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## Article

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# The theoretical model of spatial production for innovation

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## Abstract

The overall aim of the study is to create the theoretical model of spatial production for innovation, which provides a measurement basis for later research as well as providing a measurement framework for the territorial indexation of innovation. In addition, it raises the question of what factors can hinder and which can help the formation and development of the spatial production of innovation. In the context of the above, based on a chronological, multidimensional review and analysis of literature research, it summarizes and presents the possibilities of interpreting the concept of innovation, paying attention to its territorial aspects. The model presented in our study builds on the literature on the external–internal divisions of innovation barriers, but also differs in that the model simultaneously displays the socio-economic space (innovation ecosystem), the regional scales as well as time. Presenting the typological barriers to innovation and summarizing the related factors, as well as developing a model to measure the issue, can help by specifically promoting the development of regions with less innovation capacity and potential in this field, at the same time providing a basis for assessing the territorial aspects of the phenomenon, which may also support the creation of development programmes to support the resolution of territorial disparities.

**Keywords:** Innovation, Innovation geography, Geography of innovation, Barriers to innovation

**JEL:** O31

## Introduction

Regarding the barriers of corporate innovation, based on the experience of the literature research presented in detail below, we consider it justified to create a theoretical model that makes the spatial indexing of the phenomenon possible, the identification of its spatial pattern, exploring its differences and measuring it along different indicators as well as identifying territorial differentiating factors.

## Methods of the theoretical exercise

Our first goal is to create a theoretical innovation model that facilitates the measurement and interpretation of innovation, taking into account its territoriality, which can contribute to the foundation of a series of qualitative and quantitative research on the topic in the future (see the empirical section later). To do this, we need to create a new

theoretical model of the spatial production of innovation, incorporating space into the problem of the origin of innovation. For the purpose of our goal, we examined the literature that captures the factors responsible for the emergence—or lack—of innovation. We draw from this literature, but we also renew it, because the literature examining the factors of innovation—the obstacles of innovation in our approach—is essentially lacking spatiality, despite the fact that innovation occurs in different (economic, social, cultural) spaces and are affected by different distances (geographical, technological, organizational, cultural). First, we give a structured synthesis of the relevant literature, then close the study with the empirical application, presenting the cartogram of the newly created innovation potential index for Hungarian settlements.

### **A framework for innovation models from the perspective of developing countries**

Innovation is a complex concept defined along a number of factors, which requires the discussion of different approaches to innovation on a territorial basis—from the most general approaches to the definitions that specifically capture the nature of innovation, allowing the widest possible range of interpretations. Accordingly, in the following, we examine in depth the conceptual framework of our theoretical model and their antecedents in the economical and geographical literature.

The comprehensive research of Maxamadumarovich et al. (2012) contributes greatly to this endeavour. The authors pointed out that the concept of innovation is a term that illustrates change, namely any change that can improve the performance of a company. The sources of this innovation can be internal sources (from research and development, marketing, management, or manufacturing), market sources (related companies, suppliers, customers, competitors, or consultants within a corporate group), research sources (university, government, research institute, agency) and generally available sources (exhibitions, communication networks, conferences, meetings, and publications) (Maxamadumarovich et al., 2012). By grouping the sources, we can actually get a structured theoretical framework for the emergence of innovation and thus for the obstacles of innovation as well. Indeed, the barriers of innovation paralyse or eliminate these sources and channels of innovation.

In addition to the above, there are several typologies for the sources of innovation, as Maxamadumarovich et al. (2012) present in detail—the number of typologies can currently reach the magnitude of a hundred, from the triple division of Tony et al. (2005) (incremental, semi-radical, radical) to the 14 types of innovation by Moore (2006), which he classifies into four groups. The best known, however, is the four divisions of OECD Oslo Manual into product, process, marketing, and organizational innovation. Bessant and Tidd (2007) speak of product, process, position, and paradigm innovation, where product innovation indicates a new product, process innovation indicates a new process, position indicates the repositioning of a product within an industry, and the paradigm is the change of long-term believed and entrenched industry-company operating methods. Zawislak et al. (2011) distinguish between technological and operational (process) as well as management and transactional innovation—where the former two are technology-driven and the latter are business innovations. Of particular interest to the present study is the concept of transactional

innovation, which points out that reducing transaction costs can also be considered an innovation even without creating a breakthrough or a radical new product, which is a good indication of the practicality of the approach mentioned earlier by the authors, according to which any efficiency or performance-enhancing improvement can be seen as innovation—in this sense, the science of innovation is the science of change, flexibility, and development, for which evolutionary economics and evolutionary geography may therefore be particularly suitable for describing. This is because evolutionary economic trends focus on change as opposed to the common feature of neoclassical economic models, statics, and innovation is essentially the result of a learning process.

According to Ahmed and Shepherd (2010), in addition to the learning–spreading process, there are five other general approaches to innovation. We can think of it as the creation of an invention, as a discrete and well-defined concrete event, as an incremental or radical change, as a corporate process, or even as a complex process taking place at the level of general context and environment. Thus, based on literature approaches, innovation can be a new thing, the process of creating a new thing, a means of creating a new thing, the conditions and environment for creating a new thing, the idea and plan of a new thing, the human ability and potential to create a new thing, or simply a change process (Table 1) (Ahmed & Shepherd, 2010).

These different interpretations give different schools of economics the opportunity to formulate their own theory of innovation (for example the institutional, the evolutionary, and the neoclassical economics also highlights other aspects). Kotsemir and Abroskin (2013) conclude that almost all definitions of innovation are related to novelty, change, and efficiency. On the other hand, it is a special economic concept that, paradoxically, cannot be given a precise, comprehensive, general definition, such as the economic concepts of inflation, depreciation, or debt. Only 16 types of dichotomous innovation typology are listed with reference to the works of Garcia and Catalone (2002) and Coccia (2006). If we highlight parts of the innovation process, we also find dozens of types (for example application, platform, or integration innovation). A typology can also be formed on the basis of what are the results of innovation, such as cost reduction, market leadership, improvement of company operations, and possibly the renewal and repositioning of the company in the value chain towards higher added value (Kotsemir & Abroskin, 2013).

**Table 1** Approaches to the concept of innovation

Approach to innovation	Focus of the definition
Creation (invention)	Using resources (human capital, time, money) to develop or invent a new product or service, a new way of doing business, a new approach to things
Spread and learning	Acquiring, embracing and using a product, service, or idea
Event	A discrete, unique event, such as a product, service, thought or decision
Change (incremental or radical)	Some innovations are just minor modifications, others are radical
Process (company level)	Innovation is not a single act, but a series of activities that a company performs in order to achieve a desired outcome
Context-level process	Acting outside or above the framework and level of a company

Source: Ahmed and Shepherd (2010)

In terms of the method, stakeholder, result, goal, and even source of innovation, as well as many other viewpoints, many definitions can be created, guided by the aspect and context to be highlighted and examined by the researcher. A good example of this is that we find a number of definitions to describe innovation processes in developing countries, which are organized by a country type, a stage of economic development (Zedtwitz et al., 2014). Thus, innovation dynamics between developed and developing countries can also form the basis of research, and researchers in development economics can also create their own innovation models.

