Bajmócy, Z. – Lengye,l I. (eds) 2009: Regional Competitiveness, Innovation and Environment. JATEPress, Szeged, pp. 122-141.

An Analysis of the Spatial Distribution of Knowledge Intensive Services in Hungary

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In today's developed countries we see an increasing headway of the services sector, while the European Union's regional policy for the period of 2007-2013 places special emphasis on the support of knowledge intensive activities. Therefore, it is important to survey the situation of services with high knowledge intensity in Hungary as well.

Economic activities, and consequently the spatial distribution of knowledge intensive services are influenced by a great deal of factors including disproportions within the given country and externalities like knowledge spillover or market size. The various trends of spatial econometrics and economic geography have developed a series of indicators and index numbers, all of which grasp this phenomenon from different aspects.

My paper aims at applying some of these indicators in Hungary for the analysis of the spatial distribution of knowledge intensive service sectors and their potential clustering.

Keywords: knowledge intensive services, cluster, Ellison-Glaeser's γ index, Moran index

1. Introduction

Today enterprises operating *in developed countries* usually outsource routine and controllable production in order to reduce labour costs and due to the more environment conscious regulation system of these countries, while strategic, financial and marketing activities requiring knowledge and creativity stay in the headquarters of the enterprise. This is partly the reason why the proportion of *services* is prominently high compared to the economic activities of developed countries, and especially the range of *knowledge intensive services* demanding prepared workforce and able to adapt to market changes flexibly undergoes dynamic development.

Since the economic driving force of sectors with high knowledge intensity is especially great, the European Union's regional policy for the period of 2007-2013 also places great emphasis on supporting innovation clusters (CEC 2005). However, it is important to underline that the majority of innovations are not closely linked to R&D activity even in the case of sectors, in which these are most intensely applied (Bajmócy 2007); consequently, it is not enough to use only the intensity of R&D activity to measure knowledge intensity.

Since Hungarian knowledge intensive sectors are able to achieve continuous increase in the area of work productivity even with constant growth in the number of employees (Bajmócy 2007), an important task lies in defining their spatial distribution, where they cluster and what intensity level of factors concentrate them in a given territorial unit.

In the course of analysing economic activity and the spatial situation of active enterprises in different sectors the gathering of enterprises at certain geographical spots is markable. Talking about uneven spatial distribution, we need to distinguish the concepts of *concentration* and *agglomeration*. While the first concept (*concentration*) only covers the difference of values in economic activities measured within a given territorial unit, the second term (*agglomeration*) also considers the spatial relations of these values, the analysis of which must also involve the relations of the different territorial units in terms of adjacency and distance (Lafourcade–Mion 2007). Both concepts may be interpreted on any division level of the examined geographical area (in Hungary, for example, on regional, county, subregional (kistérség) and local levels as well).

After the differentiation of concepts, the indicators developed for their analysis can also be systematized accordingly. In the course of analysis, I used the following indicators and index-numbers:

- Ellison-Glaeser's γ index and the location quotient (LQ) for measuring spatial concentration,
- and the *Moran index* for characterizing spatial auto-correlation, i.e. agglomeration.

The present paper aims at analysing the spatiality of national knowledge intensive sectors. The spatial distribution of knowledge intensive services is examined with the use of statistical methodology, i.e. providing the statistical analysis of the spatial dispersion of these sectors. The second section elaborates on some important considerations of the knowledge based economy. In the following, section three reviews the basic concepts of spatial differentiation and the theoretical background of the survey, then introduces the Hungarian data applied for measuring the spatial distribution of economic activities. Section four discusses the results of the survey comparing the different models built on different assumptions for the total of the 13 analysed knowledge intensive service sectors as well as mentioning the different sectors one by one. Finally, section five describes the summarising observations of the survey.

2. Knowledge based economy

Different sectors are likely to represent different technological standards. In order to display technological differences, OECD and Eurostat surveys usually regard *high-*

tech and *medium-tech* industrial sectors as well as *knowledge intensive services* to be the economic sectors that realize knowledge based economy (OECD 2001). According to this principle, the technological standard of enterprises can be assessed by the two-digit code of their primary activity (Pavitt 1984). Owing to standardized European data collection, Hungary's Standard Industry Code'03 numbers can be adapted for this goal[1] (In the case of services, see Table 1).

Table 1. Knowledge intensive service sectors

Knowledge intensive services	
61 Water transport	71 Renting
62 Air transport	72 Computer and related activities
64 Post, telecommunications	73 Research and development
65 Financial intermediation	74 Other business activities
66 Insurance and pension funding	80 Education
67 Activities auxiliary to financial intermediation	85 Health and social work
70 Real estate activities	92 Recreational, cultural and sporting activities

Note: Sectors 64, 72 and 73 are qualified as high-tech knowledge intensive services.
Source: Laafia (2002, p. 7.)

OECD assessed first the *knowledge intensity* of sectors only in the case of processing industry branches. It defined knowledge intensity based on the R&D data of the sector by comparing the amount of R&D expenditures to the added value of the sector. Later, this method was expanded to also consider *purchased technologies* that were applied through mediator or capital. This way, assessing the *knowledge intensity of the service providing sector* also becomes possible, since these sectors are more technology utilizing than technology producing ones.

