

**VILNIAUS UNIVERSITETAS**

**GIEDRĖ DZEMYDAITĖ**

**EFFICIENCY OF REGIONAL ECONOMIC DEVELOPMENT  
IN THE PROCESS OF THE EUROPEAN UNION INTEGRATION**

Summary of doctoral dissertation

Social sciences, Economics (04 S)

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PROCESŲ EUROPOS SĄJUNGOJE SĄLYGOMIS**

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## INTRODUCTION

**Relevance of the topic.** The European Union regions and countries have to solve regional economic development problems that occur in global economy and the context of the EU integration: income inequality, inability of some business areas to adapt to the global changes, technological changes, labour migration. A significant part of the value-added and resources for generating economic activity are concentrated in the more economically developed regions and urban areas. Other regions have to find paths to restructure business and to be competitive.

The EU integration processes affect the regional economies of member countries that are different in business structures, the level of specialization and diversification (Burda, Severgnini, 2009; Ertur, Koch, 2006). The integration influences a more intensive movement of production factors between regions, induces a foreign direct investment and migration flows (Marrocu et al., 2013). The movement of production factors encourage a greater regional business specialization (Burda, Severgnini, 2009). The regional economic development and policies related with that have a significant role in today's economy, since the aim is to identify regional strategic development directions, sources of growth, and to ensure competitiveness in the global and integrated EU market.

According to the „Europe 2020“ strategy, the EU aims to exploit the potential of the workforce, to increase employment rates and productivity, to deal with an aging population and high global competitive challenges (European Commission, 2010). However, without a territorial cohesion it will be difficult to provide equal opportunities for all regions to achieve positive economic results. The economic disparities between the EU regions remains significant (ESPON 2012; Okubo 2012; Becker et al. 2012; Busillo et al. 2012; Butkus, Matuzevičiūtė, 2011; European Commission, 2010; Simanavičienė, et al., 2010 ; Barca, 2009).

After the EU territorial expansion (since 2004), regional economic differences in the EU have increased significantly (EESC, 2006). The new member states (that joined the EU in 2004) are still not creating enough of high value-added goods and knowledge-intensive services. A significantly increased differentiation between the NUTS2 and NUTS3 regional levels in the EU reveals that economic structure of the the new member

states is more focused on low-tech industries and intermediary services (Becker et al. 2012; Busillo et al. 2012; Barca, 2009). The technological progress is not intensive enough to change the current economic structures.

The new member states' joining in the EU means that the EU has to take some responsibility of new members' economic development problems. The EU provides investment support for economically less developed regions and initiates action programs. One of the objectives of the Europe 2020 strategy for the period 2014-2020 is to promote regional development, increase productivity and employment (European Commission, 2010). About a third of the EU budget (over 350 billion) is planned for the EU cohesion policy during the period of 2014-2020. It is important for each region to identify its paths for economic growth and to provide information how it will contribute to the achievement of the EU's strategic goals.

The EU member states also have to deal with the problems related to a financial stability and a budget deficit, and emergence of the refugee crisis when there is a lack of financial resources. Under these circumstances it is very important that the cohesion policy funds were invested and managed properly, even though some of national, regional, and local administrations could be not efficient enough to implement relevant programs successfully (European Commission, 2015). Originally, the refugee crisis provides both opportunities and threats to the EU regional development (IMF, 2016; Draghi, 2016.). Therefore, an efficient allocation of financial resources and appropriate regional policy options in response to emerging new threats are becoming one of the EU's economic policy challenges to a sustainable regional economic development and a greater economic growth.

**Research problem.** In the modern economic theory, there is a lack of practical solutions and scientific knowledge for a reasonable assessment of regional economic development and its efficiency, taking into account the new circumstances created by globalization and integration processes in the European Union under the conditions, which were not adequately covered. There are new approaches to the regional economic development of the various European Union countries, regional priorities, including a sustainable development, competitiveness and productivity objectives, and the innovation promotion priority. In practice of the economic development efficiency these new circumstances are not adequately covered, so the modern economic theory lacks

adequate solutions and evaluation of the circumstances of the European Union integration. Such theoretical attitudes make it possible to try to find a more precise solution to the current regional economic problems.

**The object of the research** is the efficiency of regional economic development and its evaluation practices, taking into account sustainable development challenges in the context of the globalization and the EU integration.

**The aim** of the thesis is to analyze the current trends, important for the regional economic development, and to develop and implement a theoretical concept for increasing the efficiency of regional economic development and to improve an assessment of the economic efficiency, taking into account sustainable development challenges in the context of the globalization and the EU integration.

To achieve the goal, the following **objectives** are set:

1. To analyze the concept of regional economic development and related economic research in the context of the European Union integration.

2. To analyze the factors of the regional economic development and to integrate them into a composite model.

3. To discuss the instruments for assessment of the regional economic development and its efficiency on the basis of the EU strategies, reports and directives.

4. To compile the research methodology for measuring regional economic development processes and their efficiency in the context of the European Union integration.

5. Based on the research methodology, to measure the economic efficiency of Central and Eastern EU regions, to evaluate the factors of regional economic development and their interactions and to give recommendations for the regional economic policy making.

**Research methods.** The research methodology is based on a systematic approach to the regional economic development and planning in the context of the European Union. The research is composed of the localized, fragmented studies that are complementing each other. Each of them has its own approach, but all of them are combined into a common methodological framework. In order to fully analyze the issues raised, both theoretical and empirical research methods were applied.

Theoretical research methods were applied in the analysis of the regional economic development concept, the main factors and trends in the European Union: systematization and synthesis of ideas presented in the recent regional research, strategies and policy documents and a descriptive analysis of statistical data.

The empirical study can be divided into two parts. The first part analyzes the regional economic resources and the efficiency of using them to create economic results. The input and output analysis is made using nonparametric linear programming methods: data envelopment analysis (DEA), full disposal hull (FDH), and order- $\alpha$  analysis.

The second part of empirical research assesses the regional economic development factors, their interactions and similarities. The analysis combines multidimensional data visualization methods: Kohonen's artificial neural network (the self-organizing map – SOM) and Sammon's projection to get most information about regional economic development processes by analyzing multidimensional data. Statistical data from Eurostat and national statistical databases are used. Statistical data are collected and processed in SPSS, Stata, Deap, and MatLab programs. EU NUTS2 and NUTS3 level regional data are analyzed.

**The defended statements:**

1. Human capital and other resources needful for a high value added are used ineffectively in the Central and Eastern regions of the EU.
2. Investment in the Central and Eastern EU regions does not efficiently contribute to restructuring of the regional economies, that leads to a lack of the regional economic growth and development.
3. To identify efficient solutions of the regional economic development, there should be made a composite evaluation of regional economic development factors and their interactions.

**Theoretical significance and scientific novelty of the research.** From a theoretical point of view, a regional economic development is not a new concept: at the end of the twentieth century and the beginning of the twenty-first century it is analyzed in various scientific directions. The result is a diversity of models underlying the different processes of regional economic development. However, the studies lack a systematic evaluation of the processes, in conjunction with the different elements on the



whole. In the thesis, methods are proposed that allow to analyze the available aggregated data, to abstract and provide a systematic assessment of the situation.

For today's economy, the new evaluation criteria of the regional economic development performance become important in the context of the European Union integration. Regions should attempt to be efficient throughout the EU area, to achieve a sustainable development, a higher social well-being and a higher quality of life. Although the Central and Eastern regions of the EU have a higher economic growth than the EU, however due to the relatively low households' disposable income, even greater manifestations of unsustainable economic development are seen. In this thesis, the proposed algorithm allows to take into account important factors, that have not been adequately taken into account, e.g. regional innovation systems efficiency, resource and infrastructure development, efficiency of human resources for creating high value-added.

In the dissertation, the regional economic development factors are systematized to the overall regional economic development model according to their interaction. The model investigates quantitative and qualitative factors, back-links and integrates the concept of technical efficiency, which was not previously included in similar models. The developed model allows us to explore and assess the regional economic development trends in a broader perspective, to identify regional deficiencies, and to pay attention to the qualitative factors in the regional economy.

The thesis has proposed research methods that reveal NUTS2 and NUTS3 regional issues and enable us to explore less tangible factors and their importance for the regional economic development by quantitative methods. In order to solve the problem of exploring more qualitative aspects, non-parametric methods are applied in the determination of an efficient frontier on the basis of assessing the total region's ability to absorb the available resources and to generate a high value-added. That renders a possibility to assess the overall performance of regional companies as a qualitative capacity to exploit regional resources.

The ability to operate efficiently covers the business and public management features, benefits from the synergy that takes place in businesses as well as business and science cooperation, leadership to realize the knowledge, experience and to commercialize the ideas, company's ability to develop competitive products in a market. Although the non-parametric analysis does not specify which of the following areas of

management is inefficient, it is possible to identify under-utilized resources and, according to that, make more precise decisions on how to modify the related management processes.

The novelty of work is based on the fact that non-parametric methods for measuring the technical efficiency are applied to analyze the Central and Eastern regions of the EU and Lithuanian NUTS3 regions, for the first time. As well as the regional economic development factors are analyzed for the first time by combination of multidimensional data visualization methods: Kohonen's artificial neural network (the self-organizing map – SOM) and Sammon's projection.

**Practical significance of the research.** The results may be useful for researchers and practitioners who study and develop the European Union and the Lithuanian regional economic policy, the integration process of the EU, convergence issues and create regional economic development strategies. Systematic assessment of the regional economic development and the proposed research methodology make the basis for developing a regional economic policy that would be problem-oriented to a higher value-added in the Central and Eastern EU regions.

The proposed research methodology can be applied to other countries or regions of the EU for a deeper analysis of economic development processes and their efficiency and for modelling economic factors interaction in order to identify potential growth areas, to examine regional economic policies and increase the efficiency of processes.

**The limitations on the research and availability of data.** Nonparametric efficient frontier methods (DEA, FDH and order- $\alpha$ ) provide opportunities to measure the efficiency of regional economic development according to the level of inputs and outputs. The main limitation of this analysis is that the estimated efficiency scores are conditional, depending on the field of survey and selected indicators. If other fields of economy will be chosen, other efficient regions could emerge in analyzed group.

This study copes with the problem of data availability. There was no possibility to analyze the latest EU regional data. The EU regional data collection and submission to Eurostat takes about 3-4 years. For example, "Europe2020" strategy, which came into force in 2014, was composed according to 2010 regional data and the regional cohesion report of European Commission, published in 2015, analyzed the regional GDP data of 2011. As a result, the most recent data analyzed in the paper, were of 2013-2014.

Another problem of data availability is that there is no possibility to systematically measure smaller than the NUTS2 level territorial units. The statistical data are fragmentary for such territorial dimensions (NUTS3, LAU1), the comparison of regional data in different countries is limited. As a result, the NUTS2 regional level was analyzed in empirical research and some aspects of NUTS3 regions were analyzed using Lithuanian data.

**The structure of the thesis.** The thesis consists of an introduction, four main sections, conclusions and recommendations, a bibliography, and appendices. The thesis is of 182 pages and contains 24 tables, 26 figures, and 21 appendices.

The first section analyzes the concept of regional economic development in the context of EU integration. The factors of regional economic development are systematized to the conceptual models. The second section consists of a detailed analysis of recent challenges for the regional economic development in the context of European integration. Planning tools and mechanisms of regional economic development are analyzed at the EU and national levels. In the third section, the research methodology for measuring the regional economic development and its efficiency is explored in detail. The fourth part presents the empirical results.

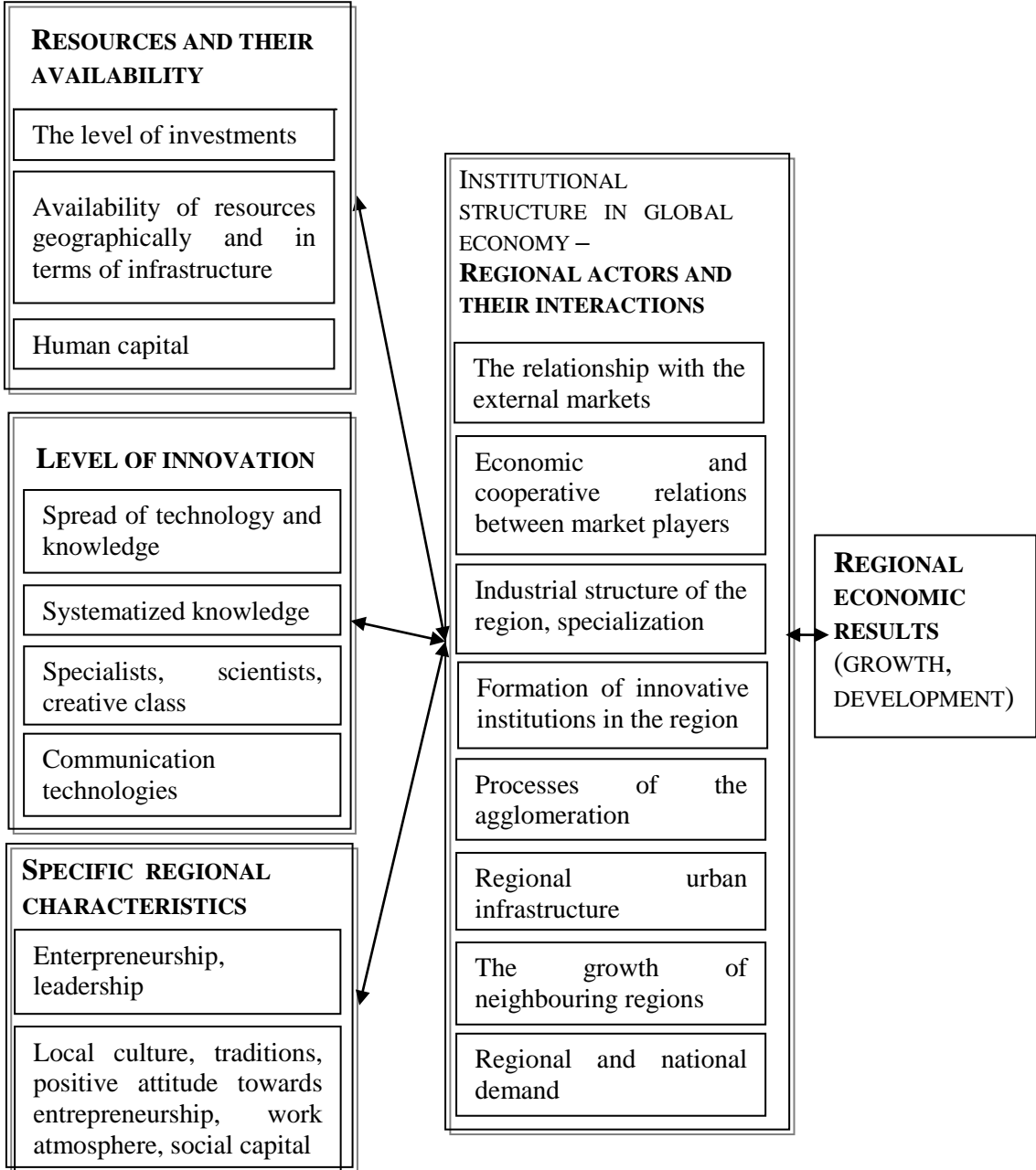
## **REVIEW OF THE CONTENT OF DISSERTATION**

### **The main factors of regional economic development in the integration process of the EU**

Over the past two decades regional economic development processes and emerging unsustainable problems are complex and diverse. Structural changes in the global economy since the 1980s have increased the importance of innovation for the economic growth, highlighted the powerful agglomeration forces in the various territorial levels and led to an increased need for enterprises' flexibility to innovate and compete in the global and integrated market (Barca et al. 2012 ).

Regional economics is an additional part of economic science, which makes this science even more difficult, to answer the question of why the areas, located in different geographic territories, are developing differently. It is not enough to explain the complex modern regional economic development processes by neoclassical growth theory. Only

recently, in the last twenty years, more attention has been paid to the importance of non-material resources and less tangible factors such as knowledge, cooperation, entrepreneurship, and the importance of institutions and their abilities to innovate, improve business competitiveness and ensure a long-term economic development.



**Fig 1.** The conceptual model of regional economic development factors

*Source: compiled by the author*

In order to fully assess the modern regional economic development issues and economic policy challenges, there are three main theoretical directions that deal with complex economic development processes: endogenous growth theory, which basically focuses on knowledge spillover and expands the neoclassical growth theory; the new

economic geography, analysing spatial concentration of resources and related processes; institutional economics, highlighting the importance of existing institutions that are involved in the creation of economic value.

Based on the current regional economic researches as well as the neoclassical growth theory, a conceptual model of regional economic development factors is proposed (Fig. 1). The model combines the importance of material resources, infrastructure, together with innovation and knowledge aspects. In the model four groups of factors are identified: resources and their availability, the level of innovation, characterized by the level of knowledge and creative class, the specific, cultural characteristics of the region and regional institutions that make usage of available resources and create the economic value in global economy.

In the model, reversible connections are involved between regional actors and other three groups of factors, which makes this model more dynamic. On the one side, institutions affect changes of resources by employee's trainings, generating new ideas, expanding the knowledge, and making new investments in infrastructure and other fields. On the other side, a mix of regional resources and positive cultural background helps attract new companies to the region and in this way, can partly shape the institutional structure. The most difficult changes are that of specific regional characteristics that are very closely related with the cultural background and values. It takes a lot of time to change attitudes and customs towards business organization, cooperation, public sector initiatives, and to enhance leadership or entrepreneurship.

To sum up, the regional economy consists of dynamic processes. Regional differences could be analyzed according to the proposed model of regional economic development factors, that integrates ideas from the recent researches and classical perspectives important in the context of globalization and integration processes of the EU. A huge importance in the model is given to the institutions that are the main subjects creating the economic value as well as to resources and specific characteristics that have a strong influence on shaping the regional economy and on the way it develops.

