Szendi, Dóra

Change in the Innovation Potential of the Northern Hungary Region

Innovation is an important indicator of regional economic development and competitiveness (for example, improved innovation performance may increase the competitiveness of countries).This recent study analyzes the innovation potential of the North Hungary region in national and international comparison. It can be stated that while the region concentrates 11.2% of the Hungarian population and 7.97% of the GDP, its weight in R&D is far below (3.2%) its economic situation or its population share. In most of the indicators examined, the region is one of the most disadvantaged within the country.
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Introduction

In the European Union, studies on territorial disparities have been a topic for decades. There is an increasing need for detecting the differences and for analysing convergence. According to the consensus of several authors, innovation is the main driver of development and convergence (Ewers and Brenck, 1992; Kocziszky et al. 2015). The literature is paying increasing attention to the regions' innovation potential, mainly due to its active contribution to economic growth and competitiveness (Szendi, 2018). In the classical concept of Schumpeter (1934, p. 66) innovation can appear in five different forms: "the introduction of a new product/or a new quality product; application of a new production technology […]; opening up a new market […]; new sources of supply for raw materials and semi-finished products […]; or introducing a new form of organization in an industry". Based on the researchers opinion, innovation is a critical factor in regional development. In Schumpeter's words, innovation is the engine of growth for individual companies, regions and nations (Lim, 2006). Similarly, in Romer's endogenous growth model, economic development depends on investment in human capital, knowledge and innovation (Romer, 1994).

Innovation is aimed at increasing productivity, contributing value added and gaining a competitive advantage, which ultimately leads to increased economic development in countries and regions (Paas and Vahi, 2012). Thus, innovation can contribute to the increase in the competitiveness of a region, as is illustrated by Lengyel's (2000) model of competitiveness. That is why it is moving increasingly into the focus of regional economic policies, and also in the EU's regional policy (Szendi and Papp, 2017). The Lisbon Strategy, and then the Europe 2020 Strategy, identified competitiveness as a high priority, which can be partly achieved by improving the capacity for innovation (Balázs and Jakab, 2017). Many authors (Kocziszky, 2004; Grosz and Rechnitzer, 2005; Rechnitzer, 2007; Bajmócy, 2008) have demonstrated the relationship between regional economic development and research and development. The purpose of this study is to investigate the R&D potential of the Northern Hungary region and to analyze its changes. The reason for selecting the region is that this is one of the least developed regions of Hungary, its innovation potential is lower than in the western part of the country, and therefore there is a risk of a development trap (a situation, when a region is at first time rapidly increasing until a given level, but it is not able to move on from this and to become a highly developed territory, Csath, 2019). In my hypothesis, the last few years have resulted in positive changes regarding the innovation potential of the region, but the catch-up is a long-lasting process that is influenced by several factors. In the first part of the study, I will summarize the main connections of innovation and competitiveness of the regions, and then I will present the

changes in the region's innovation potential from 1996 until now, including the positioning of the region and its counties.

Theoretical background

According to the consensus of Hungarian and international literature (e.g. Kocziszky, 2004; Paas and Vahi, 2012; Lee and Rodríguez-Pose, 2013; Ciocanel and Pavelescu, 2015), there is a significant relationship between the innovation potential of a region (R&D capacity of a given region) and its competitiveness and long-term development. The innovation potential of the sub-national levels has particular importance, since there are no two points in space which have the same characteristics, because their economic, social and cultural parameters are different (Benedek and Kurkó, 2011). Thus, the innovation potential of a country may have a characteristic spatial structure and show significant territorial disparities (Bajmócy and Szakálné, 2009).

The examination of the regional innovation potential is an important priority for the EU, since the cohesion and convergence objectives of the regional policy can be effectively achieved by improved R&D and innovation activities (Grosz and Rechnitzer, 2005). The less-developed regions with lower GDP have lower R&D expenditures and lower innovation potential than the more developed regions (Grosz and Rechnitzer, 2005), and the performance of the more innovative regions is higher (Weibert, 1999).

When analyzing the relationship between innovation and economic growth, Lee and Rodriguez-Pose found that innovation is one of the drivers of regional economic success. Innovative regions grow faster and can achieve higher average incomes (Lee and Rodríguez-Pose, 2013). The reason for this can be found in high technology, a high number of patent applications and R&D expenditure. Others, on the other hand, emphasize that as innovative regions tend to achieve higher productivity and income levels, they further enhance the regional economic disparities (Paas and Vahi, 2012). Thus, it is indisputable that regional development and convergence depend on innovation, but it is also influenced by many other factors (Paas and Vahi, 2012).

In Hungary, the R&D activities (expenditure, research sites, patents and publications) are characterized by a strong concentration in Budapest. Besides that, only counties with university centers have significant R&D potential (Keczer, 2009). The mid-term vision of the Northern Hungary region for the period 2014-2020 states that the region aims to achieve a higher level of environmental efficiency through the higher, more efficient and sustainable utilization of natural resources, and the competitiveness of traditional and intelligent specialization industries, to become an international recognized innovation center (NORRIA, 2013).

In this study, I have structured the analysis of the region's innovation potential as seen in *Figure 1*. In the first step I review the input side factors (number of R&D sites and their researchers, R&D expenditures), which basically represent the innovation potential of a region, then I examine the outputs (publications, patents) resulting from the innovation process, which highlight the performance of the regions.

