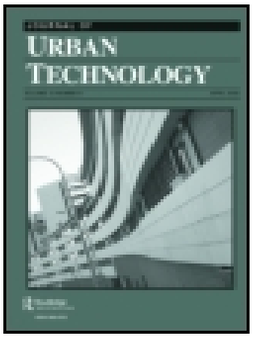

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Economic Geography of Knowledge-Intensive Technology Clusters: Lessons from the Helsinki Metropolitan Area

Tommi Inkinen and Inka Kaakinen

ABSTRACT *This paper analyzes industrial clusters in the Helsinki Metropolitan Area (HMA) in Finland. The HMA is the largest and most powerful concentration of population and economic activity in Finland. The paper analyzes knowledge-intensive industrial clusters and their structures. Clusters are identified according to a statistical analysis that provides a systematic perspective on the knowledge-intensive economic geography of the HMA. There are two main questions: how diverse are the identified clusters in terms of their internal structure; and, are there spatial irregularities identifiable in these structures? Knowledge-intensive clusters are strongly localized close to the infrastructural nodes: their physical localization is closely linked to road- and rail-structures and terminals. In general, clusters become smaller as their distance to the center of Helsinki increases: distance decay is evidently present. Our findings indicate that clusters are plural entities and their diversities do not follow a clearly identifiable pre-determined logic. Knowledge-based industries focusing on immaterial products tend to have closer central proximity than other industries but variations are extensive. This cluster diversity indicates that the HMA has a threshold for manifesting agglomeration gains that generate and extend industrial diversities within key clusters. The most diverse clusters tend to be located in the urban core, whereas the more narrowly focused clusters may be found in relatively peripheral locations.*

KEYWORDS *knowledge and innovation spaces; clusters; ICT clusters; knowledge-based development; knowledge-intensive businesses; Helsinki Metropolitan Area*

Introduction

Urban and regional development (and differentiation) is one of the key topics in economic geography. There are fundamental spatial variations involved: the scale and scope of the production process, the geographical scale of markets, the arrangement of after sales services, marketing management, and labor markets determining the availability of educated "know-how" workers (Dawkins, 2003). Knowledge creation in specific locations requires an acknowledgement of these contextual characteristics and networks (Bathelt et al., 2004).

Every production network functions in a spatial setting. An extensive analytical literature captures the diversity of knowledge-based and innovative regional

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and urban development (e.g., Asheim and Coenen, 2005; Boschma, 2005; Baba et al., 2009; MacKinnon et al., 2002). Cities provide a challenging field for the exploration of knowledge and innovation. First, they are nodes of regional structures, and they gain inputs from their functional surroundings. Second, these cities locate always in relational space––a city's relative success or failure in knowledge-based development is measured and interpreted in relation to other cities. Cities are composed of, and developed by, concentrations of economic activity. Commonly, these are called either agglomerations or clusters. They require physical proximity as well as network structure ("pipelines") bridging them organizationally and spatially (Bathelt et al., 2004), linking them into broader spatial scales that interact vertically (Breschi and Cusmano, 2004; Pinto, 2009).

In this paper, knowledge-based industry statistics are applied to examine the current condition of clustering in the Helsinki Metropolitan Area (HMA). Geographical measuring provides a grounded starting point, because spatial scales interact and tend to create clusters of specific industries (e.g., Gordon and McCann, 2000). This paper addresses two questions:

(1) How diverse are knowledge-based clusters (internal structure)?
(2) Are there spatial irregularities identifiable within the clusters concerning employment and economic input?

Conceptual and Theoretical Background

Knowledge and Innovation Spaces in the Economy

A knowledge-based economy is founded on the understanding that knowledge production, innovativeness, intelligence, and human capital contribute positively to an economy. These keywords are interwoven with human competence, creativity, and talent. Education, and particularly tertiary education, plays a key role as it leads us to the characteristics of knowledge production. Asheim (2012) classified a triad typology for differentiated knowledge bases, where "analytical" refers to scientific knowledge, "synthetic" refers to engineering knowledge, and "symbolic" refers to arts and creativity. Similarly, Manniche (2012) argued for the importance of differentiated knowledge bases by combining synthetic, analytic, and symbolic forms of knowledge. The interaction between universities, companies, and intermediaries is needed to create combinations of these knowledge bases in order to produce new ideas, practices, and products with market potential (Cooke, 2005).

Economic agglomerations and clusters have been a traditional research topic in economic geography since the emergence of Marshallian agglomerations and industrial districts. Clusters may be defined according to their geographical properties or according to their specific fields and networks. Porter (1990, 1998, 2000) has gained an acknowledged position in the literature with his diamond approach and local competitive advantage proposition taking into account an element of corporate strategy and competition in the setting of traditional location factors of production including availability of skilled workforce, natural resources, quality of administration, and governance. All these are embedded into societal and organizational qualities together with information infrastructure as Saxenian (1996) indicated in the context of Silicon Valley.

Clusters and the companies comprising them tend to have properties that self-reinforce their growth. These include attraction of other industries and activities to the same vicinity or close proximity. Strong cluster locations also tend to stimulate entrepreneurship and innovation (Baptista and Swann, 1998; Bathelt and Taylor, 2002). This is in line with the critical mass hypothesis of the markets––when a successful cluster develops, it often also broadens economic diversity and benefits local labor markets by enriching and thickening local organizations and the economic sphere in that particular location. There are, however, also critical assessments concerning cluster significance in innovation production concerning particularly technological spillover effects (Huber, 2012) and conceptual definitions (Taylor, 2010).

There are several fundamental questions in the identification of the spatiality of knowledge-intensive locations––where do they locate in absolute, relative, and relational senses; what indicators depict them; and are there models (or classifications) applicable for creating common ground for generalizations exceeding case studies and single contexts? Traditionally this involves the recognition of education and human capital as the impetus for growth (Florida et al., 2008). Makkonen and Inkinen (2013) conducted a Cranger-causality analysis on factors determining the outcome levels of innovations in European regions (see also Hinloopen, 2003; Inkinen, 2005). The analysis brought clearly up that educational levels precede innovations (measured in patents, research and development expenditures, and researcher employments) and economic investments. Therefore, knowledge-based spaces and locales are commonly urban environments having one or more research universities that both contribute to the availability of a highly educated workforce and allow collaboration between them and the private sector. In some cases, intermediaries play an important role in combining regional and local expertise in order to promote location-based growth, but their significance is not straightforward as it varies according to firm specifications (Inkinen and Suorsa, 2010).