3. Basic methodological concepts

The geographical and spatial concentration of economic activities derive from various reasons, with special local characteristics, natural, social and economic factors lying in their background. The concept of *cluster* tries to describe this phenomenon: "*… a geographically bounded concentration of interdependent firms"* (based on Rosenfeld 1997 p. 10., CEC 2002, p. 9.), or in a different way: *the geographically proximate group of enterprises, suppliers, service providers and associated institutions active, competing or interconnected in the same industry sector linked by different types of externalities* (Porter 2003, p. 562.).

The externalities in Porter's definition include increasing returns to size, raw material concentration, transportation costs, knowledge spillover and the effects of market size. Since the reach of these external effects may be significantly different

[1] These data are taken from a database compiled in 2007, therefore, I do not deal with the changes of the Standard Industry Code that entered into force in 2008.

from one another, it is important to map out what extension the spatial clustering of the different economic activities has, or in other words, on what level of spatial division it becomes measurable.

The concept of clusters has rich literature with a wide variety of different approaches; consequently, the scale of *indices* and indicators *defining the degree of clustering* is also rather wide.

3.1. Concentration or agglomeration

All of the concepts aiming to grasp the core of the uneven spatial distribution of economic activities and the local concentration of enterprises – *concentration*, *agglomeration* and *specialization* – examine this phenomenon from a slightly different point of view. Accordingly, the indicators and index numbers serving their measurement also characterize spatial distribution in a different way.

Agglomeration and concentration – the literature of clusters tends to use these two concepts as synonyms, although according to Lafourcade–Mion's (2007) approach, it is recommended to differentiate between these two terms, since the size of enterprises may be closely linked to which form of gathering is realized.

We use the concept of *concentration* when enterprises are clustered in a given region, while these regions can be adjacent or isolated as well. In this case, the only important aspect is whether two enterprises settle in the same territorial unit or not. In such cases the adjacency relations of the territorial units are disregarded.

In the case of *agglomeration*, the spatial bunching of enterprises occur in adjacent territorial units, therefore, in the case of agglomeration, territorial units are not separate and discrete elements of spatial division any more, but interrelated units, where connection is determined by spatial adjacency/distance. In this case, the concept and measurement of spatial auto-correlation emerge.

Figure 1. Concentration and/or agglomeration

3	3	
3	3	

	3	
3		3
	3	

Source: Lafourcade–Mion (2007, p. 49.)

The difference between the two concepts is easy to understand. Figure 1 shows two types of position assumed by 12 companies in 9 territorial units. Both territorial divisions may be called *equally concentrated*, since in the case of concentration, it is not relevant how the nodes of densifying are situated in space compared to one another. However, while in the first case (on the left), companies

agglomerate in space, the second case (on the right) is specifically *not agglomerated*, since the data of the adjacent territorial units are systematically different from one another.

From the aspect of clustering, it is obviously important whether the areas where the economic activity in question is concentrated tend to be adjacent or are situated sporadically in space.

This also means that comparing the degree of agglomeration and concentration in a sector, the *level of spatial division* enabling the measurement of the *range* of factors attracting the different companies of the sector together may be defined.

If spatial distribution corresponds to the figure on the left, then we can conclude that *the range of factors* serving as the reasons of clustering *is larger than* the range of the units in *the* chosen *level of spatial division.* If spatial distribution follows the figure on the right, then the *range* mentioned above *is smaller than* or equal to *the size of territorial units*.

Thus, at least one level above the level of spatial division serving as the basis of measurement, agglomeration may already be grasped as concentration.

3.2. The index numbers of concentration and agglomeration

Based on the above mentioned conceptual distinction, I would like to review the underlying content of calculated index numbers.

In the case of surveys and studies conducted with the goal of economic development and job creation, the degree of clustering is mostly measured with the help of index numbers based on employment data:

The *LQ index* or *Location Quotient* is an indicator often used in the case of employment data. This is the statistical indicator of the under- or overrepresentation of a certain economic activity in the economy of a given region compared to the whole of the national economy (Pearce 1993, p. 336.).

$$LQ_{ij} = \frac{e_{ij} \diagup E_i}{e_j \diagup E} = \frac{s_{ij}}{x_j}, \text{ where}$$

- e_{ij} is the number of employees in service sector i in territorial unit j,
- e_j is the number of employees in services in territorial unit j,
- E_i is the number of employees in service sector I, on the national level, while
- E is the number of national employees in the services.

So

- s_{ij} shows what proportion of the employees of service sector i work in territorial unit j,

- while x_j indicates what proportion of the employees of services (or the total number of employees) work in territorial unit j.

The index number serving for measuring the distribution in the number of enterprises operating in the same field of activity, that is, sectoral (not spatial) concentration is the *Herfindahl-index* (Ellison–Glaeser 1997).

$$H_i = \sum_{k=1}^{N_i} z_{ik}^2 \text{ , where}$$

- N_i : is the number of enterprises operating in sector i,
- z_{ik} : is the proportion of employees per enterprise k in sector i.