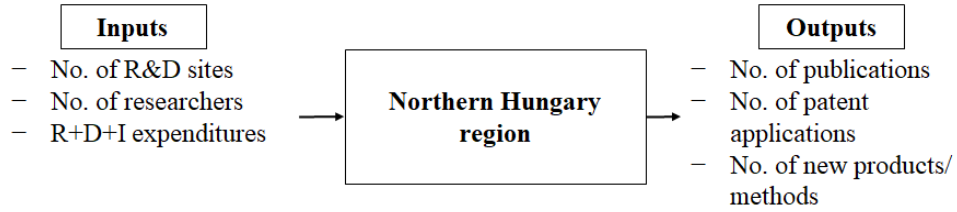

Figure 1: Research logic
Source: own compilation
Note: HCSO – Hungarian Central Statistical Office (KSH)

The innovation potential in the region according to the European Innovation Scoreboard

When analyzing the innovation potential of the Northern Hungary region, first I have positioned the region among the EU regions. The European Innovation Scoreboard compares the innovation performance of the EU member states on the basis of a complex innovation index; the current version (2019) contains 10 groups of factors and 27 indicators. Indicators are defined in four key areas: framework conditions, investments, innovation activities, impacts. These factors help us to analyze the strengths and weaknesses of each country and identify the key areas to focus on when assessing innovation potential (European Commission, 2019).

The European Innovation Scoreboard has been published since 2010, so we can identify the trends and monitor the changes. Based on the complex innovation index, the member states can be classified into four different groups (European Commission, 2019):

- Leading innovators (Sweden, Finland, Denmark and the Netherlands) whose performance is more than 20% above the EU average;
- Strong innovators (Luxembourg, Belgium, UK, Germany, Austria, Ireland, France, Estonia), where the innovation performance is around 90-120% of the EU average;
- Moderate innovators, whose performance is slightly below (about 50-90%) the EU average (Portugal, Czechia, Slovenia, Cyprus, Malta, Italy, Spain, Greece, Latvia, Slovakia, Hungary, Lithuania, Poland and Croatia);
- lagging innovators, where the innovation performance is below the 50% of the EU average (Bulgaria and Romania) (Balázs and Jakab, 2017; European Commission, 2019).

Hungary belongs to the group of the moderate innovators, but its innovation performance has slightly improved since 2011 (from 66% to 69% by 2019 compared to the EU average). Hungary is the 23rd among the 28 member states in 2019 and third among the Visegrad countries after Czechia and Slovakia *(Table 1)*.

Table1:
Hungary's position in 2019 compared to the "Visegrád Four" on the basis of the European Innovation Scoreboard (EU2011=100%)

	Summary innovation index	1. Human resources	2. Attractive research systems	3. Innovation-friendly environment	4. Finance and support	5. Firm investments	6. Innovators	7. Linkages	8. Intellectual assets	9. Employment impacts	10. Sales impacts
EU	108.8	122.3	112.6	158.1	109.4	119.2	90.8	103.9	97.3	104.4	103.0
CZE	89.4	91.7	73.6	118.6	51.1	112.6	88.0	87.3	62.1	123.6	95.8
HUN	69.0	53.7	55.9	144.7	46.2	98.0	30.9	57.1	40.1	124.2	84.1
POL	61.1	70.4	34.6	197.9	39.1	87.3	15.0	32.4	67.4	96.5	56.1
SVK	69.1	86.1	46.7	90.9	26.1	79.7	37.9	60.1	38.7	113.3	114.5

Source: Own compilation based on European Commission (2019)

The innovation scoreboard does not distinguish between input and output factors, but establishes a cumulative score based on each factor. However, an overview of the components indicates that Pillars 1, 3, 4 and 5 make up the input side, while the remaining six pillars form the output side.

Input-side factors

In the case of Hungary, in terms of input factors the human resources pillar, which counts the number of new doctoral degrees granted and the number of people involved in lifelong learning, is one of the worst among the Visegrad countries in 2019. The biggest problem can be identified in the case of this pillar, where only Romania and Italy are behind us. The country ranks second among the V4 countries in the pillar of innovation, corporate investments (business R&D expenditure) and finance (public R&D expenditure and venture capital investment).

Output-side factors

The output side of indicators shows that Hungary is ranked third in the Visegrád Four in terms of its cumulative score. In international-domestic co-publications, both the Czech Republic and Slovakia have significantly higher values; however, in the number of scientific publications among the top 10 most cited, the Hungarian value is the highest in the V4. The Hungarian rating in the pillars of innovators (innovative products and services of small and medium-sized enterprises) and intellectual property (number of patents, trademarks) is extremely low, which also worsens the overall evaluation of Hungary.

The Regional Innovation Scoreboard (RIS), a regional extension of the European Innovation Scoreboard, measures the innovation performance of European regions based on 18 indicators. The RIS 2019 examines 238 regions and presents the position of the regions according to the components shown above.

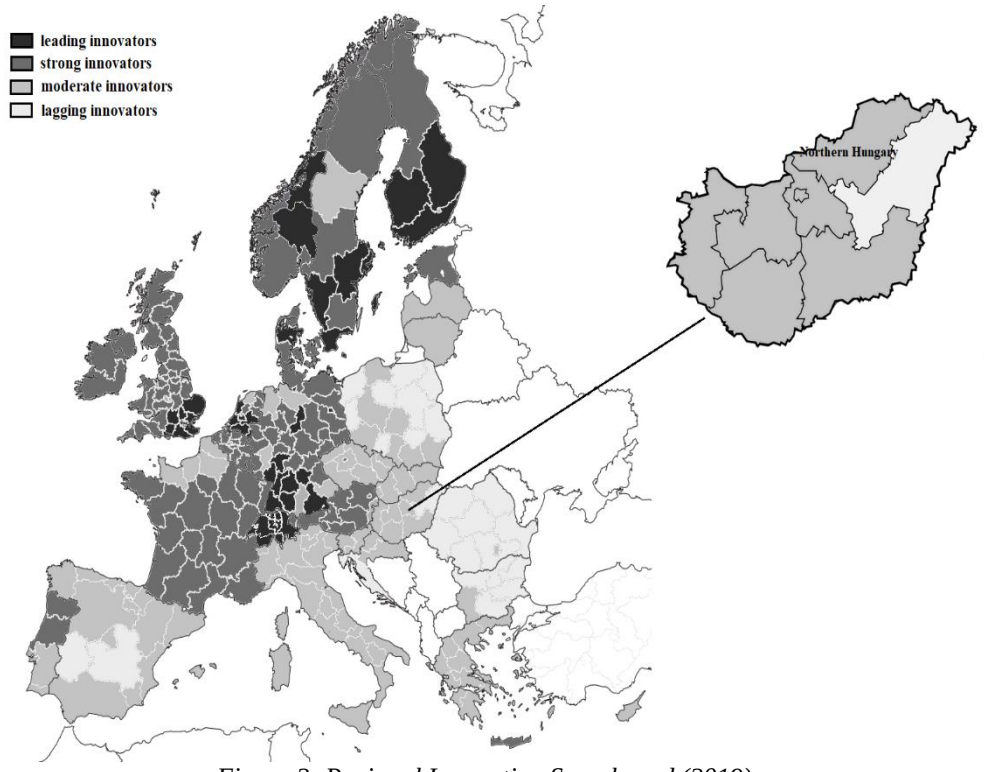

Figure 2: Regional Innovation Scoreboard (2019)
Source: European Commission (2019)

