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The 'KIBS Engine' of Regional Innovation Systems: Empirical Evidence from European Regions

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The 'KIBS Engine' of Regional Innovation Systems: Empirical Evidence from European Regions

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CORROCHER N. and CUSMANO L. The 'KIBS engine' of regional innovation systems: empirical evidence from European regions, *Regional Studies*. Knowledge-intensive business services (KIBS) are key players in innovation systems, particularly in advanced regions where manufacturing competitiveness largely depends on knowledge contents provided by highly specialized suppliers. This paper investigates the relationship between KIBS and the structure and performance of regional innovation systems in Europe. It maps the co-evolution between KIBS and manufacturing in European regions, identifying emergent typologies of regional innovation systems. Results show that KIBS are a defining element of innovation-oriented regions, whereas their scarcity and slow growth distinctively characterize poor performing innovation systems. However, the analysis also identifies a set of core manufacturing regions in Europe, which are evolving along a different trajectory into knowledge-oriented service-manufacturing complexes.

Knowledge-intensive business services (KIBS) Regional innovation systems European regions

CORROCHER N. and CUSMANO L. 区域创新系统的"知识密集服务业 (KIBS) 引擎"：来自欧洲区域的经验证据，*区域研究*。知识密集服务业 (KIBS) 是创新系统中的要角，特别是在制造业竞争力大幅仰赖高度专业化的供给者提供知识内容的先进区域。本文探讨欧洲的知识密集服务业与区域创新系统的结构和表现之间的关联性。本研究描绘欧洲区域的知识密集服务业与制造业的共同发展关系，辨识出区域创新系统中浮现的类型。研究结果显示，知识密集服务业是创新导向区域的定义特征元素，这些元素的缺乏或缓慢成长，将显著地具有创新系统表现低落的特征。但本分析同时指认欧洲一系列的核心制造业区域，这些区域分别以不同的轨迹，发展成为知识导向的服务－制造业集团。

知识密集服务业 (KIBS) 区域创新系统 欧洲区域

CORROCHER N. et CUSMANO L. Le 'moteur KIBS'des systèmes d'innovation régionaux: des preuves empiriques provenant des régions européennes, *Regional Studies*. Les services aux entreprises à forte densité de connaissance (Knowledge-intensive business services - KIBS) sont les acteurs clés des systèmes d'innovation, notamment dans les régions avancées où la compétitivité de l'industrie dépend dans une large mesure des connaissances assurées par des fournisseurs hautement spécialisés. Cet article cherche à examiner le rapport entre les KIBS et la structure et la performance des systèmes d'innovation régionaux en Europe. On balise l'évolution parallèle des KIBS et de l'industrie dans les régions européennes, identifiant les typologies naissantes des systèmes d'innovation régionaux. Les résultats laissent voir que les KIBS sont un préalable au développement régional axé sur l'innovation, alors que leur rareté et leur croissance lente caractérisent clairement les sytèmes d'innovation peu performants. Cependant, l'analyse identifie aussi un ensemble de régions industrielles centrales en Europe qui évoluent le long d'une trajectoire différente, plutôt en faveur de la notion de complexes industriels et de services axés sur les connaissances.

Services aux entreprises à forte densité de connaissance (KIBS) Systèmes d'innovation régionaux Régions européennes

CORROCHER N. und CUSMANO L. Der 'Motor' der wissensintensiven Geschäftsdienste in regionalen Innovationssystemen: empirische Belege aus europäischen Regionen, *Regional Studies*. Wissensintensive Geschäftsdienste spielen in Innovationssystemen eine zentrale Rolle, insbesondere in hochentwickelten Regionen, wo die Konkurrenzfähigkeit von produzierenden Betrieben zum großen Teil von dem durch hochspezialisierte Zulieferer bereitgestellten Wissen abhängt. In diesem Beitrag wird das Verhältnis zwischen wissensintensiven Geschäftsdiensten und der Struktur und Leistungsfähigkeit von regionalen Innovationssystemen in Europa untersucht. Wir veranschaulichen die gemeinsame Evolution von wissensintensiven Geschäftsdiensten und produzierenden Betrieben in europäischen Regionen und identifizieren die entstehenden Typologien von regionalen Innovationssystemen.

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Aus den Ergebnissen geht hervor, dass wissensintensive Geschäftsdienste ein definierendes Element von innovationsorientierten Regionen darstellen, während ein Mangel und ein langsames Wachstum dieser Dienste charakteristisch sind für schlecht funktionierende Innovationssysteme. Allerdings lässt sich bei der Analyse auch eine Gruppe von Kernregionen der produzierenden Industrie in Europa identifizieren, die sich auf einem anderen Weg zu wissensorientierten Dienstleistungs- und Produktionskomplexen entwickeln.

Wissensintensive Geschäftsdienste Regionale Innovationssysteme Europäische Regionen

CORROCHER N. y CUSMANO L. El 'motor' de los servicios a empresas intensivos en conocimiento en los sistemas regionales de innovación: evidencia empírica de las regiones europeas, *Regional Studies*. Los servicios a empresas intensivos en conocimiento desempeñan una función clave en los sistemas de innovación, en particular en las regiones avanzadas donde la competitividad de la industria manufacturera depende en gran medida de los contenidos de conocimiento ofrecidos por proveedores altamente especializados. En este artículo analizamos la relación entre los servicios a empresas intensivos en conocimiento y la estructura y el rendimiento de los sistemas regionales de innovación en Europa. Describimos la evolución conjunta de los servicios a empresas intensivos en conocimiento y la manufactura en las regiones europeas identificando las tipologías emergentes de los sistemas regionales de innovación. Los resultados indican que los servicios a empresas intensivos en conocimiento son un elemento determinante para las regiones con afán innovador, mientras que la deficiencia y un lento crecimiento de estos servicios son características distintivas de sistemas de innovación con bajo rendimiento. Sin embargo, el análisis también identifica un grupo central de regiones manufactureras en Europa que se están convirtiendo por una ruta diferente en complejos de manufactura y servicios orientados hacia el conocimiento.

Servicios a empresas intensivos en conocimiento (SEIC) Sistemas regionales de innovación Regiones europeas

JEL classifications: L84, O52, R11

INTRODUCTION

The quest for growth and innovation at the regional level has been for a long time a key policy challenge in Europe. The development of knowledge-intensive clusters or world class 'knowledge hubs' has become a popular target for policy-makers, epitomizing the tension between globalization and territorialization in the knowledge-based economy. The increasing attention on regional innovation policies, or 'place-based' approaches to innovation, reflects the recognition that the conditions for competing effectively at the global level are often based on specific local advantages and on the capacity to harness localized assets (ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD), 2011). In particular, it is recognized that 'soft' or intangible factors are a major source of regional competitiveness. At the same time, the regional focus of innovation policies responds to cohesion objectives, since the late evolutionary patterns have often resulted in widening gaps between leaders and followers, whereas the catching-up experiences have been mainly based on the connectivity to knowledge networks and on the rapid development or upgrading of knowledge-based capabilities.

