University of Pardubice

Faculty of Economics and Administration

Analysis of Regional Innovation Systems – International Comparative Study

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Diploma Thesis

2021

University of Pardubice
Faculty of Economics and Administration
Academic year: 2020/2021

ASSIGNMENT OF DIPLOMA THESIS
(project, art work, art performance)

Name and surname:	**Bc. Ondřej Dobeš**
Personal number:	**E18903**
Study programme:	**N6202 Economic Policy and Administration**
Field of study:	**Regional Development and Governance**
Work topic:	**Analysis of Regional Innovation Systems – International Comparative Study**
Assigning department:	**Institute of Economic Sciences**

Theses guidelines

The aim of the thesis is to analyse regional innovation systems in selected EU countries and to evaluate and to compare them with the help of existing methodology.

Contents:
- Regional innovation systems.
- Methodology of the evaluation.
- Comparative study.
- Results and recommendations.

Extent of work report:	**approx. 50 pages**
Extent of graphics content:	**–**
Form processing of diploma thesis:	**printed/electronic**
Language of elaboration:	**English**

Recommended resources:

ASHEIM, T., ISAKSEN, A., TRIPPL, M. Advanced Introduction to Regional Innovation Systems. Cheltenham: Edward Elgar Publishing, 2019.
BLAŽEK, J. and UHLÍŘ D. Teorie regionálního rozvoje. Praha: Karolinum press, 2011.
ISAKSEN, A., MARTIN, R., TRIPPL, M. New Avenues for Regional Innovation Systems: Theoretical Advances, Empirical Cases and Policy Lessons. Cham: Springer, 2018.
PROKOP, V. and STEJSKAL, J. Role veřejného a soukromého sektoru v inovačním prostředí. Praha: Wolters Kluwer, 2018.
STEJSKAL, J., HAJEK, P., HUDEC, O. Knowledge Spillovers in Regional Innovation Systems. Berlin: Springer, 2018.

Supervisors of diploma thesis:	**Ing. Viktor Prokop, Ph.D.** Institute of Economic Sciences
Date of assignment of diploma thesis:	**September 1, 2020**
Submission deadline of diploma thesis:	**April 30, 2021**

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In Pardubice September 1, 2020

DECLARATION

I declare:

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ACKNOWLEDGEMENT

I would like to thank my supervisor Ing. Viktor Prokop, Ph.D. for his valuable comments, advice, and time that gave me support to complete my work as well as prof. Ing. Jan Stejskal, Ph.D. for his professional and valuable advice at the beginning of my work and permanently willing and patient approach. At the same time, I would like to thank the director of the CzechInvest regional office in Pardubice, Mr. Ing. Tomáš Vlasák, whose expert comments helped me during the elaboration of the work. I would also like to thank Mgr. Petra Srdínková for her willingness and help with editing the text. Thanks also to my colleagues and my mother, without whose support and motivation the work could never be completed.

ABSTRACT

The aim of the thesis is to analyze regional innovation systems in selected EU countries and then evaluate and compare them using the existing methodology. The first part of the work is focused on explaining the basic concepts, describing regional innovation systems and how to evaluate them. Subsequently, the socio-economic indicators of selected countries and selected regions are described. The last part of the thesis deals with the analysis of regional innovation systems, evaluation and design of recommendations.

KEYWORDS

regional innovation systems, innovations, triple helix, cooperation, regional policy

TITLE

Analysis of Regional Innovation Systems – International Comparative Study

ANOTACE

Cílem práce je analyzovat regionální inovační systémy ve vybraných EU zemích následně je vyhodnotit a poronovat pomocí stávající metodiky. První část práce je zaměřena na vysvětlení základních pojmů, popsání regionálních inovačních systémů a způsob jejich hodnocení. Následně jsou popsány socio-ekonomické indiktory vybraných zemí a vybraných regionů. Poslední část práce se věnuje samotné analýze regionálních inovačních systémů, vyhodnocení a návrhu doporučení.

KLÍČOVÁ SLOVA

regionální inovační systémy, inovace, triple helix, spolupráce, regionální politika

Content

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LIST OF ABBREVIATION

OECD	Organisation for Economic Co-operation and Development
EU	European Union
SME	Small and medium-sized enterprises
R&D	Research and development
NGO	Non-Governmental Organization
R&I	Research and Innovation
EIB	European Investment Bank
EIF	European Investment Fund
ICT	Information and Communication Technologies
RIS	Regional innovation system
NIS	National innovation system
IE	Innovation Environment
UNIDO	United Nations Industrial Development Organization
WSA	Weighted Sum Approach
CNB	Czech National Bank
CEE	Central and Eastern Europe

Introduction

There are apparent differences in the development of regional economies in individual states of the European Union. This is the reason why the European Union uses regional policy to help regions in individual member states of the European Union to support business competitiveness, job creation, sustainable economic growth and improve the quality of life. It is important for competitiveness in individual regions to have the ability to bring innovations. Regions that are producing innovations often have a better position on the market and higher gross regional product than regions that do not produce any innovations. The European Union, therefore, seeks to encourage innovation in the regions through various regional policy instruments. Regional innovation systems are an example of the regional policy instruments used by EU member states. The main goal of regional innovation systems is to create a connection between the private and public sector entities. The application of regional innovation systems does not guarantee the desired results such as bringing innovation and the already mentioned competitiveness of the region.

The aim of the thesis is to analyze regional innovation systems in selected EU countries and to evaluate and to compare them with the help of existing methodology.

In the first chapter, concept of innovations, innovation infrastructure, innovation environemnt and tools to support innovations in the European Union are described theoretically. Also, their importance is mentioned. Then in the second chapter, innovation cooperation, innovation systems, national innovation systems, regional innovation systems their characteristics, division, limitations and evaluation of regional innovation systems are described. Furthermore, it is focused on the triple-helix.

The third chapter is focused on selected regions in particular countries of the European Union and description of their socio-economic characteristics and information about environment is added. The fourth chapter is devoted to describing the appropriate method for analysis. At the same time, the weights of the individual regional innovation system elements are determined according to their importance. Subsequently, the individual elements of regional innovation systems are analyzed and compared. The fifth chapter contains the overall evaluation of regional innovation systems, summary of the overall results and draft recommendations. The final part of the thesis includes conclusion.

1 Innovations

Innovation is the key element for further developing and increasing of competitiveness in the globalized market. Innovation is closely linked to research and development, which provides the necessary primary basis for the creation and implementation of innovation, especially with a focus on the production of new products and services.

This chapter contains theoretical description and classification of innovations and their importance. Also inovation infrastructure, innovation environment and tools to support innovations in the European Union.

1.1 Concept of innovations

The term innovation was derived from the latin verb "innovare" – to reform, to change. From the meaning of the word it is clear that it is a novelty, a new development in human thought and activity or (mainly) in production (Heřman et al., 2008; Capelo et al., 2019). The term „innovation“ was first used in the literature by Schumpeter in 1939. At the most general level, it can be understood as creating something new, synonymous with the word novelty, invention, renewing, or improving something already existing (Croitoru, 2017).

Schumpeter (1939) considered innovation as the basis of the dynamic development of the economy. He defined innovation as follows (Mlčoch, 2002; Urbancová and Königová, 2013):

- product launch or producing an existing product with new attributes,
- introducing a new production method into production or a new type of sale or purchase,
- opening a new market,
- product improvement by using new sources of raw materials,
- creating a new form of work organization or new production.

Drucker (1985, p. 10), which also dealt with the issue of innovations, state that „*purposeful innovations results from the analysis, systemic review and hard work and can be taught, replicated and learned. Analysis of opportunities is prerequisite for purposeful innovations. The search must be organized and conducted on a regular basis.“* Drucker (1985) identified sources leading to innovations:

- the unexpected phenomena such as unexpected success, failure or an external event,
- the incongruity between the actual reality and the idea of what the presence might look like between reality as it actually is and reality as it is assumed to be or as it ought to be,
- the need for process change leading to innovation,

- changes resulting from market structure or industry structure unpreparedness.

Sources from a change outside the enterprise or industry:

- population aging,
- perception and mood of individuals and groups in the population,
- discovery of new knowledge.

According to Drucker (2002), innovation could be conceptual and perceptual. The success of innovation lies in focusing on specific solutions. Innovation should focus on one thing and address a specific need. It is also important that innovation can be used by ordinary people, and innovation alone not being a complicated solution. It is appropriate to focus innovation on the present and not on the future needs. Furthermore, Drucker defined three conditions under which successful innovations are achieved (Luebke, 2010):

- the innovation process requires ingenuity, knowledge and creativity. Innovators are usually focused only on one area,
- innovators focused on working with their strengths. They look for opportunities on a wider scale and ask questions like: "*Which of these opportunities fits me, fits this company, puts to work what we are good at and have shown capacity for a performance?*",
- innovation affects society and the economy. It changes the behavior of market participants or changes the process by which people work. It must therefore be market-driven.

Skokan (2004, p. 27) defined innovations as „*synonymous with successful creation, adaptation and exploitation of novelty in the economic and social spheres. Innovation offers new problem solutions to meet individual and corporate goals*".

International Organization for Economic Co-operation and Development (OECD) defines innovations in the Oslo Manual as follows „*an innovation is a new or improved product, or process (or a combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (proces)*" (OECD, 2018; Mesquita, 2018).

The above definitions show the characteristics of innovations. The common factors of innovations are:

- novelty,
- intentional change of the current situation,
- improvement,
- concerns products (goods and services) and procedures (organizational and production).

The next part is focused on the importance of creating and implementing innovations in companies.

1.2 Importance of innovations

Innovations are generally regarded as the key to economic and social development (Cooke, 2001; Shucksmith and Brown, 2016; Mitra, 2017; Grashof et al., 2019; Liu, 2020). Innovation is a crucial endogenous factor of economic growth, a source of extraordinary value for customers and extraordinary profits for entrepreneurs (Rao, 2001; Silvestre et al., 2019). Innovations as a pillar of competitiveness on the one hand, and as a result of creative intellectual processing of information, experience and knowledge on the other, thus becomes a means of further development of society, which in turn influences elements of the innovations process. Innovation is, therefore, a significant component of entrepreneurship and is becoming one of the fundamental aspects of the growth of the world economy (Autio, 2014). The innovative potential of large economic firms, R&D collaboration with the application sector and innovative SMEs working with university spin-offs[1] and science and technology parks are becoming a significant source of growth in prosperity, competitiveness and living standards in a modern knowledge-based economy[2] (Cantwell, 2005; Nieto and Santamaria, 2007; Heřman et al., 2008).

From the European Union's point of view, innovation is essential for Europe's competitiveness on the global market. The European Union therefore provides supportive policies and programs for its member states that focus on developing innovation and seek to help invest in science and research (European Commission, 2017).

According to Veber et al. (2016) innovations are the driving factor of every organization or institution, through which it updates the product portfolio and thus improves the efficiency of operational activities, improving quality and reducing costs. Janusonis and Krievina (2009) confirmed that the company's financial performance is strongly dependent on successful innovations, which can also contribute to increasing safety, improving health care, improving product quality, and introducing more environmentally friendly products. Innovations have enabled a significant increase in productivity and have significantly changed the way we live. Innovations and education are critical conditions for success, a rapidly evolving world offer businesses many challenges and opportunities, and innovations can help them succeed. The changing requirements and expectations of customers, competition, technology, the legislative

[1]University spin-offs are companies that are based on technological ideas or scientific / technical know-how created in an university environment by a member of the academic community (Pirnay et al., 2003; Tietz, 2013).
[2]Knowledge based economy is a term denoting economies in which knowledge and information are primarily created, disseminated and used (Godin, 2006; Hadad et al., 2017; Švarc and Dabić, 2017).

environment, and a market that is increasingly globalized and dynamic – all create opportunities for innovations.

Innovation is, therefore, a prerequisite for competitiveness. Developed economies considered their growth of competitiveness with innovation activities. Innovations can be part of the solution to economic growth by providing the basis for (Veber et al., 2016):

- new businesses,
- new jobs and productivity growth,
- solving problems with high production prices,
- developing new needs.

Innovation can also help address other challenges in societal change, resource scarcity, climate change and other global challenges. Economies that innovate are more productive and better able to cope with the changes that are taking place.

1.3 Classification of innovations

Primarily, innovations can be divided into technological and non-technological. **Technological innovations** create new products, processes, and essential technical changes in products and processes (Mothe, 2010; Zizlavsky, 2020). An established innovation is an innovation that is marketed or implemented into the production process. **Non-technological innovations** include particularly organizational, entrepreneurial, and social innovations (Geldes, 2017). According to the Oslo Manual (2018) there are two categories of non-technological innovations: organisational innovations and managerial innovations (Hyard, 2013).

The Oslo manual defines the following types of innovation (see Figure 1; OECD, 2005):

- poduct innovations,
- process innovations,
- organizational innovations,
- marketing innovations.

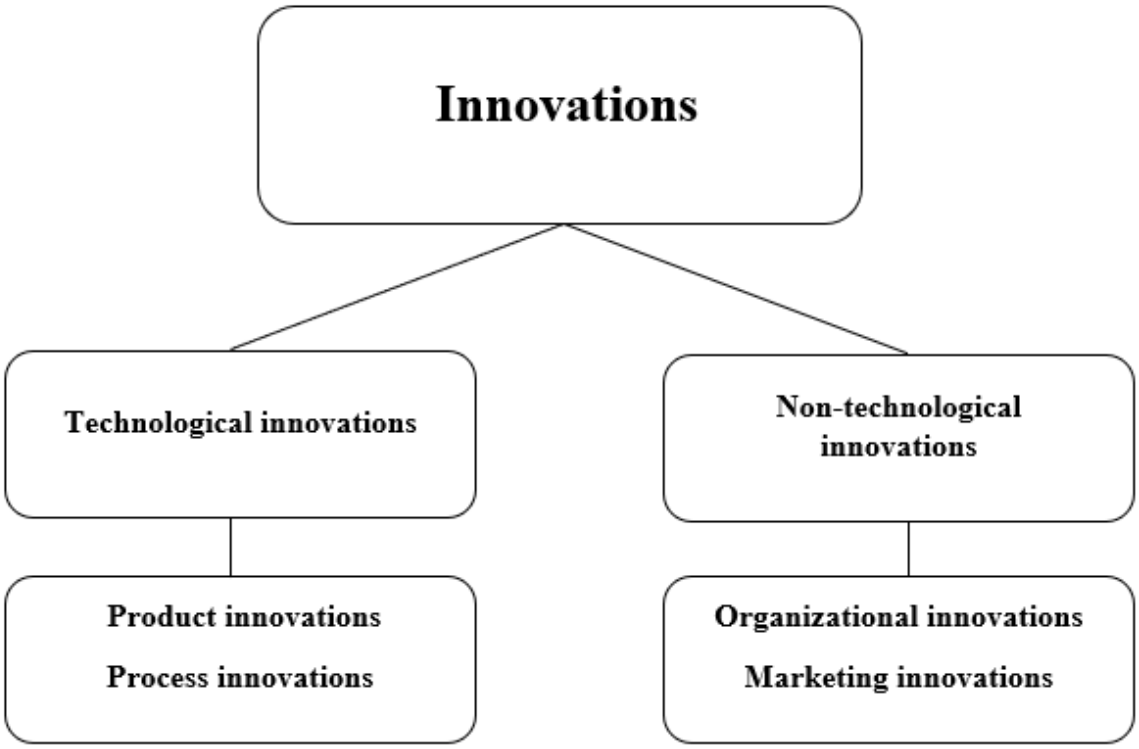


Figure 1: Classification of innovation activities according to the Oslo Manual
Source: Oslo manual (2005)

Product innovations contain changes in the properties of goods or services. These are completely new goods and services or even improvements to existing ones. Significant improvements may be reflected in changes to technical specifications of components, production materials, software used, user environment and other characteristics (Au-Yong-Oliveira et al., 2018). New products differ significantly from their predecessors in their characteristics or their intended use. The innovations of a product that has the nature of a service may include significant improvements in how these services are provided, adding new features or characteristics to existing services, or introducing brand new services (Kniazevych et al., 2018). The aim of product innovations is usually the replacement of obsolete products with improved products and the preparation of entirely new products. This contributes to maintaining and increasing market share and attracting new markets (Tucker, 2008; Jaravel, 2019).

Process innovations contain changes in the production and delivery of goods and services. These are significant changes in equipment, software, technology, support activities (accounting and other services). These innovations can lead to reduced material and labor costs, improved working conditions, reducing energy consumption, improving the environment and reducing scrap (Khazanchi et al., 2007; Flores-Garcia et al., 2019). Especially for products based on new

technology concepts and principles, the decrease in production costs can take considerable proportions (e.g., multiple reductions of production costs for electronic products in a few years; Synek et al., 2011). It leads both to profit growth and to new marketing strategy alternatives to competition (a drop in production costs allows lower prices and consequently increased market share at the expense of competitors; Kahn, 2018).

Organizational innovations include the implementation of new organizational procedures such as the organization of the work environment, business practices or changes in the external relations of the company (Chan and López-Fresno, 2017). This may include changes in the division of labor within and between business activities, the creation of new types of cooperation with suppliers, or outsourcing, this is the separation of specific activities (e.g., maintenance or information technology) outside the enterprise (Lam, 2004).

Marketing innovations contain the implementation of new marketing procedures that the company has not used before and which are part of a new marketing strategy. The changes may affect the content of the packaging, the method of promotion, the location of the products or the prices of goods and services. Its aim is to give value to the customers and to improve competitive advantage (Ajayi and Morton, 2015; Bortoluzzi et al., 2015; Cluster, 2015).

Heřman (2008) extended and divided innovations into material and technological innovations.

Material innovations include improving the quality of the material component of the product by increasing the mechanical and qualitative parameters, reducing weight and processing costs, obtaining a more attractive appearance, eventually easier maintenance. A significant effect is also the achievement of the final lower price as well as ensuring the ecological continuity of the product due to the new material or raw material used in the production process.

Technological innovations include the application of the latest trends and the introduction of changes in production technologies and technical processes. Production technology must always meet the requirements for high quality production, and if the manufacturer is not able to make significant innovations in its technology, it thus significantly jeopardizes its competitive position on the market (Bartelsman, 2019). Technology must flexibly respond to changing requirements, wishes and needs of customers, and it must also focus on achieving high efficiency both in the production process itself and in the end user's operation (e.g., low energy consumption). Technological innovations aim to reduce production costs and hence product prices (Mothe and Nguyen, 2010).

Innovations also could be divided according to its levels into three groups depending on nature of change compared to the growth of profits and revenues (see Figure 2; Tucker, 2008).

Incremental innovations can increase customer satisfaction, increase the effects of a product or service, and have positive impact with a small level of the financial implications for the firm's bottom line. Incremental innovations typically follow a well-planned and structured process (Ringberg et al., 2019). At the same time, they increase productivity and reduce the company's costs. Incremental innovations usually do not require major changes in customer behavior or the behavior of company employees (Staniškis and Katiliuté, 2019). The opposite are **radical innovations**, which includes the development of completely new product lines. New ideas and technologies are used for their implementation. They are used to reduce costs and transform entire business economies. For that reason research competencies are needed to implement them (Leifer et al., 2000; Berndt, 2006; Crum, 2019). Radical innovation project should have one or more of the followings (Leifer et al., Berndt, 2006):

- an entirely new feature sets,
- performance improvement five times or more,
- significant reduction in costs, by at least 30 %.

In the service sector, incremental innovations occur when the customer achieves the desired service with less difficulty than before. Therefore, there is no change in the service itself, it only facilitates the achievement of this service and simplifies the processes (De Morais and Monteiro, 2019). For example, simplify the booking creation processes. They are resolving a more complicated situation without the presence of a manager. Introduce the use of fingerprints to open the mobile app.

Constant improvement is the basis for companies dealing with new markets and different products. For small and medium-sized enterprises (SME) operating in a competitive environment, incremental innovations are an important and indispensable strategic tool. It is essential that incremental innovations are accompanied by a strong vision of company and the constant building of better products and services (Bhaskaran, 2006).

Substantial innovations are important for the customer who benefits from these innovations, but also sponsoring companies expects a positive impact on its growth and the creation of the company's assets. These are not breakthrough innovations, but they do allow companies to achieve their business growth goals, increase market shares and reduce the company's running costs. Substantial innovations in goods and services are a noticeable improvement for both the customer and society. (Tucker, 2008).

Breakthrough innovations deliver significant revenue gains and net profits, which are generated through new products, services, or strategy changes. Breakthrough innovations cannot be determined by exact sum of money received by a company. Each company has a different size and differently defines what a significant increase in growth means. Breakthrough innovations are also processed enhancements that significantly reduce costs or increase production (Davis and Tomoda, 2018). Breakthrough inventions are a huge step for humanity, they may not provide the benefit of one company (the originator of the innovations, but they can set up a whole new industry (Sharek, 2019). Examples are the invention of electricity, the internet or the discovery of penicillin. The invention of the automobile was a benefit to humanity, but no company gained an exclusive market position thanks to this invention. Nevertheless, for some breaktrhough innovations, the firm may obtain a temporary monopoly through patents (Tucker, 2008; Cooke, 2013).

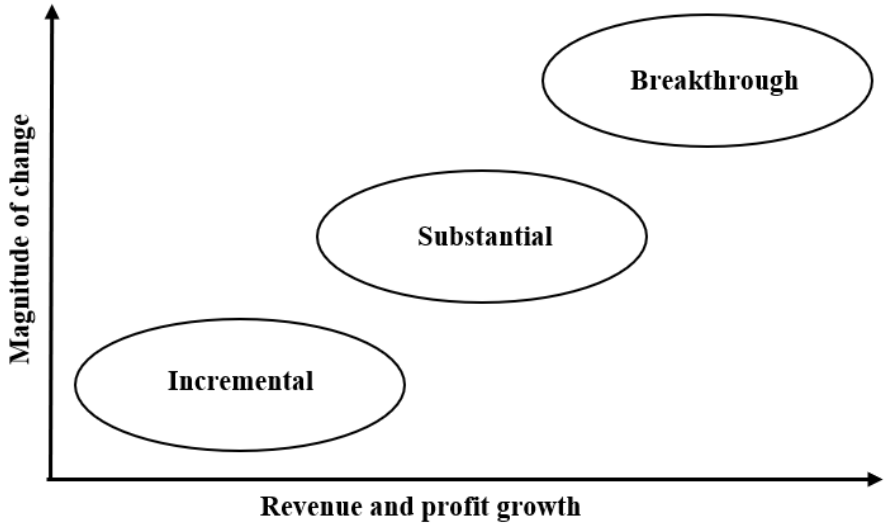


Figure 2: Levels of innovations
Source: own processing acroding to Tucker (2008)

The aspect of the subject's original contribution to innovations is divided into four types of innovations (Vlček, 2011):

- acceptance is simply accepting or adopting a known solution without change,
- application represents the adaptation or imitation of the known solution as a model,
- adaptation is a reshaping of the known model as a solution,
- absolute innovations is an original change that has no connection with previous practice.