Ellison-Glaeser's concentration index (G_i) is the index similar to the well-known Gini coefficient, which measures disparity. It compares the spatial distribution of employment in sector i to the original spatial distribution of employment (Ellison–Glaeser 1997).

$$G_i = \frac{\sum_{j=1}^{M} \left(s_{ij} - x_j\right)^2}{1 - \sum_{j=1}^{M} x_j^2} \text{, where}$$

- M : is the number of territorial units within the examined territorial unit,
- x_j and s_{ij} are values defined together with the *LQ* index.

If the value of Ellison-Glaeser's concentration index (G_i) is low (around 0), the spatial distribution of sectoral employment is similar to the original spatial distribution of employment, while a value close to 1 indicates a high degree of concentration in the sector.

It is recommended to modify the G_i index with the help of the H_i index value, since why a sector is concentrated in one territorial unit may prove a significant question: either because it consists of a single large enterprise or the sector includes many smaller companies that settled in the same territorial unit.

The modified indicator published in the 1990s (Ellison–Glaeser 1997) is called *Ellison-Glaeser's γ_i index,* and is the estimation of the value of correlation between the choice of plant location by two companies operating in any service sector i. For its calculation, two important index numbers, the Herfindahl index (H_i) and the Ellison–Glaeser concentration index (G_i) are used. *Ellison-Glaeser's γ_i index* (EG γ)

$$\gamma_i = \frac{G_i - H_i}{1 - H_i}$$

The *Moran index*, the index number proposed by Moran in 1948, indicates whether the spatial distribution of the currently analysed data values show any kind of regularity, i.e. whether the data of adjacent territorial units are similar. (Moran 1950. Dusek 2004, Lafourcade–Mion 2007) If our data are the territorial values of the Location Quotient $\left(LQ = \frac{s_i}{x_i} \right)$ or some other numerical value indicating concentration like $s_i - x_i$, that results in the territorial auto-correlation coefficient of concentration values.

$$I = \frac{M}{\sum_{i=1}^{M}\sum_{j=1}^{M} w_{ij}} \frac{\sum_{i=1}^{M}\sum_{j=1}^{M} (s_i - x_i) w_{ij} (s_j - x_j)}{\sum_{i=1}^{M} (s_i - x_i)^2}, \text{ where}$$

- M : is the number of territorial units within the analyzed territorial unit,
- w_{ij}: is element j of row i of the adjacency matrix, its value is 1 if territorial units i and j are adjacent, otherwise it is 0.

3.3. Data

Subregional employment data are taken from the 2006 edition of the Hungarian Central Statistical Office's (KSH) Regional Statistical Yearbook and from the data on the population census of 2001 published on the KSH's website, while the data of the different companies derive from the 2007/2 publication of KSH's company informational data register (The Company Code Register – Cég–Kód–Tár) (KSH 2007).

I calculated the data of the different corporate enterprises on staff number, plant location and sector (Hungarian NACE) by association to the relevant subregion. I collected subregional level employment data by sectors (TEÁOR'03, 2 digits) and staff categories.

Exact company *data on staff number* would have been necessary for computing each index number, however, these were not available, so they had to be estimated. For this sake, I presumed that company staff numbers are distributed evenly within the staff categories (Ellison–Glaeser 1997), therefore, when computing the *Herfindahl index* (when the sum of squares is computed), I substituted each staff figure with *the square average* of the values within its own staff category, while in the case of calculating potential total staff number, I substituted each staff figure with the *arithmetic mean* of the values within its own

staff category. Since within staff categories, distribution is usually not even, this simplification may result in a distortion, however, the degree and direction of this is difficult to estimate.

Subregional level employment data derive from the data on the population census of 2001, which data series correlate with the subregional data series of 2006 on the *number of personal income tax payers* to the extent of 0.999, therefore, I used the former one as the basis of my calculations. I estimated the subregional number of employees in the industrial, construction industry and service providing sectors based on these data as well.

I compiled the data of the *subregional adjacency matrix* necessary for computing the Moran index based on the spatial situation of the 168 subregions (kistérség) using *'rook' adjacency* as the basis, which means that element j of row i in the matrix received the value (w_{ij}) 1 if subregions i and j have a shared border area, otherwise the value is 0 (Anselin 1988).

In the empirical analysis, I classified service sectors based on OECD's above mentioned division (Table 1). I took the number of companies belonging here based on their primary activity and the number of their employees as a basis. I used the 168 subregions as territorial units.

4. Results

With one exception, (*70 Real estate activities*[2]), I defined the index numbers of spatial concentration (EG γ) and agglomeration (Moran index) for two different cases for each knowledge intensive service sector listed in table 1: taking data on Budapest into consideration and without Budapest, due to two important reasons. On one hand, the determining social and economic power of the capital is obvious, nevertheless, in statistical terms, the fact that the majority of institutions concentrated in Budapest (for example, institutions of national importance) occur only in Budapest's statistical data in spite of also serving the rest of the country *may be defined as a distortion* (Lukovics 2007). On the other hand, Budapest is included in all territorial divisions – whether local, subregional (kistérség) or county level – as one unit, although the approximately 1.7 million inhabitants represent 17% of Hungary's population, therefore, this can also be regarded as a distorting factor.

