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STRENGTHENING FINANCIAL DECENTRALIZATION: DRIVER OR RISK FACTOR FOR SUSTAINABLE SOCIO-ECONOMIC DEVELOPMENT OF TERRITORIES? *

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Abstract. The article deals with the problem of modeling the effectiveness of the development of financial decentralization mechanisms. A conceptual approach is proposed, which allows to form a complex of models. The models allow to evaluate the socio-economic effects of financial decentralization increase; to determine the "threshold" value of the level of financial decentralization, upon which slowdown in economic growth may occur. The models are based on based on the principal components' method, canonical correlations, cluster analysis, Kohonen neural networks, the level of development method, production and institutional functions. The modeling results showed that a high level of financial decentralization is inherent to countries with a high level of economic development, where high quality institutional environment and administrative decentralization lead to the increase of the efficiency of the public sector functioning. At the same time, in countries with a high level of competitiveness and socio-economic development the gap between the growth rates of income and expenditure powers of budgets of various levels and the growth rate of GDP is growing. This fact reduces the level of budget and debt security. Models of production and institutional functions have been developed, countries with a "reference" development model have been identified, as well as groups of countries that would have a higher effect from the re-centralization of government finances or financial decentralization.

Keywords: financial decentralization, efficiency, modeling, multidimensional analysis, production and institutional functions

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1. Introduction

The present stage of the world economy development is characterized by significant regional disparities, a high level of polarization of economic development. Thus, as of 2018, 36 countries (18% of the total number of countries) accounted for 60% of world GDP and 18% of the population. The remaining 159 countries (82%) accounted for respectively 40% of world GDP and 82% of the population (OECD, 2018). These proportions of economic development polarization are reproduced both at the level of individual countries and regions. This increases the absolute inequality. In particular, the gap in the per capita GDP levels of states with high and low levels of development increased from 74 times in 1961 to 1048 times in the pre-crisis 2008 (WORLDBANK, 2018).

The current situation forced us to talk about the imperfection of the adopted strategy of economic growth, which creates additional risks and threats, especially in conditions of cyclical crises. This is confirmed by a series of financial, economic, and social crises that permanently arose during 2008–2018. In the context of a cyclical downturn the government were forced to make cuts in social programs, which led to a sharp decline in the quality of life of individual groups of the population, the growth of social tension, strikes, crisis of social and economic situations. In particular, one of the examples of the growth of social tension in society is the "strikes of yellow vests" in France, which dealt a tangible blow to the economy by blocking transport routes, disrupting traditional supply chains, reducing sales. Economic losses from protest sentiments in France, affecting the requirements of reducing taxes on gasoline, increasing pensions, restoring the wealth tax and reducing the salaries of politicians amounted to billions of euros. The decline in the growth rate of French GDP from 2.3% in 2017 to 1.6% in 2018 was occurred due to these strikes (Viscusi & Horobin, 2018).

Protest sentiments are also typical for the group of so-called donor regions. Under the conditions of a cyclical crisis and a slowdown in economic growth, donor regions are forced to direct funds not for financial and investment support of innovatively oriented industries-catalysts of economic growth, but for subsidies, subventions, transfers to regions with a low level of development, thereby the duration of the period of economic recession is increased and a "funnel" of the economic crisis is formed. An example of such a conflict between "donors" and "recipients" is the referendum on the independence of Catalonia in 2017. Spain's economic losses were more than 1 billion euros, more than 3 thousand companies have withdrawn their representative offices outside of Catalonia (Segodnya, 2018).