Knowledge transfer and networks are important for knowledge-intensive locales and spaces. The process of transferring tacit knowledge into explicit or codified knowledge involves the consideration of organizational culture and its capability to embed knowledge-possessing employees into the organization. In several cases, highly innovative small- and medium-sized companies rely on key individuals––if they leave the company, the shock could have cumulative effects (e.g., loss of networks and disruptions in processes) resulting in profound difficulties in recovering from the changes in human capital. The opening up of this black box of individual talent into a codified transferable business remains a key challenge for innovation research.

Geography and spatial analysis provide a starting point to open up this black box. An interesting distinction might be to consider urban and rural in relation to their "innovativeness." Commonly, knowledge-based development is associated with urban environments––also in this study. There are significant innovative activities present in rural settings concerning agriculture and food production, but cities are most often appreciated as the key drivers in economic growth (Perry and May, 2010). We might ask what preceding requirements are needed in a locality that aims to build momentum in knowledge-intensive industries. Also, infrequently studied are the internal structures of clusters within urban space, and particularly the business performance (relative efficiency) in these clusters. This paper aims to provide a case study from the HMA concerning knowl-

edge-intensive business services (KIBS). We also want to examine traditional location factors such as center distance, transport corridors, passenger terminals, and reachability (in time) in respect to the agglomeration of economic activity in HMA space.

Spatial Clustering of Knowledge and Innovation Spaces

One conceptual challenge is to consider the interconnection and overlapping of "innovation" and "knowledge-based" development. Innovation is fundamentally a micro-level concept, because an innovation is created by competent individuals and teams, who often benefit from their professional networks. Organizational structures should only give platforms for creating innovation that is defined traditionally here as a new idea that results in a new service, product, or practice that has market demand. Knowledge-based development, on the other hand, has a macro starting point. It commonly stresses the importance of the highest level of education (universities), public and private sector relationships, and the role of "creativity" in the pursuit of regional (economic) development (Martin, 2006).

Knowledge-based development is approached here through three main concepts: knowledge-intensive business services (KIBS), innovation systems, and clusters. The literature on these topics has traditionally focused on areas in which knowledge-based development is associated with the creative class and human capital, whereas an innovation system is oriented more towards technology and production economies (Pratt, 2008; Vorley et al., 2008). Innovation research traditionally uses patents, intellectual property rights (IPRs), the number of highly educated people available, and years of research as indicators.

The development of contemporary societies is tightly interwoven with economic development, competition, and growth. Bristow (2010) has produced an extensive analysis of regional competition and its measurements. She makes a distinction between "cultural political" and "neoliberal" approaches. According to Bristow, the doctrine of competition has a hegemonic position in regional policy-making across industrialized countries (see also Hudson, 1999; Hospers et al., 2009). Bristow's view is in accordance with that of Martin (2006), who uses evolutionary economics, thereby espousing a neo-Schumpeterian view of development. Innovation creation is a multi-dimensional process originating from one or several individuals and their networks (Tang and Le, 2007). Understanding these aggregated local clusters, therefore, involves recognizing their socio-spatial contexts. Scales have varying characteristics, and they manifest in accordance to the locations' history and traditions (Hackler, 2007; Makkonen and Inkinen, 2014).

Martin (2006) points out that regional competitiveness is profoundly driven by innovation and adoption. In effect, the cycle of innovation creation and adoption leads to the notion of "path-dependency," a term describing a historical development process that determines future outcomes of economic decisions (see also Mackinnon et al., 2009; Boschma and Fornhahl, 2011). Evolutionary economics is relevant to this study in an empirical sense as Finland has had national technology policies since the 1980s, and, thus, the tradition of an innovation system has deep roots in the study location of the HMA. Implementing and then integrating an innovation support system into the societal fabric is dependent on a society's values and traditions (Bristow, 2010; Polenske, 2007; Mayer, 2007).

Perry and May (2010) illustrate policy rationales for knowledge-based urban development (KBUD). They define aspects of economic, scientific, socio-cultural, and political dimensions for knowledge-based development. Their classification highlights the importance of science in national and local economies. May and Perry (2010: 10) state that the "scientific" dimension relates in theoretical terms to a "knowledge production of regions," and they stress the significance of the highest levels of education and research. Similarly, Tan (2002) demonstrated, in his statistical analysis of information-sharing in a corporate context, that activity in the private sector drives national economies in market environments.

Another theoretical consideration is the connection between clustering and the economic success of firms. Some locations are more investment-intensive than others. One example of this would be that regions with strong production industries (e.g., machinery and physical production) are usually different from locations that focus on immaterial production. They also require different development policies and planning. For a long time, global economic competition has forced labor and investment-intensive production industries away from high-cost locations. However, at the same time another process has emerged, which shows that the production requiring the highest quality standards and product development does not follow lowest cost driven logic. Third, the measurement of cost is relative. The gap between the cost of employing a non-skilled worker and a highly skilled engineer varies considerably between countries.

A hypothesis can be formulated that knowledge intensity reflects on the broader economic conditions of a particular urban location. Green (2006: 236–237) identified the following currents in present labor market theories, including market adjustments (to structural and technological change), the role of labor market intermediaries (with parallels to innovation system intermediaries), and place perception (location image, knowledge-intensive brand, and place promotion). These currents are examined as they relate to the firms that are the major employers within the HMA clusters. The existence or non-existence of a relationship between knowledge-intensiveness and employment is, therefore, significant and we use employment statistics as one of the key indicators of the importance and size of each identified cluster.