As a summary of the above highly diversified innovation concept and typology, Kotsemir and Abroskin (2013) finally classify the definitions of innovation into four categories: (1) classical and (2) new, not yet widespread types, as well as (3) describing the strength and degree of innovation, and finally, the (4) dichotomous definitions seeking to divide innovation into two groups. Researchers fill these categories in a historical timeline-like way with content and examples, citing hundreds of twentieth-century definitions of innovation—following Rothwell (1994), Marinova and Phillimore (2003), and Godin (2008)—that they think fits well into these four categories. We should add that the typology is relatively general in order to integrate all innovation definitions into its system.

The aim of this research is not to re-examine previous conceptual approaches, as Kotsemir and Abroskin (2013) have already done so. It is not a goal to create another, in a long line of innovation concepts; we see that the study of the spatial development of innovation as an efficiency-enhancing improvement is the relevant research task. At the same time, we build on the approaches that are most closely related to the spatial production of innovation and prove to be useful in the theoretical foundation of the model for the creation of the spatial innovation model.

### **Creating innovation and its barriers**

In addition to the knowledge of the conceptual framework of innovation, the knowledge of the barriers to innovation is well-founded in order to create a spatial production model of innovation. The open innovation paradigm is an ‘implemented, practical theory’ that can hardly be avoided in this respect and is characterized by the fact that companies go through a common learning process and cannot or do not try to ‘dominate’ all elements of the innovation process (Oumlil & Juiz, 2016). Networking, the common, uncertain learning process described by evolutionary theories, and the learning regions that emerge within it, denote the open innovation paradigm. In this, in contrast to the previous closed innovation system, the best experts in a field do not necessarily work for a single employer. Therefore, in the open model, in order for a company to be able to connect to the knowledge flow networks, it is necessary to open up and look around to take advantage of developments in the outside world as well. In the same way, external research and development can now be of great business value also, namely it is not necessary to be the initiators and executors of a research in order for the company to benefit from it. In the traditional closed model (in which the vertical corporate integration is strong), after winning the best representatives in the field, the company was able to develop key innovations in the industry on its own, which it eventually sought to bring to market first, controlling the entire process. In the open model, being first is not

an urgent compulsion, because entering the market second at a well-timed point with knowledge of market and technological trends can also lead to success, however, this requires innovation in many other areas, among other things including organizational and business models, namely the importance of innovation is increasing, its methods and forms are expanding.

From the point of view of creating a spatial innovation model, it is important that in the open paradigm, companies that make the best use of external and internal ideas gain advantages, which are not necessarily the inventors of these ideas. The flow of intellectual property, as opposed to the closed model is not restricted by companies; in fact, they even purchase the intellectual products of others in order to develop the business model. In our age, learning and innovation have become a joint activity rather than an individual one, and companies jointly produce new innovation and products from information, when we analyse the barriers of innovation, we also analyse the barriers of an open innovation paradigm. With the open innovation model, we can examine the new innovation production mechanism of our time (Chesbrough 2003).

The globalization of the world economy has fundamentally shaped the characteristics of innovation paradigms. In 2000, the IMF described the process in four key aspects: through trade and transactions, capital and investment flows, migration and the movement of people, as well as through the flow of knowledge or technology. What is certain is that with the increase in the number of people working in the knowledge sector and breakthroughs in information technology, increasing mobility of workers, the increasing presence of venture capital, the shorter product life cycles, increasing competition, the globalization of the economy, the more efficient and widespread use of IT (information technology) and breaking down the barriers of knowledge flow, the open innovation paradigm gained significant ground (Herstad et al. 2008). The framework for the creation of innovation is an *open innovation system* in line with the dominant paradigm of the twenty-first century, innovation system theories.

The barriers of innovation can also be interpreted in this open innovation paradigm in the twenty-first century, in which economic relations, the external environment, and the different partners of a company, as well as the interactions of stakeholders and factors, play a special role (Oumlil & Juiz, 2016).

### **The typologies of barriers to innovation**

One of the very first studies on the barriers of innovation was written by Piatier (1984), which was followed by dozens of analyses for different countries.<sup>1</sup> The literature structuring and exploring the barriers of innovation, with a few exceptions, began to expand after the turn of the millennium. These researches seek to empirically assess the difficulties of the innovation process in mostly SMEs (small and medium-sized enterprises), in many cases using questionnaire methods. As Hadjimanolis (2003) points out, the complex and intricate process of innovation can be hampered by a variety of factors, knowledge of which is essential for policy to mitigate and transform these into incentives for innovation—this aspect places spatial innovation modelling into the dimension of applied science, increasing the practical relevance of research.

As a preface, we note that according to Cordeiro and Vieira (2012a), most authors divide barriers into external and internal factors (Cordeiro & Vieira, 2012a refer to:

Piatier, 1984; Hadjimanolis, 2003; Madrid-Guijarro et al., 2009; Stanislawski & Olczak, 2010). Internal factors stem from the company's internal mechanisms and inhibit corporate innovation, while external ones are presented to the company by the environment (Cordeiro & Vieira, 2012). Sandberg and Aarikka-Stenroos (2014) examine 103 studies in connection with barriers to radical innovation and also apply the external–internal barrier division. An internal obstacle for them is a limiting attitude (restrictive “mind-set”), a lack of innovation competencies, and insufficient resources, especially for a non-supportive corporate structure. External constraints are consumer resistance as well as the lack of an advanced innovation network and ecosystem.

External–internal barriers can also be called exogenous and endogenous factors. Illustrating this structure with examples, Saatcioglu and Ozmen (2010) argue that an internal barrier is (1) the lack of skilled labour; (2) bureaucracy; (3) the lack of R&D (research and development), design, and testing along with other technical problems; (4) the long-term return on innovation; (5) perceiving innovation as a costly endeavour; (6) weak control over innovation costs, and (7) the financing of innovation. External barriers in their interpretation are (1) patent and licensing policies; (2) the lack of government incentives for innovation; (3) foreign trade policy, and (4) competition. According to the authors, these factors can be divided into four groups: in addition to economic, knowledge, and market factors, the fourth group is the arguments and reasons against starting innovation (Table 2). According to Madrid-Guijarro et al. (2009), internal barriers include the lack of financial resources, human resource constraints, poor financial situation, high costs, and high risks. External barriers include the turbulent external business environment, the lack of collaboration opportunities, the lack of information, and insufficient government support.