In this framework, the attention of scholars and policy-makers has increasingly focused on local 'knowledge agents', that is, on economic players that generate, convert and/or diffuse knowledge through the system, contributing to the development of the regional knowledge base. In particular, knowledge-intensive business services (KIBS) – firms involved in activities such as consultancy, market research, design, engineering and technical services – are increasingly perceived to play a crucial role in regional innovation systems (RIS), generating opportunities for interactive learning, favouring the creation of local linkages and contributing to the systems' connectivity to outside knowledge networks.

Over the last couple of decades the KIBS sector has experienced a remarkable growth in entry rates, number of firms, share of employment and value added. Its relevance, however, goes beyond their actual employment share and extends to innovation dynamics and technical change (CZARNITZKI and SPIELKAMP, 2000; MULLER and ZENKER, 2001; MILES, 2005; DOLOREUX and MULLER, 2007). TETHER and HIPP (2002) suggested that the recent tertiary evolution and outsourcing trends of the economies imply a redistribution of knowledge in favour of KIBS and away from traditional manufacturers and service providers. In this respect, if KIBS were early characterized as providers or transferers of specific information for their clients (WOOD *et al.*, 1993), more recently they have been identified as key nodes of knowledge-related networks, 'bridges of innovation' that can trigger and strengthen the processes of knowledge conversion in client firms (DEN HERTOG, 2000; DOLOREUX and MULLER, 2007). The role of KIBS appears to be particularly significant in advanced regions, where manufacturing competitiveness increasingly depends on knowledge contents, provided by highly specialized suppliers. As regional economies develop, the demand for knowledge inputs becomes more sophisticated and the role of private specialized providers becomes more prominent, with functions

that are complementary or competing with those of the public knowledge-generating institutions that form essential parts of RIS (COOKE and MEMEDOVIC, 2003).

Notwithstanding the burgeoning literature on KIBS, the investigation about their role for regional competitiveness and in the evolution of RIS is still at an early stage. More in-depth analysis is required to improve the understanding about their role in the competitive transformation of regions. In this regard, some recent empirical studies highlight relevant lines of research. For instance, FREEL (2006) and CORROCHER *et al.* (2009, 2012) suggested that not all KIBS are driven by a clearly defined orientation towards innovation, and even within groups of innovative KIBS innovation takes place in various forms as a result of different competitive strategies and produces different impacts on the business environment. Furthermore, the innovative contribution of KIBS to the RIS is inevitably affected by region-specific factors, such as the structural composition of the regional economy – that is, sectoral specialization, innovation patterns in the manufacturing sector, degree and type of tertiarization – and the innovative environment in which these companies are embedded.

The aim of this paper is to investigate empirically the relationship between KIBS and RIS across European regions. It does so by bridging the bodies of literature that investigate KIBS and RIS, by mapping the characteristics of service and manufacturing functions across European regions, and by assessing the degree at which the different growth patterns of KIBS explain differences in regional innovation performance. In particular, the paper intends to examine the relationship between the industrial structure and the relevance of KIBS in high- and low-growth regions, identifying and characterizing emergent typologies of RIS in Europe. In doing so, it addresses the following research questions:

- What is the interplay between the transformation of the manufacturing sectors and the presence of KIBS across regional systems?
- What are the key elements in the RIS that are associated with the development of KIBS?
- Are innovative regions characterized by specific patterns of KIBS' activity?

The empirical analysis relies upon a dataset of 220 European regions (NUTS-2 level). The authors are interested, in particular, in relating KIBS relevance and manufacturing specialization with innovation indicators. The results show that KIBS are indeed a defining element of innovation-oriented regions. In other terms, it is in high-income and high-technology systems, endowed also with an extensive public research and development (R&D) infrastructure, that KIBS account for the largest share of employment and exhibit the highest rate of growth. However, the empirical analysis also singles out a different group of innovative regions, characterized by a lower presence and growth of KIBS, which co-exist with a persistent high-technology manufacturing core. These regions represent the traditional manufacturing backbone of Europe and are evolving along a different trajectory into knowledge-oriented service–manufacturing complexes. These regions still represent an engine of industrial transformation within Europe, exhibiting a very good performance in terms of innovation indicators, especially with reference to private R&D activity and high-technology patents. Typically, these regions are specialized in mid-to-high-technology sectors, such as medical, production technologies, heavy machinery and instruments. Finally, there is evidence of a group of regions that are affected to a limited degree by knowledge-intensive tertiarization. This group also exhibits poor innovative activity and low levels of investment in both private and public R&D. However, within this group it is possible to identify a set of high-growth regions, which differ from the stagnating ones particularly in the level of tertiary education.

LITERATURE REVIEW: KIBS AND THE RIS

Scholars and practitioners recognize that advanced services have become increasingly important for economic growth, as performers and enablers of innovative activity (HOWELLS, 2000; TETHER and METCALFE, 2004). This is particularly the case for KIBS, that is, firms involved in consultancy, market research, design, engineering and technical services, whose role in the dynamics of modern 'knowledge economies' extends well beyond their actual direct employment relevance (MULLER and ZENKER, 2001; GALLOUJ, 2002; MILES, 2005). Different types of KIBS share the basic feature of providing non-material knowledge-intensive services to other firms and public institutions (MILES, 2005; STRAMBACH, 1998; SUNDBO and GALLOUJ, 2000), possibly generating knowledge in interaction with the customers, bringing external knowledge to the client companies and supporting their innovative processes. In this respect, the perception of KIBS has evolved from an early characterization as providers or transferers of specific information for their clients (WOOD *et al.*, 1993) to their identification as key nodes of knowledge-related networks, which take an active role in the interactive processes that favour the development of innovation capabilities and innovation outcomes (DOLOREUX and MULLER, 2007; DEN HERTOG, 2000).

According to the burgeoning literature about regional (and local) innovation systems (RIS), the process of interactive learning and systemic innovation has a strong local dimension, as spatial, institutional and cultural proximity favours closer links, as well as stable knowledge partnering among different types of actors. Firms are embedded into a dense web of vertical

(along the supply chain) and horizontal relationships. The territorial system in which firms operate is shaped by a set of 'soft' factors (for example, norms, codes of conducts, modes of social regulation) and is characterized by specific infrastructure (transport, telecom), knowledge providers (universities, research institutes, technology transfer centres, etc.), and governance mechanisms, which often work through institutions such as government departments, as well as private business associations, chambers of commerce and development, training and promotion agencies (COOKE *et al.*, 1997; COOKE, 2001a). Accordingly, a large number of empirical studies on RIS relate regional innovation performance with the composition of the business sector, the presence of knowledge providers – mainly universities and research centres – and the organizations that form the institutional architecture of the region.

