Handling regional research, development and innovation (RDI) disparities in Hungary: New measures of university-based innovation ecosystem

Zoltán Birkner
National Research, Development and Innovation Office,
University of Pannonia,
Hungary
E-mail: zoltan.birkner@nkfih.gov.hu

Ádám Mészáros
IFUA Horváth & Partners Ltd.,
Hungary
E-mail: adam.meszaros2@horvath-parterns.com

István Szabó
National Research, Development and Innovation Office,
Hungary
E-mail: istvan.szabo@nkfih.gov.hu

According to the Nomenclature of Territorial Units for Statistics (NUTS2) level data from Eurostat and the Regional Innovation Scoreboard (RIS), a strong geographical concentration in the field of RDI can be observed in Hungary. Regional disparities are more significant than in most European Union (EU) member countries and have not changed for a long time. The development of regional innovation capacity is a fundamental aspect from an economic policy point of view; therefore, the Hungarian RDI policy considers higher education institutions that play a major role in the region and have a strong knowledge production capacity, as potential key players in knowledge transfer. According to the intervention logic of the introduced new measures, university-based project- and system-level programs launched can have an impact on local actors through several channels. The university's knowledge base can be exploited, local businesses can increase their competitiveness through access to technology and RDI services, and their innovation performance can be improved. The key result of this study, based on a review of innovation policy measures, is to show how the new programs launched and the new institutions created under this new innovation policy paradigm will contribute to a longer and more sustainable way of reducing regional disparities in RDI capacities and enhance regional innovation performance through their impact on economic development.

Keywords:
innovation policy,
smart specialization strategy,
regional inequalities,
regional innovation system

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Introduction

The issue of regional innovation capacity in recent times, in line with the application of smart specialization strategies (Foray 2014, 2016, Foray et al. 2018) and the prominence of regional aspects of the innovation system as an approach (OECD 2007, Lundvall 2007) (Cooke 1992, Varga 2021) became increasingly appreciated. Innovation performance plays a significant role in increasing the competitiveness and productivity of enterprises (Halpern–Muraközy 2012, Mansury–Love 2008). This approach is reflected in the fact that Policy Objective 1 of the EU Cycle 2021–2027 addresses innovation, enterprise development, and digitalisation closely together (European Parliament and European Council 2021).

In recent times, innovation policy focuses on the actors and factors that interact with each other, placing their interrelated system, that is, the innovation system, at the forefront (Edquist 2005, Fagerberg–Sapprasert 2011). Consequently, innovation policy not only deals with individual actors, but also focuses on their interactions. The national innovation system as a model involves various actors (such as higher education institutions, large companies, small and medium-sized enterprises (SMEs), and local and central government), institutions (rules, norms, etc.), and relationships (interactions) at both the national and regional levels. Regional inequalities in RDI exists in all countries (in many cases, significant); however, significant regional differences in Hungarian RDI performance in international comparisons draw attention to the enforcement of the regional aspect in Hungarian innovation policy.

This study analyses regional inequalities, their development, and new policy responses in relation to Hungary. The Hungarian case is remarkable in three aspects: 1) The Research, Development and Innovation Strategy 2021–2030 and the National Smart Specialization Strategy 2021–2027 were accepted by the Hungarian government in mid-2021, and these documents laid down the strategic framework for the new decade. 2) The new programming period of the European Union for 2021–2027 enables the financing of many of the analysed programs and institutions. 3) The paradigm shift (i.e. the application of the university-based innovation ecosystem approach and the initial implementation of programs according to this new concept) allowed us to examine the intervention logic of the new measures.

Our goal is to analyse the inequalities of the RDI system of Hungary at the county and regional levels and their dimensions, and to present the intervention logic of the tools that, by influencing local RDI actors through university knowledge bases, create the opportunity to exploit local strengths and opportunities, thereby potentially reducing regional inequalities. Hungary's innovation policy begins with the approach of the national innovation system and aims to create a university-centred innovation ecosystem. Our basis is that connections with other actors can boost the innovation performance of enterprises if they are primarily linked to technologically related and technologically similar organisations (Broekel–Boschma 2016). This study examines how policy measures to create a university-centered innovation system can contribute to the development of regional innovation capacities, thus reducing regional disparities. Owing to the novelty of the programs, their aim and content are not described in the scientific literature, and their intervention logic regarding regional aspects has never been analysed before.

Regional inequalities in research and development (R&D) and innovation performance of Hungary in international comparison

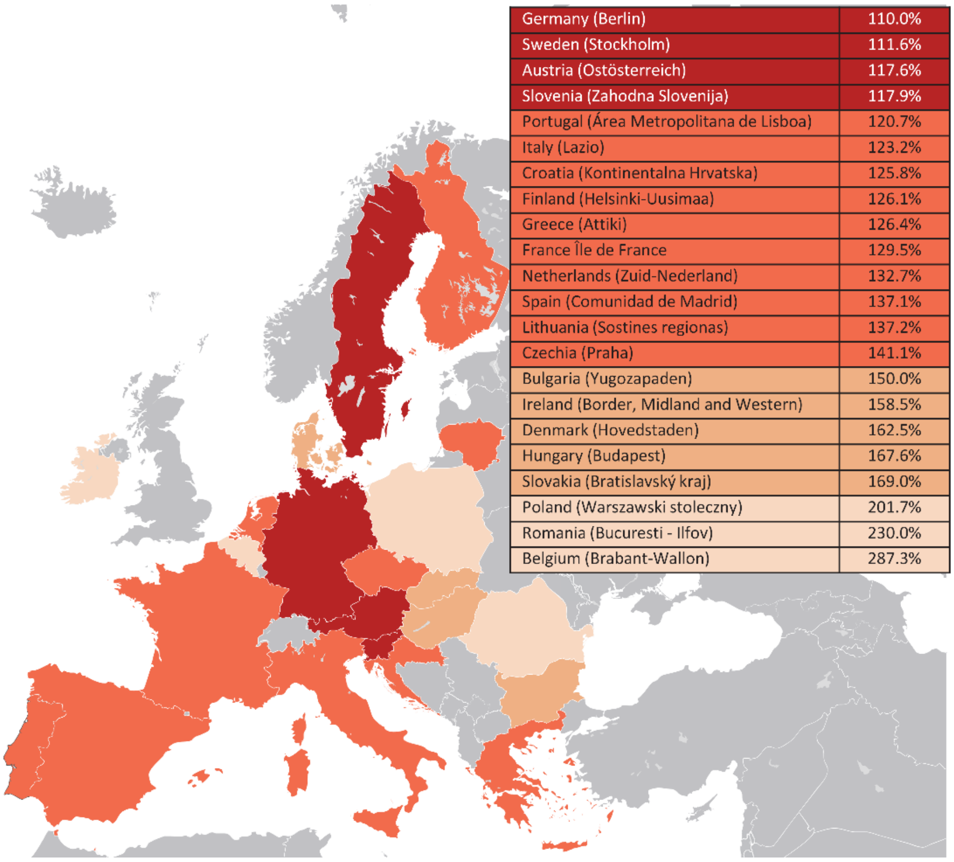
The issue of regional disparities (e.g. income, growth, unemployment, or convergence) has been the subject of a number of empirical studies analysing the situation in the European Union for a long time (Camagni et al. 2020). Measuring the regional distribution of particular socioeconomic parameters is a vital tool for demonstrating the existence of regional disparities. There are sophisticated tools for that (Spiezia 2003, Villaverde–Maza 2009, Lukovics 2009,; Tvrdoň–Skokan 2011), and a number of papers dealt with several aspects of regional inequalities and convergence of Hungarian regions (Szabó 2017, Egri–Tánczos 2018, Budai–Tózsa 2020, Demeter 2020); however, to achieve the objective of this study (to analyse how to handle regional disparities with policy interventions) it is sufficient to use R&D expenditures in proportion of gross domestic product (GDP) and the summary innovation index (SII) of RIS to compare the Hungarian disparities in international dimension and analyse these trends in an extended time frame.

