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Improvement of financial autonomy of the rural municipalities in Lithuania using the spatial modelling method

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Abstract

In the scientific literature, the financial autonomy (FA) of rural municipalities has been referred to as a complex and dynamic phenomenon. Its manifestation has been claimed to depend on a variety of externalities and internalities of the local government. Rural municipalities occupy a significant share of the geographical space of the European Union and are very diverse. Hence, the manifestation of autonomy of the local government and possibilities for improvement of the FA in the rural areas are specific for each country and are characterised by their diversity and complexity. The issue of improvement of the FA has become of particularly topical interest in the context of regional and rural development in recent years. It has become increasingly relevant in autonomous and sustainable decision-making and implementation by the local governments as well as in the search for sustainable financial resources in spatial terms. Research aim: to develop the recommendations on improvement of the FA of the rural municipalities in Lithuania in the context of the key endogenous factors identified.

The article presents the empirical research findings obtained as a result of an assessment of the FA of 36 rural municipalities in Lithuania under the multi-criteria decision analysis method TOPSIS. The restraining and driving endogenous factors of the FA of the rural municipalities were analysed by applying the Moran's I statistic method. Global Moran's I statistic and Cluster and Outlier Analysis (Anselin Local Moran's I) were used to check for global and local patterns in the distribution of the FA of Lithuanian municipalities and related factors.

The research findings have demonstrated low or medium low the FA of rural municipalities in Lithuania. The result has been determined by the rapidly deteriorating demographic situation, restraining social factors, and contrasting economic environment observed in rural areas of Lithuania during the recent 11 years. The spatial autocorrelation models enabled the identification of the rural municipality clusters characterized by insufficient economic development and concentrated in the western and southern regions of the country. The spatial modelling-based assessment of the endogenous factors and using the tree-based regression model technique has shown the possibilities for improvement of the FA of rural municipalities of Lithuania.

Keywords: financial autonomy, endogenous factors, TOPSIS method, spatial autocorrelation, tree-based modelling, rural municipalities.

JEL Classification H72, R11, R15.

1 Introduction

The contemporary theory of public finance (Slavinskaitė, 2017; Ulbrich, 2013; Stegarescu, 2005; Blöchliger, Rabesona, 2009) emphasizes the relevance of the financial autonomy (FA) of a local government on the sub-national, regional, and local levels. The importance of the FA of a local government is broadly declared in the European Union's (hereinafter – the EU's) and national strategic documents, programmes of the President and Government of the Republic of Lithuania (hereinafter – the RL) (2020). The regional, rural, and local objectives are implemented in the EU member countries by the local government units (LGUs). The LGUs are the municipalities holding the authority and capacities to autonomously handle and manage the major share of public affairs by assuming full liability and respecting the local residents' interests as established by the European Charter of Local Self-Government. Self-governance of the EU member countries is largely manifested through the rural municipalities, and the Common Agricultural Policy (hereinafter – the CAP) of the European Commission (hereinafter – the EC) by the year 2027 (Regulation of the EC, of the European Parliament and the Council, 2018) emphasizes solid social and economic structure of the rural areas and the importance of rural development for development of the countries' regions.

In the scientific literature, the FA of a local government is referred to as a complex and dynamic phenomenon influenced by the changing external and internal environment of the local government and the factors thereof. Therefore, the identified possibilities for improvement of the FA of rural municipalities are therefore based on the assessment of the endogenous factors of rural development. A large number of the empirical studies analysed show the impact of the demographic, social and economic factors on not only the endogenous development of rural areas and regions (OECD, 2021; Masot, Alonso, Moriche, 2020; Kriaučiūnas, 2018; Standar, Kozera, 2019; Kriaučiūnas et al., 2014; Šimanskienė, Burbulytė-Tsiskarishvili, 2012; Atkočiūnienė, 2009, 2008; and others), but also on the FA of municipalities (Maličká, 2021; Wichowska, 2021; Dziekański, Prus, 2020; Dziekanski, 2020; Luszak, Just, 2020; Satola et al., 2019; Standar, 2019; Wichowska, Wierzejski, 2019; Vavrek, Pukala, 2019; Głowicka-Wołoszyn, Satola, 2018; Luczak et al., 2018; Kozera, Luszak, Wysocki, 2017; Kozera, Głowicka-

Woloszyn, 2016; Jemna, Onofrei, Cigu, 2013; and others) in individual countries of the EU (in particular, the Eastern and Central European countries as well as the member countries which have acceded to the EU more recently). In view of the above, the researchers (Maličká, 2021; Wichovska, 2021; Dziekanski et al., 2020; Malinowski, 2019; Standar, Kozera, 2019; Just, Łuczak, 2019; and others) focus on the endogenous factors determining the FA of rural municipalities and the assessment of the impact thereof on a country by country basis in their empirical studies.

Spatial approach towards assessment of the demographic, social and economic factors determining the FA of rural municipalities has recently become particularly relevant. It enables systematic assessment of the possibilities for improvement of the FA. The studies involving spatial assessment are characterised by vast diversity of methods and techniques. The authors of the present article build on the empirical studies of the FA of rural municipalities conducted by the researchers of the EU countries. It should be noted that, in the spatial context, the factors determining the FA of municipalities have little been assessed yet. Nonetheless, according to the researchers (Dziekański, Prus, 2020; Dziekanski, 2020; Malinowski, 2019; Kozera, Glowicka-Woloszyn, 2016; Šimanskienė, Burbulytė-Tsiskarishvili, 2012), spatial modelling has become increasingly important in assessment of the endogenous development of rural areas and regions. The scientific literature analysis therefore suggests that there is a lack of research on improvement of the FA of rural municipalities in the context of endogenous spatial development. To identify the possibilities for improvement of the FA of rural municipalities in individual countries, the assessment should integrate not only the multi-criteria methods, but also spatial modelling techniques.

The scientific literature (Dziekanski, 2020; Dziekański, Prus, 2020; Dziekanski et al., 2020; Malinowski, 2019; Kozera, Glowicka-Woloszyn, 2016) proposes using spatial modelling for the integrated assessment of the FA of rural municipalities by employing the global and local Moran's I statistic methods. These methods enable the researchers to identify how the rural municipalities of a specific country are distributed spatially by identifying the rural municipalities clusters of the FA and the determining endogenous factors and the outliers.

According to the economists and policy makers, the rural municipalities of Lithuania demonstrate poor performance in terms of promotion of investments, creation of new jobs, use of local resources, and exploration of the possibilities for improvement of the FA by tapping on the possibilities offered by the neighbourhood in general. Therefore, spatial modelling would provide the perspective on how the neighbouring rural municipalities could jointly make use of the financial, human, technological, natural and other resources for improvement of the FA.

The following two hypotheses are subject to verification in the present study:

H1. The geographically neighbouring rural municipalities are homogenous in terms of the FA.

H2. Financial autonomy of rural municipalities largely depends on the endogenous demographic factors.

Research aim: to develop the recommendations on improvement of the FA of the rural municipalities in Lithuania in the context of the key endogenous factors identified.

The problem analyzed in the empirical study is defined by the following question: *Which endogenous factors largely influence improvement of the FA?*

Methods of the empirical study. Financial autonomy of the rural municipalities was assessed by using the TOPSIS method, while the endogenous factors determining the FA have been selected on the basis of the scientific literature analysis according to their importance for the Lithuanian context. Global and local Moran's I statistics and mapping method were applied to identification of the spatial effects. The possibilities for improvement of the FA of the rural municipalities of Lithuania were identified by using the tree-based regression models.

2 Scientific literature review

2.1 Financial autonomy of a local government and theoretical assumptions in the context of the endogenous factors of improvement thereof

In the scientific literature, the FA of a local government is referred to as a complex (Łuczak, Just, 2020; Beer-Tóth, 2009), multi-faceted (Ladner, Keuffer, 2021; Ladner, Keuffer, 2018; Łuczak et al., 2018), and multidimensional economic phenomenon (Blöchliger, Rabesona, 2009; Ouali & Boussetta, 2017). It is based on theories and principles of public economics, fiscal policy, public finance, public administration, fiscal decentralisation, regional development, and local economics related to allocation, redistribution, stabilisation of the financial resources and improvement of the local and the FA. The level of FA of local governments depends on the decentralization processes taking place in the respective countries (Satola, Standar, Kozera, 2019). This phenomenon is one of the key components of autonomy of a local government (Standar, Kozera 2019; Łuczak et al., 2018; Ladner, Keuffer, 2021). Greater the FA means not only greater power in policy-making but also greater responsibility (Chen, 2022). The global financial crisis has had only repercussions on the financial capacity of local governments. The combination of the indexes showing various patterns of intergovernmental relations calls for the update of the institutional indicators and for a more detailed analysis of multi-level governance mechanisms (Keuffer, Ladner, 2021).

