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Milan Stamenković
University of Kragujevac
Faculty of Economics
Department of Informatics and Quantitative Methods

Marina Milanović
University of Kragujevac
Faculty of Economics
Department of Informatics and Quantitative Methods

Petar Veselinović
University of Kragujevac
Faculty of Economics
Department of General Economics and Economic Development

STATISTICAL ESTIMATION OF ECONOMIC DEVELOPMENT INEQUALITIES AT MUNICIPALITY LEVEL: THE CASE OF SERBIA

Statistička ocena ekonomskih razvojnih nejednakosti na nivou opština u Srbiji

Abstract

Starting from its importance, as a valuable source of information in strategic planning of balanced regional development, the issue of measurement of achieved economic development level of local administrative territorial units (i.e. LAUs), represents the subject of this research. Using municipalities in the Republic of Serbia as a working basis, the following objectives are formulated: first, the creation of factor analysis based statistical model, in the form of composite indicator (i.e. Index of Economic Development – IED) for measuring the economic development level of LAUs within state, and second, the creation of a MANOVA evaluated IED-based classification of observed municipalities into internally homogeneous and externally heterogeneous groups, for identifying the extent of present regional economic disparities. The main contribution of this research is reflected in a clear and detailed demonstration of statistically valid, combined application of selected multivariate methods in regional economic development research. Created classification of LAUs confirms the well-known statement regarding the presence of pronounced regional and intra-regional polarization in Serbia, primarily in direction "developed north – underdeveloped south". Proposed composite indicator and, on its values based, classification of LAUs can provide information useful for decision makers and experts in the field of planning and implementation of regional development strategy.

Keywords: *factor analysis, MANOVA, composite indicator, economic development level, regional inequalities, municipalities, Serbia*

Sažetak

Polazeći od njegovog značaja kao dragocenog izvora informacija u strateškom planiranju ravnomernog regionalnog razvoja, pitanje merenja dostignutog nivoa ekonomske razvijenosti jedinica lokalne samouprave (JLS) predstavlja predmet ovog istraživanja. Korišćenjem opština u Republici Srbiji kao radne osnove, formulisani su sledeći ciljevi: prvi, kreiranje statističkog modela zasnovanog na primeni faktorske analize, u formi odgovarajućeg kompozitnog indikatora (Indeks ekonomske razvijenosti – IER) za merenje nivoa ekonomske razvijenosti opština u sastavu države, i drugi, kreiranje, MANOVA metodom evaluirane, IER zasnovane klasifikacije posmatranih opština u interno homogene i eksterno heterogene grupe, namenjene identifikavanju razmera prisutnih regionalnih ekonomskih dispariteta. Glavni doprinos sprovedenog istraživanja ogleda se u jasnoj i detaljnoj demonstraciji statistički validne, kombinovane primene odabranih multivarijacionih metoda u istraživanju regionalne ekonomske razvijenosti. Predložena klasifikacija jedinica lokalne samouprave potvrđuje dobro poznatu konstataciju o prisustvu izražene regionalne i unutar-regionalne polarizacije u Srbiji, primarno na relaciji "razvijeni sever – nerazvijeni jug". Predloženi kompozitni pokazatelj i, na njegovim vrednostima zasnovana, klasifikacija JLS-a mogu obezbediti informacije korisne za donosioce odluka i eksperte u domenu planiranja i sprovođenja strategije regionalnog razvoja.

Ključne reči: *faktorska analiza, MANOVA, kompozitni indikator, nivo ekonomske razvijenosti, regionalne nejednakosti, opštine, Srbija*

Introduction

One of the most important, but also complex socio-economic problems, that development policymakers face today is related to inequalities in the development of regional (RAU) and local (LAU) administrative territorial units within a particular state.[1] This statement stems from the fact that pronounced disparities in development level of RAUs/LAUs can have a serious (negative) impact on socio-political stability of particular state [5] and performance of the national economy. Since economic development of regions is a basis for realization of national economic goals [10], achieving intensive growth and sustainable economic development of the country necessarily implies respect for the concept of regional equality, i.e. undertaking activities aimed at balancing the level of development of all its regions, and thus the well-being of all its inhabitants [8]. Creating conditions for the establishment of balanced regional development is a priority task of every state and a key step in efforts to ensure the successful integration of the national economy into global economic flows. In this context, objective assessment and "measurement" of the achieved development level and categorization of RAUs/LAUs, with consideration of different dimensions of their development potentials and limitations, is an important source of information in strategic planning of balanced regional development and effective implementation of formulated measures and policies. In the relevant literature, as the main and most frequently used, for quantifying the extent of regional disparities, the following development dimensions are highlighted: economic, infrastructural, social, environmental, demographic and educational. Each of these dimensions can be considered as a separate multidimensional latent variable, whose "measurement" is usually performed indirectly, based on simultaneous analysis of values and relationships between several, in terms of specific dimensions, representative, directly measurable, numerical indicators [15]. Without diminishing the importance of other dimensions, when assessing the level of regional development, it is necessary to emphasize the dominant role of economic dimension [25], which best illustrate the extent of regional/local inequalities, because "without economic parity there is no national and regional equality" [27]. Also, quantitative research conducted at lower levels of territorial aggregation provides the best insight into the magnitude of development asymmetry and regional (under)development [16]. According to the emphasized multidimensionality of regional development concept and individual development dimensions, the quantification of achieved development level of territorial units is a demanding and difficult task. Due to multiple-multidimensionality, its realization has led to the shift of analytical framework from monitoring a large number of individual indicators of different development dimensions to the development and implementation of various methodological procedures based on exploitation of application potentials of multivariate analysis methods. Used individually or combined, these statistical methods enable measurement of the degree of development of specific territorial units (mainly through the development of adequate composite indicators) and their classification into internally homogeneous and externally heterogeneous clusters, according to the available potentials and development constraints.

Accordingly, as the main scientific motives for the realization of this research, the following stand out: (1) demonstration of the application potential of multivariate statistical methods in researching the structure and modelling of relations between indicators of regional economic inequalities, as a specific multidimensional economic phenomenon; (2) overcoming the immanent limitations of composite indicators of regional development present in the case of their application to territorial units of LAU level (e.g. poor data quality, data unavailability); (3) "demystification" of the analytical procedures used in the development of composite indicator, primarily initiated by deficiencies mainly present in the studies of a similar type.

Having these in mind the issue of measurement of achieved economic development level of LAUs represents the subject of this research. Using municipalities in the

1 According to the Nomenclature of Territorial Units for Statistics (NUTS), as a specific methodology for the statistical hierarchical classification of sub-national territorial units of the Member States of the European Union, created by the Statistical Office of the EU (EUROSTAT), the state territory is divided into three basic regional levels (NUTS 1, NUTS 2, NUTS 3) and an additional LAU level (Local Administrative Units).

Republic of Serbia as a working basis, in the context of a defined subject, the following objectives have been formulated: first, the creation of a multivariate statistical model, in the form of a composite indicator (i.e. Index of Economic Development – IED) for measuring the achieved level of economic development of LAUs within the state; and second, the creation of a statistically evaluated IED based classification of the observed municipalities into internally homogeneous and externally heterogeneous groups, for identifying the extent of the present regional economic disparities. The main contribution of the research is reflected in a clear, detailed demonstration of statistically valid application of selected multivariate methods in economic development research. The proposed composite indicator and, on its values based, the classification of LAUs provide information useful for decision makers and experts in the field of planning and implementation of regional development strategy.