Empirical Analysis

Data and Methods

The main data source for the study was the statistical and geographic dataset on the HMA's business establishments maintained by the Helsinki Region Environmental Services Authority in cooperation with the cities of Helsinki, Espoo, and Vantaa. In practice, we have applied the 10-year period (averages) from June 2001 to the end of May 2011 as our unit of observation. This, in turn, is based on Statistics Finland's *Register of Enterprises and Establishments*, the data of which are obtained from two main sources: the Tax Administration's registers and Statistics Finland's own surveys. Our database provides each establishment with exact coordinates according to their street address, and we used these coordinates to place them on a 150 m × 150 m grid, which we found apt for identifying the clusters. In our analysis, we included only genuinely trading, at least "one-person year," enterprises.

HMA provides excellent case study locations because Finland has been considered one of the leading knowledge-intensive economies in several international benchmarking studies conducted by the World Trade Organization, the World Bank, and the United Nations. In addition, "innovative" or "knowledge-based" creativity is strongly present in the Finnish and HMA economic scene. For example, currently, the production of applications for the gaming industry and social media are two of the major development areas in the information technology sector supported by the success of companies such as Supercell (*Clash of Clans*) and Rovio (*Angry Birds*). Additionally, the geographical structure of HMA is fragmented into several small nodes. This provides a potential for analyzing dispersed economic activity in the selected KIBS nodes as our analysis will indicate.

Recognizing the problems that accompany the visualization of the locational data on a color-scaled map (setting a certain scale of map necessarily either cuts off the highest concentrations of economic activity or blurs areas of weaker concentrations into unreadable zero-values), we opted for smoothing out the data as a means to get a more realistic picture of cluster volumes. This was done by creating a map where establishments with more than 400 employees were pinned down with a 300m*300 m sized box, whereas establishments with fewer than 100 employees were marked with a 150m*150 m box. As for establishments where the number of employees fell in between these limits, we used linear interpolation to determine their box size on the map. We still want to emphasize here that each of these boxes is placed on the exact coordinates of the respective establishment, that is, independently of the grid lines, and that the resulting map thus forms a sharp picture of the way enterprises spread over and cluster within the HMA.

Our cluster identification meets with systematic criteria as we apply NACE 2008 codes (Appendix 2) in the classification of KIBS industries. The classification uses similar base categorization as used by the Helsinki Region Services Authority (2013) that monitors business development in the HMA. The second issue is to define and model "close proximity." In this study, we consider a cluster proximity, in physical terms, to be an area composed of at least 10 contiguous grid cells, each of which have a minimum density of 100 (or more) employees in identified businesses. While this might seem too sparse an agglomeration, we tested the criteria with a specific branch of industry, KIBS, and found that the limits in question capture KIBS' activities in clusters better than denser limit values on a narrower area do. With the above-mentioned criteria, we then identified 25 clusters for closer analysis.

The dataset provided us with three numeric variables––the number of establishments, the number of employees, and turnover––that we used for calculating densities and productivities within the clusters. For enterprises with more than one establishment, the latter two variables are averages, which should be considered when interpreting the data. Data analysis and visualization was done on a program we created in Matlab.

Methodological Considerations

We recognize problems associated with the aggregate units of statistical observation as our analysis is based on spatial employment and business statistics. One of these is identified as MAUP (Modifiable Areal Unit Problem), which refers to the use of constructed aggregate units as the raw data. This aggregation

problem has been kept in mind, and as Fischer and Varga (2003: 315) pointed out, we also consider that "political districts" (such as the HMA) are the most appropriate unit of observation. Additionally, the significance of city cores and their surrounding vicinities blurs on the normal 250*250-level, and the detailed analysis requires (150*150 m GIS data as used here) a closer observation level than mere political districts commonly defined as municipalities or even postal code areas.

Second, statistical observation provides information that is always at least a year or two behind the current date. However, the validity and reliability of the data is high. In addition, the selection of relevant indicators is crucial in this type of analysis. Ter Wal and Boschma (2009: 753) identify similar problems in relation to regional innovation network construction based on patents. The authors point out that patents have their limitations in constructing an empirical view of existing and emerging networks, although patents still have a function as a good indicator for studying innovation structures and networks.

We recognize these generic limitations of statistical analysis and therefore focused on KIBS as they provide an interesting indicator platform. We used three subsections comprising the "KIBS broad" category (Appendix 2) and the distinctiveness of these categories provide a robust view of existing knowledge businesses in Finland. For example, a 10-year average turnover was used as a general indicator of economic activity compared to value-adding, as it was easier to obtain. Overall, we consider this data set to be reliable both in its quality and its extensiveness as it covers all the companies in the study.

Mapping Knowledge-Based Clusters

The first task to perform was to identify cluster locations within the HMA. Figures 1–3 include six maps. Figure 1a illustrates the overall concentrations of economic activity (all companies) employing more than 100 people. The other five maps indicate the distributions and locations of knowledge-intensive businesses as a whole, identified here as "KIBS broad" (Figure 1b) and according to the three subclasses (Figures 2a and b; Figure 3a) comprising KIBS broad. We also added a final map (Figure 3b) in order to illustrate the locations of gaming and software industries in the HMA, as it has been argued that they represent one of the potential future growth platforms for the innovative economy.

There are three main interpretations observable from Figures 1, 2, and 3. First, the geographical distribution of economic activity within the HMA is presented in Figure 1a based on the number of employees. We identified 25 clusters (see Appendix 1) within the HMA and conducted the statistical analysis according to these clusters. The most significant employment cluster both in terms of total employment and KIBS activities is the center of Helsinki. The economic clustering tends to disperse rather evenly across the HMA. This means that the center of Helsinki is clearly visible as the most important large cluster of economic activity in terms of employment. However, smaller economic concentrations are identifiable both in the west, as well as in eastern and northern locations of the HMA.

Second, KIBS clusters are relatively small in terms of their employment levels. They do have a significant impact on the overall clusters, but they represent around one-third of the current level of employment within the largest (in absolute terms) knowledge-intensive cluster of the Helsinki center (See Figure 1b). Figures 2 and 3 also indicate interesting diversities in the cluster compositions.