According to COOKE (2001b), the emphasis of scholars and policy-makers on the linkages between industry and the public research system follows the key role played by universities or publicly funded research institutions in the most notable regional success cases in the United States, but also the increasing attention in Europe on clustering and technological transfer for addressing the 'European paradox'[1] and strengthening regional competitiveness (for example, ASHEIM and GERTLER, 2004). In the view of COOKE and MEMEDOVIC (2003), the analytical attention on public-related institutions can be related with the fact that in accomplished advanced regions, the provision of knowledge services has been heavily dependent on public initiatives in the form of university funding, research funding, technology transfer services and training systems. However, the evolutionary trajectory in more knowledge-based and high-technology regions, such as California, Massachusetts or the Thames Valley, shows that private knowledge services, though they may arrive later than public ones, may ultimately rise in prominence over them. As regional economic structures develop and demand more sophisticated services, the subsystem of 'knowledge generation and diffusion', which complements the 'knowledge application and exploitation' subsystem formed by the market players that apply and commercialize knowledge (COOKE, 2001a), is expected to evolve more and more into a mix of private and public entities.

The literature on KIBS takes a step further and highlights the role that these market actors play in bridging the functions of knowledge generation and knowledge application. Indeed, KIBS are portrayed as 'bridges of innovation' in the regional system (that play a key strategic function for turning technology into competitive performance (STRAMBACH, 1998; CZARNITZKI and SPIELKAMP, 2000; DEN HERTOG, 2000; MULLER and ZENKER, 2001; THOMI and BÖHN, 2003). Technologically innovative KIBS not only develop their own knowledge, but also stimulate the production of knowledge among their clients, particularly manufacturing firms, as knowledge purchasers, providers and partners. According to WOOD (2005), the strategic role of KIBS in regions lies in their capacity to support 'regional adaptability', as they can adapt generic technical and commercial knowledge and experience to specific needs across different sectors.

If KIBS are a constitutive element of RIS and an important driver of their transformation, at the same time their emergence and nature depend upon the technological, economic and institutional structure of the regions in which they are embedded (KOCH and STAHLECKER, 2006). In other words, the variety of regional settings represents a variety of conducive environments for KIBS and their contribution to innovative activities in other sectors. In particular, the quality of the entrepreneurial 'social' networks and the structure of the regional knowledge potential constitute important enabling factors. For example, it is reasonable to argue that the emergence and growth of KIBS require a qualified and diversified labour pool, and that, at the same time, the educational levels influence the system's capacity to absorb and elaborate the knowledge produced by KIBS. In this respect, the literature underlines that the role of KIBS can be particularly significant in advanced regions, where the competitiveness of manufacturing companies increasingly depends on the knowledge provided by highly specialized suppliers and qualified human capital is dedicated to interact with KIBS and integrate their knowledge into the firm (CHADWICK *et al.*, 2008; COOKE and PICCALUGA, 2004; SIMMIE and STRAMBACH, 2006).

If different economic, technological and institutional preconditions at the regional level affect the characteristics and evolution of the KIBS sector, according to WOOD (2005) the polarization between regions, in terms of economic and technological evolutionary patterns, is being largely influenced by knowledge-based service functions, much more than by the invention or adoption of new technologies. Although the increasing contribution of KIBS to the economy is a response to a virtually universal growth in business and public sector demand for knowledge-intensive, specialized expertises, there have been marked contrasts in KIBS dynamics between the more and less industrially developed areas. This is especially evident in Europe, where the emergence of KIBS has responded to different needs: the restructuring of manufacturing companies towards high-technology functions in mature industrial regions; the support of a catalytic and global bridging role in the dominant city-regions; the liberalization and significant transformation towards new competitive technical and organizational cultures in the Southern regions. If the evolution of KIBS reflects the local characteristics, their growth is likely to strengthen the differences across regions, as the conditions that favour a structural change towards a knowledge-intensive economy are cumulative and difficult to extend elsewhere (WOOD, 2005).

Notwithstanding the recognition of KIBS' relevance to regional competitiveness and the debate about their role in the evolution of RIS, so far little empirical research has been devoted to investigate, in a comparative perspective, the dynamics of KIBS at the regional level and their different role within heterogeneous innovation systems across Europe. Early contributions propose region-specific investigations about the role of KIBS as facilitators of networking and innovation. For instance, taking the case of Baden-Württemberg, STRAMBACH (1998) focused on the relationship between the presence of KIBS and regional competitiveness, arguing that the underdevelopment of KIBS in the region can be considered as a major cause of the loss of competitiveness in the 1990s. The author disentangles the evolution of different sectors within KIBS, emphasizing in particular the role of technical and engineering services in determining the evolution of the RIS. More in general, technical services with close connections to the manufacturing sector may contribute to a mixed service–manufacturing cluster, while weakly embedded KIBS (for example, software and information services, consultancies) may rather serve as a nucleus for a sectoral service cluster and/or connect the region with external knowledge resources. MULLER and ZENKER (2001) examined the interaction between KIBS and small and medium-sized enterprises in different regions of France and Germany. Their investigation showed that virtuous cycles of learning take place between KIBS and small and medium-sized enterprises, so that interacting businesses are more oriented towards innovation than non-interacting ones. THOMI and BÖHN (2003) relied on a broad survey to analyse the key role of KIBS in the innovation system of the Southeast Finland region and the correlation between the KIBS characteristics and activities and the regional productive specialization. All these early contributors agree that further studies on the relationship between KIBS and RIS are needed in order to generalize the findings and patterns identified so far. Further investigation is also needed to understand the degree at which private knowledge services are complementing or competing with public ones in providing the specialized knowledge inputs increasingly required in innovative regions (COOKE, 2001a, 2001b; COOKE and MEMEDOVIC, 2003), or, in other terms, the function different knowledge actors may play in the evolution of RIS.

EMPIRICAL ANALYSIS

The analysis aims at mapping the relationship between KIBS and regional economic characteristics within a set of 220 European regions (NUTS-2 level). First, by means of a factor analysis, KIBS' relevance and growth are related to the characteristics of the regional economic structure. Second, similar groups of regions are identified by performing a cluster analysis on the previously mentioned factors. Finally, the different clusters are compared according to a set of innovation-related indicators at the regional level in order to evaluate, through a multivariate analysis, to what extent the performance of the RIS is related to the expansion of the KIBS sector or to the co-evolution of manufacturing and advanced service functions.

Following the enlargement of the European Union, the European landscape is characterized by large differences in income levels, but also by significant divergences in the pace of economic growth: high growth rates in New Member States or in emerging regions co-exist with a sluggish economic performance in mature industrial areas or in traditional backward regions. KIBS play a relatively major role in advanced (high-income) regions, in which the economic competitiveness increasingly depends on the production and distribution of knowledge contents, hence, tertiary functions respond to evolving complex and diversified needs (Table 1). However, as far as the regional industrial structure is concerned, the simple correlation between the employment share of KIBS and the share of employment accounted for by high-technology manufacturing does not provide a clear-cut indication. Therefore, the argument developed in the literature (see the second section) about the role of KIBS as 'bridges of innovation' or providers of specialized knowledge for advanced manufacturers needs further qualification and finer articulation.

