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ASSESSMENT OF THE INNOVATION POTENTIAL OF THE REGIONS OF LATVIA, LITHUANIA AND BELARUS *

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Abstract. The concept of innovation potential is complicated and complex, its evolution is closely related to the concept of innovation. There are several approaches to define the innovation potential. Some scientists and researchers define innovation potential as a set of several resources, other scientists - as a result of innovative activity. The author is a supporter of the resource approach and explores the potential of innovation from the perspective of resources. There are several approaches to determining the innovation potential from the resource perspective, however, they are mostly intended for the evaluation of the innovation potential at the national level or at the level of large regions. In addition, most of the assessment methodologies are tailored to the analysis of specific regions and it is difficult to adapt them to the evaluation of other regions. Therefore, the author develops his own methodology for assessing innovation potential, adapted for NUTS3 regions, and uses it to assess the innovation potential of Latvian, Lithuanian and Belarusian regions. The given approach makes it possible to promptly evaluate existing resources and define opportunities, thus providing the region with a stable market position, especially within the regional context, which is required by the ever-increasing and fierce competition.

Keywords: innovation; innovation potential; innovation capacity; resources of the innovation potential; concept of the innovation potential; quantitative and structural differences in innovation potential; cluster analysis; development vector

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JEL Classifications: O11, O31, R11

1. Introduction

The modern regional economics is a complex management mechanism where various structural components interact. In order for the regional economics to develop effectively, transformations in the form of innovations are required. Therefore, the introduction of innovations is considered an essential factor in the social and economic development of any region.

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Regional cooperation problems has been supported by the implementation of various EU cross-border cooperation programs, e.g. European Neighborhood and Partnership Instrument 2007-2013, 2008; European neighbourhood instrument Cross-border cooperation programme Latvia - Lithuania - Belarus 2014-2020, 2015.

In the conditions of Covid 19, regional studies become even more relevant, as regional cooperation is difficult. Due to several reasons: epidemiological security measures limit the movement of people between countries, the operation of several institutions has been suspended or liquidated, several regional cooperation connections have been lost, which are quite difficult to restore even if the measures to limit Covid 19 are lifted.

As part of the study of the innovation potential of the regions of Latvia, Lithuania and Belarus, the author elaborated his evaluation methodology and, based on the results, analyzed the level of development of the innovation potential of the regions of these countries, which is extremely important to improve the competitiveness, image and recognition of these regions in the world, attract investments and improve the quality of life of the inhabitants of these regions.

The following materials were used to implement the research tasks: statistical data, data from various organizations engaged in the study of regional economic problems, research materials, as well as the works of various scientists and researchers.

2. Theoretical and methodological framework of innovation potential

The concept of innovation is multifaceted. In order to measure innovation, it is necessary to examine the definitions of the given concept in the scientific literature. Scientists distinguish various classical approaches, within the framework of which innovation is analyzed. One of them embraces changes, resources, processes, result (Schumpeter, 1939; Schlesinger Jr., 1986; Twiss, 1989; Chekulina & Tamakhina, 2011; Freeman, 1995, 2017; Zhits, 2007; Danko, 1999; Porter & Stern 2002; Hudakova, Fila & Marosh, 2018; Zhizhlavsky, 2011; Zholnierski, 2005; Alekseyev, 2009; Pichlak, 2012; Chehabeddine, Grabowska & Adekola, 2022; Atwa, 2022; Davies, Gann & Douglas, 2009; Waldron & Wetherbe, 2020; Prud'homme van Reine, 2022; Sinclair-Desgagne, 2022; Acemoglu, Akcigit & Celik, 2022; Agarwal et al., 2022; Andriushchenko et al., 2022; Birkner, Meszaros & Szabo 2022; Bora, Brazda & Slíva 2021; Bychin, 2022; Cantarelli & Genovese, 2021; Carlström, 2022; Erdin & Caglar, 2022; Farrow, 2021; Franco et al., 2022; Gijon, Lozano & Molina, 2022; Giuliano et al., 2022; Heilala, 2022; Jaiswal et al., 2022; Krivosheya, 2022; Kulakov, Verstina & Meshcheryakova, 2022; Langham & Paulsen, 2020; Liu & Shao, 2022; Mikelsone et al., 2022; Nikina-Ruohonen, 2022; Paraska et al., 2022; Repeshko, 2022; Rodivilov, 2022; Saloff-Coste, 2022; Samson, Ellis & Black, 2022; Sawalkar et al., 2022; Sheffield, Kars Unluoglu & Jarvis 2022; Shvets & Dubiei, 2021; Sundaram, Murgod & Sowmya, 2022; White, 2022). Latvia has adopted the following definition of innovation (Ministry of Economy of the Republic of Latvia 2019): “Innovation is a process in which new scientific, technical, social, cultural or other ideas, developments and technologies are implemented in a market-demanded and competitive product or service”. Definition of the Law on scientific activity of the Republic of Latvia – innovation is the implementation of new scientific, technical, social, cultural or other ideas, developments and technologies in a product or service.

Economic theory and practice widely use the concept of innovation potential. Anyway, the definition of the management and development of the innovation potential of is still under discussion.

The idea of “innovation potential” is introduced by Freeman (1995), by which the scientist understands the systems’ growth, using measures for development of production, economic, social and organizational potentials, their acquisition and performance.

The practical aspect of the concept of innovation potential is reflected in Drucker's works, in which he studies the sources of modern industrial development (Drucker 2009). For example, he notes that innovation begins with the analysis of existing potential in order to use it effectively.

Researchers provide different definitions of innovation potential:

- Zhits (2007) understands with the innovation potential the economic resource amount, which may be used in the society for own development at the given moment. He mentions scientific-technical, educational potential and investment potential. The set of these factors, according to Zhits, constitutes the innovation potential of the macrosystem;
- Danko (1999) defines the innovation potential as accumulated specific amount of information about scientifically technical work, invention, the results of the introduction of design developments, new techniques and products;
- Porter and Stern (2002) understand the national innovation potential as the ability of the national economy to develop and commercialize the flow of new technologies in the long term. Thus, only technological innovations are considered within this approach. According to the authors, the national innovation potential consists of three main parts: the national innovation infrastructure, the economic environment (innovation clusters), the connection between clusters.
- Poznanska (1998) claims that innovation potential is the ability to effectively implement innovations, i.e. new products, new technologies, organizational methods and marketing innovations. Potential understood in this way depends on four main elements: financial potential, human potential, material potential, knowledge;
- Hudakova, Fila and Marosh (2018) considers the innovation potential of regions as the main source of their competitiveness for achieving their economic, social and environmental goals;
- Zhizhlavsky (2011) understands innovation potential as a description of the existing innovation environment, in which innovations are created, developed and implemented;
- Zholnierski (2005) recognizes the narrow understanding in the definition of innovation potential. He believes that it is determined by internal innovation potential and access to external sources of innovation. The internal innovation potential is formed of: personnel (their knowledge and experience, skills and qualifications, as well as the way available resources are managed, information management), research and development (isolated research and development objects, completed research and production, etc.), technologies (computers and ICT, machines and facilities and the degree of their technological development), while external sources of innovation are mainly higher education institutions and research and development departments, as well as competing companies, customers and suppliers;
- Alekseyev (2009) mentions the availability of all necessary resources and opportunities in the region for the implementation of innovative measures as the main factor that determines innovation potential;
- Pichlak (2012) Pichlak's approach states that a company's model depends on its determinants. Pichlak mentions research resources, communication system, culture of innovation and its characteristics (leadership style dominates in the organization), characteristics of the members of the management team, size of the organization and intensity of cooperation in innovative activities;
- Lunarski and Stadnicka (2007) emphasize that an organization's innovation potential consists of nine elements. These elements are marketing and personnel potential, research and development, technology and production, management style and system, adopted information system, external contacts of the organization and financial potential;

- Fathulina and Shabaltina (2011) think that the innovation potential is a set of human, social, legal, material, technical, informational and other resources intended for the region's innovation development;
- Sangadiyev and Ayusheva (2006) assume that the innovation potential is the ability of all structures of the region to implement innovations, taking into account resource opportunities, as well as changes and trends in the external environment;
- Chekulina and Tamakhina (2011) think that it is a set of scientific, personnel, technical, financial, economic, information and communication resources that ensure the activity of innovation and determine the level of development of the regional economy;
- Chehabeddine, Grabowska, and Adekola (2022); Maâlej (2022) point out that innovation play important role in the environmental dimensions of economic growth;
- Atwa (2022) believes that the creation of an artificial intelligence innovation hub is related to the unification of entertainment, educational and commercial resources, which improves the leadership positions of the country and reģions;
- Davies, Gann and Douglas (2009) argue that the innovation potential can only be realized with collaborative behavior between different structures;
- The GII (Global Innovation Index) 2021 model includes 81 indicators, which fall into three categories: quantitative data (63 indicators), index data (15 indicators) and qualitative data (3 indicators), including indicators relating to the political situation, education system, infrastructure and knowledge creation in each country;
- Waldron and Wetherbe (2020) emphasize that innovations do not sustain, transform and create value themselves– it requires intention, attention and action;
- Prud'homme van Reine, P. (2022) argues that successful innovation requires integral approach. Product innovation cannot be considered separately from process and service innovation. Product, process and service innovations must be embedded in innovation strategy;
- Shvindina, Taraniuk, Kotenko, Abayomi, Taraniuk and Qiu (2022) understand the innovation potential as a difference between the system's current state in terms of innovation performance and its potential outcomes based on existing innovative capabilities;
- Sinclair-Desgagne (2022) sees innovation as the key to economic growth, sustainable development, productivity improvement, strong competitiveness and social cohesion. Therefore, the government and companies must invest significant resources to promote innovation.

The object of the research is the innovation potential of the regions in Latvia, Lithuania and Belarus.
The subject of the study is the quantitative and structural differences of innovation potential.

The aim of the study is to develop a methodology for assessing the innovation potential of regions, with its help to evaluate the resources of the innovation potential of the regions of Latvia, Lithuania and Belarus and to analyze the quantitative and structural differences of the innovation potential.
Tasks of the research:

- analyze the theoretical and methodological foundations of the region's innovation potential;
- determine the innovation potential resources of the regions of Latvia, Lithuania and Belarus;
- define the determinant indicators of innovation potential resources;
- develop a methodology for the assessment of innovation potential in the regions;
- approbate the developed methodology and with its help to assess the innovation potential of the regions of Latvia, Lithuania and Belarus;
- assess the regional quantitative and structural differences of innovation potential and the development vector in the regions of Latvia, Lithuania, and Belarus;

- assess the resource structure of the innovation potential of the regions of Latvia, Lithuania and Belarus and divide them into clusters;
- determine the resource profile and location of the innovation potential of the regions of Latvia, Lithuania and Belarus;
- determine the degree of influence of innovation potential on the level of economic development of the regions of Latvia, Lithuania and Belarus.

Research methods for the implementation of tasks - methods of logical analysis and synthesis, monographic, analytical, logical-constructive, statistical quantitative data processing and analysis methods of researching economic theoretical and empirical sources at the international level – the largest dependent variable, the method of the sum of the coefficients of determination by the explanatory variable, the method of the linear scaling principle, frequency analysis, correlation analysis, cluster analysis, analysis of the sum method, the method of grouping into quintiles, the cartographic method, etc. methods of statistical analysis.