The Northern Hungary region belongs to the group of moderate innovators *(Figure 2)*, with significant difference to the EU average (53.1%). The largest gap compared to the EU average can be found in the following components *(Table 2)*:

- input side: share of population with tertiary education (48%), lifelong learning (35%), public R&D expenditure (20%),
- output side: scientific publications (29%), public-private joint publications (19%), patents and trademarks (26%).

Table 2:
Innovation score of the Hungarian regions according to the Regional Innovation Scoreboard (EU2011=100%)

	RIS2011	RIS2013	RIS2015	RIS2017	RIS2019
Budapest	85.6	85.0	83.6	84.1	84.4
Pest	75.2	75.9	73.0	77.4	81.5
Central Transdanubia	59.7	57.3	55.8	58.1	53.4
Western Transdanubia	60.1	50.3	56.2	51.5	55.1
Southern Transdanubia	50.5	48.9	52.3	49.2	53.3
Northern Hungary	47.6	46.9	51.2	47.8	53.1
Northern Great Plain	50.8	49.4	51.5	53.2	52.0
Southern Great Plain	53.4	55.8	59.4	58.4	54.5

Source: Own compilation based on European Commission (2019)

It can be seen that both the input and the output side have a significant lag in some components. In Hungary, the Central Hungarian region is the only one with good performance among the moderate innovators, while the Northern Great Plain region belongs to the lagging innovators. The performance of the Northern Hungary region has improved since 2011, mostly in two input-side factors (innovation expenditures in non-R&D sector; employment in high-tech manufacturing and knowledge-intensive services). This may be a favorable trend towards the outputs in the future.

4. Analysis of the region's innovation potential

Through the analysis of the innovation potential and R&D position of the Northern Hungary region in the period of 1996-2018, I have examined the number of R&D sites in the region, the number of their employees, the R&D expenditures used and the number of patents they create. The sources of the data are the database of the Central Statistical Office and the Eurostat database. The three counties of the Northern Hungary region (Borsod-Abaúj-Zemplén, Heves and Nógrád) contain 11.2% of the country's population and 7.97% of its total GDP, but only 3.2% of its R&D expenditure.

Input side factors

A detailed review of R&D data shows that the region's position among the Hungarian regions is not very favorable. The number of research and development sites in the Northern Hungary region is the lowest. In 2018, there were 191 research sites, which is 6.2% of the national total *(Table 3)*. Most of the R&D sites in Hungary are located in the capital region, which concentrates more than half of all Hungarian research locations.

Table 3:
Number of research and development sites in the Hungarian regions and in counties of the Northern Hungary region

	Number of research and development sites				Number of research and development sites (% of total)			
	1996	**2000**	**2010**	**2018**	**1996**	**2000**	**2010**	**2018**
Central Hungary	710	998	1471	1820	48.6	49.4	49.3	52.1
Central Transdanubia	64	161	203	228	4.4	8.0	6.8	6.5
Western Transdanubia	109	146	256	260	7.5	7.2	8.6	7.4
Southern Transdanubia	125	130	203	233	8.6	6.4	6.8	6.7
Northern Hungary	101	110	191	218	6.9	5.4	6.4	6.2
Northern Great Plain	162	248	307	313	11.1	12.3	10.3	9.0
Southern Great Plain	190	227	352	419	13.0	11.2	11.8	12.0
Borsod-Abaúj-Zemplén	63	81	109	114	4.3	4.0	3.7	3.3
Heves	36	35	71	83	2.5	1.7	2.4	2.4
Nógrád	2	2	11	21	0.1	0.1	0.4	0.6

Source: own compilation based on HCSO data

Analyzing the change in the number of research sites, we can see that in1996 the Central Transdanubian region had the lowest value, which underwent significant improvement until 2000, while the Northern Hungarian region was almost always in the last position *(Figure 3)*. The fact that Nógrád County has one of the lowest numbers of R&D sites (tied with Tolna County) plays a significant role in the region's unfavorable situation. For research and development sites per 10,000 inhabitants there was a slight decline in all regions after 2013, followed by an improving trend from 2016 in almost all regions.

In terms of the EU, there have been significant positive shifts in the number of researchers in the CEE region, counting also the regions of the former country of East Germany (Berlin and its surroundings, Sachsen and Sachsen-Anhalt) and the Visegrad countries. In the Visegrád country group, the number of regions with more than 5,000 researchers has increased in all countries (in Hungary: the Central Hungary, Northern Great Plain and Southern Great Plain regions belong to this group). In the EU, the differences between the western and the eastern countries are sharp regarding the number of researchers among the most developed and the least developed regions (maximum: Oberbayern (Germany) 87,300 and minimum: Ciudad Autónoma de Ceuta (Spain) 35).