It is obvious that the modern strategies of economic growth show their inconsistency, which leads to the highlighting, along with such concepts as "economic efficiency" and "social justice", the concepts of "sustainability" and "balance". Thus, in the works of Stiglitz (2013), Piketty (2014), it is noted that widening inequality in income and wealth threatens long-term prosperity and stability of a market economy. The attention of international institutions such as the World Bank, the IMF, the OECD and the WEF to the identified problems of economic growth, inequality and sustainability, has led to the formation of the concept of "inclusive economic growth". According to the OECD definition, "inclusive growth is an economic development, within which opportunities for all segments of the population arise, and material and non-material benefits in society are fairly distributed to increase their well-being" (OECD, 2018). It must be said that one of the areas of high priority for the formation of an effective economic policy of inclusive growth, along with the transformation of security systems, education, advanced training, promotion of effective employment in the labor market, etc., is the formation of a new fiscal systems architecture. Therefore, the focus of current economic research are such concepts as "models of fiscal federalism" and "efficiency of financial decentralization mechanisms".

2. Literature review and the problem statement

It is necessary to note that in modern economic literature (Aldasoro & Seiferling, 2014; Bartolini at al., 2016; Baskaran at al., 2016; Brumnik at al., 2014; Peshina & Strekalova, 2016; Sasongko et al., 2019), the concept of "fiscal federalism" is considered simultaneously with such concepts as "financial decentralization", "leveling federalism", "fiscal decentralization". However, this division is rather arbitrary and is mainly due to regional interpretations. The generally accepted and universal interpretation of the system of transfers (subsidies) through which the federal government shares its revenues with the governments of territorial-administrative units (states, cantons, etc.) and local authorities, based on optimizing the size and number of local administrations, the separation of powers to collect taxes and expenses between different levels of government are equivalent to the concept of "fiscal federalism". Therefore, in this paper, the concepts of "fiscal federalism", "financial decentralization" are considered as synonymous terms. There are the following main characteristics of "fiscal federalism": the components of fiscal federalism emphasize: multi-level management; different levels of administration; multi-level government; in the focus of fiscal federalism, the following are distinguished: effective provision of public services and an increase in the well-being of the population at decentralization levels; mutual restrictions on the intervention of management levels in the functioning of the economy, economic decisions.

Thus, fiscal federalism is the architecture of a financial mechanism that ensures the coordinated and balanced development of the revenue and expenditure budgets of various levels of hierarchy in the system of government in accordance with the competencies assigned to these levels to improve the quality of life of the population and a balanced socio-economic development of regions and states in general, within the framework of the national development strategy and priorities supported by the population.

Analysis of the financial decentralization mechanisms development allowed to identify two of its basic vectors: 1) reducing vertical gaps and ensuring the balance of revenue and expenditure powers of budgets of various levels, autonomization of budgets, expanding sources of formation of the revenue base of local budgets; 2) development of leveling federalism, streamlining and enhancing the consistency of intergovernmental agreements. The first development vector is preferable mainly for countries with middle level of socio-economic development and competitiveness, such as Spain and Italy. The second vector of development is supported mainly by countries with a high level of socio-economic development and competitiveness, in particular, Germany and Sweden.

Regardless of the concept of financial decentralization adopted in various EU countries, its results ambiguously influence the socio-economic development of both individual regions and the country as a whole. So, experts note both positive and negative effects of financial decentralization. The positive effects include the following: reducing the time taken to make decisions on the strategies for the socio-economic development of regions that meet the expectations of society; openness and transparency of decision-making procedures; increasing initiative and decision-making responsibility, the possibility of quickly leveling the impact of "shocks" on the regional economy in the context of increasing globalization and openness of the economy. The set of negative effects includes consists of: autonomization and confrontation of the goals of the socio-economic development of individual territorial entities and the state as a whole; disintegration of activities related to the provision of public services; coordination difficulties, etc.

The foregoing raises the need to model the effectiveness of the development of financial decentralization mechanisms in the EU countries in order to form adequate financial federalism mechanisms ensuring sustainable development both for individual regions and for the country as a whole.

The problem of evaluating the effectiveness of the development of financial decentralization mechanisms is researched in works of such authors as Aldasoro & Seiferling M. (2014), Asatryan & Feld (2014), Bartolini at al.