In fact, the patterns of KIBS' growth across Europe seem to reflect both a large heterogeneity across advanced high-income areas and a broad trend towards a highly qualified tertiarization, which, as WOOD (2005) argued, responds to differentiated needs at the regional level. Fig. 1 illustrates within- and between-countries differences in KIBS' share of employment.

The picture is indeed one of increasing knowledge-based polarization at the regional level. This evidence supports the argument by WOOD (2005) that the growth of KIBS strengthens differences across RIS. The leading regions in terms of KIBS relevance are

Table 1. *Knowledge-intensive business services (KIBS), income level and type of manufacturing*

	Correlation coefficient
GDP 1999 – share KIBS 1999	0.821*
GDP 2006 – share KIBS 2006	0.808*
High-technology manufacturing – KIBS 2006	–0.061
Medium-technology manufacturing – KIBS 2006	–0.227*
Low-technology manufacturing – KIBS 2006	–0.390*

Notes: GDP, gross domestic product.
*Significant at the 0.05 level.

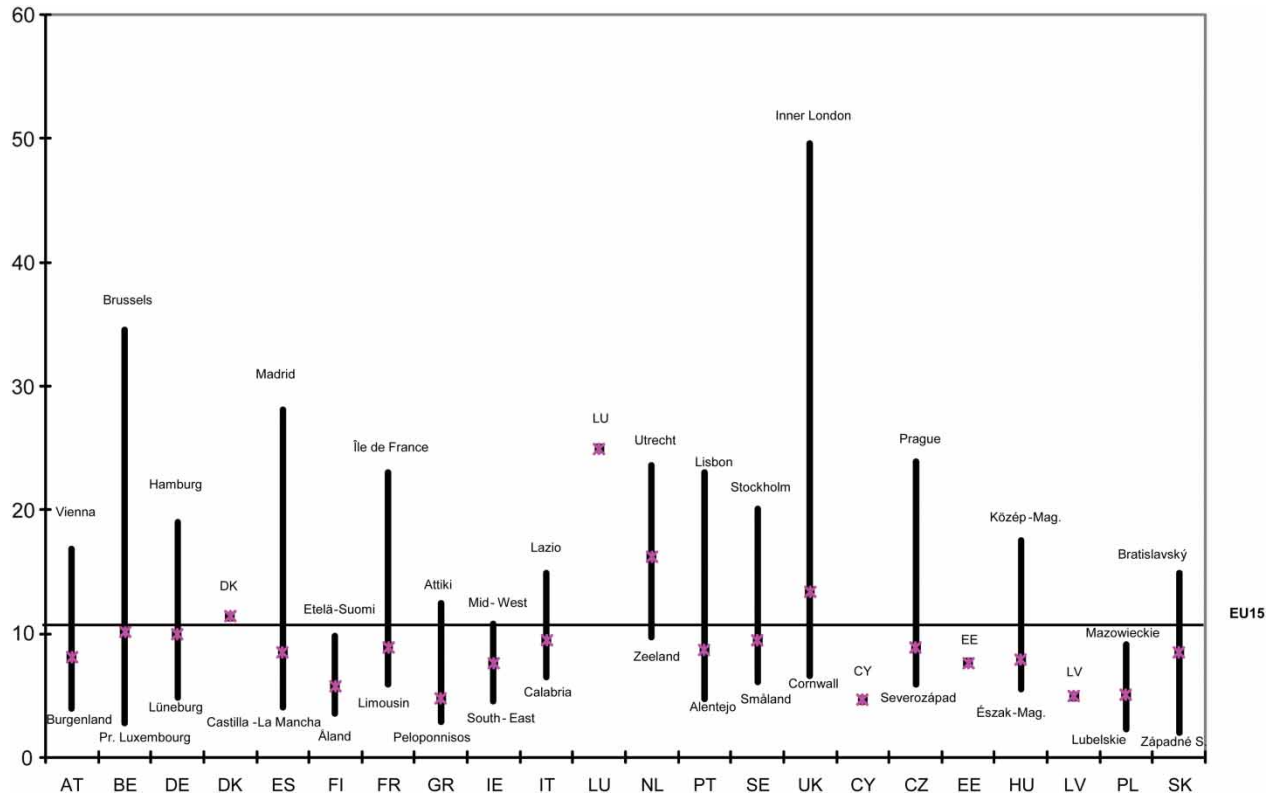

Fig. 1. *Knowledge-intensive business services' (KIBS) share of employment in European regions: between and within country differences, 2006*

the capital city ones, with the exception of Hamburg in Germany and Utrecht in the Netherlands. As expected, major city regions are the ideal locus of innovation and knowledge-intensive interdependence among different types of economic activities. Metropolitan areas represent a nexus of highly dynamic markets to be served by knowledge-intensive service inputs, and are generally centres of provision at the broader national and international level. Furthermore, metropolitan areas offer a large and diversified labour market for advanced services and facilitate interaction and knowledge diffusion. In short, the evidence clearly supports the idea that urban agglomeration economies play a distinct role for KIBS growth. At the same time, it is interesting to observe that high-performing areas, such as the Finnish high-technology regions and the dynamic Irish counties, do not stand out in terms of KIBS intensity and are indeed characterized by a share of KIBS employment that is below the EU-15 average.

PATTERNS OF REGIONAL ECONOMIC STRUCTURE: A FACTOR ANALYSIS

The first step of this empirical analysis aims at exploring the underlying factors behind the economic structure of European Union regions. The factor analysis is carried out on 220 regions (excluding outliers from the initial set of 243 regions[2]) and twelve variables describing the economic structure of each region in 2006: gross domestic product (GDP) growth rate over the period 1999–2006 (*GROWTH*); average GDP per inhabitant (*GDP*); active population share (employed persons aged 15–64 years as a percentage of the population of the same group – *ACT_POP*); share of employment in total industry (*EMPL_IND*); share of employment in high-, medium- and low-technology manufacturing (*EMPL_M_HT*, *EMPL_M_MT* and *EMPL_M_LT*); share of employment in public administration and social activities (*EMPL_PA*); share of employment in transport, storage and communications (*EMPL_COMM*); share of employment in KIBS by sector (*EMPL_K72*, *EMPL_K73* and *EMPL_K74*).[3] Table 2 presents the correlation matrix of the variables used to account for the economic structure of the regions.

A factor analysis is performed in order to investigate the pattern of correlations which is highlighted in Table 2 and to assess what latent factors might be associated with these relationships.[4] A three-factor solution is selected that allows one to explain 66% of the total variance.[5] Table 3 presents the results.