In Hungary, R&D performance is highly concentrated in the European comparisons. Based on this, we can obtain an idea to compare the R&D intensity of the NUTS2 regions with the region of the highest R&D intensity, which is measured by the ratio of gross expenditure on R&D (GERD) to GDP.

In most countries, regions including the capital city, are the most R&D intensive. However, there were two exemptions: Belgium and the Netherlands. In Belgium, the most R&D-intensive region was the province of Brabant Wallon (GERD/GDP: 7.67%), and not the capital region (Région de Bruxelles-Capitale). The high GERD/GDP ratio is presumably based on the performance of the University of Louvain, the Louvain-la-Neuve Science Park which is developing cooperation between industry and the university, and a leading global pharmaceutical company located in the region. In the Netherlands, according to Eurostat data, not the North Netherlands region (Noord-Nederland, including the capital Amsterdam) but the South Netherlands (Zuid-Nederland), including Eindhoven (with a number of important research capacities, including the largest electronic companies' research centre) had the highest GERD/GDP ratio.

Figure 1

GERD/GDP ratios in the most R&D intensive region of the country and on country level and their ratio in 2018



Germany (Berlin)	110.0%
Sweden (Stockholm)	111.6%
Austria (Ostösterreich)	117.6%
Slovenia (Zahodna Slovenija)	117.9%
Portugal (Área Metropolitana de Lisboa)	120.7%
Italy (Lazio)	123.2%
Croatia (Kontinentalna Hrvatska)	125.8%
Finland (Helsinki-Uusimaa)	126.1%
Greece (Attiki)	126.4%
France Île de France	129.5%
Netherlands (Zuid-Nederland)	132.7%
Spain (Comunidad de Madrid)	137.1%
Lithuania (Sostines regionas)	137.2%
Czechia (Praha)	141.1%
Bulgaria (Yugozapaden)	150.0%
Ireland (Border, Midland and Western)	158.5%
Denmark (Hovedstaden)	162.5%
Hungary (Budapest)	167.6%
Slovakia (Bratislavský kraj)	169.0%
Poland (Warszawski stoleczny)	201.7%
Romania (Bucuresti - Ilfov)	230.0%
Belgium (Brabant-Wallon)	287.3%

Notes: The GERD/GDP ratios are the latest data published by Eurostat: from 2017 for Austria, Belgium, Germany, and Sweden, from 2013 for France, and from 2015 for Ireland.

Source: Eurostat GERD by sector of performance and NUTS2 regions [rd_e_gerdreg], own calculations.

In Sweden, Germany, Austria, and Slovenia, the differences were the lowest among the most R&D intensive NUTS2 regions and the national average. In Hungary and Budapest, there was a 67.6% difference. Belgium, Poland, Romania, and Slovakia had a higher geographical concentration of R&D than Hungary.[1] Thus, it can be

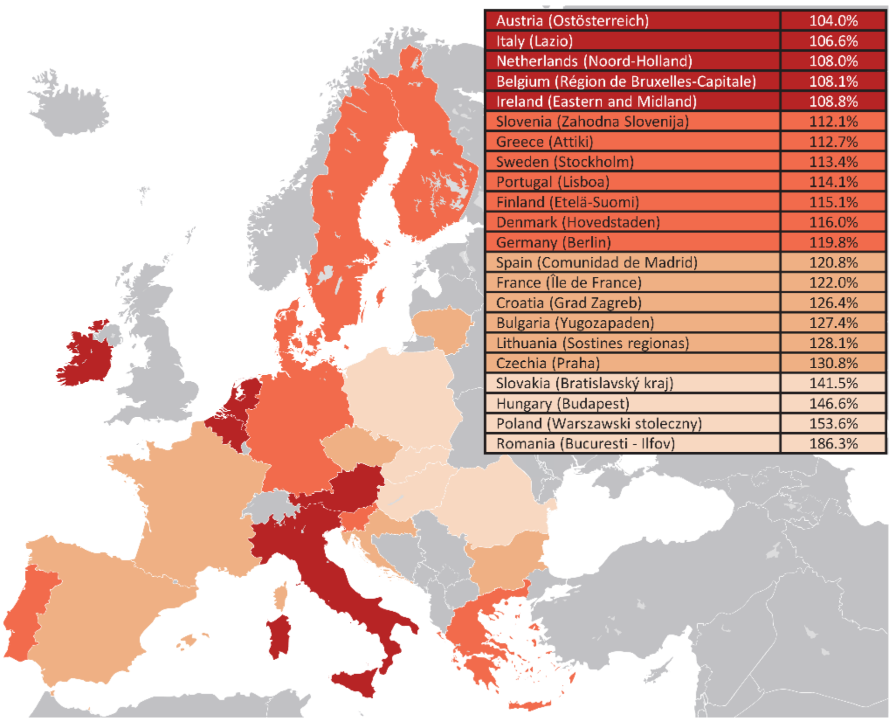
[1] It should be noted that we will achieve similar result by measuring the concentration of R&D expenditure, that is, comparing the share of R&D expenditure and GDP in the most R&D intensive regions.

stated that R&D expenditure in Hungary is highly concentrated in the European comparison (Figure 1).[2]

The RIS, modelled after the European innovation scoreboard (EIS), summarizes and compares the innovation performance of European regions, and by utilising it, we can also analyse the relative situation of Hungarian regions. As RIS has been published since 2000 (Hollanders 2009), it is also a suitable tool for tracking changes in performance across regions over time. RIS 2021 presents data for 240 regions in 22 EU Member States, while for small countries (Cyprus, Estonia, Latvia, Luxembourg, and Malta) it introduces the country levels.

Figure 2

Ratio of Summary Innovation Index of capitals or central regions in percentage of country averages, 2021



Austria (Ostösterreich)	104.0%
Italy (Lazio)	106.6%
Netherlands (Noord-Holland)	108.0%
Belgium (Région de Bruxelles-Capitale)	108.1%
Ireland (Eastern and Midland)	108.8%
Slovenia (Zahodna Slovenija)	112.1%
Greece (Attiki)	112.7%
Sweden (Stockholm)	113.4%
Portugal (Lisboa)	114.1%
Finland (Etelä-Suomi)	115.1%
Denmark (Hovedstaden)	116.0%
Germany (Berlin)	119.8%
Spain (Comunidad de Madrid)	120.8%
France (Île de France)	122.0%
Croatia (Grad Zagreb)	126.4%
Bulgaria (Yugozapaden)	127.4%
Lithuania (Sostines regionas)	128.1%
Czechia (Praha)	130.8%
Slovakia (Bratislavský kraj)	141.5%
Hungary (Budapest)	146.6%
Poland (Warszawski stoleczny)	153.6%
Romania (Bucuresti - Ilfov)	186.3%

Source: European Commission (2021a) own calculations.