In determining innovation potential even within the EU at NUTS 3 level, there is a problem of lack of statistical data. The problem of the limitation of the study increases even more when the comparative analysis with non-EU countries is to be carried out, as some statistical data cannot be compared at all due to differences in their calculation and definitions of indicators. The following limitations should be taken into consideration when performing a comparative analysis:

- a person of working age (women aged 16-58, men aged 16-63) without work and income, who is registered in employment institutions, looking for work and is ready to work, is considered unemployed in Belarus, while in Latvia and Lithuania the category of unemployed is much wider - they are persons aged 15-74 who are unemployed, actively looking for work and ready to start working within two weeks;
- in Belarus, the retirement age for women starts at 55, for men at 60, in Latvia at 62 for both women and men, at 62 for women and 64 for men in Lithuania;
- in Belarus, the average number of employees in a micro-enterprise should be up to 15 people per calendar year, in Latvia and Lithuania - up to 9 employees; In Belarus, a small company has 16-100 employees, in Latvia, Lithuania - 10-49 employees; In Belarus, the average company has 101-250 employees, in Latvia, Lithuania - 50-249 employees;
- author does not analyze GII (Global Competitiveness Index) indicators, which is due to the fact that many of these indicators are not collected in official statistics in the regions of the given research, some of them are not available at all or are only available at the national level or are available in several regions. Thus, the author uses selected (Schumpeter, 1939; Freeman, 1995; Schlesinger Jr., 1986; Carlström, 2022; Erdin & Caglar, 2022.; Farrow, 2021; Franco et al., 2022.; Jaiswal et al., 2022; Liu & Shao 2022) and available indicators, which will be used for evaluation of innovation potential of the regions of Latvia, Lithuania and Belarus.

3. Evaluation methodology of the innovation potential

The authors adopt resource approach and studies the resources of the region's innovation potential according to the following components (see Figure 1):

- scientifically technical and educational, which include the number of scientific research centers and the number of people employed in them, the number of students in secondary schools of general education, the number of students enrolled in vocational schools and universities, etc. indicators in relative units of measurement;

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- labor force resources which include population density, population up to working age, at the working age, above working age, natural increase, migration rate, level of demographic burden, economic activity, etc. indicators in relative units;
- economic investment resources, which include GDP, value-added indicators by types of activity, distribution of companies by main types of activity, volumes of accumulated direct foreign investments, volumes of non-financial investments, inflation, average wages, number of companies, etc. indicators in relative units;
- infrastructure resources, which include the relative indicators of the region's territorial area, distribution of the territory by land type, road density, computer and Internet availability, purposes of Internet use, provision of passenger cars, etc. indicators in relative units;
- ecological health which includes indicators of emissions of harmful substances into the atmosphere (kg per capita), relative indicators of the chemical composition of harmful substances.

The author optimizes the number of influencing resources by combining several factors into one and eliminating less important factors whose indicators are not available in the required quantity.
The resource structure of innovation potential is different for different levels of the economy. When determining the resources of the region's innovation potential, the level of innovation development of the regional economy must be assessed, as well as the innovation development opportunities of existing organizations in the specific territory. Therefore, the assessment of the resources of the innovation potential of the region should be carried out comprehensively and in relation to various components (see Figure 1).

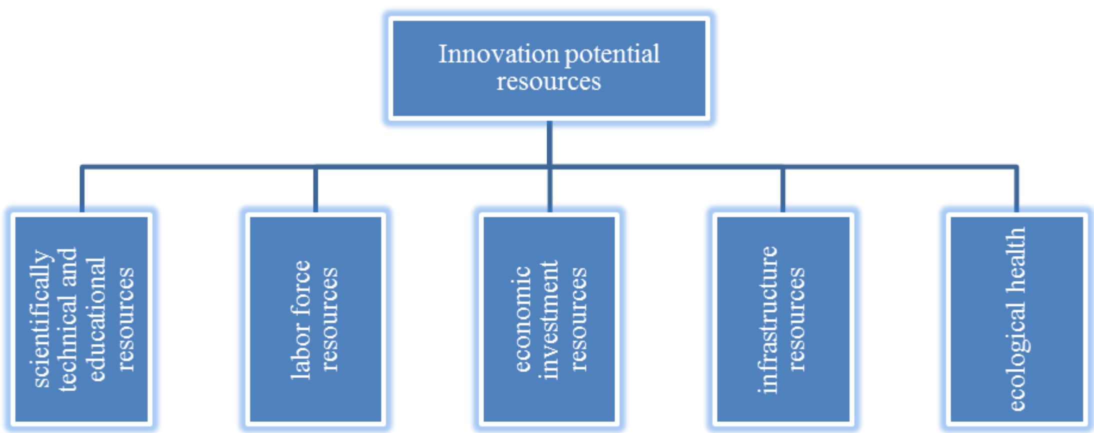

Figure 1. Structure of the innovation potential resources in the innovation system
Source: made by author using critical review of literature provided above

The previous approach classification also is not final. The set of these approaches can be created in a completely different way if other criteria are adopted and used, for example, directly using approaches to the definition of the concept of innovation potential.

The pool of innovation potential resources at the regional level is a strategic factor in the market, which is part of the overall business development strategy aimed at gaining or maintaining a leading position in the sector.
Without the development of innovation potential resources, it is almost impossible to create competitive products to ensure long-term development

Based on various research methodologies, as well as taking into account the positive experience accumulated by many scientists and trying to avoid the shortcomings of existing innovation potential evaluation methods, the author develops his own evaluation methodology.

The author determines that the concept of innovation potential is a complex and complicated category, it is determined by various statistical indicators that can be represented in the form of a two-dimensional matrix:

$$X = \begin{bmatrix} x_{11}, x_{12}, \dots, x_{1n} \\ \dots\dots\dots\dots\dots\dots \\ x_{i1}, x_{i2}, \dots, x_{in} \\ \dots\dots\dots\dots\dots\dots \\ x_{m1}, x_{m2}, \dots, x_{mn} \end{bmatrix},$$

where m – number of regions and n – number of indicators, which describes the innovation potential.

The construction of an integral indicator shall be applied to evaluate this type of data. (Soshnikova et al., 1999). The method of creating the integral indicator consists of several stages:

- unification of statistical indicators,
- dimension reduction for the selection of diagnostic indicators of the innovation potential from the wide range of available statistical indicators, which can replace all other indicators, without decreasing impartiality of the results, and conclude the indicators with doubling or similar value,
- creation of the integral indicator based on the selected indicators.

Unification of statistical data

The author performs the unification of statistical data according to the principle of linear scaling - transformation, the result of which is the range of possible values in a certain interval [0;10] (Ayvazyan 2005):

- indicators-stimulants: $$x'_{ij} = \frac{x_{ij} - x_{\min j}}{x_{\max j} - x_{\min j}} * 10, \quad (1)$$
- indicators-destimulants: $$x'_{ij} = \frac{x_{\max j} - x_{ij}}{x_{\max j} - x_{\min j}} * 10, \quad (2)$$

where x'_{ij} – "j" indicator's unified value for the "I" region,

$x_{\min}$ – the smallest (worst) value of the output indicator in the studied period,

$x_{\max}$ – the highest (best) value of the output indicator in the studied period.

The given method includes the negative or positive impact of a set of indicators on the integral indicator of the innovation potential of regions, and the scale of values is limited to the range from 0 to 10, which allows for a quick and convenient comparison of regions (Lavrinenko 2008). As a result, the influencing indicators of innovation potential resources are obtained in numerical terms from 0 to 10 for each region, which determine the level of attractiveness and significance of these factors.

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Dimension decrease

The author uses the method of the sum of the coefficients of determination of the **largest dependent variable after the explanatory variable to reduce dimensions and optimize statistical indicators** (Ayvazyan 2005). The given analysis method is used to select the number of indicators from a relatively small number of initial indicators, as well as to select the most informative criteria from the indicators of the initial list of each factor, excluding unimportant indicators, as well as indicators that duplicate the phenomena. First of all, the correlation coefficient for statistical indicators is calculated according to the following formula:

$$r_{xy} = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{(n-1)s_x s_y}, \tag{3}$$

where x_i, y_i - value of indicators x, y,

$\bar{x}, \bar{y}$ - mean arithmetical value of indicators x, y,

s_x, s_y - standard deviation of indicators x, y,

n – number of observations.

At this stage, the coefficient of determination is calculated for each statistical indicator, for which the value of the correlation coefficient is within the interval from 0.01 to 0.05 according to the formula:

$$R^2 = r^2. \tag{4}$$

The determination of the coefficient of values shows what part (proportion) of the variation of the dependent variable is determined by the variation of the explanatory variable. The resulting analysis identifies pairs or larger groups of closely related variables to select one indicator from each set of indicators. The strength of the connection can be judged by the size of the coefficient of determination, if it is close to one ($0,9< R^2< 1$).

For a correct assessment of the innovation potential of regions, from several available indicators of various factors, it is necessary to select those that have the greatest influence on the given category according to the sum of the coefficients of determination of the largest dependent variable according to the explanatory variable. Therefore, for each statistical indicator, the sum of the obtained coefficients of determination is calculated according to the formula:

$$y_i = \sum_{i=1}^{n} R^2{}_{ij}\ , \tag{5}$$

where y_i - the sum of the coefficients of determination of the dependent variable by the explanatory variable,
R^2_{ij}- value of determination coefficient „*j*" for the region „*i*",
n – number of observations.

Those groups of indicators that have the largest sum of the coefficient of determination of the dependent variable after the explanatory variables are considered to be the most influential. The selection of the qualitative composition of the set of statistical indicators takes place in each specific case, harmonizing the theoretical (substantive) knowledge and the requirements for the minimum permissible values of the coefficients of determination R^2_{min} (Ayvazyan 2005).

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The dimension reduction process to exclude similar and duplicate indicators without reducing the objectivity of the results consists of several steps:

- calculation of correlation coefficients (r(Pearson)) for statistical indicators by the formula: (6)

$$r(\text{Pearson}) = \frac{\sum_{i=1}^{n}(x_i - \bar{x}) \cdot (y_i - \bar{y})}{(n-1) \cdot S_x \cdot S_y} = \frac{\text{cov}(x, y)}{\sqrt{S_x^2 S_y^2}},$$

- calculation of coefficients of determination for statistical indicators whose value of correlation coefficients is in the range [0.01;0.05] according to the formula:
  $R^2 = r^2$, (7)
- calculation of the sum of the obtained coefficients of determination for each statistical indicator:

$$y_i = \sum_{j=1}^{m} R^2{}_{ij} , \quad (8)$$

- selection of statistical indicators based on the obtained sums of determination coefficients, using the logical and largest sum principle.

Creating an integral indicator by the selected indicators

Complex evaluation with the **sum method** (Tsindin & Akzhigitova 2006) provides for summing up of the actual values of the innovation potential resources indicators:

$$y_i = \sum_{j=1}^{n} x_{ij} , \quad (9)$$

where $i = \overline{1, n}$,

y_i – complex evaluation for the region *i*;

x_{ij} – *j* indicator's value for the region *i*.

The best rating is the rating based on the maximum sum of indicators-stimulators and the minimum sum of indicators-destimulators.

The author applies the given method in the research, because there is a one-way effect of the studied indicators on the innovation potential and its structural components, as well as the most optimal differentiation of the quantitative and structural differences of the regions.

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The creation of an integral indicator consists of the following stages:

- summing-up of indicators of determining factors of innovation potential:

$$y_{ij} = \sum_{j=1}^{m} x_{ij} \ , \qquad (10)$$

- unification of the obtained values of the factors of the innovation potential, determining the value in the row interval [0;10] according to the formula 1,
- summing up of the obtained unified values of the factors of the innovation potential to create the integral indicator of the innovation potential of the region:

$$y_{i} = \sum_{j=1}^{m} x_{ij} \ , \qquad (11)$$

- unification of the obtained values of the factors of the innovation potential, determining the value in the row interval [0;10] according to the formula 1.