In their analysis of the phenomenon of the FA of a local government, the researchers have identified the following characteristics thereof: availability of sufficient financial resources (Burbulytė-Tsiskarishvili et al., 2018; Psycharis et al., 2016; Scutariu, Scutariu, 2015; Jemna, Onofrei, Cigu, 2014; Beer-Toth, 2009); proper allocation of the financial resources among the central and local governments (Slavinskaitė, 2017; Ulbrich, 2013; Stegarescu, 2005); capabilities and capacities for autonomous management of the financial resources by the local government (Skauronė, Miceikienė, Krikštolaitis, 2020; Tan, 2020; Kozera, Glowicka-Woloszyn, 2016; Scutariu, A., L, Scutariu, P., 2015; Cigu, 2014); sustainable assurance of balance between the revenue and expenditure (Tan, 2020; Beer-Toth, 2009; Mclure, Martinez-Vazquez, 2000); autonomous management of the tax base and tax rates (Stegarescu, 2005; Beer-Toth, 2009; Kozera, Glowicka-Woloszyn, 2016; etc.), financial responsibility (Chen, 2022; Slavinskaitė, 2017; Oates, 1999), and financial sustainability (Standar, Kozera, 2019; Hajilou et al., 2018).

The expression of the FA of local governments includes the areas of revenues, spending, borrowing, autonomous budget management, and responsibility for the provision of public services to members of their community. In empirical studies, scholars and researchers (Wichovska, 2021; Dziekanski, 2020; OECD, 2020; Satola et al., 2019; Standar, 2019; Standar, Kozera 2019; Wichovska, Wierzejski, 2018; Hajilou, et al. 2018; Kozera, Luczak, Wysocki, 2017; Kozera, Glowicka-Woloszyn, 2016; etc.) usually assess the FA of local governments in terms of revenue. This is understandable, as revenue is one of the key financial resources of local governments. According to Standar (2019), revenue is one of the key economic categories against which the financial position of local governments is measured. Therefore, improvement of the FA is also mainly related to the municipality's most important resources, i.e. revenue and endogenous factors for rural development.

In the EU countries, the interests of rural areas and their communities are mostly represented by legitimate units of government. These units of government are the municipalities, which, according to Cigu (2014), are the main promoters of local sustainable development processes. Rural municipalities are responsible for bringing together and engaging the rural communities to ensure sustainable rural development. According to Jacob et al. (2008), the rural decision-making process is very different from the urban environment, as rural municipalities are distinguished by their inherent social, economic, natural conditions and infrastructure potential. In addition, the inconsistent development of rural policies often impedes their autonomy initiatives. Therefore, recent empirical studies (Malička, 2021; Dziekanski et al., 2020; Luczak & Just, 2020; Just, Luszak, 2019; Satola, et al., 2019; Standar & Kozera, 2019; Glowicka-Woloszyn, Satola, 2018; Łuczak et al., 2018; Kozera et al., 2017; Kozera, Glowicka-Woloszyn, 2016; and others), rural municipalities are often identified as having low and medium low FA. Similarly, researchers (Dziekanski et al., 2020; Just, Luczak, 2019; Satola et. al., 2019; Standar, Kozera, 2019; Luczak et. al., 2018; Kozera, Glowicka-Woloszyn, 2016) emphasize the concentration of rural municipalities with a high FA level around major cities.

When examining the possibilities for improvement of the FA of rural municipalities, it is important to first identify endogenous factors and their indicators from theoretical point of view, and then carry out the spatial assessment of these factors from the empirical perspective.

Rural municipalities, as local government units, operate in a macro- and micro-environment in which a number of external and internal factors determine their ability to increase their FA. Although according to Beer-Toth (2009), the key determinants of the effective autonomy of local governments are external (exogenous) constraints imposed by governmental entities outside the local government unit, rural municipalities are very closely linked to internal (endogenous) rural development. In general, researchers have stressed the importance not only of managing the endogenous development factors in rural areas but also of continuously performing assessment thereof by the local authorities. The scientific literature focuses on the identification of demographic, social, and economic factors determining the FA, that explain the levels of FA of local government units in different countries. Meanwhile, the spatial assessment of endogenous factors determining the potential for improvement of the FA among rural municipalities in different countries has been less studied. Nonetheless, certain authors (Dziekanski et al., 2020; Dziekański, 2020; Malinowski, 2019; Kozera Głowicka-Włoszyn, 2016) have already demonstrated that the geographic and spatial location of rural municipalities may influence the extent and differences in FA in different spatial clusters. The integrated assessment of endogenous factors and their combinations enables the development of spatial typologies. Spatial Moran's I statistics techniques are useful in local government strategic decision-making. Unfortunately, there are no studies on the spatial assessment of FA of local government units in Lithuania. In general, there is a lack of research findings on the assessment of the FA of rural municipalities in Lithuania, although the programmes both by the President of the Republic of Lithuania and the Government (2020) identify the improvement of the FA of local governments as one of the main objectives. Therefore, the expression and improvement of the FA of rural municipalities are inseparable from the assessment of the impact of endogenous factors.

It has been observed that empirical studies on the FA of rural municipalities (Wichovska, 2021; Dziekanski et al., 2020; Luczak, Just, 2020; Just, Luszak, 2019; Standar, Kozera, 2019; Satola et. al., 2019; Luczak et. al., 2018; and others) have been addressing a wide range of endogenous factors¹ (see Table 1). Due to the wide

¹In empirical studies, researchers have identified and evaluated a wide range of endogenous factors. The endogenous factors examined in the literature analysis have been grouped into four groups: demographic, social, economic and geographical. The endogenous factors relevant to the environment of Lithuanian municipalities selected in the empirical study are assessed from the spatial perspective. This

variety of factors, Table 1 below presents the endogenous factors most often analysed by researchers that have an impact on the improvement of the FA of rural municipalities.

Table 1 Endogenous factors and their indicators assessed in studies of the FA in rural municipalities

Environment and its factor		Indicators describing the factor
Demographics	Demographics	Population density; Population growth rate per 1,000 inhabitants; Population birth rate per 1,000 inhabitants; Net migration rate per 1,000 inhabitants; Rural population as a share of the total population, %; Number of registered inhabitants in the municipality; Educational attainment of the population by education, %.
Social	Social	Working age population as a share in the total population, %; Unemployed as a share in the total working age population, %; Unemployment rate, %; Employment rate, %; Proportion of the Council members with tertiary education, %; Number of people employed in agriculture, industry, construction and services per 100 working age inhabitants; Number of people employed in individual farms per 100 working age people; Share of social assistance recipients in the total population, %.
Economic	Local economy	Number of operators listed in the REGON register per 10,000 inhabitants; Number of natural persons engaged in business activities per 1,000 inhabitants; Amounts of local taxes (mainly property tax), EUR.
	Size of local economic operators	Share of economic operators with 10 to 49 employees, %; Share of economic operators with 50 or more employees, %; Number of economic operators with 50 or more employees per 10,000 working age inhabitants.
	Agriculture	Number of farms with 15 ha or more of land in the total number of farms, %; Share of agricultural land in use in the total land structure, %.
Geographic	Spatial	Geographical location of the municipality; Neighbourhood; Transport options.
	Resources	Available natural resources.

Source: made by the authors.

A lot of theories of the FA propose an assumption that local governments should finance their needs largely using own sources of revenue, while the central government should provide the local governments with control. Nevertheless, rural municipalities are usually constrained in terms of their the FA and development of their endogenous potential. Most studies have found that the deterioration in the indicator values of demographic, and socio-economic factors in rural municipalities in the EU (in particular, in Eastern and Central European countries) (as the labour and endogenous capital resources are rapidly declining in rural municipalities in the EU countries) poses a threat to rural municipalities compared to other municipalities, not only in terms of the rural development process but also in terms of the improvement of the FA. These negative changes are determined by the state policy, which, according to the researchers (Standar, Kozera, 2019; Kriauciūnas, 2018; Psycharis, Zoi, Iliopoulou, 2016; Kriauciūnas et al., 2014) has an impact on the development of peripheral rural areas and is lagging behind the development trends.