### **The technical efficiency concept in the regional economic development analysis**

When analysing the regional economy, it is important not only to identify the factors for regional economic development, but also to assess whether the factors and

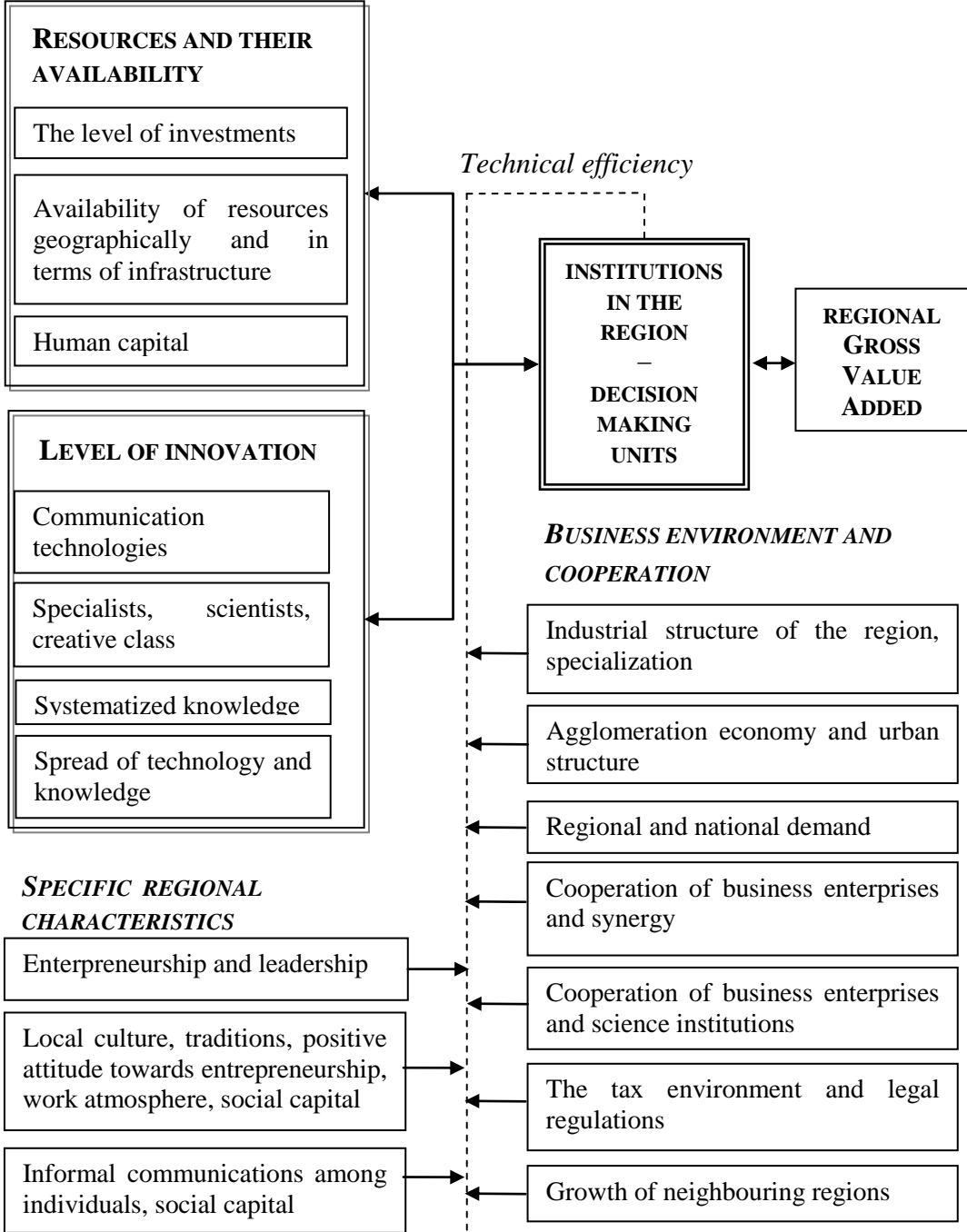
available regional resources are used efficiently. According to OECD (2014), the regional economic policy has not sufficiently reduced regional economic and social disparities. The focus was on a large-scale investment into infrastructure, which did not have a significant impact on the region's economic growth and it did not efficiently help for economically weaker areas to catch up with more developed areas. So it is very important for the investment and regional resources to be directed to appropriate programs and be efficiently used, so that regions could exploit the available economic potential and achieve desired returns.

Regional economic development differences could be analyzed in two ways (Fritsch and Slavchev, 2011). First, the regional differences could be explained by different levels and qualitative characteristics of the resources. Secondly, the regional differences could be assessed by evaluating decision making units' efficiency how these resources are turned into economic results. So it is very important to analyze not only the resources available, but also the efficiency of their usage.

The efficiency analysis of regional economic development is related to the region's production function, measuring the level of resources and outputs achieved (Schaffer et al., 2011; Fritsch, Slavchev, 2011; Daou et al 2012; D'Agostino et al. 2013). Recent researches of efficiency is based on Farrell's (1957) ideas, that investigated the economic efficiency, consisting of a technical efficiency and an allocative efficiency. The technical efficiency is the ability of a decision making unit to achieve the maximum output with the available economic resources. The resource allocation efficiency reveals the company's ability to choose the best resource ratio according to the market prices. By means of the regional analysis it is not possible to assess the price of different resources, so the economic efficiency is evaluated using the concept of the technical efficiency.

The economic efficiency and performance measurement are applied in the investigation of the EU economic policy in order to find out more effective decisions for distributing financial resources and policy formation (Broekel et al., 2010; Autant-Bernard and LeSage, 2011; Castells and Sole-Olle, 2005; Schaffer, 2011; Schaffer et al., 2011; Matei and Spiricu, 2012; Bosco and Brugnoli, 2010; Fritsch and Slavchev, 2011). In the case of the lack of financial resources, when governments face budget deficit problems, an efficient allocation of resources between the different programs is one of the key EU regional policy challenges in the period of 2014-2020. The recent regional

economic research has defined that it is important to analyze the region's production function efficiency, i. e. how efficiently the available resources are used to create economic value.



**Fig. 2.** The conceptual model of regional economic development factors with the technical efficiency involved

*Source: compiled by the author*

In line with these ideas, the concept of technical efficiency is integrated into the conceptual model bringing together the factors of regional economic development (Fig.

2). The technical efficiency in the model is revealed as a filter that separates regional economic resources from the economic value-added. Larger economic resources do not necessarily generate a higher value-added. Such technical inefficiencies may exist in the regions for a variety of qualitative and cultural characteristics that are important to the regional economic development: leadership and the general ability to apply the knowledge, abilities, to develop and commercialize globally competitive products, business skills to manage the business, to build up cooperative relations with external and internal market participants, cultural background. The economic environment and trends, that are affected by the agglomeration economies, urban changes, legal and tax liabilities, might also be important for the level of productivity and further development.

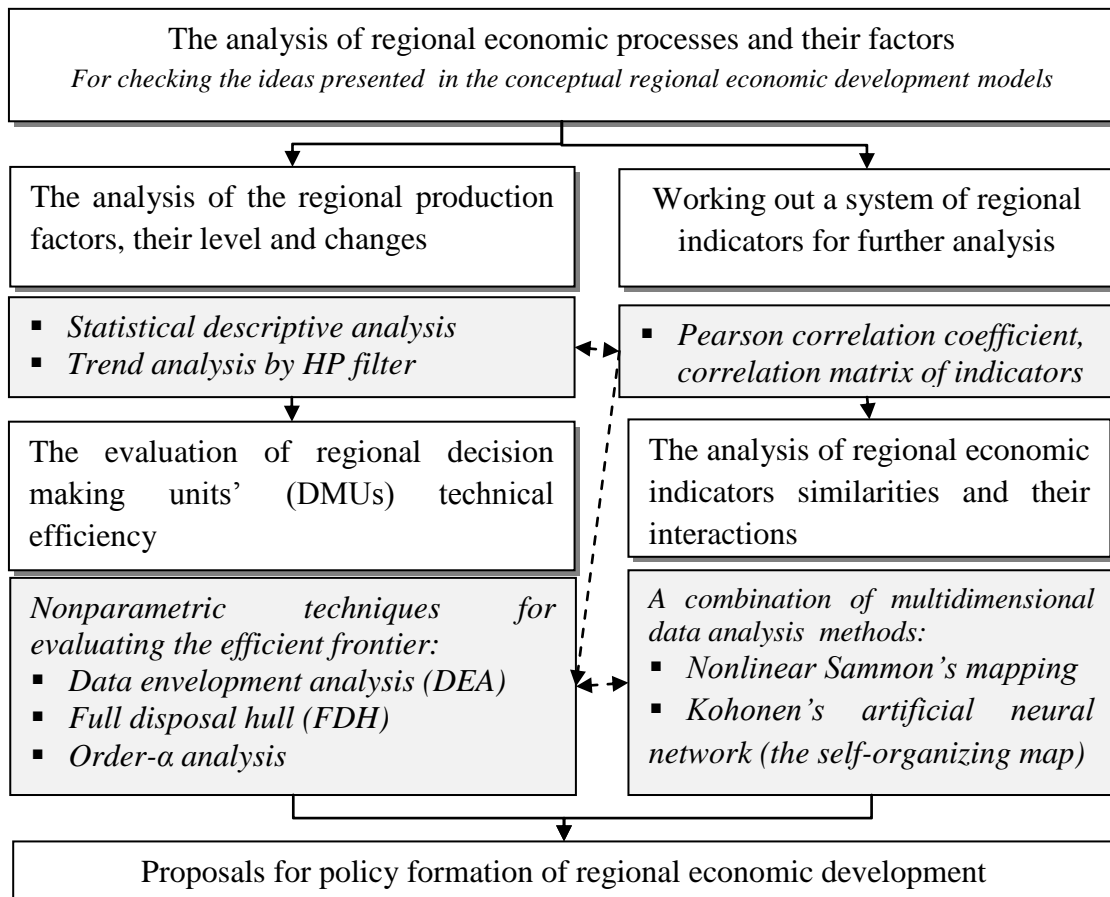
By evaluating the overall level of efficiency it is possible to identify how much region DMUs are able to absorb economic resources and create the gross value-added. If a region is indicated as being technically inefficient, it means that the increase of the economic resources and investments will not necessarily contribute to the economic growth. More attention in these areas should be paid to other factors that might influence the efficiency, for instance, promotion of entrepreneurship, support for cooperation of companies, and the efficiency of public administration and related areas. For the implementation of regional policy, it is worth to evaluate the regional performance and to monitor regional DMUs' abilities to transfer economic resources to the creation of a higher economic and social value.

To sum up, the economic development is influenced not only by the factors that can be measured by quantitative indicators - investment, human capital, road infrastructure, telecommunications, persons in science and technology or others,- but also by economic development processes, affected by the less tangible, qualitative and cultural factors, benefits from cooperation and synergy, leadership and the ability to apply the knowledge gained. Regions with a similar level of resources gain different economic results that make up some inefficiencies in the economy. Even though the level of technical efficiency is a relative factor gained through a comparison with other regions, it is an important aspect to be evaluated while forming programs for the regional economic development. All these tendencies make up a high complexity of regional economic development studies.



## Summary of the research methodology

The summary of the methods, used to evaluate the regional economic development factors, their similarities and the level of technical efficiency is presented in Fig. 3. The research consists of two main blocks. The first block combines methods for the evaluation of regional production factors that are needed for creating a higher value-added. Different efficiency levels of the EU regions' decision making units (DMUs) are identified by applying DEA, FDH and order- $\alpha$  techniques. The second block combines multidimensional data analysis methods - Kohonen's artificial neural network (the self-organizing map – SOM) and Sammon's projection - to get most information on regional economic development processes, the main factors, their correlation and similarities.



**Fig. 3.** The structure of empirical analysis

*Source: compiled by the author*

The Central and Eastern EU regions are analyzed. These regions have a similar historical and cultural background, common experiences of joining the EU in 2004 and implementing the EU regional policy as well as being a part of integration processes in

the EU. Overall 40 NUTS2 regions of 8 countries are investigated in both research blocks: Estonia, Latvia, Lithuania, Slovakia, Slovenia, Hungary and Czech Republic (Eurostat, 2015). A part of the efficiency research is made at a more detailed regional level – NUTS3 according to Lithuanian context.

*Multidimensional data visualization methods for the analysis of regional economic development processes*

The regional economic development is affected by various processes in the regional economy, that could be described by multidimensional data. The goal of this research is to acquire most information on the processes in the regional economy, using multidimensional data visualization methods, and to discover knowledge about the interaction and similarity of subjects (regional economic indicators). The research consists of several steps – setting a matrix  $\bar{X}$  of regional economic indicators, setting their correlation matrix  $R$ , conducting a system of vectors  $X$  according to the correlation matrix and finding out similarities of the data by using a combination of nonlinear Sammon's mapping and Kohonen's artificial neural network – the self-organizing map.

Assume that  $\bar{X} = \{\bar{x}_{ij}, i = \overline{1, m}, j = \overline{1, n}\}$  is the matrix of regional indicators, where  $m$  is the number of regions,  $n$  is the number of indicators,  $x_{ij}$  is the value of the  $i$ -th indicator for the  $j$ -th region.  $R = \{r_{x_i x_j}, i, j = \overline{1, n}\}$  is the correlation matrix of subjects determined by the matrix  $X$  of regional indicators, where  $r_{x_i x_j}$  is a correlation coefficient of indicators  $x_i$  and  $x_j$ . The matrix  $R$  is considered via the visual presentation of a set of variables by using a combination of nonlinear Sammon's mapping and Kohonen's artificial neural network – the self-organizing map (SOM).

Let  $S^n$  be a subset of an  $n$ -dimensional Euclidean space  $R^n$  containing vectors of unit length, i.e.  $S^n$  is a unit sphere,  $\|Y\| = 1$  if  $Y \in S^n$ . Dzemyda (2001) proposed to determine a system of vectors  $Y_1, \dots, Y_n \in S^n$  corresponding to the system of variables  $x_1, \dots, x_n$  so that  $\cos(Y_i, Y_j) = |r_{x_i x_j}|$  or  $\cos(Y_i, Y_j) = r_{x_i x_j}^2$ . If only the matrix of cosines  $K = \{\cos(Y_i, Y_j), i, j = \overline{1, n}\}$  is known, it is possible to restore the system of vectors  $Y_s = (y_{s1}, \dots, y_{sn}) \in S^n$ ,  $s = \overline{1, n}$ , as follows:  $y_{sk} = \sqrt{\lambda_k} \alpha_{sk}$ ,  $k = \overline{1, n}$ , where  $\lambda_k$  is the  $k$ -th

eigenvalue of matrix  $K$ ,  $(\alpha_{1k}, \dots, \alpha_{nk})$  is a normalized eigenvector corresponding to the eigenvalue  $\lambda_k$ . The mapping of the set of vectors  $Y_1, \dots, Y_n \in S^n$ , which corresponds to the set of variables  $x_1, \dots, x_n$ , on a plane, trying to preserve a relative distance between  $Y_1, \dots, Y_n \in S^n$ , leads to the visual observation of a layout of variables  $x_1, \dots, x_n$  on the plane.

In this research, the  $n$ -dimensional vectors  $Y_1, \dots, Y_n \in S^n$  are visualized by integrated application of the self-organizing maps and Sammon's mapping, proposed by Dzemyda (2001, 2005). Sammon's mapping nonlinear projection method tries to optimize a cost function that describes how well the pairwise distances in a data set are preserved. Denote the distance between the vector  $Y_i$  and the vector  $Y_j$  in the feature space (in this case, in  $S^n$ ) by  $d_{ij}^*$ , and the distance between the same vectors in the projected space by  $d_{ij}$ . In this case, the initial dimensionality is  $n$ , and the resulting one is 2. The cost function of Sammon's mapping is the following distortion of projection:

$$E = \frac{1}{\sum_{\substack{i,j=1 \\ i < j}}^n d_{ij}^*} \sum_{\substack{i,j=1 \\ i < j}}^n \frac{(d_{ij}^* - d_{ij})^2}{d_{ij}^*}, \quad (1)$$

The self-organizing map (SOM), proposed by Kohonen (2001), is a class of neural networks that are trained in an unsupervised manner, using competitive learning. It is a well-known method for mapping a high-dimensional space onto a low-dimensional one. In this research, it is considered a mapping onto a two-dimensional grid of neurons. The method allows putting complex data into order, based on their similarity, and shows a map by which the features of the data can be identified and evaluated. In this research, a rectangular topology of neurons connection is selected.

The rectangular SOM is a two-dimensional array of neurons  $M = \{m_{ij}, i = \overline{1, k_x}, j = \overline{1, k_y}\}$ . Here  $k_x$  is the number of rows, and  $k_y$  is the number of columns. The dimension of the vectors, which will be presented as inputs to train the network, is  $n$ . Each component of the input vector is connected to every individual neuron. Thus, there is a connection between a neuron of the network and every component of the input vector. The weights of these connections form an  $n$ -dimensional synaptic weight vector (the codebook vector). Thus, any neuron is entirely defined by its

location on the grid (the number of row  $i$  and column  $j$ ) and by the codebook vector, i.e. considering a neuron as an  $n$ -dimensional vector  $m_{ij} = (m_{ij}^1, m_{ij}^2, \dots, m_{ij}^n)$ . In this way, each vector (neuron)  $m_{ij}$  represents a part of  $S^n$  because  $Y_1, \dots, Y_n \in S^n$ .

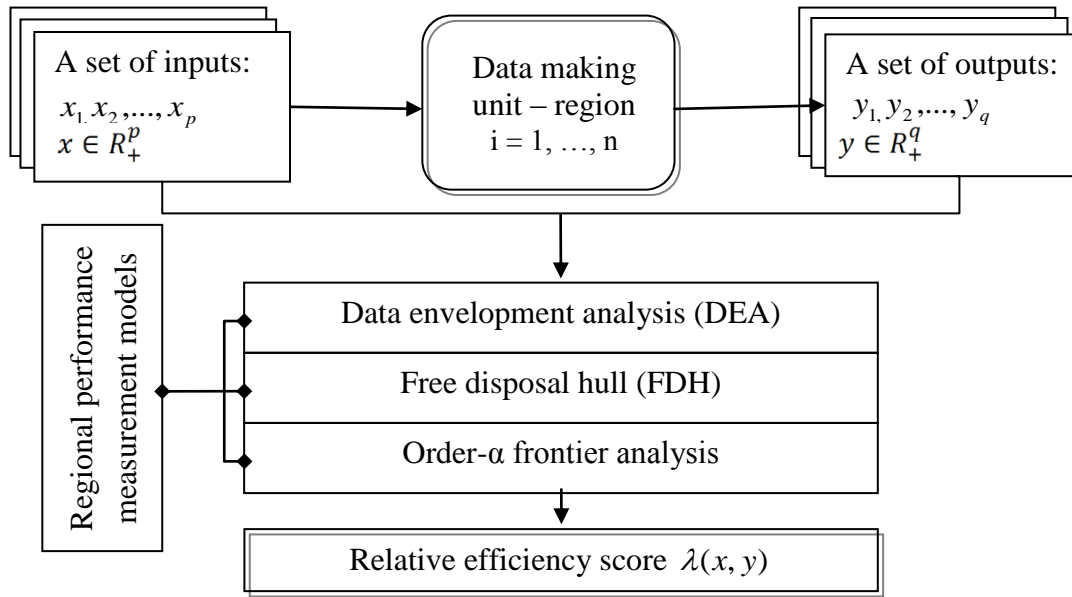
Using the SOM-based approach above, a table with cells corresponding to the neurons can be drawn. The cells, corresponding to the neurons-winners, are filled with numbers of vectors  $Y_1, \dots, Y_n$ . Some cells may remain empty. One can decide visually on the distribution of vectors  $Y_1, \dots, Y_n$  in the  $n$ -dimensional space in accordance with their distribution among the cells of the table. However, the table does not answer the question, how much the vectors of the neighbouring cells are close in the  $n$ -dimensional space. Therefore, Sammon's mapping may be used for such a purpose. Finally, we obtain information on similarities of different economic indicators that cluster together as well as on the distance between indicators' groups, visualised by Sammon's mapping, to gain an additional insight.