In order to achieve the aim of the research, the author groups the regions of Latvia, Lithuania and Belarus into quintiles according to the obtained results and displays them on maps for the most convenient perception and visualization. After the typology of regional innovation potential, 5 groups of regions were obtained, where 5 – the best rating, 1 – the worst rating.

The author uses the complex assessment with the sum method to evaluate the innovation potential of the regions, because this method most optimally differentiates the quantitative and structural differences of the regions in comparison with other methodologies, which differentiate the regional differences too much or the differentiation is too weak, because these regions are economically rather poorly developed. The objective factor analysis has not been structurally established, it has not been possible to express the weights of factors or indicators, therefore, in order to avoid subjectivity in determining the weight coefficients, the author assumes the weight coefficients to be equal to one. In this case, there is a one-way influence of the studied innovation potential indicators, which determines the choice of the given method.

4. Empirical data and analysis

Latvia and Lithuania are members of the EU, Belarus is a member of the CIS, thus the studied regions are cross-border territories of the EU and the CIS.
In the studied countries, according to the administrative-territorial division, the following administrative-territorial and statistical units are distinguished:

- Latvia - 6 statistical regions (Order of the Cabinet of Ministers No. 911 of 07.12.2021 “About the statistical regions of the Republic of Latvia and the administrative units included in them” 2021): Riga region, Pieriga region, Vidzeme region, Kurzeme region, Zemgale region, Latgale region;
- Lithuania - 10 counties (Law of Republic of Lithuania No I-558 “Law on the Territorial Administrative Units and their Boundaries” 1994): Vilnius county, Alytus county, Kaunas county, Klaipeda county, Marijampole county, Panevežys county, Siauliai county, Taurage county, Telšiai county, Utena county;
- Belarus (Law of Republic of Belarus 154-3 “On the administrative and territorial division and the procedure for solving the issues of the administrative and territorial organization of the Republic of Belarus” 1998): 6 oblasts. i.e. Brest oblast, Vitebsk oblast, Gomel oblast, Grodno oblast, Minsk oblast, Mogilev oblast, and Minsk (capital).

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According to the nomenclature of the EU Territorial Statistics Units, the studied regions of Latvia and Lithuania are considered NUTS3 level regions (Regulation (EC) No 1059/2003 of the European Parliament and of the Council 2003).

The author performs dimension reduction for optimization of statistical indicators using the method of the sum of the coefficients of determination of the largest dependent variable by the explanatory variable and evaluates the innovation potential according to the following indicators:

- scientifically technical and educational resources:
  - the number of scientific research centers per 100,000 inhabitants,
  - the number of people employed in scientific research centers per 100,000 inhabitants,
  - the number of students enrolled in vocational colleges per 10,000 inhabitants,
  - the number of students enrolled in higher education institutions per 10,000 inhabitants,
  - number of general education schools per 10,000 inhabitants,
  - number of library visitors per 100,000 inhabitants,
  - distribution of companies by main types of activity in Latvia, Lithuania, Belarus and their regions, % - scientific and technical services;
- labor force resources:
  - population density (people/sq.km),
  - number of population up to working age, %,
  - number of population at the working age, %,
  - the level of the demographic burden - in total,
  - employment level, %,
  - unemployment level, %,
  - economic activity, %;
- economic investment resources:
  - GDP per 1 inhabitant, euro,
  - distribution of companies by main types of activity in Latvia, Lithuania, Belarus and their regions, % - production,
  - distribution of companies by main types of activity in Latvia, Lithuania, Belarus and their regions, % - power industry,
  - distribution of companies by main types of activity in Latvia, Lithuania, Belarus and their regions, % - information and communication,
  - distribution of companies by main types of activity in Latvia, Lithuania, Belarus and their regions, % - education, healthcare, social work,
  - the amount of accumulated foreign direct investment in the region relative to the total amount in the country, %,
  - amount of non-financial investments, in act. prices, in the region relative to the total volume of the country, %,
  - inflation,
  - average salary (gross), euro,
  - total number of enterprises (micro (small), small, medium, large) per 1000 inhabitants,
  - purposes of inhabitants' internet use – for internet banking, %,
  - purposes of inhabitants' internet use – for goods sale, %;
- infrastructure resources:
  - the proportion of cities in the total number of cities, counties or districts of the country, %,
  - the proportion of the area of the region in the total area of the three countries, %,
  - agricultural land, %,
  - land of other type, %,
  - road density per 1000 km^2 of the territory,
  - internet availability in various households, %,
  - provision of passenger cars per 1000 inhabitants,
  - purposes of inhabitants' internet use – for information search, %,
  - purposes of inhabitants' internet use – receiving/sending e-mails, %,
  - purposes of inhabitants' internet use – for communication with the state, %;

- ecological health:
    - emissions of harmful substances into the atmosphere (kg per inhabitant),
    - emissions of harmful substances into the atmosphere, kg per inhabitant - solid particles,
    - emissions of harmful substances into the atmosphere, kg per inhabitant – carbon monoxide,
    - emissions of harmful substances into the atmosphere, kg per inhabitant - other substances.

Analysis of innovation potential in the context of the regions of Latvia, Lithuania and Belarus

The author evaluates each resource included in the innovation potential with the help of an integral indicator, summing the indicators of each resource and determining the value in the row interval [0;10]. The author evaluates the innovation potential of regions with the help of an integral indicator, summing up the resources included in the innovation potential and determining the range of the indicator's value in the interval [0;10].

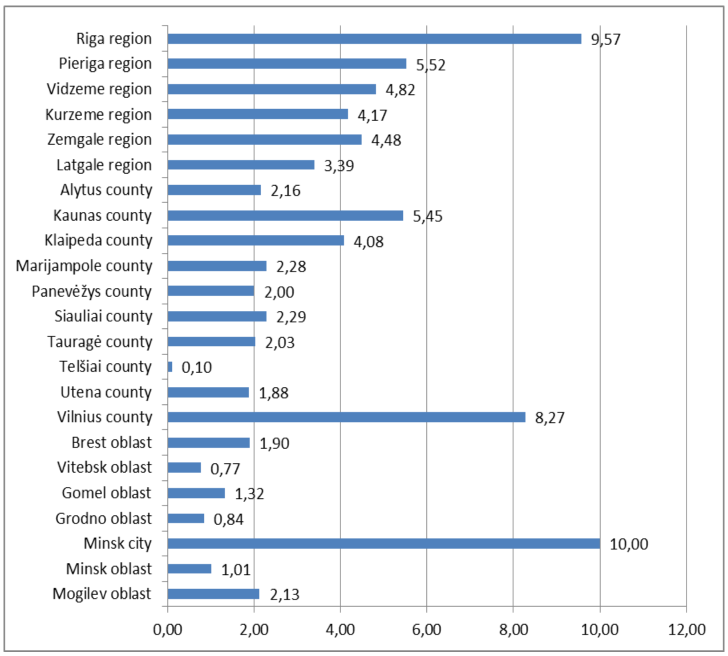

Figure 2. Assessment of innovation potential of regions of Latvia, Lithuania, Belarus
Source: created by the author based on the data of the regions of Latvia, Lithuania, Belarus, using the developed methodology for evaluating the innovation potential

According to the obtained results, the author classifies the regions of Latvia, Lithuania and Belarus, dividing the value series into quintiles. The first quintile group includes regions with a very low level of innovation potential, while the fifth quintile group includes regions with a very high level of innovation potential.

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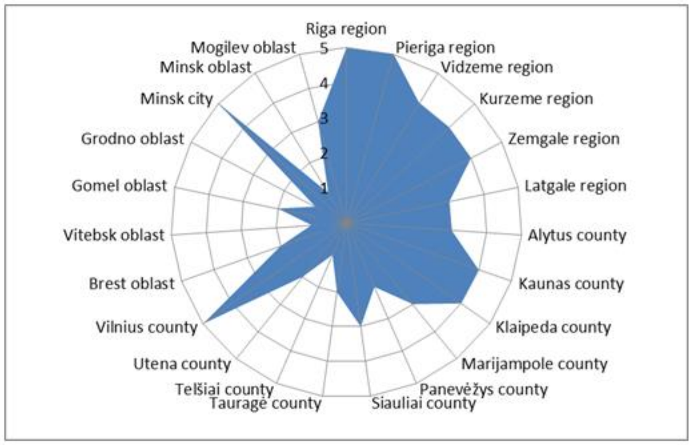

Figure 3. Map of quintile groups of innovation potential of regions of Latvia, Lithuania, Belarus
Source: created by the author based on the data of the regions of Latvia, Lithuania, Belarus, using the developed methodology for evaluating the innovation potential

According to the map of the quintiles of the innovation potential of the regions of Latvia, Lithuania, Belarus, it can be seen that the regions of Latvia have a fairly high level of the innovation potential, Lithuanian counties have a lower level of innovation potential, while Belarusian oblasts have a very low level of innovation potential. A very high level of innovation potential has been found in the capital cities, but in other regions – a much lower level of innovation potential, which, according to the author, is related to the direction of the flow of resources towards the capital cities.

The biggest quantitative and structural differences in innovation potential between capital cities and other oblasts can be observed in Belarus. The highest rating according to the level of innovation potential is obtained by Minsk, while the other oblasts have lower values. The China-Belarus Innovation Commercialization Center (see Annex A) operates in Minsk, which largely determines the development of the innovation potential of Minsk. The center implements scientific, technical and innovative projects, seeks investors with the aim of establishing joint ventures "on the basis of the industrial park "Great Stone". The park "Great Stone " is designed to service high-tech production and innovations in this field. The task of the park is to provide the infrastructures already existing and still developing with various types of projects.

The Innovation and Technology Transfer Center of Riga Technical University (RTU) operates in Riga (RTU Innovation and Technology Transfer Center homepage 2019), which contributes greatly to the high assessment of the innovation potential of Riga (see Annex A). The center promotes the development of innovation and technology transfer, ensuring the commercialization of scientific research results, creates sustainable relationships and professional communication with external partners, represents the interests of RTU, promotes recognition locally and internationally.

A laser research and production company operates in Vilnius - „*Šviesos konversija*" (Vilnius city website 2019), which conducts scientific research, implements various projects related to the implementation of innovations and produces new products that are in demand on the world market. Many other innovation potential development centers also operate in Vilnius, which determine the degree of innovation potential development of the Vilnius county (see Annex A).

The author presents the obtained research results using the cartographic method (see Figure 4).