However, researchers (Maličká, 2021; Wichovska, 2021; Dziekanski, Prus, 2020; Dziekanski, 2020; Malinovski, 2019; Standar, Kozera, 2019; Psycharis, Zoi, Iliopoulou, 2016; Šimanskiene, Burbulytė-Tsiskarishvili, 2012; and others), assessing the financial potential of municipalities in individual countries (Poland, Slovakia, Greece, Lithuania) and the endogenous factors determining them, emphasize the issue of the lack of endogenous resources in rural municipalities. Empirical studies have shown that most rural municipalities in other countries are generally experiencing a demographic crisis, which leads to the respective expression of the FA. On the one hand, the negative consequences of the demographic environment in rural municipalities clearly have an impact on the improvement of the FA. On the other hand, as argued by Malinovski (2019), for the local government to manage the trends of the demographic environment and to improve the social environment, it needs to have the FA, which plays a particular role in the attainment of the respective living standards for the population. Therefore, the researchers (Wichovska, 2021; Dziekanski et al., 2020;) often identify the size of the population and the size of its wages as the key variables determining the volume of the local government's revenue, the main source of which is the share of the revenue from the Personal Income Tax (hereafter referred to as the PIT). In addition, the standard of living in one municipality may have an impact on the lives of people in neighbouring municipalities (Malinovski, 2019). The economic situation of municipalities is also determined by the financial potential, the occupational activity of the population, the local labour market, entrepreneurship, infrastructure, and the state of the natural environment (Dziekanski et al., 2020; Standar, Kozera, 2019; Psycharis, Zoi, Iliopoulou, 2016).

The lack of endogenous resources is thus an obstacle to the autonomous development of rural areas and to the improvement of the FA of rural municipalities. In summary, researchers suggest a range of options to address the issue of improvement of the FA of rural municipalities. There is a diversity of approaches towards this issue. Some scholars believe that the primary focus should be placed on improving and strengthening the endogenous environment, others – on the building of their own revenue potential. There are also those who suggest focusing on attracting and exploiting resources and creating value, while others – on seeking investment and developing sectors of the rural economy by promoting the creation of new local enterprises based on high quality and differentiation of products, production processes, and services. Cigu (2014) also believes that the local authorities, with their capacity in terms of expression their the FA, could undertake sustainable development

enables assessment of the demographic, social and economic position of a rural municipality and identification of the possibilities for improvement of its FA.

initiatives through a wide range of programmes aimed at improvement of individual workers' human capital and by the development of new funding instruments to meet the needs of local small and micro-enterprises.

The scientific literature review has revealed a wide range of endogenous factors that may influence the FA of local governments and improvement thereof. Assessing the level of FA of rural municipalities and its determinants from the spatial perspective is important for both local and central governments. This kind of empirical studies provides the insights that enable important decisions on the creation of economic and social wellbeing and the sustainable allocation and redistribution of financial resources.

3 Empirical research methodology, data and tools

In the empirical study, first, a group of rural municipalities, which included 36 municipalities out of 60 municipalities in Lithuania, was formed to reflect the set of alternatives $A = (A_1, A_2, A_3, \dots, A_4, \dots, A_{36})^2$. The empirical study covered the 11-year period, i.e. 2009 to 2010, that was subject to the data analysis and evaluation. This period is associated with the recently growing interest not only in the local economic growth, regional development, and development but also in the improvement of the FA of municipalities.

In order to assess the possibilities for improvement of the FA of rural municipalities from the spatial perspective, the first step was to assess the FA using the multi-criteria TOPSIS method. In the empirical study, the expression of the FA of rural municipalities and the possibilities for the improvement thereof is related to their revenue. Therefore, based on the subject matter-related criteria, eight revenue indicators were selected forming the basis for the construction of the set of indicators: $R = PIT$ per capita, EUR/capita (r_1); fiscal wealth index or tax revenues per capita, EUR/capita (r_2); PIT in the total municipal revenues, EUR (r_3); own revenues per capita, EUR/capita (r_4)³; share of own revenues in the total revenues or first-degree the FA, %; (r_5)⁴; non-tax revenues per capita, EUR/capita (r_6); share of grants in the total municipal revenues or State financial intervention ratio, % (r_7); transfers per capita, EUR/capita (r_8). The study assumes that two revenue indicators – State financial intervention ratio R_7 and transfers per capita R_8 – have a minimising character (dampening effect on the FA), while the remaining indicators have a maximising character (a driving effect on the FA).

The selected revenue indicators were transformed into dimensionless values and normalised using vector normalisation according to the formula (Simanavičienė, 2011; Ginevičius, Podvezko, 2008; Podvezko, 2008; Hwang, Yoon, 1981):

$$\widetilde{p}_{ij} = \frac{r_{ij}}{\sqrt{\sum_{i=1}^m r_{ij}^2}} \quad (1)$$

It was decided to consider all the relative indicators reflecting the FA of rural municipalities as equally important in the study. The objective significance of the revenue indicators was determined by the Entropy approach according to the formulas (Simanavičienė, 2011):

$$E_j = -k \cdot \sum_{i=1}^m p_{ij} \ln p_{ij}, \quad (i = \overline{1, m}; \quad j = \overline{1, n}), \quad \text{where } k = \frac{1}{\ln m} \quad (2)$$

The entropy value varied within the interval $[0,1]$, hence $0 \leq E_j \leq 1$.

The variation level of the j -th indicator was determined by calculating the revenue indicators:

$$d_j = 1 - E_j, \quad (j = \overline{1, n}) \quad (3)$$

$$q_j = \frac{d_j}{\sum_{j=1}^n d_j}, \quad (j = \overline{1, n}) \quad (4)$$

Here: q_j – objective significance values of the indicators.

The calculated objective significance values of the revenue indicators enabled the researchers to make a decision on the significance and importance of the respective indicator in the empirical study.

Next, the distance between the positive and negative ideal decision for each rural municipality was calculated. The positive, i.e. ideally best, point was calculated according to the formula (Hwang, Yoon, 1981; Simanavičienė, 2011):

$$A^+ = \left\{ \left(\max_i v_{ij} \mid j \in J \right), \left(\min_i v_{ij} \mid j \in J' \right) \mid i = \overline{1, m} \right\} = \{a_1^+, a_2^+, \dots, a_n^+\}, \quad (5)$$

where: J is the set of indices for the indicators with higher values as a more preferable option;

J' is the set of indices with lower values as a more preferable option.

Negative ideal variant was determined according to the formula (Hwang, Yoon, 1981; Simanavičienė, 2011):

$$A^- = \left\{ \left(\min_i v_{ij} \mid j \in J \right), \left(\max_i v_{ij} \mid j \in J' \right) \mid i = \overline{1, m} \right\} = \{a_1^-, a_2^-, \dots, a_n^-\}, \quad (6)$$

² The methodology by the Organisation for Economic Co-operation and Development (OECD) (1996) defines rural municipalities as the municipalities with more than 50% of the population living in rural-type residential areas.

^{3,4} These indicators are essential in the foreign researchers' empirical studies and are particularly reflective of the FA level of local governments. Meanwhile, in Lithuania, the challenge in calculation of these indicators is caused by legal limitations due to the absence of a clear definition of own revenues. Therefore, in the empirical study, own revenues are defined as tax and non-tax revenues.

Following the calculation of the positive ideal and the negative ideal variant, the distances of each rural municipality to the positive ideal decision on development (A^+) and the negative ideal decision (A^-) was determined in n-dimensional Euclidean space according to the formulas (Hwang, Yoon, 1981; Simanavičienė, 2011):

$$L_i^+ = \sqrt{\sum_{j=1}^n (v_{ij} - a_j^+)^2}, (i = \overline{1, m}), \quad (7)$$

$$L_i^- = \sqrt{\sum_{j=1}^n (v_{ij} - a_j^-)^2}, (i = \overline{1, m}), \quad (8)$$

The TOPSIS method (Hwang, Yoon, 1981) was used to combine eight revenue indicators into a single Financial Autonomy Synthetic Index (FASI). The FASI determines the FA level of each rural municipality over the period of interest. This index is mathematically expressed by the formula (Hwang, Yoon, 1981; Ginevičius, Podvezko, 2008; Simanavičienė, 2011):

$$K_i = \frac{L_i^-}{L_i^+ + L_i^-}, (i = \overline{1, m}), \text{ where } K_i \in [0, 1] \quad (9)$$

where: K_i is the TOPSIS score for the i-th alternative, where the best alternative corresponds to the highest K_i value.

L_j^+ – total distance of alternative j to the ideal best variant;

L_j^- – total distance of alternative j to the ideally worst variant.

The revenue ratio-based FA index enabled evaluation of the FA level of municipalities on the scale from 0 to 1. The identified index values were used as the basis for grouping of the rural municipalities into typological classes by the FA level. The quartile method was used to group the rural municipalities into classes by 4 FA levels: high (0,46–0,49), medium high (0,40–0,45), medium low (0,35–0,39), low (0,31–0,34). The quartile method (Standar and Kozera, 2019) was chosen by the authors of the present paper for grouping at their own discretion.

In the empirical study, the spatial analysis of the FA of rural municipalities was performed using the global and local Moran's I statistics methods, and spatial autocorrelation was calculated according to the respective formulas.