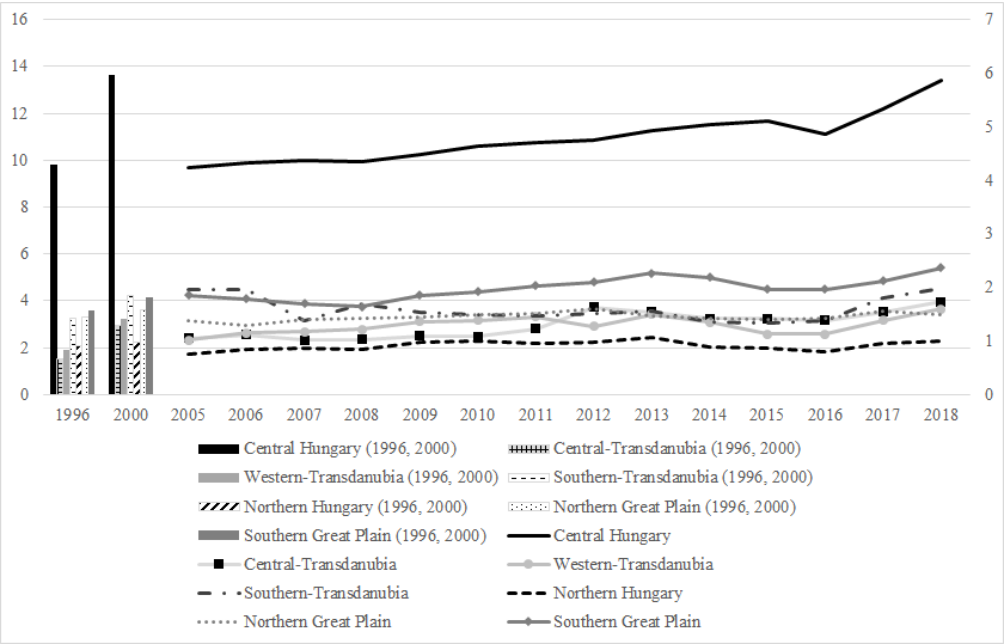

Figure 3: Number of research and development sites per 10,000 inhabitants (1996, 2000, 2005-2018)

Source: own compilation based on HCSO data

The number of researchers per 1,000 inhabitants has been the lowest in the Northern Hungary region in every year since 2000, with an average of two R&D personnel per 1,000 people, while in the case of Northern Great Plain and Western Transdanubia this is around 3.5 people. In Northern Hungary, 60% of the nearly 2,600 researchers worked in Borsod-Abaúj-Zemplén County in 2018, compared to the only 199 in Nógrád. Looking at the changes, all regions have experienced stagnation or lower growth rates since 2005, which, combined with the previous research sites data, results in a decline in the number of researchers per research site in some regions, including the Northern Hungary region. The specific number of R&D personnel in the Central Hungary region is outstanding in European comparison as well, since 2002 it has been among the best (Eurostat, 2005).

In terms of R&D expenditures, the country is more centralized than in the previous cases, as 66.9% of the expenditures were concentrated in the central region in 2018. The Northern Hungary region had the second lowest proportion (3.2%) among the regions of the country, ahead of the Southern Transdanubian region, due to the extremely low values of Heves and Nógrád counties *(Table 4)*.

Table 4:
Research and development expenditure in each region and in counties of the Northern Hungary region

	Research and development expenditures (million HUF, current prices)				Research and development expenditures (% of total)			
	1996	**2000**	**2010**	**2018**	**1996**	**2000**	**2010**	**2018**
Central Hungary	29311	73254	202588.6	434233.1	68.9	70.3	66.5	66.9
Central Transdanubia	2415	5229	16476.9	56933.6	5.7	5.0	5.4	8.8
Western Transdanubia	1218	2949	15532.3	33042.5	2.9	2.8	5.1	5.1
Southern Transdanubia	1306	3918	7927.6	17500.1	3.1	3.8	2.6	2.7
Northern Hungary	1268	2504	11354.3	20947.7	3.0	2.4	3.7	3.2
Northern Great Plain	3068	8144	27320.5	39393.1	7.2	7.8	9.0	6.1
Southern Great Plain	3979	8201	23616.5	46764.4	9.3	7.9	7.7	7.2
Borsod-Abaúj-Zemplén	899.6	1857.2	7147.7	14212.4	2.1	1.8	2.3	2.2
Heves	355.1	745.4	3399.3	5167.4	0.8	0.7	1.1	0.8
Nógrád	14.4	39.9	807.3	1568	0.0	0.0	0.3	0.2

Source: own compilation based on the HCSO data

The structure of expenditures in the Northern Hungary region changed after 2000, and there was a significant reorganization/reallocation process among the different sectors. The share of R&D spending in the higher education sector (46.8% in 2000) dropped to 21.6% by 2017, which is roughly equivalent to the EU average, while the corporate sector spending increased significantly from 45.1% to 77.7%, which is higher than the EU average. The remaining 0.7% was held by the government sector in 2017 (down from 8% 17 years earlier). According to the HCSO (2017), between 2014 and 2016 the proportion of innovative enterprises in the Northern Hungary region reached 28.4%, following only Budapest (34.4%) and the Western Transdanubia region (28.9%).

In terms of R&D expenditure as a percentage of the GDP, the region is one of the least developed areas (0.49%). At the same time, it should be noted that none of the Hungarian regions reached the EU average (2.07% in 2017) and the national value is also relatively low compared to international standards. An overview of the changes shows that all Hungarian regions had increasing R&D expenditures after 2000, but in most cases persistent differences are seen among the regions *(Figure 4)*, even though sigma convergence seemed to be achieved between 2000 and 2017, as the CV indicator (coefficient of variation) has been decreasing since 2000.