(2016), Baskaran at al. (2016), Bloch (2016), Hughes & Smith (1991), Oates (2008), Tanzi (2007), Weingast (2007), Brumnik R. at al. (2014), Guryanova at al. (2015), Peshina & Strekalova (2016), Volohova (2016) at al. Thus, Aldasoro & Seiferling (2014) discusses the impact of vertical fiscal imbalances on the level of debt security. The researchs of Bloch (2016), Hughes & Smith (1991), Oates (2008), Tanzi (2007), Weingast (2007), Peshina & Strekalova (2016), Idrisova (2016) are devoted to the analysis of trends in the development of mechanisms for financial decentralization, the formation of the topological characteristics of financial decentralization models. Authors Asatryan & Feld (2014), Bartolini at al. (2016), Baskaran at al. (2016), Stossberg & Blöchliger (2017), Fabus (2018) research the issues of modeling the impact of the level of financial decentralization on the rate of economic growth and uneven regional development. Various aspects of modeling the production, fiscal and social effects of fiscal policy at various levels of management are discussed by Guryanova at al. (2015), Brumnik at al. (2014), Baltgailis (2019).

Emphasizing the unconditional efficiency of the approaches proposed by the authors, we note that those works do not fully investigate the issues of building an integrated assessment of the level of financial decentralization and analyzing its impact on the rates of socio-economic development of countries with developing economies, choosing a "reference" model of developing financial decentralization that take into account the level of competitiveness and socio-economic development of territories.

The main aim of the research is to form a set of models for evaluating the effectiveness of financial decentralization mechanisms. The models are based on the principal component's method, canonical correlations, cluster analysis, Kohonen neural networks, the level of development method, production and institutional functions. The models allow to evaluate the socio-economic effects of financial decentralization increase; to determine the "threshold" value of the level of financial decentralization, upon which slowdown in economic growth may occur.

3. Conceptual research scheme

The proposed conceptual scheme of the research (see Table 1) includes the following modules: ***module 1***: grouping countries by the level of competitiveness and socio-economic development, the formation of a comparable research base; ***module 2***: formation of a system of indicators and diagnostic classes of the level of financial decentralization; ***module 3***: developing models for integrated assessment of the level of financial decentralization; ***module 4***: development of models of production and institutional functions.

Table 1. **The main modules of the conceptual research scheme**

The modules title and contents	*Research methods*	*Models*
Module 1. Grouping countries by the level of competitiveness and socio-economic development, the formation of a comparable research base 1.1. Rationale for the indicator system 1.2. Development of classifications 1.3. Classification quality assessment 1.4. Evaluation of the propensity of elements to migrate from cluster to cluster 1.5. Formation of a comparable base of research	principal component method; canonical correlations; hierarchical agglomerative methods; iterative methods; Kohonen's neural network models	Model 1 - country classification model by socio-economic development and competitiveness
Module 2. Formation of a system of indicators and diagnostic classes of the level of financial decentralization 2.1. Rationale for the system of indicators of the financial decentralization development level 2.2. Grouping of macroregions according to the level of financial decentralization development 2.3. Analysis of the diagnostic characteristics of macroregions groups	principal component method; canonical correlations; hierarchical agglomerative methods; iterative methods; two-way joining	Model 2 - model of the formation of diagnostic classes of the financial decentralization level
Module 3. Developing models for integrated assessment of the level of	methods for	Model 3 –model of the complex

financial decentralization 3.1. Standardization of the system of indicators of the financial decentralization development level 3.2. Determining the coordinates of the reference object 3.3. Formation of a system of integrate (complex and local) indicators of the level of development of financial decentralization 3.4. Assessment of convergence of development of the level of financial decentralization in macroregions	constructing a reference object; convergence analysis methods	assessment of the level of development of financial decentralization
Module 4. Development of models of production and institutional functions. 4.1. Building a model of production and institutional functions 4.2. Definition of the financial decentralization "threshold" level	development level method; production and institutional functions	Model 4 - model of production and institutional functions

Source: developed by the authors

The detailed description of the modules presented in the Table 1, is given below.

