — Creative KIBS; M74-75 — OPST activities.

Source: own calculations based on WIOD, transposed tables.

The KIBS/other inputs ratios for market services industries are presented in Table 5. The most relatively intensive users of KIBS as a whole were found to be financial services (K64, K66) and administrative and support services (N) while different types of transport services (H49-H53) and accommodation and food service activities (I) were characterized by the lowest levels of KIBS intermediate consumption compared to the consumption of other inputs. This appears to differentiate services involving a great deal of office-based information work, from services reliant more on unskilled labor and/or on handling physical products.

Substantial differences in the relative importance of KIBS for market services industries are observed when separately examining different types of KIBS. Thus, financial services other than insurance (K64 and K66) were found to be the most 'dependent' users of both IT-related (J62-63) and professional (M69-70) KIBS while being 'medium-dependent' users of other types of KIBS. Similarly, publishing (J58) and telecommunication (J61) industries are characterized by the high levels of importance of IT-related KIBS (J62-63) while trade-related industries (G45-G47) intensively use creative KIBS (M73). The most specialized KIBS for the market services industries were found to be architecture and engineering services (M71) and R&D services (M72). The former are used particularly intensively by administrative and support services (N) and real estate (L68) industries; the latter are intensively used by the publishing industry (J58) as compared to other sectors in the considered subset.

The analysis of the KIBS/other inputs ratios of other industries is presented in Table 6. Public administration and defense (O84), arts, entertainment and recreation (R-S) and education (P85) are found to be the most intensive users of KIBS as a whole and also of both IT-related (J62-63) and professional (M69-70) KIBS. The public administration and defense sector (O84) is also characterized by a quite high level of importance of consumption of each of the other types of KIBS; the arts, entertainment and recreation (R-S) and education (P85) industries are both characterized by quite high importance of the consumption of OPST services (M74-75). However, these two industries differ in the relative importance of the consumption of the other two types of KIBS – while the arts, entertainment and recreation industry (R-S) tend to be among the most relatively intensive users of creative KIBS (M73), the education industry (P85) is ranked as the most relatively intensive user of R&D services (M72).

Another relatively intensive user of R&D services (M72) is the human health industry (Q) which significantly outperforms other considered industries (except for education) here. It may be also concluded that architecture and engineering services

Table 6. **KIBS/Other Inputs Ratio in Other Industries (per 100 units of other inputs, ordered by ratio for KIBS in total)**

Consuming industry (NACE Rev.2 Code)	KIBS total	KIBS types					
		J62-63	M69-70	M71	M72	M73	M74-75
Public administration & defence (O84)	13.82	3.21	5.97	2.34	0.20	0.88	1.23
Arts, entertainment, recreation & other services (R-S)	13.32	3.29	5.36	1.51	0.15	1.69	1.32
Education (P85)	12.18	3.22	4.64	1.50	0.35	0.59	1.88
Sewerage, waste collection, treatment &disposal activities; materials recovery & remediation activities, etc. (E37-39)	10.78	1.96	3.74	3.69	0.14	0.49	0.78
Mining & quarrying (B)	9.59	1.29	4.47	2.73	0.13	0.45	0.52
Water collection, treatment & supply (E36)	9.36	1.92	3.33	2.92	0.11	0.46	0.61
Human health & social work activities (Q)	7.92	1.76	3.66	0.98	0.33	0.41	0.78
Construction (F)	7.68	0.67	2.44	3.88	0.08	0.24	0.37
Electricity, gas, steam & air conditioning supply (D35)	4.65	0.75	2.25	1.13	0.05	0.25	0.23
Forestry & logging (A02)	4.19	0.58	2.07	0.69	0.12	0.30	0.42
Crop, animal production, hunting & related services (A01)	3.19	0.19	0.95	0.40	0.13	0.11	1.40
Fishing & aquaculture (A03)	2.96	0.28	1.88	0.18	0.18	0.17	0.27

Legend: J62-63 — IT-related KIBS; M69-70 — Professional KIBS; M71 — Architecture and engineering; M72 — R&D services; M73 — Creative KIBS; M74-75 — OPST activities.

Source: own calculations based on WIOD, transposed tables.