#### *Nonparametric techniques for evaluating the regional economic development efficiency*

In the analysis of a production function, the locus of the maximal attainable level of an output (the production) is estimated by given a set of inputs (the production factors) (Daouia et al, 2012). Nonparametric frontier methods expand the application of a production function while analyzing a case of multiple inputs and multiple outputs. It is assumed that the regional efficiency is improved more likely by growing outputs rather than by decreasing inputs because of the nature of infrastructure capital and human capital (Schaffer et al., 2011). According to this fact, an output-oriented version of the model is used.

The order- $\alpha$  frontier method is applied together with the data envelopment analysis and free disposal hull to determine their capabilities for evaluating regional efficiency. These mathematical programming methods allow evaluating the efficiency of the regional spatial aspects presented. The data envelopment analysis and free disposal hull are applied as full frontier unconditional methods, while the order- $\alpha$  frontier is a partially frontier method. For the research a set of different frontier methods is chosen in order to

evaluate the appropriate tools for the Lithuanian regional analysis as well as the relative efficiency scores of data making units.



**Fig. 4.** Conceptual framework for measuring the regional performance

*Source: compiled by the author*

The relative efficiency score reveals how much output quantities can be proportionally expanded without altering the inputs used (Schaffer et al., 2011). The term non-parametric is not meant to imply that methods lack parameters, but that the number and the nature of indicators are not fixed in advance. The nonparametric frontier models help to consolidate multiple performance measures into the efficiency score without having to define the complex relationships among the indicators (Kuah et al., 2012).

The estimation of regional efficiency follows the techniques of data envelopment analysis. The selection of data making units, explanation of inputs and outputs and formulation of the model are considered. The enhanced data envelopment analysis is described in detail by Daouia and Simar (2007a). Mathematical formulas (2)-(4) below reflect a reduced version of this model. Formula (5) explains the efficiency score calculated by a more advanced form of efficient frontier evaluation – order- $\alpha$  analysis.

It is assumed that every region disposes of a set of inputs  $x \in R_+^p$  for producing a set of outputs  $y \in R_+^q$  that are positive numbers. Feasible combinations of  $(x,y)$  are defined as (Schaffer et al., 2011):

$$\psi = \{(x, y) \in r_+^{p+q} | x \text{ can produce } y\} \quad (2)$$

The boundaries of  $\psi$  reflect maximum outputs that can be generated by the given inputs. The efficiency frontier is defined as:

$$Y^\delta = \{(x, y^\delta(x)) | y^\delta(x) \in Y(x) : \lambda y^\delta(x) \notin Y(x), \forall \lambda > 1\} \quad (3)$$

$Y(x)$  means a set of technology feasible outputs and  $y^\delta(x)$  is the maximum achievable output of the unit with the input level  $x$ . The efficiency score of a decision-making unit is defined as:

$$\lambda(x, y) = \sup\{\lambda | (x, \lambda y) \in \psi\} = \sup\{\lambda | \lambda y \in Y(x)\} \quad (4)$$

In this formula,  $\lambda(x, y) \geq 1$  is the proportionate increase of output  $y$  of the region operating at the output level  $x$  for a region to be efficient (Schaffer et al., 2011). To determine the unknown  $\psi$  nonparametric estimators, such as data envelopment analysis and free disposal hull, have been proposed. Free disposal hull and data envelopment analysis define an efficient boundary according to the highest technically achievable output according to the performance of decision making units.

With  $S_{(Y|X)}(\lambda y|x)$  defined as the probability  $Prob(Y \geq y | X \leq x)$  and  $F_X(x)$  as the probability  $Prob(X \leq x)$ , Daouia and Simar (2007a) defined the order- $\alpha$  quantile efficiency score of the output-oriented case for each unit  $(x, y) \in \psi$  as

$$\lambda_\alpha(x, y) = \sup \{\lambda | S_{(Y|X)}(\lambda y|x) > 1 - \alpha\}, \quad F_X(x) > 0, \quad \alpha \in [0,1] \quad (5)$$

In this paper, the order- $\alpha$  frontier analysis is also applied which allows extreme observations to be above a partial frontier at different levels of confidence ( $\alpha$ ) while searching for the efficiency of data making units. Efficiency scores, calculated by the free disposal hull technique, are evaluated in the same way as by the order- $\alpha$  frontier method with the confidence level of  $\alpha=1$ . In the data envelopment analysis, the confidence level of  $\alpha=1$  is also used.

In selecting the appropriate analysis method to evaluate the efficiency score  $\lambda_\alpha(x, y)$ , Table 1 represents selection process that was compiled according to Daouia and Simar (2007a, 2007b), Schaffer et al. (2012). It is important to observe with what confidence interval the super-efficient values of  $\lambda_\alpha$  are obtained. If the confidence interval is comparatively low that means there are no super-efficient values in the data set and DEA or FDH could be more appropriate techniques for the analysis.

**Table 1.** Regional efficiency scores with different confidence levels for selecting nonparametric techniques (DEA, FDH, order- $\alpha$ )

Regions	Confidence levels			
	$\alpha=0.80$	...	$\alpha=0.95$	FDH ( $\alpha=1$ )
Region 1	$\lambda_{\alpha=0.8}(x_1, y_1)$	...	$\lambda_{\alpha=0.95}(x_1, y_1)$	$\lambda_{\alpha=1}(x_1, y_1)$
Region 2	$\lambda_{\alpha=0.8}(x_2, y_2)$	...	$\lambda_{\alpha=0.95}(x_2, y_2)$	$\lambda_{\alpha=1}(x_2, y_2)$
....	...	...	...	...
Region n	$\lambda_{\alpha=0.8}(x_n, y_n)$	...	$\lambda_{\alpha=0.95}(x_n, y_n)$	$\lambda_{\alpha=1}(x_n, y_n)$
<b>Average efficiency score</b>	$\bar{\lambda}_{\alpha=0.8}$	...	$\bar{\lambda}_{\alpha=0.95}$	$\bar{\lambda}_{\alpha=1}$

Source: compiled by the author according to Daouia and Simar (2007a, 2007b), Schaffer et al (2012)

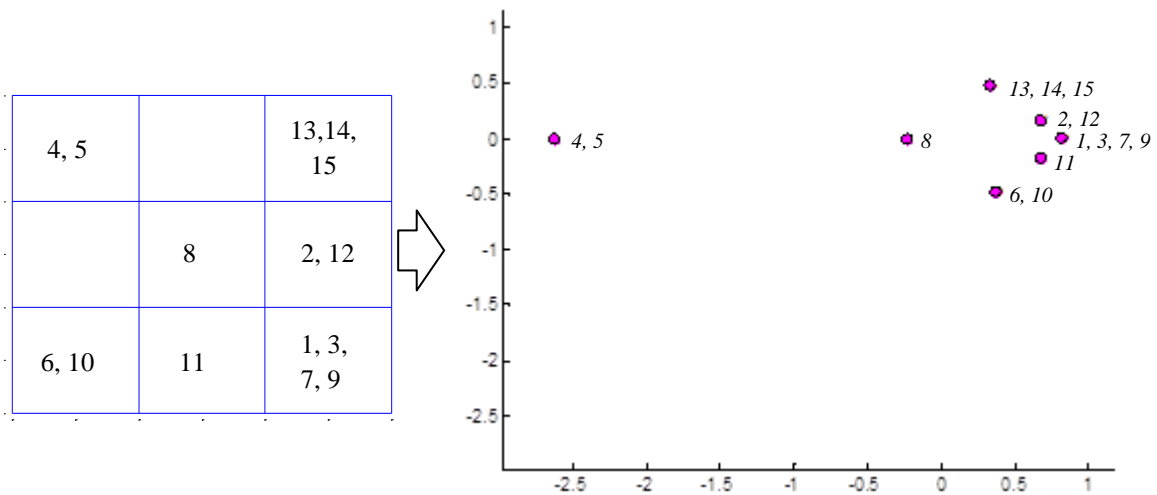
It is important to mention that DEA calculations were performed by the DEAP program where efficiency score interpretations are different. If  $\lambda_{\alpha}(x, y) < 1$ , it means that region is inefficient. The FDH and order- $\alpha$  analysis are calculated by Stata where efficiency scores are as that given in the explanation.

### **Regional economic development factors and their interactions in the Central and Eastern EU NUTS2 regions obtained by the multidimensional data analysis**

The results of the regional economic development factors and their indicators analysis obtained by combining Kohonen's artificial neural network – the self-organizing map (SOM) and Sammon's mapping - are presented in Figures 5, 6 and Tables 3, 4. The numbers in the figures are of the indicators, as presented in Table 2. All the indicators involved in the analysis are significantly correlated with the GDP per inhabitant indicator (with significance of 0,05) and are related with various important factors, such as the level of regional resources, innovative processes, infrastructure, tourism development, and others.

**Table 2.** Indicators involved in the multidimensional analysis

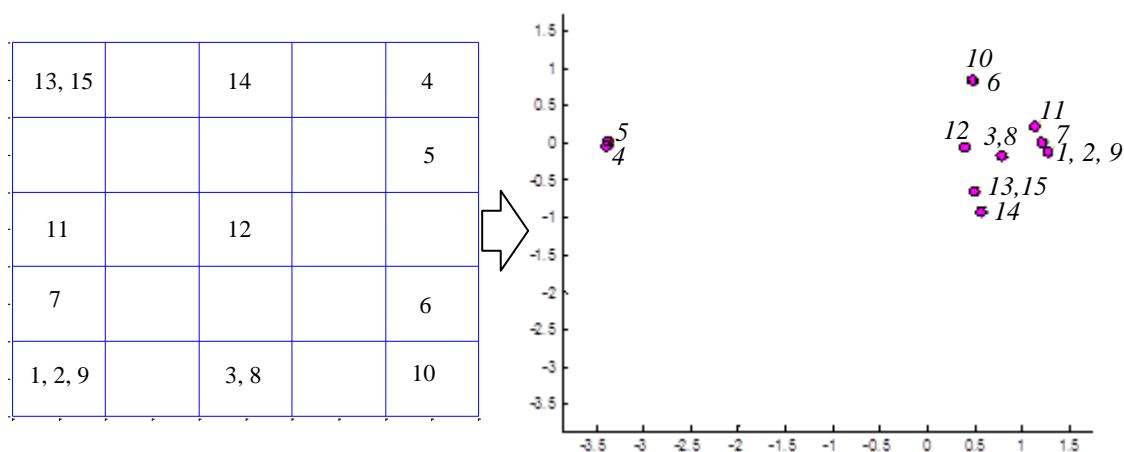
1. Gross domestic product, eur per capita	7. Persons in science and technology, %
2. Gross capital formation, eur per capita	8. Patents, per capita
3. Employment in high-technology manufacturing and knowledge-intensive high-technology services, %	9. R&D expenditure, eur per capita
4. Employment in low and medium technology manufacturing, %	10. Labour force ( <i>calculated according to Schaffer et al. (2011)</i> )
5. Employment in agricultural sector, %	11. Students in tertiary education, per capita
6. Persons with tertiary education, %	12. Employment (of 15–64 years), %
	13. Population density, inhabitants per km <sup>2</sup>
	14. Nights spent at tourist accommodation establishments, per capita
	15. Railway network density, <i>thousand km<sup>2</sup></i>



**Fig. 5.** Cluster of indicators in a self-organizing map SOM of 3x3 dimensions and its’ Sammon’s projection for 2013

*Source: compiled by the author according to Eurostat data (2016)*

By applying of SOM and Sammon’s projection it is possible to evaluate the distance of different groups of indicators. The data analysis of 2011 and 2013 reveals that the GDP indicator and most similar indicators make up a cluster and other indicators surround this cluster, except indicators 4 and 5 that are remote from other indicators in Sammon’s projection (Fig. 5, 6).



**Fig. 6.** Cluster of indicators in a self-organizing map SOM of 5x5 dimensions and its’ Sammon’s projection for 2013

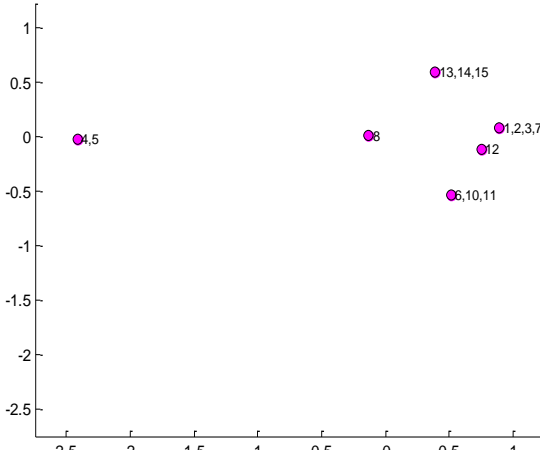
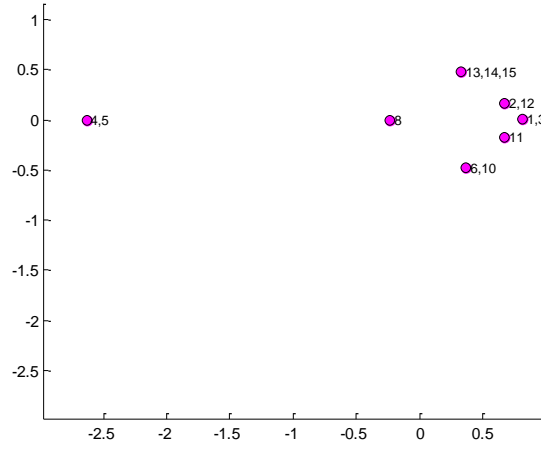
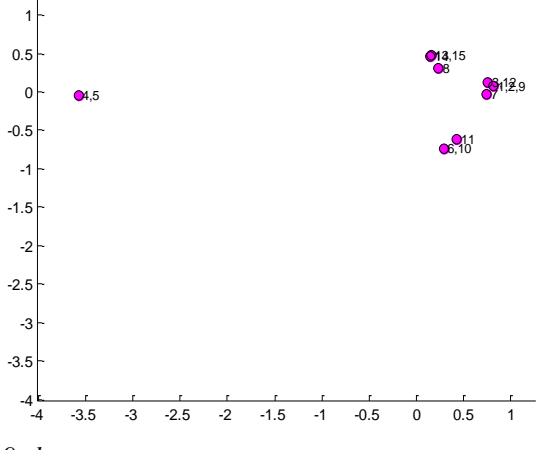
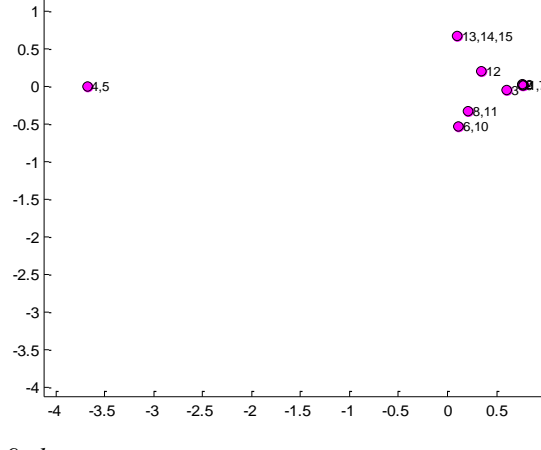
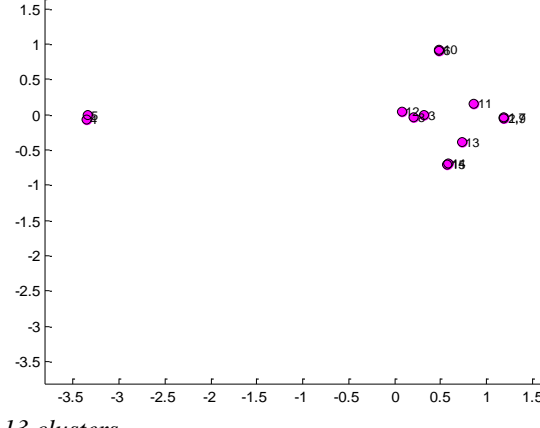
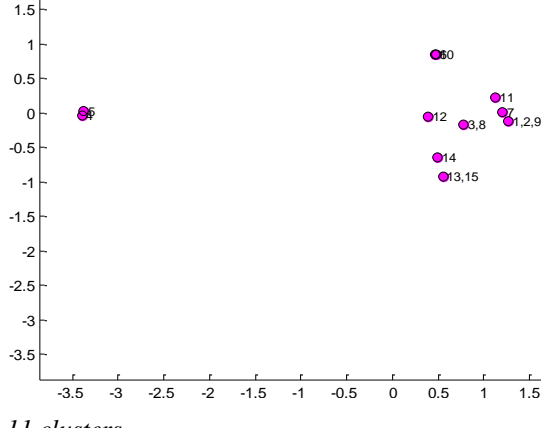
*Source: compiled by the author according to Eurostat data (2016)*

The indicators tend to be in similar interaction groups during both 2011 and 2013 periods 3x3, 4x4, and 5x5 SOMs. If in a more detailed neuron map indicators decompose



into different clusters, they still tend to be very close to one another in Sammon's projection (Table 3).