[2] In the case of small countries (Cyprus, Estonia, Latvia, Luxembourg, and Malta) NUTS2 level is missing and the Eurostat publishes only country level data, therefore we could not calculate these ratios for the five countries. In the case of Austria, only NUTS1 level regions were published in RIS and by Eurostat and for the Netherlands in the case of R&D expenditures we used NUTS1 data as the last NUTS2 level data were from 2012. Croatia changed the geographical classification from 2021; therefore, in the 2018 GERD/GDP dataset we can find Kontinentalna Hrvatska and in the later published RIS Grad Zagreb (which is a part formerly used Kontinentalna Hrvatska). Data for Ireland are hard to compare because the geographical areas of the two datasets are not comparable. In case of Finland, Etela-Suomi region includes Helsinki-Uusimaa.

Similar to the method applied for R&D, we can compare the innovation performance of the most innovative regions of the countries and their averages. RIS measures the innovation performance of regions using the SII. It is based on 32 indicators that are grouped into four main types: framework conditions, investments, innovation activities, and impacts (Figure 2).

According to the RIS data, we can observe that the innovation performance of Budapest outperforms the national average significantly (by 46.6%). Only in Poland and Romania the differences between the innovation performance of capitals or central regions are higher than in Hungary.[3]

The differences in the two data series (i.e. R&D and innovation performance) manifest in two important aspects: in terms of the distribution of variables and significantly different positions of some countries in the two rankings. Regarding the distribution, we can observe that the ranges are different: they vary from 110–287.3% in the dataset of R&D/GDP ratios and 104–186.3% in the RIS values. The standard deviation is 42.8% in the case of R&D expenditures and only 19.4% in the values of relative RIS performance).

Both phenomena can be explained by the same reason. Although there is a clear connection between the two indicators (R&D performance is part of the RIS as R&D expenditures are presented by two indicators: R&D expenditures in the public and business sectors), RIS measures the performance of the entire innovation ecosystem, and not only that of research units (research institutions, higher education institutions, and businesses) conducting R&D. The RIS has 21 indicators (related to education, digitalisation, venture capital, information technologies, intellectual assets, employment and sales impacts, environmental sustainability, and innovation) and measures a wide range of actors. It is clear that the R&D performance indicator is based on the activity of fewer actors compared to RIS, as in the first one, only R&D expenditures of research units are measured.

An important characteristic of R&D is that, in most cases, it is concentrated in large firms.[4] Consequently, the geographical distribution of the largest research units matters: some of them might have a significant impact on the performance of the region: the higher standard deviation and the large differences between the performance of the central region and the national average can be caused by this factor, particularly in the case of smaller countries. Another consequence is that in

[3] Similar to the GERD/GDP data, RIS Summary Innovation Index is only available for country level in the case of Cyprus, Estonia, Latvia, Luxembourg, and Malta.

[4] As statistical offices do not publish data on the level of research units, we can only indirectly verify our hypothesis on the level of concentration. According to the analyses of Hungarian Central Statistical Office (HCSO 2020a), more than two-thirds of the total national economy's R&D expenditure was spent by the top 100 enterprises in 2019. As the total number of business research units was 2082 in that year, a very high level of concentration was observed.

the Netherlands and Belgium, the capital regions are not the most R&D intensive, and some case differences can be observed in innovation and R&D performance.

Following the performance of Hungary's regions, it can be observed that no significant progress has been made since our accession to the EU, however the changing nomenclature and number of categories have also affected the classification of Hungarian regions, mainly causing temporary shifts. In 2004, RIS used five categories (high innovators, medium-high innovators, average innovators, medium-low innovators, and low innovators). Central Hungary was in the average innovator category, and our other regions were in the group of low innovators. In 2006, Central Transdanubia was placed in the medium-low innovators category, while the other Hungarian regions remained in the low innovators category, and the situation in Central Hungary did not change [1]. In 2012, EIS used only four categories (innovation leader, innovation follower, moderate innovator, and modest innovator). Central Hungary was placed in the moderate innovator category, while the other regions became modest innovators [2]. In 2014, Southern Transdanubia, Northern Hungary, and the Northern Great Plain belonged to the modest innovator group, whereas the others belonged to the moderate innovator group [3].

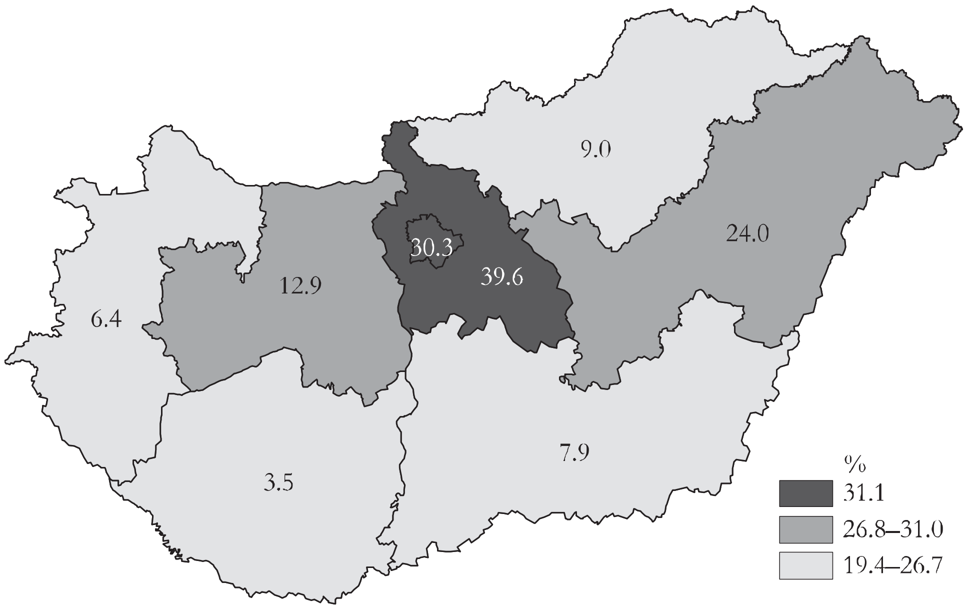
In 2017, RIS introduced another type of categorisation, dividing each of the former four categories into three additional groups: the best one-third with a "+" sign and the weakest one-third with a "-" sign. In this study, Central Hungary was marked as moderate +, Southern Great Plain and Central Transdanubia as moderate, and others as moderate [4]. In 2019, Budapest and Pest counties were measured separately (moderate +), the Northern Great Plain received only modest +, and the other regions received moderate [5].

The 2021 report [6], in line with the methodological changes of the EIS, introduced the emerging innovator category instead of the modest category and linked the categorisation to a strict performance relative to the EU average (European Commission 2021b). Here, Budapest belongs to the moderate + group, Pest, Central Transdanubia, Western Transdanubia, and the Southern Great Plain belong to the emerging + category, while the other regions belong to the emerging group (Figure 3).