The aspect of participation of entities in the creation of innovations is divided into closed and open innovations. Closed innovations are entirely under the control of the innovating company. All stages of the innovations process are attended only by the company's employees. In this case, consistent intellectual property protection is in place (Vlček, 2011). Open innovations are activities

of internal and external experts. Innovative companies are linked to external entities through an innovations network. Open innovations can be categorized as inbound innovations and outbound innovations. Through open innovations, investment-intensive innovations can be realized through the concentration of capital resources in the innovations network (Yuan and Li, 2019).

Valenta's classification of innovations (Tabas et al., 2014), which represents another way of innovations classification by the rate of change in an innovated object, shown in Table 1. Valenta perceives innovations more broadly, including innovations already introduced elsewhere but applied first in the system. Valenta also reminds that not every change is a change for the better, not every novelty necessarily has positive effects.

Table 1: Valenta's classification of innovations

Classification	Description
-n	„degeneration" - change for the worse, opposite positive innovations (wear)
0	„regeneration" - renewal of innovated elements, maintaining the original state of the business unit (maintenance, repairs)
1	„change of quantity" - maintaining properties, changing the number of machines and workers (another workforce)
2	„intensity" - maintaining quality and interconnection, improving the speed of process operations (increased belt speed)
3	„reorganization" - keeping the quality of properties, materials, and preparation, the workplace is changed
4	„qualitative adaptation" - it preserves the product, changes its relationship to other factors and improves the technological process (technological construction)
5	„variation" – it keeps the constructional solutions, the functionality of the innovated element is changed (faster machine)
6	„generation" – keeps the construction concept, essential features of the innovated feature change (machine with electronics)
7	„species" - the principle of technology is maintained, the concept of the innovated element is changing (airship)
8	„genus" - keeps an affinity for the tribe, changing the principle of technology (nonwoven)
9	„tribe" - nothing is preserved, the approach to nature is changing (gene manipulation)

Source: Valenta (2001) and Sirůček (2016)

1.4 Innovation infrastructure

Innovations may be the result of research activities, the result of purchasing know-how or licenses, the result of business activity (investing in new production or another establishment, organizational measures, usage of information technology, etc.) or other measures or activities (social activities, education, etc.). An innovative infrastructure is needed for these activities, which can be created by private entities or by the state (Heřman et al., 2008; Pittaway, 2017).

Governments are implementing intervention measures aimed at creating high-quality hard infrastructures for existing as well as potential entrepreneurs. By these measures, governments contribute to the achievement of defined public policy objectives. Specific infrastructure tools are: (Prokop and Stejskal, 2018):

- technology and innovation platforms,
- industrial zones,
- science and technology parks,
- business incubators.

Technology and innovation platforms

Technology and innovation platforms create an environment designed to realize collaborative activities. The platform can be seen as a passive environment with a bid for those interested in cooperation or an institutionalized environment actively supporting various activities.

According to Harmaakorpi (2006) the purpose of the platforms is to provide a knowledge base for coordinating the various activities based on technology specialization across sectors. It creates various thematic or sectoral platforms or regional networks where adaptive learning is taking place. Such platforms should be integrated into the economic environment of the region and accentuated in the conception of public policies and subsequent political decisions.

The establishment of the platform may be initiated by a public or private entity associated with the creation of a legal entity which becomes the coordinator of the activities entrusted to it. It also serves to fulfill government strategies and priorities in the area of research and development and to coordinate various projects in regions with the aim of contributing to technological progress. Technology and innovations platforms are the bases for research and development using new knowledge through new technologies and expertise (Nourani, 2017).

Technology and innovation platforms work similarly to quadruple helix (digram is in Figure 3), bringing together stakeholders from the public sector, industry, the knowledge sector, and civil

society. It creates so-called political platforms which, based on a defined public policy promoting technology or innovation, use technological or knowledge bases to develop a regional advantage (Prokop and Stejskal, 2018).

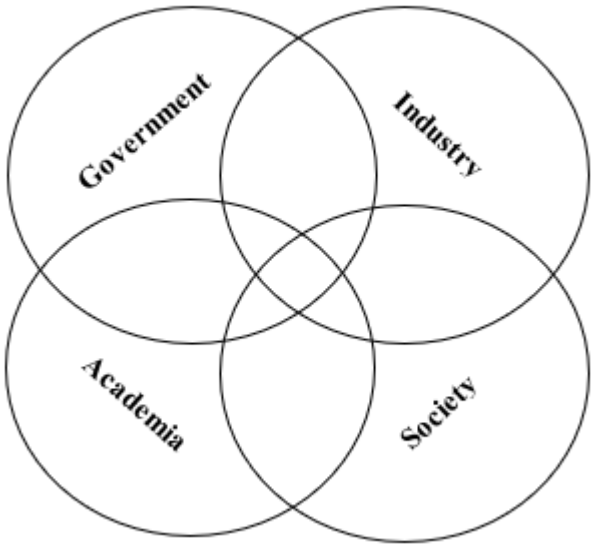


Figure 3: Quadruple helix model
Source: own processing acording to Parveen et al. (2015)

Industrial zones

Industrial zones are specific, artificially created environments, equipped with quality infrastructure, and providing a select range of services to locate significant entrepreneurs in the region. At the same time, industrial zones seek to attract foreign businesses through industrial zones to help reduce current unemployment and help restructure existing industrial production (Prokop and Stejskal, 2018; Sun et al., 2020).

The industrial zone provides a high quality environment for companies in various fields through production, assembly and sales. It is a large building area that provides the land and equipment of factories or even factory halls. They are designed for the types of businesses that usually engage in production activities (Rylková, 2011; Pan, 2017).

Science and technology parks

Science and technology parks provide the necessary space and services to companies with a long history of the business. The presence of advanced companies within such a park promotes the drawing of the less "experienced" into the business world (CzechInvest, 2012).

The main use of science and technology parks was to boost economic growth and reduce the high unemployment rate. In general, science and technology parks are understood as functionally

structured architectural complexes of R&D and laboratory buildings, design and construction offices, production halls, warehouses, pavilions and conference halls, hotels, and recreational facilities on an area of several hectares (Prokop and Stejskal, 2018).

Science and technology parks are usually profiled into three main types (Veber et al., 2016):

- science park,
- technology park,
- business and innovation center.

Science and technology parks are recruited from state and regional authorities, universities, research, and development organizations, industrial enterprises, private companies, associations, and unions. Science and technology parks focus on science, technology, innovative entrepreneurship, and vocational education. Science and technology parks work in close cooperation with universities, research institutes, and research institutes. They provide system support in the area of development of innovative business, technology transfer, support of innovative small and medium-sized companies. Science and technology parks should fulfill several functions (Macdonald and Joseph, 2001; Veber et al., 2016):

- incubation – consists in providing services that are typical for a business incubator it is about helping and supporting the entrepreneur in the phase of starting a business,
- innovative – consists in creating an environment for business activities of companies that are dedicated to modern technologies, offering laboratories, prototype workshops, sharing exclusive technologies,
- technology transfer – consists in providing facilities for the transfer of technical knowledge, solutions, etc. It is a connection of research institutions or universities with business entities that are ready to transfer these theoretical solutions to the implementation phase.

Business incubators

Business incubators are organizations set up to promote the intensity, quality, and speed of innovations dissemination and technology transfer into the region's economic practice with an emphasis on progressive high tech technologies (Mavi et al., 2019).

For starting entrepreneurs (businesses) that have the innovation potential given by an exciting idea or a right idea of product innovation, business incubators can offer business facilities in the form of offices, conference and meeting rooms, internet, cleaning, kitchen, etc. Business incubators also provide consulting services business activities or the establishment of a company, marketing, bookkeeping, taxes, etc. An essential part of their offer is also the provision of research laboratory

equipment or operational background for the start of production (Veber et al., 2016; Wolniak, 2019; Haugh, 2020).

Business incubators primarily perform the incubation function. They help with the organization of professional seminars and courses, meetings of companies with the aim of exchanging experience, etc. By arranging contacts with suppliers and customers both at home and abroad (Heřman et al., 2008). Business incubators are trying to cope with market failures. Incubators have different orientations, economic development incubators are focused on closing gaps in regional development. Technology incubators are focused on the development of technology companies (Aernoudt, 2004).

Prokop and Stejskal (2018) add that the main goal of business incubators is the education of self-sufficient companies that will be financially viable after leaving the business incubator and will have the ability to compete on the market. This, in turn, creates the potential for creating new jobs, creating innovations, and thus strengthening the regional and national economy.

1.5 Innovation environment

Businesses are affected by the innovation environment (IE) both internally and externally. Significant IE for internal processes is mainly caused by globalization, changes in forms of competitive advantage and increased importance of Information and Communication Technologies (ICT; Prokop and Stejskal, 2018).

According to Ribeiro and Cherobim (2017) innovation environment indicates issues that take place outside the organization's boundaries, but which influence the organization's decisions. Tsuja and Mariño (2013) add that IE is a direct motivator for implementing changes in society. It is a major factor for organizational innovations and stimulating the creation of new products, services and processes leading to market competitiveness. The innovation environment is an external force that affects the behavior of organizations depending on the market in which the organization operates and the technology it uses. Rapid changes in IE force companies to modify existing ones and create new goods, services and processes.

Blažek and Uhlíř (2011) state that innovations usually take place on the basis of the influence of the relationship between the company and the innovation environment, not on the basis of the company's internal stimulation. The IE is not only about the relationship between companies and institutions, but it is also a general framework for corporate activities such as the structure of the company, political culture and social values of the company in which the company is based. In this

context, the proximity (social, cultural, organizational, spatial) is important, spatial proximity alone does not guarantee the initiation of the innovation process.

Some authors also use the term innovation ecosystem (Jackson, 2011; Sun et al., 2019; Fukuda, 2020; Xie and Wang, 2020). According to Granstrand and Holgersson (2020, p. 1) „*innovation ecosystem is the evolving set of actors, activities, and artifacts* (tangible, intangible resources, products, services and other system inputs, including innovations), *and the institutions and relations, including complementary and substitute relations, that are important for the innovative performance of an actor or a population of actors.“* This definition is compatible with related conceptualizations of innovation systems.

According to Fransman (2018) innovation ecosystem is a set of players and processes that, through their interactions, make innovation happen, and by so doing coevolve.

Companies respond differently to new innovation environmental challenges. Some companies take technology from other companies, while others make their own research and development efforts to remain competitive (Barkema et al., 2002). Innovative activities are supported in a society with high demand and sufficient resources. In contrast, in a society with low demand and limited resources, innovation activities are rare (Katila and Shane, 2005).

Other important elements of the innovation ecosystem, according to Prokop and Stejskal (2018) are:

- dynamics – change of pace within the innovation environment is determined primarily by the competitive IE and the speed of technological development and rapid changes in ICT. All these forces individual economic entities to adapt and respond dynamically through the outputs of their innovation activities,
- proximity – based on the proximity criterion, there are two categories microeconomic and macroeconomic. The microeconomic environment has a direct impact on business and the performance of businesses and other market participants. The macroeconomic environment is less significant and has the potential to influence individual entities rather indirectly, and with impact in the long-term. The macroeconomic environment includes mainly political, economic, social, cultural, technological, and legal factors. The proximity of economic entities can also be perceived from a geographical perspective. The region is the most suitable platform for the creation of innovative ecosystems. Geographical proximity is the most appropriate and is, therefore, an important attribute of the innovation environment (Zhang et al., 2011),

- co-evolution – development of the economic community, which arises through connections between individual entities in the environment. More important is the activity of companies that are more developed. It makes a distinction between evolution, which is a mechanism based on own will and evolution that is externally controlled or regulated,
- interdependencies – different types of chaining and cooperative forms can be distinguished according to the level of strength and frequency of links between individual subjects. Reciprocity expresses the interdependence of economic activities on which success depends (Radziwon and Bogers, 2019),
- orchestrator – a key player in the innovation environment, which is either the strongest economic entity with interest in the creation and functioning of a quality innovation system, or it can be any large enterprise or research organization that delivers a significant production resource that can influence the entire innovation system.

1.6 Tools to support innovations in the European Union

Because the aim of this diploma thesis is to analyze regional innovation systems in two European countries, the following part is focused on tools to support innovations in the European Union.

It has already been mentioned that innovation is essential for the EU's competitiveness in the global economy. The European Union uses regional policy and European funds, which are implemented through operational programs, whose administrators are ministries.

The government can support economic activities in a selected part of the country through the direction of regional policy. Regional policy in the European Union operates on the principle of solidarity, where more developed EU countries contribute to the development of less developed EU countries and thus help to improve the lives of citizens throughout the European Union. This policy is sometimes called social cohesion policy or cohesion policy (National Coordination Authority, 2006). The European Union invests strategically in all regions and cities in the EU and seeks to achieve economic growth, job creation and a better quality of life (Radicic et al., 2016; European Comission, 2019). It comes out from the Single European Act (1986, p. 105) where definition of economic and social cohesion is "*reducing disparities between the various regions and the backwardness of the least-favored regions.*"

The European Union regional policy is focused on these main themes (European Comission, 2019):

- promoting social inclusion through investment in education and employment,
- supporting SMEs,
- support for the creation and strengthening of research jobs for research and innovation,

- support for projects improving the environment,
- support for projects focusing on transport and energy production with regard to climate change and focusing on renewable energy sources.

Crescenzi and Rodríguez-Pose (2011) state that investing in research & innovation (R&I) leads to the promotion of a sustainable future for the EU, the maintenance of its competitiveness and the possibility of preserving its social model. At the same time, R&I helps to solve the greatest societal challenges and improves the everyday lives of people in the EU.

The EU's support for R&I creates the collaboration of research teams across countries and disciplines that are essential to breakthrough discoveries. EU funds support the following:

- consolidating position in science,
- supports the emergence of important technologies, industrial innovation and SME access to capital,
- supports tackling climate change and building sustainable transport and energy,
- supports the commercialization of technological discovery by building partnerships in industry and with governments,
- supports the expansion of cooperation in R&I.

Primary goals of European Union's R&I policies are (Mazzucato, 2018; European Commission, 2019):

- open innovation – enables non-academic and non-science professionals to engage in innovation processes. By involving more people in innovation processes, it helps to spread knowledge, which can then lead to the creation of new products and services,
- open science – enables faster dissemination of new knowledge in science using digital and collaborative technology already in the course of research. Previously, scientific results were not published until the research process was completed,
- open to the world – seeks international cooperation in research, enabling the EU to gain access to the latest knowledge in the world, attract new experts and create new business opportunities.

An important fund for innovation, as well as a fund with the most enormous financial volume, is the **European Regional Development Fund** (ERDF). The ERDF focused its investments on the following areas (Torkkeli, 2016; European Commision, 2017):

- R&I,
- support SMEs,

- the digital agenda,
- minimizing carbon formation in the economy.

The ERDF allocated its resources according to the following levels of regions:

- more developed regions must allocate at least 80 % of resources to at least two of the above-mentioned priorities,
- transition regions must allocate at least 60 % of resources to at least two of the above-mentioned priorities,
- less developed regions must allocate at least 50 % of resources to at least two of the above-mentioned priorities.

Investment priorities of the ERDF are more specific by European Parliament and of the Counci in Article 5 in regulation No. 1301/2013.

To strengthen R&I and technological development is achieved by:

- strengthening R&I infrastructure, development capacities and expansion of competence centers,
- support for private sector investment in R&I, support for the creation of links between companies, development centers and universities. Support for networking, clusters and technological and applied research, pilot lines, early product validation actions, advanced manufacturing capabilities, and first production, in particular in key enabling technologies and diffusion of general-purpose technologies.

Strengthening the competitiveness of SMEs through:

- business support through business incubators, the use of new ideas and the establishment of companies,
- implementation and development of new business models with regard to internationalization,
- support for the creation of additional capacities for product and service development,
- supporting the ability of SMEs to participate in innovation processes and participation in global markets.

Another relevant fund is the **European Fund for Strategic Investments** (EFSI) is aimed to activate the liquidity held by economic subjects in times of limited public resources and to help solve the lack of confidence and investment caused by the economic crisis. The EFSI is focused on investments in infrastructure, sustainable energy, R&I, environment, digital technologies,

agriculture and health. At the same time, it helps SMEs expand them by providing risk finance (Romero-Martínez et al., 2009; European Commision, 2018).

The EFSI provides guarantees for European Investment Bank (EIB), thus protecting it from loss. With this guarantee, the European Investment Bank can provide financing for riskier projects. The EU has a European Investment Fund (EIF) to provide loans to SMEs.

The European Investment Bank (EIB) provides the following (EIB, 2017):

- loans – provides loans to entities of all sizes in order to promote sustainable growth and job creation and thus attract other investors,
- equity – uses the private capital of investors through equity funds,
- guarantees – It offers loan portfolios to make projects more attractive to investors and provides guarantees for SMEs,
- advisory services – offers expertise for the development and implementation of investment projects and programs,
- blending – helps companies solve the lack of finance in the markets through a combination of loans and grants provided by private, public and philanthropic organizations.

The European Investment Fund (EIF, 2015) supports SMEs in EU by ensuring better access to funding from selected financial intermediaries. The EIF designs promote and implement equity and debt financial instruments that target SMEs and also enforces the EU objectives to promote entrepreneurship, growth, innovation, R&D, and employment.

The EIF is a specialized provider of risk financing for SMEs across Europe. The EIF carries out its activities from its own resources, from funds provided by the EIB and the European Commission or by individual EU countries. These funds are reached by companies through banks, funds and other for-profit and leasing companies.

Horizon 2020

Among the R&I programs to support the EU's competitiveness, Horizon 2020 is the most important, allocating € 80 billion for the period 2014-2020. By connecting R&I, Horizon 2020 helps to achieve competitiveness by focusing on R&D, industry and solve societal challenges. The goal is to remove barriers to innovation, facilitate public-private partnerships and help produce world-class science (European Commission, 2017).

The target group of Horizon 2020 are researchers working in universities, research institutes and industrial companies, as well as companies that can fund technological research and activities

through the program. There is also the possibility of drawing support for non-profit organizations and other interest groups focusing on research and industry (AVCR, 2016).

Horizon 2020 is focsed on the following priorities**:**

- excellent science strengthen the level of quality of science in the EU,
- industrial leadership – support for SMEs, entrepreneurship and innovations,
- societal challenges – respond to the challenges in society and support their solution.

These tools, together with the innovation infrastructure and innovation environment, helps to transfer knowledge, create innovation, and are part of innovation systems, which are described in the next chapter.

2 Innovation systems in economies

This chapter contains theoretical description of innovation cooperation, innovation systems, national innovation systems, regional innovation systems, types of regional innovation systems, limitations of regional innovation systems, and evaluation of regional innovation systems.

2.1 Innovation cooperation

Companies cooperate with other actors not only to reduce the costs and risks of R&D but also to gain access to new markets, technologies, and other people's capabilities. These relationships, based on mutual trust and social cohesion, are creating innovation networks (Gust-Bardon, 2014). Companies that are part of innovation networks and work with other companies are better able to create innovations. The ability to innovate is linked to how companies can spread knowledge among themselves. Companies learn from each other and supplement their mutual shortcomings, which they would not be able to solve without cooperation with other companies (Doloreux, 2002).

Well-functioning innovation networks have following features (Gust-Bardon, 2014):

- involve many actors in the region with diversified knowledge and information,
- include external actors who provide information in regional networks and technologies absent from the region and representing new markets,
- interactions between regional actors lead to innovations,
- regional actors are able to respond with solutions that one of the other companies has already used, adapting these solutions to the current situation and thus creating a new solution.

On the idea of mutual cooperation are formed industrial clusters which work on the principle of cooperative competition. The companies that are most competitive will find a way to work together even though they are rivals fighting for the same place in the market. In this way, companies minimize risks and maximize their competitiveness by exchanging information with their competitors. This way of cooperation based on trust and strong ties is most often described in industrial districts in third Italy, where SMEs faced more competition in this way (Bergman, 2020).

According to Porter (1998) clusters are formed by connecting companies and institutions in the same field and in a certain region. They are made up of interconnected industries and other institutions that are important for competitiveness as suppliers, service providers and providers of critical infrastructure. Many clusters also include public institutions such as universities and

various business organizations that provide education and support. The individual subjects of the cluster and their connections are shown in Figure 4.

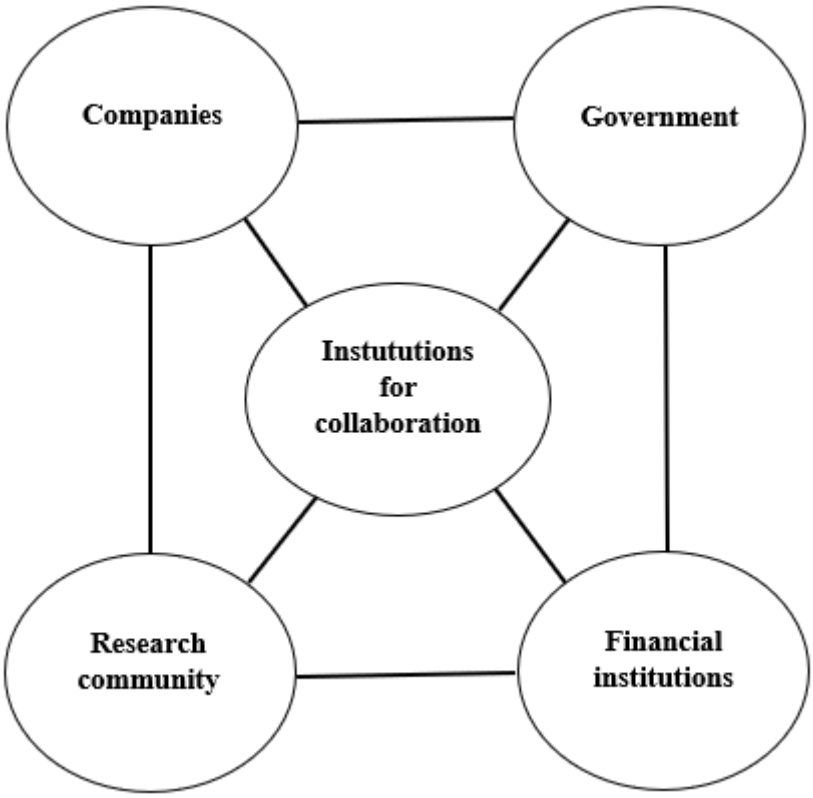


Figure 4: Cluster's actors
Source: own processing acording to Andresson (2004)

The concept of innovation systems emphasizes the importance of networks as a key factor influencing innovation performance (Powell and Grodal, 2006; Roettmer, 2011). Other forms of cooperation (national innovation systems and regional innovation systems) are described in individual parts of this thesis.