4.1. Concentration

The value of *Ellison-Glaeser's γ index* can take its value in the interval [-1,1]. *Its negative value* shows the sparseness of the sector (in this case, companies' choice of plant location is not random, what is more, they try to settle as far from one

[2] I left out service sector *70 of real estate activities* from the survey because in the absence of capacity, the analysis of the sector was not possible with my methods.

another as possible), while in the case of *positive values*: values between 0 and 0.02 indicate weak concentration, between 0.02 and 0.05 they show moderate concentration, while values over 0.05 suggest strong concentration. Based on the value of Ellison-Glaeser's γ index, I classified sectors in the following categories. If

- $\gamma < 0$, then the sector is spatially sparse;
- $0 \leq \gamma < 0.02$, then the sector is weakly concentrated;
- $0.02 \leq \gamma < 0.05$, then the sector is moderately concentrated;
- $0.05 \leq \gamma$, then the sector is strongly concentrated.

Table 2. Ranking of knowledge intensive services compared to the spatial distribution of employees based on Ellison-Glaeser's γ index (concentration, 2007)

Including Budapest			**Excluding Budapest**		
Sectors	EG γ	Classification	Sectors	EG γ	Classification
62 Air transport	-0.0115	sparse	66 Insurance and pension funding	-0.0337	sparse
61 Water transport	-0.0015		61 Water transport	-0.0066	
85 Health and social work	0.0022	weakly concentrated	74 Other business activities	0.0013	
74 Other business activities	0.0071		85 Health and social work	0.0017	
80 Education	0.0351	moderately concentrated	71 Renting	0.0027	
71 Renting	0.0453		67 Activities auxiliary to financial intermediation	0.0033	
92 Recreational, cultural and sporting activities	0.1361	strongly concentrated	92 Recreational, cultural and sporting activities	0.0034	weakly concentrated
73 Research and development	0.1787		65 Financial intermediation	0.0046	
72 Computer and related activities	0.1944		80 Education	0.0057	
67 Activities auxiliary to financial intermediation	0.2087		72 Computer and related activities	0.0100	
64 Post, telecommunications	0.2129		73 Research and development	0.0153	
65 Financial intermediation	0.2685		64 Post, telecommunications	0.1037	strongly concentrated
66 Insurance and pension funding	0.3360		62 Air transport	0.3706	

Source: own calculations

Table 2 includes the ranking of the 13 examined knowledge intensive service sectors in terms of concentration determined on the basis of the *Ellison-Glaeser's γ indices*.

On the basis of spatial concentration, it can be stated that the majority of knowledge intensive service sectors, namely, 9 out of 13 may be called at least moderately concentrated, and this great degree of concentration is mainly due to Budapest, since upon omitting its figures, only two sectors remain strongly concentrated (61 *Air transport* and 64 *Post, telecommunications*), while the rest only qualifies as moderately concentrated at the most.

Table 3. Ranking of knowledge intensive services compared to the spatial distribution of employees based on Moran index (concentration, 2007)

Including Budapest			**Excluding Budapest**		
Sectors	Moran index	Auto-correlation	Sectors	Moran index	Auto-correlation
85 Health and social work	-0.0791	strongly negative	80 Education	-0.0603	strongly negative
65 Financial intermediation	-0.0343		65 Financial intermediation	-0.0606	negative
66 Insurance and pension funding	-0.0288		74 Other business activities	-0.0108	none
67 Activities auxiliary to financial intermediation	-0.0224		66 Insurance and pension funding	-0.0062	
80 Education	-0.0156	negative	71 Renting	0.0006	
74 Other business activities	-0.0046	none	64 Post, telecommunications	0.003	
73 Research and development	-0.0012		85 Health and social work	0.0102	
92 Recreational, cultural and sporting activities	-0.0002		61 Water transport	0.0044	positive
61 Water transport	0.0031	positive	73 Research and development	0.0322	
72 Computer and related activities	0.0093	strongly positive	67 Activities auxiliary to financial intermediation	0.0362	
62 Air transport	0.0109		62 Air transport	0.0181	strongly positive
71 Renting	0.0262		92 Recreational, cultural and sporting activities	0.0653	
64 Post, telecommunications	0.0285		72 Computer and related activities	0.1436	

Source: own calculations

4.2. Agglomeration

In the case of the *Moran index*, it is impossible to determine the auto-correlation level of the sector's spatial distribution based on values only. For determining this, the (estimated) distribution defined using actual concentration values, with the help

of the *Monte Carlo method* is also necessary. The *Geoda 0.9.5-i software*[3] developed by *Luc Anselin* is suitable for completing these calculations, therefore, with its help it is possible to determine the spatial distribution of the given service sector with a preliminary defined significance level:

- with strongly negative auto-correlation;
- with negative auto-correlation;
- with no auto-correlation;
- with positive auto-correlation;
- with strongly positive auto-correlation.

Table 3 includes the ranking of sectors in terms of agglomeration provided on the basis of the Moran index. Based on the index number of agglomeration, sectors are divided, *positive auto-correlation* occurs *in 5 out of 13 sectors*, while this index number is distorted (in the direction of positive auto-correlation) in the event if there are a lot of adjacent areas "empty" in sectoral terms, that is, having low employment level. This result is not surprising, since concentration measures the effect of forces having narrower range, while agglomeration also assesses the effect of forces going beyond area borders. Therefore, it would be worth conducting the survey on the *local level* as well.