Research background

The search for quantitative approaches intended for an objective assessment of achieved development level of RAUs/LAUs and consideration of efficiency of the proposed measures for mitigating present disparities belongs to those research topics whose applicative value and social significance are self-evident. In that sense, a particularly attractive research niche of scientific community is the analysis of development level of territorial units within a particular country or group of countries using different combinations of representative indicators of one or more development dimensions and creation of resulting classifications of the observed territories into relatively homogeneous groups [27]. Having in mind their indisputable application potential it is not surprising that the authors rely predominantly on the methods of multivariate statistical analysis in the realization of previously specified research goals. In accordance with the defined objectives of this paper, in Table 1, the key methodological determinants of selected relevant approaches of similar research character are presented. The common denominator of presented studies is the expressed variability, present in terms of the following analytical issues: spatial-temporal scope of analysis, selection of individual indicators and dimensions of development and, finally, applied multivariate method(s).

By analyzing the methodological characteristics of presented studies, it can be noticed that only a small number of authors approach the issue of regional disparities

Table 1: Comparative overview of relevant multivariate research studies

Author(s) / [reference number]	Temporal scope	Territorial units (NUTS / LAU)	State(s)	Development dimension(s)	Multivariate method(s)
Research objective – Classification					
Maletić & Bucalo-Jelić [13]	2012	LAU	SRB	Ec/S/A	FA/CA
Rašić-Bakarić [23]	2001	LAU	CRO	Ec/D/Ed	FA/CA
Rovan & Sambt [25]	2001	LAU	SLO	Ec/D/S/Ed	CA
Brauksa [1]	Mixed	LAU	LVA	Ec/S	CA
Pastor et al. [19]	Mixed	LAU	ESP	Ec/D/S	FA/CA/DA
Mazzocchi & Montresor [14]	1990	LAU	ITA	Ec/D/S/A	PCA/CA
Perišić [20]	‘06–‘08	LAU / NUTS 3	CRO	Ec/D/S/Ed	CA/DA
Polednikova [22]	2010	NUTS 2	V4	Ec/S	CA
del Campo et al. [3]	2003	NUTS 2	EU–25	Ec/D/Ed	FA/CA
Kurnoga-Živadinović [11]	2006	NUTS 3	CRO	Ec/S	CA/FA/DA
Kvičalova et al. [12]	2011	NUTS 3	CZE	Ec/S	CA
Istrate & Horea-Serban [8]	2014	NUTS 3	ROU	Ec	CA
Research objective – measuring development level & classification					
Rovan et al. [24]	2005	LAU	SLO	Ec/D/S/En	PCA/CA
Winkler [30]	2009	LAU	SRB	Ec/D/Ed/S/H	FA
Soares et al. [26]	1995	LAU	POR	Ec/D/S/Ed	FA/CA
Goletsis & Chletsos [5]	‘95/’00/’07	NUTS 2	GRE	Ec/S/Ed/H	FA/CA
Stamenković & Savić [27]	2013	NUTS 3	SRB	Ec	FA/CA

Notes: (Ec) economic, (S) social, (D) demographic, (Ed) education, (En) environment, (A) agricultural, (H) health, (CA) cluster analysis, (PCA) principal component analysis, (FA) factor analysis, (DA) discriminant analysis.

only from the perspective of the economic dimension of development. However, it is important to note that the analysis of a number of different dimensions and related indicators may result in a classification that is strongly influenced by the effects of compensation between individual dimensions, thus preventing a clear view of their individual contribution to the identified position of specific RAUs/LAUs. More precisely, the simultaneous observation of several development dimensions can result in a blurred multidimensional image of the situation in a certain territory in terms of the observed aspects of development. This methodological issue is of particular importance in studies aimed at quantitative assessment of development levels through the construction of appropriate composite indicators (e.g. [5], [24], [26], [27], [30]). A detailed critical review of this, but also other methodological issues of importance in the implementation of composite approach in the analysis of regional disparities was presented by Perišić and Wagner [21] and Cziraky et al. [2].

Data and Methodology

In this section, aspects of the conducted research in terms of the selected variables, sources used, temporal–spatial data coverage, and used methodology framework are presented.

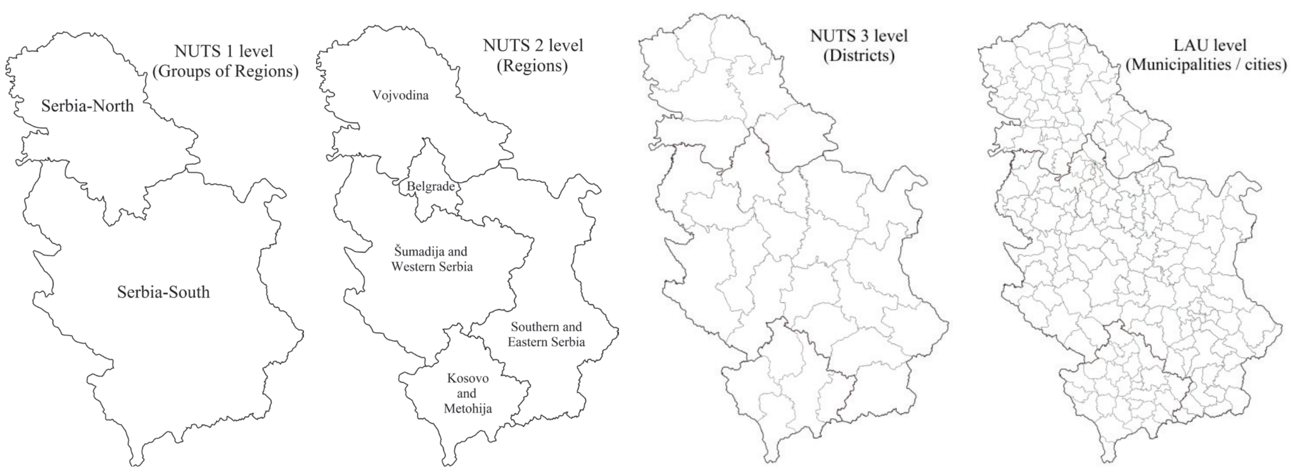
Variables, sources of data and temporal-spatial scope of research

Using the official statistical organization of territory of the Republic of Serbia (RS), based on the NUTS classification (Figure 1), secondary, at the time of realization of the empirical research last available, data for selected four indicators of different aspects of economic development (Table 2) were collected for each of 165 territorial units of LAU level (i.e. municipalities and cities) within the following four (out of a total of five) regions (NUTS-2 level) in the RS, namely: Belgrade Region, Vojvodina Region, Region of Šumadija and Western Serbia, and Region of Southern and Eastern Serbia. Data were obtained from the electronic database of *the Serbian Business Registers Agency* [*http://www.apr.gov.rs/*] and thematic publication of the Statistical Office of the RS (SORS) entitled *Municipalities and Regions of the Republic of Serbia 2016* [28]. All data refer do the year 2015. Since 1999 SORS provides no data for LAUs within the Kosovo and Metohija Region, they are not included in the research.

Table 2: List of used indicators of LAUs' economic development

Symbols	Economic indicators	Measurement units
X_1	Number of enterprises per 1000 inhabitants	number of enterprises
X_2	Employment rate	in %
X_3	Unemployment per 1000 inhabitants	number of unemployed
X_4	Average wage per employee	in RS Dinar

Figure 1: Cartographic representation of territorial organization of the RS



Instead of using the absolute values of selected indicators of economic development, their expression in the form of values (or numbers) per 1000 inhabitants or percentage is performed, in order to neutralize / mitigate the impact of total demographic mass of territorial units on the outcome of multivariate analysis and resulting classification. Besides respecting the research objectives and availability of data for a given level of territorial coverage, the additional justification of the selection of variables is supported by the fact that they represent the most commonly used economic indicators in relevant studies aimed at analyzing regional development level (e.g. [9], [27]).