The level of financial decentralization and the level of socio-economic development are categories that are characterized by a two-way causal relationship. Thus, the level of financial decentralization depends on the level of economic development, the scale of the territory, the degree of homogeneity of the economic space. At the same time, the effectiveness of financial decentralization largely determines the rate of economic growth and the quality of life of the population in the regions. Therefore, the target orientation of the first module is the formation of a comparable base of the relationship research between the level of financial decentralization and the rate of socio-economic development. In the first module, the following tasks are accomplished: task 1.1 - assessment of informativeness and formation of a system of indicators of socio-economic development and competitiveness of territories; task 1.2 - grouping countries by level of socio-economic development and competitiveness.

To solve task 1.1, various methods can be used: methods based on autoinformative criteria; methods focused on the assessment of informativeness based on the analysis of cause-effect relationships (Geetz at al., 2006; Kizim at al., 2007; Guryanova at al., 2017). The first group of methods makes it possible to evaluate the informational significance of indicators, to reveal hidden properties and patterns in large volumes of raw data, in the case when the structure of the input and output data is unknown. The advantage of the second group of methods is the possibility of reducing the dimensionality of the information space of indicators based on the analysis of causal relationships of the set of input and output indicators. The choice of method is determined by the complete or incomplete provision of information, the sample size, the structure of the set of input and output indicators, the presence of a training sample. The scheme of the filter for indicator system is developed based on restrictions on data type and structure of indicator groups. The detailed description of the scheme is given in the work of Guryanova (2013). The proposed approach is based on the methods of canonical analysis and the principal components.

Principal components f_i are linear orthogonal combinations of basic indicators of socio-economic development and competitiveness of countries: $f_i = \sum_{j=1}^{m} b_{ij} x_j$, $\sum_{j=1}^{m} b_{ij}^2 = 1$, $\sum_{i=1}^{m} b_{ij} b_{ik} = 0$, $j \neq k$. The formation of a system of principal components is reduced to a step-by-step transformation of the initial matrix, which can be represented as follows: $X \rightarrow R \rightarrow \lambda, U \rightarrow V \rightarrow A \rightarrow F$, where X - initial data matrix, x_j − the j-th indicator of socio-economic development and competitiveness of countries , m – number of principal components, b_{ij} - loadings of the i-th principal component, R - pair correlation matrix, λ, U - eigenvalues and eigenvector matrix, V - matrix of normalized values of eigenvectors, A - factor mapping matrix, F - principal components matrix. Analysis of the elements of the factor maping matrix $A = (a_{jr})$ allows to form the following subsets: φ_1 - subset of insignificant indicators; φ_2 - subset of significant indicators (as a rule, this set includes indicators, whose factor loadings satisfy the condition $a_{jr} \geq 0,7$); φ_3 - a subset of significant indicators that are not involved in the formation of the principal components; φ_4 - a subset of significant indicators that are involved in the formation of

the principal components (a set of informative, "diagnostic" indicators). The first level of the filter of the initial system of indicators is based on the selection of a subset φ_4. It is considered informative if the following condition is true: $K_r = \frac{\sum_{j=1}^{n} a_{jr}^2 \{\varphi_2 - \varphi_8 = \varphi_4\}}{\sum_{j=1}^{n} a_{jr}^2} \geq 0,75, r = \overline{1,k}$ Thus, the choice of the principal components method is explained by the possibility of forming a system of generalized latent factors, determining the most informative indicators.