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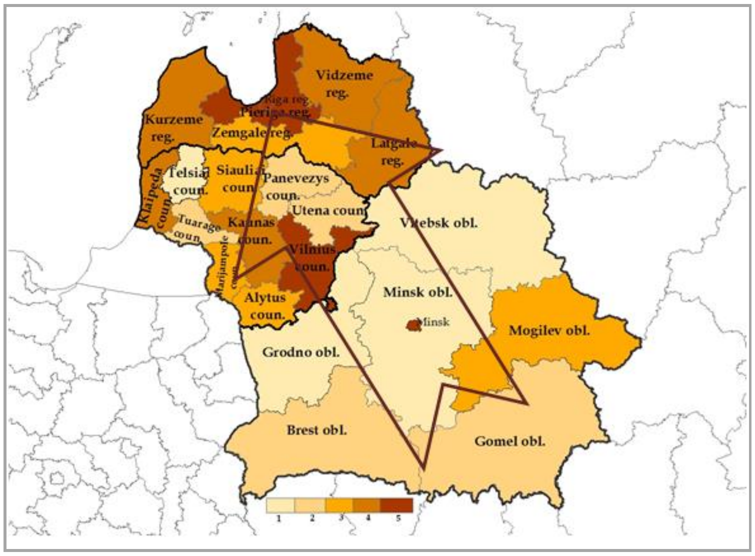

Figure 4. Classification map of the regions of Latvia, Lithuania, Belarus according to the values of the integral indicator of innovation potential in quintiles

Source: the author's drawing in the ArcGis 10 program after calculating the statistical indicators of the regions of Latvia, Lithuania, Belarus, using the developed methodology for evaluating the of innovation potential

The highest innovation potential level indicator is for the regions of Riga (9.57 standardized values), Pieriga (5.52), Vilnius (8.27) and Minsk (10,00). These regions are associated with national capitals, which also determine a high level of the innovation potential. The resources included in the innovation potential of the Riga and Vilnius region get a very high rating, with the exception of labor resources, which are rated as high in the Riga region, and as average in the Vilnius region. In Minsk, scientific, technical and educational resources, as well as economic investment resources, receive a high rating, the others - a very high rating. The investment resources of Pieriga's economy are rated as very high, the others as high.

The regions of Vidzeme (4.82), Kurzeme (4.17), Zemgale (4.48), Kaunas (5.45) and Klaipėda (4.08) have a high index of innovation potential. They belong to the 4^{th} quintile. Scientific, technical and educational resources are very high in Vidzeme and Kaunas regions, in Kurzeme, Zemgale regions they are rated as high, in Klaipėda region - as average. Economic investment resources in the Vidzeme region are rated as very high, in the other regions - as high, in the Kaunas and Klaipėda regions, the infrastructure resources are also rated as high, in the Klaipėda region - the ecological health also gets a high rating. In the regions of the fourth quintile, low ratings are obtained: in the regions of Vidzeme and Kurzeme - infrastructure resources are very low, as well as labor resources are low, but ecological health is also rated low in the Vidzeme region, ecological health is rated low in the Zemgale region. There are no resources in the Kaunas and Klaipeda regions that are rated as low and very low, but an average rating is obtained in the Kaunas region for labor resources and ecological health, in the Klaipeda region for scientific, technical and educational, as well as labor resources.

The regions of Latgale (3.39), Alytus (2.16), Marijampole (2.28), Šiauliai (2.29) and Mogilev (2.13) are ranked in the third quintile with a medium level of innovation potential. In the Latgale region, scientific, technical and educational resources, as well as ecological health, receive a high rating, while labor and infrastructure resources receive a very low rating. In the Alytus region, ecological health has a high rating, but very low, as in the Latgale region, for labor and infrastructure resources. In the Marijampole region, infrastructure resources get a very high rating and ecological health gets a high rating, but labor resources get a very low rating. In the Šiauliai region, almost all resources get an average rating, except for labor resources, which get a low rating. In the Mogilev oblast, labor and infrastructure resources are highly valued, but economic investment and ecological health is poorly valued.

The regions of Panevėžys (2.00), Tauragė (2.03), Utena (1.88), Brest (1.90) and Gomel (1.32) are ranked in the second quintile. In the Panevežys region, scientific, technical and educational, labor and economic investment resources are rated low, while infrastructure and ecological health is rated as average. In the Tauragė county, scientific, technical and educational resources are rated very low, labor and economic investment resources are rated low, but ecological health receives a very high rating. The Utena county has a very low assessment of labor resources, a low assessment of infrastructure resources as well. Economic investment resources are rated very low in the Brest oblast, and scientific, technical and educational, infrastructure and ecological health is also rated low. On the other hand, labor resources are rated as very high. In the Gomel oblast, ecological health is rated very low, scientific-technical and educational, economic investment resources are also rated low, labor and infrastructure resources are highly rated.

In the first quintile are the regions of Telšiai county (0.01), Vitebsk oblast (0.77), Grodno oblast (0.84), Minsk oblast (1.01), which get a very low assessment of innovation potential. Scientific, technical, educational, and ecological health has a very low rating in the Telšiai county, the others have an average rating. In the Vitebsk oblast, there is a very low assessment of economic investment resources and ecological health, a low assessment of scientific and technical and educational, infrastructure resources, but labor resources are assessed as high. In the Grodno oblast, scientific, technical and educational, economic investment, ecological health gets a very low rating, infrastructure resources get a low rating, but labor resources are rated as very high. In the Minsk oblast, scientific, technical and educational, economic investment resources get a very low rating, infrastructure resources and ecological health get a low rating, but labor resources are rated as very high.

The author created an innovation potential development vector - the values of the innovation potential level increase in the direction from southeast to northwest.
The author assesses the correlation of the innovation potential of the region with the development of the national economy.

The author finds that there is a moderate linear positive relationship between the level of innovation potential and GDP (r(Pearson)=0,6, p-value=0,002).
There is a moderate linear positive relationship between scientific, technical and educational resources and GDP (r(Pearson)=0,535, p-value=0,009).

There is a weak linear negative relationship between labor resources and GDP (r(Pearson)=-0,422, p-value=0,045). In Belarus, specific unemployment registration is carried out, which also, according to the author, determines the negative dependence between these indicators.

There is a strong linear positive relationship between the investment resources of the economy and GDP (r(Pearson)=0,804, p-value=0,000).
No linear relationship was found between infrastructure resources and GDP (r(Pearson)=0,290, p-value=0,180).

There is a moderate linear positive relationship between ecological health and GDP (r(Pearson)=0,624, p-value=0,001).

To provide opportunities for comparison and analysis, the author estimates the innovation potential by dividing them into quintiles of the value series (see Table 1).

Table 1. Quintile groups of the innovation potential of the regions of Latvia, Lithuania and Belarus, 2017

Region	Scientifically technical and educational resources	Labor resources	Economic investment resources	Infrastructural resources	Ecological health
Riga region	5	4	5	5	5
Pieriga region	4	4	5	4	4
Vidzeme region	5	2	5	1	2
Kurzeme region	4	2	4	1	3
Zemgale region	4	3	4	3	2
Latgale region	4	1	3	1	4
Alytus county	3	1	3	1	4
Kaunas county	5	3	4	4	3
Klaipeda county	3	3	4	4	4
Marijampole county	2	1	2	5	4
Panevežys county	2	2	2	3	3
Siauliai county	3	2	3	3	3
Taurage county	1	2	2	3	5
Telšiai county	1	3	3	3	1
Utena county	3	1	3	2	3
Vilnius county	5	3	5	5	5
Brest oblast	2	5	1	2	2
Vitebsk oblast	2	4	1	2	1
Gomel oblast	2	4	2	4	1
Grodno oblast	1	5	1	2	1
Minsk city	4	5	4	5	5
Minsk oblast	1	5	1	2	2
Mogilev oblast	3	4	2	4	2

Source: author's calculations based on the statistical indicators of the regions of Latvia, Lithuania, Belarus, using the developed innovation potential assessment methodology

In order to study in more detail the influence of each resource type in the regions of Latvia, Lithuania and Belarus on the overall level of the innovation potential, the author conducts an analysis of the innovation potential of the regions using quintile and cartographic methods.

Analyzing scientific, technical and educational resources as an element of the innovation potential according to the values of the integral indicator of scientific, technical and educational resources, the author concludes that the level of scientific, technical and educational resources is very high in the regions of Riga (8.40), Vidzeme (9.40), Kaunas (10.00) and Vilnius (8.97) (5th quintile). Such results were achieved in the Riga region thanks to the following indicators: "The number of scientific research centers per 100,000 inhabitants", "The number of students enrolled in higher education institutions per 10,000 inhabitants" and "Distribution of companies by main types of activity in Latvia, Lithuania, Belarus and their regions, % - scientific and technical services", Vidzeme region: "Number of library visitors per 100,000 inhabitants" and "Distribution of companies by main types of activity in Latvia, Lithuania, Belarus and their regions, % - scientific and technical services", Kaunas and Vilnius counties: "The number of people employed in scientific research centers per 100,000 inhabitants", "The number of students enrolled in higher education institutions per 10,000 inhabitants", In the Kaunas county, this indicator also has a great impact "The number of students enrolled in vocational colleges per 10,000 inhabitants".

The regions of Pieriga (5.35), Kurzeme (6.65), Zemgale (7.51), Latgale (8.31) and Minsk oblast (6.00) have a high level of the mentioned resources (4th quintile). The counties of Alytus (3.44), Klaipėda (4.12), Šiauliai (2.95), Utena (2.54), Mogilev oblast (2.76) receive an average rating for scientific, technical and educational resources (3rd quintile). A low assessment of scientific, technical and educational resources (2nd quintile) is in the counties of Marijampole (1.73), Panevežys (1.92), Brest oblast (1.36), Vitebsk oblast (2.09), Gomel oblast (2.26), very low (1st quintile) – for Tauragė (0.01), Telsiai (0.59), Grodno (1.23), Minsk oblast (0.38). According to the values of the integral indicator of labor resources, the labor resources (5th quintile) in the Brest oblast (8.09), Grodno oblast (8.40), Minsk oblast (8.69) and Minsk city (10.00) are very highly rated. Labor force resources in Riga region (4,75), Pieriga region (5,13), Vitebsk oblast (7,64), Gomel oblast (7,62) and Mogilev oblast (7,75) receive a high rating (4th quintile).

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Labor resources (3rd quintile) get an average rating in the regions of Zemgale (2.82), Kaunas (3.07), Klaipėda (3.75), Telsiai (3.07), Vilnius (4.68). Labor resources (2nd quintile) get a low rating in the regions of Vidzeme (2.50), Kurzeme (2.68), Panevėžys (1.83), Šiauliai (1.94), Tauragė (2.33), very low (1st quintile) – in the regions of Latgale (0.22), Alytus (0.74), Marijampole (1.56), Utena (0.01).
According to the values of the integral indicator of economic investment resources, a very high rating is obtained (5th quintile) in the regions of Riga (10.00), Pieriga (6.29), Vidzeme (6.59), Vilnius (8.93), high (4th quintile) – in Kurzeme (5.56), Zemgale (4.75), Kaunas (4.23), Klaipeda (4.02) regions and the city of Minsk (5,76). Average rating (3rd quintile) of economic investment resources is obtained in the regions of Latgale (3.95), Alytus (3.29), Siauliai (3.07), Telšiai (3.43), Utena (3.66). Low evaluation of economic investment resources (2nd quintile) is in the regions of Marijampole (2.49), Panevežys (2.99), Tauragė (2.22), Gomel (0.73), Mogilev (0.46), very low (1st quintile) – in the regions of Brest (0.01), Vitebsk (0.05), Grodno (0.19) and Minsk region (0.35). According to the values of the integral indicator of infrastructure resources, infrastructure resources (1st quintile) are very highly underestimated in the regions of Riga (7.19), Marijampole (3.38), Vilnius (4.08) and Minsk (10,00). A high assessment of infrastructure resources (2nd quintile) is in the regions of Pieriga (2.89), Kaunas (3.27), Klaipėda (2.99), Gomel (2.97) and Mogilev (3.05).The regions of Zemgale (2.76), Panevežys (2.60), Siauliai (2.38), Tauragė (2.40), Telšiai (2.37) get an average rating of infrastructure resources (3rd quintile). Low assessment of given resources (2nd quintile) is in the regions of Utena (2.16), Brest (1.86), Vitebsk (2.04), Grodno (2.25) and Minsk oblast (2.13), very low (1st quintile) – in the regions of Vidzeme (1.45), Kurzeme (1.59), Latgale (0.01), Alytus (1.35). According to the values of the integral indicator of ecological health, the regions of Riga (10.00), Tauragė (9.07), Vilnius (9.47) and Minsk (9.96) have a very high assessment (quintile 5), high (quintile 4) – for the regions of Pieriga (7.61), Latgale (7.91), Alytus (7.60), Klaipeda (7.75), Marijampole (7.67), average (3rd quintile) – Kurzeme (6.43), Kaunas (6.47), Panevezys (6.58), Šiauliai (6.50), Utena (7.17) counties, low (2nd quintile) – Vidzeme (5.08), Zemgale (6.08) , Brest (4.28), Mogilev (2.32), Minsk oblast (1.16), very low (1st quintile) – Telšiai (0.01), Vitebsk (0.11), Gomel (0, 14), Grodno oblast (0.11).