**Table 3.** Sammons' projections of SOM 3x3, 4x4, 5x5 in 2011 and 2013

SOM	2011	2013
3X3	 <p>6 clusters</p>	 <p>7 clusters</p>
4X4	 <p>9 clusters</p>	 <p>9 clusters</p>
5X5	 <p>13 clusters</p>	 <p>11 clusters</p>

Source: compiled by the author according to Eurostat data (2016)

In the same cluster with GDP (indicator 1) most often the same indicators tend to appear in different dimensions of self-organizing neuron maps: gross capital formation (2), employment in high-technology manufacturing and knowledge-intensive high-

technology services (3), persons in science and technology (7) and R&D expenditure (9) (Table 4). The 9-th indicator was most closely related with GDP in all the dimensions, which means that total intramural R&D expenditures are the main attribute to a high value-added. This tendency supports the idea that new knowledge generation, innovative activities, the spread of high technology and investments related with that are essential for the growth of regional economy.

The number of patents (8) tend to be apart from GDP, the level of investments and human capital indicators. The number of patents is commonly analyzed in the research as an output indicator of regional innovation systems. In this analysis, a number of patents tend to be apart from the resources, generally needed for generating new ideas. In 2013, there were some links of patents and 11 and 3 indicators in SOM 5x5 and 4x4 which reveal the tendency that the number of patents becomes more related with an intensity of universities' activities and employment in sectors of a high technology manufacturing and knowledge-intensive services.

**Table 4.** Clusters of indicators according to SOM 3x3, 4x4, 5x5 in 2011 and 2013

Years	Dimensions of self-organizing map			Discription
	SOM 3x3	SOM 4x4	SOM 5x5	
2011	1, 2, 3, 7, 9	1,2,9	(1,7) (2, 9)	Close similarities with GDP (1)
2013	1, 3, 7, 9	(1,7) (2, 9)	1,2,9	
2011	6, 10, 11	6, 10 (11)	(6) (10) (11)	Labour force indicators
2013	(6, 10) (11)	(6, 10) (8, 11)	(6) (10)	
2011	8	8	8	Patents (8) – as a separate cluster
2013	8	8, 11	8, 3	

*Source: compiled by the author according to Eurostat data (2016)*

*\*In brackets are clusters that are very close to one another in Sammon's projection even though they fall into different clusters.*

Other indicators, such as persons with tertiary education (6), the size of regional labour force (10), and students in tertiary education (11) tend to be in the same group and more apart from GDP and innovative activity indicators, especially indicators 6 and 10. This tendency reveals that people with a high level of education are still not enough involved in the creation of a higher value-added and innovation processes in Central and Eastern EU regions. From the qualitative and quatitative viewpoint even a higher level of human capital does not necessarily mean a higher value-added. This tendency supports

the idea that there is no straight path between resources and economic results and reveals some technical inefficiency that is measured in detail in the the next section.

This section of the research has revealed that all the activities, related with science and technology, investments in the gross capital formation and R&D, are very important and have most interactions with a high value-added in regions. By means of this research, some inefficiencies in regional economies of Central and Eastern EU are identified: such an output indicator as patents is still apart from the resources needed for generating new ideas; the size of labour market and its qualitative aspects are apart from the GDP. And finally, employment of low-technology manufacturing and the agricultural sector are those areas to cope with in less economically developed regions.

### **The analysis of technical efficiency in Central and Eastern EU NUTS2 and NUTS3 regions**

In this part, the efficiency is measured in two territorial levels NUTS2 and NUTS3. Input and output indicators were selected according to the territorial dimensions and data reliability. In the study of the Central and Eastern EU NUTS2 regional level, resources needed for a higher value-added and innovative activities were involved in the research. A smaller territorial dimension – NUTS3 regional level - was analyzed according to the Lithuanian internal regions. The infrastructure and human capital indicators were explored.

#### ***The efficiency of regional innovation systems in the Central and Eastern EU NUTS2 regional level***

The main indicators for evaluating the regional innovation system efficiency were selected according to the reliability of regional datasets and to the latest research of regional innovation systems. Two outputs were selected and evaluated in the first stage of the research:  $y_1$  is a gross domestic product in purchasing power parity per inhabitant;  $y_2$  is a number of patents per inhabitant.  $y_1$  is commonly used as the output of the overall regional economy and  $y_2$  is commonly applied as the output of regional innovation systems (Bosco, Brugnoli 2010; Fritsch, Slavtchev, 2011; Dzemydaite et al., 2015). The latest regional data of indicators from the Eurostat database were used in the research, i.e. GDP in 2013 and the number of patent applications in 2012 (Eurostat, 2015).

Three input indicators were selected that were mostly related to human capital characteristics and investments to the regions:  $x_1$  is the intramural cumulative expenditures for research and development (R&D) in the purchasing power standard per inhabitant,  $x_2$  is human resources in science and technology, calculated as the number of persons with tertiary education (ISCED) and/or employed in science and technology, as the percentage of total population,  $x_3$  is the human capital employed in high technology and knowledge-intensive sectors, the percentage of total employment.

**Table 5.** Correlation of GDP ( $y_1$ ) and Input Indicators

Indicators	The intramural cumulative R&D expenditures ( $x_1$ )	Human resources in science and technology ( $x_2$ )	Human capital employed in high technology and knowledge-intensive sectors ( $x_3$ )	Number of patents ( $y_2$ )
Pearson's correlation rate	0.847	0.865	0.794	0.384
<i>p value</i>	0.000	0.000	0.000	0.015

*Source: evaluated by the author according to Eurostat data (2015)*

In order to select the most feasible indicators for the data envelopment analysis, the Pearson correlation coefficient was evaluated. For the data analysed, the input indicators significantly correlated with the output indicator – GDP per capita at the 0.01 level of confidence (2-tailed). There was a strong correlation with all the input indicators  $x_1$ ,  $x_2$  and  $x_3$ . Therefore, all the three input indicators were involved in the further analysis.

With the number of patents, the situation was different. Correlation coefficients revealed that the relations between all input indicators and  $y_2$  were weaker and/or not significant. The number of patents was indicated as being an indicator not reliable enough for the further analysis. This indicator did not significantly correlate with GDP per capita, which was supposed to be the main indicator of overall economic output. In other studies made by Bosco and Brugnoli (2010), similar conclusions were drawn while using the number of patents as an output indicator in the model. The calculation techniques for this indicator differ among countries and due to this fact the results remain unreliable for the analysis of different countries. Therefore, GDP per capita ( $y_1$ ) was selected as an output indicator for the further analysis.

At the beginning of the research, regions were ranked according to the input and output indicators. The highest values of almost all indicators tended to be in the capital regions – in Slovakia the capital region is Bratislavský (SK01), in the Czech Republic –

Praha region (CZ01), in Hungary – Közép-Magyarország region (HU10), in Slovenia – Zahodna (SI02), in Poland – Mazowieckie (PL12). Higher values of all indicators tended to be in capital regions of the Central EU rather than in the Eastern part of EU and Baltic States. All the Baltic countries were between the highest values with indicator  $x_2$ . One of the Baltic States – Estonia (EE00) was between the leading regions with indicator  $x_1$  – cumulative intramural investments in R&D. The Praha region (CZ01) and Bratislavský region (SK01) tended to be the leaders in all the indicators.

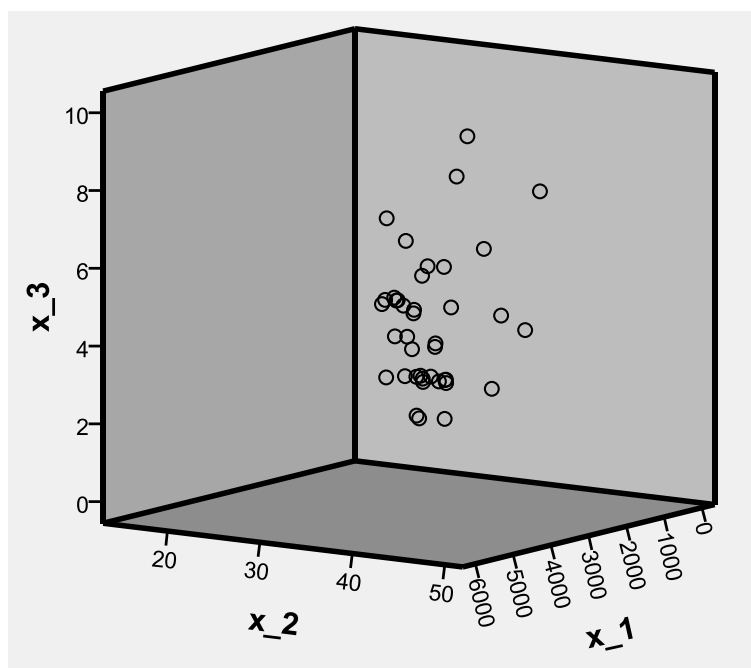
**Table 6.** Regions in the Central and Eastern EU with the Highest Inputs and Output (2013)

TOP10 regions according to the values of $y_1$				TOP10 regions according to the values of $x_1$			
No.	Region	Country	$y_1$	No.	Region	Country	$x_1$
1	SK01 – Bratislavský	SK	49000	1	CZ01 – Praha	CZ	5040.0
2	CZ01 – Praha	CZ	46000	2	SI02 – Zahodna	SI	3360.5
3	HU10 – Közép-Magyarország	HU	28700	3	SK01 – Bratislavský	SK	2589.1
4	PL12 – Mazowieckie	PL	28500	4	HU10 – Közép-Magyarország	HU	2062.8
5	SI02 – Zahodna	SI	25900	5	CZ06 – Jihovýchod	CZ	1733.8
6	CZ06 – Jihovýchod	CZ	20600	6	PL12 – Mazowieckie	PL	1626.1
7	PL51 – Dolnoslaskie	PL	20100	7	<b>EE00 – Eesti</b>	<b>EE</b>	<b>1511.5</b>
8	CZ02 – Střední Čechy	CZ	19500	8	CZ02 – Střední Čechy	CZ	1303.8
9	EE00 – Eesti	EE	19500	9	SI01 – Vzhodna	SI	1287.5
10	LT00 – Lietuva	LT	19400	10	CZ03 – Jihozápad	CZ	1080.7
TOP10 regions according to the values of $x_2$				TOP10 regions according to the values of $x_3$			
No.	Region	Country	$x_2$	No.	Region	Country	$x_3$
1	CZ01 – Praha	CZ	8.6	1	CZ01 – Praha	CZ	59.1
2	SK01 – Bratislavský kraj	SI	7.9	2	HU10 – Közép-Magyarország	HU	56.6
3	<b>EE00 – Eesti</b>	<b>EE</b>	<b>7.6</b>	3	SK01 – Bratislavský	SI	44.3
4	SI02 – Zahodna	SI	6.5	4	SI02 – Zahodna	SI	43.8
5	HU10 – Közép-Magyarország	HU	5.7	5	CZ06 – Jihovýchod	CZ	43.1
6	PL12 – Mazowieckie	PL	5.2	6	HU31 – Észak-Magyarország	HU	42.9
7	<b>LT00 – Lietuva</b>	<b>LT</b>	<b>5.1</b>	7	PL12 – Mazowieckie	PL	41.5
8	<b>LV00 – Latvija</b>	<b>LV</b>	<b>4.8</b>	8	CZ02 – Střední Čechy	CZ	37.6
9	CZ02 – Střední Čechy	CZ	4.8	9	PL51 – Dolnoslaskie	PL	36.3
10	PL63 – Pomorskie	PL	4.8	10	PL63 – Pomorskie	PL	36.0

Source: evaluated by the author according to Eurostat data (2015)

The ranking of the regional indicators revealed how many resources the regions had and which regions were leading with the input indicators. The main tendency is that the highest levels of resources are in several capital regions in the Czech Republic and

Slovakia from all the analyzed groups (Fig. 7). The further analysis gives a deeper insight into how efficiently the available resources are used.



**Fig. 7.** Spatial visualization of the level of regional resources  $x_1$ ,  $x_2$ , and  $x_3$  in the Central and Eastern EU NUTS2 regions in 2013

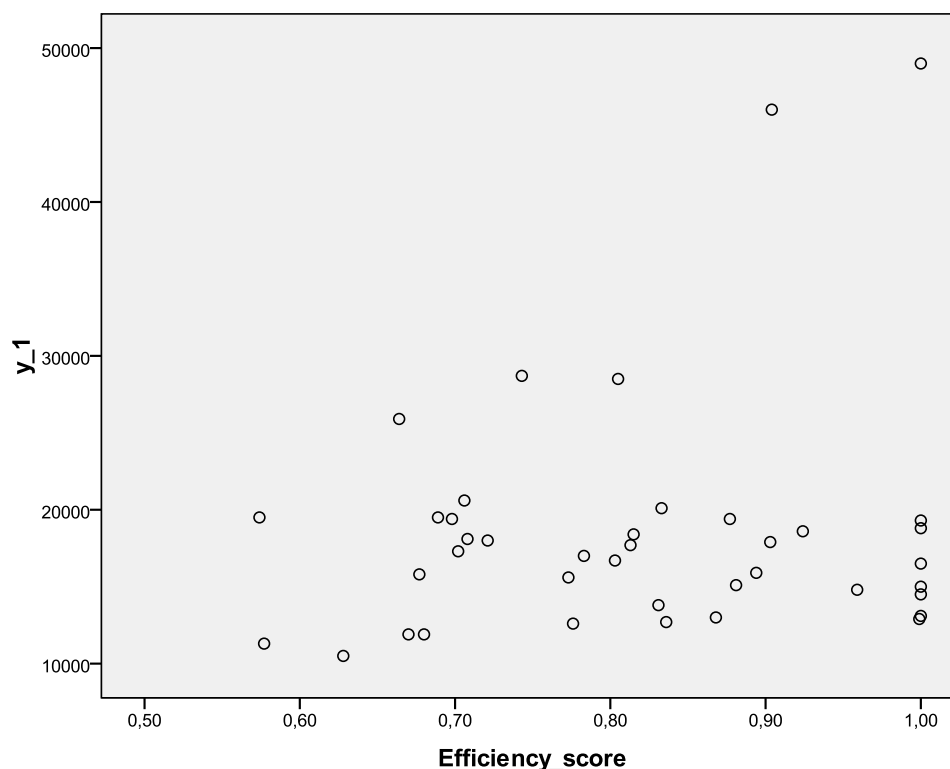
*Source: compiled by the author according to Eurostat data (2015)*

According to the results of data envelopment analysis, 7 efficient regions were indicated out of 40 regions in Central and Eastern Europe. The average efficiency score of all the regions analysed was 0.818. This score means that, if available resources were used more intensively, it would be possible to reach about 18.2 % higher output. Therefore, in inefficient regions more attention should be paid how to generate a higher output with the current resources, how to exploit the human capital in science and technology and R&D investments in order to create and better commercialise products for a market.

Among the efficient regions (with the efficiency score  $\lambda_i = 1$ ) the highest output was in SK01 – Bratislavský region. This region was the leader both in the economic output ( $y_1$ ) and in the efficiency score. Other capital regions did not reach such good results. In most of the capital regions with a comparatively high GDP per capita, such as CZ01 – Praha, HU10 – Közép-Magyarország, PL12 – Mazowieckie, a higher GDP could be achieved with the current resources. These regions were considered to be inefficient, since they had a lot of input indicators, but they were comparatively not efficient enough

in generating the real output to the regional economy. The Bratislavský region was considered a peer-region and an example for other capital regions.

The regions such as PL41 – Wielkopolskie, SK02 – Západné Slovensko, CZ04 – Severozápad, were considered to be efficient, even though they had comparatively lower GDP per capita (Fig. 8). These regions with low input indicators generated comparatively high economic results. To enhance the economic growth in these regions, more investments in science and technology should be made.



**Fig. 8.** The relationship between the efficiency score ( $\lambda_i$ ) and GDP per capita in purchasing power parity ( $y_1$ ), 2013

*Source:evaluated by the author according to Eurostat data (2015)*

The Baltic countries were evaluated as the least efficient regions. Estonia stood out from other regions with high rates of intramural cumulative expenditures on R&D that could be used in a more efficient way. But the common tendencies for the Baltic States were that they had comparatively high levels of human capital with tertiary education, but that did not generate significantly higher GDP per capita. More programmes in these countries should be worked out to solve the problem – how to the human capital with tertiary education and in science and technology to create more output with a higher value-added to the regional economy.

**Table 7.** Central and Eastern EU NUTS2 Regions with Highest and Lowest Efficiency Scores ( $\lambda_i$ ) Applying DEA

TOP10 most efficient regions				TOP10 least efficient regions			
No.	Region	Country	Efficiency score ( $\lambda_i$ )	No.	Region	Country	Efficiency score ( $\lambda_i$ )
1	SK01 – Bratislavský	SK	1	30	CZ06 – Jihovýchod	CZ	0.706
2	PL41 – Wielkopolskie	PL	1	31	PL63 – Pomorskie	PL	0.702
3	SK02 – Západné Slovensko	SK	1	32	LT00 – Lietuva	LT	0.698
4	CZ04 – Severozápad	CZ	1	33	CZ02 – Střední Čechy	CZ	0.689
5	PL43 – Lubuskie	PL	1	34	HU23 – Dél-Dunántúl	HU	0.68
6	PL52 – Opolskie	PL	1	35	PL21 – Malopolskie	PL	0.677
7	PL33 – Swietokrzyskie	PL	1	36	HU33 – Dél-Alföld	HU	0.67
8	PL62 – Warminsko-Mazurskie	PL	0.999	37	SI02 – Zahodna Slovenija	SI	0.664
9	PL61 – Kujawsko-Pomorskie	PL	0.959	38	HU31 – Észak-Magyarország	HU	0.628
10	PL22 – Slaskie	PL	0.924	39	HU32 – Észak-Alföld	HU	0.577
11	CZ01 – Praha	CZ	0.904	<b>40</b>	<b>EE00 – Eesti</b>	<b>EE</b>	<b>0.574</b>

Source: evaluated by the author according to Eurostat data(2015)

The variance of the efficiency score among the Polish regions was the highest one. This fact has revealed great regional efficiency disparities among the Polish regions. The regional efficiency was not constant in all the country's regions. Therefore, there is a potential to spread good practices from one region to another, trying to find a higher level of cooperation between different territories.