Owing to methodological changes, the development of the regions cannot be compared over time for the entire period; however, the RIS interactive database shows the development of the performance between 2014–2021, compared to the EU average. The performance of Budapest and Pest county changed the most, Budapest's rose from 88.81% to 115.75% of the EU average in 2014, Pest county's from 48.97% to 68.31%. As a result of the performance gains in 2021, the performance of the Northern Great Plain has increased significantly (but still remained below the half of the EU average of 2014) and Central Transdanubia rose by 12.9%. The performance of other Hungarian regions has changed only slightly since 2014 compared to the EU average of 2014.

Figure 3

Change in relative performance of Hungarian NUTS2 regions to the EU average of 2014



Source: European Commission (2021a).

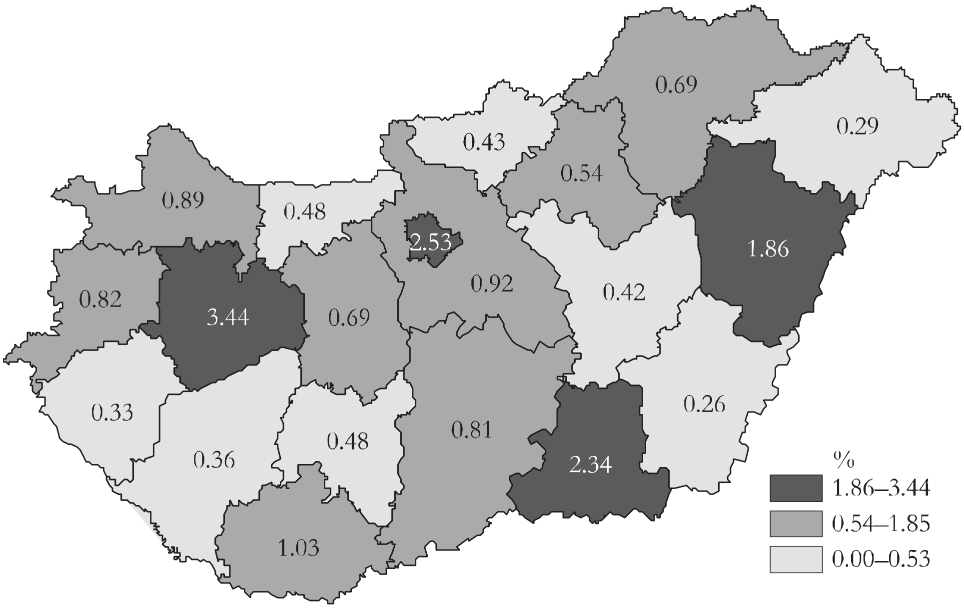
Regional inequalities in R&D and innovation performance – comparison of Hungarian regions

If we compare the performance of Hungarian regions with each other and measure the dynamics of Budapest relative to other countries, we can use the same methods as in the previous section on international comparison.

We observe significant inequalities when comparing the amount of R&D expenditure as a proportion of GDP at the regional level (in this case, county data are also available). Above the Hungarian average in 2018 (1.51%) are Veszprém (3.44%), Budapest (2.53%), Csongrád-Csanád (2.34%), and Hajdú-Bihar (1.86) counties, however the performance of Baranya (1.03%), Pest (0.92%), and Győr-Moson-Sopron (0.89%) can also be mentioned. All of these are counties with large university centres. There are eight counties in which this indicator does not reach the value of 0.5%, which indicates low R&D performance of these regions (Figure 4).

Figure 4

GERD/GDP by Hungarian counties in 2018



Source: [9].

The concentration is indicated by the fact that the share of Budapest has remained unchanged for a long time, apart from some minor fluctuations in R&D expenditures and the number of researchers: according to the Hungarian Central Statistical Office (HCSO) data, the capital accounted for 60.2% of R&D expenditures in 2004, and in 2019 this rate remained almost unchanged at 60.6%.

To measure the concentration of R&D expenditures in Hungary, we used the Herfindahl–Hirschman index (HHI) to scale its dynamics. As we consider county level R&D expenditure data of the HCSO, we observed that it was 0.41 in 2004 and 0.39 in 2019 (fluctuating between 0.35 and 0.45 in this period). This indicates that during the one and a half decades, no significant changes could be observed in terms of the concentration of R&D performance in Hungary.

According to the RIS data, regional disparities in the level of innovation have increased since 2014. The only exception is Pest County, which performed slightly better than Budapest, while the performance of other regions, although to a different extent, deteriorated compared to the capital; this is shown in Table 1.

Supporting business innovation is key to the Hungarian RDI policy. The proportion of innovative companies has been "traditionally" low for a long time, and it is no coincidence that this is one of the weakest points of Hungarian RDI performance, as confirmed by the European Commission's country reports published in the framework of the European Semester (European Commission 2020). It is problematic that the majority of Hungarian enterprises, particularly SMEs, do not innovate, and the proportion of innovative companies shows an unequal regional picture. Furthermore, a significant proportion of Hungarian companies do not see a reason for innovation. According to the Community Innovation Survey (CIS), 86.5% of non-innovative Hungarian companies with at least 10 employees do not have a significant barrier to innovation, and most of these companies are likely to see no point in performing innovation.

Table 1

Performance of Hungarian regions relative to Budapest

(%)

Year	Pest County	Central Trans-danubia	Western Trans-danubia	Southern Trans-danubia	Northern Hungary	Northern Great Plain	Southern Great Plain
2014	55,1	55,8	54,4	46,4	44,3	41,5	57,7
2015	54,7	51,8	46,6	41,7	35,6	39,3	51,3
2016	59,4	50,8	50,9	39,2	36,3	40,7	51,1
2017	54,6	49,5	41,7	38,2	34,8	41,0	48,5
2018	59,7	49,8	42,1	36,7	35,0	39,8	49,2
2019	59,8	47,9	48,7	37,6	40,8	39,9	42,8
2020	58,2	45,1	44,0	39,7	39,0	38,1	47,2
2021	59,0	48,3	44,5	36,8	37,1	39,4	47,8

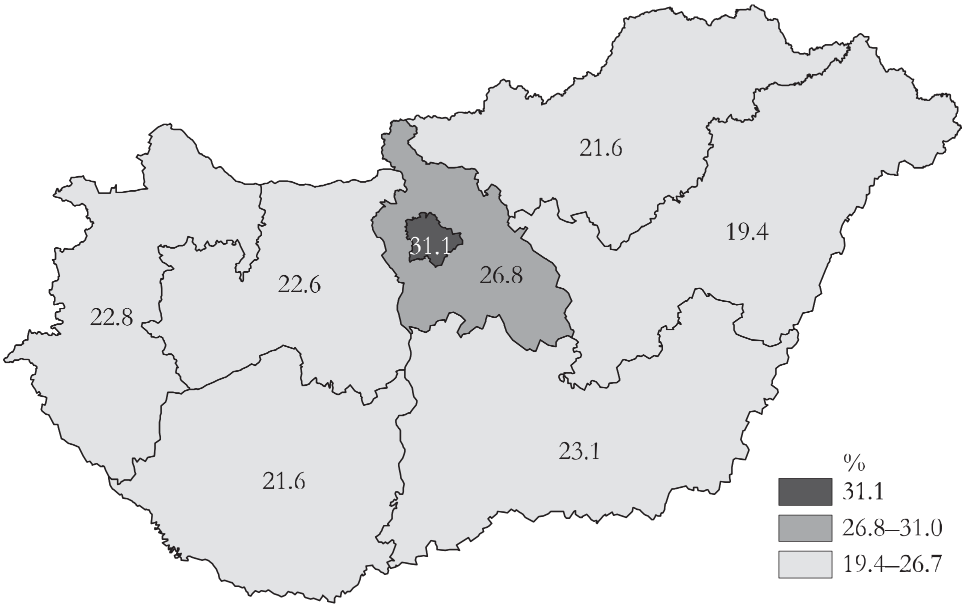
Source: European Commission (2021a) own calculations.