Cluster analysis of innovation potential indicators of regions of Latvia, Lithuania and Belarus

The author divides the regions of Latvia, Lithuania and Belarus into clusters according to the resource structure of the regions' innovation potential (see Figure 5).

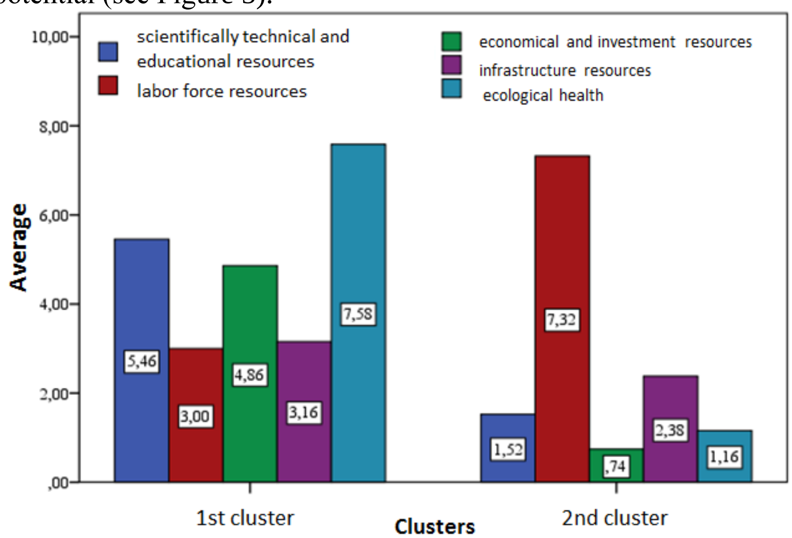

Figure 5. The structure of innovation potential clusters in the regions of Latvia, Lithuania and Belarus according to the integral normalized values of the objective indicators

Source: created by the author in the SPSS program based on statistical data calculations of the regions of Latvia, Lithuania and Belarus

The resource structure of the innovation potential of the regions of Latvia, Lithuania and Belarus according to the integral normalized values of the objective indicators (see Figure 5) shows that these regions can be divided into two clusters. In the first cluster, ecological health has the highest value with an absolute value of 7.58, while infrastructure resources (3.16) and labor resources have the lowest values (3,00). In the second cluster, labor resources are in first place with an absolute value of 7.32, which greatly exceeds the values of the other resources: the absolute values of infrastructure resources are three times lower, scientific, technical and educational resources – 5 times, ecological health – 6 times, and the absolute value of economic investment resources is almost 10 times lower.

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The distribution of regions in clusters is as follows:

- 1st cluster: Riga region, Pieriga region,Vidzeme region, Kurzeme region, Zemgale region, Latgale region, Vilnius county, Alytus county, Kaunas county, Klaipeda county, Marijampole county, Panevežus county, Siauliai county, Taurage county, Utena county, Minsk city.
- 2nd cluster: Telšiai county, Brest oblast, Vitebsk oblast, Gomel oblast, Grodno oblast, Minsk oblast, Mogilev oblast.

The first cluster includes all regions and counties of Latvia and Lithuania, except for the Telši county, which is included in the second cluster, and Minsk city - the capital of Belarus, and the second cluster - all oblasts of Belarus, except for the capital of the country.

According to the author, it would be useful to develop cooperation between the regions of the two clusters by attracting labor resources from the second cluster to the regions of the first cluster, because there is a large surplus of them in the second cluster and they are not used fully, but the regions of the second cluster have a rather low level of infrastructural resources and absolutely certainly – the level of other resources is extremely insufficient. By combining resources, the development of the studied regions would reach a new level of development.
The resource analysis of the innovation potential of the first cluster regions is reflected in Table 2.

Table 2. Analysis of the innovation potential resources of the first cluster regions

Region	Scientifically technical and educational resources	Labor force resources	Economic investment resources	Infrastructural resources	Ecological health
Riga region	8,40	4,75	10,00	7,19	10,00
Pierigas region	5,35	5,13	6,29	2,89	7,61
Vidzeme region	9,40	2,50	6,59	1,45	5,08
Kurzeme region	6,65	2,68	5,56	1,59	6,43
Zemgale region	7,51	2,82	4,75	2,76	6,08
Latgale region	8,31	0,22	3,95	0,01	7,91
Alytus county	3,44	0,74	3,29	1,35	7,60
Kaunas county	10,00	3,07	4,23	3,27	6,47
Klaipeda county	4,12	3,75	4,02	2,99	7,75
Marijampole county	1,73	1,56	2,49	3,38	7,67
Panevežys county	1,92	1,83	2,99	2,60	6,58
Siauliai county	2,95	1,94	3,07	2,38	6,50
Taurage county	0,01	2,33	2,22	2,40	9,07
Utena county	2,54	0,01	3,66	2,16	7,17
Vilnius county	8,97	4,68	8,93	4,08	9,47
Minsk city	6,00	10,00	5,76	10,00	9,96
Average	5,46	3,00	4,86	3,16	7,58
Median	5,68	2,59	4,13	2,68	7,60
Standard deviation	3,14	2,41	2,23	2,39	1,43

Source: author's calculations based on the statistical indicators of the regions of Latvia, Lithuania, Belarus, using the developed innovation potential assessment methodology

In the regions of the first cluster, after evaluating the scientific, technical and educational resources, the highest value is obtained by the Kaunas county (10.00 normalized values), and the lowest by the Tauragė county (0,01), after evaluating labor resources, the highest value is obtained by Minsk (10.00), and the lowest by Utena county (0,01), according to the assessment of economic investment resources, the highest value is for the Riga region (10.00), and the lowest - for the Tauragė county (2,22), after assessing the infrastructure resources, the highest value is obtained by Minsk (10.00), and the lowest by the Latgale region (0,01), after evaluating ecological health, the highest value is for the Riga region (10.00), and the lowest for the Vidzeme region (5,08).

The analysis of the innovation resources of the regions of the second cluster is shown in Table 3.

Table 3. Analysis of innovation potential resources of the second cluster regions

Region	Scientifically technical and educational resources	Labor force resources	Economic investment resources	Infrastructural resources	Ecological health
Telšiai county	0,59	3,07	3,43	2,37	0,01
Brest oblast	1,36	8,09	0,01	1,86	4,28
Vitebsk oblast	2,09	7,64	0,05	2,04	0,11
Gomel oblast	2,26	7,62	0,73	2,97	0,14
Grodno oblast	1,23	8,40	0,19	2,25	0,11
Minsk oblast	0,38	8,69	0,35	2,13	1,16
Mogilev oblast	2,76	7,75	0,46	3,05	2,32
Average	1,52	7,32	0,74	2,38	1,16
Median	1,36	7,75	0,35	2,25	0,14
Standard deviation	0,88	1,92	1,21	0,46	1,62

Source: author's calculations based on the statistical indicators of the regions of Latvia, Lithuania, Belarus, using the developed innovation potential assessment methodology

In the regions of the second cluster, after evaluating scientific, technical and educational resources, the highest value is obtained by the Mogilev oblast (2.76), and the lowest by the Minsk oblast (0,38), after evaluating labor resources, the highest value is obtained by the Minsk oblast (8.69), and the lowest by the Telsiai county (3,07), according to the assessment of economic investment resources, Telšiai county has the highest value (3.43), and Brest oblast has the lowest value (0,01), after evaluating infrastructure resources, Mogilev oblast gets the highest value (3,05), and the lowest goes to Brest oblast (1,86), after evaluating ecological health, the highest value is for Brest oblast (4.28), and the lowest - for Vitebsk (0.11) and Grodno (0.11) oblasts.

The author's analysis shows that the standardized values of innovation potential resources in the regions of the second cluster are very low for all resources, except for the labor resource, which also determines the low level of the innovation potential of the regions of the second cluster. In order to more accurately analyze the reasons for the creation of innovation potential clusters in the regions of Latvia, Lithuania, Belarus and their structure, the author studies the profile of each innovation potential resource by cluster.

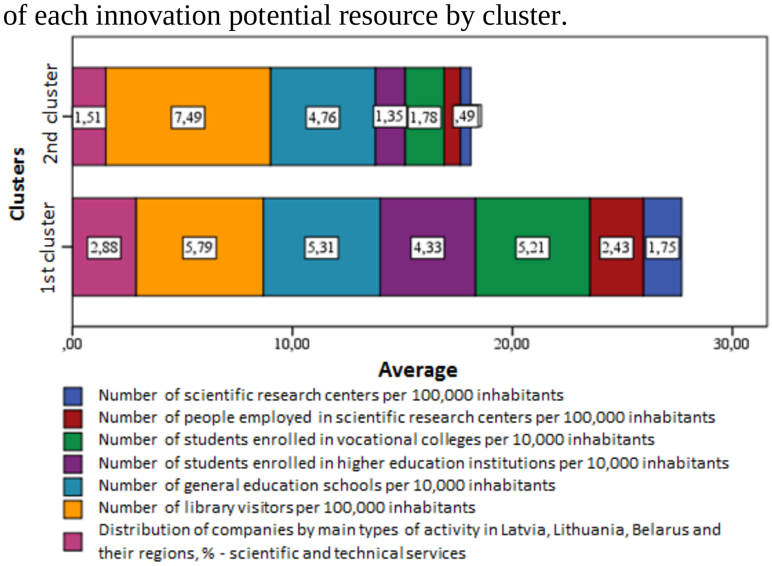

Figure 6. Profile of the scientific, technical and educational resources of the regions of Latvia, Lithuania and Belarus according to the integral normalized values of objective indicators

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Source: created by the author in the SPSS program based on statistical data calculations of the regions of Latvia, Lithuania and Belarus

In both clusters, the following indicators generally have the same influence on the creation of scientific, technical and educational resources (see Figure 6): “number of general education schools per 10,000 inhabitants" and “number of library visitors per 100,000 inhabitants”. In the first cluster, “the number of students enrolled in vocational colleges per 10,000 inhabitants”, “the number of students enrolled in higher education institutions per 10,000 inhabitants” and “the distribution of companies by main types of activity in Latvia, Lithuania, Belarus and their regions, % - scientific and technical services” have a great influence. In the formation of the first cluster, all indicators have a rather high importance compared to the second cluster, where some indicators, such as “the number of scientific research centers per 100,000 inhabitants”, “the number of people employed in scientific research centers per 100,000 inhabitants” have a very weak importance.

Figure 7. Profile of labor resources of the regions of Latvia, Lithuania and Belarus according to the integral normalized values of the objective indicators

Source: created by the author in the SPSS program based on statistical data calculations of the regions of Latvia, Lithuania and Belarus

The formation of labor resources of the first cluster (see Figure 7) is largely influenced by an indicator such as “population of working age, %”, but practically has no effect on “population density (person/sq.km)”, the other indicators have almost the same effect.