2.2 Concept of innovation systems

In the 1980s and 1990s, as a result of the recognition of the importance of innovation in economic development, a new, systemic approach to innovation emerged (Ludvall, 1992; Edquist, 2000; Doloreux and Parto, 2005). Innovation systems represent a set of institutions and participants influencing innovation processes in the state (Skokan, 2004).

The essence of innovation systems is an interactive and dynamic process that leads to the creation of innovations. These are two-way processes during which learning takes place, and the individual subjects involved in these processes acquire new tacit knowledge (Uyarra, 2011). These processes

can take place at different levels and geographically defined territorial areas, which usually determines their type (Prokop and Stejskal, 2018).

The innovation system consists of individual elements such as companies that have their own research and the necessary infrastructure. These include private research institutions, public research institutions, technology agencies, knowledge dissemination organizations and educational institutions (Skokan, 2004). The set of various institutions that together and independently contribute to the development and dissemination of new knowledge and technologies that operate within a governments set framework and create the innovation process is called the innovation system.

Innovations do not arise in isolation, according to Prokop and Stejskal (2018), innovations need a suitable environment for their effective emergence, ideally a network of suitable entities operating in a similar field, which are willing to cooperate and share. In such a network, a number of synergy effects based on the knowledge base are created, know-how is diffused, and platforms are created that facilitate individual processes. Based on these processes, Lundvall (2010) defined the innovation system as elements and relationships through which the production, dissemination and use of new knowledge arises. This definition is extended by another characteristic of the complex innovation system (Uyarra 2011):

- the dynamic structure has interdependent components that cooperate comprehensively,
- the system is open, and it is difficult to identify borders,
- the organization takes place independently, and urgent events can help change the structure or create a completely new system.

The approach to innovation systems has spread rapidly in academia and public innovation policy. It is used for economic policy purposes by the OECD, the European Union, United Nations Industrial Development Organization (UNIDO), and many individual countries. Innovation systems are at the heart of thinking about innovation and its relationship to economic growth, competitiveness, and employment. The European Union initiates and pays the development of regional innovation strategies from the Structural Funds to help develop innovation systems (Fisher and Fröhlich, 2001; Skokan, 2004).

2.3 National Innovation Systems

In this part, National Innovation Systems (NIS) are defined because these systems are seen as prerequisites for defining regional innovation systems.

Tinguely (2013) states that term national innovation system was first used in a study of the innovation environment in the Japanese economy in 1987 by Christopher Freeman. Freeman (1987) defined national innovation systems as a network of private and public institutions that combine joint activities and interactions leading to the import, modification and dissemination of new technologies. The innovation performance of NIS is influenced by the involvement of the private and public spheres in innovation processes, social affairs and the policy framework in the country.

According to Lundvall (2016), Friedrich List was the first who used term national innovation systems. List used term NIS in a paper which distinguishes between Adam Smith's cosmopolitan approach, which is focused on development and productivity from a national perspective and the exchange and allocation associated with it. His in-depth analysis indicated the need for government responsibility for education and training and the development of infrastructure to support industrial development.

According to Prokop and Stejskal (2018) NIS is a specific subsystem of the national economy, in which there is a specific circle of entities and institutions that carry out innovative activities at a certain level of cooperation and a certain stage of technological development. This concept has been used, for example, by the World Bank or the United Nations to assess technological change in emerging economies.

Many economists agree that NIS has various follow-up processes (Balzat and Hanush, 2004):

- research,
- production of innovation,
- end-use of innovation,
- linkage,
- education.

These innovation processes can be characterized by many different indicators that can be used for macroeconomic analysis or international comparisons. Examples are the volume of expenditure on science and research, the performance of science and research measured by various indicators, the targeting of public policy aimed at supporting innovation or technological development, human capital development or entrepreneurial innovation activity, and their performance (Tödtling and Trippl, 2005; Skokan, 2010).

Different countries have different variants of innovation systems, but the following common characteristics can be found (Edquist, 2000; Skokan, 2004):

- the focus is on innovation and learning processes,
- the holistic approach is used, which includes different levels of innovation systems (national, regional, sectoral) and an interdisciplinary approach,
- historical view (path dependence) is used, innovation processes are considered to be evolutionary processes, which can be very different in different countries. The same applies to regional and sectoral systems. It does not insist on the concept of an optimal system, which is difficult to define,
- the interdependence or interconnectedness of the participants in the innovation process, non-linearity and the importance of demand as determinants of innovation are emphasized,
- include the development and dissemination of product and process innovations,
- mainly the institutions providing the invoicing process are important, such as industrial R&D, universities and state policy,
- however, there are a number of ambiguities and conceptual dispersals,
- innovation systems represent a conceptual framework rather than a formal theory.

In the case of national innovations systems, many studies agreed on several fundamental limitations of this type of innovation systems (Maťátková, 2013):

- only a verbal description of the national innovation formulas is given,
- national innovation systems are usually concentrated in only one economy and focus on the description of the innovation system of only one country,
- the conclusions of the NIS studies differ considerably in the absence of a formalized methodology for carrying out this type of analysis,
- elements of the innovation system may be represented in the given economy (from the national point of view), but in the detailed view, they may be missing in individual regions, which significantly limits the possibility of its creation or functioning.

Other weaknesses of NIS are difficulties in trying to shift the development of the innovation environment from the national level because despite the application of public policies aimed at balanced regional development, differences in regional development remain. Due to this specificity of individual regions, it was necessary to move lower to the regional level, where it is possible to eliminate significant differences in development more effectively. Due to these limiting reasons, the NIS experienced a significant change in 1990s, and a new concept of regional innovation systems (RIS) was emerged (Asheim et al., 2011; Uyarra, 2011).

2.4 Regional Innovation Systems

This part is focused on the Regional Innovation Systems (RIS), which are analyzed in chapter 4 of this diploma thesis.

Cooke came up with the concept of regional innovation systems in the 1990s (Cooke, 1992). This theory has gained great popularity and is addressed by many renowned economists and academics, as well as representatives of the political scene, as it provides an analytical framework for a conceptual approach to supporting and strengthening innovation processes at the regional level. McCann and Ortega-Argilés (2013) also confirmed that the concept of RIS has fundamentally influenced the policy view of innovation around the world, both in providing guidance on why innovation varies greatly between different locations and in identifying possible policy responses. The regional innovations system is a tool to support the dissemination of knowledge and create a competitive advantage for entities. It makes it possible to define public policy and support systems to enable the connection of local businesses and other organizations that will support the growth of the region through the creation of innovation and jobs (Cooke et al., 2011).

Doloreux (2002) described 4 basic elements of RIS, namely enterprises, institutions, knowledge infrastructure, and policy (Uyarra, 2010):

- enterprises are learning organizations that interact with other companies and create the environment. All companies are simultaneously users, manufacturers, and associates as well as competitors (Asheim et al., 2011),
- institutions are governments and institutions that have the competence to decide how knowledge will be created and transferred. They coordinate the use of knowledge, provide incentives and prevent conflicts (Žítek and Klímová, 2016),
- knowledge infrastructure is the physical and organizational infrastructure used to support innovation. These can be science and technology parks, business incubators, technology transfer centers, innovation centers, or consulting agencies. It also includes research institutes, laboratories, and universities which provide support and information for knowledge-based companies (Jin et al., 2015),
- regional innovation policy is aimed to promote interaction between businesses, institutions and knowledge infrastructure. Its goal is to develop the potential of the region by supporting the dissemination of knowledge in the region. At the same time, it focuses on improving innovation performance by creating an institutional framework (Fischer, 2001).

These key elements create critical activities in the innovation system (Edquist, 2011).

Providing input knowledge for innovation processes.

- Ensuring the implementation and results of research and development,
- creating competencies of employees that are applicable in innovation and research activities.

Activities on the demand side.

- Creating new markets for products,
- creating requirements arising from the demand for new products.

Providing elements for the innovation system.

- Transformation and creating organizations needed for the development of new innovations (government agencies),
- cooperation through the market and other mechanisms,
- institution building and change.

Support services for innovative companies.

- Incubation activities,
- financing of innovation processes and other activities leading to the commercialization of knowledge,
- providing consulting services relevant to innovation activities.

According to Wolfe (2000), successful RIS has five key factors (presence of the leader, civic awareness, the scientific and technological infrastructure, the availability of the local finance, regional government). The presence of the leader and the vision is the most important of them. This leader can be a political institution, an industry association, a major company, or a university. Its main role is to mobilize the local community to support innovation. Another factor is civic awareness, which influences the building of a shared vision and goals and creates a suitable environment for innovation. The third factor is the scientific and technological infrastructure (i.e., especially educational and research organizations), which should work closely with industry. The fourth key factor is the availability of local finance to support innovative companies, such as local banks or venture capital funds. The last factor is the regional government, which should work with industry (business) leaders. Although the role of government is not crucial, can significantly influence the development of Innovation.

Skokan (2005) evaluates successful regional innovation systems according to several common features, especially in the following areas:

- economic indicators (high GDP, large number of companies, presence of companies in knowledge-intensive industries, skilled labor, exports),
- research activity (emergence of innovations in the region, innovations in research and development from private entities),
- research infrastructure (institutions providing the required facilities for R&D), policy (legal framework enabling the necessary activities and support),
- social networks (interaction between companies and research institutions, business-to-business cooperation).

According to Tödtling and Trippl (2011) RIS is consisted of two subsystems with a common socio-economic and cultural environment in the region (Autio, 1998):

- the knowledge application and exploitation subsystem,
- the knowledge generation and diffusion subsystem.

The knowledge application and exploitation subsystem contains companies, their suppliers, competitors, customers and other partners from the region. The knowledge generation and diffusion subsystem contains organizations involved in the creation and dissemination of knowledge. The key elements are public research institutions and institutions that mediate the transfer of results, educational institutions and staffing organizations. The setting of policy in the region also plays an important role, which can significantly influence the implementation of innovations (Cooke et al., 2000; Asheim and Coenen, 2005; Tödtling and Trippl, 2005; Asheim, 2007; Trippl and Otto, 2009). There are relationships between these subsystems that facilitate the flow and exchange of knowledge, human capital and other resources (Svetikas, 2014, Stejskal et al., 2018). The basic structure of regional innovation systems is shown in Figure 5, and also can be divided into several types of RIS.

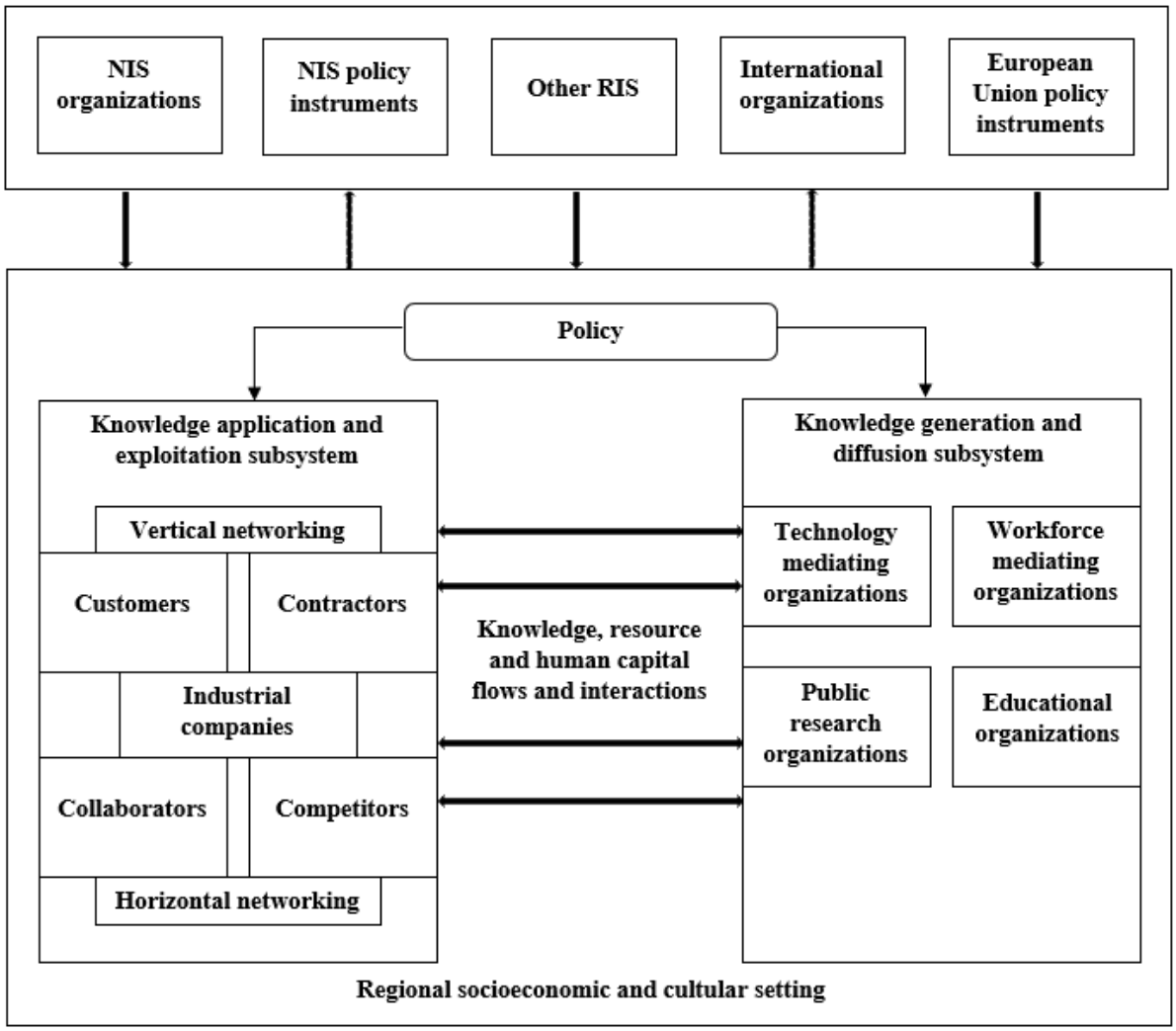


Figure 5: Basic structure of regional innovation systems
Source: own processing according to Tödtling and Trippl (2005)

2.4.1 Types of Regional Innovation Systems

Braczyk et al. (1998) divided RIS into three parts according to its level of business structure: locally-patriotic, cooperatively-interactive, globalized.

According to Braczyk et al. (1998) RIS are divided into three levels

The **local-patriotic** type of RIS is based on the links between SMEs and the creator of the regional policy framework. Companies cooperate with each other in the field of research and development only to a small extent. Within the defined policy, public support for the creation of innovations is provided to companies, and the innovation environment is saturated with the establishment of research centers owned by the public sector. Interest in private investment is very minimal (Stuck et al., 2016; Prokop and Stejskal, 2018).

The **cooperative-interactive** type of RIS assumes that there are medium and large domestic and foreign companies in the region. At the same time, it presupposes the existence of private and public research organizations. Individual subjects in RIS have created strong and high-quality links leading to the creation of innovations. These activities are financed from a number of different sources, starting with foreign direct investment and ending with public support determined by innovative public policy (Stuck et al., 2016).

The **globalized** type of RIS presupposes the participation of large multinational companies, members of global production chains and networks, major internationally operating clusters. This type of RIS assumes a certain dependence of local SMEs on business opportunities within the supply chains of dominant companies. Research and educational organizations in this type of RIS are rather private, often an internal part of large companies, or responding strictly to their internal needs (Skokan, 2005). Appropriately targeted support for SMEs can also help to involve these companies in the knowledge flows of large companies. An example of globalized RIS is Silicon Valley, which is the most industrialized part of the United States and is a significant center for the high-tech industry in the world (Stuck et al., 2016)

Cooke (1992) divided RIS into three types, which emphasizes in particular, the transfer of knowledge and its influence on the creation of innovations that take place in RIS. These types are: grass-rooted, networked, dirigistic.

In the **grassroots** type of RIS, the need for technology transfer, and the creation of innovations at the local level arises unevenly in various economic entities. The local university is perceived in certain specific areas as a source of new technologies and can become a partner of local industrial enterprises. The local government also plays a role in this type of RIS. It can support technology transfer through subsidies from its budget, or run a local development agency. Support from the regional or national level is usually not provided, nor are there any significant coordination activities (Lundvall, 1992; Hassink, 2002; Cooke, 2004)

The **network** type RIS represents a more developed grass-roots type of RIS. In this type, mutually innovation-oriented relations between subjects are strengthened, and local, regional, or national governments also play a more active role. This type of RIS is more coordinated, it is managed in terms of efficient operation, it works according to the needs of large, but also medium and small enterprises. Coordination is carried out sensitively so that its interventions do not disrupt relations between the subjects of the system. There are support organizations to facilitate technology transfer, which are publicly funded and an instrument of innovative public policy (Nauweleaers et al., 2000; Hassink, 2002).

The **dirigiste** type is the opposite of the RIS grass-roots type. The networking initiative comes directly from localized organizations. This system is supported by the external environment of the system from the supranational, national, and regional levels (Hassink, 2002). The public sector's role in this type of RIS is to prepare a suitable technological infrastructure and to locate it in a decentralized manner in the territory and to strengthen the knowledge environment. In accordance with their development, the created technology centers will strengthen and tend to grow into the system and cooperate mainly with large companies outside and inside the region (Nauweleaers et al., 2000; Cooke, 2004).

This Cooke's (1992) division was extended by Asheim and Coenen (2005) by the following types: territorially embedded, regionally networked, regionalized.

The **territorially embedded** type of RIS can be likened to an entrenched innovation system. It is primarily a business network of SMEs in one region. A limited number of companies based in the region enter this system and the public sector creates investment offers and knowledge infrastructure. The advantages are geographical, social, and cultural proximity, which motivate localized subjects to cooperate (Cooke, 1998; Asheim and Isaksen, 2002).

The **regionally networked** type of RIS is defined on the basis of a common strategy between the knowledge provider and localized enterprises. Individual subjects cooperate in the creation of innovations and accept emerging side effects in the form of adaptive learning outcomes, spill-over effects of knowledge, or synergistic effects. In this type of RIS, there is relatively massive public support aimed at increasing the absorption capacity of companies, establishing new forms of cooperation, and creating innovations. It is similar to the RIS network model (Cooke, 1998; Asheim and Coenen, 2005).

The **regionalized** type of RIS differs from the territorially delimited and regionally networked RIS in that part of the investor or knowledge infrastructure as well as institutions operating in the region are significantly connected to the national innovation system. That is why some authors refer to this as a regionalized NIS. In the regionalized system, the linear innovation model is mainly applied, which often takes place in technology platforms, technopolis, or science and technology parks (Amin and Cohendet, 2003; Asheim and Coenen, 2005; Asheim, 2007).

2.4.2 Limitations of Regional Innovation Systems

Regional Innovation Systems have similary to National Innovations Systems their limitations that prevent them from functioning effectively and thus reduce the region's ability to generate innovations and achieve economic growth and competitiveness.

Tödtling and Trippl (2005) defined deficiencies (see Figure 6) in RIS, the required development of research and innovation activities is not achieved, and an innovation paradox[3] has occurred. These deficiencies are:

- organisational thinness – RIS, in which some of the basic elements are missing or poorly developed (lack of innovative companies and key knowledge-oriented organizations, insufficient knowledge infrastructure, lack of motivation to transfer technology, low level of networking, or clustering). This type of RIS occurs in peripheral regions (Isaksen, 2001; Stejskal, 2018; Trippl et al., 2019),
- lock-in – RIS is characterized by excessive rooting and an excess of specialization from traditional, often declining industries using outdated technologies. The region is closed from the surroundings and is not interested in further development. This type of RIS occurs in old industrial areas or in metropolitan regions, which are highly developed, which reduces interest in their own development. There is a technological and knowledge stagnation, lagging behind and a low pace of development (Isaksen and Trippl, 2016; Martin et al., 2018),
- fragmentation – RIS with lack of mutual relations between subjects, exchange of knowledge and technology transfer between some subject in systems not taking place. The result of it is an insufficient level of collective learning and systemic innovation activities. This type of RIS occurs in metropolitan regions (Asheim et al., 2016; Tödtling and Trippl 2018).

[3] Innovative paradox occurs in situation when regional or national governments provide public funds to support the emergence of RIS, but in the end it does not occur required results even after a long time. This may be due to low capacity and the ability to absorb public funds for support innovation systems. The reason for inefficient allocation may also be the fact that the functionality of RIS depends primarily on the willingness of entities to cooperate, share and transfer knowledge or technology. Willingness depends mainly on previous experience, the degree of trust and the business environment and cannot be significantly influenced by public investment (Oughton et al., 2002; Cirera and Maloney, 2017).

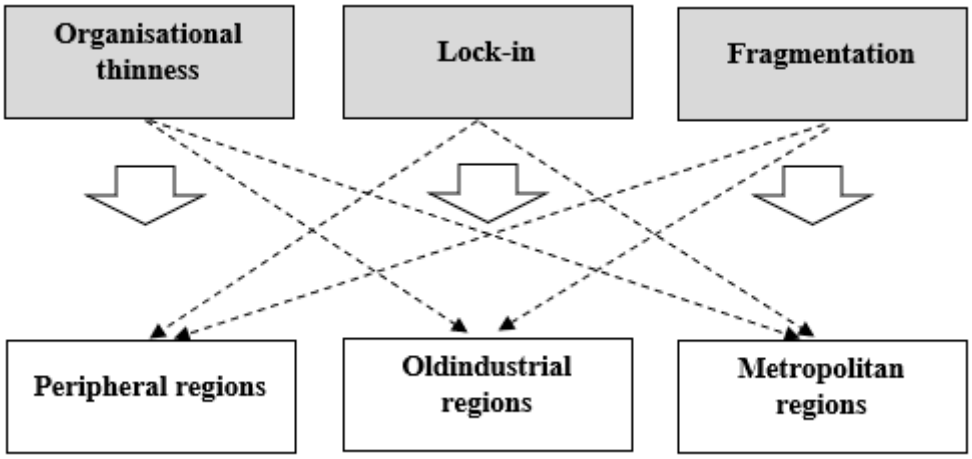


Figure 6: Main innovation barriers
Source: own processing acording to Tödtling and Trippl (2005)

These deficiencies of RIS are found in the following regions.