The global Moran's I statistics enabled the authors to identify the overall estimate of autocorrelation according to the formula (Anselin, 1995; Kozera, Glowicka-Woloszyn, 2016):

$$I = \frac{N}{S_0} \cdot \frac{\sum_i \sum_j W_{ij} (x_i - \bar{x})(x_j - \bar{x})}{\sum_j (x_j - \bar{x})^2}, \quad (10)$$

where: W_{ij} – spatial weight of the relationship between the i-th and j-th rural municipality (and an element of the 0-1 neighbourhood weight matrix W based on the common border criterion):

$$W_{ij} = \begin{cases} 1, & \text{if the } i - \text{th rural municipality is a neighbour of the } j - \text{th rural municipality} \\ 0, & \text{if the } i - \text{th rural municipality is not a neighbour of the } j - \text{th rural municipality} \\ 0, & \text{if } i = j \text{ (diagonal elements of the matrix)} \end{cases} \quad (11)$$

N – number of rural municipalities in the alternatives studied.

$$S_0 = \sum_i \sum_j w_{ij}, \quad (12)$$

where:

x_i – the value of the dependent or independent variable of the i – th rural municipality;

\bar{x} – mean value of the dependent or independent variable of all rural municipalities;

N is the number of rural municipalities for all the alternatives studied.

A positive and statistically significant estimate of autocorrelation of the global Moran's I statistic enabled the authors to make a clustering decision. Based on the Anselin local Moran's I statistics (*local cluster analysis*), an inverse leverage distance index (*LMiIndex*) was calculated to identify the clusters of spatial objects at local level. Therefore, the Anselin local Moran's I statistics is applied to the individual clusters using the formula (Anselin, 1995; Kozera, Glowicka-Woloszyn, 2016):

$$I_i = \frac{(x_i - \bar{x}) \sum_{j=1}^N W_{ij} (x_j - \bar{x})}{\sum_{j=1}^N (x_j - \bar{x})^2 / N}, \quad (13)$$

where: W_{ij} – the elements of the spatial weight matrix W of the standardised series.

The calculations in the empirical study have led to the formation of local clusters and outliers consisting of rural municipalities with significant Moran's I statistics values: HH – where rural municipalities with high values of FA and FA determinants are surrounded by rural municipalities with similar high values, LL – where rural municipalities with low values of FA and FA determinants share common borders with similar neighbouring rural municipalities, LH – where rural municipalities with low values of FA and FA determinants are surrounded by rural municipalities with high values of FA and FA determinants, HL – where rural municipalities with high values of FA and FA determinants are surrounded by rural municipalities with low values of FA and FA determinants.

The interval of Moran's statistics I values ranged from -1 to +1. The empirical study assessed the extent to which the neighbouring rural municipalities were spatially similar to each other in terms of FA and the endogenous factors of FA. The reliability of the index calculated on the basis of the global Moran's I statistics and the significance of clusters and outliers while Anselin local Moran's I analysis was assessed according to z-scores and p-values where $z < -1.65$ or $z > +1.65$, $p < 0.10$, and the confidence level of 90%.

In order to assess the endogenous potential of rural municipalities to improve their FA, the factors considered to be a special and key endogenous potential of the Lithuanian rural municipalities during the period of interest were selected. The study follows an assumption that the research findings should be used as the basis for decisions on which endogenous factors would enable the improvement of the FA of rural municipalities from the spatial perspective. Based on the scientific literature analysis, 6 endogenous factors were selected to reflect the essential demographic, social, and economic endogenous environment of rural municipalities in Lithuania. The selected factors enabled the researchers to construct a set of variables: *share of the rural population in the total population, %*; *population density at the start of the year, people/1 km²*; *employment rate (men and women aged 15-64), %*; *share of persons employed at active enterprises at the start of year, %*; *wage (gross), EUR/month*; *the average size of the farmer's farm holding, ha*. The empirical study employed the mean values of the endogenous factors for the period 2009–2019.

The Moran's I statistics analysis and spatial mapping of the rural municipalities were performed using the ArcGIS tool of the geographic information systems. This tool enables the researchers to identify the spatial differentiation of rural municipalities from the perspective of the FA determinants. In general, researchers in Lithuania do not use of ArcGIS tool actively in the financial and economic studies of municipalities.

Tree-based modelling exploratory technique was employed in order to analyse the FA determinants of the rural municipality. Following the assessment of the endogenous factors of FA of the rural municipality, the tree-based modelling exploratory technique was further used in relation to the improvement of the FA. Tree-based models offer an alternative to linear and additive models for regression problems, and to linear and additive logistic models for classification problems. Tree models are fit by successively splitting the data to form homogeneous subsets. The result is a hierarchical tree of decision rules useful for prediction or classification⁵.

The empirical study to assess the revenue indicators of FA of rural municipalities and the determinants thereof was based on the data on the respective rural municipalities for the period 2009-2019 provided by the Statistics Lithuania (the Department of Statistics of the Republic of Lithuania) and the database of the State Enterprise Centre for Agricultural Information and Rural Business.

4 Empirical study results

Improvement of the FA of rural areas and the rural municipalities representing the interests thereof has been of the major issues in the country's regional policy in recent. The statements and assessments by the policy-makers, economists, and researchers have been emphasizing the challenges of rural areas linked to the highly deteriorating demographic and changing social and economic situation. Lithuania's national documents implementing the new CAP policy by 2027 provide for various objectives and measures to improve the demographic, social, and economic environment. These are strengthening of the viability of rural areas, reduction of migration from rural areas, promotion of entrepreneurship, implementation of innovation, diversification of economic activities, cooperation and the use of opportunities for cooperation, etc. Nonetheless, the financial situation of rural municipalities is affected by negative demographic, social, and economic changes. In this context, the national documents of the Republic of Lithuania, such as the programme of the Government (2020), the Ministry of Finance Programme for the Development of Sustainable Public Finances for 2021-2030 (2022), refer to the FA of municipalities as a challenge due to the low capacity of municipalities to increase their budget revenues.

Therefore, the empirical study was aimed at assessing the endogenous factors of FA in rural municipalities and identifying their spatial impact on the improvement of FA.

There are 10 regions in Lithuania: Alytus, Marijampolė, Panevėžys, Kaunas, Klaipėda, Šiauliai, Tauragė, Telšiai, Vilnius, Utena, with 36 rural municipalities out of the total of 60 municipalities. The rural municipalities cover two-thirds of the territory of Lithuania. The rural municipalities are depicted in green on the map (see Figure 1).

Following the objective significance (q_n) of the revenue indicators of FA of the rural municipalities under the analysis, the following indicators were found to have the highest weights: non-tax revenues per capita, EUR (r_6) – 0.333 (q_6); PIT per capita, EUR (r_1) – 0.195 (q_1); own revenues per capita, EUR (r_4) – 0.181 (q_4); tax revenues per capita, EUR (r_2) – 0.174 (q_2); PIT in the total municipal revenues, % (r_3) – 0.033 (q_3); transfers per capita, EUR (r_8) – 0.031 (q_8); share of grants in the total municipal revenues, % (r_7) – 0.027 (q_7); share of own revenues in total revenues, % (r_5) – 0.026 (q_5).

⁵ S-PLUS® 8 for Windows® User's Guide, Insightful Corporation, Seattle, WA. (2007). Available online <http://www.stat.rice.edu/~dobelman/courses/SPlus8usersguide.pdf>