The formation of the second cluster is influenced by the following indicators: “population up to working age, %”, “demographic load level – total”, “employment rate, %”, “unemployment rate, %”, “economic activity, %”, the level of influence of which is practically the same. The influence of the indicator “population of working age, %” is much weaker than the other indicators, which is due to the fact that the regions of the second cluster have an abundance of labor potential.

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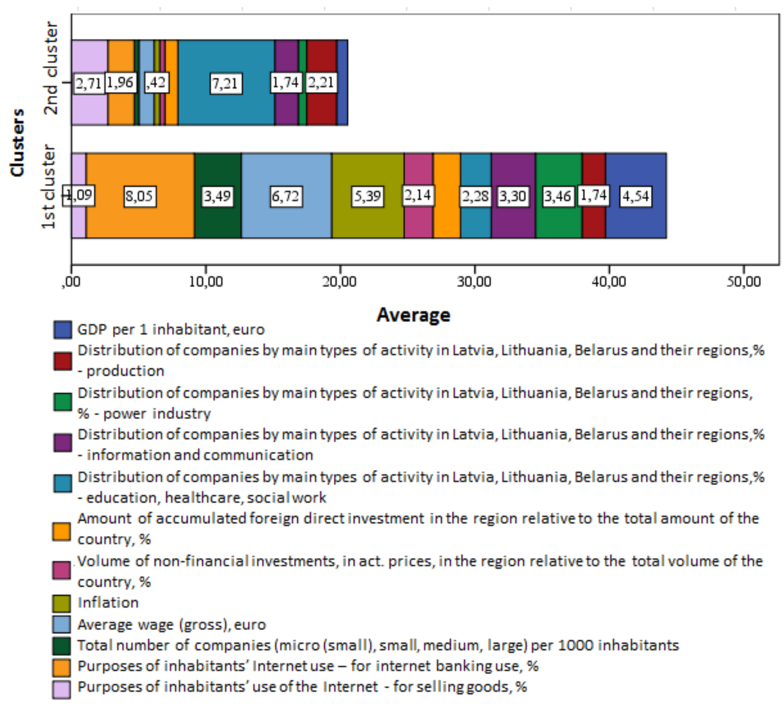

Figure 8. Profile of economic investment resources of the regions of Latvia, Lithuania and Belarus according to the integral normalized values of objective indicators

Source: created by the author in the SPSS program based on statistical data calculations of the regions of Latvia, Lithuania and Belarus

In the first cluster, in the creation of economic investment resources (see Figure 8), the indicator "purposes of inhabitants' Internet use – for internet banking use, %" has the greatest impact, indicators such as "average wage (gross), euro", "inflation", "GDP per 1 inhabitant, euro" also have a great influence, as well as the average impact of indicators such as "total number of companies (micro (small), small, medium, large) per 1000 inhabitants", "distribution of companies by main types of activity in Latvia, Lithuania, Belarus and their regions,% - information and communication", "distribution of companies by main types of activity in Latvia, Lithuania, Belarus and their regions, % - power industry". Indicators such as "volume of non-financial investments, in act. prices, in the region relative to the total volume of the country, %", "the amount of accumulated foreign direct investment in the region relative to the total amount of the country, %,", "distribution of companies by main types of activity in Latvia, Lithuania, Belarus and their regions,% - education, healthcare, social work".

In the second cluster, the indicator "distribution of companies by main types of activity in Latvia, Lithuania, Belarus and their regions,% - education, health care, social work" has the greatest impact", lower than average is for the indicators "purposes of inhabitants' use of the Internet - for selling goods, %", "purposes of inhabitants' use of the Internet – for Internet banking use, „ distribution of companies by main types of activity in Latvia, Lithuania, Belarus and their regions,% - production", %", "distribution of companies by main types of activity in Latvia, Lithuania, Belarus and their regions,% - information and communication".

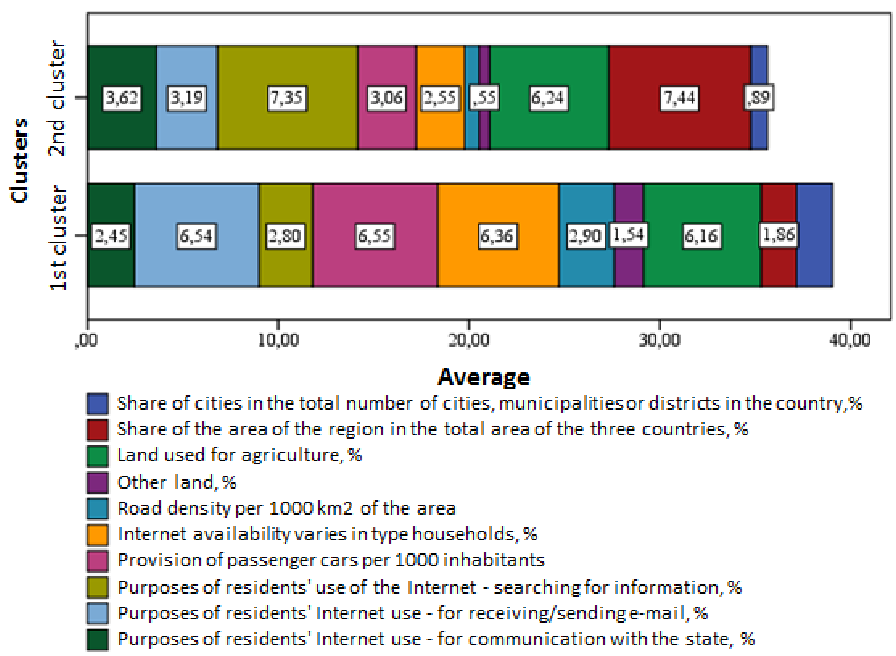

Figure 9. Profile of the infrastructure resources of the regions of Latvia, Lithuania and Belarus according to the integral normalized values of the objective indicators

Source: created by the author in the SPSS program based on statistical data calculations of the regions of Latvia, Lithuania and Belarus

Indicators such as "provision of passenger cars per 1000 inhabitants", "purposes of residents' Internet use - for receiving/sending e-mail, %" are of great importance in the creation of infrastructure resources of the first cluster (see Figure 9), "internet availability varies in type households, %", "land used for agriculture, %", which are evenly distributed between each other. In the second cluster, the following factors have a great influence: "the share of the area of the region in the total area of the three countries, %", "purposes of residents' use of the Internet - searching for information, %", "land used for agriculture, %". The distribution of the indicators of the first cluster is more even, the quantitative and structural differences of the indicators affecting the regions of the second cluster are clearly expressed.

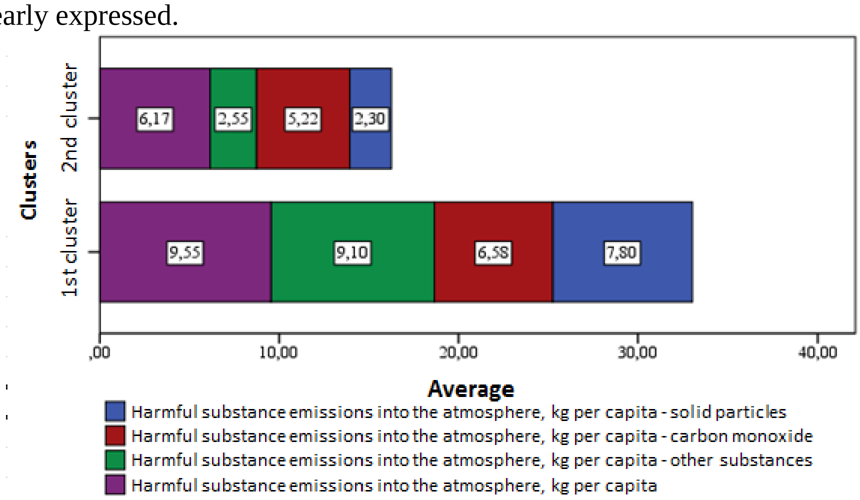

Figure 10. Profile of the ecological health of the regions of Latvia, Lithuania and Belarus according to the integral normalized values of the objective indicators

Source: created by the author in the SPSS program based on statistical data calculations of the regions of Latvia, Lithuania and Belarus

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In the creation of ecological health of the first cluster (see Figure 10), the following indicators have the greatest influence: "harmful substance emissions into the atmosphere, kg per capita" and "harmful substance emissions into the atmosphere, kg per capita - other substances". The indicators "harmful substance emissions into the atmosphere, kg per capita - solid particles" and "harmful substance emissions into the atmosphere, kg per capita - carbon monoxide" also have a great influence. In the second cluster, the following producers have the greatest impact: "harmful substance emissions into the atmosphere, kg per capita" and "harmful substance emissions into the atmosphere, kg per capita - carbon monoxide". The influence of indicators "harmful substance emissions into the atmosphere, kg per capita - solid particles", "harmful substance emissions into the atmosphere, kg per capita - other substances" is lower than the average. The indicators of the first cluster are evenly distributed, but the second cluster shows large regional quantitative and structural differences of the influencing creators.

Assessment of regional and national quantitative and structural differences in innovation potential

In order to study the quantitative and structural differences in innovation potential of the regions of Latvia, Lithuania and Belarus, the author calculates σ-convergence indicators.

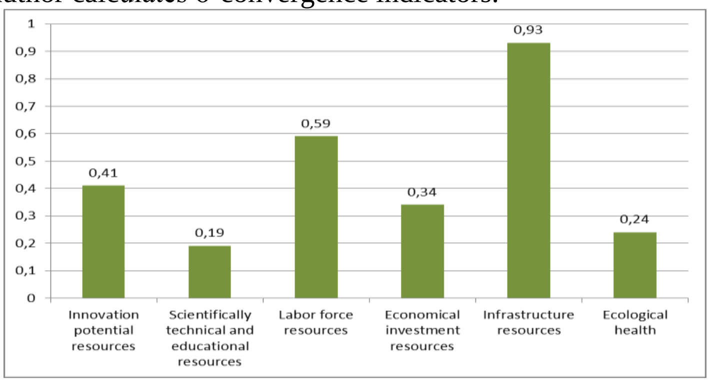

Figure 11. Variation coefficients of innovation potential in Latvian regions, 2017
Source: the author's calculations based on the data of the regions of Latvia, Lithuania, Belarus, obtained using the developed innovation potential assessment methodology

The calculations of σ-convergence indicators in Latvian regions (see Figure 11) show that the fluctuations of the individual values of the innovation potential level are high, the set is heterogeneous, its average value is not stable.

Analyzing the resources of innovation potential, the author concludes that Latvian regions are homogeneous in terms of scientific, technical, educational resources, and ecological health, their average sizes are stable, and the fluctuations of individual sizes are small.

Fluctuations of individual values of other resources are high, their average values are not stable, regional quantitative and structural differences are quite large.