The first factor is induced by the association between knowledge-intensive services and the overall economic prosperity of a region (in terms of GDP per capita and active population share). KIBS is labelled the 'latent force' and it can be observed that the presence of these services is associated with the overall level of development

Table 2. Regional economic structure

	Correlation matrix											
	ACT_POP	*GDP*	*GROWTH*	*EMPL_K72*	*EMPL_K73*	*EMPL_K74*	*EMPL_COMM*	*EMPL_PA*	*EMPL_IND*	*EMPL_M_HT*	*EMPL_M_MT*	*EMPL_M_LT*
ACT_POP	1.0000											
GDP	0.4096*	1.000										
GROWTH	0.0310	–0.4015*	1.0000									
EMPL_K72	0.3189*	0.6391*	–0.1185	1.0000								
EMPL_K73	0.3254	0.3981*	–0.0078	0.5227*	1.0000							
EMPL_K74	0.3130	0.6961*	–0.2058*	0.7594*	0.4516*	1.0000						
EMPL_COMM	0.1852	0.4117*	–0.0545	0.6010*	0.1353*	0.5614*	1.0000					
EMPL_PA	0.1249	0.3351*	–0.3559*	0.2111*	0.2273*	0.2940*	0.1768*	1.0000				
EMPL_IND	–0.0411	–0.1619*	0.0953	–0.1336*	–0.1887*	–0.2285*	–0.2241*	–0.4676*	1.0000			
EMPL_M_HT	0.1814	0.2506*	–0.0602	0.2470*	0.1198	0.1542*	–0.0614	–0.0060	0.4825*	1.0000		
EMPL_M_MT	0.0485	0.0786	–0.0953	0.0269	–0.0679	–0.0512	–0.1697*	–0.2401*	0.8740*	0.5717*	1.0000	
EMPL_M_LT	–0.1156	–0.3890*	0.2133*	–0.3056*	–0.2830*	–0.3295*	–0.2299*	–0.5372*	0.6746*	0.0894	0.3330*	1.0000

Note: *Significant at the 0.05 level.

Table 3. Economic structure of the regions

	KIBS		Manufacturing		Growth	
EMPL_K72	88	*	.		.	
EMPL_K74	83	*	.		.	
GDP_HAB	71	*	.		–48	*
EMPL_COMM	67	*	.		.	
EMPL_K73	63	*	.		.	
ACT_POP_SHARE	56	*	.		.	
EMPL_M_MT	.		93	*	.	
EMPL_IND	.		89	*	34	
EMPL_M_HT	.		74	*	.	
GDP_GR_99_06	.				81	*
EMPL_M_LT	–30		46		58	*
EMPL_PA	.				–73	*

Note: Rotated factor pattern (varimax rotation). The values shown were multiplied by 100 and rounded to the nearest integer. Values greater than 0.469565 are flagged with an asterisk (*). Values less than 0.3 are not reported.

and growth of the regions. The second factor – MANUFACTURING – captures the association between the share of employment in medium- and high-technology manufacturing and the overall share of employment in industry. The third factor – GROWTH – reflects the association between high growth rates and high levels of employment in low-technology manufacturing. Regions inducing this factor also display low rates of employment in the public administration and social activities and, most interestingly, low GDP levels. This suggests that regional convergence has been taking place, to some degree, at the European level as regions at the early stages of economic development and mainly focused on low-technology industries are growing quickly.

If one maps European regions according to the first two factors in order to identify, at a more disaggregated level, the association between an expanded KIBS sector and high employment in the mid-to-high-technology manufacturing sector the following results are found.

On the positive side, the manufacturing factor is mainly dominated by the German and the North Italian regions; on the other side of the spectrum, Greek regions and selected French, Polish and Spanish regions exhibit poor levels of employment in high-to-medium-technology manufacturing. As expected, the KIBS factor is mostly dominated by UK and Dutch regions.[6] On the negative side of the KIBS factor, the tendency is dominated by the Italian islands, selected French regions and the regions belonging to East European countries.[7] Some regions dominate (negatively) both factors: the bottom-left quadrant (low levels of employment in both KIBS and high-to-medium-technology manufacturing) is mainly populated by Greek and South Italian regions.

The factor analysis provides the basic input for the cluster analysis, which is meant to detect commonalities and differences across European Union regions on the basis of the previously described factors. In this way, the intention is to identify and describe the variety of development patterns in European Union regions in terms of the emerging relationships between KIBS and manufacturing sectors. The clustering exercise also provides the input for a multinomial logistic regression, which aims at exploring the relationship between the performance of the RIS and the patterns of KIBS development.

CLUSTER ANALYSIS ON EUROPEAN UNION REGIONS

This section performs a hierarchical cluster analysis based on the scores of the factor analysis. In order to determine

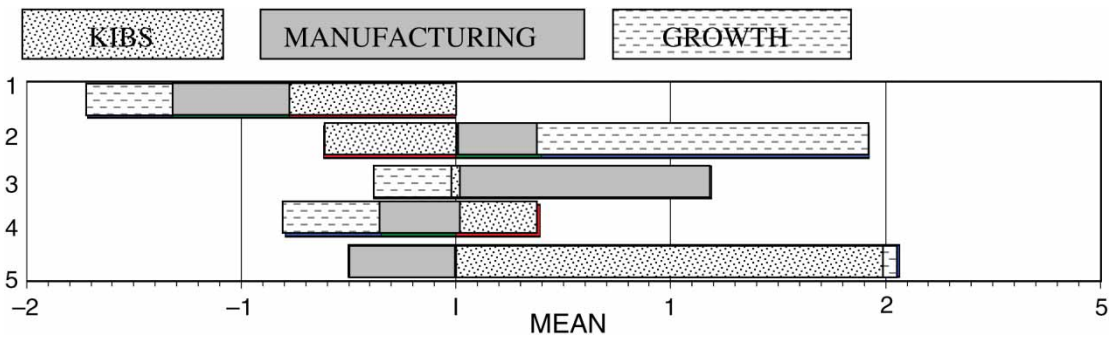

Fig. 2. Clusters of European Union regions (comparison with the European Union mean)