Many studies differ from mentioning the external–internal barriers to innovation. Najda-Janoszka and Kopera (2014), studying Polish tourism, set up an organizational, environmental, and innovation process-specific triple group. Bartels et al. (2016) define barriers following the trend of national innovation systems, collecting responses from a five-point Likert scale electronic questionnaire and then performing factor analysis on the Ghanaian economy. According to their analysis, information as well as information and communication technology capabilities, namely the lack of organizational capital;

**Table 2** A possible grouping of barriers to innovation

Lack of resources within the company or group of companies	Economic factors
Lack of resources from outside the company	
Innovation costs too high	
Lack of skilled labour	Knowledge factors
Insufficient information about technologies	
Insufficient information about markets	
Difficult to find cooperating partners for innovation	
The market is dominated by strengthened large corporations	Market factors
Uncertain demand for innovative products and services	
There is no need for innovation because the company has already done the necessary innovations	Why does not the company innovate
There is no need for innovation because there is no market demand for it	

Source: Saatcioglu and Ozmen (2010)



non-sophisticated markets, specifically weak demand; inadequate fiscal policies, and organizational risks are major barriers to innovation. For developing countries, they claim these factors can be narrowed down to institutional and financial constraints—the two are interlinked, and significant foreign capital stays away from the markets of developing countries due to, among other things, the weak institutional system.

### **Country-specific results on potential barriers to innovation**

As part of the modelling process, we present area-specific, already empirical innovation research that provides an important basis for understanding the spatial context of innovation of our own model framework. The literature on barriers to innovation refers to an empirical approach to the creation of models that capture the emergence of innovations—thus, by organizing and examining the barriers of innovation, a model for the emergence of innovations can also be created. In policy terms, it is particularly worthwhile to start by examining the real barriers to innovation when economic policy seeks to create an innovative environment.

#### **Spanish–Portuguese territories**

The analysis of barriers to innovation is also essential from the point of view of the European integration, which is why research on innovation barriers for SMEs has been carried out in many European countries. Based on our literature search, the literature on the territorial study of innovation in the Spanish–Portuguese area is extremely extensive. The most important barriers faced by Spanish rural SMEs are the high costs of innovation, the difficulties in accessing resources, the lack of skilled labour, the lack of in-depth knowledge of the market, and the risks of innovation (Gargallo-Castel et al., 2017).

Ten years earlier, Silva et al. (2007), by analysing Portuguese manufacturing companies, found that the barriers to innovation ranked in order of importance are the high innovation costs, the lack of resources, the lack of skilled labour, the high economic risk, organizational inflexibility, government regulations, the lack of consumer interest and reaction, the lack of information about information technology and finally the modest knowledge of the market itself (Silva et al., 2007). Barañano (2005) highlighted two main obstacles for Portuguese SMEs: the lack of trained human resources and the lack of links with knowledge producers such as universities. According to Silva et al. (2007), the barrier to innovation for Portuguese SMEs are the high cost and risk of innovation, the lack of funding, organizational inflexibility, the lack of skilled labour, the lack of market and technological information, government regulations, difficulties in approaching customers and weak links with learning centres (Vieira, 2007).

According to Cordeiro and Vieira's (2012b) own research, barriers for Portuguese SMEs include economic climate, financial resource constraints, the limited risk-taking culture, routine and perpetuated processes, organizational and human resistance to change, the lack of incentives for innovation, the high cost of new assets and the small size of companies.

Similar results are found in other Mediterranean regions as well: according to Pipero-poulos (2007), old management techniques, bureaucratic structures, the lack of government financial support, and lack of university–business cooperation hinder innovation for Greek SMEs. Segarra-Blasco et al. (2008) identified cost factors, knowledge factors,



and market constraints as the Catalan barriers. Below market constraints, the market power of the currently dominant (incumbent) company, the uncertainty of demand, and the lack of demand for innovative solutions are decisive. All of this gives an empirical picture of the most important factors hindering innovation in regions that can also be called European Mediterranean periphery compared to continental countries—even if the role of space does not usually or only indirectly appear in the mentioned research.

As the summary of Cordeiro and Vieira (2012a) point out by citing previous research, the Italian researches suggest that the main barriers are financing problems, excessive financial risk, innovation costs, the lack of human resources, the lack of knowledge about markets, lack of knowledge about technology and inflexible regulations. And a Cyprian study found that the internal barrier was the lack of time, insufficient research and development, design and testing, and insufficient financial resources. External barriers include easy copying of innovations by other companies, government bureaucracy, the lack of government subsidies, lack of strategies to find quality labour, and problems with lending from banks, as commercial banks require collateral for lending money, which is not as difficult when buying a new machine as when developing a new product (Cordeiro & Vieira, 2012a).

### **Western Europe**

Research was not only carried out concerning the “periphery” of the Mediterranean Europe, this can be seen from the summary of Cordeiro and Vieira (2012a), that is why we also provide a keyword overview of the barriers to innovation in Western Europe. In Switzerland, risk aversion, the atmosphere of calm complacency that sometimes characterizes long-time leaders, the lack of recognition of high-value innovation, provincialism, and closed networks can appear as a barrier at the *cultural* level. At the *educational* level, we can see weaknesses in the emergence of innovation in education, limited human capital, or even the lack of entrepreneurship. At the *political* level, poor access to resources, legal constraints, insufficient political vision, underused infrastructure, and intellectual capital are the constraints of innovation.

In France, the prominently appearing barriers include the high costs of innovation, the lack of funding, internal resistance of companies to change, overestimation of economic risk, the lack of quality labour, lack of technological information, weak knowledge of markets, strong regulatory barriers and that the consumer does not commit oneself in favour of the new products. And according to the German research quoted by the authors, low budgets, finding the right people, bureaucracy and the lack of cooperation between companies are the main barriers. Comparison of the above countries (quantitative) based on individual country-specific researches is difficult to do, but it can be concluded that companies, even if they highlight different aspects and concerns, identify similar (nature and character) obstacle areas (Cordeiro & Vieira, 2012a).

### **Central Europe**

In the Czech Republic, high costs, the lack of specialists, length of the return period, technological equipment, standards and regulations, the lack of capital, lack of consumer reactions, resistance to change, fear of risks, disregard for the market situation, and corporate infrastructure are the main barriers (Cordeiro & Vieira, 2012a).

Innovation in the Slovakian SMEs is hampered by four factors (Lesáková, 2009). The first is the lack of financial resources. The second is the lack of awareness of innovation on the part of firms, which generally do not believe this would affect their competitiveness. In addition, the innovation infrastructure is deficient—services, consultancy, incubation, technology-innovation centres, science parks, namely the innovation ecosystem as a whole (which could be called an information infrastructure or a part of the national innovation system). Finally, gaps can be observed in the networking, clustering, local partnerships, and the number of interactions (Lesáková, 2009). These factors can already be the means of overcoming the barriers to innovation, as companies facing barriers to innovation can increase their cooperation efforts, thus enabling cost-sharing. In the case of knowledge barriers, firms can interact with research institutions (Antonioli et al., 2017).