**Table 8.** The descriptive statistics of efficiency scores ( $\lambda_i$ ) by DEA, 2009–2013

Indicators	2009	2010	2011	2012	2013
Average efficiency score ( $\lambda_i$ )	0,792	0,824	0,819	0,804	0,818
Median	0,759	0,774	0,869	0,844	0,814
Minimal value	0,48	0,55	0,56	0,57	0,57
Number of efficient regions ( $\lambda_i=1$ )	6	7	6	7	7
Coefficient of variation (CV)	0,155	0,166	0,176	0,155	0,170

Source: evaluated by the author according to Eurostat (2015)

To sum up, the research has revealed different levels of innovation system efficiency in the Central and Eastern EU regions. These efficiency scores indicated imbalances between the available regional inputs and the real output. It means that, even though regions spend a lot on R&D and have a lot of human capital with tertiary education and working in science and technology, it does not guarantee that innovative



products with a higher value-added will be created and commercialised in the economy. This type of analysis shows the results of innovation system efficiency and could be used for the developing more precise and problem oriented regional innovation strategies.

***Evaluation of regions' efficiency in using the infrastructure and human capital in Lithuanian NUTS3 regions***

Assuming that regional endowment with immobile factors is essential to generate regional production (Bronzini and Piseli, 2009), input variables are characterised by a region's transport infrastructure and human capital. With regard to infrastructure capital, the input factor determines the intraregional equipment with transport infrastructure characterised by the intensity of investments in regional transport infrastructure and the density of local roads in the region. The transport infrastructure of a region  $i$  ( $I_i$ ) is determined by the formula:

$$I_i = \frac{r_{w,i}}{a_i} \quad (6)$$

$r_{w,i}$  is the length of road network (in km) weighted by the differences of construction and the maintenance cost of a region  $i$ ;  $a_i$  is the area of region  $i$  (in sq. km).

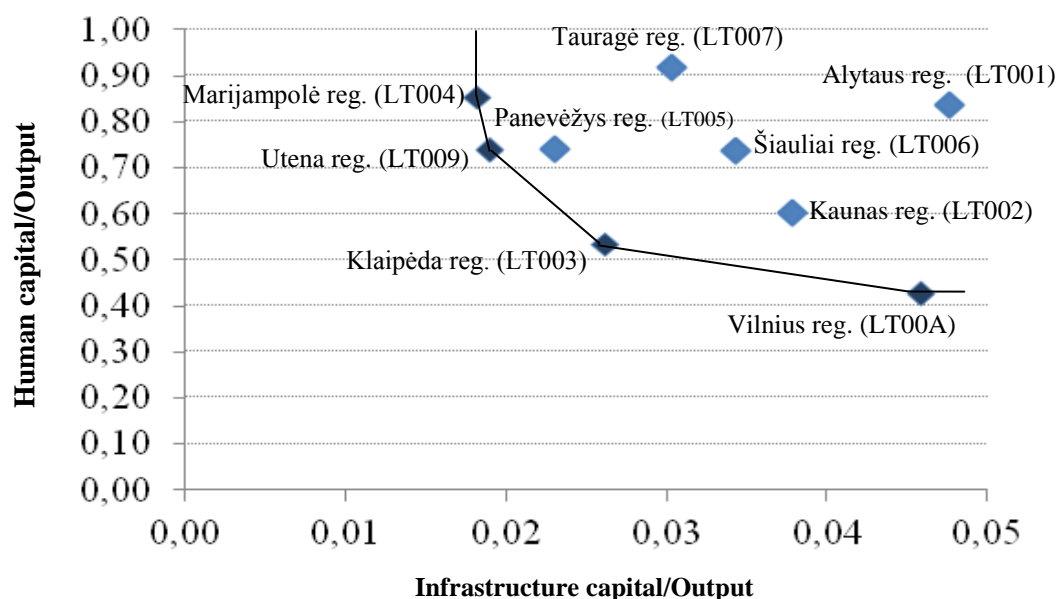
The human capital indicator is calculated according to educational achievements of the regional workforce. The formula of human capital indicator ( $Q_i$ ) is as follows:

$$Q_i = \frac{\sum_{j=1}^3 \omega_j f_{ij}}{\sum_{j=1}^3 f_{ij}} \quad (7)$$

According to the International Standard Classification of Education (ISED),  $w_i$  is a weighting factor of the educational level. Educational achievements are weighted to 1, 1.8, and 2.6, respectively, according to the average time needed to obtain the qualification (Schaffer et al., 2011),  $f_{ij}$  is the number of workforce. Selected input indicators significantly correlate with the GDP per capita indicator ( $p=0,01$  2-tailed).

The convexity of Lithuanian regional data is evaluated by analysing the distribution of efficiency scores, using different levels of confidence in the frame of order- $\alpha$  analysis. The idea behind the order- $\alpha$  quantile-type frontier is to determine the frontier by fixing first the probability  $(1 - \alpha)$  of observing points above this order- $\alpha$  frontier (Daraio, Simar, 2007a). There are no extreme values in the input data set at the level of  $\alpha=0.90$ ,

0.95, or 0.99. According to these results, the full frontier method DEA is applied for evaluation of regional efficiency.



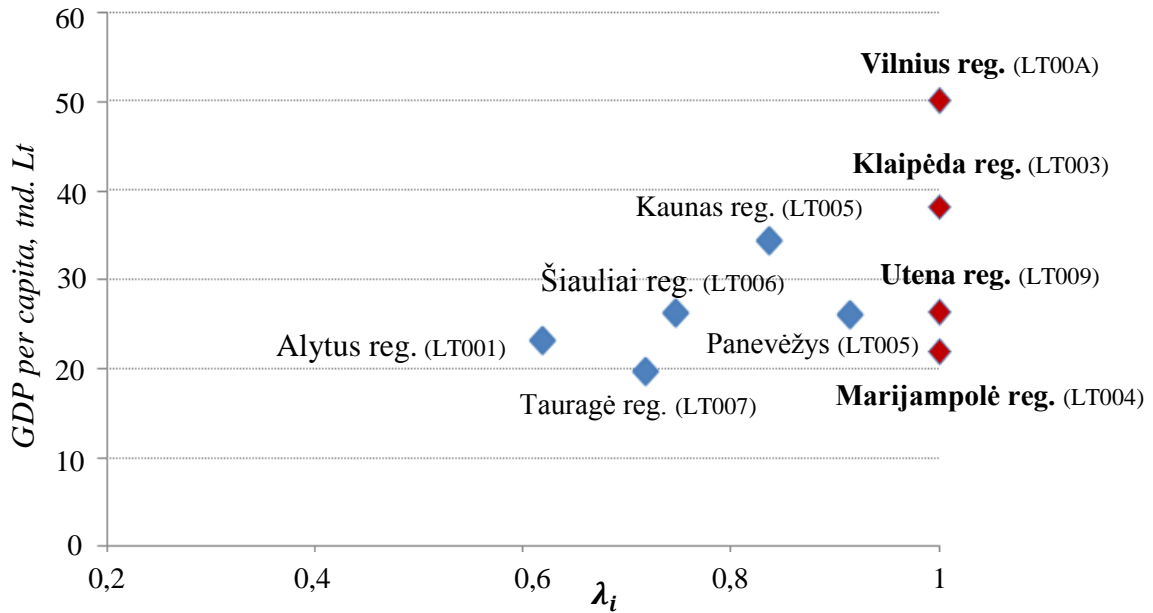
**Fig. 9.** Nonparametrically estimated production possibility frontier (isoquant) of Lithuanian NUTS3 regions, 2011

*Source: Compiled by the author according to Statistics Lithuania (2016)*

The highest efficiency scores of Vilnius (LT00A), Klaipėda (LT003), Utena (LT009) and Marijampolė (LT004) regions ( $\lambda = 1$ ) reveal that a possible production frontier is reached with the current human capital and infrastructure capital indicators. DMUs of Marijampolė (LT004) and Utena (LT009) regions, with lower than average gross domestic product per capita, are considered to use limited regional resources in more efficient way than in other Lithuanian regions. To enhance the regional growth in these regions, more emphasis should be put on indirect programs for human capital development, enhancement of current qualifications, attraction of more workforce to the region and also for the improvement of transport infrastructure, because the "bottleneck" of using these resources is reached.

In comparatively inefficient regions, such as Alytus (LT001), Tauragė (LT007), Kaunas (LT002), Šiauliai (LT006), Panevėžys (LT005), different programs should be implemented. More emphasis should be put on direct economic activity programmes to improve the economic activity so that the current resources could be used much more efficiently. The model helps to evaluate not only inefficient DMUs, but also to project possible outputs according to the efficient peers (DMUs). For example, the Kaunas

(LT002) regional production technology is most similar to that of Klaipėda (LT003) and Vilnius (LT00A) regions (77 and 23 per cent of similarity, respectively). These similarities lead to the idea that regional GDP could be enhanced by 10-15 per cent with the current resources.



**Fig. 10.** Efficiency scores of Lithuanian NUTS3 regions by DEA, 2011

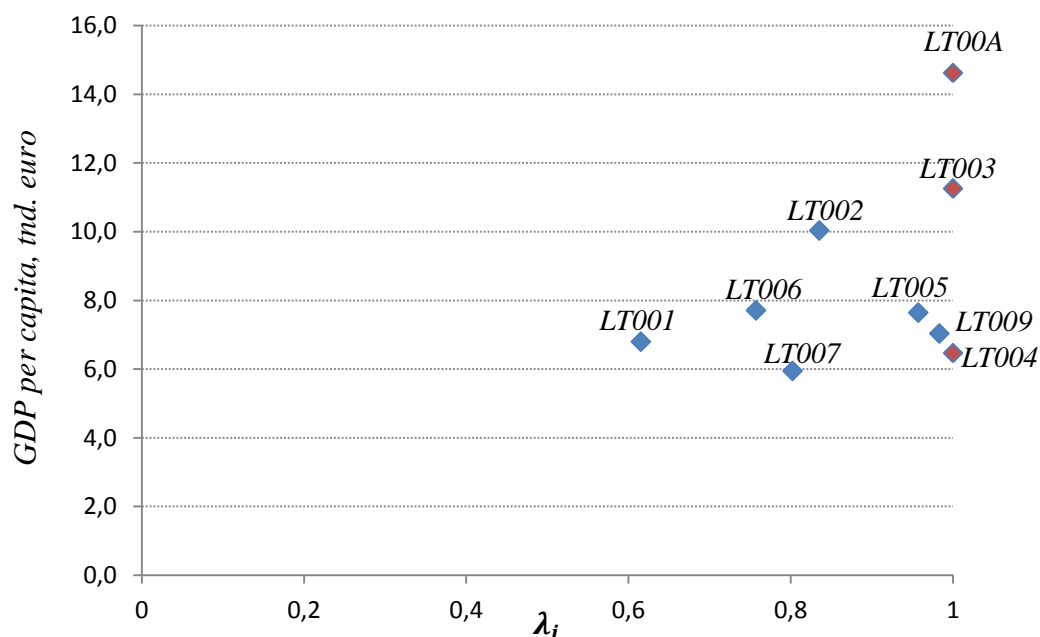
Source: compiled by the author according to Statistics Lithuania (2016)

A further analysis supplements the evaluation of infrastructure capital. Transport infrastructure indicator is divided in two indicators: internal transport infrastructure ( $I_i^{in}$ ) - as in the previous analysis, and external transport infrastructure ( $I_i^{ex}$ ), calculated by the formula:

$$I_i^{ex} = \sum_{j=1}^m GRP_j \cdot e^{\omega \cdot \min t_{road}(i,j)} \quad (8)$$

$GRP$  is the gross region product of  $j$  region per-capita,  $t_{road}(i, j)$  is a travel time between the regions  $i$  and  $j$ ,  $m$  is the number of regions, and  $\omega$  is a weighting factor that fulfils the following condition that  $e^{\omega \cdot \min T} = 0,5$  for  $T=90$  min. GRP that can be reached in 90 minutes is weighted by 0,5. Smaller weights account for geographically further regions and vice versa (Schaffer et al., 2011). 90 minutes is considered according to the size of Lithuania and is commonly analyzed travel time for daily business trips (Schoch, 2004).

According to the new indicators, efficient NUTS3 regions are Vilnius (LT00A) and Klaipėda (LT003) with the efficiency score  $\lambda = 1$ . Panevėžys region (LT005) made the most significant change during 2010 and 2014 because of the GDP growth. Most apart from the efficient frontier are Alytus (LT001), Tauragė (LT007), and Kaunas (LT002) regions. During all periods, closest to the efficient frontier were Utenos (LT009) and Marijampolė (LT004) regions. These regions need more human capital and investment into transport infrastructure to have economic growth opportunities.



**Fig. 11.** Efficiency scores of Lithuanian NUTS3 regions by DEA (with  $I_i^{in}$ ,  $I_i^{ex}$ ), 2011

*Source: compiled by the author according to Statistics Lithuania (2016)*

Inefficient regions - Alytus (LT001), Šiauliai (LT006), Tauragė (LT007), and Kaunas (LT002) - could enhance economic output by 20-40% with current resources. More efforts should be put to achieve a higher intensity of economic activities, since capital levels are sufficient to achieve the projected growth by DEA.

**Table 9.** The descriptive statistics of efficiency scores ( $\lambda_i$ ) by DEA with the transport input factors ( $I_i^{in}$  ir  $I_i^{ex}$ ), 2010–2014

Indicators	2010	2011	2012	2013	2014
Average efficiency score ( $\lambda_i$ )	0,868	0,883	0,896	0,910	0,902
Median	0,875	0,957	0,936	0,904	0,983
Minimal value	0,611	0,615	0,705	0,719	0,709
Number of efficient regions ( $\lambda_i=1$ )	4	3	4	4	4
Coefficient of variation (CV)	0,160	0,148	0,121	0,105	0,133

*Source: compiled by the author according to the data of Statistics Lithuania (2016)*

Dynamic tendencies during the period 2010-2014 show that in Lithuania there is a comparatively high number of efficient regions or close to efficient frontier. This tendency reveals that in most NUTS3 regions the economic growth is possible by expanding transport infrastructure, connectivity, and human capital. During the period of 2010-2014, the average efficiency score increased by 3,4 pp, the minimal efficiency score also increased from 0,611 to 0,709 (Table 9).

The largest positive changes in the efficiency results were achieved in Alytus, Panevėžys and Šiauliai regions, by increase of  $\lambda_i$  by 11,1 pp, 12,5 pp and 23 pp, respectively. It happened because of the growth of GDP and shows good signs of economic development in these regions. The least progress was in Tauragė and Kaunas regions. In Tauragė, the efficiency score has not changed during the whole period analyzed ( $\lambda_i = 0,781$ ), which indicates that there were no good economic changes in this region. In the Kaunas region, efficiency fell by 13 pp, since resources increased more than the economic value created. So it is important to find new paths for the regional economic development in Kaunas and Tauragė, because the previous programs do not help to enhance economic results.

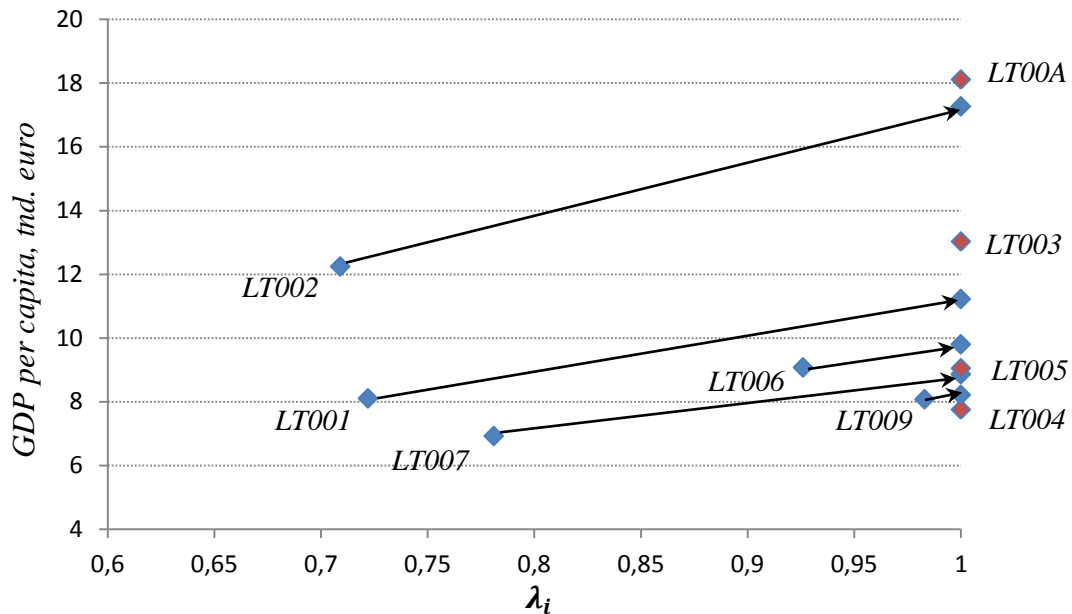
**Table 10.** Similarities of inefficient regions to efficient regions by DEA in 2014

Inefficient regions with $\lambda_i < 1$	Efficient peers and their similarities			
	LT003	LT004	LT005	LT00A
LT001	0,627	-	<b>0,337</b>	-
LT002	0,077	-	-	<b>0,898</b>
LT006	0,197	-	<b>0,798</b>	-
LT007	0,100	-	<b>0,835</b>	-
LT008	0,154	-	<b>0,686</b>	-

*Source: compiled by the author according to Statistics Lithuania (2016)*

Regional economic growth opportunities were also evaluated in the case the resources were used in an efficient way. This projection is made according to peer regions that have similarities in the production function. The Kaunas region (LT002) is mostly similar with Klaipėda (LT003) and Vilnius (LT00A) regions regarding the level of resources. To Vilnius region (LT00A) only Kaunas could be a peer. All other inefficient regions have comparative similarities with Klaipėda (LT003) and Panevėžys (LT005) (Table 10).

The similarities of regions reveal the coordinates on the efficient frontier (isoquant). The coordinates are calculated according to the technologically feasible output with the current level of input indicators. According to the model calculation, Kaunas should be the second region in terms of GDP per capita. Also the Alytus region (LT001) could be the fourth region according to the output indicator.



**Fig. 12.** Projected values of Lithuanian regions' efficient outputs in 2014

*Source: compiled by the author according to Statistics Lithuania (2016)*

To sum up, the nonparametric estimation of regional technical efficiency scores and their distribution among different territories revealed inefficient regions. The comparatively large number of efficient regions in Lithuania (4-5) reveals that transport infrastructure and human capital should be increased to achieve the economic growth. The worst situation was in Kaunas and Tauragė districts where there were no positive change in the economic activity during 2000-2014, which indicates the inefficiency of regional development programs during the analyzed period. The largest growth potential could be seen in Kaunas and Alytus regions, but only Alytus tends to move to the efficient frontier during the analyzed period.