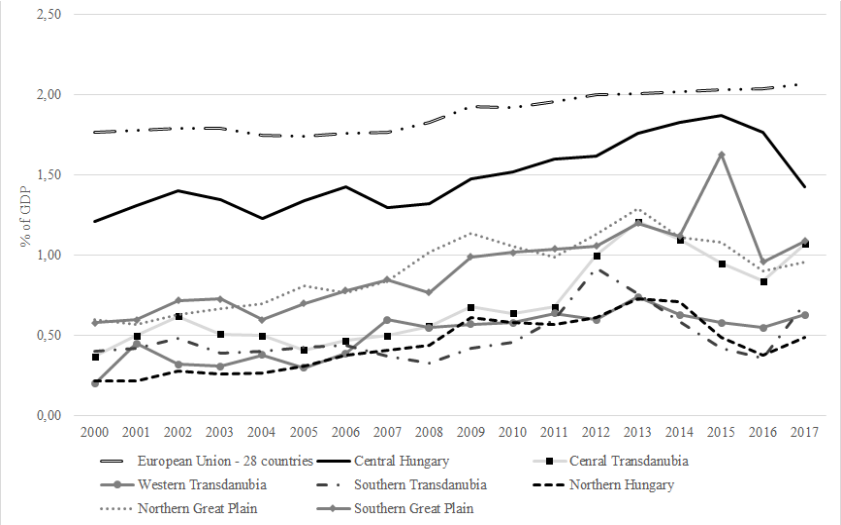

Figure 4: R&D expenditures as a percentage of GDP (2000-2017)
Source: own compilation based on the Eurostat data

Output side factors

There are significant inequalities in the number of patent applications per million inhabitants across the EU along a western-eastern slope. In this indicator, besides the advanced area of the blue banana there is another highly developed territory, the Swedish-Danish-German "boomerang". The areas with the most patent applications can be identified in these areas, with the city of Erlangen having the highest value, with an average of 1,770.5 patents per million inhabitants based on the Eurostat data *(Figure 5)*.

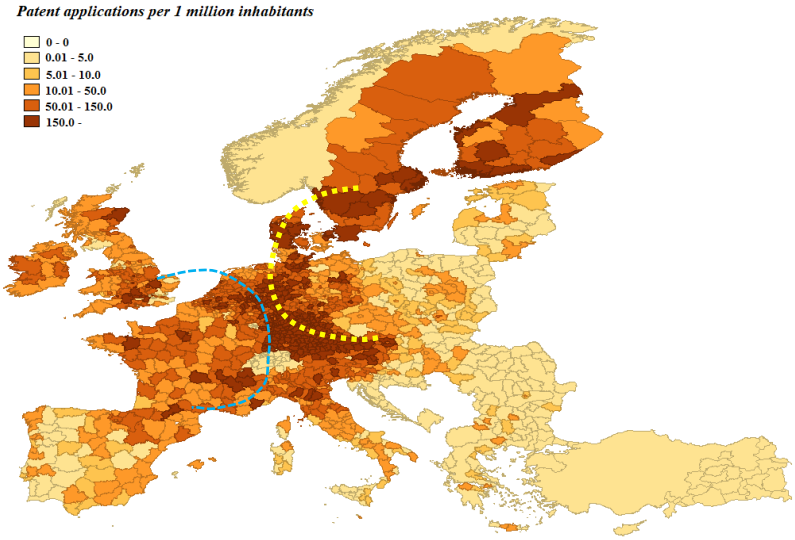

Figure 5: Number of patent applications per million inhabitants in the European Union (NUTS3, 2013)
Source: own compilation based on Eurostat data
Note: the blue line indicates the blue banana territory, while the yellow line is the Swedish-Danish-German "boomerang"

The lowest values are concentrated in the southern and eastern peripheries of the European Union. Apart from zero values, two Romanian regions have the fewest patent applications per 1 million inhabitants: Arges (0.409) and Mures (0.309). The number of patents is also low in the counties of the Northern Hungarian region, with an average of 1-5 patents per million inhabitants (Szendi and Papp 2017).

The patent disparities are also shown in the graph of the next Local G_i index, which represents the hot and cold spots in the European Union *(Figure 6)*. The Local G_i indicator is the local measure of autocorrelation created by Getis and Ord (1992). G-statistics can take values between 0 and 1 (Abdulhafedh, 2017). Positive G_i indicates the local concentration of hot spots, while negative G_i indicates the local concentration of cold spots. It is important to note that G statistics do not take into account the spatial outliers (Anselin, 2016). The data suggests that the southern German provinces form a continuous hot spot area, while the central and eastern European countries (including two counties of the Northern Hungary region: Borsod-Abaúj-Zemplén and Nógrád) form a cold spot area.

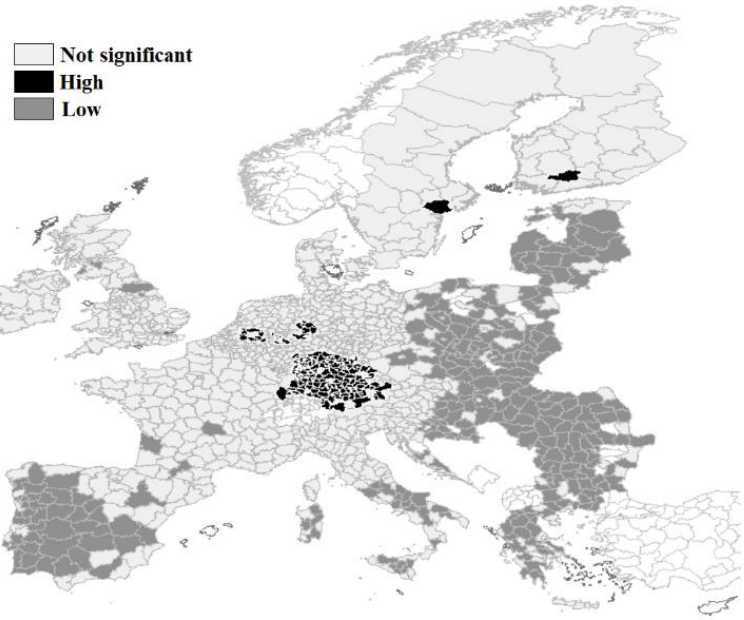

Figure 6: Territorial autocorrelation of patent applications per million inhabitants
Source: own compilation based on the Eurostat data

In Hungary, the territorial concentration of R&D activity is well illustrated by the fact that there are significant regional differences in the number of patent applications per 1 million inhabitants. The dominance of the Central Hungarian region is clear, but at the end of the list there was a significant shift in the 2000-2012 period. Until 2006, the regions were close to each other, but after that the Western Transdanubia and Northern Great Plain regions showed slight decreases, so the inequalities began to increase *(Figure 7)*.