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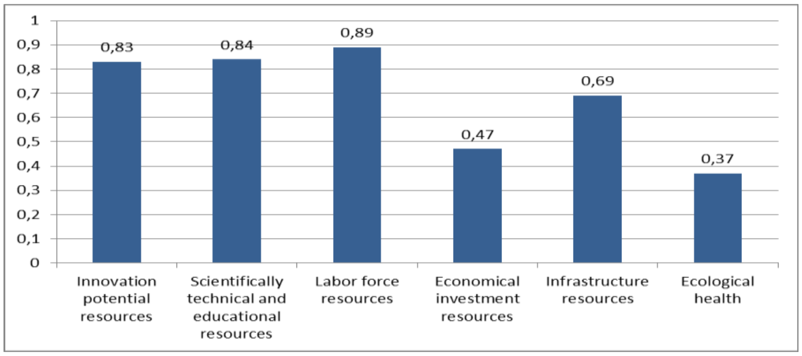

Figure 12. Variation coefficients of innovation potential and its resources in Lithuanian counties, 2017
Source: the author's calculations based on the data of the regions of Latvia, Lithuania, Belarus, obtained using the developed innovation potential assessment methodology

The calculations of σ-convergence indicators in the counties of Lithuania (see Figure 12) show that the fluctuations of the individual values of the innovation potential level are high, their average value is not stable, the set is heterogeneous, the quantitative and structural differences of the regional innovation potential are big.
Analyzing the resources of the innovation potential, the author concludes that the resources forming the innovation potential are generally heterogeneous, the fluctuations of their individual values are also high, the average values are not stable, the quantitative and structural differences of the factors of the regional innovation potential are large.

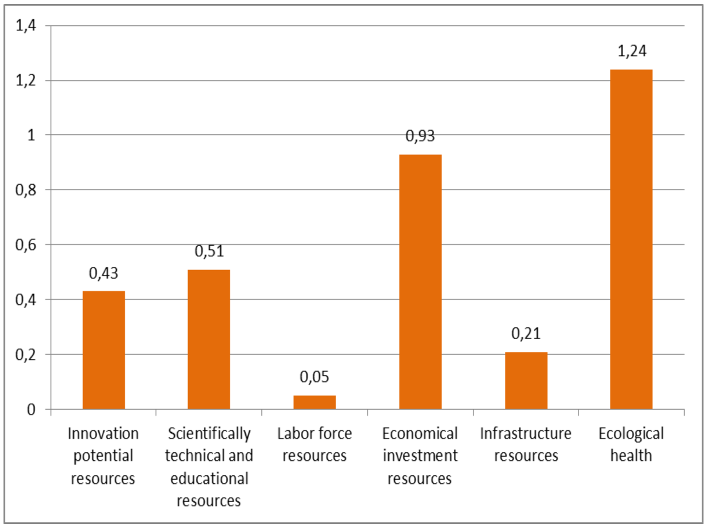

Figure 13. Variation coefficients of innovation potential and its resources in the oblasts of Belarus, 2017
Source: the author's calculations based on the data of the regions of Latvia, Lithuania, Belarus, obtained using the developed innovation potential assessment methodology

The calculations of σ-convergence indicators in the oblasts of Belarus (see Figure 13) show that the set of innovation potential resources is heterogeneous, the fluctuations of individual values are high, their average value is not stable, and the quantitative and structural differences of the regional innovation potential are quite high.
Analyzing the resources of innovation potential, the author concludes that labor and infrastructure resources are a homogeneous set. The fluctuations of their individual sizes are small, the average sizes are stable.

Regional quantitative and structural differences in scientific, technical and educational, economic investment resources and ecological health are large, the fluctuations of their individual values are high, and the average valuesare not stable.

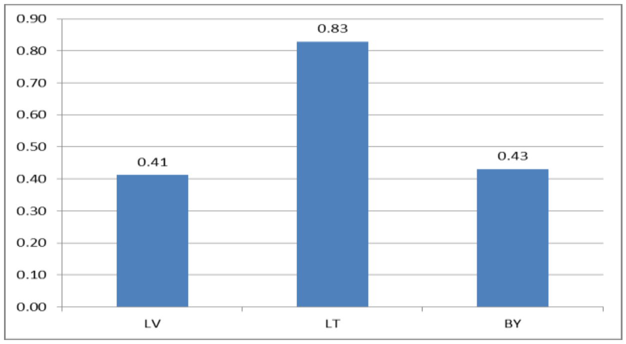

Figure 14. Coefficients of variation of the pool of innovation potential in the regions of Latvia, Lithuania and Belarus, 2017
Source: the author's calculations based on the data of the regions of Latvia, Lithuania, Belarus, obtained using the developed innovation potential assessment methodology

Analyzing the regional quantitative and structural differences of the innovation potential of Latvia, Lithuania and Belarus (see Figure 14), it has been established that in all the studied countries the sets of the innovation potential are heterogeneous, the fluctuations of their individual values are high, and the average valuesare not stable. Regional quantitative and structural differences are almost at the same level in Latvia ($V\sigma$ = 0.41) and Belarus ($V\sigma$ = 0.43), but in Lithuania regional quantitative and structural differences are twice as large (V_σ = 0,83). In Lithuania, along with very high and highly developed counties (Vilnius county - 5th quintile, Kaunas, Klaipėda counties - 4th quintile), there are poorly developed counties, which get a very low evaluation in terms of development of scientific and technical, educational, labor force resources, ecological health, for example, Telšiai county. It also creates large regional quantitative and structural differences in Lithuania.

In order to investigate in more detail the reasons for the formation of regional quantitative and structural differences of the innovation potential of Latvia, Lithuania and Belarus, the author studied the quantitative and structural differences of the innovation potential of each region at the national level (see Figure 15).

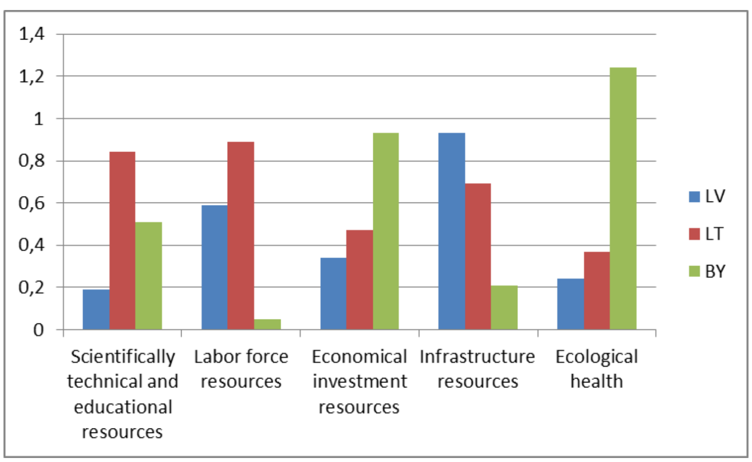

Figure 15. Variation coefficients of innovation potential resources in the regions of Latvia, Lithuania and Belarus, 2017
Source: author's calculations based on the data of the regions of Latvia, Lithuania, Belarus, using the developed methodology for evaluating the innovation potential

The set of scientific, technical and educational resources of the regions in Latvia is homogeneous. The fluctuations of its individual values are small, the average values are stable. In Lithuania and Belarus, sets of

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scientific, technical and educational resources are heterogeneous, the fluctuations of their individual values are high, and the average valuesare not stable.

The sets of regional innovation potential in Latvia and Lithuania are heterogeneous, the fluctuations of their individual values are high, and the average valuesare not reliable. In Belarus, the level of regional quantitative and structural differences in labor resources is very low, the fluctuations of the total individual values are small, and the average valuesare stable.

Small regional quantitative and structural differences can be observed in Latvia in terms of economic investment resources, in Lithuania they are more pronounced, but in Belarus the sets of economic investment resources are very heterogeneous, the level of regional quantitative and structural differences is twice as high as in Lithuania and three times as high as in Latvia, the fluctuations of the individual values of the aggregates are high, the average values are not stable.

In terms of infrastructural resources, the regions of Belarus have homogeneous groups, the fluctuations of their individual values are small, and the average valuesare stable. On the other hand, in Latvia and Lithuania there are large regional quantitative and structural differences of infrastructure resources, the fluctuations of the individual values of the aggregates are high, the average values are not reliable.

Ecological health is homogenous in Latvia, regional quantitative and structural differences are small, fluctuations of individual sizes of aggregates are small, average sizes are stable. In Lithuania, the sets of ecological health are quite heterogeneous, while in Belarus there are very large regional quantitative and structural differences of ecological health, the fluctuations of the individual sizes of the sets are high, the average sizes are not stable.

5. Results

Evaluating the innovation potential of the regions of Latvia, Lithuania and Belarus, the author finds that the regions of Latvia have an uneven and relatively high level of innovation potential, the highest is the Riga and Pieriga regions (5th quintile), while the lowest level of innovation potential is the Latgale region (3rd quintile). The counties of Lithuania have a lower level of innovation potential than the regions of Latvia and it is very uneven: the highest – for Vilnius county (5th quintile), as well as there are representatives in each quintile, in contrast to Latvia, where only representatives of the 3rd, 4th and 5th quintiles are found. The oblasts of Belarus have the lowest level of innovation potential, except for Minsk city, which is in the 5th quintile, the other counties are in the 1st-3rd quintiles.

The regions of Latvia, Lithuania and Belarus can be divided into two clusters according to the integral normalized values of the objective indicators. The first cluster includes regions with a large shortage of labor resources and fairly high values of other resources. This cluster includes regions of Latvia and Lithuania and Minsk city. The second cluster includes regions with extremely high levels of labor resources and very low values of other resources. There are a little more infrastructure resources, but their level is certainly not sufficient either. This cluster includes all oblasts of Belarus, except Minsk city, and also the Telsiai county. Latvian and Lithuanian state administration institutions and local government institutions should develop cooperation with Belarus by attracting free labor resources, and develop cross-border cooperation programs.

The regions of Latvia and the counties of Lithuania have an average level of economic investment resources and a lower than average level of labor resources. The oblasts of Belarus have a low level of economic investment resources with a high level of labor resources. Only in capital regions, economic investment resources get a fairly high rating. Infrastructural resources in the oblasts of Belarus have a low rating, in the regions of Latvia and the

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counties of Lithuania - approaching average values, in the capital regions - a rather high rating. The author recommends the development of cross-border cooperation for the equalization of the mentioned quantitative and structural differences.

In the first cluster, the impact of indicators of scientific, technical and educational resources is much more homogeneous than in the second cluster, and it is most affected by the following indicators: "number of general education schools per 10,000 inhabitants" and "number of library visitors per 100,000 inhabitants". The formation of the first cluster is also largely influenced by the "number of students enrolled in vocational colleges per 10,000 inhabitants". Regional quantitative and structural differences in both clusters are strongly expressed.
On the other hand, the creators of labor resources are more evenly distributed in the second cluster. In the first cluster, the greatest impact has the "population of working age, %", while in the second cluster, the impact of this indicator is low. However, the other indicators in the second cluster are of great importance, except for the population density (person/sq.m) indicator.

In the first cluster, the impact of indicators of economic investment resources is more homogeneous than in the second cluster, however, the regional quantitative and structural differences are sufficiently large. The indicators have the greatest influence: "purposes of residents' internet use - internet banking use, %", "average salary (gross), Euro". In the second cluster, regional quantitative and structural differences are very clearly expressed. The indicator "distribution of companies by main types of activity in Latvia, Lithuania, Belarus and their regions,% - education, health care, social work" has the greatest influence, the influence of other factors is weak.
The indicators of infrastructure resources have smaller quantitative and structural differences in the first cluster, however, heterogeneity remains in both clusters. The range of values in the second cluster is much larger than in the first. The formation of the first cluster is largely influenced by the following indicators: "provision of passenger cars per 1000 inhabitants", "purposes of citizens' Internet use – for receiving/sending e-mail, %", „ internet availability in different types of households, %", "agricultural land, %". The values of these indicators are generally similar. The formation of the second cluster is influenced to a greater extent by "the share of the area of the region in the total area of the three countries, %", "purposes of residents' use of the Internet - searching for information, %", "land used for agriculture, %".