Research methodology framework

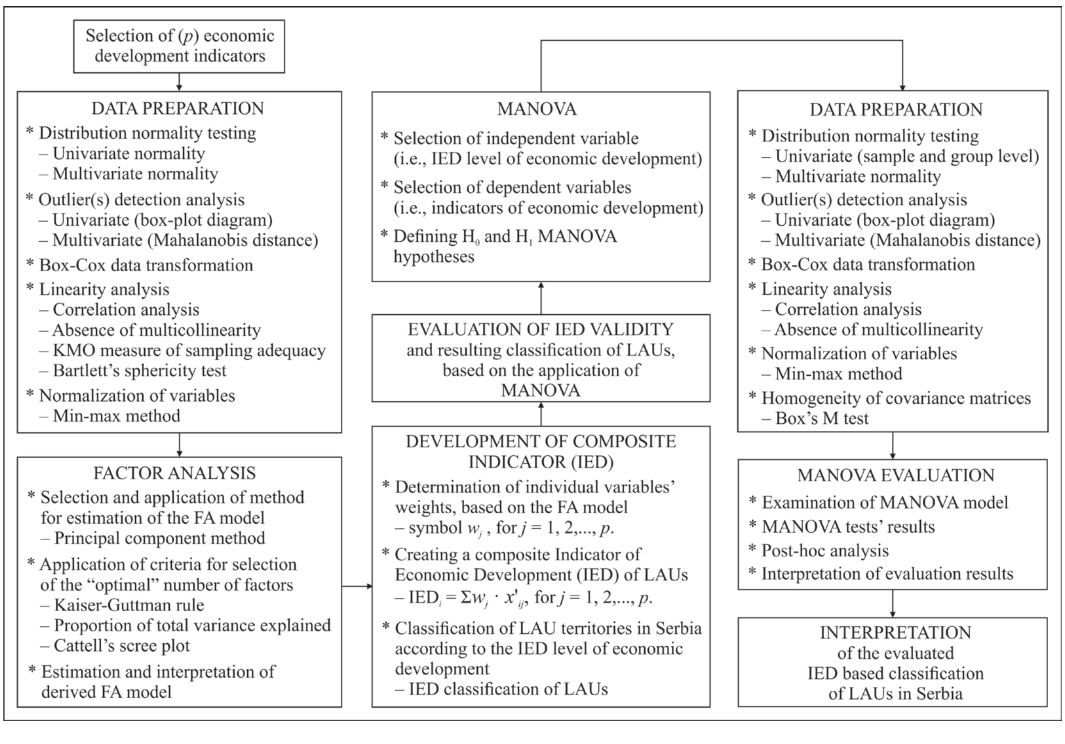
A comprehensive methodology framework, used as a basis for development of a composite (multivariate) model for measuring the degree of economic development of the observed LAUs and, consequently, the realization of formulated research objectives, is presented in Figure 2. It is based on a combined and complementary usage of factor analysis (FA) and one-way multivariate ANOVA method (MANOVA), aimed at examination of interdependencies between individual economic indicators and discovery of "natural", but hidden, latent structure (i.e. economic development level) within the analyzed set of multivariate observations. The application of exploratory FA is based on the assumption that there is at least one non-observable dimension in the basis of quantitative interrelationships of carefully selected indicators of economic development of LAUs, which can be considered as the main "cause" or "most responsible" factor of correlations present between them.

The estimated FA model is used as a basis for development of a composite indicator that provides "indirect measurement" of latent variable of interest. Starting from the estimated one-factor FA model, the isolated common factor is expressed in the form of a linear combination of p indicators and corresponding weight coefficients. The general mathematical expression of the created composite index, called the Index of Economic Development (acronym, IED), is:

$$IED_{(i)} \rightarrow F_{1(i)} = \sum_{j=1}^{p} w_j x'_{ij} = w_1 x'_{11} + w_2 x'_{12} + \ldots + w_p x'_{1p}, \quad (1)$$

where used symbols denote: x'_{ij} – normalized value of j^{th} variable X_j for i^{th} observation unit (for $j = 1, 2, \ldots, p$, and $i = 1, 2, \ldots, n$); $F_{(i)}$ – "estimated value" of extracted common factor (i.e. the IED value) for i^{th} observation; w_j – relative weight of j^{th} variable in the context of the common factor.

Figure 2: Schematic representation of the research methodology framework



The presented composite indicator aggregates the weighted values of individual indicators that represent different aspects of latent target dimension, in order to determine the "estimated values" of a single common factor for each i^{th} observation. This ensures the summarization and conversion of the original multidimensional research problem into a specific and, for understanding, much simpler one-dimensional form, which, as a rule, is "worth" (something) more than a simple sum of constituent parts. The determination of the weight coefficients (w_j) assigned to the individual indicators in expression (1) is based on the structure analysis of the proportion of total sample variance explained by the retained (single-factor) FA solution. The relative importance of indicators is equivalent to the proportion of estimated values of communalities in the explained share of total sample variance (i.e. the eigenvalue λ_1, which corresponds to the extracted common factor F_1), symbolically [4]:

$$w_j = \frac{communality_j}{\sum_{j=1}^{p} communality_j} = \frac{communality_j}{\lambda_1} \,. \qquad (2)$$

This methodological procedure, used in determining the weights, as opposed to the mostly present subjective approach of researchers in the literature, is considered as an objective approach since it is based on a specific statistical model [17], according to the evident connection with the estimated values of parameters of derived FA model. Consequently, the calculated values of the IED composite indicator represent a suitable basis for ranking and initial classification of analyzed LAUs, regarding the achieved economic development level. The classification of LAUs in RS was conducted on the basis of a comparison of individual IED values and their (adequate) mean value at the level of analyzed sample (i.e. national central tendency value). By testing the validity of the MANOVA assumption regarding the statistical significance of differences between the vectors of average values of selected economic indicators at the level of different groups of LAUs, created within the IED-based classification, the final verification of practical significance of the proposed IED indicator is performed. In accordance with the presented methodology, before applying the selected parametric multivariate methods, a detailed examination of the fulfilment of statistical assumptions on which their valid implementation is based, is conducted. The importance of this activity comes from the fact that neglect or incomplete implementation of preliminary data preparation phase is one of the key shortcomings of most previously conducted studies of a similar character. Since the analyzed variables are expressed in different measurement units, within the last step of data preparation, the procedure of normalization of their values was conducted aimed at eliminating differences in units and conversion to the same comparative basis.

Normalization of the original or previously transformed variables (marked as, *Xj* and $T\text{-}X_j$) is performed using the *min–max* method. The values of corresponding normalized variables (marked as, X_j') range from 0 to 1 [18]. For the purpose of precise comparison of the obtained IED values, the range of normalized values is expanded by converting the initial scale to the scale from 1 to 10, using expressions [27]:

$$\text{positive coding: } x'_{ij} = 9 \times \frac{x_{ij} - x_j^{min}}{x_j^{max} - x_j^{min}} + 1 \qquad \text{and}$$

$$\text{inverse coding: } x'_{ij} = -9 \times \frac{x_{ij} - x_j^{min}}{x_j^{max} - x_j^{min}} + 10 \qquad (3)$$

where, x'_{ij} is normalized value of *j*th indicator for i^{th} LAU (for $i = 1, 2,\ldots, n$, and $j = 1, 2,\ldots, p$), *xij* denotes original *i*th value of *j*th variable, while x_j^{min} and x_j^{max} represent minimum and maximum original value of j^{th} variable. Inverse coding was performed only for the variable *X*3, since a higher value of this indicator implies a lower level of economic development and vice versa. Data analysis and all necessary statistical calculations were carried out using the IBM SPSS Statistics, version 20, and SYSTAT, version 13.1.