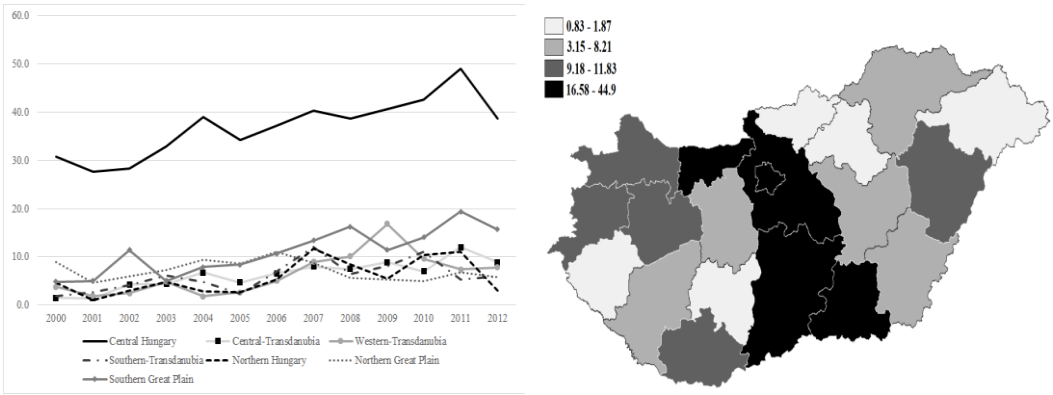

Figure 7: The number of patent applications per million inhabitants (2000-2012, left) and its spatial concentration (2012, right)
Source: own compilation based on the HCSO data

In 2012, the largest number of patent applications were created in the capital and Pest County, as well as in Komárom-Esztergom, Bács-Kiskun and Csongrád Counties. In Europe, the Northern Hungary region is one of the moderate innovators, with an average of 1-5 patents per million inhabitants (Szendi and Papp 2017).

There is a strong Central Hungarian concentration also in the number of Hungarian and international academic publications per 1,000 inhabitants, where between 2005 and 2018, approximately 7-8 publications per 1,000 inhabitants are created. In contrast, the other regions are lagging behind this significantly (with values lower than four). The Northern Hungary region is ahead of the Central Transdanubia region with a publication value of around 1.5 per 1,000 inhabitants.

5. Complex evaluation of the Northern Hungarian region's innovation potential

The innovation potential, as can be seen from the above, is a complex notion that can be described by several factors together. Grosz and Rechnitzer (2005) carried out a complex ranking system for the innovation potential of the subnational territorial units. This is based on three criteria: number of R&D sites, specific R&D expenditure, and number of researchers per 10,000 inhabitants. The study looked at the base years of 1995 and 2001, but in the authors' opinion, this is a short period of time for reviewing significant changes. Therefore, in this study, I compare the 1995 base to the 2018 data, following the methodological considerations of Grosz and Rechnitzer (2005). The results are summarized in *Table 5*.

Table 5:
Ranking of R&D potential for the Hungarian counties (1995, 2018)

		1995						2018			
		1	**2**	**3**	**sum**			**1**	**2**	**3**	**sum**
1	Budapest	1	1	1	3	1	Budapest	1	1	1	3
2	Csongrád	2	2	2	6	2	Csongrád	2	3	2	7
3	Hajdú-Bihar	4	3	3	10	3	Hajdú-Bihar	4	4	4	12
4	Baranya	3	7	4	14	4	Veszprém	9	2	5	16
5	Győr-Moson-Sopron	6	5	5	16	5	Győr-Moson-Sopron	5	5	6	16
6	Veszprém	8	4	6	18	6	Baranya	6	9	3	18
7	Pest	7	8	8	23	7	Pest	3	7	8	18
8	Borsod-Abaúj-Zemplén	5	11	7	23	8	Fejér	8	8	7	23

		1995						2018			
		1	**2**	**3**	**sum**			**1**	**2**	**3**	**sum**
9	Fejér	12	6	12	30	9	Borsod-Abaúj-Zemplén	7	11	11	29
10	Szabolcs-Szatmár-Bereg	9	10	11	30	10	Heves	11	13	9	33
11	Heves	10	12	10	32	11	Bács-Kiskun	10	10	13	33
12	Jász-Nagykun-Szolnok	13	13	8	34	12	Vas	16	6	12	34
13	Békés	16	9	15	40	13	Somogy	12	17	10	39
14	Vas	11	17	14	42	14	Komárom-Esztergom	17	12	14	43
15	Somogy	17	14	13	44	15	Zala	14	16	15	45
16	Bács-Kiskun	14	15	16	45	16	Szabolcs-Szatmár-Bereg	13	19	16	48
17	Tolna	18	16	18	52	17	Tolna	19	14	18	51
18	Zala	15	19	19	53	18	Békés	15	20	17	52
19	Komárom-Esztergom	18	18	20	56	19	Jász-Nagykun-Szolnok	18	15	19	52
20	Nógrád	20	20	16	56	20	Nógrád	20	18	20	58

Source: own compilation based on HCSO data

Note: 1. number of R&D sites, 2. R&D expenditure per person, 3. number of researchers per 10,000 inhabitants.

Based on the data of *Table 5*, it can be stated that the three counties in the leading position (Budapest, Csongrád and Hajdú-Bihar) maintained their position in the aggregate ranking, but they performed a bit worse than before in the individual indicators. Veszprém and Baranya Counties have changed their positions due to the fact that Veszprém County has significantly improved its specific R&D expenditure. Borsod-Abaúj-Zemplén county ranked 9th among the counties, despite the fact that it significantly improved its ranking in the number of research sites (however, there was a significant decline in the R&D expenditures). Heves County is ranked 10th in the rankings, which means that the two counties above are among the medium-developed ones, but the third county of the region (Nógrád) is in last place of the ranking in both years, worsening its overall score by 2018. In terms of the ranking, the situation of 3 counties improved significantly (Bács-Kiskun and Komárom-Esztergom improved 5 places and Zala 3 places). The largest declines were shown by Jász-Nagykun-Szolnok (a decrease of 7 places), Békés (5 places) and Szabolcs-Szatmár-Bereg (6 places). I have also examined the changes in the R&D performance and the GDP/capita relative to each other, which can be seen in the currently examined 1995-2018 time series in *Figure 8*.