4.3. The different sectors[4]

According to the results displayed by the tables, knowledge intensive service sectors show a rather mixed picture in terms of concentration and agglomeration. Figures 2 and 3 indicate how sectors can be classified along these two dimensions.

In order to make the typization of examined service sectors possible, I selected some of the 13 sectors that I will introduce in more detail now.

In the case of sectors *61 Water transport* and *62 Air transport*, based on the values of the γ index number, we find that the choice of plant location by enterprises operating in these sectors does not or only slightly depend on other enterprises' choice of plant location, and if it does depend on it, instead of attractions it is rather repelling forces that lie in the background. On the other hand, the values of the Moran index indicate very strong spatial auto-correlation, which in this case is not the consequence of an attracting force going beyond subregional borders, but rather the relatively low number of enterprises operating in the sectors (104 and 110), since this way, many subregions have low s_i - x_i value similar to their neighbours.

If data on Budapest are excluded from our calculations, the two sectors behave in different ways; the index values of sector 61 *Water transport* display a similar picture to the case when Budapest was included in the calculation, while sector 62 Air transport shows strong spatial concentration. The reason for this may

[3] The software can be downloaded free of charge from http://geodacenter.asu.edu/software/downloads.
[4] Only some sectors are discussed in more detail here.

be that the very few smaller enterprises of the Air transport sector operating in the countryside are concentrated in some subregions; while enterprises located in Budapest take up the majority of the whole sector (2102 of 2369 people are employed by companies with plant location in Budapest).

Figure 2. Results including data on Budapest

Concentration	Spatial auto-correlation: strong negative	weak negative	none	weak positive	strong positive
strong	65; 66; *67*		*73*; 92		64; 72
medium		80			*71*
weak	85		74		
sparse				*61*	*62*

Source: own calculations

Figure 3. Results excluding data on Budapest

Concentration	Spatial auto-correlation: strong negative	weak negative	none	weak positive	strong positive
strong			64		*62*
medium					
weak	80	65	*71*; 74; 85	*67; 73*	72; 92
sparse			66	*61*	

Source: own calculations

In the following, I will introduce the results of three knowledge intensive service sectors different both in terms of index number values and from Budapest's aspect.

4.3.1. Activities auxiliary to financial intermediation (67)

Every service provided in close relation to financial intermediation falls in this service sector (KSH 2003).

In the case of considering data on Budapest, enterprises' choice of plant location in the sector is

- strongly concentrated in space $\gamma = 0.2087$,
- with strongly negative auto-correlation $I = -0.0224$,
- the sector is scattered $H = 0.0908$.

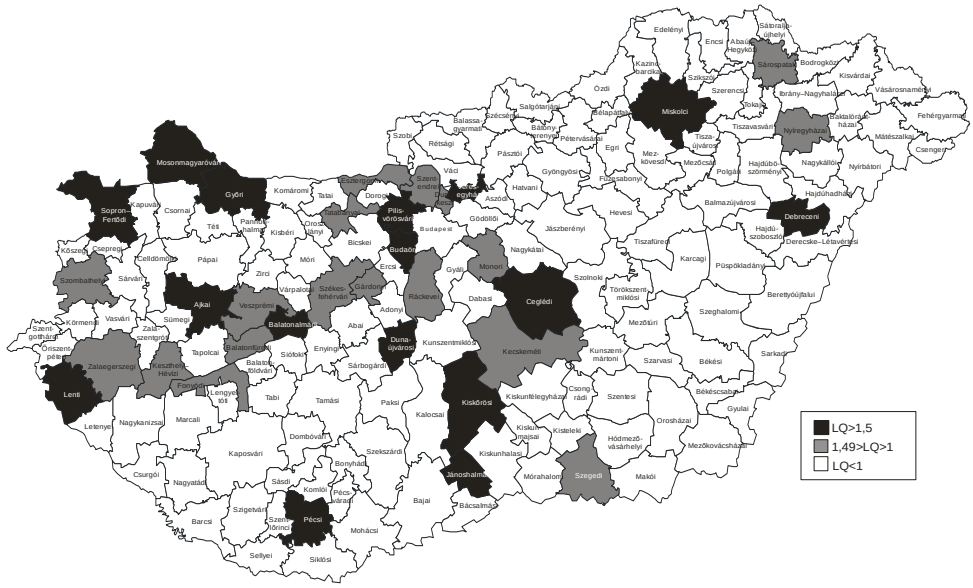
If, on the other hand, we disregard data on Budapest, then enterprises' choice of plant location is

- weakly concentrated in space $\gamma = 0.0033$;
- with positive auto-correlation $I = 0.0362$;
- the sector is strongly scattered $H = 0.0014$.

The comparison of index values and the analysis of different subregional *LQ* values lead us to the following conclusions.