Results of the research

In this Section, the results of FA-based construction of IED composite indicator, IED-based classification of observed LAUs and MANOVA-based evaluation of IED indicator validity are presented, with detailed verification of underlying statistical assumptions.

Examination of FA assumptions

In order to ensure valid application of FA, a complex iterative procedure for verifying the fulfilment of underlying statistical assumptions, presented in Figure 3, is conducted.

Since the Box–Cox data transformation process did not sufficiently mitigate the impact of all atypical values, a total of 20 observations identified as univariate (6 LAUs) and multivariate outliers (14 LAUs) were excluded from the initial sample ($n = 165$). In the newly formed, reduced sample ($n = 145$) there are no univariate (Figure 4), nor multivariate outliers, since the values of Mahalanobis distance, calculated for individual municipalities, are less than the corresponding critical value of χ^2 distribution ($\chi^2_{(4;\,0.975)} = 11.143$).

The results of testing hypotheses about univariate and multivariate normality of transformed variables' distribution are shown in Table 3.

The calculated values of Pearson's correlation coefficients (r) and results of testing their statistical significance (Table 4), suggest that there is a statistically significant linear relationship at population level between all pairs of economic indicators, thus confirming the fulfilment of linearity assumption. The presence of direct correlation is dominant. The exception is $T\text{-}X_3$, which is negatively correlated with the remaining indicators. The coefficient values higher than 0.80 or 0.90 are not recorded, since they, in absolute value, range from $|r_{min}| = 0.233$ to $|r_{max}| = 0.541$, thus confirming the absence of multicollinearity.

Figure 3: Schematic representation of the multivariate assumptions verification procedure

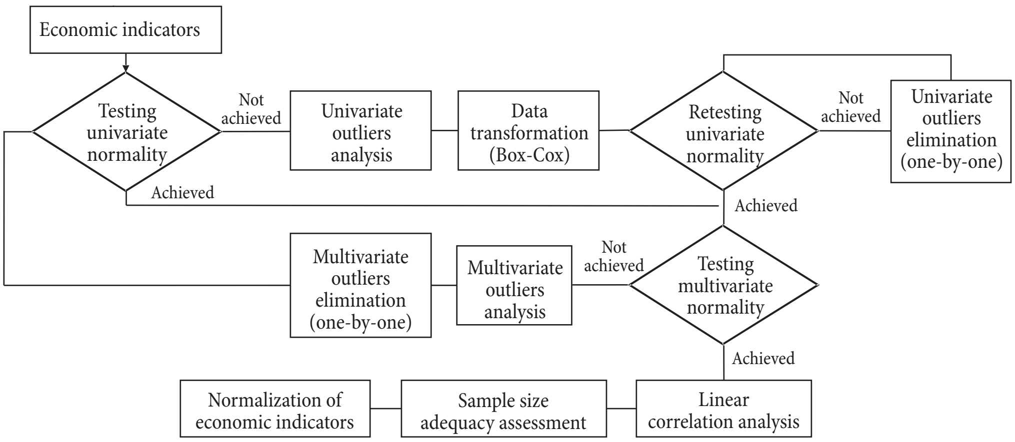


Figure 4: Box-plots of transformed variables

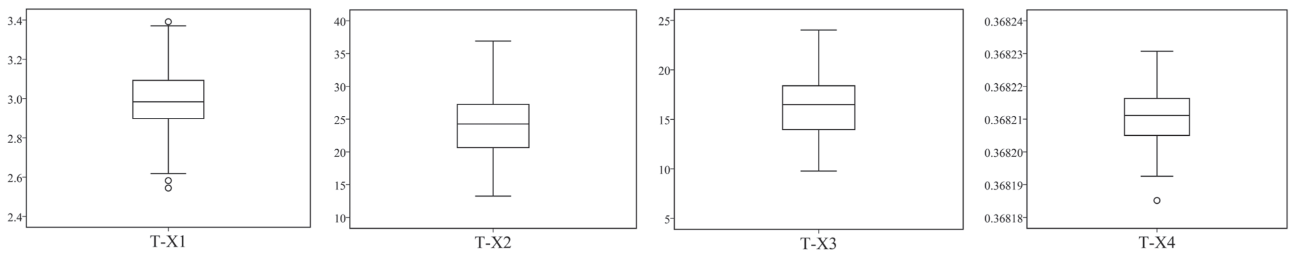


Table 3: The results of statistical tests for univariate and multivariate distribution normality

Variables	Anderson–Darling test[1]		Multivariate distribution	Mardia skewness test[2]		Mardia kurtosis test[3]	
	Statistics	p-value		Statistic	p-value	Statistic	p-value
$T\text{-}X_1$	0.591	0.121	Joint distribution of four variables	27.066	0.133 (H_0)	-1.315	0.189 (H_0)
$T\text{-}X_2$	0.388	0.383					
$T\text{-}X_3$	0.322	0.525					
$T\text{-}X_4$	0.251	0.737					

[1] Anderson-Darling normality test → H0: The analyzed variable is normally distributed;
[2] Mardia skewness test → H0: The multivariate distribution of p variables is symmetric;
[3] Mardia kurtosis test → H0: The multivariate distribution of p variables has normal kurtosis.

Table 4: Correlation matrix

Variables	$T\text{-}X_1$	$T\text{-}X_2$	$T\text{-}X_3$	$T\text{-}X_4$
$T\text{-}X_1$	1.000	-	-	-
$T\text{-}X_2$	0.475 [**]	1.000	-	-
$T\text{-}X_3$	−0.405 [**]	−0.541 [**]	1.000	-
$T\text{-}X_4$	0.233 [**]	0.446 [**]	−0.353 [**]	1.000

Note: Symbol [**] indicates the statistical significance of the calculated estimates at α = 0.01 level of significance.

For the purpose of additional assessment of the degree of interrelationship of variables and adequacy of their selection in context of FA application, the interpretation of values of Kaiser–Meyer–Olkin measure of sampling adequacy, calculated for complete correlation matrix (*Overall KMO–MSA*) and individual variables ($KMO\text{–}MSA_j$), is performed. The *overall KMO–MSA* is 0.732 and suggests an average level of adequacy of the selection of four variables, viewed from the perspective of the overall "strength" of correlation present between them. Table 5 contains individual $KMO\text{–}MSA_j$ values. The obtained approximate values, evidently above the minimum acceptable level of 0.50, indicate that the correlation of each individual variable with the remaining variables is, in general, at an average, satisfactory level, which unequivocally confirms and justifies their selection as FA input components.