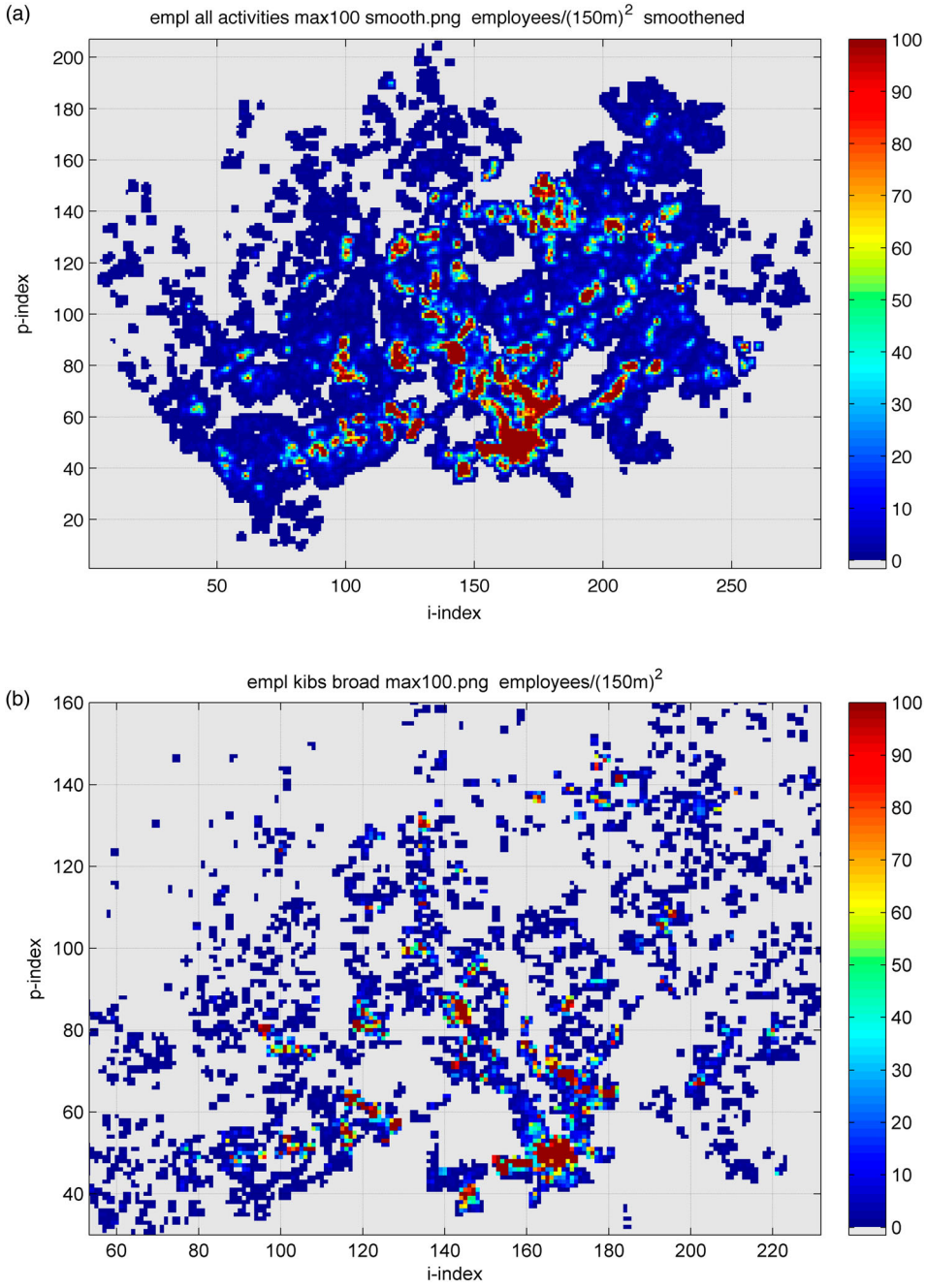

Figure 1: The maps represent the spatial variation for (a) the sum of all employees in 150m*150 m grid cells in all establishments and (b) employees in KIBS broad activities

An industrial mix of knowledge-intensive companies is present and there are clear profiles identifiable among the 25 clusters according to the applied KIBS sub-classes of data processing, information and communication services (KIBS1), research and development, private education (KIBS2), and business services (KIBS3).