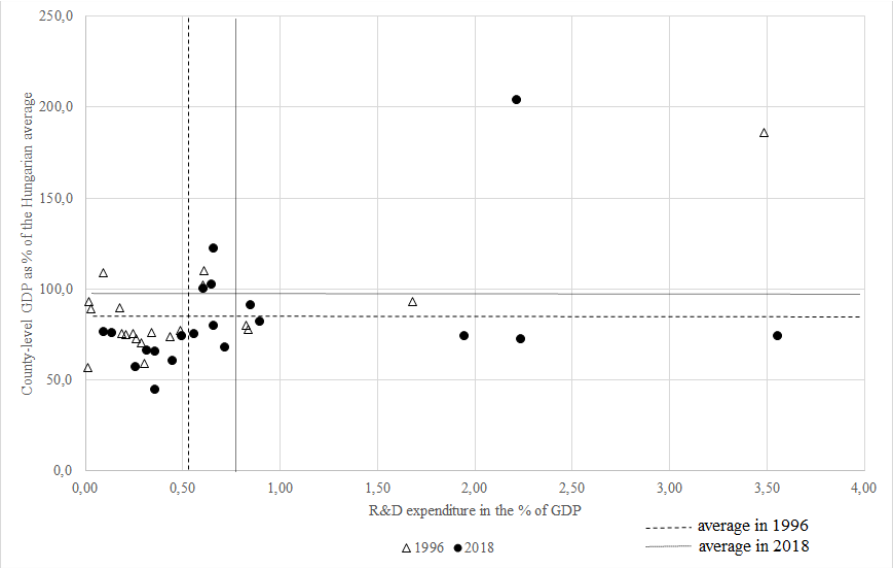

Figure 8: The situation of counties in terms of their R&D and GDP share (1996, 2018)
Source: own compilation
Note: based on Grosz and Rechnitzer (2005) 1. (upper left field): Strong economic potential and moderate R&D capacity; 2. (upper right field): Strong economic potential and favorable R&D capacity; 3. (bottom left field): Weak economic potential and moderate R&D capacity; 4. (bottom right field): Weak economic potential and favorable R&D capacity.

Table 6:
Changes in the position of counties by the share of R&D and GDP (1996, 2018)

1996			**2018**		
	Moderate R&D	**Strong R&D**		**Moderate R&D**	**Strong R&D**
Strong economic potential	Vas, Zala, Komárom-Esztergom, Tolna	Győr-Moson-Sopron, Fejér, Csongrád, Budapest	**Strong economic potential**	Komárom-Esztergom, Fejér, Győr-Moson-Sopron	Budapest
Weak economic potential	Nógrád, Szabolcs-Szatmár-Bereg, Borsod-Abaúj-Zemplén, Somogy, Pest, Baranya, Heves, Jász-Nagykun-Szolnok, Bács-Kiskun, Békés	Hajdú-Bihar, Veszprém	**Weak economic potential**	Nógrád, Szabolcs-Szatmár-Bereg, Borsod-Abaúj-Zemplén, Somogy, Pest, Baranya, Heves, Jász-Nagykun-Szolnok, Békés, Vas, Zala, Tolna	Csongrád, Hajdú-Bihar, Veszprém, Bács-Kiskun

Source: own compilation

We can see from *Table 6* that there has been a slight shift in the position of the counties in terms of R&D performance and GDP share. All three counties in the Northern Hungary region are classified as having a weak economy and a low level of R&D performance. For some counties, the change in R&D has resulted in a significant shift, so in the case of Bács-Kiskun County, due to improved R&D performance, the county can be classified in a better cluster in

2018 than before, while Fejér and Győr-Moson-Sopron Counties have lost their positions (*Figure 9*).

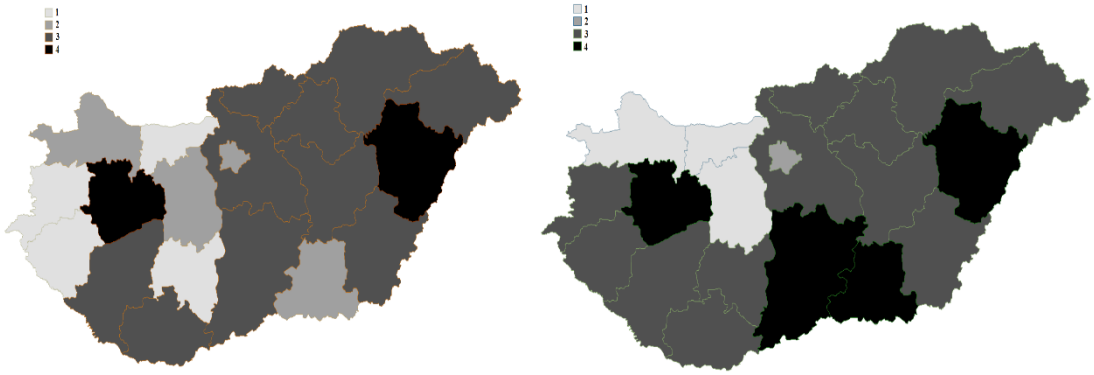

Figure 9: Change in counties' positions based on R&D and GDP share (1996 – left, 2018 – right)
Source: own compilation
Note: based on Grosz – Rechnitzer (2005) 1. Strong economic potential and moderate R&D capacity; 2. Strong economic potential and favorable R&D capacity; 3. Weak economic potential and moderate R&D capacity; 4. Weak economic potential and favorable R&D capacity.