Table 5: KMO–MSA values for individual indicators

Variables	$KMO\text{–}MSA_j$ values	Correlation strength
$T\text{-}X_1$	0.760	middling
$T\text{-}X_2$	0.687	mediocre
$T\text{-}X_3$	0.751	middling
$T\text{-}X_4$	0.764	middling

For testing the assumption that sample correlation matrix comes from population in which the analyzed variables are not statistically significantly correlated with each other (i.e. H_0: |R| = |I| = 1), the Bartlett's sphericity test statistic, $\chi^2_{(6;\,0.95)}$ = 125.788, is calculated. Since resulting p-value (0.000) is less than test significance level $\alpha = 0.05$, it can be concluded that there is enough evidence to accept the alternative hypothesis, which claims that population correlation matrix R is different from the identity matrix I. This confirms the justification of FA application on elements of the analyzed matrix. Finally, since the sample size can significantly affect the accuracy of statistical procedures for the evaluation of FA model, it is necessary to emphasize that the (reduced) sample size satisfies general recommendations regarding the "desirable" number of observations. Available sample (n = 145) contains more than 100 observations, while the number of LAUs per each variable is greater than 30 (i.e. $n / p = 145{:}4 \approx 36{:}1$).

FA results and IED construction

Using correlation matrix data as input elements and principal components method, the estimation of FA model parameters was performed. The initial form of the estimated p-dimensional FA model is:

$$\begin{aligned} X'_1 &= (0.700)F_1 - (0.546)F_2 + (0.421)F_3 + (0.184)F_4 \\ X'_2 &= (0.843)F_1 - (0.001)F_2 - (0.041)F_3 - (0.536)F_4 \\ X'_3 &= (0.782)F_1 - (0.082)F_2 - (0.559)F_3 + (0.264)F_4 \\ X'_4 &= (0.656)F_1 + (0.682)F_2 + (0.270)F_3 + (0.178)F_4 \end{aligned} \quad (4)$$

Characteristic roots (i.e. λf, for $f = 1, 2, \ldots, p$ where $p = 4$) in the basis of the presented model, and their corresponding shares of variables' total sample variance explained by each common factor (Ff), are shown in Table 6. Since there is only one characteristic root, specifically λ_1, whose value is greater than trace of analyzed correlation matrix (i.e. the average of four characteristic roots, $\bar{\lambda}=1$), according to Kaiser-Guttman rule, in order to redefine initially developed model and reduce its dimensionality, the decision to keep only the first common factor (F_1) in the reduced FA model is made.

Table 6: Results of the common factors extraction procedure

Common factors	Eigenvalues	Explained proportion of total initial variability	Cumulative proportions
F_1	2.242	56.053	56.053
F_2	0.771	19.267	75.320
F_3	0.564	14.110	89.430
F_4	0.423	10.570	100.00

The selection of a single-common factor solution as "optimal", in terms of the number of extracted factors, is confirmed by the criteria based on Cattell's scree plot and explained proportion of total sample variance, since more than half of total sample variability of analyzed variables (≈ 56%) is explained by F_1. Table 7 shows estimated values of parameters of the reduced single-factor model.

Table 7: Estimated (reduced) FA model*

Reduced FA model	Variables	Factor loadings	Communalities	Proportion of the explained variance	Specific variance
$X'_1 = 0.700\ F_1 + e_1$	X'_1	0.700	0.490	49.10	0.510
$X'_2 = 0.843\ F_1 + e_2$	X'_2	0.843	0.711	71.10	0.289
$X'_3 = 0.782\ F_1 + e_3$	X'_3	0.782	0.611	61.10	0.389
$X'_4 = 0.656\ F_1 + e_4$	X'_4	0.656	0.430	43.00	0.570
Total	/	/	$2.242 = \lambda_1$	≈ 56.053%	1.758

* In third column, the un-rotated factor loadings are presented, since only one common factor was extracted.
Note: Initial variability of each variable is 1.

Estimated values of factor loadings range from 0.656 to 0.843, indicating the presence of a moderate (in case of X'_4), or strong (for other variables) linear correlation between individual variables and the common factor F_1. Hence, they can be considered practically significant, in terms of providing an adequate approximation of interrelationship of selected indicators of economic development of LAUs. Since the sample size is 145 LAUs, it can be stated that the estimates of factor loadings are also statistically significant [7]. Comparing the estimated values of common and specific variance at the level of individual indicators, it is noticeable that variables X'_2 and X'_3 represent, in general, better and more reliable measures of extracted factor, as it explains ≈ 71% and 61% of their initial variability, respectively. The proportion of variability that remaining two variables "share" with other indicators is evidently lower, which can also be seen based on the size of estimates of their specific variances, but still at an acceptable level (≈ 50%). Factor F_1 is named the level of economic development, since all four variables measure one particular of several different aspects of LAUs' economic development.

Considering the factor F_1 as a non-observable multidimensional phenomenon of interest, and indicator-variables as "auxiliary means" necessary for indirect "measurement" of its level, using expression (1), a composite indicator, named *Index of Economic Development* (IED), is created. The weights (w_j) assigned to variables were determined using expression (2). The form of created indicator IED*i* (for *i* = 1, 2,..., *n*) is:

$$IED_{(i)} = 0.219 \cdot x'_{i1} + 0.317 \cdot x'_{i2} + 0.272 \cdot x'_{i3} + 0.192 \cdot x'_{i4}. \quad (5)$$

The greatest relative importance in calculating aggregate value of extracted common factor was given to the variable X_2, since it is characterized by the highest factor loading, followed by indicators X_3, X_1 and X_4.

Since the IED was developed using a reduced sample (145 LAUs), its application on all 165 LAUs, requires re-implementation of *min-max* transformation of indicators on initial sample in order to ensure comparability of their normalized values, x'_{ij}. IED values were calculated for each of 165 LAUs and, in accordance with performed normalization, range from 1 to 10, with higher values

Figure 5: Histogram of frequencies (left) and Box-plot (right) of IED values for 165 LAUs

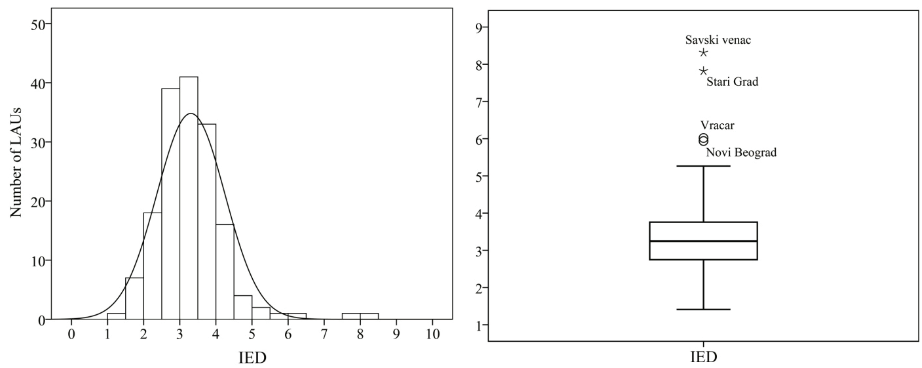


Table 8: Descriptive statistical measures of IED values for 165 LAUs

Average	Median	Mode interval	Minimum	Maximum	Standard deviation	Coefficient of variation
3.31	3.25	3.00–3.99	1.41	8.31	0.95	28.70%

indicating a higher economic development level and vice versa. The key characteristics of IED values' distribution are shown in Figure 5 and Table 8.

IED–based classification of the observed LAUs

The classification of LAUs in RS, according to "measured" level of economic development, is conducted on the basis of a comparison of individual IED values and adequate sample mean (i.e. national mean value). Since the results of descriptive analysis confirmed the presence of two real outliers, as a more appropriate measure of central tendency for the role of comparative basis, the median was chosen instead of the commonly used national average. This approach requires expression of absolute IED values as percentage of median, i.e. as achieved percent of national median level of economic development, $(\%m_e)_i$, using:

$$IED_i \rightarrow (\%\, m_e)_i = \frac{IED_i}{m_e} \cdot 100. \qquad (6)$$

By comparative analysis of series of converted values $(\%m_e)_i$ of individual LAUs, the specific classification criteria are defined, as the basis for allocating LAUs into one of six separate categories. Classification rules are given in Table 9, in the form of corresponding intervals of $(\%m_e)_i$ values.