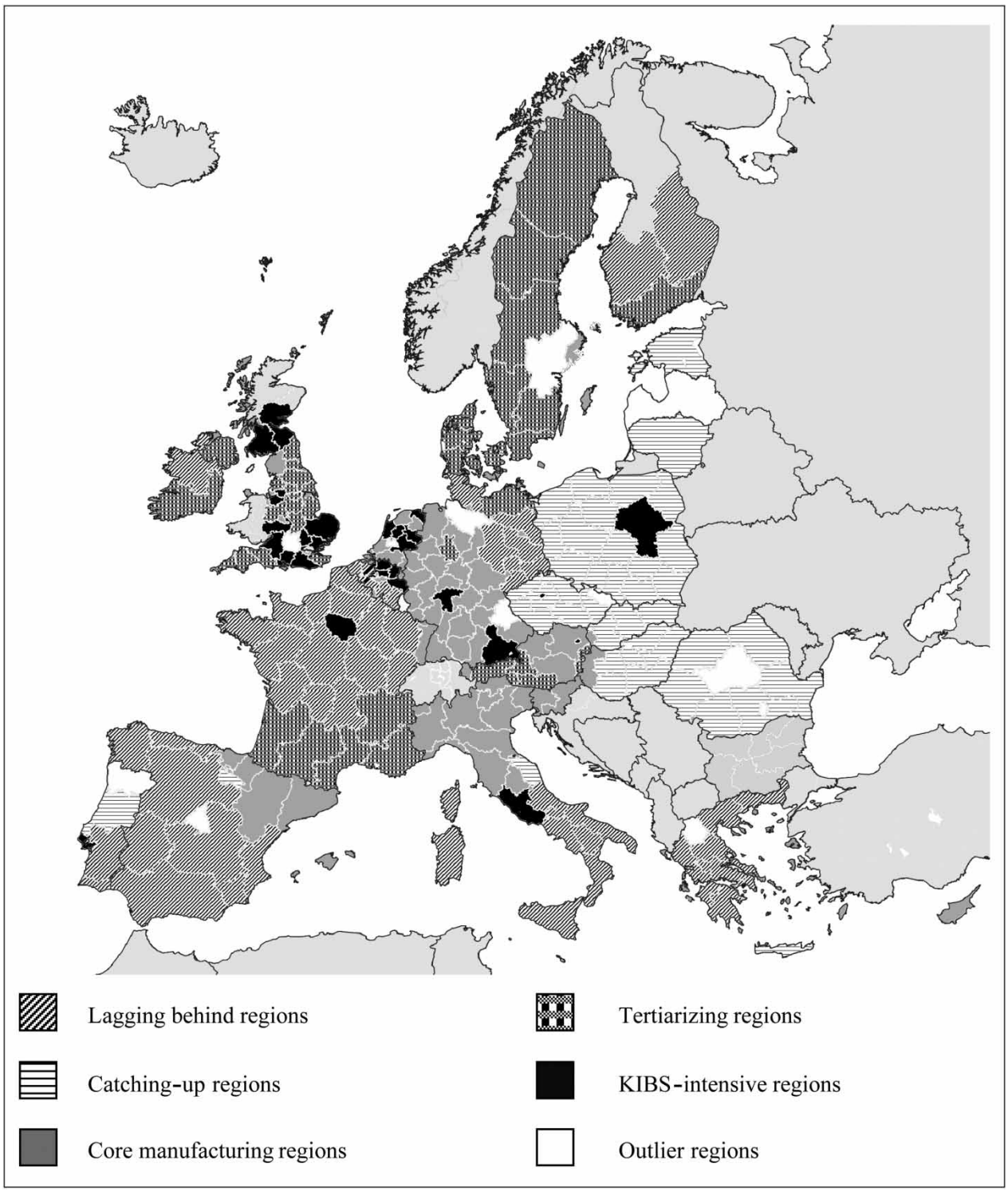

Fig. 3. *Clusters of European Union regions*

the most appropriate number of clusters, it applies Ward's algorithm, which measures the dissimilarity across clusters. The distance between cases is measured by the statistical distance (upon standardized variables). The analysis of the dendrogram showing the distance between cases, combined with other statistical criteria (for example, semi-partial R^2, R^2 and pseudo-T^2 statistics), suggests that one extracts five clusters, whose difference in terms of factors is statistically significant. Fig. 2 illustrates how each cluster performs with respect to the three factors.

Clusters 1 and 2 stand out for being little concerned by the recent growth of KIBS activities, although these clusters are significantly different in terms of

manufacturing employment and economic growth rates. In particular, Cluster 1 includes seventy-five regions that are described here as LAGGING BEHIND, as they are poorly performing with respect to all the three factors: they display poor employment levels across all the manufacturing industries, have a small KIBS sector and underperform in terms of economic growth variables.[8] It is relevant to mention that the GROWTH factor also includes, with a negative sign, the employment in the public administration. In other terms, these regions are typically characterized by a sluggish growth performance *and* a large share of employment in the public administration. On the other hand, Cluster 2, composed by eleven regions, is characterized by a positive performance along the third factor (growth) and a significant high share of employment in high-to-medium-technology manufacturing: this group of regions is labelled CATCHING-UP REGIONS. Cluster 3 groups regions with high levels of employment in high-to-medium-technology manufacturing industries, but a relatively small share of KIBS employment and low levels of growth. This cluster is labelled CORE MANUFACTURING REGIONS. Cluster 4 scores low along the growth dimension; it is relatively oriented towards KIBS, although at far distance with respect to Cluster 5, but is well below the European Union average in terms of high-to-medium-technology manufacturing: this group is labelled TERTIARIZING REGIONS as it identifies regions that have clearly undergone a process of tertiarization, largely towards traditional services. Finally, Cluster 5 – KIBS-INTENSIVE REGIONS – groups the regions with a high level of employment in KIBS, a relatively low level of employment in manufacturing and high growth rates.

Fig. 3 maps European Union regions according to the clusters identified. Notice that some countries tend to have a fairly homogeneous group of regions (for example, Sweden and Poland) while within-country differences are more evident in the case of the large European economies (for example, Italy, France and the UK). The outlier regions, omitted from the factor and cluster analyses, are also included in Fig. 3.

KIBS AND THE RIS

The cluster analysis highlights the variety of economic structures across European regions. The present section aims at investigating how different clusters perform in terms of innovation indicators and, in particular, whether, at the regional level, high levels of employment in KIBS, or specific KIBS–manufacturing combinations, are associated with a good innovation performance as measured by a set of science and technology indicators. For this purpose, the following multinomial logistic model is estimated by taking cluster membership as the dependent variable and setting Cluster 5 (KIBS-INTENSIVE REGIONS) as the base case:

$$\Pr(Y_i = j) = \frac{\exp\left(\alpha_i + \sum_{k=1}^{K} \beta_{jk} X_{ik}\right)}{1 + \left[\sum_{h=2}^{J} \exp\left(\alpha_h + \sum_{k=1}^{K} \beta_{hk} X_{hk}\right)\right]}$$

$$\text{for } j = 2, \ldots, 5$$

$$\Pr(Y_i = 1) = \frac{1}{1 + \left[\sum_{h=2}^{J} \exp\left(\alpha_h + \sum_{k=1}^{K} \beta_{hk} X_{hk}\right)\right]}$$

$$\text{for the reference category } j = 1$$

where Y is the dependent variable status (in this case cluster membership); X is the vector of covariates; and β is a vector of coefficients. It is important to underline that the analysis does not try to identify cause–effect relationships; rather, its aim is to highlight the robust relationship between different clusters of regions and the covariates.