(M71) are most necessarily required by 'land-based' industries with large technical facilities - construction (F) and sewerage, waste collection, treatment and disposal activities (E37-39) followed by water collection (E36) and mining (B). Finally, agricultural industries (A01-A03) were found to have the lowest levels of KIBS/other inputs ratios, even taking into consideration the idea that crop and animal production and hunting industry (A01) is a quite intensive user of veterinary services (merged with other OPST services into a single WIOD category (M74-75).

The results presented in Tables 4-6 shed the light on the relevance of KIBS consumption for different industries measured by the ratio of used KIBS inputs to all the other inputs. First, the hypothesis of the higher relevance of KIBS for more technologically-intensive manufacturing industries was only partially confirmed as some low-tech industries were also found to be characterized by quite high relative levels of KIBS consumption. Second, the level of the KIBS/other input ratio tends to differentiate market services with higher levels being observed in industries with higher levels of office-based information work, while lower levels are observed in industries that tend to use less skilled labor. Third, the disparities observed when different types of KIBS are separately considered also supports the hypothesis of the existence of specific synergies between some types of KIBS and some specific industries, like:

- the high relevance of IT-related and especially of professional KIBS for financial industries was fully confirmed, while other industries being relatively more dependent on these services are telecoms (for IT-related KIBS) and administrative and support services (for professional KIBS).
- architecture and engineering services were found to be relatively more important for construction, sewerage and waste collection and management services, production of some transport equipment, but also for administrative services and mining and quarrying industries.
- HT manufacturing industries (the production of pharmaceuticals and computers) are characterized by the highest ratios of KIBS/other inputs consumption in the case of R&D services. In contrast, human health and social work activities industry, which was found to be the largest consumer of R&D services in absolute terms, rely less upon these services and require a much greater number of other inputs.
- creative KIBS represented by advertising and marketing services were found to be relatively more relevant for the publishing industry and for both retail and wholesale trade.

Conclusions

The main goal of this paper was to examine the patterns of KIBS consumption (in terms of its structure and relevance) at the industry level across EU countries. The WIOD data allows for the examination of the consumption of KIBS as a whole and of six different types of KIBS. This is a greater level of disaggregation than most previous studies of KIBS consumption and vertical integration into other sectors could manage. Among the user industries, the largest direct users of KIBS were found to be

not manufacturing, but market services industries - in particular financial and trade-related ones. Substantial variations in both the consumption and the relevance of different types of KIBS across different industries were apparent. It was shown that some of the six types of KIBS have some 'core' user industries, characterized by a significantly higher relevance of KIBS consumption relative to other inputs. These findings confirm the high level of heterogeneity across different types of KIBS and highlight the need to use disaggregated data when examining the intersectoral relationship between KIBS and other industries as well as KIBS' role in the economy. In addition, these results suggest that more targeted innovation policy actions may be developed aimed at either supporting the innovative development of those industries consuming different types of KIBS or the growth of KIBS industries through the support of their key consumers.

This paper inevitably features some limitations, which suggest important issues for future research. First, understanding KIBS' evolution can draw upon the analysis of country-level differences in the consumption and intensity of different types of KIBS. On the one hand, it may be useful to compare not only broad groups of countries but also to explore the factors that may explain the existing differences. On the other hand, as the WIOD also contains some data on non-European economies it provides some opportunities for making some comparisons among a wider range of economies.[8] Second, it should be possible to link the consumption of KIBS with other sectoral features, such as their consumption of non-KIBS inputs, their productivity (trends), and the destination of their outputs. Finally, some alternative modes of provision of knowledge services might be examined, for example, those relating sectoral KIBS purchases to sectoral employment of 'KIBS-type' professionals like accountants, lawyers, and so on. Finally, trade in KIBS inputs and outputs could also be a fruitful topic for analysis.

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[8] It may be especially interesting to compare patterns of KIBS consumption in advanced economies and less developed ones, such as BRICS countries. Although WIOD contains some data for emerging non-European economies, the applicability of these data is limited. For instance, the WIOD creators recommended (e.g. Timmer et al., 2016) to use Russian data only for the analysis of the international trade rather than for the analysis of the economy itself due to the outdated nature of the presented data.

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