## CONCLUSIONS AND RECOMENDATIONS

The theoretical analysis and empirical studies of the dissertation have revealed that the regional economic development is a relevant scientific and practical theme in the context of the EU integration. According to the research results, the following main conclusions and recommendations were drawn:

1. From the analysis of theoretical aspects of the regional economic development in the context of the EU integration, the main conclusions are as follows:

a. The regional economic development process could be understood in two ways: as being a multifaceted process, involving the region's dynamic social and economic development, and also it could include political tools and strategies for encouraging the regional economic and social change. The results of regional economic development should be evaluated with regard to dynamic changes in the regional economy: economic growth, increasing level of economic and social cohesion, regional technological development.

b. The recent regional economic development problems could be explained by three main theoretical trends, that try to explain complex economic development problems in the context of global competition and an inegration processes of the EU – endogenous growth theory that expands neoclassical growth theory and emphasizes the importance of knowledge and the abilities for human capital to learn; the new economic geography that analyze the processes of concentration in spatial dimensions and emphasizes the influence of urban areas for a higher level of production; and institutional economies, that reveal the importance of institutions, as being the main actors of generating the economic value. Other important concepts overlap with these theoretical trends, trying to explain the importance of various aspects to the regional economic development, as entrepreneurship, leadership, learning regions, urban economies, social capital, regional innovation clusters, and so on.

c. In the thesis, a conceptual model of regional economic development is proposed. It summarizes the main ideas and important factors, presented in the resent researches, and aims to reveal dynamic processes that shape the regional economy and economic development differences among territories. Four groups of factors are identified that explain the level of resources, innovative activities, specific and cultural

characteristics of a region and the role of institutions – regional actors, that create the economic value. The model integrates the reverse links among regional actors and other groups of factors. It means that both regional institutions could have influence on the changes of the level of resources, knowledge and specific regional characteristics from both the qualitative and quantitative viewpoint. Thus the level of resources and all the other circumstances, presented in the model, could shape companies that are established and come to the regional economy.

d. The conceptual model of regional economic development and its factors could be reorganized by integrating the concept of a technical efficiency. Recent trends in EU reveal a need for a higher level of efficiency so that the maximum output could be reached with the current financial and other resources. The technical efficiency in the model is visualized as a filter that separates regional economic resources from the economic value-added. Larger economic resources do not necessarily generate a higher value-added. Such technical inefficiencies may exist in the regions for a variety of reasons, related to qualitative factors and cultural characteristics, that shape the regional economy, for example, leadership and a person's ability to apply knowledge, abilities to commercialize innovative products, some synergies that arise from cooperations, cultural background, and agglomeration economies. This model forms a basis for a better understanding of complex processes in the regional economy and supports the idea that there is no straight pathway between inputs and economic results.

2. According to the theoretical analysis of economic tendencies in the EU and the main regional economic development strategies, policies and instruments, the following conclusions could be drawn:

a. The results of implementation of the EU Cohesion Policy revealed a greater convergence only in a part of regions in the EU. Less economically developed regions still lack the high value-added activities, the spread of knowledge, technology development and sustainable development. The economic results have reflected that there is an inefficient use of investments in some areas, which means that the EU has to find the way to increase the efficiency of EU regional policy that could yield real economic results.

b. In regard to a situation, the EU Cohesion policy has been reviewed in the programming period of 2014-2020. When shaping the Europe 2020 strategy, the latest



researches and insights into the current globalization circumstances were taken into account: a strong focus on innovation, the search for regional uniqueness and strengths that could be a basis for creating the competitive products, a greater emphasis on the real economic and social results, and their monitoring. The importance of specialization and the need to promote specific potential growth of regional economic activities, not only to improve the general regional infrastructure, where emphasized as well.

c. The financial support for regional cohesion was significantly increased in the programming period of 2014-2020. It is planned to allocate about one-third of the EU budget. Thus, there is a need to monitor the regional economic and social progress, which could be expressed by the real economic indicators and not only by increased levels of financial resources and better infrastructure indicators.

3. The empirical research methodology is proposed in this thesis to assess the effectiveness of the regional economic development. To obtain the most information from the multidimensional data it is proposed to apply a combination of the self-organizing neural maps and Sammon's projection, that has not been previously applied to regional economic studies. Methods provide the possibility to analyze regional economic development factors according to their similarities and to find their interaction components. Also nonparametric linear programming methods (DEA FDH, order- $\alpha$ ) are applied, that expand the capabilities of the multidimensional data analysis, and assess more accurately the distribution of the technical efficiency between regions. Thus, fragmented, but complementary to each other methods are proposed for the efficiency analysis of regional economic development.

4. The efficiency evaluation of the Central and Eastern EU NUTS2 regions by nonparametric techniques has disclosed some technical efficiency problems:

a. The Baltic states are among the regions with the lowest efficiency scores. Among the Baltic countries Estonia stands out because of its relatively high investment in R&D. All Baltic countries have relatively high level of the skilled human capital. The main inefficiency occurs because these resources do not create an efficient level of the gross value-added compared to the other Central and Eastern EU regions.

b. This analysis reveals uneven regional economic growth possibilities. For example, by DEA estimates, Estonia could reach the economic output up to 40% higher with the current resources by increasing its efficiency. According to the model, if the

Central and Eastern EU regions used their current resources to the maximum, it would be possible to reach up to 20% greater economic results.

5. With regard to the efficiency scores of the Central and Eastern EU regions, the following proposals for regional economic policies are given:

a. In technically inefficient regions, it is important to intensify the economic and business activities that generate a higher value-added, since the available resources and human capital characteristics indicate that it is possible to achieve about 20% better economic results.

b. More attention should be paid to attract companies from other areas and to promote the expansion of the regions' local business. The sufficient amount of resources could be attractive for business development.

c. The distance from the efficient frontier of some regions shows that there is some potential to achieve better economic results, if more attention is paid to achieving real results - scientific production commercialization. The current resources, human capital, and investments are not used in the appropriate way to maximize economic results.

d. Inefficient regions with high education indicators, such as the Baltic states, should pay more attention to the system of education and promoting of entrepreneurship, because highly educated people lack to realize their knowledge in the creation of high value-added products and are not sufficiently involved in knowledge-intensive services.

e. One of the reasons of this process is the lack of opportunities in the regional market to realize the accumulated knowledge in the high value-added sectors. So more responsibility should be put on the regional government how to create more better working places with the ability to generate a high value-added and fully exploit all the knowledge gained.

6. The allocation of financial resources for the regional economic development should be made with respect to the regional performance in using the existing resources. That could allow each region to choose the right tools and avoid wastage of excess allocation of financial resources to the areas not adequately promoting the regional economic growth.

7. The efficiency measurement of Lithuanian NUTS3 regions taking into account the development of road infrastructure and human capital elements has revealed:

a. The least efficient regions over the period of 2010-2014 were the Kaunas (LT002) and Tauragė (LT007) regions. According to the DEA, the Kaunas region could achieve a significantly higher GDP per capita with the available economic resources and road infrastructure and could be the second region with regard to the economic development after the capital region (now it is in the third place). In the period of 2010-2014 the efficiency results did not improve in the Kaunas and Tauragė regions, which shows economic policy problems, as it is important to find a new path for the regional economic development, because the current strategies do not increase the economic efficiency.

b. A high economic growth potential is seen in the Alytus region. Although it is one of the least effective regions in Lithuania, the improvement of economic results during the recent years has shown that it has the ability, under the existing transport infrastructure and geographical position, to improve the economic performance about 30% and reach the fourth position in terms of GDP per capita in Lithuania. Improving results are also visible in the Šiauliai region.

c. The relatively high number of efficient NUTS3 regions (4-5 regions from 10) in Lithuania reveal that it is important to increase the quantities of economic resources to achieve a better regional economic development. The economic growth of Vilnius, Klaipėda, and Panevėžys regions can be achieved primarily by increasing the amount of human capital, and that of Utena and Marijampolė regions by improving the transport infrastructure.

8. In the thesis, some methodological aspects are suggested for evaluating the efficiency in the selected region group of the EU:

a. The paper has proposed a methodological interpretation, how to choose the appropriate non-parametric linear programming method from the DEA, FDH and order- $\alpha$  analysis for the regional analysis. It is applied in a thesis.

b. For the efficiency analysis of a group of technologically similar regions, the DEA method is more appropriate, because it helps to better identify the technological differences among regions. FDH and order- $\alpha$  methods could be used for a larger sets of regions. The main difference is that DEA tries to find the efficient regions according to the data of the whole regional group, and the remaining methods evaluate the efficiency according to the comparison to the regions, with a lower or similar level of resources.

c. The paper presents two ways to evaluate the road infrastructure. While evaluating the road infrastructure, it is proposed to analyze not only the density of the road, but also the travel time and connectivity with other regions.

### **Further research fields and recommendations**

The thesis has proposed the conceptual models to disclose the factors of regional economic development. These models pay attention to the fact that, in order to design and implement effective regional economic policies, it is important to evaluate not only the quantity of resources in the regions, but also the other circumstances that effectively transform the resources into economic results. The increased economic resources do not necessarily mean an increase in the economic performance or social welfare. This technical inefficiency scores are important for economic policy-makers to achieve the real and tangible economic development and social cohesion results, since the increased investments in infrastructure do not necessarily cause a higher value-added and social welfare in some regions. This should be taken into account of the EU and Lithuanian regional economic policy makers.

In the dissertation, a combination of methods are applied to estimate the efficiency and to identify the resources that are used inefficiently in creating the value-added. In further studies, it is worthwhile to measure factors that influence the level of efficiency. Evaluation of these processes could provide more information about what regional economic development policies are needed according to territorial specificities.

The author of dissertation proposes for future research fellows, scientists, and regional economic policy makers to expand the conceptual model of regional economic development and its factors with regard to the emerging challenges for the regional economic development. The study methodology could also be applied to other countries in the analysis of their inner regions or other regional groups for measuring the efficiency and development factors in the context of the European Union and globalization.

**Approbation and dissemination of the scientific research results.** Statements and results of the scientific research were published in 9 academic publications and presented in 7 international and national scientific conferences.

## List of publications:

### *Articles in Monographs:*

1. Dzemydaitė, G. (2015). Regionų socialinė ekonominė raida ir jos ypatumai integracinių procesų Europos Sąjungos sąlygomis. Straipsnis kolektyvinėje monografijoje „Ekonomikos modernizavimas: globalizacijos iššūkiai ir ekonominė politika“ (2 spaudos lankų). Moksl. redaktorius B. Melnikas // Regional social economic development and its peculiarities in the process of European Union integration. Scientific article in collective monograph ‘Modernization of Economy: the Challenges of globalization and Economic Policy’ (2 press quires), scientific ed. B. Melnikas. Accepted for publication.

### *Scientific Articles in Peer Reviewed Scientific Journals:*

2. Dzemydaitė, G., Dzemyda, I., Galinienė, B. (2016). The Efficiency of Regional Innovation Systems in New Member States of the European Union: A Nonparametric DEA Approach. *Economics and Business*. Vol. 28, p. 83-89. ISSN 2256-0386.

3. Dzemydaitė, G., Dzemyda, I., Galinienė, B. (2015). The Evaluation of Regional Innovation Systems' Efficiency in New Member States of European Union. *Journal of Applied Economic Sciences*. Vol. X, Issue 3(33), p. 317–328. ISSN 2393 – 5162.

4. Dzemydienė, D., Maskeliūnas, S., Miliauskas, A., Naujikiėnė, R., Dzemydaitė, D. (2015). E-service composition for decision support based on monitoring of contamination processes and analysis of water resource data. *Technological and Economic Development of Economy*. Vol. 21, No. 6, p. 869–884. ISSN: 2029-4913.

5. Dzemydaitė, G., Galinienė, B. (2013). Evaluation of regional efficiency disparities using efficient frontier analysis. *Ekonomika*. Vol. 92, No. 4, p. 21–36, ISSN 1392-1258.

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7. Dzemydaitė, G., Dzemyda, I., Jurgelevičius, A. (2012). Evaluation of implementation of the national export development strategy: case study of the Republic of Lithuania. *Intellectual economics*. Vol. 6, No. 1, p. 776–797, ISSN 1822-8011.

*Conference Proceedings:*

8. Dzemydaitė, G. (2014). Regionų inovacijų efektyvumo vertinimas duomenų apsuptys analizės metodu. Mokslinės-praktinės konferencijos „Lietuvos turto vertintojai – 20 metų veiklos patirtis nacionalinės ir Europos ekonominės erdvės kontekste“, vykusios Vilniuje 2014 m. kovo 28 d., mokslo darbai, Vilnius, p. 93–103, ISBN 978-609-459-299-7. // The efficiency of regional innovation systems by data envelopment analysis. Scientific – practical conference „ Lithuanian asset evaluators – 20 year experience in the national and European economic context”, held in Vilnius 28/03/2014, conference proceedings.

9. Dzemydienė, D., Maskeliūnas, S., Miliauskas, A., Naujikiene, R., Dzemydaitė, D. (2014). An approach of e-service composition for multi-spectral analysis of data warehouses of water resource management sector. Databases and information systems: Proceedings of the 11th international Baltic conference, June 8–11, 2014, Tallinn, Estonia / editors: H.-M. Haav, A. Kalja, T. Robal, p. 291–302, ISBN 978-9949-23-632-9

**Presentations in international and national scientific conferences:**

1. Dzemydaitė, G. Regionų inovacinio potencialo vertinimas Rytų ir Centrinės ES regionuose. // The Potential of Regional Innovative Activities in the Eastern and Central EU. A presentation in the international scientific conference ‘Rethinking Regional Competitiveness’, Šiauliai, 2015 11 26.

2. Dzemydaitė, G. Neparametrinių metodų taikymas naujųjų ES šalių regionų efektyvumo tyrimams. // Nonparametric methods for evaluating regional efficiency in the EU. A presentation in the international scientific conference ‘Rethinking Regional Competitiveness’, Šiauliai, 2014 11 27.

3. Dzemydaitė, G., Dzemyda, I., Galinienė, B. The evaluation of regional innovation systems’ efficiency in new member states of EU: a nonparametric approach. A presentation in the international scientific conference ‘Contemporary Issues in Business, Management and Education’, Vilnius, 2014 11 13–14.

4. Dzemydienė, D., Maskeliūnas, S., Miliauskas, A., Naujikiene, R., Dzemydaitė, D. An Approach of E-Service Composition for Multi-Spectral Analysis of Data Warehouses of Data Resource Management Sector. A presentation in the international

scientific conference ‘International Baltic Conference on Databases and Information Systems’, Tallinn, Estonia, 2014 06 08–11.

5. Dzemydaitė, G. Regionų inovacijų efektyvumo vertinimas taikant duomenų apsuptyes analizės metodą. // The efficiency of regional innovation systems by data envelopment analysis. A presentation in the national scientific – practical conference “Lithuanian asset evaluators – 20-year experience in the national and European economic context”, Vilnius, 2014 03 28.

6. Dzemydaitė, G., Galinienė, B. Evaluation of regional efficiency disparities using efficient frontier analysis. A presentation in the national scientific – practical conference “Economic Transformations and Business Prospects”, Vilnius, 2013 09 26.

7. Galinienė, B., Dzemydaitė, G. Spatial data order- $\alpha$ -frontier analysis method for the evaluation of regional infrastructure development disparities. Pranešimas tarptautinėje konferencijoje “Social innovations: theoretical and practical insights”, Vilnius, 2012 10 25–26.

## **About the author**

Giedrė Dzemydaitė was born on 22 September 1987, Vilnius, Lithuania

### *Education*

- 2012-2016 Doctoral studies in Social Sciences, Economics, *Vilnius University, Lithuania*
- 2010 - 2012 Master’s degree in Social Sciences, Economics, Applied Macroeconomics, *Vilnius University, Lithuania*
- 2006 - 2010 Bachelor’s degree in Social Sciences, Economics, *Vilnius University, Lithuania*

### *Professional Background*

- 2014 - now Lecturer at Vilnius University the Faculty of Economics the Department of Economic Policy, Vilnius, Lithuania  
*Subjects: Regional Economics and Planning, Regional Economic Analysis, Economic policy and Strategic Planning*

### *Honors and Awards*

- 2013/2014, Grant from the Research Council of Lithuania
- 2014/2015 *Awarded for the contribution to the research in the field of the regional economics and social sciences (2 times) during doctoral studies.*

## REZIUMĖ

**Temos aktualumas.** Europos Sąjungos regionai ir šalys susiduria su nevienodomis regionų išsivystymo problemomis: pajamų nelygybe, tam tikrų verslo sričių nesugebėjimu prisitaikyti prie atviros rinkos pokyčių, ūkio sektorių technologiniais pokyčiais, darbo jėgos migracija. Didelę pridėtinę vertę generuojanti ekonominė veikla ir ištekliai sutelkiami labiau ekonomiškai išsivysčiusiose šalyse ir urbanistinėse teritorijose. O kitos teritorijos turi ieškoti priemonių ir šaltinių didinti sukuriama pridėtinę vertę, restruktūrizuoti verslą.

ES rinkos integracija veikia šalių narių ekonomikas, skirtingas verslo struktūromis, specializacijos ir diversifikacijos pobūdžiu (Burda, Severgnini, 2009; Ertur, Koch, 2006). Integracija skatina gamybos veiksmų judėjimą tarp šalių regionų, tiesioginių užsienio investicijų ir migracijos srautus (Marrocu ir kt., 2013). Gamybos veiksmų judėjimas skatina didesnę regioninio verslo specializaciją (Burda, Severgnini, 2009). Regionų ekonominės plėtros planavimas įgauna reikšmingą vaidmenį šiuolaikinėje ekonomikoje, nes siekiama identifikuoti regionų strateginio vystymosi kryptis, augimo šaltinius, kurie užtikrintų konkurencingumą globalioje ir integruotoje ES rinkoje.