Covariates are selected that reflect the most distinctive traits of the RIS as described in the academic literature presented in the second section and as acknowledged by policy-makers and international organizations (for example, EUROSTAT, 2006; OECD, 2011). First, a measure of innovative output at the regional level is included by computing the number of patents in high- and medium-technology classes (*PATENTS_HT*, *PATENTS_MT*). On the one hand, it might be expected that KIBS-intensive regions perform better than others with respect to the output of their innovative activity, as advanced services facilitate knowledge diffusion and innovation in the manufacturing sector (WOOD, 2005). On the other hand, since service companies do not make an extensive use of patents as a means to protect innovation (TETHER, 2005), a high rate of patents in high-to-medium-technology classes is more likely to be associated with the cluster of core manufacturing regions. Second, one controls for the relevance of R&D employment in government (*EMPL_RD_GOV*) and in private companies (*EMPL_RD_BUS*). With reference to this variable, one expects to find more private R&D in regions with a core manufacturing sector. The literature is less conclusive on the relationship between public R&D and the development of advanced services, particularly private R&D services (or R&D functions within manufacturing firms). On the one hand, knowledge institutions such as public research centres and universities can act as incubators of entrepreneurial ideas related to the KIBS sector, which may develop through spin-off processes (DI MARIA *et al.*, 2012). Also, there is evidence that high levels of public R&D expenditure in regional contexts favour innovation in high-technology manufacturing and positively affects regional specialization in business services (MELICIANI and SAVONA,

2011). On the other hand, however, formal (public and private) R&D is less necessary for innovation in services, and when it comes to core manufacturing areas, the empirical literature has not provided a conclusive answer on whether complementarity or substitutability between public and private R&D takes place. In other terms, a crowding-out effect of public R&D on private R&D expenditures might also be observed (DAVID *et al.*, 2000; MELICIANI and SAVONA, 2011). In this sense, the degree to which public and private knowledge services are complementary or substitutes along RIS evolutionary trajectories, that is, as regional systems evolve into knowledge-based economic systems, is an open question and a matter for empirical investigation. Finally, this section introduces a variable accounting for the level of high education in the region (*EDU_HIGH*) and one expects this to be particularly strong for KIBS-intensive regions, as the pattern of specialization requires the employment of highly skilled labour force (CHADWICK *et al.*, 2008).

Table 4 illustrates the results of the estimates. First, with respect to the research inputs, it is the base case (KIBS-INTENSIVE REGIONS) that outperforms in terms of public research infrastructure. The weakness of public R&D, on the contrary, clearly distinguishes LAGGING BEHIND regions, which are also characterized by significantly lower levels of employment in business R&D. Interestingly, for the other clusters significant differences in terms of private R&D are not detected. In other terms, a strong public R&D infrastructure is a distinctive feature of KIBS-INTENSIVE REGIONS, which, on the other hand, do not stand out for private R&D intensity. As suggested by COOKE and MEMEDOVIC (2003), it appears that a strong public knowledge infrastructure facilitates the expansion of KIBS, whose prominence may increase over time, as these players respond to a demand for more specialized knowledge inputs and also capture the knowledge-intensive functions outsourced by manufacturing firms. Important differences across clusters are observed in the levels of tertiary education. KIBS-INTENSIVE REGIONS outperform the other clusters but the TERTIARIZING REGIONS. The result is consistent with the argument that the proliferation of KIBS occurs in a context characterized by highly qualified and specialized human capital. As far as the innovative output (patenting activity) is concerned, CORE MANUFACTURING REGIONS stand out for their performance in high-technology fields. When it comes to mid-technology patent classes, however, similarly to the other clusters, these regions perform worse than KIBS-INTENSIVE ones.

Table 5 further qualifies this finding, illustrating the differences in the patterns of sectoral specialization across clusters. In particular, on the basis of data from the European Cluster Observatory,[9] the authors computed for each cluster the average employment specialization of regions belonging to that cluster and considered the top five sectors. In the KIBS-INTENSIVE cluster, the expected specialization in services for businesses and households typically goes together with the development of a large information technology (IT) sector. The CORE MANUFACTURING cluster is distinctively characterized by specialization in mid-to-high-technology fields, including production technologies, power, instruments, medical and heavy machinery. It is interesting to notice that the Aerospace sector is the main distinctive area of manufacturing specialization for the otherwise service oriented Cluster 4. This might reflect the geographical concentration of the Aerospace industry in a few advanced European regions, characterized by a highly qualified labour force (HOLLANDERS *et al.*, 2008). As expected,

Table 4. Regional clusters and innovation performance[a]

	Lagging behind regions	Catching-up regions	Core manufacturing regions	Tertiarizing regions
PATENTS_HT	–0.151	–0.195	0.077***	0.042
	(0.097)	(0.15)	(0.028)	(0.028)
PATENTS_MT	–0.041***	–0.074***	–0.014*	–0.013**
	(0.010)	(0.021)	(0.007)	(0.007)
EMPL_RD_GOV	–15.133***	–10.470*	–6.624*	–11.241**
	(5.568)	(6.017)	(3.843)	(4.551)
EMPL_RD_BUS	–3.841*	–3.183	0.223	–0.177
	(2.167)	(3.014)	(1.444)	(1.236)
EDU_HIGH	–0.336***	–0.542***	–0.535***	–0.162
	(0.120)	(0.143)	(0.123)	(0.101)
Constant	11.250***	13.600***	9.672***	5.112***
	(2.102)	(2.253)	(2.069)	(1.900)
Number of observations	158			
Pseudo-R^2	0.3519			
LR $Chi^2(20)$	176.69			
Prob > Chi^2	0.0000			

Notes: [a]Base case: KIBS-intensive regions.
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.
Standard errors are given in parentheses.

Table 5. *Employment specialization in regional clusters: top five sectors*

Sector	Mean	Standard deviation (SD)	Minimum	Maximum	Cluster
Sporting	2.11	3.53	0.10	10.74	KIBS-intensive regions
Business services	1.75	0.74	0.37	3.10	
Education	1.48	0.45	0.40	2.41	
Information technology (IT)	1.42	0.49	0.73	2.56	
Entertainment	1.42	0.46	0.50	2.73	
Aerospace	1.62	3.05	0	12.72	Tertiarizing regions
Hospitality	1.38	1.18	0.38	5.36	
Sporting	1.35	2.25	0	10.21	
Entertainment	1.33	0.35	0.73	2.36	
Education	1.17	0.47	0.31	1.92	
Production technologies	2.59	1.36	0.69	5.56	Core manufacturing regions
Power	2.44	3.76	0.35	18.89	
Instruments	2.13	1.93	0.11	8.59	
Medical	2.12	1.69	0.44	7.74	
Heavy machinery	2.02	1.25	0.24	6.16	
Footwear	3.18	4.73	0.05	20.56	Catching-up regions
Furniture	2.49	1.87	0.57	9.26	
Apparel	2.43	1.61	0.43	6.74	
Heavy machinery	2.03	1.31	0.32	6.83	
Oil and gas	1.98	4.18	0	21.97	
Fishing	2.24	3.74	0	24.14	Lagging behind regions
Food	1.22	0.45	0.50	2.89	
Construction	1.21	0.61	0.57	3.98	
Agricultural	1.21	0.73	0.16	4.04	
Materials	1.20	1.07	0.28	8.25	

regions in Cluster 1 are specialized in traditional and low-technology manufacturing sectors, which reflects their relative backwardness, while region in Cluster 2 (CATCHING-UP REGIONS) shows a more capital-intensive type of specialization, in line with the process of catching-up.