In the case of Poland, based on a summary of a study, barriers to innovation can be divided into five groups (Sieradzka, 2014). The first is market constraints, the strength of market competition, and regional disparities in the strength of demand. The second is financial barriers, such as difficulties in accessing the resources needed for a new business, financing improvements or even accessing information about business partners. The third barrier is related to government policy, including rulemaking, unclear regulations in company law, permits for economic activities, or regional policies. The company's own internal preparedness is the fourth barrier group, where shortcomings related to the factors of production are the barriers to innovation with poor-quality workforce, technical infrastructure, or barriers to space and location selection. The fifth group includes access to local information. One of the biggest barriers to innovation is the sometimes complete lack of cooperation between R&D performers and stakeholders engaged in industrial production (Sieradzka, 2014).

The barriers to innovation of Latvian SMEs were examined by Lukjanska (2010) in the traditional division of external and internal barriers created by Piattier (1984). He considers the lack of governmental barriers, bureaucracy (Acs & Audretsch, 1990; Rammer et al., 2006), weaknesses in the communication and implementation of economic strategy and policy to be external barriers, recalling that Piattier points out in a 1984 study, that the third most important barrier in European countries is the lack of adequate government support (Freel, 2000; Frenkel, 2003; Hadjimanolis, 1999). The second group of external barriers is the lack of external partners and the difficulty of building relationships (Freel, 2000; Hausman, 2005; Hewitt-Dundas, 2006; Mohnen & Röller, 2005). Internal barriers include financial barriers (Acs & Audretsch, 1990; Baldwin & Gellatly, 2004; Rammer et al., 2006), the lack of adequate labour (Rammer et al., 2005, 2006; Ylinenpää, 1998), lack of knowledge to manage the innovation process (Mohnen & Rosa, 1999; Rammer et al., 2005), the lack of knowledge about market access (Baldwin & Lin, 2002; Frenkel, 2003; Galia & Legros, 2004; Hewitt-Dundas, 2006; Ylinenpää, 1998), the lack of knowledge of technologies (Frenkel, 2003; Galia & Legros, 2004) and the lack of intellectual property rights (Baldwin & Gellatly, 2004).

The above provides a good picture of what a significant body of the literature understands as external and internal barriers to innovation and confirms that this basic innovation factor division can be a useful pillar of a spatial innovation model. At the same time, experience shows that the territorial framework of the study of innovation-related

factors is less important primarily at the national level and the sub-national scale, in connection with which the aim of the present study is to develop a model framework for indexing the territorial characteristics of innovation at the micro level.

### **Attempts to systematize barriers to innovation**

The above list helps to illustrate the extremely wide range of barriers to innovation. However, it also raises the need to systematize individual factors. There have been several attempts to do this in the literature. A possible system distinguishes between human factors, general factors, policy factors, and barriers of market competition (Rahman & Ramos, 2013). Another study considers organizational, formal, and informal barriers (Bobera & Lekovic, 2013). According to Tabas et al. (2011), in addition to financial, labour, and organizational barriers, the lack of innovation infrastructure and government support is the relevant group of barriers.

There are also several examples of not grouping factors. In the study of Shiang and Nagaraj (2007), for example, rank the most important barriers for Malaysian companies in an enumeration manner. These are: the cost and risk of innovation, cost, and availability of financial resources, the lack of market and technological knowledge, “indifference” of consumers and uncertain demand for innovative solutions, lack of adequate labour, barriers to market entry due to large companies with market power, inflexible government regulation, inflexible international regulation, and internal organizational inflexibility.

A study of Australian SMEs (Kotey & Sorensen, 2014) divides barriers into only external and internal groups. The internal group includes access to resources such as financial, human, and knowledge capital. In addition, risk aversion, resistance to change, the education, technological competence, and leadership skills of owners or managers can be internal barriers. External factors include local and national economic activity and performance in general as well as technological, legal, and political conditions at different levels.

Demirbas (2011) comprehensively groups the experience of literature research into four categories, which are external, internal, environmental, and skill barriers. As with several structures, there are commonalities: a possible way to differentiate between external and environmental barriers if we talk about the policy environment and the general environment separately, but as policy indirectly influences most external factors, it is difficult to differentiate here as well. Meanwhile, the issue of skill shortages could be one of the internal factors—in fact, the seemingly internal problem could even belong to the political and external environment.

King (1990) sets up a different typology based on different scales and identifies individual, group, corporate, inter-firm and regional/national barriers to innovation—elements from this approach also appear in our innovation model, as the creation of innovation takes place on a scale ranging from the individual to the international innovation system. Klein (2002) also builds on individual–group dichotomy when identifying five barriers. Lukjanska (2010) traces this model back to Corsten’s (1989) model, which already groups individual–organizational innovation barriers. This type of division emphasizes ability and motivation at the individual level, as well as the appropriate corporate structure, innovation culture, and management attitude at the organizational level (Mosey

et al., 2002). Change management, resistance to change, corporate culture, the ability to absorb innovation, or finding the right leaders within the company all determine the appearance of individual creativity and also the possibility of transforming it into business advantage and innovation. The ability to absorb—the extent to which information and knowledge that can be transformed into innovation can be “organisationalise” in the corporate structure—is influenced by the listed knowledge factors.

It is worth noting that innovation barriers affect different types of innovation differently. Based on this, an order of importance can also be established among the barriers, for example, overcoming financial obstacles may be more difficult than overcoming resistance within the company (Madrid-Guijarro et al., 2009). Barriers may also vary by industry, for example, of the three examined innovation barriers (external environmental, financial, and human), external environmental factors proved to be the strongest barrier for SMEs in the service sector (Maldonado-Guzman et al., 2016).

A meta-analysis of the literature examining barriers to open innovation was conducted in 2016, providing a summary of research between 2009 and 2015 (Oumlil & Juiz, 2016). The research also seeks to promote an understanding of the open innovation paradigm by presenting its barriers. The topicality of the issue is indicated by the fact that during this time the authors found only 19 studies for analysis, so the authors drew their conclusions from a small number of studies (this study also significantly expands this literature). By analysing the text of examined studies, the research found that the most common words in studies of innovation barriers are management, market, knowledge, partners, technology, trust, and extern. Unlike previous practices, the authors established a typology based on this, which identifies environmental (legislative), managerial–organizational, unique (lack of commitment, inflexible work processes), cultural (not-invented-test syndrome), innovative and process-related (processual) barriers. What is interesting is the not-invented-here (NIH) cultural attitude, in which an organization refrains from engaging, using, and buying external knowledge, products, standards, mainly because of their costs and fees. Not wanting to use the results of others in an organization can also be a cultural attitude. In informatics, all of this is characterized as the reinvention of the wheel syndrome, driven by the belief that in-house improvements can replace external solutions (Oumlil & Juiz, 2016).