Metropolitan regions are those where specialized companies, knowledge and research organizations are located. There is also investment and knowledge infrastructure enabling cooperation on various projects. Knowledge-intensive companies or branches of large international corporations are often located in the region. In these conditions, above-average research and innovation activities take place (Fischer, 2001; Ženka and Slach, 2019; Galland and Harrison, 2020).

Old industrial regions suffer from various structural problems. These are regions where there are highly specialized large companies, the production of which is of little interest in the world and other markets. High specialization and current economic problems lead to a loss of competitiveness and usually a halt to innovation activities. This situation is typical for regions with a strong mining, metallurgical industry, but also regions specializing in some specific electronic products (Birch et al., 2010; Gagarina, 2019).

Peripheral regions are regions in which important elements of RIS are not developed, innovation activity, and the absorption capacity of enterprises is low. There are mostly SMEs that do not focus on R&D. Firms are primarily focused on the production or manufacture of intermediate products in the business chain. There are not enough innovative companies in the region to allow the creation of an industrial cluster or other types of networks. There is a lack of quality educational or scientific research organization. Infrastructure and institutions to support technology transfer or business support are present in this region. However, they are usually obsolete and do not work effectively (Doloreux and Dionne, 2008; Grillitsch and Nilsson, 2015; Isaksen and Trippl, 2017).

2.4.3 Evaluation of Regional Innovation Systems

Maťátková and Stejskal (2011) proposed a set of standard (average) RIS characters. The existence of these elements (layers), which are in Table 2, is a prerequisite for a well-functioning RIS. At the same time, there is a precondition for the active cooperation of these layers on the basis of the triple helix model, which is perceived as a general platform for the creation and operation of innovation systems. Triple helix represents cooperative relations between individual actors in the region, mainly companies, universities or research organizations, and public sector representatives (Peris Ortiz et al., 2016).

Table 2: Elements of the Regional Innovation Systems

RIS layer	Elements
Businesses	Industrial clusters Innovative companies Registered patents
Support organizations	Institutions supporting cooperation Business incubators Regional development agencies Other supporting and complementary organizations
Environment and infrastructure	Regional innovation strategies Animators in the industry Organizations forming a professional community Professional societies and associations in the field Public financial scheme Private financial initiatives Elements of technological, knowledge and physical infrastructure
Relationships, ties	Communication channels Projects confirming cooperation and synergy

Source: Maťátková and Stejskal (2011)

The model proposed by Maťátková and Stejskal (2011) mainly evaluates the existence of these elements. However, their mutual cooperation is important for the functioning of RIS, as evidenced by some results of studies, the results of which are in Table 3.

Table 3: Evaluation of regional innovation systems

Author	Evaluated country	Analyzed factors	Results
Koschatzky and Sternberg (2000)	Austria, France, Spain, Germany, Slovenia, Holland, United	Relationship between space (size of manufacturing firms) and innovation networks (types of cooperation).	Authors state that the spatial innovation links depend on the size and type of cooperating company, as well as on the complexity of R&D in a particular industry. The higher the technological complexity of the sector is, the greater

	Kingdom, Sweden		is the need to use and create interregional links.
Doloreux et al. (2004)	Sweden	Innovation activities (product innovations), and collaborations (with external partner, types of collaborators).	Authors confirmed strong evidence of co-operation and collaboration formed to achieve product innovation. Of these, user-producer collaborations are the dominant type of relationships.
Doloreux and Dionne (2008)	Canada	Elements leading to innovation activities and the emergence of RIS in peripheral regions (knowledge infrastructure, size, location etc.)	The authors state that the location and size do not limit the existence of the innovation system. Knowledge infrastructure, technology transfer and social capital are key factors for innovation activities, growth and development.
Kallio et al. (2010)	Finland	Absorptive capacity and social capital.	The authors divide social capital into (1) organizational bonding social capital, which mediates acquired knowledge and uses it in innovation processes, (2) regional bridging social capital, which mediates knowledge through structural holes, facilitates knowledge absorption and diversifies the knowledge base in the region, (3) personal creative social capital, which indicates the ability of people to take risks and continue even after making a mistake.
Fritch and Graf (2011)	Germany	Innovative activity (R&D, funding, start-ups) expressed by patents.	The authors argue that it is necessary to look at RIS analysis from a spatial environment and simply focusing on the region itself is not enough. To explain the performance of RIS, it is necessary to look at macroeconomic conditions in the surrounding regions. Cooperation in R&D alone may not lead to productive RIS.
Pechlander et al. (2012)	Italy	Interviews on following topics: cooperation between organizations, possible development of further cooperation, vision and expectations of organizations.	The authors argue that for the effective functioning of RIS it is necessary to distinguish three groups of inhabitants. (1) residents, (2) tourists and (3) companies. Each group has different needs and these should be taken into account. At the same time, synergies need to be created between these groups.
Lau and Lo (2015)	China	The impact of knowledge-intensive services and	The authors argue that knowledge-intensive process services and information resources improve

		information resources on acquisition, assimilation and transformation (absortive capacity)	acquisition, assimilation, and initiative for innovation and transformation processes.
Svare (2016)	Norway	Behavior of individuals at the time of innovations, who are inside SMEs but also outside. Behavior includes knowledge, knowledge development and the ways in which they are shared and play a role in the innovation process.	The authors argue that customer interaction has the greatest impact on innovations, and that practical knowledge is more important than scientific knowledge. Practical knowledge is taken as production skill, practical knowledge of customers and the ability to work together.
Fernández-Serrano et al. (2019)	Spain	The impact of regional development on innovations.	The authors argue that in low-income regions, human capital and infrastructure are the biggest problems for innovations. In high-income regions, these are the legal, fiscal and financial systems.
Kostić and Květoň (2020)	Czech Republic	Impact of innovation support on RIS development.	The authors claim that there is no single way to build a competitive region. Support measures for the development of RIS should therefore be not uniform for all, but active and targeted support is needed at an early stage of development. The need and motivation to participate in support programs decreases with the growth and development of the companies.

Source: own processing

For the purposes of the analysis performed in this diploma thesis, the elements of the basic model of Maťátková and Stejskal (2011) were subjected to an analysis of whether they are still relevant according to the results of recent research. Subsequently, the evaluated indicators were adjusted. Supporting results and adjusted indicators of individual evaluation elements can be found in Table 4.

Table 4: Confirmed elements of the Regional Innovation Systems

RIS layer	Elements	Supporting results
Businesses	Existence of industrial clusters	The existence of industrial clusters means the interconnection of companies of the same focus, which are in a given region and interact. Due to their interconnectedness and interdependence, growth (or decline) in one company creates a better (or worse) business environment for other members of the group (Cheruiyot, 2018; Prokhorova et al., 2018).
	Innovative companies	Innovative companies bring innovations to RIS that play a crucial role in growth, enable higher productivity, industrial competitiveness, and ultimately, the prosperity of the entire region (European Comission, 2016; Lendel et al., 2017; Sousa and Martins, 2018).
	Number of patents	Patents provide benefits and return to companies with that patent. Companies can at least partially and temporarily capture appropriate benefits from patents. The production of patents itself means that companies innovate and come up with a new solution (Basit, 2016; Burhan et al., 2017; Heikkilä and Lorenz, 2018).
Support organizations	Existence of a business incubator / innovation centers	Business incubators are organizations set up to promote the intensity, quality, and speed of innovations dissemination and technology transfer into the region's economic practice with an emphasis on progressive high-tech technologies. Also, they help reduce costs when starting a business, help entrepreneurs with confidence and connect them with other entrepreneurs. (Alpenidze et al., 2019; Mavi et al., 2019).
	Existence of a technology transfer center	Technology transfer leads to the application of the knowledge results of universities and other research organizations on the market. Technology transfer between research organizations and industry is beneficial for direct actors and the region itself (Onida and Malerba, 1989; Lis and Majewska, 2016; Link et al., 2017).
Environment and infrastructure	Existence of a regional innovation strategy	The regional innovation strategy is based on an analysis of the innovation system and conditions in the region. The analytical part is essential for the further development of the region, and there are described priority areas with specific goals, leading to changes in selected areas (Woronowicz, 2017; Rentková, 2018).
	Existence of organizations forming a professional community in the field (universities, research centers)	The proper functioning of RIS requires a professional community to create knowledge such as universities and research organizations. These institutions generate knowledge, help to implement innovations (Asheim et al., 2016; Yao et al., 2018).
	Existence of public financial schemes - public expenditures on R&D / support programs / vouchers	Public expenditure on R&D should support the increase of creating and producing knowledge that helps businesses compete, for example, by investing in the construction and opening of centers such as science parks (Archibugi and Filippetti, 2018; Švarc et al., 2020).
	Existence of hard innovation infrastructure (house for settlement, with laboratory)	Innovation infrastructure is an important prerequisite for the emergence and diffusion of new innovations. It enables the acquisition of new knowledge, technology transfer, and the

		support of innovative companies (Pittaway, 2017; Järvenpää and Pavlik, 2020).
Relationships, ties	Existence of communication channels (regional council for innovations, smart accelerator)	Communication channels are important for disseminating innovations, increasing their visibility, and ensuring the interconnection of actors using innovations (Mannan et al., 2017; Lien and Jiang, 2017).
	Existence of projects confirming cooperation and synergy	Projects confirming cooperation and synergy proves the cooperation of individual entities (only the existence of RIS elements is not enough) and helps to spread innovation (Zhang et al., 2018; Franco and Pinho, 2019).
	Existence of triple helix cooperation	The main function of cooperation based on the triple helix model is the generation, usage and dissemination of knowledge and innovation (Ranga and Etzkowitz, 2013; Farinha et al., 2016; Galvao et al., 2019).
	Existence of cooperation outputs (patents, startups, value added, innovations)	The cooperation of the individual RIS actors is important, but it needs to lead to real outputs / innovations (Hou et al., 2019; Tojeiro-Rivero and Moreno, 2019).

Source: own processing according to Maťátková and Stejskal (2011)

The elements listed in Table 4 are the basis for evaluating of RIS in selected regions, the description and subsequent analysis on what to focus in the following parts of the thesis.

3 Description of selected EU regions

Socio-economic characteristics are presented in this chapter. It includes information about environment of selected EU countries and their selected regions.

For the purposes of this thesis Central and Eastern Europe (CEE) countries the Czech Republic, Slovakia and Estonia were chosen. In contrast to Western European countries, CEE countries face problems such as lack of funding, less developed social capital, problems with information sharing and strategic planning (Kotkova Striteska and Prokop, 2020). Until the end of 1992, the Czech Republic and Slovakia were united in one country, Czechoslovakia, situated in Central Europe. Estonia is one of the Baltic states in Northern Europe. All three countries have been members of the European Union since 2004. For the purposes of RIS analysis, were selected regions specified as NUTS 3[4]. These regions were selected for analysis:

- Pardubice Region (The Czech Republic),
- Prešov Region (Slovakia),
- Lõuna-Eesti (South Estonia).

Data for the description were drawn from statistical yearbooks of selected countries and regions, statistical offices of these countries, OECD and Eurostat. The data were used from the accession of all three countries to the EU, since 2004. The following were included as socio-economic indicators:

- population,
- municipalities,
- land area,
- average age of the population,
- gross domestic product (GDP),
- GDP per capita,
- year on year change of GDP,
- unemployment rate,
- inflation rate,
- average gross salary.

[4] The Nomenclature of Territorial Units for Statistics (NUTS) is a system that divides economic territories in the EU, for reasons of development and unification of regional development and statistics (Eurostat, 2020):

- NUTS 1: major socio-economic regions,
- NUTS 2: basic regions for the application of regional policies,
- NUTS 3: small regions for specific diagnoses.

3.1 The Czech Republic

The Czech Republic, also known as Czechia, is situated in central Europe bordered by Germany, Austria, Slovakia and Poland.

According to the NUTS 3 division, the Czech Republic has 14 regions (see Figure 7) spread over land area of 77 240 km^2 (Worldpopulationreview, 2020): Prague, Central Bohemia Region, South Bohemia Region, Plzeň Region, Karlovy Vary Region, Ústí Region, Liberec Region, Hradec Králové Region, Pardubice Region, Vysočina Region, South Moravia Region, Olomouc Region, Zlín Region, Moravia-Silesia Region.

Figure 7: Division of regions in the Czech Republic
Source: Regions of the Czech Republic. *EU2009.cz - Regions of the Czech Republic* [online]. [cit. 1-3-2021]. Available at: http://www.eu2009.cz/en/czech-republic/regions/regions-of-the-czech-republic-329/index.html

The population in 2020 was around 10.7 million people (Czech Statistical Office, 2020), and 6258 municipalities (Council of European Municipalities and Regions, 2016). Median age in the Czech Republic in 2020 is 43.2 years (Worldpopulationreview, 2020).

The Czech Republic has its own currency, the Czech crown (CZK), the exchange rate CZK / EUR was approximately 26 CZK / EUR in 2020. For the purposes of this thesis, the values are converted to EUR to the current exchange rate of the year from which the data comes (Czech National Bank). Table 5 shows the development of GDP, GDP per capita, and year on year change of GDP since the Czech Republic joined the European Union.

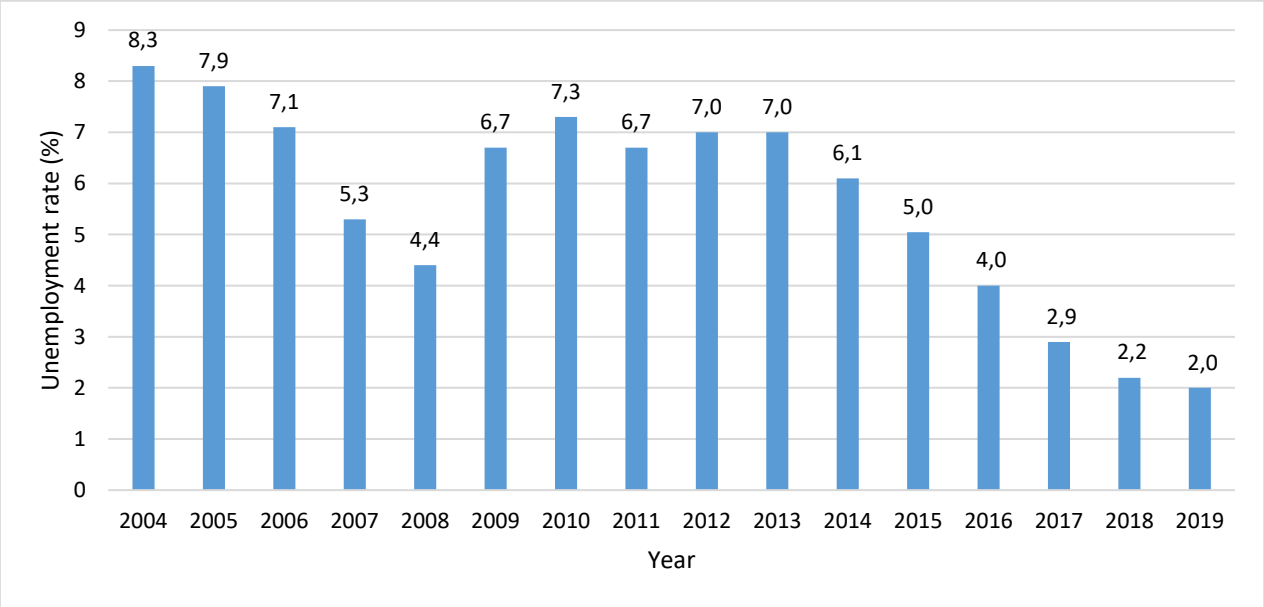
Table 5: GDP and GDP per capita of the Czech Republic 2004-2019

Year	GDP (mil. EUR)	GDP per capita (EUR)	Year on year change GDP (%)
2004	96515	9456	
2005	110314	10779	6,7
2006	124577	12134	7,5
2007	139022	13468	9,3
2008	162090	15541	4,7
2009	149530	14252	-2,2
2010	157883	15012	1
2011	165229	15741	1,7
2012	162626	15475	0,7
2013	159498	15175	1,3
2014	157838	14997	4,9
2015	169533	16080	6,4
2016	177445	16795	3,7
2017	194103	18330	6,5
2018	210926	19849	5,8
2019	223928	20988	6,3

Source: own processing, data from Czech Statistical Office

Unemployment rate in The Czech Republic is the lowest in the EU (OECD, 2020), and its development is shown in Chart 1.

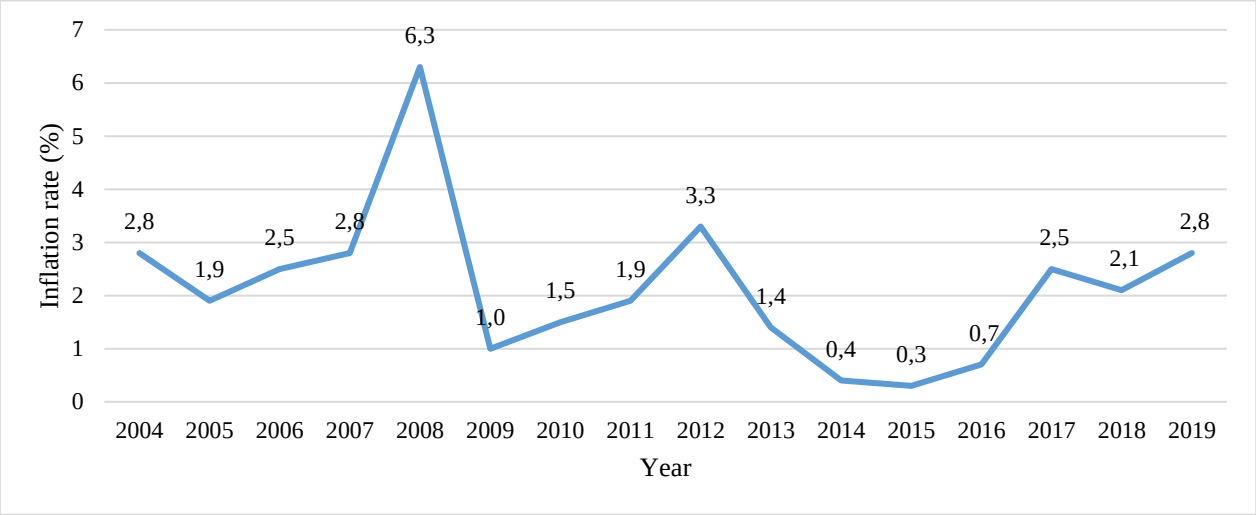
Chart 1: Unemployment rate in The Czech Republic 2004-2019



Source: own processing, data from Czech Statistical Office

The inflation goal of Czech National Bank is 2 %, and the tolerant zone is between 1 % and 3 %. Development of inflation rate since 2004 is in Chart 2.

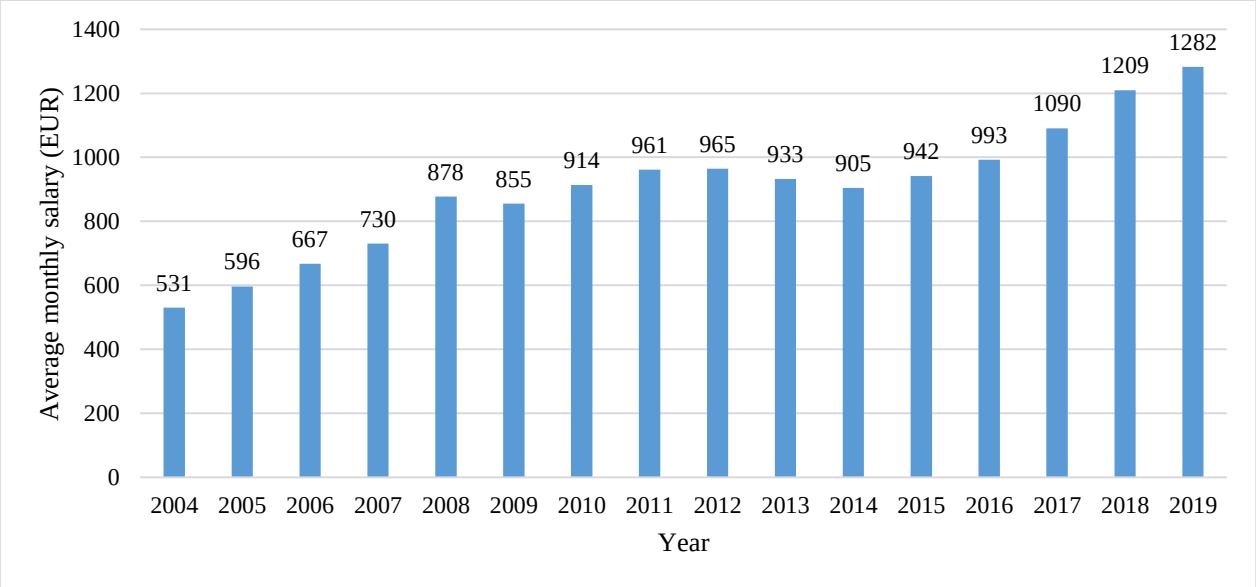
Chart 2: Inflation rate in the Czech Republic 2004-2019



Source: own processing, data from Czech Statistical Office

Development of average monthly salary in the Czech Republic converted from CZK to EUR is in Chart 3.

Chart 3: Average monthly salary in the Czech Republic 2004-2019



Source: own processing, data from Czech Statistical Office
The Pardubice region was chosen for a more detailed analysis of RIS in the Czech Republic.

3.1.1 Pardubice Region

The Pardubice region lies in the eastern part of the Czech Republic and is bordered by Hradec Králové Region, Central Bohemia Region, Vysočina Region, South Moravia Region, and Olomouc Region.

The Pardubice Region consists of four districts spread over the land area of 4519 km^2 (Czech Statistical Office, 2020): Pardubice, Chrudim, Svitavy, Ústí nad Orlicí.

The population of Pardubice Region is 523 054, living in 451 municipalities. Median age in the Pardubice Region in 2020 is 42,4 (Czech Statistical Office, 2020).

The development of GDP, GDP per capita, and year on year change of GDP is shown in Table 6.