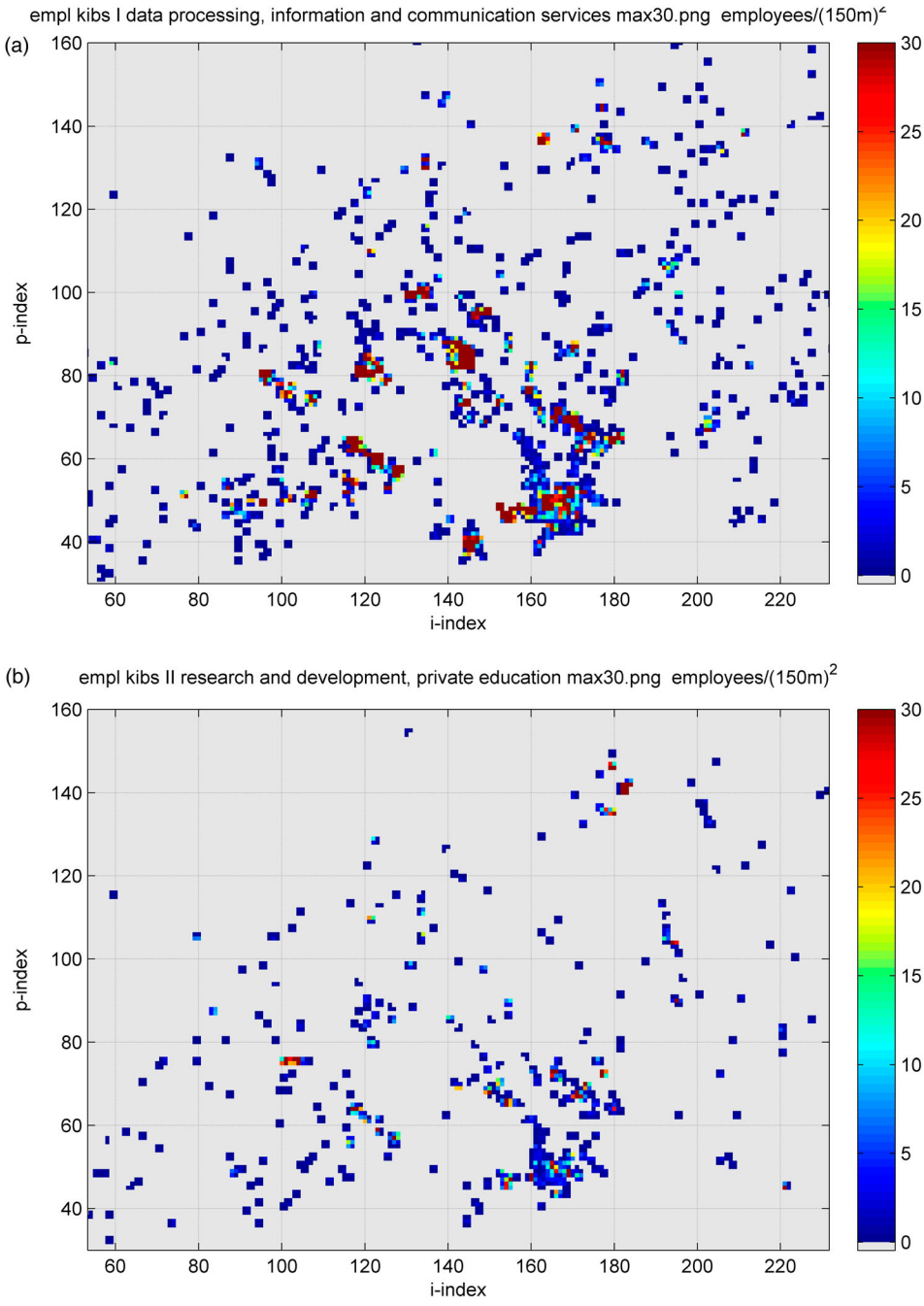

Figure 2: The spatial variation for (a) employees in KIBS 1 category and (b) employees in KIBS 2 category

Third, KIBS follow quite a similar path compared to that of other more production-oriented industries. They tend to accumulate in certain locations, with a variation factor of some 20 percent. This means that around every fifth KIBS company locates to non-knowledge-intensive clusters and, therefore, they experi-

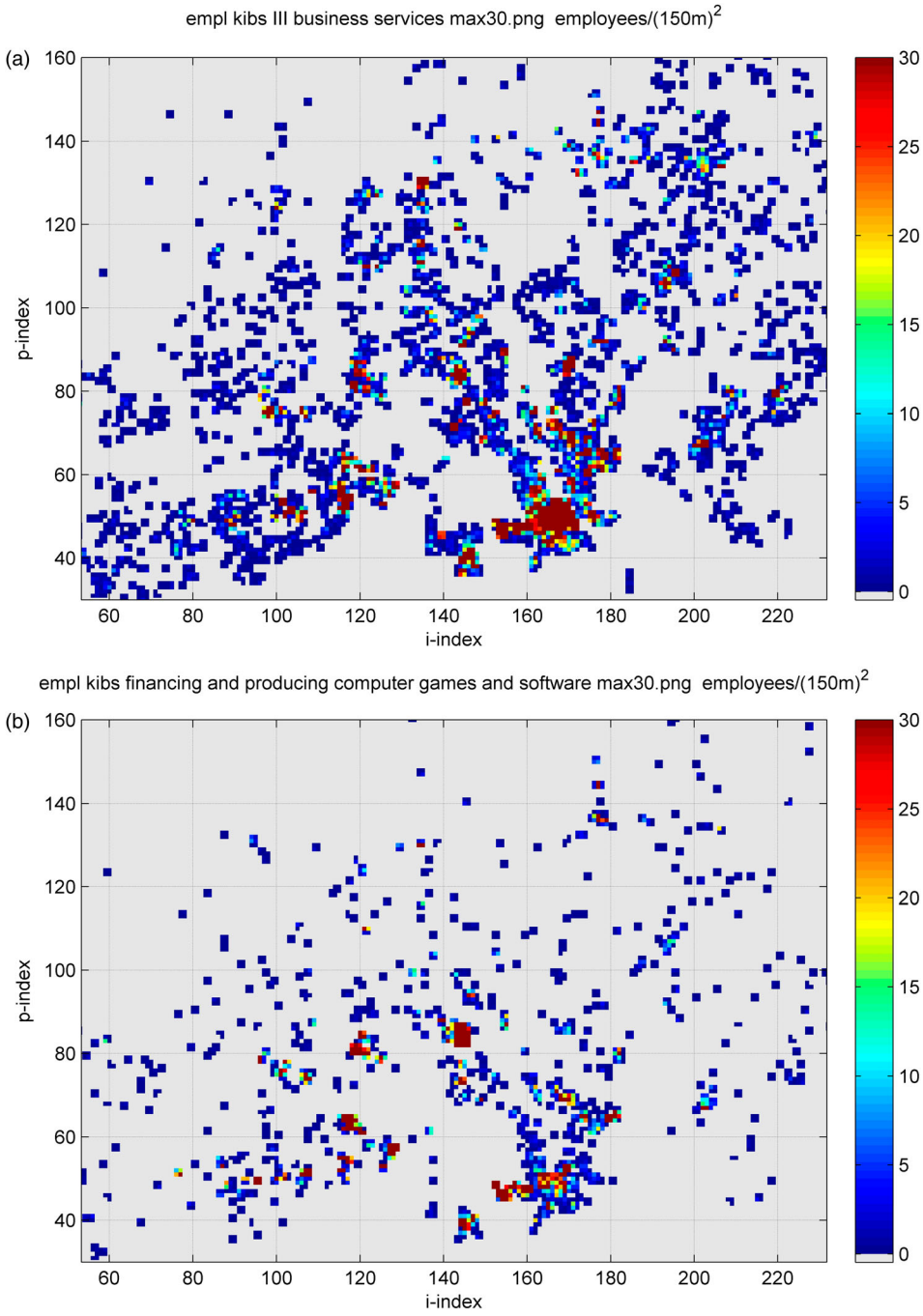

Figure 3: The spatial variation for (a) employees in KIBS 3 category and (b) special example of companies producing or financing computer games and software employing more than 30 people

ence locational freedom. This is an important finding as the great majority of KIBS produce immaterial products that enjoy greater freedom of spatial decision-making concerning their locations than companies requiring fixed production facilities.