CONCLUSIONS

Since the mid-1990s, the perception of KIBS has evolved from providers or transferers of specific information for their clients to key nodes of knowledge-related networks and innovation systems, at the national and, particularly, at the regional level (for example, WOOD *et al.*, 1993; STRAMBACH, 1998; DOLOREUX and MULLER, 2007). As stressed by HERAUD (2000), from a policy perspective, the idea that KIBS contribute to knowledge development and diffusion at the regional level, enhancing the innovative capabilities of other manufacturing and service firms, calls for a revision of the tools aiming at fostering the growth potential of RIS. Notwithstanding this attention and the demand for KIBS-oriented policies, the empirical investigation of KIBS dynamics and related changes in RIS is still at an early stage and mostly composed of case studies.

The present paper contributes to this area of study by setting the analysis of KIBS expansion within the framework of RIS. It provides an original empirical contribution to the debate by elaborating a Europe-wide mapping of KIBS trajectories at the regional level, by investigating the interplay between the evolution of manufacturing and the growth of KIBS across regions, and by assessing the differentiated innovation performance across these differently structured RIS. In doing so, the work identifies emergent typologies of RIS and contributes to explaining persistent differences in innovation patterns across Europe.

The work highlights that KIBS are an important dimension of the heterogeneity in regional structures and innovation performance in Europe. In fact, although the emergence of KIBS responds to a broad increase in demand for specialized knowledge providers, which cuts across typologies of regional systems, it can be observed that KIBS are indeed a defining element of high-income, innovation-oriented regions. On the other hand, a large group of low-technology regions, characterized by sluggish growth, experiences little knowledge-intensive tertiarization. In this perspective, support to the claim (WOOD, 2005) that KIBS' growth is likely to strengthen differences across regions is found, as the conditions that favour a structural change towards a knowledge-intensive economy are cumulative. Interestingly, the high-income, KIBS-intensive RIS are generally also endowed with an important public R&D infrastructure. This suggests

that private knowledge services find a fertile environment in those regions characterized by well-established public knowledge networks, typically centred on universities and public research centres. The presence of large capital regions in this group suggests that the 'mosaic of specialized technology areas', described by STORPER (1997) as the essential nodes of the global economy, is increasingly a mosaic of KIBS-intensive regions, which play the role of knowledge producers, convertors, attractors and gatekeepers for larger economic areas.

However, the analysis highlights that KIBS intensity is not the only pattern to innovation. In fact, where business R&D intensity is high, as in the case of innovative mid-to-high-technology manufacturing regions, the expansion of KIBS has been slower, though significant. These regions represent the traditional manufacturing backbone of Europe and are evolving along a different but equally successful trajectory into knowledge-oriented service–manufacturing complexes. This finding suggests that the patterns of KIBS evolution are importantly affected by the characteristics of the manufacturing sector and that strong knowledge-intensive manufacturing functions can combine with a moderately growing market for knowledge services to determine highly performing RIS.

The present evidence about the variety of regional patterns in manufacturing and KIBS co-evolution calls for further analysis, possibly at a more disaggregate level, in order to assess how different typologies of KIBS and manufacturing segments interact, defining novel knowledge contents and contributing to system-wide knowledge diffusion and application. Recent studies (for example, CORROCHER *et al.*, 2009) have underlined that also within the KIBS sector innovation takes place in various forms, as a result of different competitive strategies, and produces different impacts on the business environment. The present paper highlights that exploring the black box of KIBS innovation and investigating their system-wide interactions is essential for improving one's understating of performance and the dynamics of RIS.

NOTES

1. The so-called European Paradox refers to the (perceived) failure by European countries to turn their scientific advantage into marketable and wealth-generating innovation (EUROPEAN COMMISSION, 1995).
2. A multivariate outlier is here defined as an observation being distant from the cloud of points, that is, lying along anomalous directions or being so extreme to induce a direction. The measure of distance adopted is the Mahalanobis distance, which measures the distance of the observations from the origin, taking into account both dispersion along the axes and the orientation of the cloud. The correlation analysis shows that the outliers regions are: GR13, DE23, CZ08, DE6, GR30, LV0, RO12, ITC2, ES30, PT11, NL31, HU22, BE10, SE11, SK01, UKJ1, DEA2, DE50, RO32, LU0, UKI1, FI2 and GR41.
3. The KIBS sector is identified by the following NACE (Nomenclature statistique des activités économiques dans les Communautés Européennes) codes: K72 – Computer and related activities; K73 – Research and development; and K74 – Other business activities. The latter includes the following subsectors, which MUELLER and ZENKER (2001) described as 'traditional professional services': Legal, accounting, bookkeeping, auditing activities and tax consultancy; Architecture and engineering activities and other technical services; Testing activities and technical analysis; Advertising; and Other professional/business services.
4. The aim of the factor analysis is to provide some hints on the correlations among the variables defining the economic structure of European regions. As such, it does not intend to suggest causal relationships, but only to group together variables that exhibit significant correlation.
5. Among the different ways to select the initial values for communalities, the principal components method is used, which focuses on the maximization of the communalities, that is, on the explanation of the variance. The eigenvalues/eigenvectors obtained by applying the principal components method are those characterizing the correlation matrix. Looking at the preliminary estimates of communalities, two variables (*ACT_POP_SHARE*, *GDP_GR_99_06*) appear to be little correlated with the others. This paper extracts the three factors, rotates the solution and evaluates the results. Note from Table 3 that the total variance explained by each factor and the final communality estimates are quite high. Moreover, low and on-average values of the off-diagonal residuals can be noticed. It is also important to stress that isolated variables have low residuals: this means that they are effectively poorly correlated to the others. This paper evaluates if there are residual correlations higher than 0.15. Only for the selected variables can it be observed that the correlation is overestimated (indeed it is known that the variables in the first column are weakly related to the factors), so it can be concluded that the model is adequate.
6. It should be recalled here that this analysis does not take into consideration some of the regions that are outperforming with respect to the rest of Europe along the first factor – KIBS. These include: a few capital city regions – London, Région de Bruxelles, Stockholm, Bratislavský kraj, Comunidad de Madrid, Bucharest; Northern-Westfalen, once the manufacturing core of Germany (especially the Land of North Rhine-Westphalia, or the Ruhr area), which today has moved towards a more service-oriented economy; Inner London and Berkshire, Buckinghamshire and Oxfordshire; Åland in Finland, which occupies a strategic position because it controls access to the gulfs of Stockholm and Botnia; and Utrecht in the Netherlands, which is an important university centre and a touristic region, as well as a strategic commercial centre for the country.
7. It is however to be noticed that in Eastern Europe high-growth capital city regions such as Budapest and Prague exhibit high levels of employment in KIBS.

8. Some notable regions belonging to this cluster are Andalucía and Comunidad Valenciana in Spain, Bourgogne and Bretagne in France, Berlin in Germany, Sicily and Umbria in Italy, and Essex and West Wales and The Valleys in the UK.
9. See http://www.clusterobservatory.eu/.

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