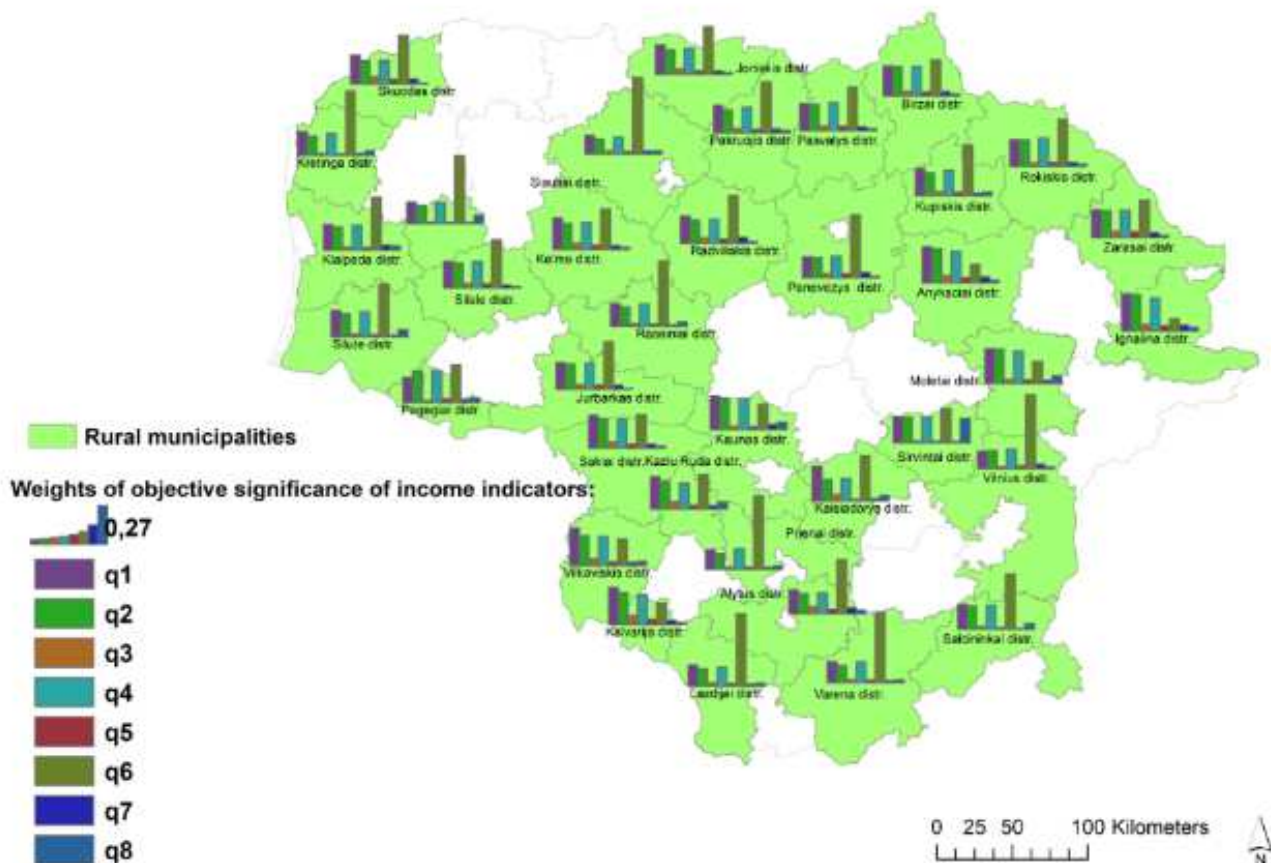


Fig. 1 Significance of the weights (q_i) of the revenue indicators of FA of Lithuanian rural municipalities in 2009-2019
Source: made by the authors.

The findings suggested that the most significant revenue indicators were the same for all rural municipalities: non-tax revenues per capita (q_6); PIT per capita (q_1); own revenues per capita (q_4); and tax revenues per capita (q_2), accounting for the highest share in the overall structure of the indicators (see Figure 1).

Local government budgets in Lithuania consist of tax revenues, non-tax revenues, and state budget grants. It should be noted that PIT is one of the major sources of revenue for the Lithuanian municipalities⁶ and the main source of financing the autonomous functions of the municipalities. However, according to the OECD, it is classified as a general-purpose grant (OECD, 2020) as it is redistributed and used for fiscal equalisation. Lithuanian municipalities cannot use this tax autonomously to meet their own needs, even though it accounts for the largest share (83% on average) in the tax revenue structure of rural municipalities, i.e. for almost half of their total budget. The empirical study found that the rural municipalities received an average of EUR 36.70 in non-tax revenue per capita in 2009-2019. In 2019, non-tax revenue accounted for the smallest share in the overall revenue structure (e.g. ranging from 3.08% in Kazlų Rūda municipality to 10.02% in Klaipėda district municipality). This shows that rural municipalities were making very little use of this potential for the improvement of their FA. The empirical study demonstrated a high share of grants in the total revenue of rural municipalities (> 50%). The analysis of the revenue indicators revealed the prevalence of high dependence on centralised redistribution and allocation among the rural municipalities. It could be argued that on the one hand, the empirical findings revealed high dependence of rural municipalities in Lithuania on the centralised redistribution of their own revenues (in particular, in terms of the PIT), which limits their FA. On the other hand, they indicated the issue of the "comfortable dependence" of rural municipalities on centralised redistribution and allocation.

During the period of interest, half (18) of Lithuania's rural municipalities had high (0.46-0.49) and medium-high (0.40-0.45) FA, while the other half (18) had medium-low (0.35-0.39) and low (0.31-0.34) FA. However, in general, the FA of rural municipalities in Lithuania was low, as the rural municipality (in Kaunas district) with the highest FA had the FASI of just 0.49. The spatial distribution of all rural municipalities based on the FA level and individual classes is depicted in the map (see Fig. 2).

⁶ PIT is classified as tax revenues according to the Methodology for Determination of Municipal Budget Revenue.

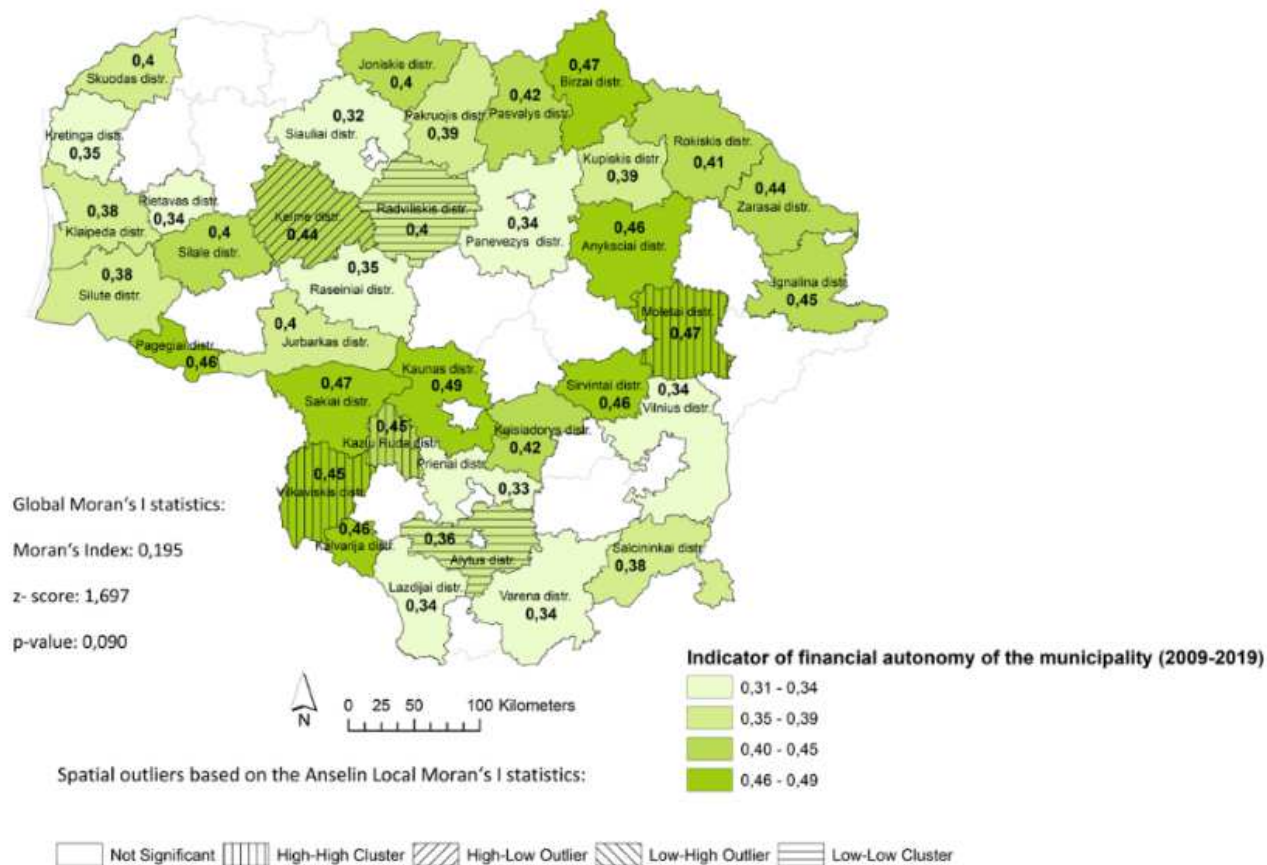


Fig. 2 Spatial distribution of rural municipalities in Lithuania by the FA class, 2009-2019
 Source: made by the authors.

The global Moran's I statistics value for the period 2009-2019 was 0.195 (see Figure 2). This empirical study result showed positive and statistically significant spatial autocorrelation. The statistical significance was supported by the transformed value of the inverse index of the global Moran's I statistics (*LMI-Index*) into the z-score and p-value of statistical confidence. The z-score of the Moran's I statistics was 1.697, which fell within the interval of critical values 1.65-1.95. The Moran's I statistics were 90% positively significant in the interval at $p < 0.10$. The result served as the basis for making the decision on the clusters of spatial dependence of rural municipalities sharing similar FA value patterns.