Selected Properties of Cluster Structures

The mapping exercise of Figure 1 needs to be opened up. The first research question of the paper was defined "How diverse are knowledge-based clusters (internal structure)?" This question is answered in Table 1, which indicates the internal structures of each cluster in relation to (a) all fields of industries and (b) knowledge-intensive businesses, according to the applied KIBS subdivision.

Table 1 has several interpretative implications. First, it indicates that all economic agglomerations in the HMA have knowledge-intensive businesses. However, their significance in terms of employment varies considerably. Relatively, the most KIBS-intensive cluster in the HMA is the Aviapolis close to the Helsinki-Vantaa airport followed by areas of Otaniemi where Aalto University's Helsinki University of Technology is located. Figure 1 indicates the absolute differences in cluster sizes, and the center of Helsinki (Eteläinen kantakaupunki) is in a class of its own. This major cluster is over twice as employment intensive as the second cluster. Statistics also show the internal composition of each cluster in relation to the various KIBS definitions (KIBS broad; KIBS1; KIBS2; and KIBS3). The areal profiles of each cluster are clearly identifiable.

We also want to focus on the economic importance of companies in terms of their age, or longevity, in order to answer the second research question "Are there spatial irregularities identifiable within the clusters concerning employment and economic input?" We applied a turnover as an indicator of economic activity within each cluster. Figures 4 and 5 answer the second research question with a compilation of four diagrams divided into the different classes of KIBS including median turnover per employee within a cluster. Figures 4 and 5 also show the significance of the company's age (years of operation) for turnover per employee. This is an important aspect as it indicates how clusters differ from each other in relation to employee efficiency over time. The figures also show the differentiation of companies according to their KIBS definition. The obtained results visually show that the clusters in the HMA have their own distinct profiles. Subsections 1 to 3 comprising "KIBS broad" have very distinct profiles. Particularly KIBS 2 companies have a highly specialized profile with respect to their cluster as there are two highly productive clusters (Vantaanportti and Nihtisilta-Mankaa) that have significantly higher per employee turnover compared to other clusters.

Figures 4 and 5 provide a unique perspective on cluster dynamics in terms of turnover adding per employee. First, the figures show that there are great variations within each cluster on how companies with different life-spans perform. In some cases, older (more than 10 years of operation) are more efficient than younger ones, but there are also a number of clusters in which relatively young companies (0 to 5 years of operation) have the most significant impact on cluster turnover. Overall, the most efficient companies considering all clusters added together are those that have operated for more than five but for less than 10 years. The result may be interpreted as illustrating that given enough time companies improve their business model and that, simultaneously, they acquire enough reputation and experience to function efficiently. There are some cases in which start-up companies with a life-span of less than two years are the most efficient ones, but those cases are rather rare. Only four clusters out of 25 gain the most efficiency from these young enterprises.

Table 1 Employment proportions of KIBS classes in HMA clusters

		KIBS subcategories (sum=100% KIBS broad)			Selected KIBS key activities			
Cluster ID	KIBS broad / all activities	KIBS 1 / KIBS broad	KIBS 2 / KIBS broad	KIBS 3 / KIBS broad	Financing services / KIBS broad	Games & software / KIBS broad	Advertising & market research / KIBS broad	PR & consultancy / KIBS broad
25	2.8	6.5	64.5	29.0	0.0	6.5	0.0	5.3
24	34.8	0.0	100.0	0.0	0.0	0.0	0.0	0.0
23	11.1	48.7	11.8	39.6	1.5	42.0	2.6	16.1
22	8.3	10.8	0.7	88.4	17.6	8.2	0.9	1.0
21	2.8	49.6	0.0	50.4	0.0	49.6	3.9	0.0
20	14.1	4.2	3.8	92.0	0.0	3.8	1.7	1.3
19	25.3	24.5	1.9	73.6	17.5	7.3	6.8	1.3
18	47.2	89.6	1.3	9.1	0.2	4.1	0.0	0.7
17	32.8	66.9	0.0	33.1	0.1	7.4	0.0	1.5
16	25.6	22.9	0.0	77.1	0.2	4.6	0.6	0.8
15	32.1	78.6	0.4	20.9	4.1	46.4	1.0	1.7
14	35.4	55.3	1.4	43.3	10.2	36.9	3.8	5.0
13	6.0	0.0	1.3	98.7	0.0	0.0	9.1	3.4
12	9.5	1.0	1.1	97.9	65.2	1.0	0.6	2.1
11	20.6	59.9	0.1	40.0	24.0	0.9	0.6	5.6
10	34.1	19.2	26.2	54.6	0.0	14.5	0.0	42.2
9	12.0	25.5	20.2	54.4	2.5	8.2	0.0	12.4
8	18.2	33.7	0.5	65.8	15.4	30.9	7.3	1.9
7	29.0	54.8	5.6	39.7	6.7	17.2	6.4	2.2
6	67.8	64.2	6.8	29.0	0.5	37.4	0.3	7.7
5	12.0	8.6	0.3	91.1	13.5	2.5	13.6	2.7
4	28.0	70.5	4.0	25.5	0.3	56.5	9.0	9.3
3	43.3	18.5	2.0	79.4	68.5	17.6	8.8	0.4
2	33.4	41.3	0.4	58.3	1.2	30.9	3.1	13.5
1	27.9	25.1	3.8	71.1	9.9	18.3	12.3	14.3
Average	24.6	35.2	10.3	54.5	10.4	18.1	3.7	6.1
Median	25.6	25.5	1.4	54.4	1.5	8.2	1.7	2.2
Max	67.8	89.6	100.0	98.7	68.5	56.5	13.6	42.2

Note: The Cluster ID chart is presented in Appendix 1.
Source: Statistics Finland; the Helsinki Region Environmental Service Authority.