Budapest's influence is especially great, since according to the result of the calculation including its data, only the capital has an *LQ* value higher than 1.5, the same value of all the other subregions is smaller than 1. Consequently, enterprises' choice of plant location is concentrated mainly in Budapest that can be interpreted as a single island[5].

Figure 4. Distribution of *LQ* values in sector 67 Activities auxiliary to financial intermediation according to subregions, excluding data on Budapest



Source: own calculations

If calculations are completed *without the data on Budapest*, the picture becomes much more differentiated (Figure 4). Distribution of *LQ* values in sector 67 of activities auxiliary to financial intermediation according to subregions, excluding

[5] That of Budapest is the only black subregion in the LQ map computed with data on Budapest, the rest of subregions are white.

data on Budapest). Relatively many enterprises operate in the sector – 5531, out of which 1970 are situated in Budapest.

In the country, we can find enterprises with fewer employees that are *concentrated,* although weakly. Concentration mainly occurs in adjacent areas; consequently, there is also *evidence of agglomeration*, so factors go beyond subregional borders.

This activity is mainly *concentrated* in the subregions of Győr – Sopron – Mosonmagyaróvár, the one surrounding Budapest and those of Pécs, Debrecen and Miskolc. The two biggest *differences* in concentration can be observed between the Békéscsaba subregion and its environment (high – low), and the Szeged subregion and its surroundings (high – low).

4.3.2. Renting (71)

Longer term Renting of machinery and equipment without operator and of personal and household goods (KSH 2003).

In the case of considering data on Budapest, companies' choice of plant location is

- moderately concentrated in space $\gamma = 0.0453$;
- with strongly positive auto-correlation $I = 0.0262$;
- the sector is strongly scattered $H = 0.005$.

If, on the other hand, we disregard data on Budapest, then enterprises' choice of plant location in the sector is

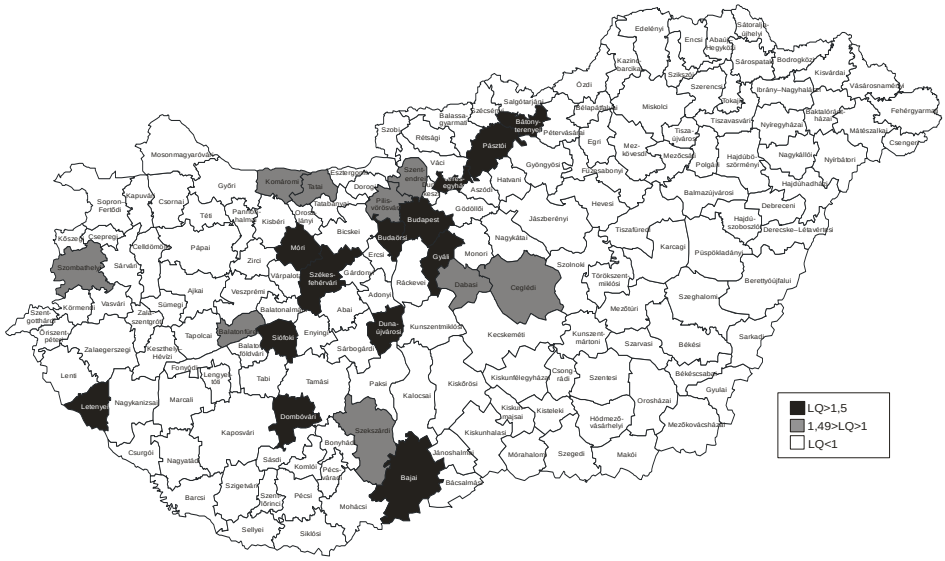
- weakly concentrated in space $\gamma = 0.0027$;
- with no auto-correlation $I = 0.0006$;
- the sector is strongly scattered $H = 0.0079$.

The analysis of the *LQ* values of the different subregions demonstrates that the picture including data on Budapest is similar to the results calculated without these values. The only major change is that while in the former case, *Budapest and the surrounding subregions* similarly have *high concentration*, which also occurs in auto-correlation values, so this activity is *agglomerated* around Budapest, without data on Budapest, with a significance level of 5% there is no auto-correlation any more – so the *Renting* sector does not have agglomeration in the rest of the country.

Disregarding data on Budapest does not bring any great change in the map displaying *LQ* values either, only gives a slightly more complex view (Figure 5 and Figure 6).