### **Barriers to innovation in spatial areas**

Given that innovation activity differs not only within companies and industries, but also differentiates in spatial structures due to environmental and social conditions, we supplement the modelling with an overview of research related to territoriality. In their study examining barriers to innovation, D'Este et al. (2008) suggested that the research direction of the future could be to analyse barriers to innovation in a spatial dimension. According to our approach, this is a useful research direction if we view space not only as a distance, but also as an independent, complex quality, as we do so in our spatial innovation model. By including geographical space in the analysis, it is clear that rural location can mean distance from consumers as well as suppliers, research institutes, and universities. According to Battisti et al. (2010), this means that rural SMEs have less (or more difficult access to) adequate human and knowledge capital as well as infrastructural and financial conditions for innovation. In addition, market size, access to labour,

or distance from urban centres can also affect their innovation activities (Siemens, 2010). As a result, rural businesses can rely more on themselves, family networks, and local communities to overcome these barriers. Or, as the research of Szörényiné (2016) has shown, companies in rural areas can also build on social innovations, which can enable other types of innovations, such as technological innovations. Life in rural areas is generally associated with slow lifestyles, permanence, and inertia according to McAdam et al. (2004), who suggest that the cultural attitudes of business leaders in rural areas can also be barriers to innovation (for example when there is no room to accommodate the innovation ideas and suggestions of the employee).

Kotey and Sorensen (2014) emphasize the need to regionalize innovation policy to supplement the national innovation policy, however, in the case of smaller countries like Hungary, the separation of regional–national innovation systems is a less significant and conspicuous matter than for example in the USA. For the authors, regional innovation policy can be based on the identification of common innovation barriers characteristic of each region, on which the identification of region-specific barriers can be based. According to Kotey and Sorensen (2014), there are examples that stem from the peripheral nature in each peripheral region. These include inadequate infrastructure, access to resources, and uncertainty about government policies. These general barriers are overshadowed by specific characteristics: for example, whether a region is dominated by agriculture or mining, namely, the dominant industry of the region; population size, attitudes and dynamism of local leaders (proactive or reactive) or social capital (apathy or social cohesion) also create differences between regions in terms of innovation. In total, the study found nine barriers to innovation: market size, access to human capital, the structure of the industry, access to resources and cash flow situation, technology, infrastructure, socio-cultural trends, political and legal conditions, and international affairs.

The literature researching barriers to innovation rarely analyses in a truly spatial, regional sense. An exceptional example is Frenkel's (2003) study, which found that in the case of Israel, peripheral regions are more likely to complain about labour shortages. Dissatisfaction with R&D services may also be stronger among peripheral companies. Interestingly, peripheral high-tech firms complained to a lesser extent about the lack of market information than metropolitan high-tech firms, a possible reason for this may be that urban high-tech firms spend more on R&D, the more actively researching and innovating companies also perceive barriers to innovation more strongly—as a non-innovative company in many cases does not perceive the barriers to innovation (Frenkel, 2003). The type of industry is also important in terms of barriers, as in Israel there are more traditional industries in rural and peripheral areas that produce to a greater extent for the local market, while in big cities there are high-tech industries that mostly produce to send abroad for the international market. Therefore, it may be that urban firms attached greater importance to the lack of information on market opportunities, while rural firms considered this a less significant barrier (Frenkel, 2003). Thus, in many cases, non-innovative companies do not complain about barriers to innovation, they perceive them less.

### **The innovation, time, and space (ITS) model**

Before developing our theoretical model, another aspect needs to be considered, namely whether the company perceives barriers to innovation. The BARINOV model emphasizes that firms have different capacities for their ability to correctly identify barriers (Cordeiro & Vieira, 2012b). By taking this aspect into account, another typology of barriers to innovation can be developed. Of the two basic categories, the first includes perceived barriers to innovation and the second includes barriers not perceived by the company. An example of the latter is when the executives of a company do not prioritize innovation because of a lack of information or resistance to change; therefore, corporate leaders do not perceive that corporate leadership itself can even be a barrier to innovation. The basic consideration of the BARINOV model is therefore the basis of our model. According to Iammarino et al. (2009), for example, there are clearly visible north–south differences in the perception of innovation barriers in Italy, but this can also be observed by firm type, for example, multinational foreign firms are less aware of the barriers than smaller domestic firms (Iammarino et al., 2009). Financial barriers are perceived as barriers for smaller companies, and larger ones tend to be more sensitive to institutional-regulatory issues. They add that the more a company is involved in innovation, the more it can perceive barriers to innovation. Moreover, the question is raised as to whether the innovation activity of companies may decline due to perceived barriers. Researchers also emphasize the practice of removing extreme corporate opinions from the study data set—as (1) firms that do not innovate at all and (2) firms that are very intensively involved in innovation may detect an excessively strong barrier (D’Este et al., 2008).

Based on the above typologies, it is necessary to create an improved theoretical model regarding the barriers to corporate innovation—for later empirical studies (Fig. 1). With this, our goal is to create an innovation model that facilitates the measurement and interpretation of innovation, also taking into account its territoriality, which can be the basis of empirical research in the future. The development of a model is needed because to measure innovation potential using exact statistical indicators, the theoretical framework and the concepts should be developed, based on a thorough literature review. Model construction is vindicated by the fact that most of the relevant literature considers innovation activity but not innovation potential. The latter is linked to a domain of innovation possibilities or future capacities, which differentiates it from the models describing innovation activity. Because of the future-oriented nature of this under-researched area, the empirical model allowing innovation potential forecasting would also support development policy planning. But in order to achieve that, we need a framework able to lay the foundations of a statistical methodology. This way we can analyse the complex, in-depth social-economic structures in a geographical approach to better understand the resiliency of regions.

The central subject of our model (not forgetting the individual either) is the company that produces innovations in geographical space and time, assisted or hindered by external and internal innovation factors, as well as in the socio-economic space (which can be called an innovation ecosystem). We also display the widely used external–internal division of barriers in research literature within our model, as we consider this to be an appropriate (but not sufficient) approach.



We have found only a limited number of such complex regional innovation models in the literature that can provide a basis for our research. Therefore, it is necessary to display the external environment in addition to the internal innovation factors of the company, but in a more structured form than the literature results, in a regional, national, and international division. After all, as we have seen, innovation system models (which emphasize the flow of technology and information in local learner, multiplayer, socially embedded networks) are also examined at different levels. The economic factors listed and examined by other typologies can be integrated by our model; they appear as external–internal innovation factors in the spatial area. In our model (see Fig. 1), the environmental-socio-economic space appears which is the result of the spatial production of the stakeholders that make it up.