Pagal strategiją „Europa 2020“ ES siekia išnaudoti darbo jėgos potencialą, didinti įdarbinimo rodiklius, produktyvumą ir taip iki 2020 m. spręsti gyventojų senėjimo ir didelės pasaulinės konkurencijos problemas (EK, 2010). Tačiau tik skatinant teritorinę sanglaudą galima suteikti vienodas galimybes visiems regionams siekti teigiamų ekonominių rezultatų. Integracijos siekiančioje ES ekonominiai netolygumai tarp regionų išlieka reikšminga ES problema (ESPON, 2012; Okubo, 2012; Becker ir kt., 2012; Busillo ir kt., 2012; Butkus, Matuzevičiūtė, 2011; EK, 2010; Simanavičienė, kt., 2010; Barca, 2009).

Įstojus naujoms šalims narėms (nuo 2004 m.) regioniniai skirtumai ES išaugo smarkiai (EESC, 2006). Naujose šalyse narėse (įstojusiose nuo 2004 m.) vis dar nepakankamai sukuriama aukštos pridėtinės vertės prekių ir paslaugų, kurios būtų imlios žinioms. Reikšmingai padidėjusi diferenciacija tarp NUTS2 ir NUTS3 lygmens ES regionų rodo, kad naujose šalyse narėse ūkio struktūra labiau orientuota į žemų technologijų pramonės sektorius ir tarpinių paslaugų teikimą (Becker ir kt., 2012; Busillo



ir kt., 2012; Barca, 2009). Technologinis progresas nėra pakankamai intensyvus, kad keistų įprastą ekonomikos struktūrą.

ES priimdama naujas šalis nares prisiėmė ir jų ekonominio vystymosi problemas. ES skiria investicinę paramą mažiau ekonomiškai išsivysčiusiems Vidurio ir Rytų ES regionams ir inicijuoja veiksmų programas. Vienas iš „Europa 2020“ strategijos 2014–2020 m. tikslų yra skatinti regionų išsivystymą, didinti produktyvumą ir užimtumą (EK, 2010). Įgyvendinti „Europa 2020“ regioninės sanglaudos strategijai 2014–2020 m. planuojama skirti apie trečdalį ES biudžeto (virš 350 mlrd. eurų). Labai svarbu, kad kiekvienas regionas identifikuotų savo ekonomikos augimo šaltinius ir numatytų priemones, kurios prisidėtų prie teritorinės sanglaudos ir sėkmingo ES strateginių tikslų įgyvendinimo.

ES šalims narėms susiduriant su finansinio stabilumo, biudžeto deficito problemomis, atsirandant naujam finansinių išteklių poreikiui pabėgėlių krizei spręsti, labai svarbu ieškoti, kaip optimaliai panaudoti finansinius išteklius. Dėl silpnos nacionalinės, regioninės ir vietos administracijos gali būti rizika sėkmingai įgyvendinti atitinkamas programas, todėl itin svarbu, kad sanglaudos politikos lėšos būtų investuojamos ir valdomos tinkamai (EK, 2015). Kilusi pabėgėlių krizė suteikia tiek galimybes ir grėsmes ES regionų vystymuisi (TVF, 2016; Draghi, 2016). Todėl efektyvus finansinių išteklių paskirstymas ir tinkamų regioninės politikos kryptių pasirinkimas, reaguojant į kylančias vis naujas grėsmes, tampa vienu iš pagrindinių ES regioninės politikos sunkumų, siekiant darnios ekonominės plėtros ir spartesnio ekonomikos augimo.

**Mokslinė problema.** Šiuolaikinėje ekonomikos teorijoje stokojama praktinių sprendimų ir mokslinio pažinimo, skirtų pagrįstai įvertinti regionų ekonominę plėtrą ir jos efektyvumą, atsižvelgiant į naujas aplinkybes, atsiradusias globalizacijos ir integracinių procesų Europos Sąjungoje sąlygomis, į kurias nebuvo adekvačiai reaguojama. Atsiranda nauji požiūriai į regionų ekonominę sanglaudą, įvairūs Europos Sąjungos šalių regionų prioritetai, tame tarpe – darnios raidos, konkurencingumo ir produktyvumo didinimo siekiai, inovacinių procesų skatinimo pirmaeiliskumas. Ekonominės plėtros efektyvumo praktikoje į šias naujas aplinkybes adekvačiai neatsižvelgta, todėl šiuolaikinėje ekonomikos teorijoje stokojama sprendimų ir adekvataus aplinkybių Europos Sąjungos integracinių procesų sąlygomis įvertinimo.

Tokių teorinių požiūrių visuma sudarytų galimybes šiai dienai aktualių ekonominių problemų sprendimui.

**Tyrimų objektas** – regionų ekonominės plėtros efektyvumo didinimo procesas bei efektyvumo vertinimo praktika, atsižvelgiant į poreikius įgyvendinti darnios subalansuotos plėtros poreikius ES integracinių procesų sąlygomis.

**Darbo tikslas** – ištirti šiuolaikinius reiškinius, svarbius regionų ekonominei plėtrai, bei parengti ir įgyvendinti teorinę koncepciją, skirtą regionų ekonominės plėtros efektyvumo didinimui bei vertinimo tobulinimui, atsižvelgiant į šiuolaikinius darnios plėtros iššūkius globalizacijos ir ES integracijos sąlygomis.

Darbo tikslui pasiekti keliami šie **uždaviniai**:

1. Išanalizuoti regionų ekonominės plėtros sampratą ir šios srities ekonominius tyrimus, aktualius ES integracijos procesų sąlygomis.

2. Atlikti regionų ekonominės plėtros ir jos veiksnių analizę ir pasiūlyti sisteminių regionų ekonominės plėtros veiksnių sąveikos modelį.

3. Išanalizuoti regionų ekonominei plėtrai ir jos efektyvumo vertinimui skirtus instrumentus, taikomus integracinių procesų Europos Sąjungoje sąlygomis, remiantis ES strategijomis, ataskaitomis ir direktyvomis.

4. Sudaryti empirinių tyrimų metodologiją, skirtą regionų ekonominės plėtros procesų ir jų efektyvumo vertinimui integracinių procesų Europos Sąjungoje sąlygomis.

5. Remiantis sudaryta metodologija atskleisti Centrinės ir Rytų ES regionų ekonominės plėtros efektyvumo skirtumus bei svarbius ekonominės plėtros veiksnius ir jų sąveikos komponentus ir pateikti siūlymus regionų ekonominės politikos formavimui.

**Tyrimo metodai.** Darbo tyrimo metodologija remiasi sisteminiu požiūriu į regionų ekonominę plėtrą ir jos planavimą Europos Sąjungos kontekste. Darbui pasirinktas įvairių tyrimo metodų derinys, numatyta atlikti lokalius fragmentiškus vienas kitą pildančius tyrimus, kiekvienas iš jų turi savo metodiką, tačiau visos jos yra sujungiamos į bendrą metodologinę sistemą. Regionų ekonominės plėtros tyrimai atlikti dviem tyrimų blokais. Atlikta regionų ekonominės plėtros bendrųjų tendencijų Europos Sąjungos kontekste analizė, ekonominės plėtros procesų ir planavimo mechanizmų sąveikos Europos Sąjungoje ir pasirinktose šalyse narėse įvertinimas ir regionų techninio efektyvumo tyrimas, siekiant įvertinti ir palyginti regionų išteklių kiekį ir gebėjimus generuoti didelę pridėtinę vertę.

Siekiant visapusiškai ištirti darbe iškeltas problemas, taikyti teoriniai ir empiriniai tyrimo metodai. Regionų ekonominės plėtros sampratos, ekonomikos augimo šaltinių ir tendencijų Europos Sąjungoje tyrimuose atlikta šiuolaikinių mokslinių tyrimų analizė, svarbiausių idėjų sisteminimas ir sintezė, politinių dokumentų analizė ir statistinių duomenų aprašomoji analizė.

Empirinį tyrimą galima skirstyti į dvi dalis. Pirmojoje dalyje analizuojami regionų ekonominiai ištekliai ir jų naudojimo efektyvumas. Tyrimai atliekami regiono produkcijos funkcijos rėmuose, taikant neparimetrinius tiesinio programavimo metodus ir siekiant nustatyti efektyvią regionų gamybos galimybių ribą. Pritaikyti metodai: duomenų apgaubties analizė (DEA), laisvai išsidėsčiusių dydžių analizė (FDH) ir order- $\alpha$  efektyvios ribos analizė. Remiantis tyrimo rezultatais siūlomos ekonominės politikos kryptys, kurios padėtų didinti išteklių naudojimo efektyvumą.

Antrojoje empirinių tyrimų dalyje siekiama įvertinti regionų ekonominės plėtros veiksnius ir jų sąveiką. Sudaryta rodiklių sistema, jos kompotentų sąveika tiriami ir vizualizuojami taikant Sammono duomenų žemėlapių ir save apsimokančių neuroninių tinklų (Kohoneno tinklo) metodų derinį. Išskiriamos panašios sąveikos rodiklių grupės bei vertinami jų tarpusavio nuotoliai.

Empiriniuose tyrimuose naudojami Eurostat ir atskirų šalių narių nacionalinių statistinių duomenų bazių duomenys. Tiriami Vidurio ir Rytų ES NUTS2 lygmens regionai (įstoję į ES nuo 2004 m.) ir Lietuvos vidiniai NUTS3 lygmens ES regionai. Statistiniai duomenys grupuojami ir apdorojami SPSS, Stata, DEAP ir MatLab programomis.

### **Ginamieji teiginiai:**

1. Žmogiškasis kapitalas ir kiti ištekliai, skirti didelei pridėtinei vertei kurti regionuose, nėra efektyviai išnaudojami Vidurio ir Rytų ES regionuose.

2. Investicijos į Vidurio ir Rytų ES regionus, jų infrastruktūrą nepakankamai prisideda prie ekonomikos restruktūrizavimo, o tai lemia nepakankamą šių regionų ekonominį augimą ir vystymąsi.

3. Nustatant regionų ekonominės plėtros sprendimus turi būti taikoma visuminė ekonomikos augimo veiksnų sąveikos vertinimo metodika, kad galima būtų identifikuoti tinkamas regionų ekonominės plėtros priemones.

**Darbo mokslinis naujumas ir teorinė reikšmė.** Teoriniu požiūriu regionų ekonominės plėtros koncepcija nėra nauja: XX a. pab.–XXI a. ją plėtoja įvairios mokslinės kryptys. Rezultatas – modelių, pabrėžiančių skirtingų procesų svarbą regionų ekonominei plėtrai, įvairovė. Vis dėlto tyrimuose trūksta sisteminio proceso vertinimo, siejant skirtingus veiksnius į visumą. Siūlomi tyrimo metodai, kurie sudarytų sąlygas apibendrinti ir išgryninti turimus agreguotus duomenis, abstrahuotų ir pateiktų sisteminę situacijos vertinimą.

Šiuolaikinėje ekonomikoje atsiranda nauji regionų ekonominės raidos efektyvumo vertinimo kriterijai Europos Sąjungos integracinių procesų sąlygomis. Regionai turi siekti būti efektyvūs visoje ES erdvėje, darniai vystytis, siekti didesnės socialinės gerovės ir gyvenimo kokybės gerinimo. Nors Centrinės ir Rytų ES regionai pasižymi didesniu nei ES ekonomikos augimu, tačiau dėl santykinai žemo namų ūkių disponuojamų pajamų lygio formuojasi dar didesnės nedarnios ekonominės plėtros apraiškos. Taikant darbe pasiūlytą tyrimų algoritmą atsiranda galimybės atsižvelgti į veiksnius, kurių nagrinėjimui nebuvo skirta pakankamai dėmesio: regionų inovacijų sistemų efektyvumui, išteklių ir infrastruktūros kuriamos ekonominės vertės ir jų naudojimo efektyvumui, žmogiškųjų išteklių įsitraukimui į didesnės pridėtinės vertės kūrimo procesus.

Disertacijoje sistemiškai vertinami regionų ekonominės plėtros veiksniai, jungiami į visuminį regionų ekonominės plėtros veiksnių ir jų sąveikos modelį. Modelis atskleidžia kiekybinių ir kokybinių veiksnių svarbą regionų ekonominei plėtrai, grįžtamuosius ryšius bei integruoja techninio efektyvumo koncepciją, kuri nebuvo ankščiau įtraukta į panašius modelius. Sudarytas modelis leidžia platesniu požiūriu tirti ir vertinti regionų ekonominės plėtros tendencijas, identifikuoti regionų trūkumus ir nepakankamo ekonominio vystymosi priežastis, atkreipia dėmesį į kokybinių veiksnių ir efektyvumo svarbą regionų ekonominės plėtros planavimo ir finansavimo procesuose.

Disertacijoje pasiūlyta tyrimo metodika, kuri geriausiai atskleistų tiriamųjų NUTS2 ir NUTS3 regionų problematiką ir sudarytų sąlygas kiekybiniais metodais ir remiantis oficialia statistika ištirti ir mažiau apčiuopiamus veiksnius ir jų svarbą regionų ekonominei plėtrai. Siekiant išspręsti kokybinių aspektų vertinimo trūkumą darbe pritaikyti neparametriniai efektyvios ribos nustatymo metodai, kurių pagrindu vertinamas bendras regiono gebėjimas absorbuoti turimus resursus ir generuoti aukštą

pridėtinę vertę. Jis sudaro galimybę vertinti regione veikiančių įmonių bendrą efektyvumą, kaip kokybinį gebėjimą bei bendras galimybes pasinaudoti turimomis ekonominėmis gėrybėmis.

Gebėjimas veikti efektyviai apima verslo ir viešojo valdymo ypatumus, ganamą naudą iš sinergijos, kuri vyksta įmonėms bei verslui ir mokslui bendradarbiaujant, lyderystės apraiškas ir gyventojų gebėjimus realizuoti įgytas žinias, patirtį, jas komercializuoti ir kurti rinkoje konkurencingus produktus. Nors neparimetriniu tyrimu ir nėra galimybės tiksliai nurodyti, kuri iš išvardintų valdymo sričių yra neefektyvi, tačiau yra galimybė identifikuoti nepakankamai išnaudojamus resursus, jų grupes ir pagal tai priimti sprendimus, kaip keisti su tuo susijusius valdymo procesus.

Darbo naujumą grindžia ir tai, kad neparimetriniai efektyvios ribos metodai pirmą kartą pritaikyti Vidurio ir Rytų ES ir Lietuvos regionų ekonominei plėtrai vertinti. Taip pat regionų ekonominės plėtros veiksniai pirmą kartą tirti daugiamatės analizės metodų kombinacija: save apsimokančių neuroninių tinklų su Sammono projekcija, kuri susidarė galimybes gauti daugiau informacijos apie tiriamą regionų grupę bei nustatyti ekonominės plėtros veiksnių tarpusavio sąveikos komponentus.

**Praktinė darbo reikšmė.** Tyrimo rezultatai gali būti naudingi mokslininkams ir praktikams, nagrinėjantiems ir formuojantiems Europos Sąjungos ir Lietuvos regionų ekonominę politiką, sprendžiantiems integracijos procese dalyvaujančių šalių ir regionų konvergencijos klausimus, formuojantiems regionų ekonominės plėtros strategijas.

Sisteminis regionų ekonominės plėtros efektyvumo ir svarbių ekonominės plėtros veiksnių identifikavimas ir siūloma tyrimų metodika sudaro pagrindą formuoti labiau į problemines sritis orientuotą regionų ekonominę politiką, įvertinti regionų ekonominio vystymosi trukdžius, kuriuos svarbu mažinti siekiant aukštesnės pridėtinės vertės kūrimo Centrinės ir Rytų ES regionuose.

Autorės siūlomą tyrimo metodologiją galima taikyti ir kitų šalių vidinių regionų arba ES regionų grupių ekonominės plėtros procesų ir jų efektyvumo tyrimams, ekonominės plėtros veiksnių sąveikos modeliavimui, siekiant identifikuoti potencialaus augimo regionus, nagrinėti regionų ekonominės politikos kryptis ir jų efektyvumo didinimo procesus.

**Tyrimo apribojimai ir duomenų prieinamumas.** Tyrime pritaikyti neparimetriniai efektyvios ribos analizės metodai (DEA, FDH ir order- $\alpha$ ) suteikia

galimybes nustatyti regionų ekonominės plėtros efektyvumo įverčius ir jų skirtumus pagal pasirinktus rodiklius, rodančius resursų lygį ir ekonominius rezultatus. Šių tyrimų esminis ribotumas, kad efektyvumo įverčiai yra sąlyginiai, priklausantys nuo tiriamos srities ir pasirinktų veiksnių. Tyrime tiriant kitas veiklos sritis, gali išsiskirti kiti efektyvūs regionai.

Tyrimuose susidurta su duomenų prieinamumo problema. Nebuvo galimybės analizuoti naujausių ES regioninių duomenų. ES regioninių duomenų surinkimas ir pateikimas Eurostat sistemoje užtrunka apie 3–4 metus. Pavyzdžiui, „Europa 2020“ strategija, įsigaliojusi 2014 metais, suformuota remiantis 2010 m. regioniniais duomenimis, EK Regioninės sanglaudos 2015 m. ataskaitoje nagrinėjami 2011 m. BVP duomenys. Dėl to naujausi tyrimuose analizuoti duomenys buvo 2013-2014 metų.

Kita duomenų prieinamumo problema – nėra galimybės sistemiškai tirti smulkesnių nei NUTS2 teritorinių vienetų. NUTS2 lygmuo apima regionus su 800 tūkst.–3 mln. gyventojų. Smulkesnių teritorinių darinių (NUTS3, LAU1) statistiniai duomenys pateikiami fragmentiškai, nėra galimybės atlikti kokybiško skirtingų šalių regionų lyginimo. Dėl to empiriniuose tyrimuose nagrinėjamas NUTS2 regioninis lygmuo, NUTS3 lygmuo tiriamas Lietuvos lygiu.

**Disertacijos struktūra.** Disertacija susideda iš įvado, keturių dalių, išvadų ir pasiūlymų, literatūros sąrašo ir priedų. Disertacijos apimtis – 182 puslapiai, joje pateiktos 24 lentelės, 26 paveikslėliai ir 21 priedas.