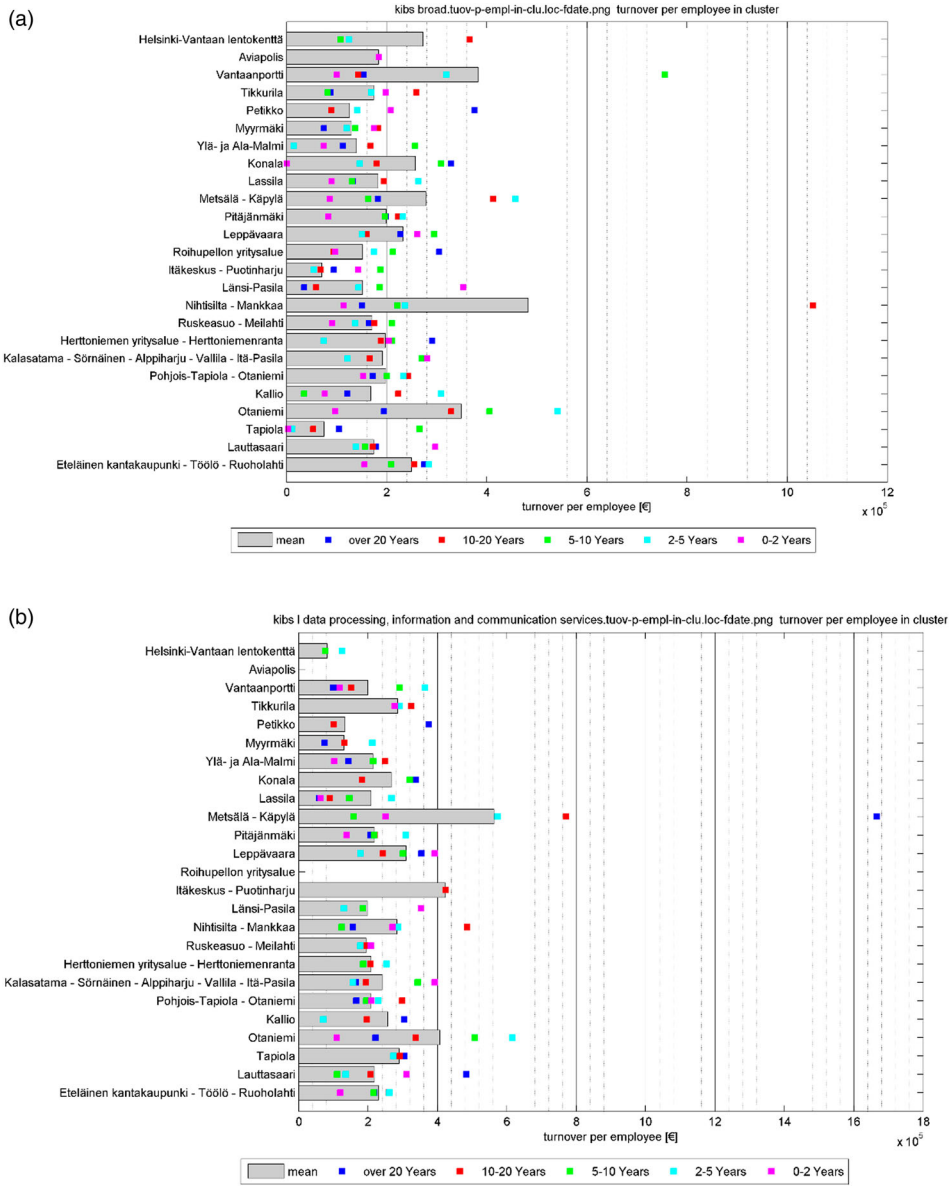

Figure 4: Twenty-five identified clusters and turnover per employee in (a) all knowledge-intensive companies (KIBS broad) and (b) KIBS 1 (data processing, information, and communication services). The charts indicate average addition to turnover per employee according to the years of operation

Reflective Discussion

Finland and Helsinki have had a long reliance on public research, knowledge-intensive development policies, and higher tertiary education. This verifies well in the HMA case as the KIBS industries tend to have approximately one-third (29.6%) of the employment in the whole industrial map of Helsinki. KIBS companies are significant employers, but they have a fragmented profile. Some of the companies are established large international players where the vast majority

Figure 5: Twenty-five identified clusters and turnover per employee in (a) KIBS 2 (research and development) and (b) KIBS 3 (business services). The charts indicate average addition to turnover per employee according to the years of operation

are micro-sized (fewer than 10 employees). Based on the analysis, it is clear that the KIBS follow rather traditional patterns of locational specialization (see Graham et al., 2010). The most important and largest concentrations of companies are found in those places where other industries are present. Still, there are some specific clusters that tend to have a strong emphasis on KIBS depending on their specific subcategory. The most KIBS intensive clusters in the HMA are Aviapolis

together with North Tapiola and Otaniemi (See Table 1). They both have a KIBS share exceeding 70 percent of all companies.

The results indicate that also KIBSs tend to locate to business parks and areas that are "easily accessible." Thus the greatest concentration of knowledge-intensive companies are easily pinpointed into places that are highly connected (to other places) via road and rail networks. Most often they are close to main routes connecting HMA to other main cities of Finland. The result is relevant as KIBS are essentially producing immaterial services and products thus they are the most "location free" in relation to material aspects of geography––they enjoy locational freedom but do not use it excessively (Boschma, 2005). A second key finding is that different KIBS categories are segmented, meaning that if a cluster has a strong profile in one KIBS category, it is likely that it lacks companies belonging to other categories. KIBS companies do not seem to attract businesses requiring knowledge-intensiveness from other fields but they tend to support the particular area they have expertise in. The third key finding is that particularly business services (KIBS3) tend to have closer center proximity than companies belonging to KIBS1. Finally, KIBS 2 is the smallest category, and it has the most diverse spatial fragmentation.