Supporting business innovation is also emphasised in the RDI Strategy of Hungary for 2021–2030. Although innovation data with a territorial breakdown deeper than the NUTS2 level are not available, it can be observed that the proportion of innovative enterprises in Budapest is the highest (31.1%), while in most regions, their share is approximately 20%. This indicates a relative weakness in the innovation capacities of the latter regions.

If we raise the question whether the disparities are diminishing as a possible consequence of the previously implemented policy measures, the picture is twofold. We can observe a constant disparity in terms of innovation performance (measured by RIS) between European regions and meanwhile a growing inequality between Hungarian regions. The same can be observed if we calculate standard deviation for GERD/GDP ratios between regions: the European data are constant while the disparities between Hungarian regions grew between 2014 and 2019 (Figure 5).

Figure 5

Share of innovative enterprises by NUTS2 regions 2018



Source: [8].

Table 2

Standard deviation of RIS Summary Innovation Index and GERD/GDP ratios between NUTS2 level EU regions and Hungarian regions

	2014	2015	2016	2017	2018	2019	2020	2021
R&D/GDP standard deviation: European regions	0.67	0.64	0.64	0.63	0.65	n.a.	n.a.	n.a.
R&D/GDP standard deviation: Hungarian regions	0.37	0.50	0.42	0.40	0.47	0.44	n.a.	n.a.
RIS Summary Innovation Index standard deviation: European regions	47.20	46.19	46.83	45.48	45.79	45.78	45.47	46.30
RIS Summary Innovation Index standard deviation: Hungarian regions	16.36	21.35	20.74	21.63	22.21	20.63	21.95	24.17

Source: European Commission (2021a) and Eurostat GERD by sector of performance and NUTS2 regions [rd_e_gerdreg]. As the dataset of Eurostat „GERD by sector of performance and NUTS2 regions [rd_e_gerdreg]" had a number of missing values, standard deviation is calculated only for regions which had data for all years of the given period (we calculated standard deviation for 122 European regions).

This indicates that despite the original aims of the Cohesion Policy, Hungary faces not only a high geographical concentration in the field of RDI and a high level of regional disparity compared to other EU countries but also a negative trend of growing regional disparity within the country. This seeks the attention of policymakers to develop a new policy framework to enhance the RDI performance of all Hungarian regions.

Addressing regional inequalities in Hungarian innovation policy – strategic level

Among the current Hungarian strategies, the National Research, Development and Innovation Strategy 2021–2030 (hereinafter: RDI Strategy) and the National Smart Specialization Strategy 2021–2027 (hereinafter, S3) address the reduction of territorial inequalities in RDI. These strategies, in addition to establishing the professional side of the allocation of domestic and EU funds, also provide a landscape of RDI and identify the planned government measures regarding the goal that must be achieved.

In addition to these, the innovation aspects of territorial inequalities are also reflected in general in the National Development and Regional Development Concept, which deals with the issues of regional, social, and economic cohesion. It outlines a long-term vision for 2030 based on Hungary's social, economic, sectoral, and territorial development needs and sets development policy goals and principles. In this study, because our aim is to examine regional inequalities in RDI, we present the regional aspects of the RDI strategy and the targets of S3, as well as the regional aspects of the latter's methodology.

In the RDI Strategy for 2021–2030, the reduction of regional disparities specific to the RDI system is markedly reflected, because the vision of the strategy is: „A high-value-added, knowledge-based, balanced, sustainable economy, and society in all areas of the country" (ITM 2021a: 27).

Consequently, one element of the horizontal objectives of the RDI strategy is to strengthen regional, social, and economic cohesion through RDI policy measures. An important goal is to encourage the innovation performance of regions outside Budapest and to raise awareness that the ability to innovate is of utmost importance for all economic actors. According to the RDI strategy, a critical mass of local and regional RDI initiatives is essential to strengthen cohesion. Large cities and the research, knowledge transfer, and economic organisations operating there can play a major role and have a spill over effect on the entire region. The university-based innovation ecosystem model is connected to the territorial capital model theory. According to this concept, regional resources can be divided into two categories: traditional and innovative. The former includes capital stock, natural and cultural resources, infrastructure, and human and social capital. The second group includes relationship capital, corporate and R&D cooperation, and networks (Tésits et al. 2021). The university-based regional development model can accelerate innovative elements; however, the success of the policy depends on the readiness of traditional elements and might cause bottlenecks despite the development of innovation policy measures. Establishing regional cooperation is a challenge: many moderately developed regions show selective collaboration patterns in European Framework Programs, mostly with an external focus, as stated in a study of European NUTS3 regions (Sebestyén et al. 2021). Based on the participant-level network in our analysis, through the waves of the framework programs of FP5, FP6, and FP7, the study showed that while the university-based model of research cooperation appears to be well-established in more developed parts of Central-Eastern European countries (including Hungary), other NUTS3 regions of Hungary showed different cooperation patterns, some of which were non-cooperative and/or had low levels of local cooperation.

A study (Grasselli 2006) on the Northern Great Plain region of Hungary showed that despite the excellent capacities of the university, it was difficult to boost the innovation performance of the region as certain parts of the institutional side were missing, and the innovation approach of the public sector must be improved.

This requires the strengthening of regional knowledge centres, research, and technological infrastructure. These organisations (mainly higher education institutions as centres of innovation) should be encouraged to play a key role in the RDI system. As many actors as possible should be given the opportunity to engage in an innovative ecosystem.

It should be added, however, that territorial inequalities in research based on excellence cannot be fully redressed; it is not a policy goal to achieve full convergence, but rather to exploit comparative advantages. Owing to the unique characteristics, strengths, and weaknesses of the regions, they can be successful in different ways, and their actors can form a competitive regional innovation system by defining different priorities and using different methods. This is also one of the central ideas of S3.

S3 is a policy tool that focuses on the development of specific, place-based, and specialization-focused directions (Foray et al. 2009, European Commission 2012a, b), the use of which has become common in the European Union in the period 2014–2020, as S3 has become an ex ante condition for access to innovation resources (European Union 2013).

From an innovation policy perspective, it is crucial to combine the expectation to consider the actors of the innovation system and the aspiration of cohesion policy, which seeks to set local strengths and opportunities into development focus. These two concepts are combined by S3 (Foray 2014). Thus, S3 linked the spatial definition of innovation and entrepreneurship with EU policies of regional aspects (including, among others, industrial, cohesion, and innovation policies), thereby becoming a regional development policy. S3 is a place-based policy tool that focuses on the development of regions and specialisation directions.

In the 2021–2027 development cycle, the aim of smart specialisation strategies is to contribute to the achievement of the policy objective of the Cohesion Policy called

„a smarter Europe by supporting innovation and economic transformation and modernization". S3 can effectively support regional cohesion by integrating the fields of RDI, digitalisation, and economic development, laying the foundation for the efficient use of resources of the cohesion policy for the modernisation of regions. Building on the strategic goals of the former three disciplines, S3 can be interpreted as an umbrella strategy for these three areas (RDI, enterprise development, and digitalisation). It fixes the specialisation directions and priorities that have great development potential, which can become the basis for the intelligent transformation of regions.