The empirical study identified the HH cluster, which consisted of the rural municipalities of Vilkaviškis district (high FA), Kazlų Rūda (medium-high FA), and Molėtai district (high FA), which were surrounded by the municipalities with high FA values. The rural municipalities of Vilkaviškis and Kazlų Rūda were concentrated in Marijampolė region distinguished by its natural resources. The region is characterised by a well-developed food, beverage, textile, furniture, chemical, metal and woodworking industry, and transport logistics system. The municipality of Vilkaviškis is characterised by land of good economic value. This is the reason behind farmers' active engagement in agricultural activities and specialization in the development of crop, livestock, horticultural and agricultural production. Therefore, the rural municipalities of Vilkaviškis and Kazlų Rūda, which are part of this region, have excellent spatial opportunities to develop bioeconomy by cooperating with each other, and develop businesses in the fields of food and timber production and woodworking, and improving their FA by pooling common local resources. The rural municipality of the HH cluster in Molėtai district (medium-high FA) was surrounded by rural municipalities with high FSSI values. Molėtai district municipality belongs to Utena region of Eastern Lithuania characterized by a concentration of the industries producing beverages, knitwear and textiles, wood and metal products. At the same time, both the region and the rural municipality of Molėtai district located within the former are distinguished by their landscapes, natural cultural resources, such as mounds, the abundance of lakes. As a result, unique local tourism is developed in these areas. In summary, as the leader of the region, Molėtai district municipality has excellent opportunities to develop the bio-economy business in the fields of the light industry, food industry, timber and wood products and tourism in the future. This could be implemented together with other nearby municipalities that, despite not being a part of the cluster, have medium-high FA level, by pooling the resources of the adjacent municipalities and improving the FA.

The HL cluster included the rural municipality of Kelme district in the medium-high FA class. Nonetheless, it was surrounded by rural municipalities with low and medium-low FA. The rural municipality of Kelme district is a part of Šiauliai region, the economy of which is not much oriented on exports. However, the region specializes in trade, transport, catering services, industry and manufacturing, which offer excellent opportunities for the development of smart manufacturing. The rural municipality of Kelme still has a strong position in transport

logistics, i.e. road and rail transport of a wide range of items such as crushed stone, timber, building materials, mineral fertilisers, and liquid fuels.

The study also identified the LL cluster, which included rural municipalities of Alytus and Radviliškis districts characterized by medium-low FA. The two municipalities are not adjacent. However, these rural municipalities were surrounded by municipalities with medium-low and low FA and low FSSI values. Alytus district municipality is located in the southern part of Lithuania, in Alytus region. The region is characterized by its tourism, recreational and natural resources. The land, however, is low-yield and forested heavily. Only one-third of the land in Alytus region is suitable for conventional agriculture. The region cultivates cereals, potatoes, various vegetables and develops meat and dairy animal husbandry. This enables the farmers of the region to develop nursery, herb and spice farming, and ancillary businesses. Some of the region's inhabitants are involved in berry and mushroom picking. In terms of the level of economic development, Alytus region lags far behind the national average. It accounts for only 3.5% of Lithuania's GDP. The other municipality in the LL cluster, the rural municipality of Radviliškis district, is located in Šiauliai region, the characteristics of which are described above. However, the rural municipality of Radviliškis district has competitive advantages in the trade, transport, catering services, agricultural processing and manufacturing sectors.

The analysis of the spatial distribution of rural municipalities and assessment of the local Moran's I statistics value demonstrated a vast majority of closely located rural municipal clusters belonging to the same FA classes. Therefore, the H1 hypothesis may be claimed to have been confirmed.

The Moran's I statistics technique was then used in the study to group the rural municipalities into separate clusters according to the endogenous factors that were indicative of the spatial characteristics. According to a number of researchers, the demographic factors of the environment are the key determinants of the FA of rural municipalities and of rural development. The assessment of demographic factors determining the FA of rural municipalities in Lithuania revealed the issue of low demographic potential in all rural municipalities. During the period 2009-2019, the majority of rural municipalities experienced an absolute demographic crisis. The population declined by an average of 15% over 11 years. In 17 municipalities, the population declined by more than 20%, e.g. Pagėgiai (25.9%), Pakruojis district (25%), Kelmė district (25.1%), Joniškis district (24.8%), Ignalina (23.4%), Biržai (23.2%), etc. During the period of interest, the population grew in only two rural municipalities in Lithuania: Kaunas district municipality (10.9%) and Vilnius district municipality (2.9%). These figures indicate the particular lack of human capital in the rural municipalities, while it is the human capital that is the basis for carrying out activities, promoting entrepreneurship and developing certain sectors of rural businesses and activities.

In addition, most rural municipalities had a very low population density, below the national average. According to the Statistics Lithuania, the average population density in Lithuania was 42.8 inhabitants per km² in 2019⁷. Over 11 years, the population density was declining in individual rural municipality classes. The greatest decline in population density (from 21.3 inhabitants/km² to 17 inhabitants/km²) of 20.2% was observed in the class of medium-high FA. The decrease in the other FA classes was as follows: class I – 12.9%; class III – 15.7%; class IV – 12.6%. Although the highest population density was found in rural municipalities in the western part of Lithuania in Klaipėda region, they were the least financially autonomous. The share of the rural population in the total population varied considerably from municipality to municipality (see Fig. 3).

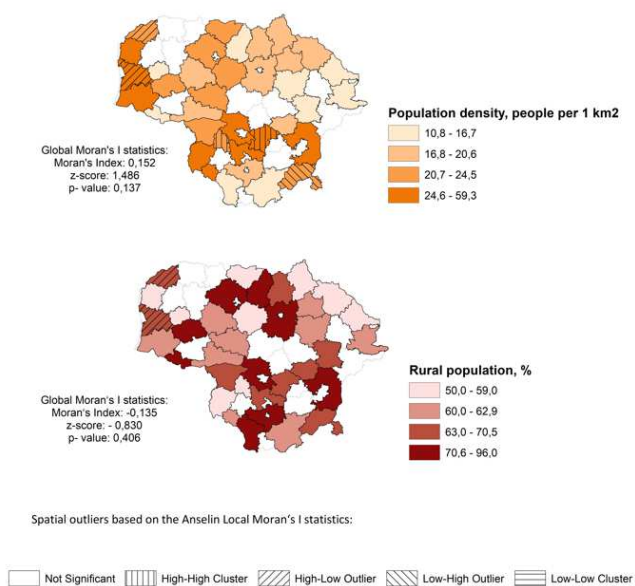


Fig. 3 Shares and spatial pattern of clusters and outliers set by factors of demographic environment (population density (number of people per km²), share of rural population, %) in the Lithuanian rural municipalities in the period 2009-2019
Source: made by the authors.

⁷ Lietuvos Respublikos Statistikos Departamentas (Department of Statistics of the Republic of Lithuania). (2020). Available online <https://osp.stat.gov.lt/statistiniu-rodikliu-analize/> (accessed on 28 April 2022). (In Lithuanian).

In summary, between 2009 and 2019, five rural municipalities formed statistically significant clusters and outliers in terms of population density:

HH cluster in Southern Lithuania: Kaišiadorys district municipality belonging to the medium-high FA class and characterised by high population density; Kazlų Rūda municipality belonging to the medium-high FA class and characterised by medium high population density. These rural municipalities bordered the municipalities with similar values of demographic factors.

HL outliers in Western Lithuania: Klaipėda district municipality and Skuodas district municipality belonging to the medium low FA class, with high and medium high values of population density. They were surrounded by rural municipalities with low and medium low FA and high population density. In terms of the rural population, these municipalities were also statistically significantly interrelated and formed the HL cluster.

LH outliers in Eastern Lithuania: Šalčininkai district municipality belonging to the medium low FA class and having medium high population density borders with Varėna municipality. The latter had low population density and belonged to the low FA class. The municipality of Vilnius district located on the other side was characterised by high population density.

In summary, the findings of the study showed that the FA of rural municipalities belonging to high FA and medium FA classes were negatively affected by low population density during the period 2009-2019.

In terms of the social environment, the employment rate was the highest in the rural municipalities of Klaipėda region in Western Lithuania and the lowest in the rural municipalities of Southern and Northern Lithuania. 8 municipalities were separated in significant clusters or outliers by the employment rates (see Fig. 4).