The first cluster is relatively homogeneous in terms of ecological health, all indicators have a fairly equal impact. However, regional quantitative and structural differences are observed in the second cluster, such indicators have the greatest influence: "emissions of harmful substances into the atmosphere (kg per inhabitant)" and „ emissions of harmful substances into the atmosphere, kg per inhabitant – carbon monoxide".
The author created a development vector of the innovation potential of the studied regions and found that its values increase in the direction from southeast to northwest.

The author finds an average linear positive relationship between GDP and the set of innovation potential, and also, when studying innovation potential resources, determines an average linear positive relationship between GDP and scientifically technical and educational resources, a weak linear negative relationship between GDP and labor resources, a strong linear positive relationship between GDP and economic investment resources, average linear positive relationship between GDP and ecological health.

Conclusions

The evolution of the concept of innovation potential is related to the concept of innovation and innovation potential. Several approaches are used to explain the concept of innovation, within which innovation is defined as a change, process or result. In defining the concept of innovation potential, world scientists use two basic

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approaches - they consider it as the result of a combination of resources or the result of an activity. The author is a supporter of the resource approach, and the innovation potential is evaluated as a set of resources.

As a result of the research, new data have been obtained on the innovation potential of regions and the essential interrelationships of resources, as well as the methodology for determining the innovation potential of regions has been developed and approved.

The author developed the following algorithm for creating an integral indicator for the evaluation of the innovation potential of the regions of Latvia, Lithuania and Belarus:

- unification of statistical indicators with a linear scaling technique in the interval from 0 to 10, sorting it into stimulants and destimulants,
- selection of determinant indicators of innovation potential from a wide set of available statistical indicators, which excludes indicators with similar or duplicate meaning without reducing the objectivity of the results,
- creating integral index by the selected indicators.

For the assessment of the innovation potential of the regions of Latvia, Lithuania and Belarus, the author uses the complex assessment with the sum method, because, compared to other methods, this methodology more optimally differentiates the quantitative and structural differences of the regions, there is a one-way effect of the indicators of the innovation potential, the given regions are economically underdeveloped.

The author assesses the innovation potential of regions of Latvia, Lithuania, and Belarus, its structure that provides for the assessment of the existing regional quantitative and structural differences and determining the innovation potential development vector. The author specifies the profile of factors influencing the innovation potential of regions of Latvia, Lithuania, and Belarus, that provides for in-depth analysis of the innovation potential development aspects.

The present research may be put to practice in national structures of diverse levels to elaborate a policy stimulating innovation introduction and development in particular regions. Within his research, the author determines the innovation potential structure of regions of Latvia, Lithuania, and Belarus according to the factors influencing the innovation potential, lack of influencing factors or their excess, that makes it possible to work out guidance for successful implementation of cross-border innovative development policy.

The author classifies regions of Latvia, Lithuania, and Belarus into clusters according to the innovation potential factor analysis, states regions with excess/lack of different potentials that facilitates the implementation of cooperation and development programmes on regional and national level. The author determines the innovation potential development level and vector that is an essential prerequisite for the elaboration of investment policy.

According to the analysis produced by the author, Minsk possesses a very high innovation resource potential level, whereas that of Minsk district is very low. Minsk is located in quintile 5, whereas Minsk district in quintile 1. In regions of Latvia and Lithuania these quantitative and structural differences are slightly less expressed, yet such a tendency is characteristic of these regions as well. This tendency is very distinct in capital city regions with dynamically developing capital city but poorly developing other regions. The flow of investments, labour force and other resources is oriented only towards the capital city development. State and local government institutions are to elaborate new programmes and promote the development of the existing ones for levelling of regional quantitative and structural differences, work out recommendations for their efficient use and uptake of EU structural fund appropriations, form separate development project financing budgets for capital cities and regions.

No monitoring of innovation resource potential is produced, there is no controlling innovation resource potential development in dynamic, the stimulating and impeding factors are not specified. There is no unified institution in Latvia to implement innovation policy. Economic policy development bodies are to elaborate innovation resource potential monitoring and control system, carry out innovation resource potential monitoring in national and regional context based on statistical data. The integral indicator for innovation resource potential assessment produced by the author may be applied as an element of innovation resource potential monitoring.

Regions of Latvia and Lithuania (cluster 1) greatly lack labour force. State and local government bodies are to elaborate programmes for attracting labour force from other regions with excess of labour force, facilitate cooperation between state and local government structures and the private sector, work out recommendations for the implementation of labour force attracting programmes.

Districts in Belarus (cluster 2) possess extremely large labour force resources, whereas indicators of economic investment, scientific technical resources and ecological health are very low, infrastructure resources are insufficient. Administration bodies of the Republic of Belarus, regional and district executive committees are to elaborate programmes of development including cross-border development programmes within which financing is attracted for various kinds of projects including cross-border financing, economic and culture relation development, improving the image of region and raising recognisability level that leads to the development of economy, science and other resources.

Accessibility of statistical indicators in widely available published collections is rather limited; there is no unified statistical indicator inventory system in various countries, especially on regional level, that aggravates the opportunities of assessing the innovation resource potential and comparing different country regions. National statistical institutions (in Latvia – Central Statistical Bureau of Latvia, in Lithuania – Statistics Lithuania, in Belarus – National Statistics Committee of the Republic of Belarus) are to improve opportunities for statistical data accessibility, within national programmes expand the range of statistical data, especially in regional perspective, within cross-border cooperation elaborate a unified system of statistical data calculating and processing.

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Annex A

Examples of innovation potential development in Latvia, Lithuania, Belarus

The management of the innovation system in Belarus takes place at different levels of government, from local governments to the orders of the President of the country. Each level of innovation management is assigned certain powers and functions. A strategy has been prepared and approved in the country „Science and innovations: 2018-2040". The given document defines the priority directions and tasks for the development of the innovation potential of Belarus. According to the given strategy, the innovative development of the country is regulated by the following theses:

- science is the foundation of advanced technologies;
- innovations must correspond to basic world trends and society's interests;
- the country must reach a new level of competitiveness;
- scientific and technical activity must be based on own resources and international scientific cooperation.

According to the Global Innovation Index, Belarus ranks 88th (2017). In two years, the ranking of Belarus according to the GII decreases by 35 positions.

The low level of development of the innovation potential in Belarus is related to the fact that the innovation potential is mostly developed in the capital Minsk, while the innovation potential develops very slowly in the oblasts. Several innovation potential development and promotion projects are developed only in Minsk, however, state support for innovation potential development projects increases every year.

The Belarus China Innovation Center operates in Minsk, which was established in 2010, implementing Innovation Development State Program 2007-2010 of the Republic of Belarus (Glavnoye upravleniye nauki BGU 2022). The purpose of the establishment of the center is to promote the expansion of the business and scientific relations of the structural units of the State University of Belarus with the scientific institutions and companies of the People's Republic of China and to develop effective coordination of the implementation of joint scientific and technical projects. Belarus China Innovation Center is founded by the Belarus State University and the Science and Technology Administration of the People's Government of Harbin City, Heilongjiang Province. The following documents were signed during the operation of the center (Ministerstvo obrazovaniya Respubliki Belarus 2020):

- Agreement on the establishment of the Belarus-China Joint Institute with Dalian Polytechnic University;
- Memorandum of cooperation in the field of education and science with Zhejiang University of Science and Technology;
- Memorandum on the long-term scientific and technical cooperation program with the Petrochemical Institute of the Heilongjiang Academy of Sciences;

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- Protocol on cooperation in the field of polymer synthesis with the Institute of Synthetic Chemistry of Mongolia;
- Memorandum of cooperation with Keqiao Industrial Region.

In Riga, the Science and Innovation Center operates on the basis of Riga Technical University (RTU), the purpose of which is to ensure the implementation and growth of RTU's strategy and sustainable valorization goals, promoting scientific activity and the involvement of academic staff and students in the processes of innovation creation and knowledge transfer, as well as developing cooperation with industry and scientific institutions (RTU homepage 2022). The center develops students' innovation and entrepreneurial abilities, offers innovative product development services, and actively engages in local and international innovation ecosystems (RTU homepage 2022). The Science and Innovation Center consists of several structural units:

- Design factory;
- Innovative product development department;
- Department of Innovation Ecosystem Development;
- Research Equipment Division.

The design factory (RTU homepage 2022) develops innovative thinking, creative skills and entrepreneurial abilities in students. It has several basic functions:

- to ensure the availability of the open-type workshop "theLAB";
- implement the project "Innovation grants for students" (ERAF co-financed project No. 1.1.1.3/18/A/001 "RTU innovation grants for students").

Basic functions of the innovative product development department:

- efficient creation of innovative products with high added value;
- research and improvement of existing products and services.

The department cooperates with various industries and scientific institutions.

The Innovation Ecosystem Development Department promotes RTU's involvement in national and international innovation and technology ecosystems, including implementing programs of the European Institute of Innovation and Technology (EIT), conducting educational work and supporting start-ups in the implementation of sustainable business ideas (RTU homepage 2022).

The Research Equipment Division (RTU homepage 2022) supports the development of science by providing modern research equipment. The High Performance Computing or HPC Center operates within the department, which develops the use of digital technologies in research.

HPC center's (HPC Center homepage 2022) mission is:

- to develop the use of digital technologies in research,
- to promote modern and more internationally competitive Latvian science.

Basic tasks of the center are:

- to provide a powerful computing infrastructure,
- to provide modeling services,
- to provide simulation services,
- to maintain scientific software for research and teaching,
- to arrange digital science courses and seminars.

HPC center (HPC Center homepage 2022) cooperates with the largest Latvian scientific institutes and universities, as well as European e-infrastructures.

Vilnius (European Innovation 2021) received the third place in the finals of the competition European Capital of Innovation (iCapital)m, where 38 cities participated with the population number not less than 50 000 people.

European Capital of Innovation (iCapital) is an annual recognition award given to European cities that best promote innovations. The eighth edition specifically recognizes the contribution of cities to the development of local innovation ecosystems to benefit from breakthrough innovations and improve public well-being. The commission evaluated Vilnius projects for 2020: Vilnius 2IN, Hack Me if You Can, IT MUST, Intelligent Energy Lab, volunteers' project Gedimino legionas etc.:

- Vilnius 2IN (Vilniaus miesto internetinis puslapis 2021) project's strategic direction is guided by the six principles of activity:
  - municipal excellence is the best practice in the international management;
  - knowledge in general – ability to detail existing knowledge, share it and try to create new applied knowledge;
  - innovation is the application of smart solutions, not the destination, but a practical benefit to the result for all participants;
  - digital equality – all members of society deserve access to technology and equal opportunities to pay for its use;
  - intelligence – the intelligent society accepts technologies, does not focus on digitization, it is vision-oriented; solve current problems in a clear, convenient way;
  - spreading initiatives, activities and results among all members of society to involve as many initiators, advisors and users as possible.
- Hack Me if You Can (Vilniaus miesto internetinis puslapis 2022) program allows every person, without violating the legal framework established in the country, to identify cyber security threats free of charge, notify them to the Vilnius city municipality and share the given information after the threats have been eliminated.
- Intelligent Energy Lab (2021) aim is to create an open platform for idea generation and development in the city of Vilnius.
- Gedimino legionas (Asociacija Gedimino legionas 2022) is an association of volunteers whose goal is to provide assistance to the surrounding environment in difficult and unexpected situations. The task of the association is to educate volunteers to use various technologies – cybernetics, internet, drones, data, etc.

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