The limit values of these intervals were determined taking into account certain aspects of the manner of classifying LAUs according to their level of development, which is specified by the Law on Regional Development in RS [6], as well as the characteristics of IED values' distribution. The results of the classification of 165 LAUs in the RS are presented in Appendix.

MANOVA–based estimation of IED validity

The verification of validity and practical significance of the IED indicator is performed by testing the assumption of statistical significance of differences between the vectors of average values of selected economic development indicators for different groups of proposed IED classification of LAUs. To achieve this goal, a one-way MANOVA was implemented, based on the following set of variables: (1) the level of economic development of LAUs is an independent (categorical) variable X_k, with six modalities (for $k = 1, 2,\ldots, 6$) that correspond to the formed groups of LAUs in the IED classification; and (2) four indicators of LAUs' economic development (used for construction of IED indicator) are dependent (numerical) variables (Y_j, for $j = 1, 2, 3, 4$), whose averages ($\bar{y}_j$) are compared by created groups.

Table 9: IED-based classification of LAUs

Category		Number of LAUs	Classification rules	IED intervals by groups
Name	Code			
Group-1	G-1	2	$(\%\, m_e)_i \geq 200\%\, m_e$	> 6.500
Group-2	G-2	2	$200\%\, m_e > (\%\, m_e)_i \geq 180\%\, m_e$	[5.850–6.500)
Group-3	G-3	3	$180\%\, m_e > (\%\, m_e)_i \geq 150\%\, m_e$	[4.875–5.850)
Group-4	G-4	75	$150\%\, m_e > (\%\, m_e)_i \geq 100\%\, m_e$	[3.250–4.875)
Group-5	G-5	77	$100\%\, m_e > (\%\, m_e)_i \geq 60\%\, m_e$	[1.950–3.250)
Group-6	G-6	6	$60\%\, m_e > (\%\, m_e)_i$	< 1.950

Table 10: Average values of dependent variables per created groups of LAUs

Independent X_k / Dependent variables		Number of enterprises per 1000 inhabitants	Employment rate	Unemployment per 1000 inhabitants	Average wage per employee
Category (k)	Size (n_k)	$\bar{y}_1$	$\bar{y}_2$	$\bar{y}_3$	$\bar{y}_4$
G-1	2	161.00	314.86	58.50	56.17
G-2	2	96.50	93.47	53.50	62.87
G-3	3	41.67	48.24	56.57	65.75
G-4	75	43.40	37.56	81.05	39.26
G-5	77	33.42	29.28	140.92	33.47
G-6	6	29.33	25.47	223.00	32.93
Total	165	40.27	37.49	113.10	37.30

Before checking the fulfilment of MANOVA assumptions, the number of initially defined modalities of independent variable was reduced. Namely, because they are characterized by a very small number of LAUs, the first three groups do not meet the experiential recommendations regarding the minimum number of elements per group [29]. In Table 10, clear differences can be seen in terms of average values of each indicator for the first three groups compared to the remaining groups, among which these differences are less pronounced. Since their size (n_k) is less than number of used dependent variables, they are excluded from further analysis, and attention is focused on testing the MANOVA hypotheses for remaining three larger groups. An additional argument for eliminating these groups is that LAUs in their composition represent outliers that would certainly be removed from the sample during the assumption verification process. Thus, the reduced sample size used in MANOVA is 158 LAUs.

The fulfilment of MANOVA assumptions was checked by implementing the iterative procedure already described in Figure 3. The obtained results can be sublimated as follows:

- A total of 16 municipalities, identified as univariate (2 LAUs) and multivariate outliers (14 LAUs) were excluded from the available sample of observations;
- The one-dimensional normality of dependent variables' distribution, both at the level of reduced sample (142 LAUs) and by selected categories of independent variable, was confirmed. Also, the normality of multivariate joint distribution of four dependent variables was confirmed;
- The results of correlation analysis suggest that there is a statistically significant linear relationship between all pairs of dependent variables at population level;
- The correlation coefficients, in absolute values, range from 0.220 to 0.515, which confirms that analyzed indicators are not highly correlated.

Finally, the calculated value of Box's M test statistic (M = 15.884) and, based on it, the value of approximate F statistic ($F_{(\alpha;\,10;\,82540.845)} = 1.537$) suggest that there is not enough empirical evidence to reject the null hypothesis of homogeneity of covariance matrices of three groups of multivariate observations, since the resulting level of significance (p-value = 0.119) is greater than $\alpha = 0.05$. Based on decomposing the total variability of four dependent variables into factor and residual variability respectively, estimated MANOVA model, in matrix form is:

$$\begin{bmatrix} 447.73 & 235.01 & 198.41 & 96.81 \\ 235.01 & 549.38 & 238.84 & 192.99 \\ 198.41 & 283.84 & 551.97 & 151.16 \\ 96.81 & 192.99 & 151.16 & 434.34 \end{bmatrix} = \begin{bmatrix} 97.50 & 139.79 & 182.37 & 105.56 \\ 139.79 & 201.20 & 261.79 & 148.80 \\ 182.37 & 261.79 & 341.25 & 196.39 \\ 105.56 & 148.80 & 196.39 & 122.64 \end{bmatrix} + \begin{bmatrix} 350.23 & 95.22 & 16.04 & -8.75 \\ 95.22 & 348.18 & 22.05 & 44.19 \\ 16.04 & 22.05 & 210.72 & -45.23 \\ -8.75 & 44.19 & -45.23 & 311.70 \end{bmatrix} \quad (7)$$

The estimation of MANOVA model with one factor (X_k, for k = G-4, G-5, G-6) was performed using normalized values of dependent variables (Y_j' for j = 1, 2, 3, 4) in a sample of 142 LAUs. The results of MANOVA null hypothesis testing are given in Table 11.

The results, unequivocally and "unanimously" suggest the acceptance of an H1, which claims that there is a statistically significant difference between at least two groups of LAUs in terms of corresponding vectors of averages of four economic indicators, since the p-values of approximate F statistics, for all four MANOVA statistics, are less than error risk $\alpha = 0.05$. Also, the results of one-way ANOVA (Table 12) suggest that, in case of all dependent variables, there are enough arguments to accept H1, which

Table 11: Results of MANOVA tests

MANOVA tests	Statistics	F approximation	Degrees of freedom		p-value
			df_1	df_2	
Wilks's lambda	0.260	32.651	8	272	0.000
Pillai's trace	0.761	21.051	8	274	0.000
Lawley–Hotelling trace	2.760	46.577	8	270	0.000
Roy's largest root	2.730	93.495	4	137	0.000

claims that there is a statistically significant difference between at least two groups of LAUs in terms of average values of individual indicators, since the p-values, are less than Bonferonni corrected significance level, $\alpha^* = 0.0125$.

Table 12: One-way ANOVA results

Dependent variables	F-statistic	Degrees of freedom		p-value
		df_1	df_2	
Y_1'	19.347	2	139	0.000
Y_2'	40.162	2	139	0.000
Y_3'	112.551	2	139	0.000
Y_4'	27.344	2	139	0.000

By confirming the statistical significance of differences between averages of economic indicators of LAUs distributed within groups 4, 5 and 6, in ANOVA and MANOVA contexts, additional verification of practical significance of created IED indicator and, based on it, classification of LAUs is provided.