6. Discussion

From the analysis of the input and output side dimensions of the R&D activity it can be stated that the situation of the Northern Hungary region is clearly unfavorable compared to the other regions of Hungary and also in EU comparison. In terms of the number of research and development sites, the number of their employees, the R&D expenditures in the proportion of GDP, and the patent applications per million inhabitants, the region is one of the most disadvantaged regions in the country. At the same time, some favorable trends have been observed in the recent period, mainly in comparison with the EU data, as the overall innovation score has improved compared to 2011, mainly in non-R&D innovation expenditure and employment in high-tech manufacturing and knowledge intensive services. The disadvantage of the region can be the result of several parallel effects, one of which is that some multinational companies operating in the region do not report their performance in this region, so in many cases statistical records are distorted and we do not see the exact picture.

The recent positive changes in the region are strengthened by the fact that the share of corporate sector R&D expenditures has increased significantly, which supports the legitimacy of bottom-up initiatives and also contributes to a better innovation environment. Between 2014 and 2016, according to the HCSO (2017), the proportion of innovative enterprises of the Northern Hungary region was the third highest among the Hungarian regions. This is important, as the traditional concept is that the innovation process is closed and innovation is essentially centered around research centers and large companies, but nowadays dynamic small and medium-sized enterprises (SMEs) and business-to-business networking are becoming more and more important (Márton, 2004, p. 127).

Innovative small and medium-sized enterprises have significant importance for the economic growth of a given region (Lovas and Rába, 2013). At the same time, supporting the innovation activities of these companies requires a huge amount of capital, but SMEs have limited resources to self-finance this innovation activity. The so-called venture capital financing, which is a special form of investment in innovation, requires the establishment of venture capital

funds, which act as an intermediary between venture capitalists and senior management of innovation firms, and provide opportunities for start-ups in the innovation process (Prime Minister's Office, 2016; Lyasnikov et al. 2017). The experience of Western European countries also shows that there is a strong correlation between the growth of innovation activity of small and medium-sized enterprises and the availability of venture capital funds (Lyasnikov et al. 2017). A good example is the German state of Baden-Württemberg, which has several districts (e.g. Tübingen, Stuttgart, and Karlsruhe) that are among the best performing regions according to the latest Regional Innovation Scoreboard data. In that province there are many so-called accelerator organizations that provide support to start-ups on various topics in partnership with the Chambers of Commerce and Industry. In addition, L-Bank, the state bank of Baden-Württemberg, provides support programs and financing concepts for start-ups. The Seed Fund BW, together with the Federal High Technology Fund, finances up to EUR 100,000 for start-ups in an active partnership (startupbw.de, 2020).

In addition, technology parks, incubator organizations and clusters play an important role in the innovation process (Lyasnikov et al. 2017; Saridakis, 2019). A science and technology park is an industrial park created or operated primarily to promote the development of knowledge-intensive enterprises engaged in technological innovation (Government of Hungary, 2016). According to the most recent data, there are 29 industrial parks and 30 clusters operating in the Northern Hungary region, which have higher than the average export activity, the distribution of which is shown in *Figure 10* below.

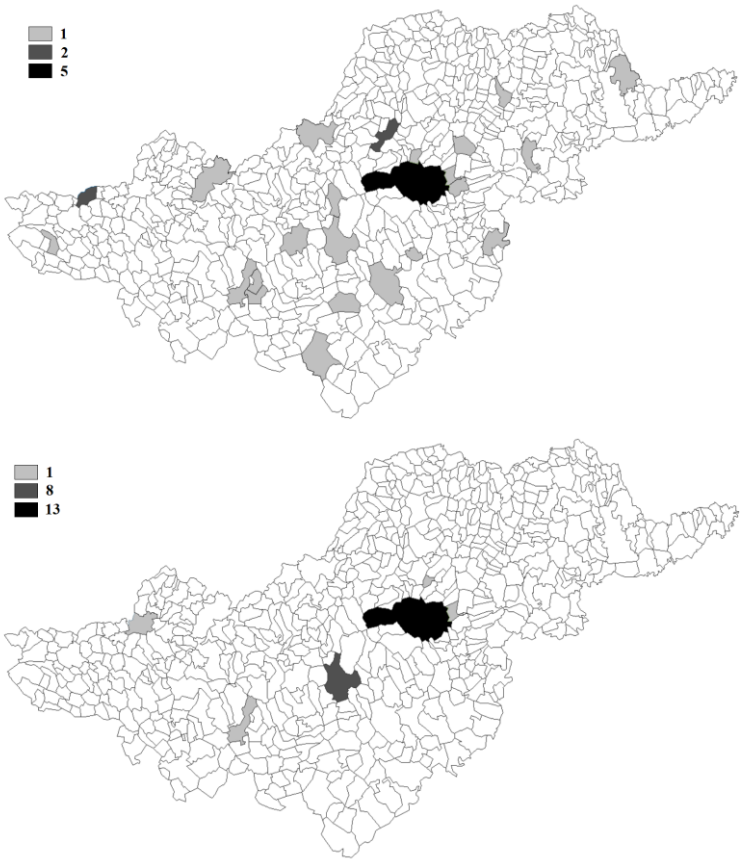

Figure 10: Location and number of industrial parks (top) and clusters (bottom) in the Northern Hungary region
Source: own compilation

It can be said that there is a significant spatial concentration in the location of both industrial parks and clusters; they are concentrated in the vicinity of big enterprises.

7. Summary

Research and development is a key factor for regional development and competitiveness. Therefore, in this study I have examined the role of R&D potential and its changes in the Northern Hungary region. Findings show that while the region holds 11.2% of the Hungarian population and has 7.97% of the GDP, its weight in R&D (3.2%) is far below its economic situation or population share. In most of the indicators examined, the region is one of the most disadvantaged within the country and can only be classified as a moderate innovator in international comparison. Another problem is that venture capital does not play an important role in the regional innovation environment, and the industrial parks and clusters also show strong concentration, which does not support the innovation activity of the enterprises.

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