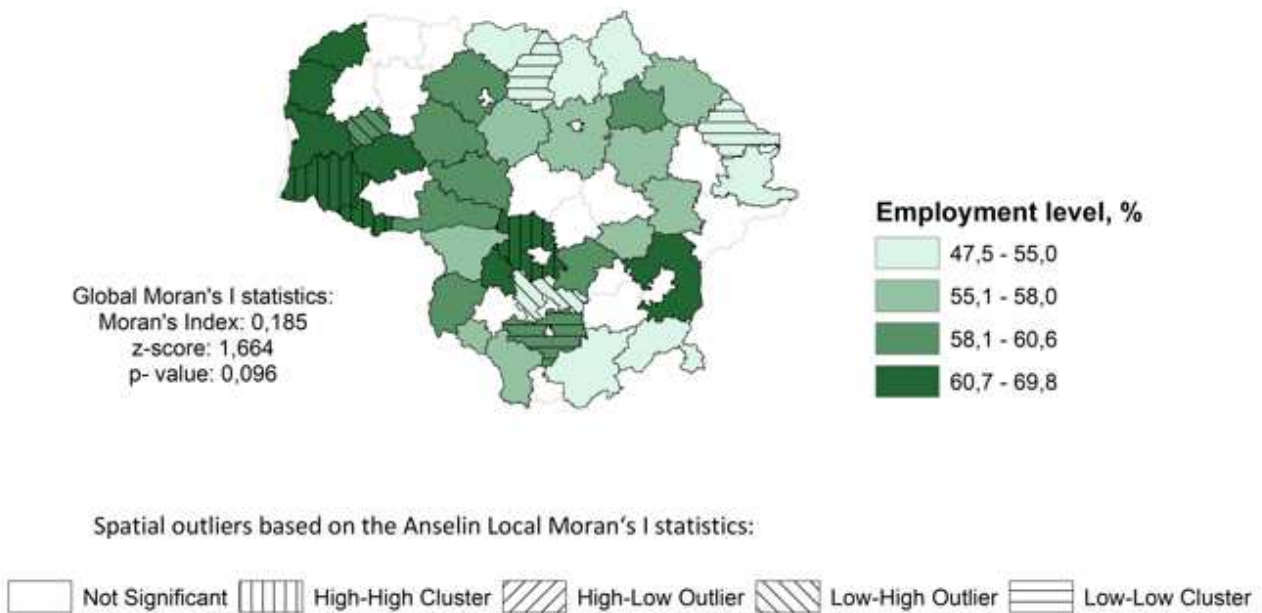


Fig. 4 Shares and spatial pattern of clusters and outliers set by social environment factor (employment rate, %) in rural municipalities in Lithuania, 2009-2019
Source: made by the authors.

The HH cluster consisted of Šilutė district municipality located in Western Lithuania, which belonged to the medium low FA class, and Pagėgiai municipality, which belonged to the high FA class. These municipalities were surrounded by other municipalities which also had a high level of employment but were characterised by medium low level of FA due to low wages.

The LH outliers consisted of Rietavas municipality in Telšiai region of Western Lithuania, which belonged to the low FA class, but had medium high to high level of employment; it borders the rural municipalities with high level of employment. The cluster also included Prienai district municipality of Kaunas region of Southern Lithuania. It belonged to the low FA class and had low level of employment. These rural municipalities bordered on municipalities with high employment values.

The LL cluster consisted of three rural municipalities: Alytus district municipality with medium low FA level, located in Alytus region of Southern Lithuania; Pakruojis district municipality with medium low FA level, located in Šiauliai region of Northern Lithuania; and Zarasai district municipality with medium high FA level, located in Utena region of Eastern Lithuania. These municipalities were characterised by low employment rates and bordered the municipalities with low and medium low employment rates.

In general, the study findings suggested that employment rate as a factor of social environment had a positive impact only on the FA of rural municipalities in Class I (high FA level).

Assessment of the factors of the economic environment showed a positive factor influencing the FA of rural municipalities: the share of employees at operating enterprises located in the territory of rural municipalities. The assessment of the economic environment factors according to the local Moran's I statistics revealed various statistically significant clusters and outliers (see Fig. 5).

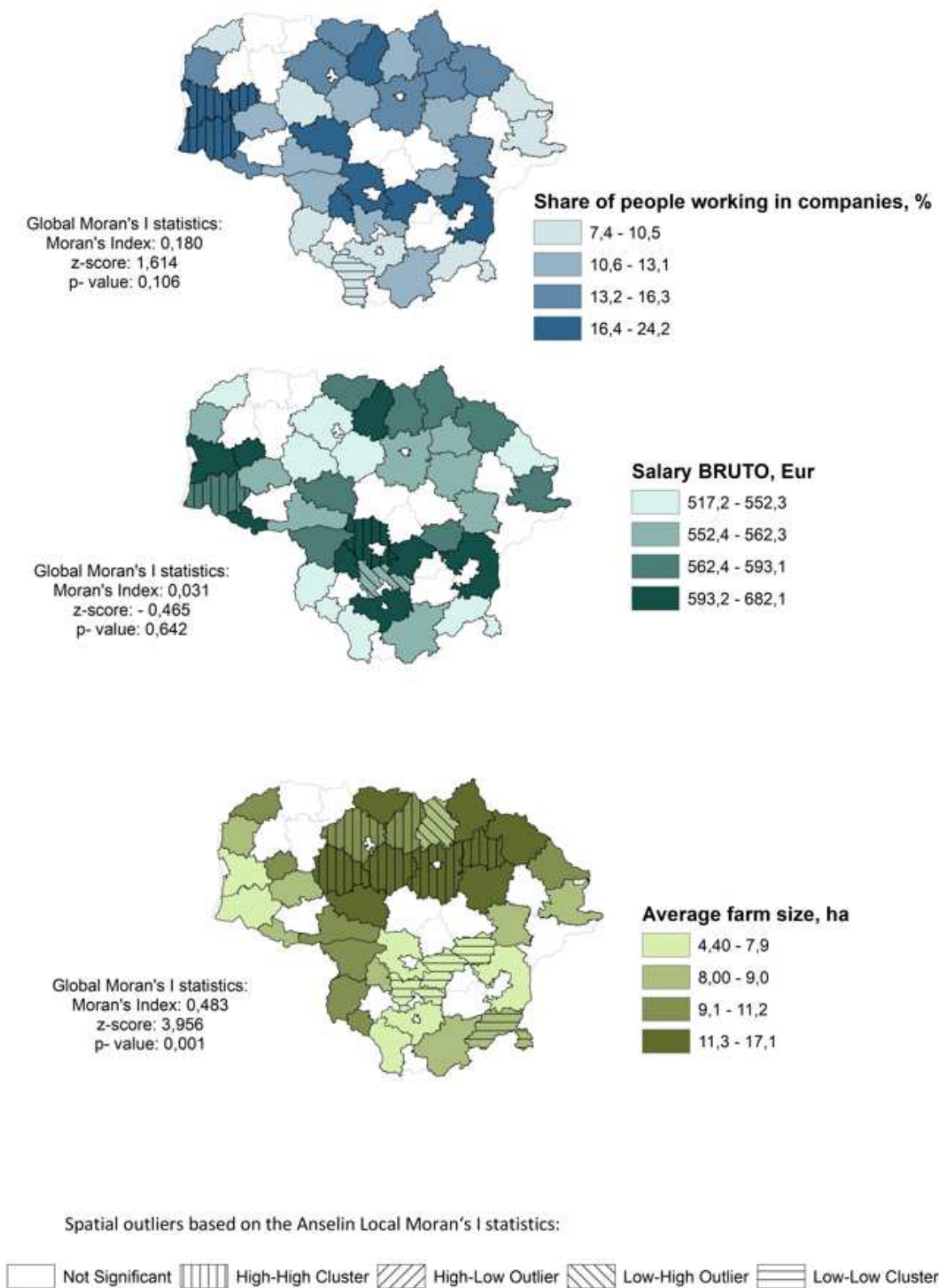


Figure 5. Shares and spatial pattern of clusters and outliers set by economic environment factors (share of employees in active enterprises, %; gross wages, EUR/month; average farm size, ha) in rural municipalities in Lithuania, 2009-2019
Source: made by the authors.

In summary, the study findings have suggested that the FA of rural municipalities depends, to a large extent, on endogenous factors, which are influenced by the public finance policy of the state and sustainable measures of the Common Agricultural Policy, which determine the conditions for local entrepreneurship and local farming. Therefore, according to the results of the study, it is primarily important to exploit the available natural resources in the rural municipalities of Lithuania with prevailing high-yield land and the largest concentration of farmers' farms in terms of the average size of farms. As suggested by the study results (see Figure 5), statistically significant clusters of HH rural municipalities (Panevėžys district municipality, Kupiškis district municipality, Radviliškis district municipality) with the largest average size of farmers' farms (from 11.3 to 17.1 ha) are forming in the northern part of Lithuania, as they are characterised by the predominance of high-yield land and well-developed agro-logistics infrastructure. These rural municipalities can develop not only productive agricultural activities among themselves, but also multifunctional agricultural activities and, in particular, bio-economy businesses.

The endogenous factors were identified by the tree modelling technique and were used to identify the opportunities for increasing the FA of rural municipalities. The Lithuanian case study shows that the FA of a rural municipality can be predicted on the basis of the population composition (share of rural population, %) and the average farm size (see Fig. 6).