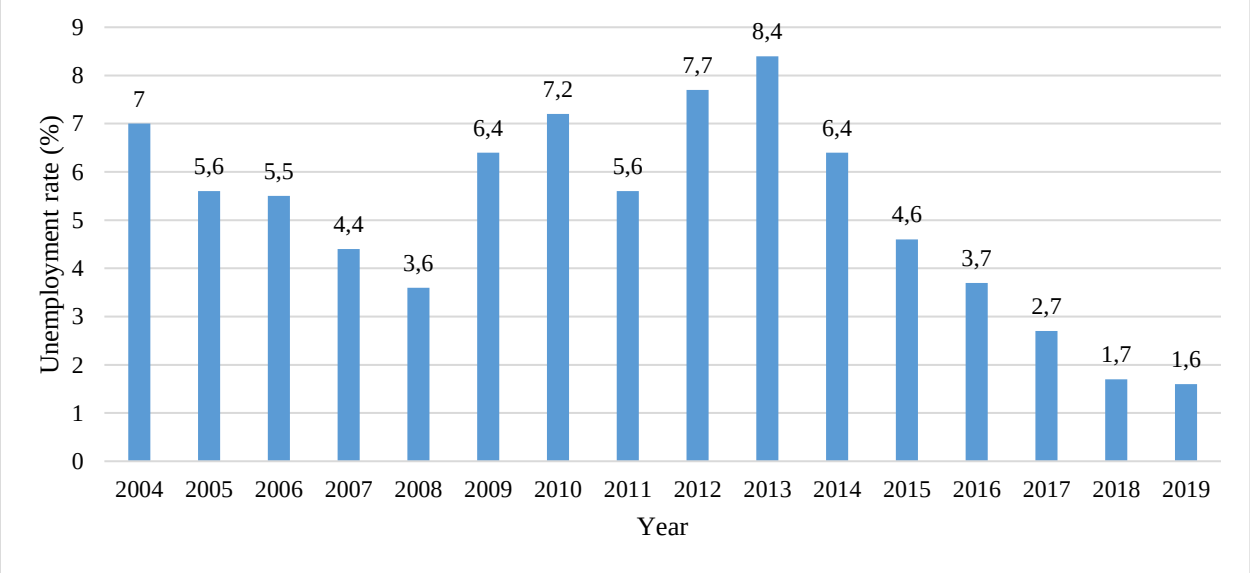
Table 6: GDP and GDP per capita of Pardubice Region 2004-2018

Year	GDP (mil. EUR)	GDP per capita (EUR)	Year on year change GDP (%)
2004	3957	7833	
2005	4422	8747	11,7
2006	5104	10071	15,4
2007	5730	11260	12,3
2008	6506	12665	13,5
2009	5933	11500	-8,8
2010	6324	12238	6,6
2011	6741	13057	6,6
2012	6294	12187	-6,6
2013	6230	12078	-1
2014	6244	12099	0,2
2015	6707	12992	7,4
2016	7027	13603	4,8
2017	7622	14736	8,5
2018	8313	16014	9,1

Source: own processing, data from Czech Statistical Office

Development of unemployment rate in Pardubice Region is shown in Chart 4.

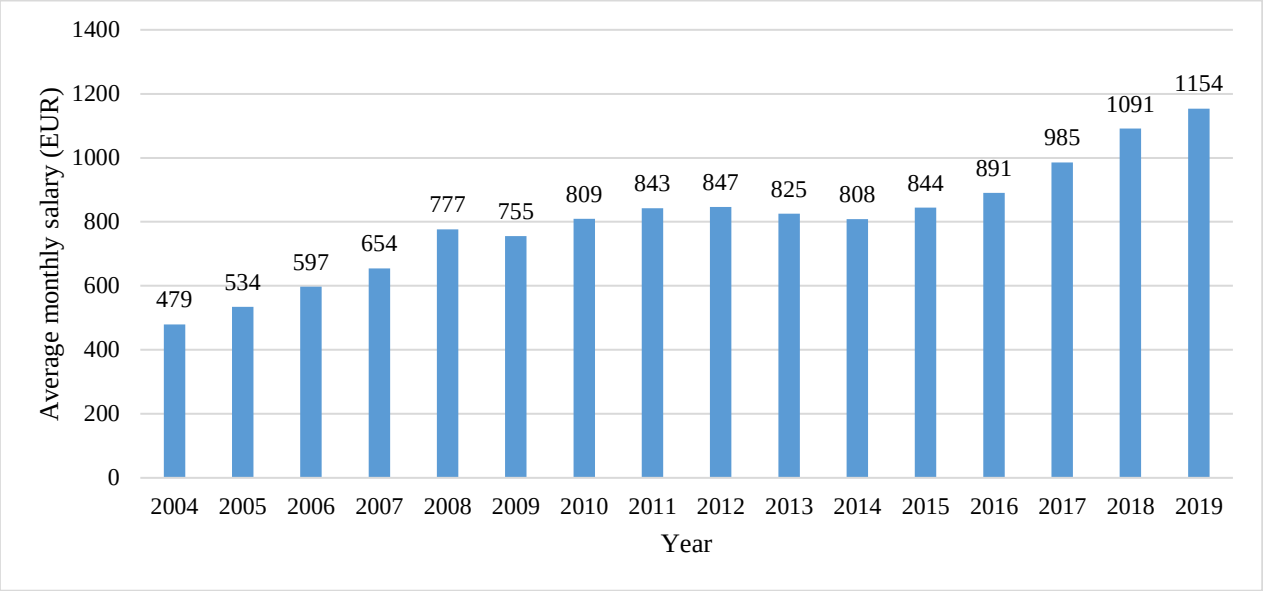
Chart 4: Unemployment rate in Pardubice Region 2004-2019



Source: own processing, data from Czech Statistical Office

Development of average monthly salary in Pardubice Region since 2004 is in Chart 5.

Chart 5: Average monthly salary in the Czech Republic 2004-2019



Source: own processing, data from Czech Statistical Office

There are 122 032 economic entities located in Pardubice Region. The industry of Pardubice region is dominated by the automotive, electrical, engineering, and chemical industries (Czech Statistical Office, 2020).

The following employers can be included among the large employers acording to number of employees in Pardubice Region:

- Foxcon European Manufacturing Services, s. r. o,
- Panasonic Automotive Systems Czech, s. r. o,
- Synthesia, a.s,
- KIEKERT-CS, s. r. o,
- Iveco Czech Republic, a.s.

3.2 Slovakia

Slovakia, also known as the Slovak Republic, is situated in central Europe bordered by the Czech Republic, Hungary, Ukraine, Austria, and Poland.

According to the NUTS 3 division, Slovakia has 8 regions (see Figure 8) spread over a land area of 44 088 km^2 (Worldpopulationreview, 2020): Bratislava Region, Trnava Region, Trenčín Region, Nitra Region, Žilina Region, Bánská Bystrica Region, Prešov Region, Košice Region.

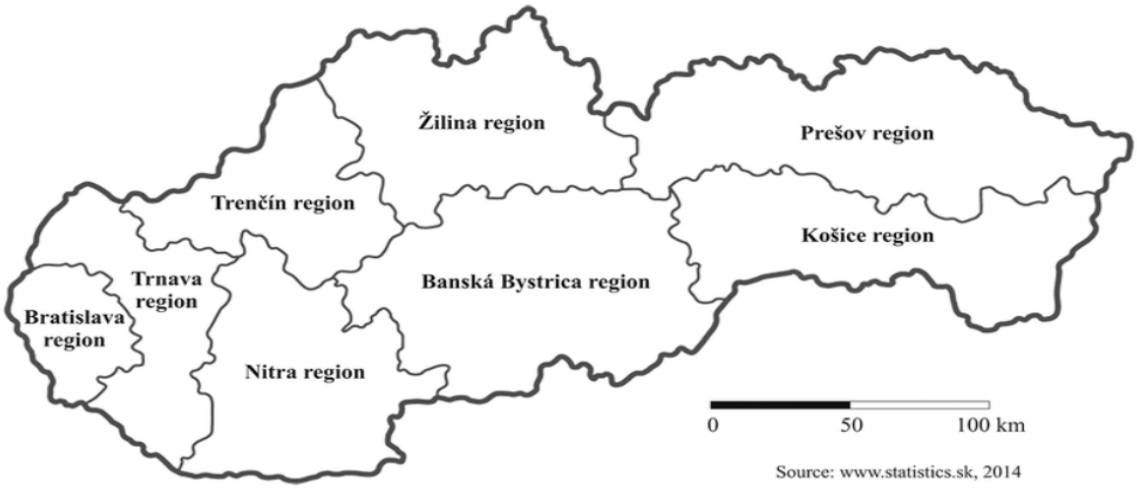


Figure 8: Division of regions in Slovakia
Source: Researchgate.net. *The self-governing regions in Slovakia* [online]. [cit. 1-3-2021]. Available at: https://www.researchgate.net/figure/The-self-governing-regions-NUTS-III-in-Slovakia-in-2014_fig1_319388358

The population of Slovakia in 2020 was around 5.45 million people (Statistical Office Of the Slovak Republic, 2020), with 2930 municipalities (Council of European Municipalities and Regions, 2016). Median age in Slovakia in 2020 was 40.5 years (Worldpopulatonreview, 2020).

Slovakia is a member of the euro area and is using the euro as its currency since 2009. Table 7 shows the development of GDP, GDP per capita, and year on year change of GDP since Slovakia joined the European Union.

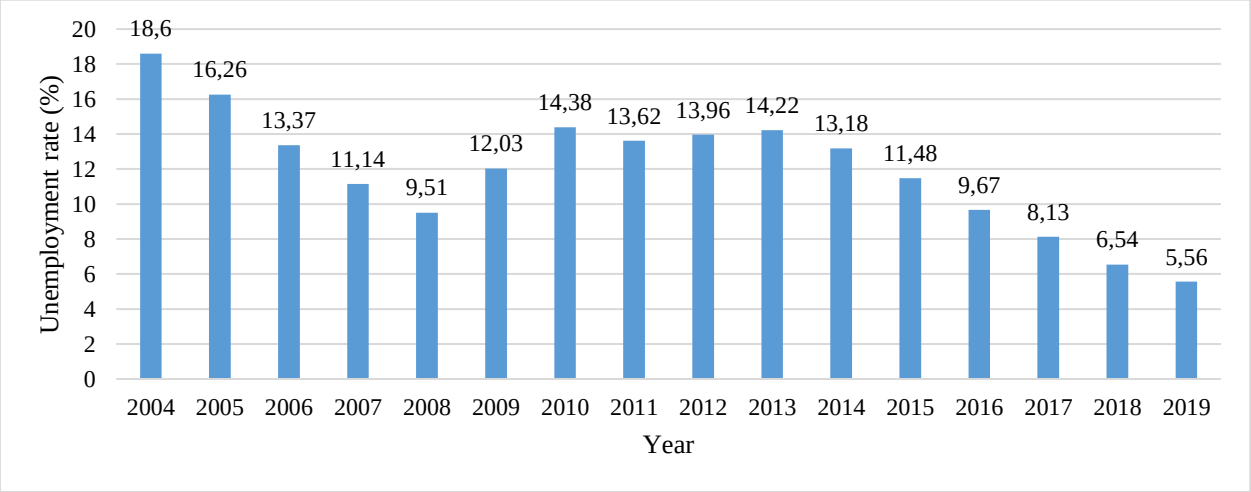
Table 7: GDP and GDP per capita of Slovakia 2004-2019

Year	GDP (mil. EUR)	GDP per capita (EUR)	Year on year change GDP (%)
2004	46 175	8579	
2005	50 486	9371	9,3
2006	56 361	10454	11,6
2007	63 163	11702	12,1
2008	68 591	12230	8,6
2009	64 096	11830	-6,6
2010	68 093	12540	6,2
2011	71 214	13190	4,6
2012	73 484	13590	3,2
2013	74 355	13740	1,2
2014	76 256	14070	2,6
2015	79 758	14710	4,6
2016	81 038	14920	1,6
2017	84 521	15540	4,3
2018	89 606	16450	6
2019	94 171	17270	5,1

Source: own processing, data from Eurostat and OECD

Development of unemployment rate in Slovakia is shown in Chart 6.

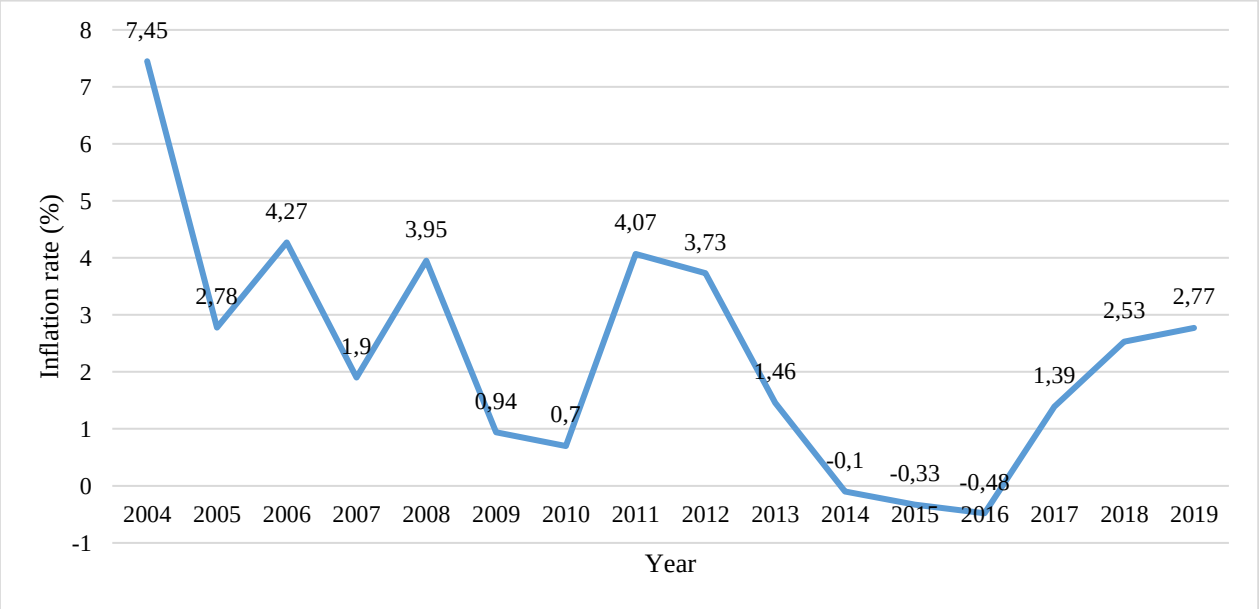
Chart 6: Unemployment rate in Slovakia 2004-2019



Source: own processing, data from Statistical Office of the Slovak Republic

Development of inflation rate in Slovakia since 2004 is in Chart 7.

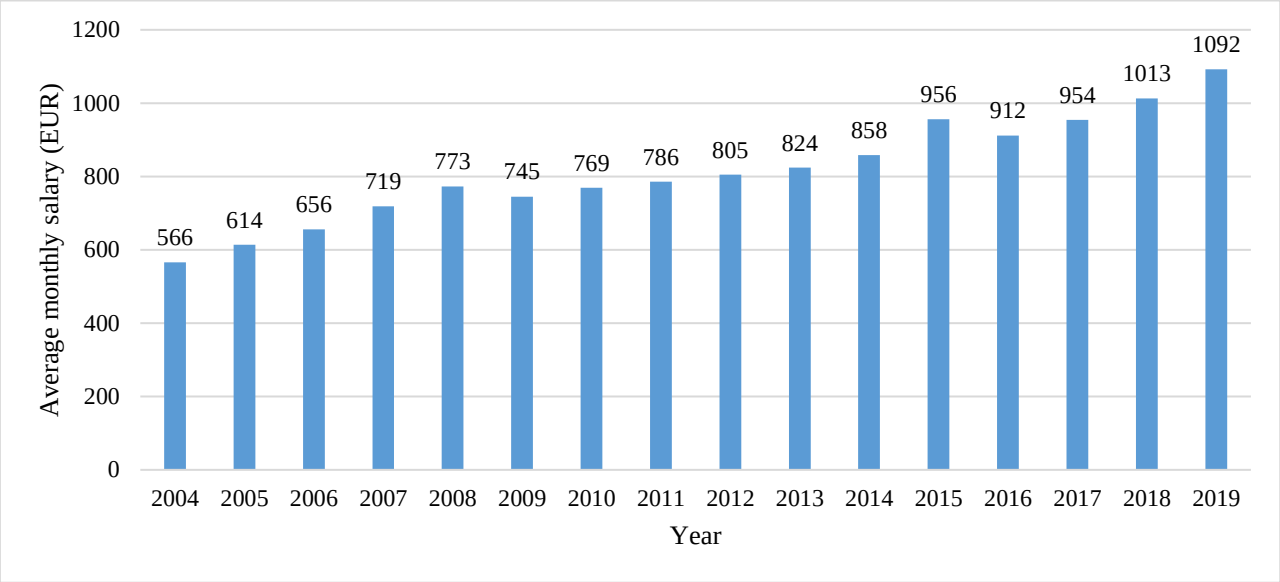
Chart 7: Inflation rate in Slovakia 2004-2019



Source: own processing, data from Statistical Office of the Slovak Republic

Development of average monthly salary in Slovakia in EUR is shown in Chart 8.

Chart 8: Average monthly salary in Slovakia 2004-2019



Source: own processing, data from Statistical Office of the Slovak Republic

Prešov Region was chosen for a more detailed analysis of RIS in Slovakia.

3.2.1 Prešov Region

Prešov Region is located in the northeast of Slovakia and bordered by Žilina Region, Bánská Bystrica Region, and Košice Region.

The territory of Prešov Region consists of 13 districts spread over the land area of 8973 km^2: Bardejov, Humnné, Kežmarok, Levoča, Medzilaborce, Poprad, Prešov, Sabinov, Snina, Stará Ľubovňa, Stropkov, Svidník and Vranov nad Topľou.

The population of Prešov Region is 825 022, living in 665 municipalities. Median age in Prešov Region is 38,6 years (Eurostat, 2019; Statistical Office of the Slovak Republic, 2019).

Development of GDP, GDP per capita, and year on year change of GDP since 2004 is shown in Table 8.

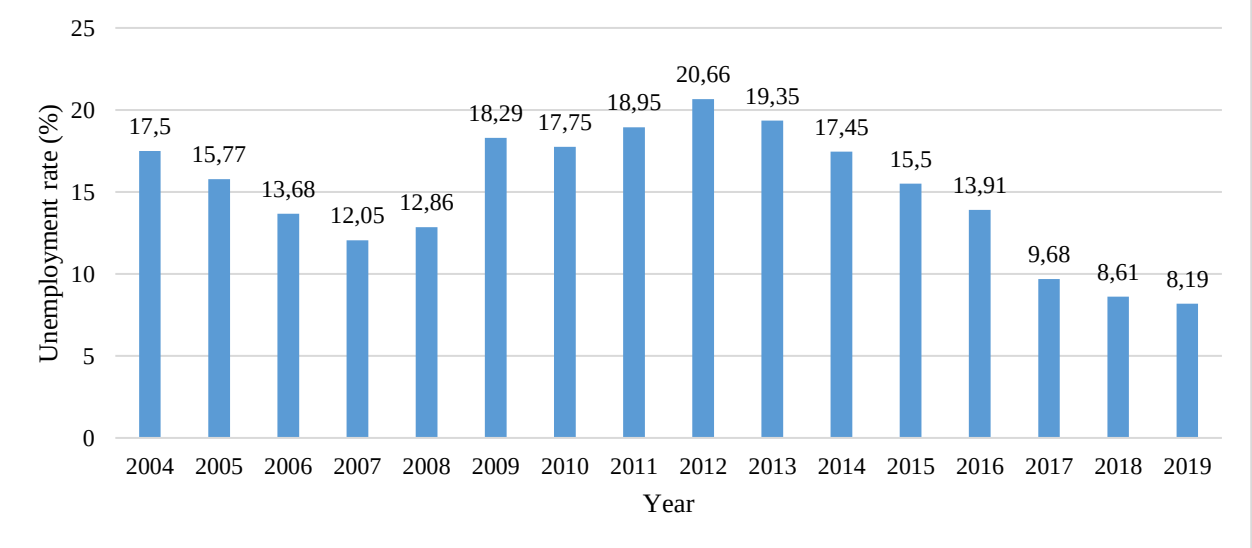
Table 8: GDP and GDP per capita of Prešov Region 2004-2017

Year	GDP (mil. EUR)	GDP per capita (EUR)	Year on year change GDP (%)
2004	4 035	3862	
2005	4 376	4296	8,5
2006	4 500	4617	2,8
2007	5 072	5713	12,7
2008	5 921	7153	16,7
2009	5 493	6833	-7,2
2010	5 705	7161	3,9
2011	6 233	7631	9,3
2012	6 560	7974	5,2
2013	6 559	8042	0
2014	6 851	8332	4,5
2015	7 223	8727	5,4
2016	7 423	9069	2,8
2017	7 661	9338	3,2

Source: own processing, data from Statistical Office of the Slovak Republic and OECD

Development of unemployment rate in Prešov Region is shown in Chart 9:

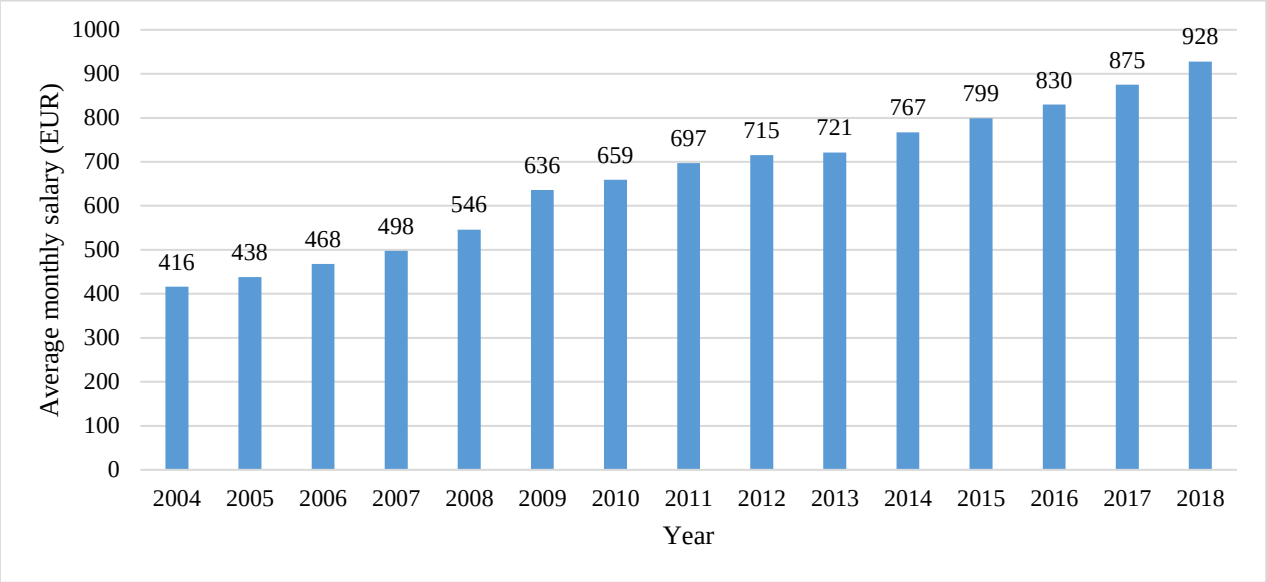
Chart 9: Unemployment rate in Prešov Region 2004-2019



Source: own processing, data from Statistical Office of the Slovak Republic

Development of average monthly salary in Prešov Region is shown in Chart 10:

Chart 10: Average monthly salary in Prešov Region 2004-2018



Source: own processing, data from Statistical Office of the Slovak Republic

There are 72 204 economic entities located in Prešov Region. The industry of Prešov Region is dominated by electrical, engineering, and chemical industries (Statistical Office of the Slovak Republic, 2019).