In the twenty-first century, innovation is becoming more and more open than closed, but many innovation models and theories do not paint a detailed, taxative picture of the stakeholders of open innovation—this shortcoming is filled in by system models. Our model also includes stakeholders outside the company that create the innovation—consumers, suppliers, government, universities, and research institutes, as well as other “service” institutions that companies can use during their operation. These stakeholders and how they operate result in the context in which the company operates, which are organized into networks in order to exchange information and learning together, exchanging tacit and explicit knowledge. First and foremost, the company and its external environment exchange information resources, market, technological and financial knowledge. Naturally, different types of relationships can be developed with each stakeholder: for example, feedback from consumers, discounts and subsidies from the government, marketable knowledge from universities and research institutes, which in some cases, companies may receive knowledge leading to intellectual property and patents, but according to anecdotal evidence the accountant becomes the chief “advisor” of many SME managers as a service provider.

The literature has already identified and described many barriers to innovation; our model was created from the need to structure these factors in order to understand the process of innovation in a geographical-socio-institutional space—to identify the regional differences of innovation barriers in Hungary, by formulating relevant policy conclusions. The new “verbal” ITS model (innovation, time, and space model) presented above for the description of innovation aims to describe the spatial formation of innovation, taking into account the different stakeholders as well (see Fig. 1).

Our model follows and goes beyond the approach of the chain-linked model (Greenacre et al., 2012). This model examines two types of interactions, the first is within a given firm and the second is between a firm and the wider scientific and technological environment. In this sense, we follow the model. However, Foxon (2003) points out that the chain-linked model interprets the system that gives the environment of the firm relatively narrowly; therefore, it does not address the economic, political, social, and cultural environment. In our model, however, a broad-based innovation ecosystem appears, along with its institutional stakeholders. The socio-economic environment inherently appears outside the ecosystem. Our model draws attention to the fact that innovation is not only produced within a corporate framework, but also in space and time, and that space has socio-economic characteristics. We emphasize that there are continuous,



reciprocal relationships between the company and the stakeholders of the ecosystem, which reflects the basic idea of the chain-linked model according to which innovation is not a linear process; innovation production is accompanied by complex feedback processes. This study aimed at modelling because it allows for a systematic mental mapping of the topic under examination, which can provide a structure for empirical studies while helping to analyse the most pressing issues of economic competitiveness and innovation policies.

### Methods of the empirical application

After building a theoretical, verbal model based on an extensive literature review, we present an empirical application with the objective of measuring innovation potential on a settlement level. Initially, a total of 78 variables were included in the analysis, using factor analysis to create groups of factors suitable for measuring innovation potential, thus reducing the weight of arbitrary analytical choices. The choice of the variables was based on a systematic literature review [see the forthcoming study of Alpek and Oláh (2021) for detailed descriptions]. Most of our variables can be considered as “proxy variables” since in many cases innovation potential can only be inferred as opposed to innovation activity (see descriptive statistics in Table 3).

The source of our variables is the TeIR (National Regional Development and Spatial Planning Information System) database, from which we selected a wide range of variables with values for all Hungarian settlements (3155), for the year 2016. The final 16 variables included in the model contain 50,480 data points. By using the factor analysis method, a reduced, empirically tractable model was obtained, preserving the ability of the variables to describe the underlying phenomenon. The 16 variables could be grouped into 7 factors—these can be interpreted as dimensions of the phenomenon of innovation potential (Table 4). The final factors given by empirical statistical modelling are in line with our previous theoretical model which confirms the applicability of the framework.

The Bartlett test applied to our variables under consideration (Chi-square value 6503.965, degree of freedom 120, significance less than 0.000) and the Kaiser–Meyer–Olkin indicator (0.577, which is above the recommended threshold of 0.5) also suggest that the set of indicators selected is suitable for factor analysis. The Kaiser criterion of “eigenvalue greater than one” was used to determine the number of rotated factors. In terms of the number of factors (based on the Kaiser criterion, the appropriateness of the eigenvalues, and the total explained variance ratio of 63.1%), we opted for the seven-factor solution. To separate the factors, they were rotated using the varimax orthogonal rotation technique.

The values of the normalized and directionally adjusted variables belonging to a factor were averaged, and the average of these averages gives the values of the innovation potential index (see descriptive in Table 5). From the seven pillars of innovation potential, we thus created an aggregated regional innovation potential index.

The values of our newly constructed index can be seen in the cartogram of Fig. 2. As for the macrostructure, compared to earlier innovation capacity research on a sub-regional level (see Bajmócy & Szakálné Kanó, 2009), we can observe a new geo-economic phenomenon. A coherent axis of a high innovation potential region lies in the north-west–southeast direction, severing the country as an innovation backbone. As for policy

**Table 3** (The variables of the final empirical model—and the factor points—and their descriptive statistics)

	N	Range	Minimum	Maximum	Average		Standard deviation		Variance		Skewness		Kurtosis	
		Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic
The fastest trip to the county seat [minutes, in case of time optimization]	3155	147,080	0.000	147,080	45.017	0.378	21.247	451.428	0.804	0.044	1.070	0.087		
The fastest trip to the regional centre [minutes, in case of time optimization]	3155	187,750	0.000	187,750	76.943	0.680	38.221	1460.815	0.472	0.044	—	0.521	0.087	
Number of domestic patent applications filed by Hungarian applicants (by share of applicants), pcs	3155	229,890	0.000	229,890	0.194	0.075	4.190	17.555	52.442	0.044	2867.187	0.087		
Higher education students as a percentage of population (%)	3155	0.183	0.000	0.183	0.001	0.000	0.008	0.000	15.868	0.044	288.247	0.087		
Labour costs per operating firm	3155	3,699,404,000	0.000	3,699,404,000	40,372,492	2870.264	161,220,977	25,992,203,437.661	10.758	0.044	179.294	0.087		
R&D tax credit per firm	3155	1,033,161.667	0.000	1,033,161.667	686.182	359.793	20,209.343	408,417,551.296	45.457	0.044	2226.376	0.087		
Unemployed for more than 180 days in proportion to the permanent resident population	3155	0.121	0.000	0.121	0.010	0.000	0.010	0.000	2.443	0.044	11.324	0.087		
IT company as a percentage of all companies	3155	1.000	0.000	1.000	0.019	0.001	0.049	0.002	10.046	0.044	165.032	0.087		
Education company as a percentage of all companies	3155	0.500	0.000	0.500	0.007	0.000	0.023	0.001	10.212	0.044	159.580	0.087		
Professional, scientific, technical firms as a percentage of all firms	3155	3.000	0.000	1.000	0.145	0.003	0.141	0.020	5.211	0.044	71.003	0.087		