One of the most essential elements of S3 methodology is the application of the entrepreneurial discovery process (EDP). During the EDP, in an interactive, bottom-up manner, the regional actors who are important elements in the "quadruple helix" at the territorial level, articulate the strengths of the region and the priorities, areas and breakout opportunities they perceive (Foray 2016, McCann–Ortega-Argilés 2016). Hungary used the EDP methodology to prepare the current S3 as follows. A key element of the EDP was the creation of regional innovation platforms (RIPs) based on local university centres, initiated by the National Research, Development and Innovation Office (NRDIO) and the Ministry for Innovation and Technology. At the regional level, RIPs provide an opportunity for cooperation between higher education, industry, central and local governments, and civil society, as well as for cross-sectoral dissemination of the innovation process, the organisation of activities related to the implementation of S3, and the development of proposals to achieve the objectives. [5]

As another EDP tool, the NRDIO assessed the suggestions and requirements of RDI actors regarding smart specialisation and priorities between November 2019 and March 2020 in the framework of an online questionnaire, which was filled in by 829 participants. [6] The established priorities were validated in November 2020 with the help of 106 organisations representing all major players in the quadruple helix (ITM 2021b).

The EDP used in the framework of S3 thus ensured that the strategy and its priorities were developed considering the actors of the innovation system and the regional conditions, as well as the requirements and concepts of the local actors.

[5] Within the framework of the EDP, RIPs were established in eight locations by June 2020 (Miskolc, Debrecen, Győr, Pécs, Szeged, Budapest, Veszprém, and Gödöllő), more than 1,100 people participated in the conferences establishing the platforms, then in 2021 five more (Nyíregyháza, Dunaújváros, Sopron, Eger, and Kecskemét) RIPs were established (in an online format, owing to the pandemic).

[6] 34.6% of the respondents are from Budapest and 12.6% from Pest county; the share of Csongrád-Csanád, Hajdú-Bihar, Veszprém, Győr-Moson-Sopron, Baranya, and Borsod-Abaúj-Zemplén counties is more than 4% (owing the larger university cities), while the share is less than 1% in Jász-Nagykun-Szolnok, Nógrád, and Tolna counties, in connection with the low RDI intensity and size of the latter.

Defining bottom-up priorities is necessary for using the strengths of the local innovation system with sufficient efficiency, thus reducing regional inequalities.

The measures described in the next section are in line with the concept of system-oriented innovation policy. This is the latest approach to innovation policies and aims to improve the performance of the national innovation system, not only of individual actors. Therefore, it is important to create sustainable institutionalised frameworks to improve cooperation between actors and develop their skills (Edler–Fagerberg 2017). The greatest improvement over the measures of the previous periods is that Hungary overcame the principles of invention-oriented innovation policy, where the focus was mostly on R&D. In this model, policymakers believe that the advancement of science and R&D support can be beneficial (according to the linear model of innovation) for the entire society. To overcome interventions that improve only the performance of individual actors in the innovation ecosystem, most of the new measures concentrate on establishing institutions which are able to formalise sustainable cooperation with common interests and visions.

Addressing regional inequalities in Hungarian innovation policy – new institutions and programs

According to an evaluation of RDI funds for operational programs from 2014–2020 (Ernst &Young 2020), Hungarian higher education institutions play an important role in RDI cooperation. Compared to the period from 2007–2013, the relations of higher education institutions in the field of RDI have expanded, both in terms of their number and intensity. Despite this, the role of business financing in R&D at universities has declined in recent years, and in 2007, the business enterprise sector financed 13.7% of R&D in higher education institutions, 9.1% in 2014, and only 2.73% in 2020. This is a low ratio compared to the European average of 7.3% in 2019 [7], [9]).[7] The general RDI trends are also twofold: despite the constant growing trend of R&D expenditures in Hungary (both in absolute values and in terms of GDP), the overall innovation performance of the country remained constant. According to the European Innovation Scoreboard, performance relative to the EU has decreased over time (70% in 2014 and 68% in 2021). As we observed in the previous section, this statement is valid at the regional level as well; the development of innovation performance of regions remained only minor. These trends highlight the fact that the former policy measures could not reach the aim of giving a new impetus for Hungarian innovation performance and were not able to raise the importance of higher education institutions in the national innovation system.

[7] The explanation of this contradiction is that the report of Ernst &Young analysed the projects of institutions involved in calls of operational programmes and the statistical office had data on all higher education institutions.

The central goal of Hungarian innovation policy, according to which higher education institutions can become fundamental actors in the dynamization of the innovation system, is primarily based on the following observations: 1) Hungary has significant university capacities, and the institutional system covers the entire country. 2) In addition to traditional research relations, the presence of universities can significantly improve the economic and social conditions of a particular region. 3) Recent examples of the development of university-company relations have shown that actors are able to develop fruitful collaborations, such as in the case of Centres for Higher Education and Industrial Cooperation (NRDIO 2019); however, these are project-like and island-like collaborations, with no general organizational or systemic background.

On the contrary, the regulatory environment hinders entrepreneurial activity of universities: the fragmented legal background and public procurement rules make it hard for universities to have equal negotiating position as market players. Remuneration frameworks, inflexibility of rules and legal environment are obstacles of motivation, while the salary gap between the university and the private sector make it hard to attract (or at least keep) talented professionals (Erdős 2019). According to Bedő–Erdős (2021), among others, low entrepreneurial spirit, lack or low number of local incubators, deficiencies in human resources, problems of social networks, weakness of knowledge creation, and lack of access to resources can be considered the main problems in this respect. Case studies of Central-Eastern European universities (Bedő–Tolmayer 2021) also underline the importance of entrepreneurial culture and institutional support for these activities.

The model change in Hungarian universities is a systematic answer to the institution-related and regulatory part of the above-mentioned problems. Structural changes can lead to a university-based innovation ecosystem with great flexibility and another type of strategic thinking in higher education institutions. The new model ownership approach generates greater responsibility and enables long-term planning. Institutions can apply new motivational schemes and performance-based evaluations (including new tasks and responsibilities derived from universities' new roles). On the contrary, institutions would continue to operate as non-budgetary organisations in a more flexible regulatory environment (e.g. in the case of public procurement). These changes will enable institutions to build successful and sustainable cooperation with local actors (Bódis 2021).

Thus, a major higher education institution operating in a particular county or region may provide a strong basis for the institution to have a positive impact on corporate innovation in addition to strengthening R&D enterprises. Indeed, this effect succeeds when universities conduct a wide range of third mission activities in addition to their traditional activities (education and research), and all of these have become top priorities for policy (Estrada et al. 2016). The three main dimensions of university activities can be defined as a third mission: a) knowledge and technology transfer, b) further education, and c) social engagement (Berghaeuser–Hoelscher 2020). In recent years, the third missionary initial approach, which was primarily a passive, service-oriented approach, has been replaced by a more engaging, proactive approach (Frondizi et al. 2019).

The success of cooperation programs between higher education institutions and businesses depends on a number of factors, and it is essential to build a concept in which the partners receive greater benefits from their cooperation that contributes to both their short-term and long-term objectives and the ability to bring research into practice creating impact (Davey et al. 2018).