The following employers can be included among the large employers acording to number of employees in Prešov Region:

- CHEMOSVIT FOLIE, s. r. o.,
- Nexis Fibers, a.s,
- Lear Corporation Seating Slovakia, s. r. o.,
- Tatravagónka, a.s.

3.3 Estonia

Estonia is situated in northern Europe and is the northernmost of the Baltic countries. It is bordered by the Baltic Sea, Latvia and Russia.

According to the NUTS3 division, Estonia has 5 regions (see Figure 9) spread over land area of 42 390 km^2 (Worldpopulationreview, 2020): EE001 Põhja-Eesti (North Estonia), EE004 Lääne-Eesti (West Estonia). EE006 Kesk-Eesti (Cental Estonia), EE007 Kirde-Eesti (East Estonia), EE008 Lõuna-Eesti (South Estonia).

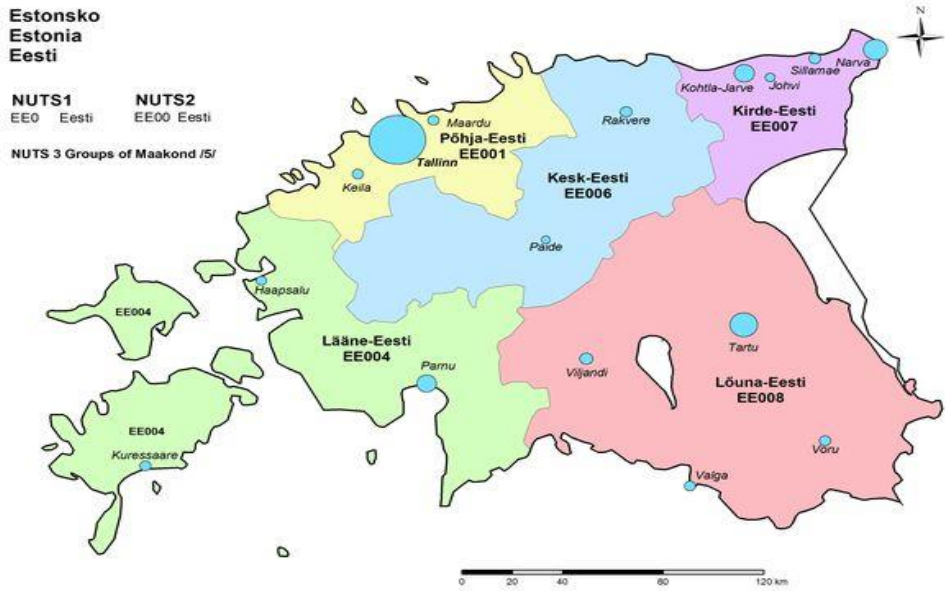


Figure 9: Division of regions in Estonia
Source: CZSO. *Estonia – NUTS* [online]. [cit. 1-3-2021]. Available at: https://www.czso.cz/csu/czso/estonia-nuts

The population in 2020 was around 1.3 people (Estonia Statistical Office, 2020), with 79 municipalities (Association of Estonian cities and municipalities, 2020). Median age in Estonia in 2020 was 42.7 years (Worldpopulationreview, 2020).

Estonia is a member of the euro area and is using the euro as its currency since 2011. Table 9 shows the development of GDP, GDP per capita, and year on year change of GDP since 2004.

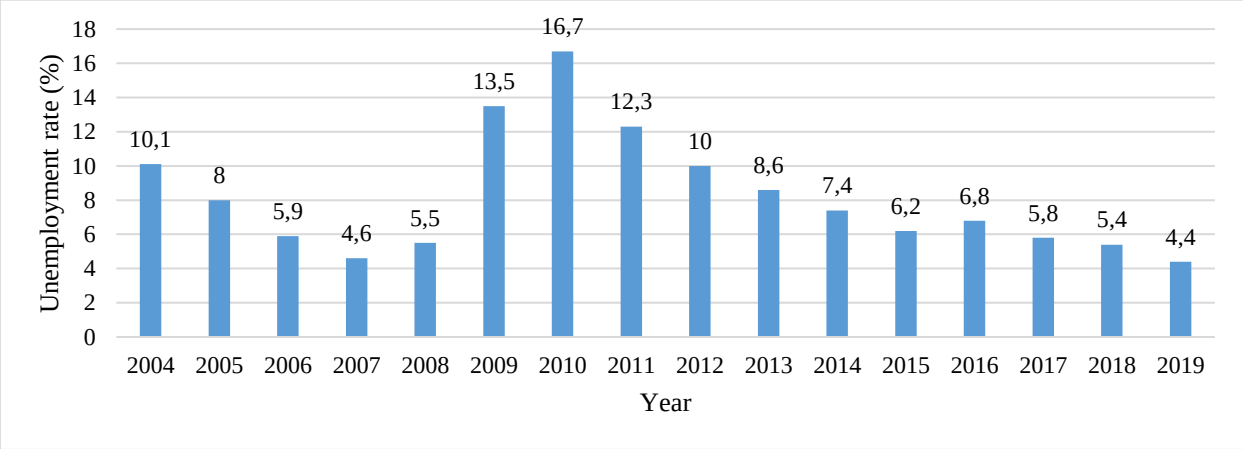
Table 9: GDP and GDP per capita of Estonia 2004-2019

Year	GDP (mil. EUR)	GDP per capita (EUR)	Year on year change GDP (%)
2004	9776	7175	
2005	11336	8368	16,0
2006	13561	10069	19,6
2007	16399	12232	20,9
2008	16638	12444	1,5
2009	14212	10649	-14,6
2010	14861	11161	4,6
2011	16827	12676	13,2
2012	18051	13647	7,3
2013	19033	14441	5,4
2014	20180	15351	6,0
2015	20782	15809	3,0
2016	21694	16487	4,4
2017	23776	18048	9,6
2018	26036	19695	9,5
2019	28037	21161	7,7

Source: own processing, data from Eurostat and OECD

Development of unemployment rate in Estonia is shown in Chart 11.

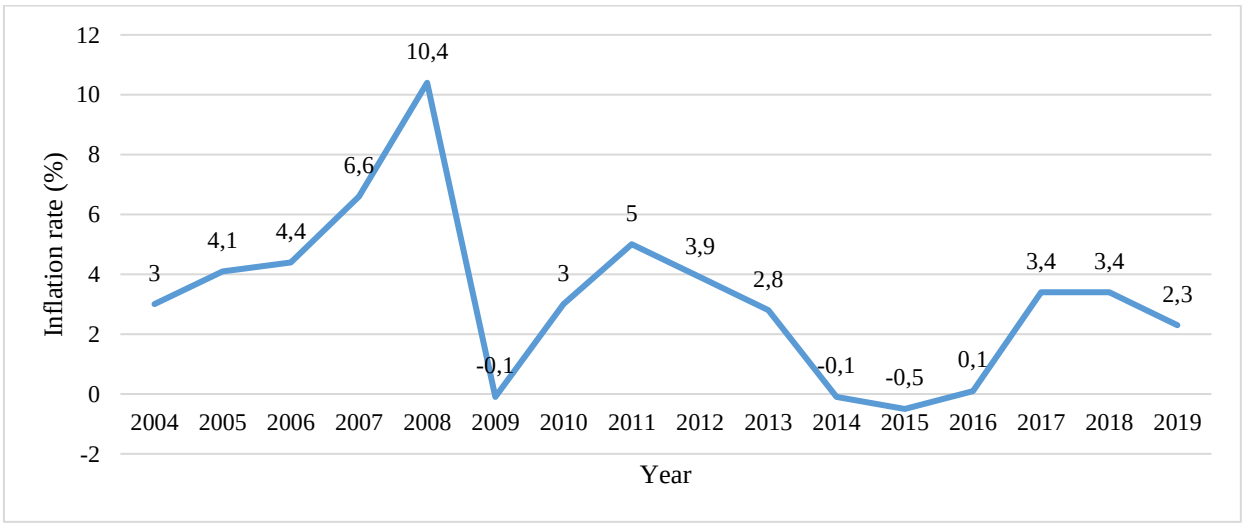
Chart 11: Unemployment rate in Estonia 2004-2019



Source: own processing, data from Estonia Statistical Office

Development of inflation rate in Estonia since 2004 is in Chart 12.

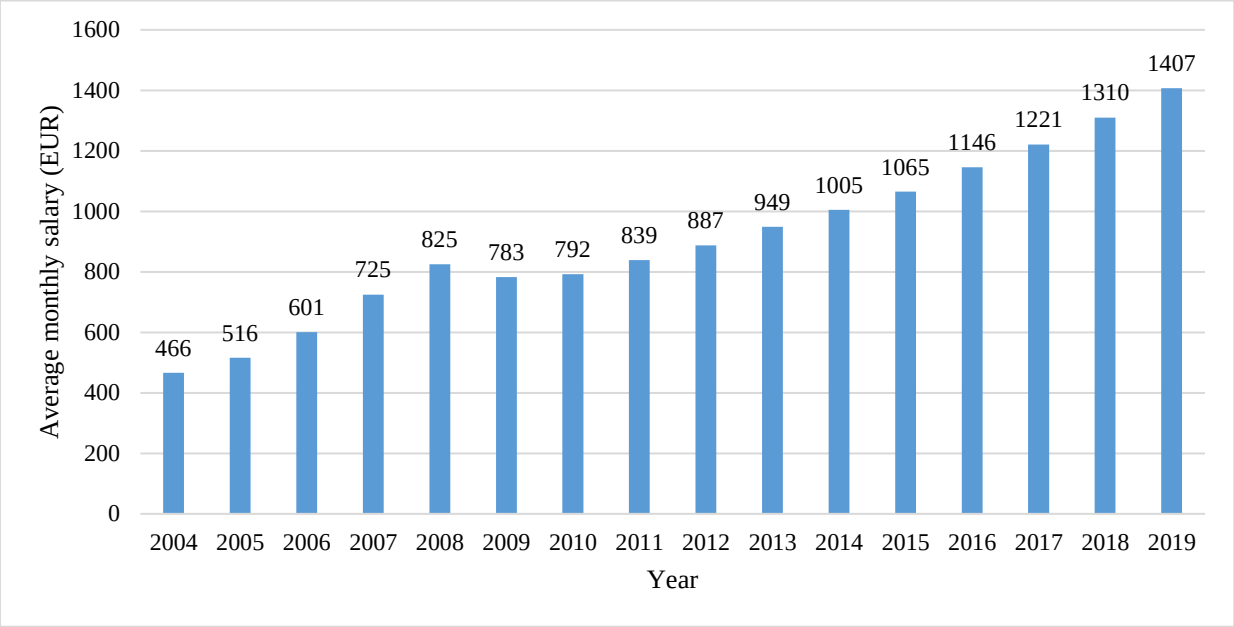
Chart 12: Inflation rate in Estonia 2004-2019



Source: own processing, data from Estonia Statistical Office

Development of average monthly salary in Estonia in EUR is shown in Chart 13.

Chart 13: Average monthly salary in Estonia 2004-2019



Source: own processing, data from Estonia Statistical Office

Lõuna-Eesti (South Estonia) region was chosen for a more detailed analysis of RIS in Estonia.

3.3.1 Lõuna-Eesti (South Estonia) Region

South Estonia Region is located in the southern part of Estonia and is bordered by Lääne-Eesti (West Estonia), Kesk-Eesti (Cental Estonia) and Kirde-Eesti (East Estonia).

The territory of South Estonia consists of 6 counties[5] spread over the land area of 16698 km^2: Jõgeva County, Põlva County, Tartu County, Valga County, Viljandi County, Võru County.

The population of South Estonia is 316 869, living in 27 municipalities. Median age in South Estonia is 41.6 years (Statista, 2020).

Development of GDP, GDPR per capita, and year on year change of GDP since 2004 is shown in Table 10.

[5] County is a geographical region a country used for administrative or other purposes (Wamae, 2014).

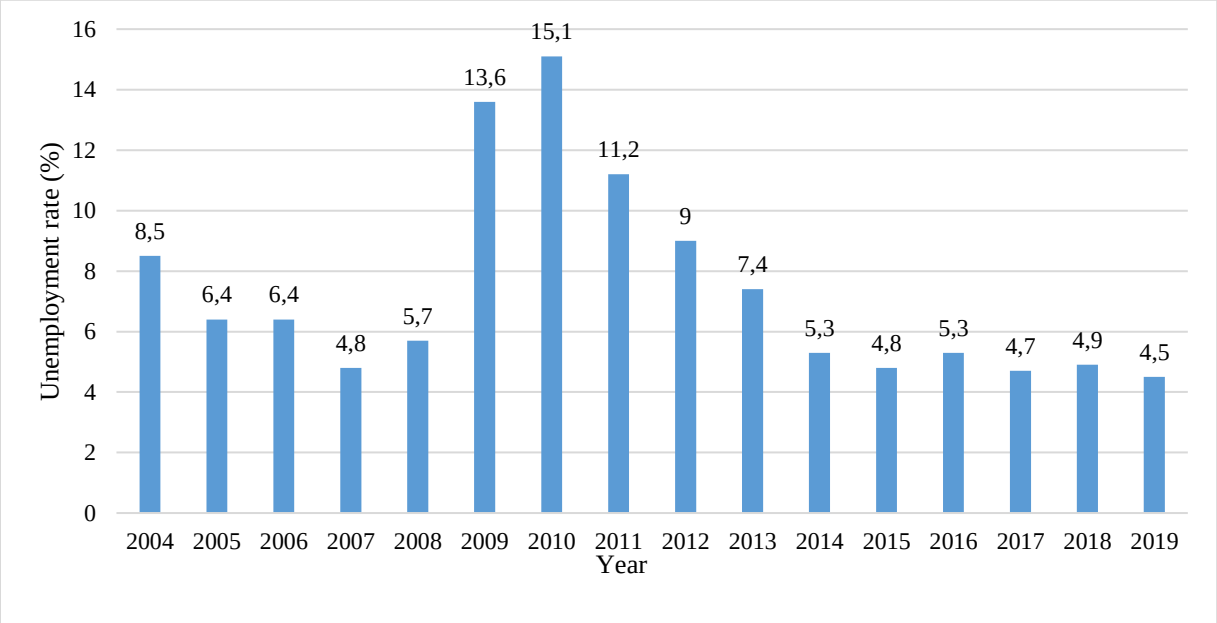
Table 10: GDP and GDP per capita of South Estonia Region 2004-2018

Year	GDP (mil. EUR)	GDP per capita (EUR)	Year on year change GDP (%)
2004	1689	5341	
2005	1999	6321	18,3
2006	2338	7393	17,0
2007	2922	9242	25,0
2008	3088	9767	5,7
2009	2649	8377	-14,2
2010	2584	8173	-2,4
2011	2834	8961	9,7
2012	2982	9430	5,2
2013	3139	9928	5,3
2014	3317	10490	5,7
2015	3453	10920	4,1
2016	3637	11502	5,3
2017	4009	12679	10,2
2018	4429	14008	10,5

Source: own processing, data from Estonia Statistical Office

Development of unemployment rate in South Estonia Region is shown in Chart 14.

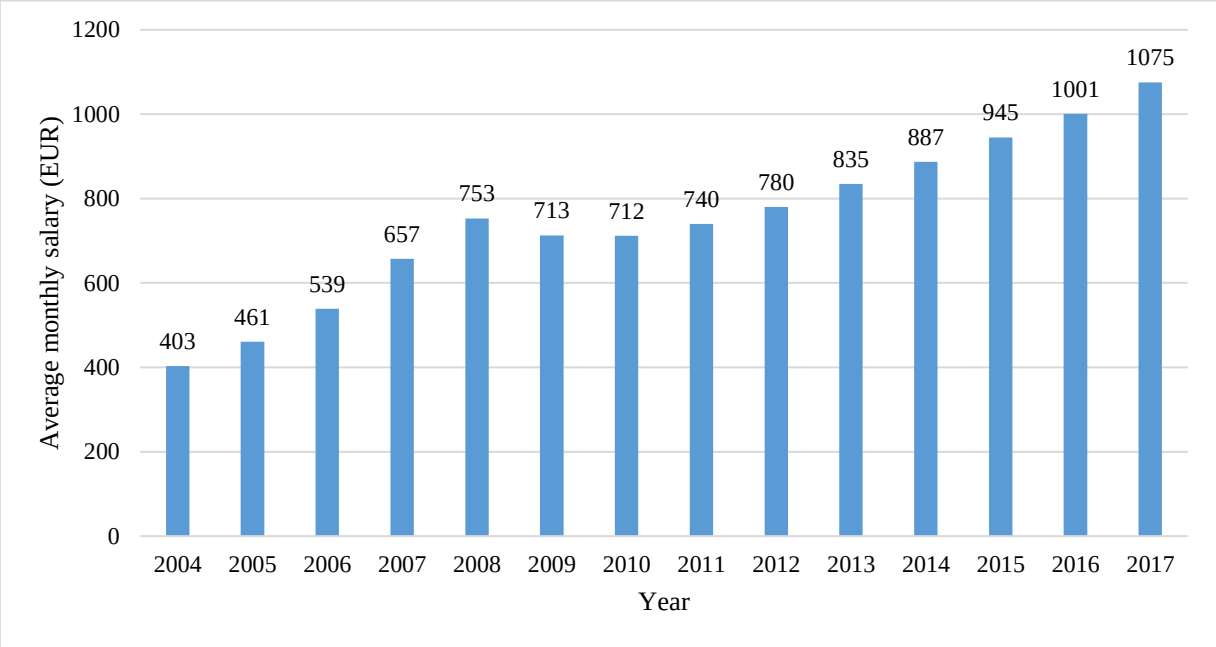
Chart 14: Unemployment rate in South Estonia Region 2004-2019



Source: own processing, data from Estonia Statistical Office

Development of average monthly salary in South Estonia Region is shown in Chart 15.

Chart 15: Average monthly salary in South Estonia Region 2004-2017



Source: own processing, data from Eurostat and Estonia Statistical Office

There are 27 604 economic entities located in South Estonia. The industry of South Estonia is dominated by the IT and Biotechnology (Estonia Statistical Office, 2019).

The following employers can be included among the large employers acording to number of employees in South Estonia:

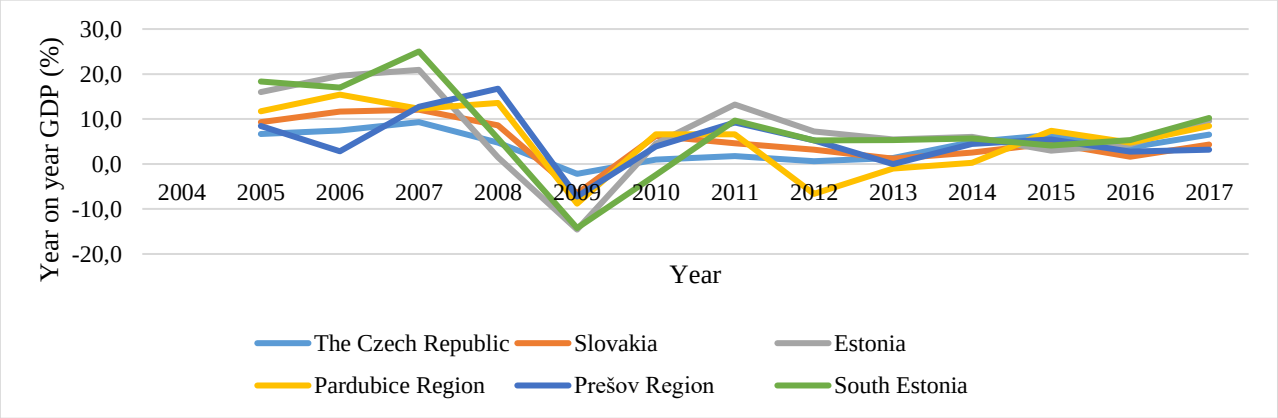
- Saint-Gobain, a.s,
- Playtech, a.s,
- Pivotal, a.s.

3.4 Comparison of socio-economic indicators in selected countries and regions

For comparison of the development of socio-economic factors were selected the following indicators (GDP per capita, unemployment rate, inflation rate, average monthly salary). Selected countries and regions were graphically compared.

Chart 16 compares the development of year on year change of GDP between The Czech Republic, Slovakia, Estonia, Pardubice Region, Prešov region and South Estonia Region. The development of the individual regions took place mostly in the same direction. The biggest decline was recorded during the great economic crisis of 2008-2009 in all these regions. At the same time, the Chart 16 shows that the largest percentage decline was recorded in the Estonia and South Estonia Region and, conversely, the largest percentage of growth was recorded in South Estonia Region in 2007. In 2012 the bigger decrease was happening in Pardubice Region.