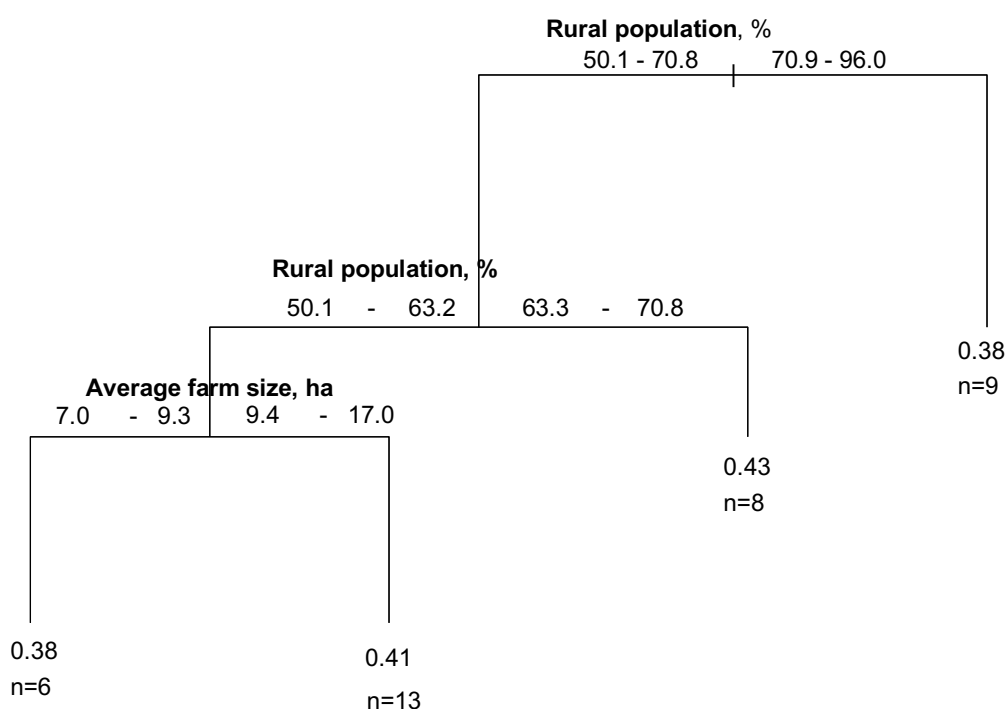


Fig. 6 The importance of FA factors of the rural municipality (the regression tree model, n - number of rural municipalities). Regression tree branch size is proportionate to node deviance
Source: made by the authors.

The results of the study show that the large rural population is a restraining factor for the FA of rural municipalities. This means that a lower share of rural population in the total population (less than 70.8%) could have contributed to the improvement of the FA of Lithuanian rural municipalities. Hence, in the case of Lithuania, the basis for improvement the FA of rural municipalities is the assurance of an optimal ratio of rural population to the population engaged in non-rural business activities (63.3 to 70.8% of the rural population). As mentioned above, rural municipalities in Lithuania are characterised by their agricultural activities, and larger farmers' farms are the foundation for greater FA. Assurance of the consolidation of farm holdings (agricultural consolidation projects, etc.) would therefore enable improvement of the agricultural conditions and FA of rural municipalities as well. However, the improvement of FA does not automatically solve the issues of the lack of endogenous potential, nor does it address the interests of sustainable development of rural areas, in the absence of strategic orientation of the central government towards regional development. In addition, rural municipalities themselves need to provide for common interventions both to attract, retain and develop the endogenous potential and to improve their FA.

Since demographic, social, economic endogenous factors are interrelated and interdependent, it can be argued that diversification of rural economic sectors in Lithuania's rural municipalities, with a spatial focus on the development of agro-processing industries and bio-economy businesses, may have a positive effect in terms of job creation. At the same time, it may assure that the population's search for financial and livelihood wealth and opportunities in a certain municipality is well served by the creation of the right environment for the development

of businesses. In particular, given that Lithuania's rural municipalities are less distant from each other and therefore are very similar in their environment. Cooperation between rural municipalities (and between municipalities of different regions, if they border each other) would positively influence attraction of new population from the cities as well as attraction and retention of the youth, in particular, with regard to human potential and well-being. The rural municipalities should therefore focus on the creation of favourable conditions for the development of entrepreneurship for the rural population, seeking joint investment for the development of bio-economy businesses, pooling common competitive advantages and creating value rather than on the receipt of grants and "comfortable dependence" on centralised redistribution and allocation. The above-mentioned interventions would enable improvement of the FA of rural municipalities, thus generating own tax revenues (especially the PIT, which would strengthen the FA of rural municipalities in terms of revenue if it is considered as own municipal funds based on the legislation) and non-tax revenues (e.g. property income).

However, further spatial modelling studies and detailed evaluation of their results are needed to further substantiate the potential of cooperation between individual municipalities from the spatial perspective for the purpose of improvement of FA and facilitation of important financial decisions by the central government on support and assistance for both the leading and the lagging municipalities.

5 Conclusions

The study dealt with the analysis of the FA of rural municipalities in Lithuania and the determining endogenous factors from the spatial perspective. The findings of the study are of practical use, as they enable the decision-makers at both central and local governments to manage the spatial endogeneity of rural municipal relations and to improve the FA at the local government level.

The FASI based on selected relative revenue indicators enabled the assessment of the level of FA of rural municipalities in Lithuania on the scale from 0 to 1 using the TOPSIS method. The closer the value of the FA index is to 1, the higher the FA of a rural municipality. On the basis of TOPSIS, rural municipalities were divided into classes according to 4 levels of FA: high, medium high, medium low, low. Rural municipalities were equally distributed in terms of their level of FA during the assessment period 2009-2019, with 9 municipalities in each of the FA levels. However, in general, Lithuania's rural municipalities were characterised by low FA level during the period under analysis. During this period, the highest FASI was in Kaunas district municipality – 0.505 (2012), the lowest – in Šiauliai district municipality – 0.294 (2018, 2019). This means high dependence of the municipalities on the centralised allocation of funds and the redistribution of their own revenues (in particular, the PIT).

The common autocorrelation estimate of the global Moran's I statistics showed the positive spatial correlation between the FA of rural municipalities. Following the verification of the statistical significance of the obtained values, it was decided to form the clusters of the rural municipalities sharing similar values of FA and endogenous factors. Different types of clusters or outliers were formed according to the study results: HH, LL, LH, HL. According to the findings, the rural municipalities with high FA comprise the clusters (HH), which mainly include not only the first, but also the second and third rings around the major cities of regions in Lithuania (Vilnius, Kaunas, Klaipėda, Šiauliai, and Panevėžys). The study also identified the economically underdeveloped clusters of low FA (LL) located in the western and southern parts of the country.

During assessment of the impact of endogenous factors on the FA of rural municipalities, statistically significant clusters emerged in different regions of Lithuania. Their cooperation would help solve the issues of the demographic environment of rural areas, improve the social environment, and strengthen the economic environment. The local Moran's I statistics highlighted the strongest spatial clusters of rural municipalities in Lithuania in terms of their endogenous potential, concentrated in the regions rather than around the major regional cities (Vilnius, Klaipėda, Šiauliai and Panevėžys). One of the rural municipalities of Kaunas region with the highest FA (mean FASI of 0.488 in the assessment period) was located next to Kaunas, one of the largest cities in the region. This rural municipality is characterised by rapid population growth and the development of the local economy. The strongest rural municipalities in terms of endogenous potential, i.e. characterised by the largest farmers' farm holdings, are those located in the northern part of Lithuania.

The authors' research has led to the confirmation of the hypotheses. It has demonstrated that the rural municipalities that are geographically close to each other are homogeneous in terms of FA. The global Moran's I statistics and the tree modelling technique have also revealed that the FA of rural municipalities depends mainly on the endogenous demographic factor – the share of the rural population, and the economic factor – the number of farmers' farm holdings, what relates to better agricultural conditions in fertile land areas.

In the case of Lithuania, increasing the FA of rural municipalities is important in order to maintain an optimal ratio of rural to non-rural population and to ensure the consolidation of farmers' farm holdings. Tree modelling can be used to forecast the endogenous potential of rural municipalities for the FA, which is the basis for its improvement.

It is worth to continue searching and combining other determining endogenous factors and their indicators for the improvement of municipalities FA while considering social, economical, nature resources context, combining spatial autocorrelation and regression tree methods suitable for decision support.

The results of this empirical study are useful for rural municipalities themselves enabling them to compare their own financial situation with that of municipalities in other countries, and for central government representatives in making strategic decisions on rural and regional development and local public finance. The development of such studies at the national level is therefore an important prerequisite for the sustainable operation of municipalities and socio-economic development of the regions.

Declarations

Conflict of interest None.

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