Although similar elements have been applied in Hungary in recent years, most measures described in this study are new. Most of the new programs of the university-based innovation ecosystem rely on the findings of theoretical frameworks and the experiences of other countries; therefore, potential bottlenecks and planned measures can be defined.

In Hungarian higher education institutions, everything is in place for success in this regard. Certainly, they play an important role in training as well as supply of human resources to enterprises, which, together with the companies' core business activity, now also considers the requirements of enterprises. Moreover, recent trends have raised the requirement for so-called micro-credentials, that is, a part of the training should conducted within an even shorter time frame and market-oriented manner (Kato et al. 2019).

The dual training system introduced in higher education in September 2015, which supports participants in undergraduate training in gaining an internship at a company of their choice, simultaneously enables not only the most practice-oriented training but also the company's involvement in education, influencing its direction.

In countries with developed cooperation patterns between companies and educational institutions (e.g. Germany, Austria, and Switzerland), the private sector plays an important role in vocational education. The Hungarian model is based on that of Baden-Württemberg, Germany, where the University of Cooperative Education was established in 1974 (DHBW 2021) and has a long tradition and expertise in this field and the introduced dual education system creates the combination of on-the-job training and academic studies and, therefore, achieves a close integration of theory and practice, both being components of cooperative education (Ehlers et al. 2019). According to international experience, the main challenge of dual education is to establish a system which is attractive to employers and students. A literature review (Valiente–Scandurra 2017) concluded that employers' associations and chambers of commerce should be involved in the governance of the programme to convince their members regarding its advantages. According to this recommendation, in the supervisory body of this programme, in the Hungarian Dual Education Council, two delegates from the Hungarian Chamber of Commerce, one from the Chamber of Agriculture, and other from the Hungarian Chamber of Engineers, participated.

As many corporate professionals are also involved in this process, cooperation between businesses and higher education institutions is already being strengthened. This, of course, also indicates that companies get to know the service activities of higher education institutions, that is, their various research and measurement capacities as well as the related fields of teaching and research, which can be marketed and transformed into services beyond traditional functions.

As can be observed, dual training is not primarily aimed at RDI-type collaborations, although it can also provide a basis for these collaborations. Simultaneously, the Cooperative Doctoral Program, which was created as an extension of the logic of training, specifically considers corporate-higher education cooperation for RDI purposes.

Apart from the „conventional" PhD degrees, different types of doctoral programs are offered in other countries: professional doctorates in the Anglo-Saxon countries aim to involve senior professionals; professional practice doctorate programmes are not equal to PhD and are increasingly required by professional associations and agencies to enter professional practice in the US. Industrial PhDs are common in continental Europe (e.g. Germany, Denmark, Sweden, France, the UK, and Italy), however their schemes and characteristics vary between countries (Ori 2013). According to studies on their results (Kuhn 2011, Danish Agency for Science, Technology and Innovation 2012, WASP 2019), it can improve the labour productivity, patent activity, rate of employment, and level of wages of companies, and can contribute to more effective technology, product development, and prototype creation.

The main goal of the Hungarian Cooperative Doctoral Program is to support the achievement of academic degrees by colleagues with corporate experience and through them, strengthen the RDI activities of enterprises. It captures corporate RDI at the doctoral student level, as participants in training receive not only scientific knowledge in their training but also research topics that can explicitly be utilised by their host company. The research topic and the research itself must, of course, meet the expectations of academia and doctoral requirements, however by ensuring that the doctoral student is assisted by a company expert in addition to the supervisor, it is guaranteed that the utilisation of research results is realised.

A further benefit of the program is the presentation of RDI activities provided by higher education institutions to enterprises through students, which may also increase the current modest utilisation of the research infrastructure (Deák–Szabó 2016). The indicators of the first year are extremely positive: 246 students received support, of which 121 students appeared in the program, who are the primary target group of the program; that is, they are already starting PhD training with corporate experience. The KDP contributes to the reduction of territorial inequalities by providing a supply of researchers in line with local requirements and the possibility of utilising scientific results, so that the performance of local enterprises can increase significantly. As the program started in September 2020, we cannot see further results, however the planned assessment and revision of the RDI strategy and its action plan ensures that the impacts and experiences of the program will be evaluated.

In addition to innovation collaboration at the individual level, institutional collaboration forms the basis of the new innovation paradigm, as highlighted in the above strategies. Although higher education institutions are present in all regions, the innovation activity of enterprises, as we have observed, is stagnant, and obvious changes have been made in their operating model.

Accordingly, institutions receive funding through a variety of support schemes designed to enable higher education to provide services for businesses in a one-stop-shop, comprehensible, and business-like manner, and even more so by engaging with them. The Thematic Excellence Program started in 2018 and specifically aimed at enabling higher education institutions to identify areas for RDI activities in interdisciplinary collaboration, similar to the logic of smart specialisation.

Research schemes similar to the Thematic Excellence Program and Competence Centres are common in other countries; institutional funding of public research projects and project-based cooperation can be observed in many OECD countries (e.g. [10]). The antecedent of Thematic Excellence Program in Hungary was the Support Scheme of Institutional Excellence: between 2013–2018 the selected universities (titled with the status of 'research university') got horizontal funding without defining research projects and therefore the program was not able to concentrate resources on thematic fields.

RDI projects financed by the Thematic Excellence Program provides a strong basis for institutions to establish collaborations between faculties and departments instead of the silo-like functioning of individual and independent units within the institution. In developing the concept, Hungary embraced the recognition of Mazzucato's (2018) mission-oriented research paradigm, that concentrates resources and uses a problem-centric approach, thus adding the "challenges" logic of the European Commission's Horizon Europe program (European Commission 2021b) to adapt to Hungarian conditions.

Under the program, 92 thematic studies from 27 higher education institutions and public research institutes received support by 2020. The continuation of the program ensures that institutions focus resources on large RDI areas, such as health, culture, security, or industry. In the case of these projects, although cooperation with businesses is not a priority, experience has demonstrated that this has been achieved in many cases, helping develop local businesses.

The program of Competence Centres is a new form of the former Regional University Knowledge Centre Program, which started in 2004. The latter aimed to establish innovation centres to enable the institution to cooperate with local actors, and the partners had to declare that they contributed to the establishment of the centre and participated in their R&D activities (NKTH 2004). The main difference between the two programs is that Competence Centres are project-based cooperation and the involvement of partners is well-defined in the structure; therefore, the establishment of a sustainable and result-oriented framework is possible. Competence Centres' RDI projects are implemented with a range of enterprises on a dedicated topic. (The previously established centres for higher education and industrial cooperation have a similar intervention logic.) They create market-based RDI capacities in higher education institutions that provide a modern research background for corporate partners and create conditions for active and continuous cooperation, ensuring a sustainable economic model even after the completion of the supported project. The latter explicitly supports the possibility of utilising the results for other companies that were not involved in the project, unlike in the case of a „traditional" RDI project. Competence Centres thus create services and products based on corporate requirements that can be integrated into the university's service portfolio.