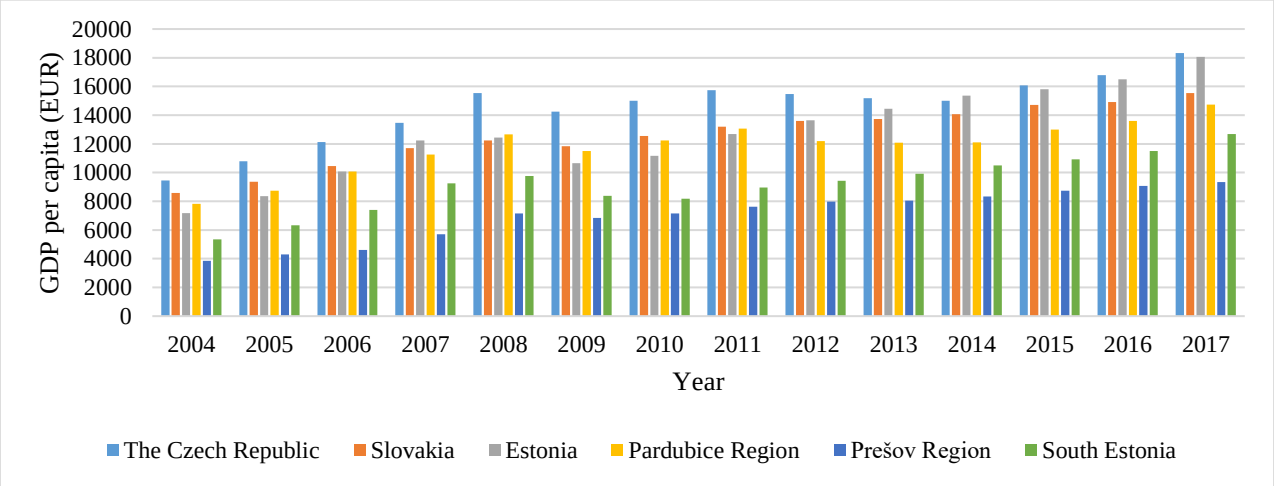
Chart 16: Year on year change of GDP comparison the Czech Republic, Slovakia, Estonia, Pardubice Region, Prešov Region and South Estonia



Source: own processing, data from Czech Statistical Office, Statistical Office of the Slovak Republic, Estonia Statistical Office, Eurostat and OECD

Chart 17 compares the development of GDP per capita in selected regions. The highest GDP per capita was noticed from the years 2004-2012 in the Czech Republic. Since 2013 GDP per capita difference in the regions began to decline and Estonia catching up with the level of GDP per capita of the Czech Republic. Despite the fact that in 2004 the development of GDP per capita in Estonia was lower than in Slovakia, in recent years Estonia has exceeded Slovakia and if it maintains the trend, it could also exceed the amount of GDP per capita in the Czech Republic. The development of selected regions has been reaching the same order since 2004, the highest GDP per capita is in the Pardubice Region, which is followed by the South Estonia Region. Prešov Region has the lowest GDP per capita.

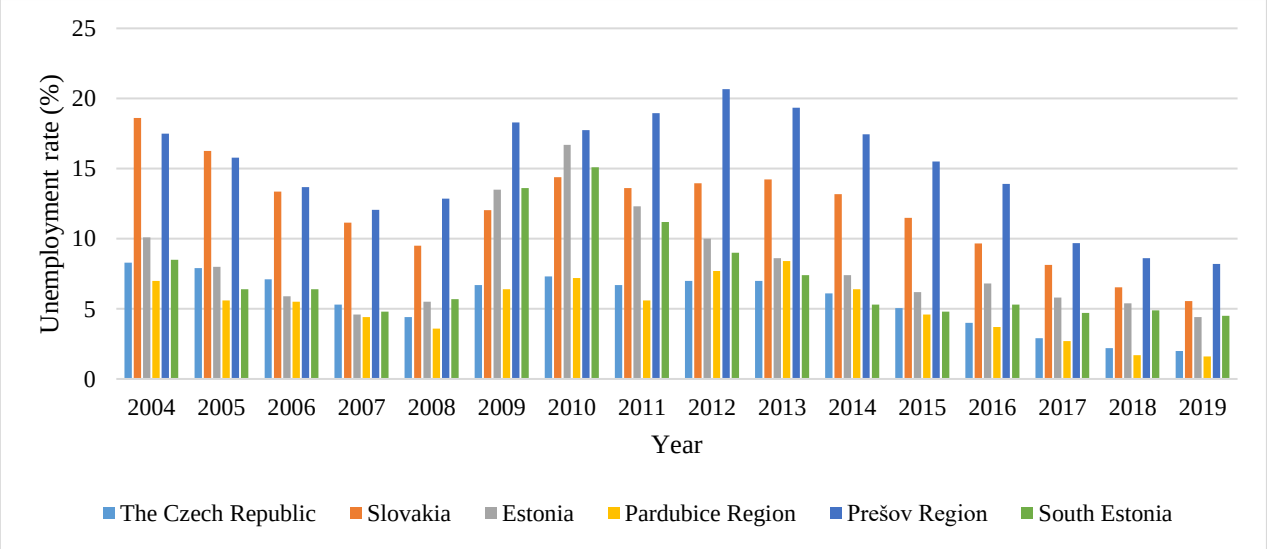
Chart 17: GDP per capita comparison the Czech Republic, Slovakia, Estonia, Pardubice Region, Prešov Region and South Estonia Region



Source: own processing, data from Czech Statistical Office, Statistical Office of the Slovak Republic, Estonia Statistical Office, Eurostat and OECD

Chart 18 shows the development of the unemployment rate in selected regions. The highest unemployment rate has been in Slovakia since 2004 and thus also in the Prešov Region. After the crisis in 2008, the unemployment rate in Slovakia began to decrease and the Prešov Region reached the highest values. The Czech Republic and Pardubice Region has in long term the lowest unemployment rate. Estonia and South Estonia have had an unemyplomet rate around 5 % in recent years.

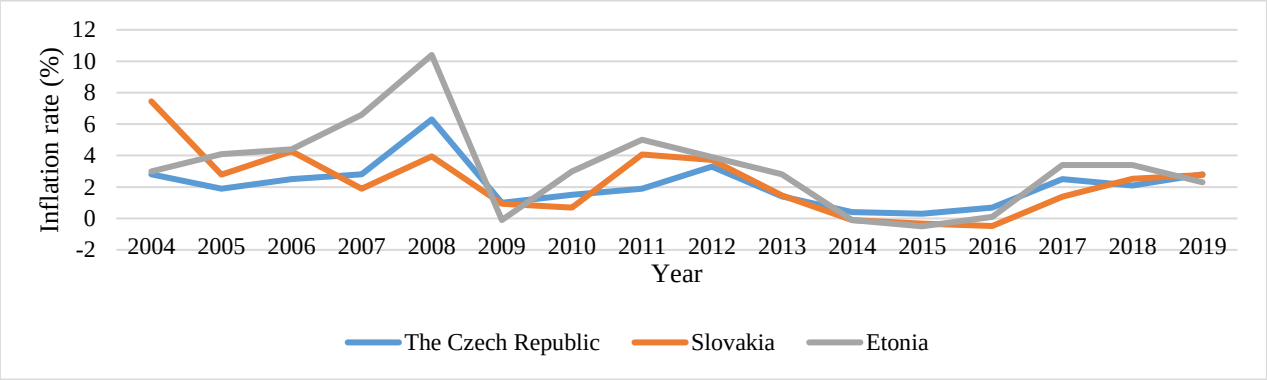
Chart 18: Unemployment rate comparison the Czech Republic, Slovakia, Estonia, Pardubice Region, Prešov Region and South Estonia Region



Source: own processing, data from Czech Statistical Office, Statistical Office of the Slovak Republic and Estonia Statistical Office

Comparison of inflation expenditure between the Czech Republic, Slovakia and Estonia is shown in Chart 19. Even though Slovakia has been using the euro since 2009, Estonia is using euro since 2011 and the Czech Republic still uses CZK, it is clear that in last years inflation is developing in the same directions in all three countries and central banks are managing to maintain the currency despite fluctuations stable.

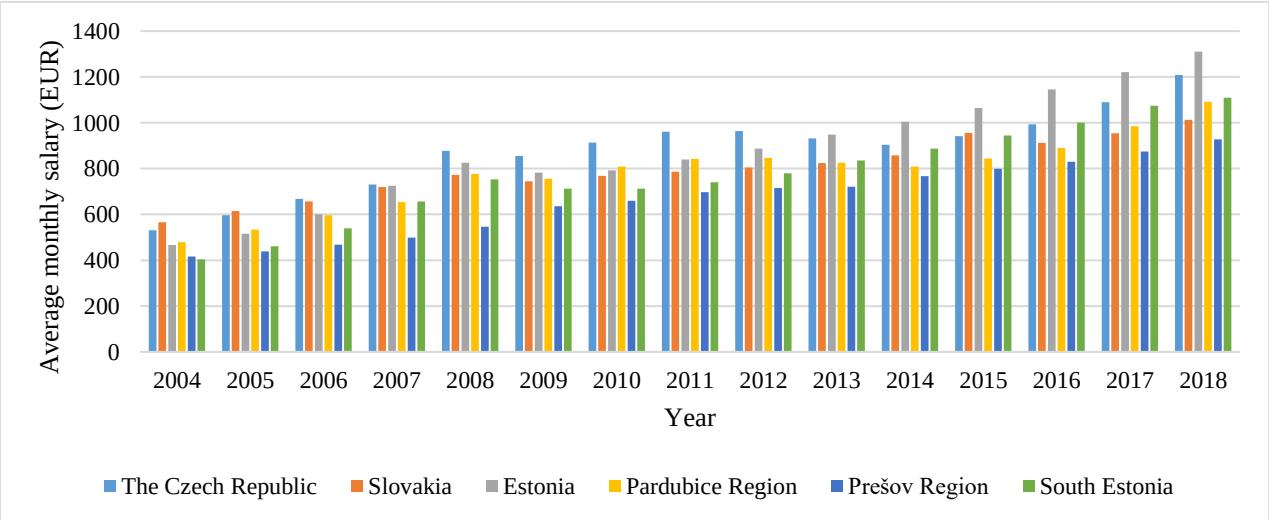
Chart 19: Inflation rate comparion the Czech Republic, Slovakia and Estonia



Source: own processing, data from Czech Statistical Office, Statistical Office of the Slovak Republic and Estonia Statistical Office

Development of average monthly salary in selected regions is shown in Chart 20. Since 2004, the highest average monthly salaries were in Slovakia and the Czech Republic, but since 2007 the highest average monthly salaries were in the Czech Republic and Estonia. Since 2013 Estonia has had the highest average monthly salaries. The lowest average monthly salaries from 2004 were in Prešov Region and South Estonia but after year 2015, South Estonia has had the 3rd highest average monthly salaries.

Chart 20: Average monthly salary comparison of the Czech Republic, Slovakia, Estonia, Pardubice Region, Prešov Region and South Estonia Region



Source: own processing, data from Czech Statistical Office, Statistical Office of the Slovak Republic and Estonia Statistical Office

From the socio-economic indicators evaluated above, it is clear that the regions have been experiencing a positive development in the long term. Since 2004, there has not been a long time since selected countries and their regions have experienced different directions of development.

The next chapter is focused on the analysis of RIS in selected EU regions.

4 Analysis of RIS in selected EU regions

This part contains analysis and comparisson of RIS in Pardubice Region, Prešov Region and South Estonia. A modified model is used for the analysis, the basis of which was created by Maťátková (2013) and which is described in chapter 2.4.3. The modified model evaluates elements whose importance is still relevant according to recent research, and, at the same time, the model was extended by elements evaluating relationships and their outputs.

4.1 Research methodology

The analytical part uses the method of Fuller triangle and the Weighted Sum Approach (WSA). These methods serve the purpose as follows. In the first step, the weights of the individual RIS elements are determined by using the statistical method of the Fuller's triangle. In the second step, the RIS comparison is performed using a Weighted Sum Approach.

A) The Fuller triangle method

The method is used in practice to determine the weights of individual elements, where the individual evaluated elements are compared in pairs. For each element, its preference over other evaluated elements is expressed. The result is then the determination of the weight of each element in the evaluated group (Maťátková, 2013).

To apply the Fuller triangle method, it is necessary to divide the evaluated elements (individual parts of RIS) into pairs so that each element gets into a pair with all other elements, but only once. For each pair, it is then determined which element in the pair is more important. Subsequently, for each element, the cases when the element in the pair was more important are summed up and then divided by the total number of paired evaluations (Collan et al., 2009; Perzina and Ramík, 2014; Agarski et al., 2019; Stopka et al., 2020).

To calculate weights of values, the equation is used:

$$v_i = \frac{n_i}{N} \tag{1}$$

where: n_i is the number of preferences for a given criterion,

V_i are the weights of the individual criteria,

N is the total number of paired evaluations.

B) The Weighted Sum Approach

The method is based on the principle of maximizing utility, but assumes only a linear function of utility. The individual variants compared by this method are then sorted according to the maximum achieved utility values (Maťátková, 2013).

The application of the Weighted Sum Approach leads to a comparison of usefulness between evaluation criteria through their weights. The WSA application consists of the following steps, the first step is normalizing the original data, where the data is converted to the same units, using equation (2):

$$r_{ij} = \frac{y_{ij} - D_j}{\mathrm{Hj} - D_j} \tag{2}$$

where: r_{ij} are the normalized values, i alternative and j criterion, and r_{ij} values are in interval (0,1),

D_j are the values of the basal alternative (the worst alternative),

H_j are the values of the ideal alternative.

The next second step is to evaluate the usefulness $[u(a_i)]$ by multiplying the normalized value (r_{ij}) by the weights (v_j) of the criteria according to equation (3):

$$u(a_i) = \sum_{j=1}^{k} v_j \, r_{ij} \tag{3}$$

The last third step determines the order of alternatives according to their final values, the best variant is the variant with the highest result (Jablonsky and Fiala, 2003; Dvorsky et al., 2006; Dincer, 2011).

4.2 Determination of weights for individual RIS elements

In this part, the individual elements of RIS are assigned a label, which is used in the next part of this work. Furthermore, the individual elements are assigned weights, which were determined using the above-mentioned method of the Fuller triangle. The elements are then divided into three auxiliary evaluation groups, each of which has its own weight according to the importance determined in RIS.

For the purposes of the analysis, it was necessary as the first step to determine the weights of individual elements and their labeling, which was performed on the basis of division into RIS layer and subsequently according to the order in which they are entered in the table. This division is

shown in the following Table 11. The importance of the individual elements is described in Table 4.

Table 11: Label of individual RIS elements

RIS layer	Label	Elements
Businesses	B1	Existence of industrial clusters
	B2	Innovative companies
	B3	Number of patents
Support organizations	SO1	Existence of a business incubator / innovation centers
	SO2	Existence of a technology transfer center
Environment and infrastructure	EaI1	Existence of a regional innovation strategy
	EaI2	Existence of organizations forming a professional community in the field (universities, research centers)
	EaI3	Existence of public financial schemes – public expenditures on R&D / support programs / vouchers
	EaI4	Existence of hard innovation infrastructure (house for settlement, with laboratory)
Relationships, ties	RT1	Existence of communication channels (regional council for innovations, smart akcelerátor)
	RT2	Existence of projects confirming cooperation and synergy
	RT3	Existence of triple helix cooperation
	RT4	Existence of cooperation outputs (patents, startups, value added, innovations)

Source: own processing

For the purposes of the analysis, the above elements are divided into three auxiliary groups in order to evaluate the qualitative and quantitative elements. Each auxiliary group also has its own weight, according to the degree of importance identified in RIS, which was determined by the author of the work on the basis of a literature research.

These auxiliary groups are as follows:

- Important quantitative elements (Table 12),
- Supportant quantitative elements (Table 13),
- Important qualitative elements (Table 14).

The following tables determine the weights of the individual elements and auxiliary groups using the Fuller triangle method.

Table 12: Important quantitative elements of RIS with weights

Label	Elements	Weight
B2	Innovative companies	0,333333
EaI1	Existence of a regional innovation strategy	0,266667
EaI2	Existence of organizations forming a professional community in the field (universities, research centers)	0,2
EaI3	Existence of public financial schemes – public expenditures on R&D / support programs / vouchers	0,066667
EaI4	Existence of hard innovation infrastructure (house for settlement, with laboratory)	0,133333

Source: own processing

The Important quantitative elements of RIS (Table 12) included elements that were identified as an important part of RIS and without their existence it is not possible to achieve the proper functioning of RIS (Asheim et al., 2016; Archibugi and Filippetti, 2018; Sousa and Martins, 2018). An example is the existence of a regional innovation strategy document and its updating. This document represents a development plan and therefore sets a clear direction. The biggest weight in this group is represented by innovative companies due to their great influence on the development and implementation of innovations (Lendel et al., 2017; Heikkilä and Lorenz, 2018).

Table 13: Supportant quantitative elements of RIS with weights

Label	Elements	Weight
B1	Existence of industrial clusters	0,4
B3	Number of patents	0,1
SO1	Existence of a business incubator / innovation centers	0,2
SO2	Existence of a technology transfer center	0,3

Source: own processing

The Supportant quantitative elements of RIS (Table 13) included supporting elements whose existence and functionality help RIS, but their existence was not evaluated as critical. An example is the Existence of industrial cluster, which provides interconnection of comapnies which are in a given region and interact. Due to their interconnectedness companies creates business environment for other members of the cluster (Cheruiyot 2018; Prokhorova et al., 2018).

Table 14: Important qualitative elements of RIS with weights

Label	Elements	Weight
RT1	Existence of communication channels (regional council for innovations, smart accelerator)	0,1
RT2	Existence of projects confirming cooperation and synergy	0,2
RT3	Existence of triple helix cooperation	0,3
RT4	Existence of cooperation outputs (patents, startups, value added, innovations)	0,4

Source: own processing

The Important qualitative elements of RIS (Table 14) include the most important element, namely the Existence of cooperation outputs (RT4). The individual elements of RIS are important, but without their mutual synergy, communication and cooperation outputs, RIS will not work (Zhang et al.,2018; Franco and Pinho, 2019).

The weights of the auxiliary groups, according to their importance in RIS, are in the following Table 15. The group of Important qualitative elements was given a higher weight in order to determine their higher importance in the functioning of RIS.

Table 15: Weight of auxiliary groups

Group of elements	**Weight**
Important quantitative	0,333333333
Supportant quantitative	0,166666667
Important qualitative	0,5

Source: own processing

The above determined values of scales are used in further calculations later in this work.

4.3 Evaluation of RIS elements in selected EU regions

For the purposes of evaluation, it was necessary to perform an analysis of individual elements of RIS for all selected regions. The results of the analysis of individual elements were evaluated on the basis of the following Table 16.

Table 16: Evaluation of RIS elements

RIS layer	**Label**	**Elements**	**Evaluation**
Businesses	**B1**	Existence of industrial clusters	0 points if there are no clusters in the region 1-3 points according to visible activity and number of clusters in the region
	B2	Innovative companies	0 points if there are no innovative companies in the region 1-3 points depending on the number of innovative companies in the region
	B3	Number of patents	0 points in case there are no patents in the region 1-3 points depending on the number of patents
Support organizations	**SO1**	Existence of a business incubator / innovation centers	0 points if there is no business incubator or innovation center in the region 1-2 points if there is an incubator or innovation center in the region and their activity
	SO2	Existence of a technology transfer center	0 points if there is no technology transfer center in the region 1 point if there is a technology transfer center in the region 2-3 points according to visible activity in the region

Environment and infrastructure	**EaI1**	Existence of a regional innovation strategy	0 points if the document does not exist 1 point if the document exists 2-3 points depending on how the document is updated
	EaI2	Existence of organizations forming a professional community in the field (universities, research centers)	0 points in case of non-existence of organizations forming a professional commune 1 point in case of existence 2-3 points according to the activity
	EaI3	Existence of public financial schemes – public expenditures on R&D / support programs / vouchers	0 points in case of non-existence of public financial schemes 1 point in case of existence of schemes 2 points in case of diversity of financial schemes 3 points in case region offers support from its own resources
	EaI4	Existence of hard innovation infrastructure (house for settlement, with laboratory)	0 points in case of non-existence of hard innovation infrastructure 1-3 points in case of existence and according to availability of infrastructure for private subjects
Relationships, ties	**RT1**	Existence of communication channels (regional council for innovations, smart accelerator)	0 points in case of non-existence of communication channels 1 point in case of their existence
	RT2	Existence of projects confirming cooperation and synergy	0 points in case of non-existence of projects confirming cooperation and synergy 1 point in case of existence of activities at least in neighboring regions 2 points in case of existence in region 3 points in case of existence in region with overlap into neighboring regions
	RT3	Existence of triple helix cooperation	0 points in case of not finding records on the existence of triple helix cooperation 1 point in case of existence 2-3 points according to the activity
	RT4	Existence of cooperation outputs (patents, startups, value added)	0 points in case of non-existence of cooperation outputs 1 point in case of existence 2-3 points according to activity

Source: own processing

Legend: activity in evaluation means comparison of activities individual elements with other regions

Publicly available resources such as the statistical offices of individual countries, OECD and Eurostat represent the basic information source for the analysis. The functioning of individual

elements was evaluated on the basis of data from the websites of individual elements and regional innovation strategies.

4.3.1 Evaluation of Important quantitative elements

The following elements of RIS are included in this auxiliary group according to Table 12:

- Innovative companies (B2; evaluation points: 1-3 YES, 0 NO),
- Existence of a regional innovation strategy (EaI1; evaluation points: 1-3 YES, 0 NO),
- Existence of organizations forming a professional community in the field (EaI2; evaluation points: 1-3 YES, 0 NO),
- Existence of public financial schemes (EaI3; evaluation points: 1-3 YES, 0 NO),
- Existence of hard innovation infrastructure (EaI4; evaluation points: 1-3 YES, 0 NO).

The result of the assessment of these elements in selected EU regions is in the following summary Table 17.

Table 17: Important quantitative elements

Region/Label	**B2**	**EaI1**	**EaI2**	**EaI3**	**EaI4**
Pardubice Region	YES (33)	YES	YES	YES	LITTLE
Prešov Region	YES (33)	YES	YES	YES	LITTLE+
South Estonia	YES (24)	YES	YES	YES	YES

Source: own processing
Legend: for indicator B2, the numbers in brackets indicate the number of innovative companies, the assessment of their functionality is expressed below by a point evaluation

After scoring the data, the following criterion matrix was created, where the rows and columns correspond to the elements contained in the above Table 17. The method of scoring is described in Chapter 4.3.

2	2	2	2	1
2	1	1	2	2
3	2	2	2	3

Maximum values in the matrix H_j = (3; 2; 2; 2; 3) and minimum values D_j = (2; 1; 1; 2; 1).