There are lessons that hold true for other locations. First, knowledge-intensive clusters are strongly localized close to the infrastructural nodes: their physical localization is closely linked to the road- and rail-structures and terminals. The results verify that several traditional location factors hold true in the current economic geography of the HMA. Distance decay is also present. The number and intensity of KIBS clusters diminishes when the distance to the core center of Helsinki increases. This is, however, not a straightforward phenomenon as transport nodes and accessibility factors have an effect on the presence of a cluster. Additionally, clusters should be defined with rigidness and analyses are needed to be framed in a spatial context as clusters have been widely used as marketing slogans and empty buzzwords for policy rhetoric (Taylor, 2010; Makkonen and Inkinen, 2014).

Our findings have implications for urban development policies and for ways of thinking how to improve and facilitate urban growth (for an evolutionary perspective, see Boschma and Sotarauta, 2007). As the main clusters are often located in the nexuses of transport and transit, they could be viewed as a parts of corridor developments. The default definition of corridor development includes elements of infrastructure and economic clusters (Martin and Sunley, 2003). A policy lesson is to consider how to combine the growth strategy of the HMA together with the goals of urban design, public transport, and residential areas. This is a question of planning, urban design, and urban technology. In this study, the Aviapolis cluster is an interesting example as its design process is underway, aiming to achieve a combination of knowledge-intensive work location, desirable residential options, and close proximity to international networks (airport). The final outcome of how Aviapolis will be integrated into the broader urban fabric of HMA will be an interesting future study topic together with what type of housing and public transport solutions it will entail.

An alternative to thinking about industrial policy and support tools is to look at the value-adding efficiency per employee. Our results indicate that companies that have had between 5 to 10 years of operation seem to be in most efficient

condition. The support tools could be designed in a way that would promote younger companies as they have not yet had time to establish themselves. Additionally, support tools also for older companies (15 years and more) could be implemented in order to reshape their operation strategies, potentially gaining them more efficiency.

Conclusions

An empirical case study of the HMA has been presented in order to provide information about the knowledge-intensive clustering that supports (economic) regional growth. GIS analysis is a way of approaching societal transformation towards a knowledge-based economy. These tasks require considerations in both theoretically stimulating and empirically rigid ways. Research showed the structural problems of the HMA's economic geography, which are typical for fragmented geographical units. The clustering of economic activity is biased and shows the need to recognize the variations in different micro-locations within the HMA.

Diversity is significant in the 25 identified clusters, and the locational composition of KIBS companies is not reflected as clear patterns in the data. Centrality both to the city center and local centers contribute to the number of employed, but their total variations are too large to provide a coherent view on the locational processes of knowledge-based development. Employment intensiveness also tends to follow a geographic pattern in terms of transit routes such as main roads and railways: the northernmost clusters experience a tendency towards lower employment. Industrial profiles and locational factors between the clusters are important to the identifying of new economic "hot spots" where new processes, ideas, and innovations may develop.

The main contribution to academic research in this field is that we were able explicitly to demonstrate the diversities related to KIBS clusters and their internal profiles. Our research shows that the internal structures of clusters experience significant variations in terms of employment as well as economic efficiency (turnover increase). We applied the age of the companies (years of operation) as a selected indicator. The analysis showed that the most successful per-employee turnover-adding companies tend to be operational between 5 to 10 years. The result also suggests that older companies (more than 15 years of activity) are well established organizations that do not necessarily function as dynamically as more recently founded companies. However, there are significant variations in the data in this regard.

In the course of our research, several new research tasks were identified. First, the identification of the most crucial clusters still needs refining. In order to achieve this, interviews with focus groups are needed. The statistical work conducted here together with the company-specific data allows us to identify an adequate number of the most important, or otherwise interesting, companies for qualitative analysis. Second, the spatial visualization of complex cluster structures in a GIS environment needs to be developed. This requires further examination of potential data sets and resources that could be combined with our already extensive dataset. These visualizations include, for example, heat charts concerning the economic performance of start-up companies and their respective employment potential in the future.

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APPENDIX 1

Cluster ID chart following the South-North order

1) Center Helsinki – Töölö – Ruoholahti	14) Leppävaara
2) Lauttasaari	15) Pitäjänmäki
3) Tapiola	16) Metsälä – Käpylä
4) Otaniemi	17) Lassila
5) Kallio	18) Konala
6) North-Tapiola – Otaniemi	19) Ylä- ja Ala-Malmi
7) Kalasatama – Sörnäinen – Alppiharju – Vallila – Itä-Pasila	20) Myyrmäki
8) Herttoniemi business area – Herttoniemenranta	21) Petikko
9) Ruskeasuo – Meilahti	22) Tikkurila
10) Nihtisilta – Mankkaa	23) Vantaanportti
11) Länsi-Pasila	24) Aviapolis
12) Itäkeskus – Puotinharju	25) Helsinki airport
13) Roihupelto business area	

APPENDIX 2

NACE2008 codes for KIBS (KIBS broad), sub-categories (I–III) and key activities (4)

KIBS subcategories I-III (KIBS I + II + III = KIBS broad)

- KIBS I data processing, information and communication services (58, 61, 62, 63)
- KIBS II research and development, private education (72, 85)
- KIBS III business services (64, 65, 66, 69, 70, 71, 73, 74, 82)

KIBS key activities (identified separately)

- KIBS financing services (642, 643, 651, 652, 653, 662, 663)
- KIBS financing and producing computer games and software (582, 620)
- KIBS advertising and market research (731, 732)
- KIBS headquarters, PR, consultancy (701, 702)

OTHER THAN KIBS (contributes to the metacategory "all activities")

- Culture-intensive activities (90–93)
- Tourism services (79)
- Logistics (transport and storage) (49–53)
- Technoindustry (27–35)
- Construction (41–43)
- Wholesale trade (45)
- Retail trade (46)
- Health and wellbeing (86–88)
- Other (94–96)