Simultaneously, as indicated, Competence Centres are project-based RDI collaborations, as opposed to the concept of program-based cooperation, for which science-and enterprise-oriented systems have been introduced. Because of the potential regional effects of the former, the system of National laboratories, are limited, in this study, we present an enterprise-oriented type of program-level collaboration: Science and Innovation Parks to be established between 2021–2027. Representing a new infrastructure that is also physically important in the field of innovation will create the possibility of cooperation between local enterprises and universities, as well as for the given RDI infrastructure to take place at a system level (i.e. beyond the project level). The aim is for the Science and Innovation Parks in the regional RDI space to bring together as many regional actors as possible in a physical sense, while mutually taking advantage of synergies.

The concept of Science and Innovation parks is based on helix models, in which the interaction and cooperation between the actors of the innovation system is a key factor of success (Etzkowitz–Leydesdorff 2000, Carayannis–Campbell 2009, Carayannis et al. 2012). A common feature of science parks is that they can facilitate the transformation of scientific knowledge and research results into marketable technologies and help the establishment and growth of technology-intensive companies. They have four models according to McCarthy's (1998) matrix. These include landlords, matchmakers, coaches, and gardeners. McCarthy's categorisation is based on two dimensions: specialisation and level of services. As Science and Innovation Parks or similar institutions have never been established in Hungary, factors of success can be drawn only from international examples.

The conditions for operating successful science parks (based on studies by Dinteren 2021, Benny 2021) can be divided into two groups. Factors of success at the level of Science and Innovation Parks can be influenced by the innovation policy and, in a large part, depend on the implementation at the institutional level. These are: 1) embeddedness into the regional economy; 2) concept and strategy based on market research; 3) clear profile of the SP: target groups and sectors; 4) optimal size, quality of research, and service infrastructure; 5) well-organized and strong management; 6) experience and skills of technology transfer offices; 7) professional, full-time, and constant management; and 8) infrastructure developed for specific target groups. The second group of success factors are regional conditions that are hard to influence within the framework of innovation policy: 1) scientific (university) bases; 2) existence of effective networks of businesses and institutions; 3) skilled labour and regional labour supply; 4) high level of urbanisation; 5) entrepreneurial culture, mentors, and role models; 6) proximity to services and large companies; 7) sectoral structure of the economy; 8) growing start-ups; and 9) adequate sources of funding (including regional investors). The desired level of business involvement is the realisation of the following advantages: the possibility of developing new products and services, cost savings, the possibility of recruiting talent, cooperation with other institutions, and more effective fundraising. The implementation of the Science and Innovation Parks has to pay special attention to these factors, and raising awareness is an essential factor of success.

Science and Innovation Parks are also the physical incarnations of the RIPs described above. Participants in RIP can find a partner in both R&D and innovation, whether in entrepreneurship, higher education, or research institutes, for the implementation of their project. The results of Thematic Excellence Programs or Competence Centres are also the most easily accessible to local actors. The structure of cooperation between Science and Innovation Parks, as well as Regional Innovation Platforms, enables the establishment of mutually beneficial innovation collaborations based purely on requirements and competencies. Such collaborations can also become internationally competitive and involve international partners.

However, in addition to the structure of the institutional system, it is important to operate it, that is, to establish collaboration and build trust between the actors. Currently, two main elements of this have been launched. On the one hand, the above-mentioned Regional Innovation Platforms, which in each case have been established on the basis of a higher education centre. On the other hand, the University Innovation Ecosystem tender encourages higher education institutions to make their RDI portfolio visible to external actors and professionalise their services related to RDI activities.

With the help of the call, a transparent system will be created, which, following a "one-stop-shop" method, will make it easier to cooperate with local partners and companies to find valuable knowledge or RDI capacity among university cooperation opportunities. In this way, the university can become the main service provider of the innovation space, thus helping SMEs in a wide range of innovation activities. This system will also make it possible to further strengthen trust by enabling higher education institutions to present their services in a manner that is clear and comprehensible to businesses.

In Table 3, we summarise the analysed measures and their most important channels affecting regional RDI actors, the expected positive outcome, and the possible bottlenecks and hindering factors.

Table 3

Summary of policy interventions: channels, outcomes, and bottlenecks in Hungary

Intervention	Most important channels	Expected positive outcome	Possible bottlenecks or hindering factors
Thematic Excellence Programme	Capacity building Mission-oriented, problem-centric, visible research topics	Starting RDI cooperation Raising company's awareness on RDI topics of universities	Weak motivation of companies involved in university projects
Centres for Higher Education and Industrial Cooperation and Competence Centres	Capacity building Project-oriented, formalized RDI projects	Well-established cooperation Mutual understanding of common vision Possibility of utilising the results for other companies	Lost interest of parties after finishing the project, unsustainable cooperation
Science and Innovation Parks	Bringing together regional actors in a physical sense Research, technology, and related infrastructure Innovation services	Transferred general and specific knowledge Institutionalised relationships	Weak local company basis Weak motivation to move into to Science Park
Dual training system	Education (practice-oriented curricula) Possibilities of further cooperation	Skilled workforce Enhanced level of innovation at local actors	Understanding of the advantages of the dual training system
Cooperative doctoral programme	Education (practice-oriented curricula) Generated side-projects Utilisation of research infrastructures	Skilled researchers Stronger RDI activities of enterprises Common RDI projects	Understanding of the advantages of the dual training system Brain drain of researchers
Regional Innovation Platforms	Matchmaking Access to research results of other programs	Finding project partners Utilising results of other projects	Weak local company basis Low level of involvement
University Innovation Ecosystem	Visibility of RDI infrastructures and innovation services	Access to RDI infrastructure Access to services	Low level of business awareness

Conclusions

Significant and long-standing regional disparities in RDI in Hungary pose challenges for innovation policy. Instead of fully compensating for regional differences, the development of regional RDI ecosystem actors based on local conditions and opportunities and the strengthening of regional innovation capacity is the goal of the policy, in line with Hungary's Smart Specialisation and RDI strategies. Hungary considers higher education institutions as actors that play a major role in the region, have a strong knowledge production capacity, and can potentially be considered the main players in the flow of knowledge, and as such, to be the key to an innovation system.

According to the intervention logic of the newly introduced measures, project- and system-level programs launched on a university basis can have an impact on local actors (through several channels). The university's knowledge base can be exploited, local businesses can increase their competitiveness through access to technology and RDI services, and their innovation performance can be improved.

The intervention logics of the launched initiatives are dissimilar; the Cooperative Doctoral Program exerts its impact by expanding research capacities tailored to local requirements and utilising scientific results. The Thematic Research Excellence Program concentrates research at universities and provides an opportunity for companies engaged in R&D to become involved. Competence Centres create project-level infrastructure and organizational conditions for sustainable collaboration. The University Innovation Ecosystem makes RDI capacities visible to the actors of the innovation system so that local businesses looking for solutions to their innovation problems know where one-stop-shop capacities are available. In addition, Regional Innovation Platforms bring together local actors, which can be the first step in developing deeper cooperation and relationships. Science and Innovation Parks provide the highest level of cooperation: they create infrastructure for all potential participants, providing a systemic solution for knowledge producers and local users to develop sustainable cooperation.

As all the analysed programs and institutions are new measures (were introduced in the last two years or are planned to be implemented from 2021), in this study we could draw up only their intervention logic and the expected results which probably will have an impact on the regional innovation ecosystem and thus on regional disparities. The planned evaluation and monitoring of the programs and regular revision of the RDI and Smart Specialisation strategies provide an opportunity to analyse the impact of the implementation of these measures on regional RDI capacities and disparities.

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