Using the transformation formula (2), a normalized criterion matrix was created. The values in this matrix express the values of the effects of the given variant according to the specified criterion.

0	1	1	0	0
0	0	0	0	0,5
1	1	1	0	1

From this normalized matrix, after using formula (3), the resulting values of the effects correspond to the presence of individual elements from individual regions (Table 17). The vector weight values are set in the Table 12.

Weights = (0,333333; 0,266667; 0,2; 0,066667; 0,133333)

After calculating the resulting effect values, the following results are sorted in descending order from the highest effect, which represents the highest development within the selected group of characters:

- South Estonia Region – 0,933333333
- Pardubice Region - 0,466666667
- Prešov Region - 0,066666667

From the above results, it is clear that the region of South Estonia predominates over Pardubice Region and Prešov Region. This is mainly due to the maturity of innovative companies, and the hard innovation infrastructure.

Prešov Region meets the existence of all elements of RIS, which according to the evaluated model should be in RIS, itself is a positive result of the evaluation, but lags behind in comparison with other evaluated EU regions. It has a regional innovation strategy, however the document is not properly updated.

4.3.2 Evaluation of Supportant quantitative elements

The following elements of RIS are included in this indicator group according to Table 13:

- Existence of industrial clusters (B1; evaluation points: 1-3 YES, 0 NO),
- Number of patents (B3; evaluation points: 1-3 YES, 0 NO),
- Existence of a business incubator / innovation centers (SO1; evaluation points: 1-2 YES, 0 NO),
- Existence of a technology transfer center (SO2; evaluation points: 1-3 YES, 0 NO).

The result of the assessment of these features in selected EU regions is in the following summary Table 18.

Table 18: Supportant quantitative and qualitative indicators

Region/Label	**B1**	**B3**	**SO1**	**SO2**
Pardubice Region	YES (3)	YES (17,27)	YES (1)	YES
Prešov Region	YES (2)	YES (7,33)	YES (2)	YES
South Estonia	YES (3)	YES (10,15)	YES (3)	YES

Source: own processing

Legend: for indicator B1 the number in brackets indicate number of industrial clusters that were found in the region, the assessment of their functionality is expressed below by a point evaluation; for indicator B3 the number in brackets is the Eurostat rating last updated in 2013; for indicator SO1 the number in brackets is the number of incubators / innovation centers, the assessment of their functionality is expressed below by a point evaluation

After scoring the data, the following criterion matrix was created, where the rows and columns correspond to the elements contained in the above Table 18. The method of scoring is described in chapter 4.3.

2	1	1	1
1	1	1	2
3	1	2	2

Maximum values in the matrix H_j = (3; 1; 2; 2) and minimum values D_j = (1; 1; 1; 1).

Using the transformation formula (2), a normalized criterion matrix was created. The values in this matrix express the values of the effects of the given variant according to the specified criterion.

0,5	0	0	0
0	0	0	1
1	0	1	1

From this normalized matrix, after using formula (3), the resulting values of the effects correspond to the presence of individual elements from individual regions (Table 18). The vector weight values are set in the Table 13.

Weights = (0,4; 0,1; 0,2; 0,3)

After calculating the resulting effect values, the following results are sorted in descending order from the highest effect, which represents the highest development within the selected group of characters:

- South Estonia – 0,9
- Prešov Region - 0,3
- Pardubice Region – 0,2

From the above results for the evaluated group Supportant quantitative indicators, the South Estonia region received the highest score. The result is most influenced by functioning of clusters in this region. This is also the reason for the results of other evaluated regions. Futhermore, low results in other regions are caused by the functioning of business incubators / innovation centers compared with South Estonia incubators and innovation centers.

4.3.3 Evaluation of Important qualitative indicators

The following elements of RIS are included in this indicator group according to Table 14:

- Existence of communication channels (RT1; evaluation points: 1 YES, 0 NO),
- Existence of projects confirming cooperation and synergy (RT2; evaluation points: 1-3 YES, 0 NO),
- Existence of triple helix cooperation (RT3; evaluation points: 1-3 YES, 0 NO),
- Existence of cooperation outputs (RT4; evaluation points: 1 LITTLE, 2-3 YES, 0 NO).

The result of the assessment of these features in selected EU regions is in the following summary Table 19.

Table 19: Important qualitative indicators

Region/Label	**RT1**	**RT2**	**RT3**	**RT4**
Pardubice Region	YES	YES	YES	LITTLE
Prešov Region	YES	YES	NO	NO
South Estonia	YES	YES	YES	YES

Source: own processing

After scoring the data, the following criterion matrix was created, where the rows and columns correspond to the elements contained in the above Table 19. The method of scoring is described in chapter 4.3.

1	2	1	1
1	1	0	0
1	3	2	2

Maximum values in the matrix H_j = (1; 3; 2; 2) and minimum values D_j = (1; 1; 0; 0).

Using the transformation formula (2), a normalized criterion matrix was created. The values in this matrix express the values of the effects of the given variant according to the specified criterion.

0	0,5	0,5	0,5
0	0	0	0
0	1	1	1

From this normalized matrix, after using formula (3), the resulting values of the effects correspond to the presence of individual elements from individual regions (Table 19). The vector weight values are set in the Table 14.

Weights = (0,1; 0,2; 0,3; 0,4)

After calculating the resulting effect values, the following results are sorted in descending order from the highest effect, which represents the highest development within the selected group of characters:

- South Estonia – 0,9
- Pardubice Region – 0,45
- Prešov Region – 0

In the evaluation of Important qualitative indicators, South Estonia received the highest rating, primarily due to the existence of cooperation outputs. On the other hand, the Prešov Region was evaluated as a region where cooperation between RIS entities does not have traceable outputs.

5 Results and recommendations

This chapter summarizes the overall evaluation of the analysis in chapter 4. Subsequently, the individual results of the evaluated regions are described and compared. Recommendations are made in the last part of the chapter.

5.1 Overall evaluation of the examined RIS of selected regions

The previous chapter 4 evaluated the presence of individual elements of RIS. This part of the work is devoted to the overall results of the analysis.

Table 20 contains the final evaluation of individual regions in the evaluated groups of indicators, including the weights of these groups, which are based on Table 15.

Table 20: Evaluation of the effects in evaluated groups by regions

Group of elements	Pardubice Region	Prešov Region	South Estonia	Weight of group
Important quantitative	0,466666667	0,066666667	0,933333333	0,333333333
Supportant quantitative	0,2	0,3	0,9	0,166666667
Important qualitative	0,45	0	0,9	0,5

Source: own processing

The total result from the presence of RIS in regions is determined by using the weighted sum of the individual effects. The values calculated in this way are in the Table 21.

At the same time, the functionality of RIS was evaluated on the basis of meeting the indicator (RT4) Existence of cooperation outputs (patents, startups, value added, innovations), which verifies whether RIS has the required outputs.

The RIS functionality was determined as follows:

- Functioning in case the existence of outputs created on the basis of cooperation of individual RIS elements were found in the region,
- Partially functioning if there are certain outputs in the region based on the cooperation of individual RIS elements, but they are rather rare.
- Limited functionality in case there are no outputs (patents, startups, innovations, …) in the region based on the cooperation of individual RIS elements.

Table 21: Overall ranking of the evaluated regions

Region	Final result	Ranking	RIS functionality
South Estonia	0,911111111	1.	Functioning
Pardubice Region	0,413888889	2.	Partially functioning
Prešov Region	0,072222222	3.	Limited functionality

Source: own processing

The following section provides an overall summary of the results obtained during the analysis.

5.2 Summary of results

Although the individual RIS belongs to the group of Central and Eastern Europe countries, it is possible to observe that the RIS equipment is completely different. After the analysis, the following findings can be stated. In the evaluated regions, the existence of all basic elements of the RIS infrastructure that have been analyzed can be confirmed. However, obvious differences can be found in the interrelationships and relationships between the individual elements of RIS. There are innovative companies and industrial clusters in all evaluated regions, but their activity differ. There is 1 active cluster in the Pardubice region, 1 active cluster in the Prešov region and 3 active clusters in South Estonia.

There are technology transfer centers (established by particular universities) in each of the evaluated regions and there are also business incubators or innovation centers there. However, approach differs in each region. Only in South Estonia the local university is the founding member of the incubator or innovation center, so the synergy between the university, business incubator, innovation center and technology transfer center can be noted. In the Prešov Region, technology transfer centers from the neighboring region have a higher scope, in which this center operates on the same principles as in South Estonia, so it is a founding member of the above-mentioned institutions and extends its activity beyond its region. Pardubice Region is the only one in which no innovation center can be found and a business incubator has existed only since 2018 here.

The differences can be seen in the equipment of hard innovation infrastructure. South Estonia, as the only evaluated region, has science parks and infrastructures in its territory, which offer extensive tools that companies can use for innovations. The Pardubice Region has an incubator infrastructure, which currently does not have enough necessary tools that could help innovations. In the region there is also an infrastructure established by a university focused on transport research. Prešov Region has an incubator infrastructure on its territory, but even here the premises of the science and technology park in the neighboring region are primarily used.

All the evaluated regions have their own regional innovation strategy, but it cannot be confirmed that the entities that are to meet the objectives set out in the regional innovation strategy are following these goals. A more thorough analysis would be needed to confirm this statement. For the individual evaluated regions, it was found that the Prešov Region has an innovation strategy, but the objectives in it are not specifically characterized and the document is not subject to updating. Pardubice Region is in a similar situation, but there has been an update. In the case of

South Estonia, it was found that there are also partial plans describing the current situation, the specific goal, specific steps and the date of implementation.

On the basis of the EU membership, regions have a number of financial schemes focused on expenditures on R&D, mostly financial schemes that are set at the state level, not directly the regions. However, none of the evaluated regions provides its own financial resources to motivate private and public entities to cooperate more leading to innovation.

There are a number of communication channels which should ensure communication between the individual RIS elements in the evaluated regions, in the case of the analysis performed in this work, only their existence was evaluated. However, based on the results, which indicate differences between the interconnectedness and relationships of individual RIS elements, it would be appropriate to analyze the individual communication channels in more depth in the sense of their goals, ways of fulfilling them and their correspondence with the regional innovation strategy of the region.

The biggest difference was found in the evaluation of outputs that are affected by the interconnectedness and mutual cooperation of individual RIS elements. Cooperation based on the tripple helix model can only be demonstrably confirmed in the South Estonia region. In the Pardubice Region, there are outputs that are based on the cooperation of the university with private entities, when patents are created. However, this cooperation is negligible compared to case of the university located in South Estonia. The university in Prešov Region does not provide enough external information for entrepreneurs and the private sector based in Prešov Region cooperates more with neighboring regions. It can therefore be stated that South Estonia has Functioning RIS, Pardubice Region Partially functioning RIS and Prešov Region has RIS with Limited functionality.

The above-mentioned differences are also confirmed by the division of individual countries. According to the European Innovation Scoreboard (2020) Estonia is one of the Strong Innovators, ie a country with a performance between 95 % and 125 % of the EU average. The Czech Republic and Slovakia belongs to the group Moderate Innovators, ie countries with a performance between 50 % and 95 % of the EU average.

5.3 Recommendations

Based on the performed analysis and findings about the differences in the evaluated RIS elements, The author of this work proposes recommendations whose implementation could lead to improvement of RIS in the given region.

Although each region has its own regional innovation strategy, it cannot be confirmed that it governs the actors involved and thus actually implements it. As the document should clearly set the direction of innovation activities, it would be appropriate for the elements of RIS to follow the strategy. The regional innovation strategy sets out visions and goals, but lacks the specification of the goal in the form of specifying the goal, determining responsibility for its implementation and in what time horizon it is to be implemented. It would therefore be appropriate for the regional innovation strategy to meet the following:

- concretization of goals and gradual steps leading to the fulfillment of the vision set out in the strategy,
- determining the responsibility of individual RIS elements for the fulfillment of partial goals and their control,
- regular evaluation of the fulfillment of objectives and responsibilities of individual RIS elements.

Another recommendation concerns hard innovation infrastructure. In case of the Pardubice Region and Prešov Region, it was found that they have a hard innovation infrastructure, but it cannot be considered sufficient. Insufficient hard innovation infrastructure can lead to a brain drain to other regions where this infrastructure is sufficient, as is the case in the Prešov Region. It is in the region's interest that emerging innovations remain directly in it. Therefore, it is appropriate to implement in the region to support the following:

- creation and support of basic hard innovation infrastructure such as technology and innovation platforms, industrial zones, science and technology parks, and business incubators (these institutions are eligible to perform expertized mapping of the environment. The output of this mapping would be specification of promising hard innovation infrastructure. These findings, could prevent the migration of emerging projects from the region),
- promoting the region's communication with private entities, which will show companies that the region cares about their staying and cooperating in the regions. An example of such communication can be a bookmark on the website of the region, specialized for entrepreneurs, where there will be all the information about the business environment in the region.

Based on the literature research, it was found that cooperation based on triple helix is beneficial as it brings positive effects in the form of innovations. It is also appropriate if the university operating in the region is in active contact with other hard innovation infrastructure, or the university is a

founding member of the business incubator or innovation center. This can make it easier for projects emerging in the region to access the services these institutions offer. In the analyzed region South Estonia, synergies can be seen in the cooperation between the university, the transfer and technology center, the incubator and the innovation center. In Pardubice Region and Prešov Region where such cooperation does not take place, the following is appropriate:

- support for the active involvement of the university in building and founding a hard innovation infrastructure, which should promote synergies between the university and the infrastructure,
- financial support from the region to projects leading to cooperation between the university and private entities, this should motivate these entities to work together and knowledge spillover.

In this chapter, general recommendations focused on regional innovation strategy, hard innovation infrastructure and cooperation on a triple helix basis were described.

Conclusion

The aim of the thesis was to analyze regional innovation systems in selected EU countries and to evaluate and to compare them with the help of existing methodology.

The first part dealt with the theoretical description and classification of innovation, innovation structure and innovation environment. Subsequently, the innovation cooperation, innovation systems and characteristics of regional innovation systems, their division, limitations and the method of their evaluation were theoretically described. The later phase of the work described the socio-economic characteristics of selected European countries and their selected regions, whose regional innovation systems were evaluated. These countries belong to the Central and Eastern Europe countries and have been members of the EU since 2004. These were the Czech Republic, Slovakia and Estonia, while the selected regions that have been analyzed were the Pardubice Region, Prešov Region and South Estonia.

Subsequently, an analysis of selected RIS was performed by using a modified RIS evaluation model, which was updated and expanded with evaluation of triple helix cooperation and outputs based on mutual cooperation of individual RIS elements. Based on a literature research, the evaluated RIS elements were divided by the author of the work according to their importance into evaluation groups and their weight was determined using statistical methods. The last part of the work described the overall results of the analysis and determined the functionality of the evaluated RIS. It must be admitted that the analyzed results depend on the criteria, the priority of which was set by the author of the diploma thesis.

The final evaluation showed that all RIS elements exist in the evaluated regions, visible differences were known in the relationships and interconnectedness of individual RIS elements. It was therefore established that South Estonia has Functioning RIS, Pardubice Region Partially functioning RIS and Prešov Region has RIS with Limited functionality. The results showed number of directions for future research. Despite the presence of the regional innovation strategy, it cannot be clearly confirmed that it cooperates with entities that are to meet the objectives set out in it. For this reason, it would be necessary to analyze how the regions and entities in it work with regional innovation strategies. There are a number of communication channels which should ensure communication between the individual RIS elements in the regions, but given the results of the analysis, it would be appropriate to make a more detailed analysis of them, what goals they set, what paths they use to fulfill them and what results they achieve. The resulting recommendations are summarized in the last part of the work and relate to regional innovation strategy, hard innovation infrastructure and cooperation on a triple helix basis.

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LIST OF ATTACHMENTS

Attachment 1: Analysis of Pardubice Region

RIS layer		Elements	Pardubice Region (Czech Republic)
Businesses	**B1**	Existence of industrial clusters	NANOPROGRESS, Hi-Tech inovační klastr, Energeticko – vodárenský inovační klastr
	B2	Innovative companies	Electro (10), chemistry (7), transport (6), engineering (7), textile (3)
	B3	Number of patents	17,27
Support organizations	**SO1**	Existence of a business incubator / innovation centers	PPINK
	SO2	Existence of a technology transfer center	CTKT UPCE
Environment and infrastructure	**EaI1**	Existence of a regional innovation strategy	RIS3, 2014, last update 062020
	EaI2	Existence of organizations forming a professional community in the field (universities, research centers)	University of Pardubice, Synpo, a.s., VUOS, a.s, Centrum organické chemie s.r.o., EXPLOSIA a.s. Výzkumný ústav průmyslové chemie, Výzkumný ústav meliorací a ochrany půdy, v. v. i. – pobočka Pardubice, TOSEDA s.r.o.
	EaI3	Existence of public financial schemes – public expenditures on R&D / support programs / vouchers	Zlaté české ručičky, OPERAČNÍ PROGRAM PODNIKÁNÍ A INOVACE PRO KONKURENCESCHOPNOST (OP PIK), OPERAČNÍ PROGRAM VÝZKUM, VÝVOJ A VZDĚLÁVÁNÍ (OP VVV), … Program rozvoje Pardubického kraje 2012–2020, Strategie integrované územní investice Hradecko–pardubické aglomerace 2014–2020, Marketingová strategie pro podporu inovací, vědy a výzkumu v Pardubickém kraji,
	EaI4	Existence of hard innovation infrastructure (house for settlement, with laboratory)	Incubator, Education and Research Center in Transport
Relationship, ties	**RT1**	Existence of communication channels (regional council for innovations, smart accelerator)	Pardubický kraj, Pardubický podnikatelský inkubátor (P-PINK) , Krajská hospodářská komora Pardubického kraje (KHK Pk), Centrum transferu technologií a znalostí (CTTZ) Upa, Czech Invest, Regionální kontaktní organizace – kontaktu pro Evropský výzkumný prostor (RKO-ERA)
	RT2	Existence of projects confirming cooperation and synergy	Konsorcium zaměstnavatelů Orlicka, Společenství firem Lanškrounska, Program vytváření a rozvíjení zájmu žáků o vědecké a technické obory v Pardubickém kraji, URBACT, ...
	RT3	Existence of triple helix cooperation	FCHT – Synthesia a.s., …, DFJP – CZ LOKO a.s., …
	RT4	Existence of cooperation outputs (patents, startups, value added)	DFJP – DAKO CZ (Telemetrická jednotka pro železniční vůz, 2020), DFJP – VÚKV a.s., FCHT

Attachment 2: Analysis of South Estonia

RIS layer		Elements	Lõuna-Eesti (South Estonia)
Businesses	**B1**	Existence of industrial clusters	Tartu Biotechnology Cluster, Tartu Health Cluster, CREATIVE ESTONIA
	B2	Innovative companies	A lot of start ups. Stable big companies: Biotechnology (5), Information Technology (8), Metal-processing and Machine-building (4), Woodworking Industry (7)
	B3	Number of patents	10,15
Support organizations	**SO1**	Existence of a business incubator / innovation centers	Tartu Science Park, Tartu Biotechnology Park, European Space Agency Estonian business incubator
	SO2	Existence of a technology transfer center	UT Centre for Entrepreneurship and Innovation
Environment and infrastructure	**EaI1**	Existence of a regional innovation strategy	Smart Specialization Strategy for South-Estonia (2013–2020)
	EaI2	Existence of organizations forming a professional community in the field (universities, research centers)	University of Tartu, Instute of Genomics, Mycology Research Centre
	EaI3	Existence of public financial schemes – public expenditures on R&D / support programs / vouchers	Funding programmes (all from EU budgets): Technological development centres and cluster, Startup Estonia program, Applied Research measure, Specialisation Scholarships measure
	EaI4	Existence of hard innovation infrastructure (house for settlement, with laboratory)	Science Park, Hubs, Biotechnology Park.
Relationship, ties	**RT1**	Existence of communication channels (regional council for innovations, smart accelerator)	Estonian Research Council, Ministry of Economic Affairs and Communications, Enterprise Estonia (CI v EE), County Development Centres
	RT2	Existence of projects confirming cooperation and synergy	sTARTUp Tartu ecosystem, Tartu - university-enterprise cooperation, biotech, medicine, IT
	RT3	Existence of triple helix cooperation	Tartu university - .Contriber (angle investors) - Incubators - … (Tartu startup ecosystem)
	RT4	Existence of cooperation outputs (patents, startups, value added)	Startups, Spin-off companies, patents (nanotechnology)

Attachment 3: Analysis of Prešov Region

RIS layer		Elements	Prešov Region (Slovakia)
Businesses	**B1**	Existence of industrial clusters	Energy Cluster of Presov Region, Automation Technology and Robotics (AT+R) Cluster
	B2	Innovative companies	Wood processing industry (13), engineering industry (20), Chemical and pharmaceutical industry (8), electro (5)
	B3	Number of patents	7,33
Support organizations	**SO1**	Existence of a business incubator / innovation centers	RPIC Prešov, Inovačné partnerské centrum
	SO2	Existence of a technology transfer center	UVP TECHNICOM
Environment and infrastructure	**EaI1**	Existence of a regional innovation strategy	RIS 2 PSK, 2015-2020
	EaI2	Existence of organizations forming a professional community in the field (universities, research centers)	University of Presov, Vysoká škola medzinárodného podnikania ISM Slovakia, Fakulta výrobných technológií patriaca Technickej univerzite v Košiciach
	EaI3	Existence of public financial schemes – public expenditures on R&D / support programs / vouchers	OP Výskum a inovácie, OP Ľudské zdroje, program cezhraničnej a nadnárodnej spolupráce Interreg V, Inovační fond, inovační vouchery, podpora klastrů
	EaI4	Existence of hard innovation infrastructure (house for settlement, with laboratory)	Incubator, Vedeckotechnický park Technicom
Relationships, ties	**RT1**	Existence of communication channels (regional council for innovations, smart accelerator)	Centrá podnikových služieb (BSC), Slovak business agency, RPIC Prešov, SARIO (slovenskej CI), SAPTI (Slovenská asociácia podnikateľských a technologických inkubátorov), SOPK (Slovenská obchodná a priemyselná komora)
	RT2	Existence of projects confirming cooperation and synergy	Košice IT Valley, poor communication of the university with the entrepreneurs (lack of information for entrepreneurs), cooperation works more between the scientific-research infrastructure in the surrounding regions
	RT3	Existence of triple helix cooperation	-
	RT4	Existence of cooperation outputs (patents, startups, value added)	-