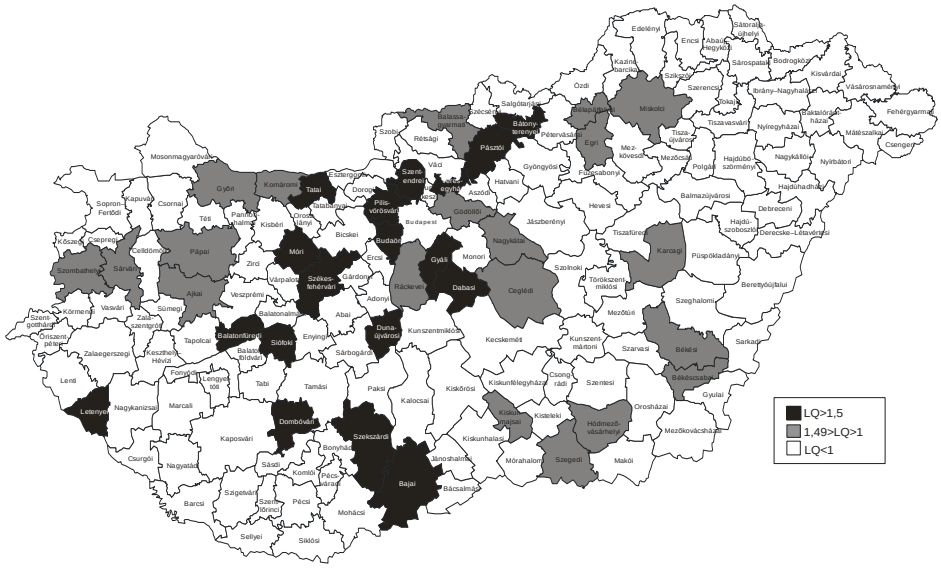
There are 2267 enterprises in this sector, 844 of them are situated in Budapest. Here, Budapest is followed by the subregions below that may be emphasized due to a greater degree of concentration: Veresegyház, Budaörs, Székesfehérvár, Dunaújváros, Gyál, Siófok, Baja, Szentendre, Szekszárd and Pilisvörösvár.

Figure 5. Distribution of *LQ* values in sector 71 Renting according to subregions, including data on Budapest



Source: own calculations

Figure 6. Distribution of *LQ* values in sector 71 Renting according to subregions, excluding data on Budapest



Source: own calculations

It is important to underline the existence of areas that prove especially "empty" from this sector's aspect: these mainly include the surroundings of the Pécs, Debrecen and Nyíregyháza subregions.

4.3.3. Research and development (73)

This sector includes three types of scientific research and development: basic research, applied research and experimental development (KSH 2003).
In the case of considering data on Budapest, companies' choice of plant location in the sector is

- strongly concentrated in space $\gamma = 0.1787$;
- with no auto-correlation $I = -0.0012$;
- however, the sector is strongly scattered $H = 0.0054$.

If, on the other hand, we disregard data on Budapest, then enterprises' choice of plant location in the sector is

- weakly concentrated in space $\gamma = 0.0153$;
- with positive auto-correlation $I = 0.0322$;
- however, the sector is scattered $H = 0.0106$.

In the case of the *research and development* sector, various changes are apparent in index values if data on Budapest are excluded; auto-correlation grows, while the γ value decreases.

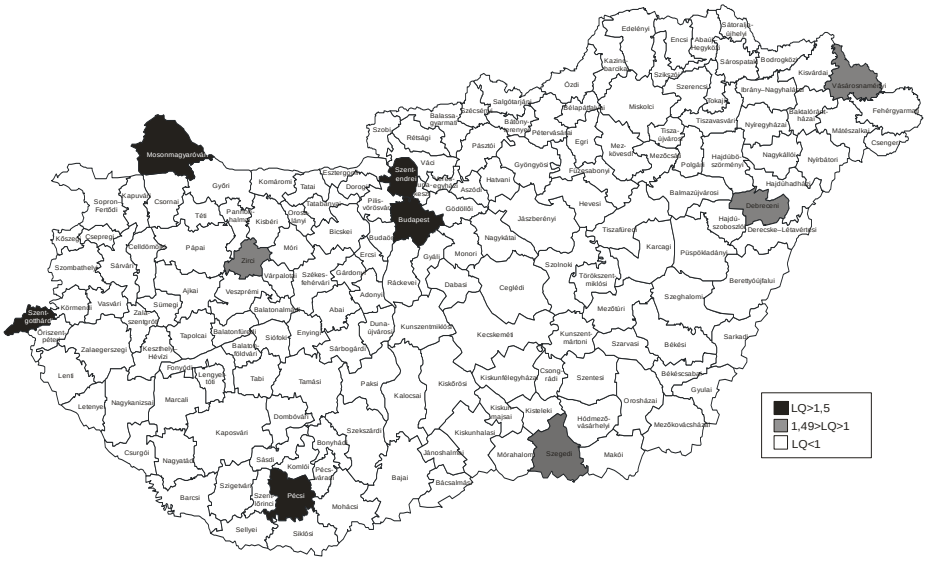
This means that in the choice of plant location made by enterprises operating in the *research and development* sector, an attractive factor going beyond subregional borders can clearly be detected. The development of some nodes is the result of this: such agglomeration points include Budapest and its surroundings like the Szentendre, Budaörs, Pilisvörösvár, Vác and Gödöllő subregions as well as the subregions of Mosonmagyaróvár and Győr.

Disregarding data on Budapest brings some change in the map displaying *LQ* values, the number of subregions having an *LQ* value higher than 1.5 increases considerably (Figure 7 and Figure 8).

Furthermore, the value of the Moran index is significantly increased by the fact that no enterprise with the main activity of R&D operates in 69 subregions, many of which are adjacent.