**Table 3** (continued)

	N	Range		Minimum	Maximum	Average		Standard error	Standard deviation		Variance		Skewness		Kurtosis	
		Statistic	Statistic	Statistic	Statistic	Statistic	Statistic		Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic
Visitors to educational events as a percentage of population	3155	8.314	0.000	8.314	0.108	0.007	0.394	0.155	12.971	0.044	226.098	0.087				
Cultural event visitors as a percentage of population	3155	519.056	0.000	519.056	3.355	0.202	11.329	128.344	32.953	0.044	1401.721	0.087				
Job seekers as a proportion of the population	3155	0.274	0.000	0.274	0.038	0.001	0.028	0.001	1.638	0.044	4.568	0.087				
Fixed assets to balance sheet total	3155	1.000	0.000	1.000	0.392	0.004	0.219	0.048	− 0.266	0.044	− 0.443	0.087				
Exports as a share of net turnover	3155	0.985	0.000	0.985	0.105	0.003	0.188	0.035	2.321	0.044	5.192	0.087				
Foreign ownership rate in subscribed capital	3155	1.000	0.000	1.000	0.097	0.004	0.218	0.047	2.612	0.044	6.052	0.087				
Factor score 1	3155	12.918	− 3.254	9.664	0.000	0.018	1.000	1.000	1.808	0.044	6.313	0.087				
Factor score 2	3155	9.124	− 4.371	4.752	0.000	0.018	1.000	1.000	1.265	0.044	2.436	0.087				
Factor score 3	3155	44.268	− 1.879	42.389	0.000	0.018	1.000	1.000	26.922	0.044	1055.695	0.087				
Factor score 4	3155	5.921	− 2.320	3.601	0.000	0.018	1.000	1.000	0.417	0.044	− 0.314	0.087				
Factor score 5	3155	42.678	− 1.526	41.152	0.000	0.018	1.000	1.000	26.901	0.044	966.338	0.087				
Factor score 6	3155	29.410	− 0.685	28.725	0.000	0.018	1.000	1.000	15.766	0.044	344.783	0.087				
Factor score 7	3155	19.932	− 1.412	18.521	0.000	0.018	1.000	1.000	6.496	0.044	80.468	0.087				
N	3155															

Source: author's calculation (SPSS software)

**Table 4** Groups of variables serving as the basis of the indexation of spatial innovation potential)

Dimension	Variable	Factor						
		1	2	3	4	5	6	7
Labour market potential—a tight labour market	Unemployed for more than 180 days in proportion to the permanent resident population	0.928						
	Job seekers as a proportion of the population	0.922	− 0.127					
Networking potential—foreign linkages	Foreign ownership rate in subscribed capital		0.757	0.195				
	Exports as a share of net turnover		0.750	0.244				
	Fixed assets to balance sheet total		0.629	− 0.217				
Corporate potential—innovative companies with high added value	R&D tax credit per firm			0.842				
	Labour costs per operating firm		0.299	0.760				
Accessibility potential—proximity to geographical hubs	The fastest trip in minutes to the regional centre [minutes, in case of time optimization]				0.820			
	The fastest trip in minutes to the county seat [minutes, in case of time optimization]				0.810			
Knowledge production potential—institutional learning	Number of domestic patent applications filed by Hungarian applicants (by share of applicants), pcs					0.818		
	Higher education students as a percentage of population (%)					0.799		
Social activity potential—social openness, creativity, networking	Cultural event visitors as a percentage of population						0.806	
	Visitors to educational events as a percentage of population						0.798	
Industrial potential—high-tech industry	IT company as a percentage of all companies							0.741
	Education company as a percentage of all companies		0.105					0.608
	Professional, scientific, technical firms as a percentage of all firms	− 0.213			− 0.136	0.101		0.503

All variables for 2016

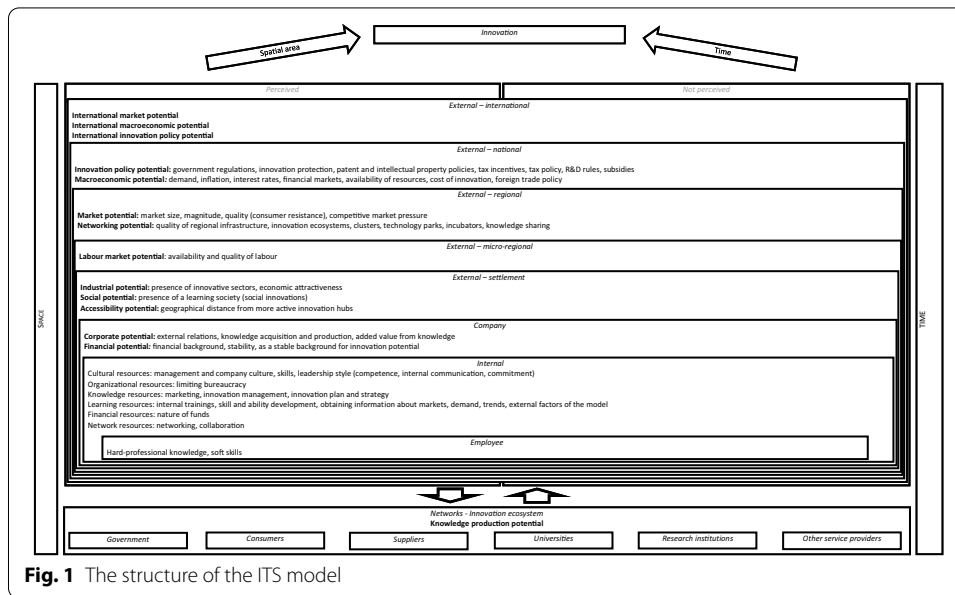
Source: Author's calculation based on TelR data

application, this may be interpreted as a developmental axis of the agglomerations of innovation potential. Policymaking may link new, peripheral areas to this innovation highway (to use another metaphor). We add that the Esztergom-Győr region on the northern-western border and the Szeged area on the southern-eastern are the two main