Discussion and interpretation of the obtained results

In this Section, the interpretation of proposed, and MANOVA–confirmed, IED–based classification of LAUs in RS according to the "measured" level of economic development (Table 9), is performed. The summary of numeric characteristics for created groups (Table 13) is supported by cartographic representation (Figure 6).

First three groups, G-1, G-2, and G-3, together comprise only 7 of a total of 165 LAUs, or approximately 4% of the sample. These groups include exclusively municipalities in the territory of the city of Belgrade, the capital of the RS, which represents the leading economic, administrative, cultural and university centre in the state, with exceptionally favourable geographical position and infrastructure preconditions (road and railroad nodes, Danube corridor, airport) for intensive economic development and attraction of domestic and foreign investments [27]. These municipalities are characterized by IED values that are above 150% of the national median value (IED ≥ 4.875). In that sense, it can be stated that their achieved level of economic development, "measured" by IED, is obviously higher compared to the members of remaining groups. This composition of groups that are characterized by the most favourable values of economic indicators is fully expected, since these municipalities were identified as outliers during the process of verifying statistical assumptions. Based on the results of intergroup comparison of their IED averages (Table 13), as well as with the corresponding national median value, the following descriptive names were determined: Group 1 – *extremely high level*, Group 2 – *high level*, and Group 3 – *above average level of economic development*.

Group 4 includes 75 LAUs (≈ 45% of the sample) whose IED values are ranging from 100% to 150% of the median value (3.250 ≤ IED < 4.875). According to the number of municipalities covered, the IED value interval that defines it, as well as slight positive differences between its IED average (3.77) and national IED median value (3.25), for this group can be said to represent "median & average" group, in statistical terms. Consequently, this group of LAUs was given the following descriptive name: Group 4 – *average level of economic development*. The ratio of average IED values of groups G-1 and G-4, which is approximately 2:1, in favour of G-1, indicates the presence of a pronounced gap in terms of their economic development.

Group 5 includes 77 LAUs (≈ 47% of the total number of LAUs), for which IED values were determined at the level of 60% to 100% of median (1.95 ≤ IED < 3.25). In Figure 6, it can be seen that these are mostly municipalities that, in comparison to the G-4, are generally more "distant" from

Table 13: Ratios of average IED values for each pair of groups of LAUs*

IED average	IED min-max values	Group	G-1	G-2	G-3	G-4	G-5	G-6
8.07	7.82 – 8.31	G-1	1:1	0.35:1	1.60:1	2.14:1	2.97:1	4.69:1
5.98	5.94 – 6.02	G-2	0.74:1	1:1	1.18:1	1.59:1	2.20:1	3.48:1
5.05	4.89 – 5.26	G-3	0.63:1	0.84:1	1:1	1.34:1	1.86:1	2.94:1
3.77	3.25 – 4.83	G-4	0.47:1	0.63:1	0.75:1	1:1	1.39:1	2.19:1
2.72	1.95 – 3.24	G-5	0.34:1	0.45:1	0.54:1	0.72:1	1:1	1.58:1
1.72	1.41 – 1.94	G-6	0.21:1	0.29:1	0.34:1	0.46:1	0.63:1	1:1

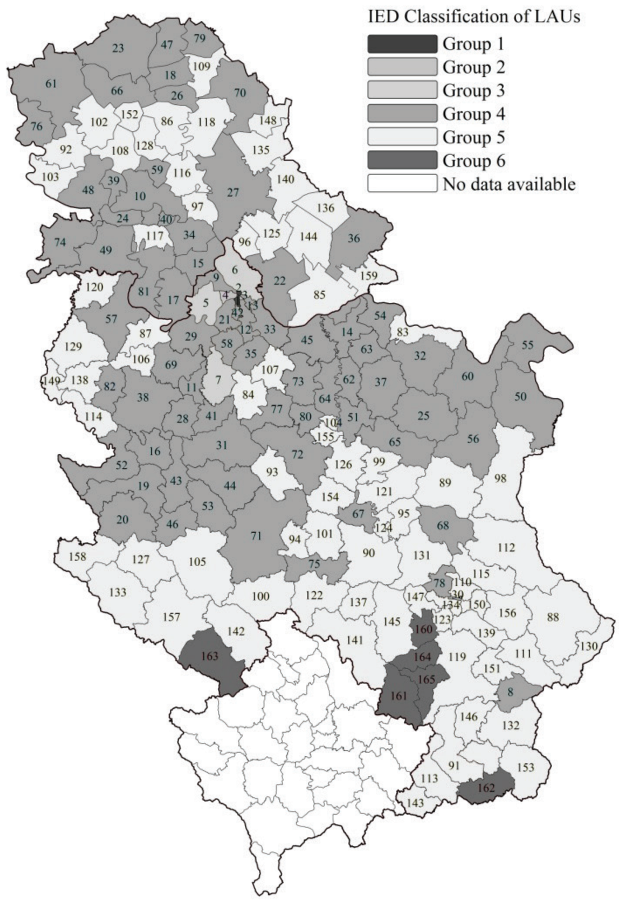
* National (republic) *IED* central tendency value: *median* = 3.25

the Belgrade region and its municipalities. Also, since it includes the largest number of LAUs compared to other groups, it can be said that G-5 is a "modal group" in the statistical sense of the word. In contrast to the situation in G-4, a comparison of national median IED value and corresponding IED average for G-5 shows a certain negative deviation, which is significantly smaller than in the case of G-6. This observation was confirmed by the ratio of IED averages for G-1 and G-5, which is approximately 3:1, in favour of G-1. Accordingly, this group was given the following descriptive name: Group 5 – *below average level of economic development*.

The structure of Group 6 includes only 6 municipalities (≈ 4% of the total number of LAUs), whose IED values are below 60% of median value (IED < 1.95). The pronounced negative difference between the IED average for this group (1.72) and national median value unequivocally indicates the worrying state of the overall economic situation in the respective municipalities. Consequently, it was given the following description: Group 6 – *extremely low level of economic development*. The ratio ≈ 4.7:1, obtained for IED average values of G-1 and G-6, clearly indicates the serious scale of economic disparities.

The above interpretation, unfortunately, confirms the presence of pronounced regional inequalities and asymmetries among the analyzed territorial units in the RS in terms of the achieved level of economic development, in 2015. This statement is best confirmed by the ratio of IED values of the most developed (Savski Venac, 8.31) and the least developed municipality (Lebane, 1.41), which is 5.89:1. In general, the proposed classification of LAUs confirms the well-known statement regarding the presence of pronounced regional and intra-regional polarization in the RS, primarily in direction of "developed north–underdeveloped south". Namely, approximately 91% of municipalities within the Region of Southern and Eastern Serbia belong to groups of extremely low and below average economic development (G-5 and G-6). On the other hand, approximately 55% of municipalities of the Vojvodina Region (located in the north of Serbia) are

Figure 6: Cartographic representation of IED classification of LAUs in RS[*]



[*] Used numbers represent IED ranks of municipalities, and their correspondent names are given in Appendix.

allocated within the G-4, while the remaining LAUs are members of the G-5, but predominantly with IED values above the corresponding average for that group. Also, 7 of the 17 Belgrade municipalities form Groups 1, 2 and 3, while the rest are in leading positions in the G-4.