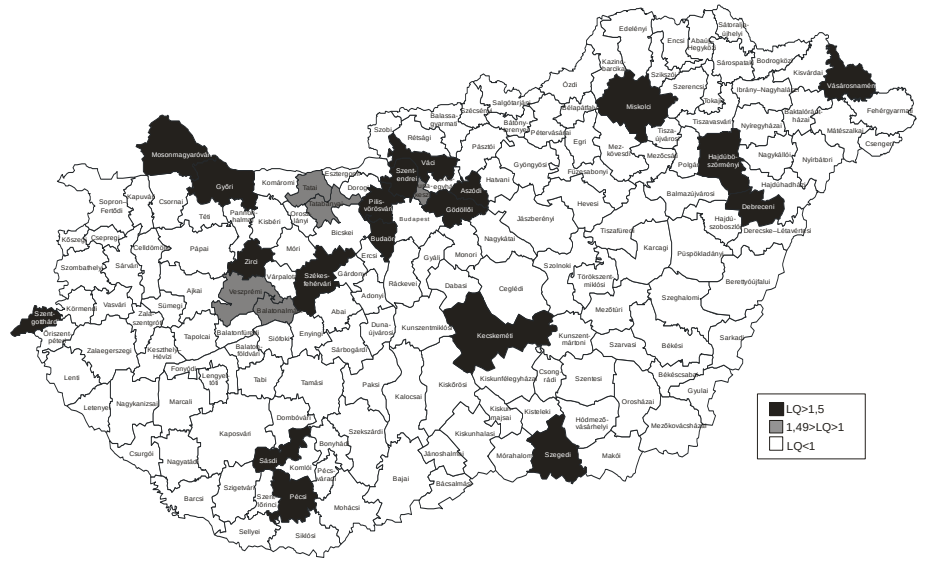
2547 enterprises are present in this sector, out of which 1402 are located in Budapest. Moreover, the subregions of Pécs, Debrecen, Szeged, Miskolc, Kecskemét, Székesfehérvár and Veszprém may also be mentioned.

Figure 7. Distribution of *LQ* values in sector 73 of research and development according to subregions, including data on Budapest



Source: own calculations

Figure 8. Distribution of *LQ* values in sector 73 of research and development according to subregions, excluding data on Budapest



Source: own calculations

4.4. The boundaries of the survey

The above applied index numbers and indicators represent useful help in analyses aiming at the measurement of agglomeration and concentration, however, it is important to underline that final conclusions cannot be drawn based on only these values. In the following, I would like to introduce the limitations of my survey:

1. Spatial division: Since I completed this research on the subregional level, my results can only show the presence and range of factors that occur on this level of spatial division, therefore, it would be useful to conduct the survey on the county level as well.
2. Absolute or relative concentration: *LQ* values mean the quotient of s_i/x_i, while both the Moran index and Ellison-Glaeser's γ index can be calculated on the basis of $s_i - x_i$ values. The former one measures concentration along the subregion's own employment level, therefore, it is relative, while the latter one measures the absolute flow (to or from) of national employment. This is why the use of both is recommended in the survey, and results must be interpreted accordingly.
3. Distortion of index numbers: Since no exact data on employment were available, only the classification of companies in terms of staff number categories, I had to assess these. This may represent a significant degree of distortion in the value of index numbers.
4. Agglomeration – is it? Behind the high value of the Moran index there may not surely lie real agglomeration; it is possible that the value increased due to the concentration of the sector in adjacent subregions with high population, or the existence of adjacent subregions that, however, have especially low employment in the sector and are "empty".

5. Summary

Based on the frequency distribution of index numbers and values included in the tables, surveying the concentration of knowledge intensive sectors suggests that knowledge intensive service sectors display a rather mixed picture in terms of concentration and agglomeration.

Based on the index number of spatial concentration (Ellison-Glaeser's γ index), it can be stated that the majority of knowledge intensive service sectors (9 out of 13) may be called at least *moderately concentrated*, and this high degree of concentration is due to Budapest, consequently, Budapest is the subregion where these knowledge intensive service sectors are present in higher concentration compared to the rest of service sectors.

However, based on the index number of agglomeration (Moran index), sectors prove more divided, positive auto-correlation can be found in 5 of the 13 sectors.

This result is not surprising, since concentration measures the effect of forces having narrower range, while agglomeration also assesses the effect of forces going beyond area borders. Therefore, it would be worth conducting the survey on the county level as well.

The so-called Budapest-effect is very high both in the measurement of agglomeration and of concentration.

Based on the *LQ* indices of knowledge intensive sectors and the values of the Moran index also examining the effects of adjacency, it can be concluded that these sectors are less clustered in Hungary. The value of $LQ > 1{,}5$ represents an internationally accepted low limit that justifies the statement that a sector undergoes clustering. In each of these sectors there exist subregions where a certain spatial concentration may be detected, but these sectors are less agglomerated in space, and we can find only three sectors that demonstrate high spatial auto-correlation, however, this is often due to the "empty" adjacent areas.

Based on the survey, it can be concluded that the clustering of knowledge intensive service sectors cannot be proved in Hungary, so there are no substantially innovative clusters in these sectors. This is not surprising, since in moderately developed countries like Hungary the economy has not yet been driven by innovation.

The survey also demonstrated that Hungarian regions, counties and subregions are in very different phases of development and are linked to the global economy very differently. Consequently, their competitiveness can only be improved by very different strategies of economic development.

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