**Išvados.** Disertacijoje išnagrinėti teoriniai šaltiniai ir atlikti tyrimai patvirtino, kad regionų ekonominė plėtra yra aktuali mokslinė ir praktinė tema ES šalių narių ir jų regionų integracijos kontekste. Remiantis Lietuvos ir užsienio mokslininkų darbų analize bei autorinio tyrimo rezultatais, suformuotos pagrindinės disertacijos išvados ir siūlymai:

1. Atlikus regionų ekonominės plėtros mokslinių šaltinių analizę ir susistemintus skirtingų autorių nagrinėtas teorines prielaidas, gauti rezultatai:

a. Lietuvių moksliniuose tyrimuose regionų ekonominės plėtros, vystymosi, ekonominio augimo sąvokos, jų skirtumai ir sąsajos nėra pateikti sistemingai, apibrėžimai yra fragmentiški. Nors iš anglų kalbos tiesiogiai verčiamas terminas „regional economic development“ gali turėti reikšmes „regionų ekonominė plėtra“ ir „regionų ekonominis vystymasis“, jos galėtų būti vartojamos kaip sinonimai, tačiau pagal LR Regioninės plėtros įstatymą ir remiantis kitų mokslinių tyrimų darbais šias

sąvokas vertėtų skirti. Regionų ekonominė plėtra gali būti apibrėžiama kaip daugialypis procesas, įtraukiantis ne tik dinamiškus regiono socialinės ir ekonominės būklės pokyčius, bet ir priemones, taikomas siekiant regiono ekonomikos pokyčių. Regiono ekonominės plėtros poveikis turėtų būti analizuojamas pagal pasiektus rezultatus: ekonomikos augimą, didėjančią regiono ekonominę ir socialinę sanglaudą, regiono technologinį vystymąsį. Regiono ekonomikai poveikį gali daryti ne tik vietinės ekonominės plėtros strategijos ir jų įgyvendinimas, bet ir išoriniai veiksniai, kurie yra globalizacijos procesų pasekmė, pavyzdžiui, eksporto rinkų pokyčiai, teigiamos arba neigiamos tendencijos tarptautinėse finansinėse rinkose, į jas taip pat svarbu reaguoti formuojant regionų ekonominės plėtros strategijas.

b. Esminės regionų ekonominę plėtrą aiškinančios teorinės kryptys, atspindinčios diversifikuotas sudėtingas šių dienų regionų ekonomines problemas ir aiškinančios atsirandančius regioninius skirtumus – tai endogeninio augimo teorija, pabrėžianti žinių ir inovacijų svarbą, naujoji ekonomikos geografija, aiškinanti ekonominių išteklių judėjimo pokyčius ir miestų plėtros svarbą, ir institucinė ekonomika, pabrėžianti rinkos veikėjų charakteristikų svarbą regiono ekonomikai. Jomis turėtų būti grindžiamos šiuolaikinės regionų ekonominės plėtros priemonės, siekiant efektyvių rezultatų.

c. Sudarytas konceptualus regionų ekonominio augimo ir ilgalaikės plėtros veiksmų modelis remiasi įprastais neoklasikų ir naujais požiūriais į regionų ekonominę plėtrą, t. y. endogeninio augimo tyrimais, naujosios ekonomikos geografija, analizuojančia aglomeracijos procesus, ir tyrimais, pabrėžiančiais žinių plitimo, technologijų sklaidos svarbą regionų ekonominei plėtrai. Modelis integruoja grįžtamuosius ryšius, vertina regionų ekonominės plėtros procesus dinamišku požiūriu. Tyrime pateikta schema, kaip sudarytą modelį grįsti empirinio tyrimo metodais ir parodyti jo taikymo galimybes, siekiant geriau įvertinti regionų ekonominės plėtros charakteristikas, ieškoti efektyvių regionų ekonominės plėtros sprendimų.

d. Atlikus empirinius tyrimus regionų ekonominės plėtros veiksmų ir jų sąveikos koncepcinis modelis papildytas, į jį integruojant techninio efektyvumo aiškinimą. Remiantis patikslintu modeliu, norima parodyti, kad siekiant didesnės pridėtinės vertės regione yra svarbu ne tik didinti ekonominius išteklius, bet taip pat sudaryti maksimaliai geras galimybes tuos išteklius integruoti į verslo veiklą ir didesnės pridėtinės vertės kūrimą. Tai ir parodo regiono rinkos veikėjų efektyvumą. Efektyvumą gali įtakoti įvairūs

veiksniai, kurie daugiausiai siejasi su kokybiniais ir kultūriniais sunkiai kiekybiškai įvertinamais aspektais: lyderyste ir gyventojų gebėjimu realizuoti savo įgytas žinias ir jas komercializuoti rinkoje, įmonių gebėjimu pasinaudoti mokslo ir verslo bendradarbiavimo, įmonių tarpusavio bendradarbiavimo sinerginiais ryšiais, aglomeracijos ekonomikos apraškomis ir kitais aspektais.

2. Išanalizavus ES teritorijų ekonominių pokyčių tendencijas ir pagrindines regioninės politikos įgyvendinimo priemones ir mechanizmus, darytinos išvados:

a. Įgyvendinamos ES Sanglaudos politikos rezultatai, siekiant didesnės konvergencijos, matomi tik dalyje ES regionų. Ekonomiškai prasčiau išsivystę regionai vis dar susiduria su nepakankama ūkinės veiklos specializacija didelę pridėtinę vertę generuojančioje ekonominėje veikloje ir urbanistinių teritorijų, palankių žinių ir technologijų skvarbai, darnios plėtros trūkumu. Ekonominiuose rezultatuose atsispindintis nepakankamai efektyvus ES išteklių naudojimas rodo, kad ES turi ieškoti priemonių, kaip didinti ES regioninės politikos efektyvumą ir kaip geriau vertinti efektyvumą lemiančius procesus.

b. Siekiant ES ekonominės ir socialinės konvergencijos, ES Sanglaudos politika buvo peržiūrėta planuojant 2014–2020 m. programavimo periodą. Formuojant „Europa 2020“ strategiją stipriai atsižvelgta į naujausių mokslinių tyrimų išvalgas ir aktualias globalizacijos procesų aplinkybes: daug dėmesio skiriama inovacijų plėtrai, regionų unikalių stiprybių, kuriomis būtų galima kurti konkurencingus produktus, paieškai, akcentuojama realių ekonominių ir socialinių rezultatų stebėsenos svarba. Taip pat pabrėžiama specializacijos svarba ir poreikis skatinti specifines potencialaus augimo ekonominės veiklos sritis, ne tik gerinti bendrąją infrastruktūrą.

c. 2014–2020 m. programavimo periodu stipriai padidėjo skiriama finansinė parama regionų sanglaudai. Jai planuojama skirti apie trečdalį ES biudžeto, tad kyla poreikis stebėti ir griežčiau vertinti regionų pasiekimus, kurie būtų išreikšti realiais ekonominiais rodikliais, o ne tik išteklių naudojimo charakteristikomis. Taigi turėtų būti taikomi metodai išteklių naudojimo efektyvumui vertinti ir ekonominei vertei kurti.

3. Darbe pasiūlyta empirinių tyrimų metodologija, kuria siekiama įvertinti regionų ekonominės plėtros efektyvumą integracinių procesų Europos Sąjungoje sąlygomis. Siekiant gauti daugiau informacijos iš daugiamačių duomenų yra pasiūlyta taikyti save apsimokančių neuroninių tinklų ir Sammon'o projekcijos metodų



kombinaciją, kuri ankščiau nebuvo taikyta regionų ekonominės plėtros tyrimuose. Metodai suteikia galimybę tirti regionų ekonominės plėtros veiksnius ir nagrinėti jų sąveikos komponentus. Tai pat siūloma taikyti neparimetrinius tiesinio programavimo metodus (DEA, FDH, order- $\alpha$ ), kurie papildo daugiamačių duomenų analizės galimybes ir tiksliau įvertina techninio efektyvumo skirtumus tarp regionų, leidžia identifikuoti silpnąsias sritis ir pateikti pasiūlymus regioninei politikai. Taigi efektyvumo ir svarbių regionų plėtros procesų tyrimui yra siūloma taikyti fragmentiškus, vienas kitą papildančius tyrimo metodus, siekiant identifikuoti problemines sritis ir gauti naudingos informacijos politikos formavimui.

4. Atliktas Vidurio ir Rytų ES NUTS2 lygmens regionų efektyvumo įverčių nustatymas neparimetriniais programavimo metodais rodo regionų technologinių skirtumų diferenciaciją ir dalies regionų efektyvumo problemas.

a. Baltijos šalys yra vienos iš prasčiausiai įvertintų pagal efektyvumą. Iš Baltijos šalių išsiskiria Estija, nes joje santykinai didelis investicijų į MTTP srautas ir santykinai didelis žmogiškojo kapitalo, turinčio aukštą išsilavinimą, kiekis, tačiau šie išteklių sukuria nepakankamai didelės pridėtinės vertės kaip bendro ekonominio rezultato Vidurio ir Rytų ES regionų grupėje.

b. Analizė atskleidžia ir nevienodas regionų galimybes, nes, pavyzdžiui, Estija, padidinusi išteklių naudojimo efektyvumą pagal DEA skaičiavimus, galėtų pasiekti iki 40 % didesnę ekonominę rezultatą. Apskritai, jei Vidurio ir Rytų Europoje turimi išteklių būtų naudojami efektyviai, būtų galima pasiekti iki 20% didesnę ekonominę efektą.

5. Pagal Vidurio ir Rytų ES regionų efektyvumo įverčius pateikti siūlymai regionų ekonominės politikos kryptims formuoti:

a. Techniškai neefektyviuose regionuose svarbu intensyvuoti ekonominę ir verslo veiklą, kuri generuotų didesnę pridėtinę vertę, nes turimi išteklių ir žmogiškojo kapitalo charakteristikos rodo, kad galima būtų pasiekti apie 20 % geresnių ekonominių rezultatų.

b. Daugiau dėmesio turėtų būti skiriama įmonėms iš kitų regionų pritraukti ir vietinio verslo plėtrai skatinti, nes regionai, pasižymintys pakankamu išteklių kiekiu ir nepakankamai išnaudotomis jų charakteristikomis, galėtų būti patrauklūs verslo plėtrai.

c. Dalies regionų nuotolis nuo efektyvios gamybos galimybių ribos rodo, kad yra potencialas pasiekti geresnius ekonominius rezultatus, jei daugiau dėmesio būtų skiriama realių rezultatų siekimui - mokslinės produkcijos patentavimui ir

komercializavimui. Su turimais ištekliais, žmogiškuoju kapitalu ir investicijomis nėra pasiekiami maksimalūs ekonominiai rezultatai.

d. Neefektyviuose regionuose, turinčiuose aukštus išsilavinimo rodiklius, pavyzdžiui, Baltijos šalyse, turėtų būti skiriama daugiau dėmesio kūrybiškumo ir verslumo ugdymui švietimo sistemoje, nes aukštąjį išsilavinimą turintys gyventojai nepakankamai prisideda prie didelės pridėtinės vertės kūrimo regionuose, nepakankamai dalyvauja žinioms imliuose paslaugų ir aukštųjų technologijų pramonės sektoriuose.

e. Viena iš šio proceso priežasčių – nepakankamos galimybės regiono rinkoje realizuoti sukauptas ir įgytas žinias didelę pridėtinę vertę kuriančiuose sektoriuose. Svarbu ieškoti sprendimų, kaip regionuose kurti daugiau ir geresnių darbo vietų .

6. Skirstant finansinius išteklius regionų ekonominei plėtrai turėtų būti atsižvelgiama į regionų efektyvumą, kai naudojami jau turimi ištekliai. Taip būtų galima parinkti kiekvienam regionui tinkamas priemones ir išvengti netikslingo perteklinio finansinių išteklių skirstymo į sritis, nepakankamai skatinančias regionų ekonomikos augimą.

7. Lietuvos NUTS3 lygmens regionų kelių infrastruktūros išvystymo ir žmogiškojo kapitalo veiksnių vertinimas, siekiant nustatyti regionų efektyvumą parodė, kad:

a. Mažiausiai efektyvūs regionai, kurių efektyvumas nepasikeitė per paskutinius 2010-2014 m. – Kauno (LT002) ir Tauragės (LT007) apskritys. Pagal DEA Kauno apskritis galėtų pasiekti iš esmės geresnį BVP 1 gyventojui rodiklį (y) su turimais ekonominiais ištekliais ir kelių infrastruktūros išvystimu ir būti antroji Lietuvoje apskritis po Vilniaus pagal BVP 1 gyventojui rodiklį. Taip pat matomas technologinis panašumas su Vilniaus apskritimi rodo, kad Kaunas turi potencialo ir pakankamai išteklių kurti didesnę pridėtinę vertę. 2010-2014 m. nepagerėjęs efektyvumo įverčiai Kauno ir Tauragės apskrityse rodo, kad svarbu ieškoti naujų ekonominės plėtros priemonių šiuose regionuose, nes esamos nepadeda didinti ekonominio efektyvumo.

b. Didelis augimo potencialas yra matomas Alytaus apskrityje. Nors ji yra viena iš mažiausiai efektyvių apskričių, tačiau jos gerėjantys ekonominiai rezultatai rodo, kad ji turi galimybę pagal esamą susisiekimo infrastruktūrą ir geografinę padėtį pagerinti ekonominius rezultatus apie 30% ir pasiekti ketvirtą poziciją pagal BVP 1 gyventojui Lietuvoje. Gerėjantys rezultatai yra matomi ir Šiaulių apskrityje. Šiose apskrityse

siekiant didesnio BVP pirmiausiai reikėtų ieškoti priemonių, kurios sudarytų galimybes daugiau ekonominių išteklių nukreipti į didesnės pridėtinės vertės kūrimą, didinti įdarbinimą, skatinti verslumą ir esamo verslo plėtrą.

c. Santykinai didelis efektyvių NUTS3 regionų skaičius (4-5 regionai iš 10) Lietuvoje rodo, kad siekiant jų ekonominės plėtros labai svarbu didinti ekonominių išteklių kiekius. Vilniaus, Klaipėdos ir Panevėžio apskrityse ekonominis augimas gali būti pasiektas pirmiausiai didinant žmogiškojo kapitalo kieki, Utenos ir Marijampolės apskrityse – gerinant susisiekimo ir kelių infrastruktūrą.

8. Darbe pasiūlyti metodologiniai dalies tyrimų atlikimo aspektai, pritaikyti tiriamajai regionų grupei:

d. Darbe pasiūlytas metodologinis išaiškinimas, kurio pagrindu būtų galima grįsti neparametrinio tiesinio programavimo metodo pasirinkimą, renkant tarp DEA, FDH arba order- $\alpha$  efektyvios ribos metodų, labiausiai tinkantį tam tikros regionų grupės efektyvumo tyrimams. Jis pritaikytas, atliekant darbo tyrimus.

e. Atliekant tyrimus pastebėta, kad mažų šalių regionų arba technologiškai labai panašių regionų tyrimams tikslinga naudoti duomenų apgaubties analizės metodą (DEA), nes jis geriau padeda išgryninti technologiškai panašių regionų efektyvumo skirtumus. FDH ir order- $\alpha$  efektyvios ribos analizės metodai nepakankamai atskleidžia tokio tipo regionų efektyvumo skirtumus. Pagrindinis skirtumas, kad DEA lygina visą regionų grupę pagal ekstremalias efektyvumo reikšmes, o likę metodai skirtingų regionų efektyvumą lygina tik su mažesnius resursus turinčiais regionais, leidžiant dalies regionų ekonominių įverčių reikšmėms būti virš efektyvios gamybos galimybių ribos su tam tikrais pasiklovimo lygmenimis  $\alpha$ . Lyginant technologiškai panašius regionus tikslingiau ieškoti visos grupės lyderių, kurių pagrindu būtų galimybė daryti išvadas apie bendrą regionų grupės efektyvumą.

f. Darbe taikomi dvejetaini kelių infrastruktūros lygmenį vertinantys rodikliai Lietuvos NUTS3 lygmens atžvilgiu, kurių pagrindu buvo tiramas regiono vidinės kelių infrastruktūros išvystymas ir susisiekimas su kitais regionais. Atliekant kelių infrastruktūros tyrimus tikslinga vertinti ne tik kelių tankumą, bet ir susisiekimo su kitais regionais greitį pasvertą pasiekiamo regiono ekonomikos dydžiu, kuris parodo tiriamojo regiono svarbą.

## **Tolesnių tyrimų kryptys ir rekomendacijos**

Disertacijoje siūlomas regionų ekonominės plėtros veiksnių ir jų sąveikos teorinis modelis atkreipia dėmesį į tai, kad siekiant numatyti ir įgyvendinti efektyvias regionų ekonominės politikos kryptis yra svarbu įvertinti ne tik išteklių lygį regionuose, bet ir jų naudojimo efektyvumą kuriant ekonominę vertę. Didesnis ekonominių išteklių kiekis nebūtinai reiškia geresnius ekonominius rezultatus ar socialinę gerovę. Šio atotrūkio (techninio neefektyvumo) įvertinimas yra svarbus ekonominės politikos formuotojams siekiant ekonominės plėtros ar socialinės sanglaudos rezultatų, nes didesnis tam tikrų sričių finansavimas nebūtinai nulemia didesnę pridėtinę vertę ar socialinę gerovę. Į tai turėtų atsižvelgti ES ir Lietuvos regionų ekonominės politikos krypčių formuotojai.

Disertacijoje pritaikytų metodų kombinacija yra įvertintas techninio efektyvumo lygis ir identifikuoti ištekliai, kurie naudojami nepakankamai efektyviai regionuose kuriant pridėtinę vertę. Tolimesniuose tyrimuose tikslinga plačiau nagrinėti ekonominę aplinką bei mažiau apčiuopiamus kultūrinius aspektus, kurie suformuoja veiklos neefektyvumo apraiškas tam tikrose teritorijose. Tikslesnis šių procesų įvardinimas suteiktų daugiau informacijos, kaip didinti regionų ekonominės politikos priemonių veiksmingumą ir kaip geriau adaptuoti politikos priemones pagal teritorijų specifiką.

Disertantė siūlo ateities tyrimuose kolegoms mokslininkams ir regionų ekonominės politikos formuotojams taikyti, plėsti regionų ekonominės plėtros ir jų veiksnių sąveikos koncepcinį modelį, identifikuojant vis naujai atsirandančius iššūkius regionų ekonominei plėtrai. Taip pat sudarytą tyrimo metodologiją būtų galima taikyti kitų šalių vidinių regionų ar regionų grupių ekonominės plėtros efektyvumo tyrimams integracinių procesų Europos Sąjungoje sąlygomis.

**Mokslinio tyrimo rezultatų aprobavimas ir sklaida.** Pagrindiniai mokslinio tyrimo teiginiai ir rezultatai paskelbti devyniose mokslinėse publikacijose, skaityti septyni pranešimai disertacijos tematika tarptautinėse ir nacionalinėse konferencijose.

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