Finally, it is important to emphasize that the comparability of presented results of measuring the level of economic development of LAUs in RS and their classification with the results of previously conducted studies of similar type and objectives is not possible, due to the presence of highly pronounced differences regarding the spatial and temporal coverage of data, the selected development dimension(s) and individual indicators, as well as the methodological approach used. Regardless of previous observation, the proposed IED classification of LAUs, can serve as a suitable basis for further and "deeper" analysis of situation and trends in other dimensions of regional development and for drawing conclusions about their interdependence.

Conclusion

Starting from indisputable importance of quantifying the economic development level of LAUs for planning and successful implementation of national strategy of balanced regional development, in this paper, an innovative and complex multivariate statistical approach, intended for objective assessment of apostrophized multidimensional economic phenomenon, is presented, using municipalities in the Republic of Serbia as a working basis. Based on a statistically valid and combined application of FA and MANOVA, the proposed methodological approach enables simultaneous analysis of four representative economic indicators, available for LAU level territories, and their objectively weighted aggregation in the form of IED composite indicator. This indicator is proven to be a very useful analytical tool for measuring the level of LAUs' economic development, their classification and, consequently, identifying the extent of existing economic disparities.

Contrary to the approaches based on monitoring the values of individual economic indicators and separate interpretation of numerous one-dimensional classifications of municipalities, the applied methodological framework enables multivariate compression of used economic indicators in the form of a described composite indicator, whose values represent a suitable basis for ranking and creating only one common classification of LAUs. The performed IED measurement and conducted classification enable a quite precise estimation of the extent of economic disparities between municipalities and monitoring the success of implemented measures of balanced regional development policy. Although demonstrated on the example of municipalities in RS, taking into account the high data availability of selected economic indicators, the proposed methodological approach can also be successfully applied on LAUs in territorial composition of other countries, which indirectly confirms its high application potential.

In addition, compared to most previously conducted studies of similar objectives in the literature, the key advantage of proposed analytical framework is a thorough verification of the fulfilment of statistical assumptions, as a crucial activity for ensuring the valid application of FA and MANOVA, but also the scientific basis of obtained results and conclusions. Taking into account the elaborated impossibility of direct comparability of presented results with the mentioned similar studies, the statistical validity and quality of developed IED indicator and created LAUs classification were verified by the MANOVA output. Additional, direct confirmation of the usage value of IED indicator arises from the fact that IED classification of LAUs confirmed the well-known official statement regarding the presence of pronounced regional and intra-regional polarization in the RS, primarily in direction of "developed north–underdeveloped south".

Although quite rigorous in statistical terms, the proposed multivariate methodological approach provides a clear, informative, objective, statistically valid and transparent quantification of the level of economic development and, consequently, an analysis of the present economic disparities between the observed territorial units, thus providing useful and reliable information input to the creators of balanced regional development strategy. Its immanent flexibility, conditioned by objective determination of the individual indicators' weights, significantly expands the range of possible ways and areas of application. Hence, its application on administrative units of the same or higher level of territorial organization of other countries, using indicators of other important development dimensions, in addition to the economic one, either in individual or integral context, with different temporal coverage, may represent some of the possible directions of future research.

Disclosure statement

Authors declare that they do not have any financial, professional, or personal interests from other parties.

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Appendix:
Overview of analyzed LAUs' distribution by IED classification categories

Category	Names of the local self-government units [IED value]		
G-1	1. Savski Venac [8,31]	2. Stari Grad [7,82]	
G-2	3. Vracar [6,02]	4. Novi Beograd [5,94]	
G-3	5. Surcin [5,26]	6. Palilula [5,00]	7. Lazarevac [4,89]
G-4	8. Crna Trava [4,83]	33. Grocka [3,88]	58. Barajevo [3,50]
	9. Zemun [4,77]	34. Indjija [3,87]	59. Temerin [3,50]
	10. Novi Sad [4,71]	35. Sopot [3,85]	60. Majdanpek [3,50]
	11. Lajkovac [4,46]	36. Vrsac [3,80]	61. Sombor [3,50]
	12. Vozdovac [4,37]	37. Petrovac na Mlavi [3,79]	62. Zabari [3,50]
	13. Zvezdara [4,36]	38. Valjevo [3,79]	63. Malo Crnice [3,50]
	14. Pozarevac [4,34]	39. Backi Petrovac [3,78]	64. Velika Plana [3,50]
	15. Stara Pazova [4,23]	40. Sremski Karlovci [3,77]	65. Despotovac [3,48]
	16. Kosjeric [4,22]	41. Ljig [3,76]	66. Backa Topola [3,48]
	17. Pecinci [4,22]	42. Rakovica [3,76]	67. Varvarin [3,46]
	18. Senta [4,20]	43. Pozega [3,75]	68. Sokobanja [3,44]
	19. Uzice [4,20]	44. Cacak [3,74]	69. Ub [3,42]
	20. Cajetina [4,19]	45. Smederevo [3,74]	70. Kikinda [3,38]
	21. Cukarica [4,18]	46. Arilje [3,72]	71. Kraljevo [3,36]
	22. Pancevo [4,16]	47. Kanjiza [3,71]	72. Kragujevac [3,35]
	23. Subotica [4,11]	48. Backa Palanka [3,69]	73. Smed. Palanka [3,34]
	24. Beocin [4,08]	49. Sremska Mitrovica [3,66]	74. Sid [3,33]
	25. Zagubica [4,03]	50. Negotin [3,66]	75. Aleksandrovac [3,32]
	26. Ada [4,00]	51. Svilajnac [3,62]	76. Apatin [3,32]
	27. Zrenjanin [3,97]	52. Bajina Basta [3,56]	77. Topola [3,32]
	28. Mionica [3,95]	53. Lucani [3,56]	78. Crveni krst [3,31]
	29. Obrenovac [3,91]	54. Veliko Gradiste [3,54]	79. Novi Knezevac [3,30]
	30. Medijana [3,91]	55. Kladovo [3,53]	80. Raca [3,28]
	31. Gornji Milanovac [3,90]	56. Bor [3,52]	81. Ruma [3,26]
	32. Kucevo [3,89]	57. Sabac [3,51]	82. Osecina [3,25]
G-5	83. Golubac [3,24]	109. Coka [2,88]	135. Zitiste [2,61]
	84. Arandjelovac [3,24]	110. Pantelej [2,87]	136. Plandiste [2,59]
	85. Kovin [3,23]	111. Babusnica [2,86]	137. Blace [2,59]
	86. Becej [3,22]	112. Knjazevac [2,85]	138. Krupanj [2,58]
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Milan Stamenković

is an Assistant Professor at the Faculty of Economics, University of Kragujevac, Department for Informatics and Quantitative Methods (teaching courses: Fundamentals of Statistics and Applied Statistics). He is a member of the Presidency of the Society of Economists of Kragujevac. His research interests are related to the topics in the field of applied statistical analysis in economics and business.

Marina Milanović

is an Assistant Professor at the Faculty of Economics, University of Kragujevac, Department for Informatics and Quantitative Methods (teaching courses: Fundamentals of Statistics and Applied Statistics). She is a member of the Society of Economists of Kragujevac. Her research interests are related to the topics in the field of applied statistical analysis in economics and business.

Petar Veselinović

is a Full Professor at the Faculty of Economics, University of Kragujevac, Department of General Economics and Economic Development (teaching courses: National Economics, Theory and Analysis of Economic Policy and Regional Economics). He is a member of the Presidency of the Serbian Association of Economists and president of the Society of Economists of Kragujevac. His research interests are related to the topics in the field of economic development, regional economics and economic policy.