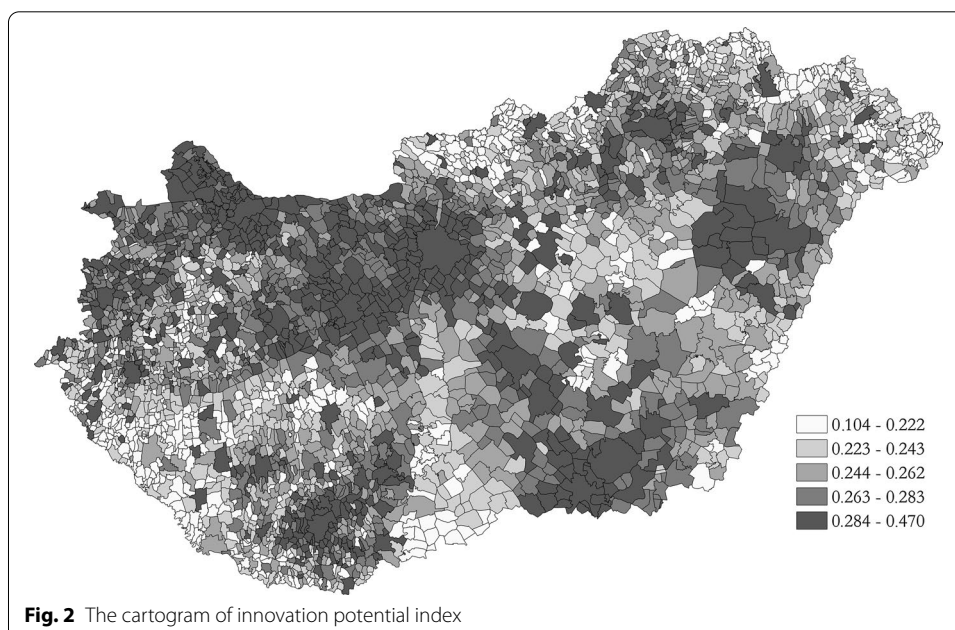
**Table 5** Descriptives of the innovation potential index

Variables	Observations	Mean	Standard deviation	Minimum	Maximum	First percentile (p1)	99th percentile (p99)	Skewness	Kurtosis
Innovation potential index	3155	0.254	0.038	0.104	0.47	0.172	0.359	0.414	3.998

Source: Author's calculation



**Fig. 1** The structure of the ITS model



**Fig. 2** The cartogram of innovation potential index

regions, where an extended high innovation potential area is located along the border. This may mark two cross-frontier high-potential areas in the Carpathian basin—both are final points of the Hungarian axis of high innovation potential.

The cartogram also presents the large “oases” of innovation potential in rural Hungary (for instance Pecs, Debrecen, Nyiregyhaza, Miskolc, Szeged, Kecskemet, Szekesfehervar, and Miskolc), which, in many cases do not have explicit linkages to the innovation highway through corridors of high-potential areas. These agglomerations make the geographical structure more balanced (see Debrecen with the BMW plant). The research confirms our earlier hypothesis that many rural areas do have innovation potential (Oláh & Alpek, 2021), although also seems to confirm the general view of the literature that larger settlements have higher chances for high innovation activity. Inner innovation peripheries can also be identified with the method. Also, the categorization of the spatial clustering of innovation potential is possible with the method: macrostructure(s), regional agglomerations, and individual high-potential settlements can also be identified.

Another preliminary finding is the emergence of a “twin region” next to Budapest with the centre of Szekesfehervar. In the extent of its high-potential areas, this agglomeration is comparable to that of Budapest. It seems that here the research finds another geographical macrostructure: a triangular of high-potential agglomerations made up by Budapest, Szekesfehervar, and Gyor as centres. Here agglomeration effects may be stronger than in other areas because of the interlinked nature and proximity of the three large centres. This is in effect the core region of innovation potential in Hungary, which further extends to Kecskemet (a main centre of the car industry with Mercedes) and Szeged (university centre and home of Extreme Light Infrastructure [ELI] Laser Research Centre among others).

The interactions of natural–social phenomena in forming path-dependent local development trajectories may be also mentioned. The line of Danube in the southern part of the country but also the differences between the northern and southern sides of lake Balaton present evidence for this future research direction.

The results provide many possibilities for future research: the innovation barriers and strengths of settlements and regions can be analysed. Innovation “oases” and “black holes” may be identified with the underlying causes of this current situation as well. The research sheds new light on areas that may be efficient catalysing forces of development policy. Since economic growth is becoming innovation-driven also in Central Europe, deep knowledge about innovation potential on a settlement level could project future regional-economic development paths.

## Conclusion

A conceptual review of innovation shows that most of the changes that can improve the performance of a company can be called innovation. For the purposes of our study, we identify with this broad concept of innovation, recognizing that the number of definitions and typologies is constantly increasing and there is no single definition. However, as the literature points out, what is common in the definitions is that in almost all cases they are related to novelty, change, and efficiency. All this is not enough to understand innovation, therefore our study chose another, partly empirical direction that examines the barriers to innovation production (if they are removed, then the factors), contributing to the fact that

we can later examine the issue empirically in a spatial approach. The ITS model presented in our study serves this purpose, building on the literature tradition of the external–internal division of innovation barriers but also deviating from the tradition in that the model simultaneously represents space, regional scales, time, and the innovation ecosystem with its stakeholders (specifically the social space) as well as the realization of the BARINOV model (Cordeiro & Vieira, 2012b), which emphasizes the subjective nature of corporate perceptions of innovation barriers. Our study provides a basis for one of the current, yet less researched, fundamental issues in the field of innovation geography, the spatial study of barriers to innovation, as such empirical results have been very limited in Hungary so far. The theoretical framework can be translated into empirical modelling by factor analysis, which reveals new geographical-economic structures of innovation potential in Hungary such as the innovation axis or the innovation triangle. The empirical results lay the foundations for innovation potential research in Hungary, while also valuable in terms of development policy.

#### Footnotes:

1 Since then, the question has arisen for many countries to identify the main barriers to the innovation process. Acs and Audretsch (1990) carried out examination in the USA, Ylinenpää (1998) for Sweden, Hadjimanolis (1999) for Cyprus, Mohnen and Rosa (1999), Baldwin and Lin (2002) and Baldwin and Gellatly (2004) for Canada, FES (2004) for Germany, Mohnen and Röller (2005) for Ireland, Denmark, Germany and Italy, Galia and Legros (2004) for France and Freel (2005) for England, and March-Chordá et al. (2002) for Spain—Demirbas (2017) mentions the above as pioneers, the his very first researches in the field. In most of the researches, the spatiality of innovation did not appear or was limited.

2 Since for us geographical space is the organic, “living” space itself, the term (geographical) space itself includes the various characteristics and qualities created as a result of social space production.

3 The chain-linked model is the contribution of Klein (2002), which describes the process of innovation as research, the existing scientific and technological knowledge base, the potential market, the various stages of the invention and the production process, and as circular feedback links between them.

#### Abbreviations

ITS-model: Innovation, time, and space model; TelR: National Regional Development and Spatial Planning Information System (Hungarian database); ELI: Extreme Light Infrastructure; SME: Small and medium-sized enterprise; R&D: Research and development; IT: Information technology.

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#### Authors' contributions

Theoretical model-building was carried out by Daniel Olah with suggestions and corrections from Levente Alpek. Empirical application was devised jointly. The cartogram was prepared by Levente Alpek. All authors read and approved the final manuscript.

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#### Availability of data and materials

The datasets analysed during the current study are available in the TelR repository, [www.teir.hu](http://www.teir.hu).



## Declarations

### Competing interests

The authors declare that they have no competing interests.

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