The second level of the filter is based on the analysis of the relationship between indicators of social (X_3) and economic (X_4) development (as a higher level subsystem) of territories using the method of canonical correlations. The canonical correlation is the correlation between canonical variables $U = \sum_{j=1}^{m_1} a_j x_{3j}$ and $V = \sum_{j=1}^{m_2} b_j x_{4j}$. The formation of a system of canonical variables can be represented by the following scheme: $X_3, X_4 \rightarrow R_{33}, R_{34}, R_{43}, R_{44} \rightarrow C \rightarrow \lambda, B \rightarrow A$, where X_3, X_4 - matrices of input data of dimension nm_1 and nm_2, $n -$ number of observations, $R_{33}, R_{34}, R_{43}, R_{44}$ - pair correlation matrices, $C = R_{44}^{-1}, R_{43}, R_{33}^{-1}, R_{34}$, λ, B - eigenvalues and eigenvector matrix, A - coefficient matrix for factor variables in the system of canonical correlations. The matrix of pairwise correlations is divided into four parts: $R = \begin{pmatrix} R_{33} & R_{34} \\ R_{43} & R_{44} \end{pmatrix}$. On its basis, auxiliary matrices are determined $R_{44}^{-1}, R_{33}^{-1}, C = R_{44}^{-1}, R_{43}, R_{33}^{-1}, R_{34}$. Next, the eigenvalues of the matrix C and the corresponding basis of the eigenvectors $B_1, B_2, ..., B_p$ are calculated. The coefficients of the factor variables in the system of canonical correlations are calculated by the formula: $A_i = \frac{R_{33}^{-1} R_{34} B_j}{\lambda_j}$. If you rank the eigenvalues in descending order $\lambda_1, \lambda_2, ..., \lambda_p$, then the maximum canonical correlation coefficient will correspond to λ_1^2.

In the process of canonical analysis, the initial data is reduced to a standardized form; therefore, the coefficients in the expressions for the canonical variables characterize the strength of the effect of the corresponding initial indicators, which makes it possible to obtain their ranked sequences. Non-essential indicators are eliminated on the
basis of a multi-step procedure, in which at each step only one variable is discarded, the least significant in this sequence. To compare the canonical correlations, the Fisher z-transformation is used.

Thus, the method of canonical correlations makes it possible to analyze the relationship between several output indicators and a large number of factors. This property is important in the justification of indicators, since the dynamics of the subsystems of social and economic development of territories is characterized by a large set of features. The choice of one of the most significant indicator will lead to a distortion of the assessment results.

To solve task 1.2 - grouping countries by level of socio-economic development and competitiveness, the methods of cluster analysis (classification methods without training) and Kohonen self-organizing maps are used.

Classification consists in splitting the initial set of objects into a relatively small number of classes $Q = \{Q_1, Q_2, ..., Q_i\}$ so that objects belonging to the same class (group) are located at relatively small distances from each other. The similarity or difference between the classified objects is established depending on the metric distance between them. For building the group, hierarchical agglomerative and iterative methods were used. Hierarchical agglomerative methods provide only a conditionally optimal solution in a certain subset of local partitions (clusters). However, the advantage of these methods is the ease of interpretation of the results. The results of clustering, presented in the form of a dendrogram, allow choosing the number of clusters at which the total intergroup dispersion will take the maximum value. This number of clusters is used to select the initial conditions of the iterative algorithm of the k-means method, a detailed description of which is given in the work of Geetz at al. (2006).

As an alternative approach of grouping, models of the Kohonen neural network were considered. We used both complex (across the entire set of indicators) and local diagnostics (for individual groups of indicators), investigated the stability of cluster formations, determined the probability of moving objects from cluster to cluster, taking into account the dynamic characteristics of socio-economic development and competitiveness (Guryanova at al., 2018).

At the end of the classification procedures it is necessary to evaluate the obtained results. For this purpose, a certain measure of the quality of classification is used, the so-called quality functional. The best for the selected functional should be considered such partition, at which the minimum value of the objective function - the quality functional - is reached. When analyzing partitions, the following quality functionals were considered: $F_1 = \sum_{l=1}^{k} \sum_{i \in S_l} d^2(x_i, \bar{x}_l), F_2 = \sum_{l=1}^{k} \sum_{i \in S_l} d_{ij}^2, \ F_3 = \sum_{l=1}^{k} \sum_{j=1}^{p} \sigma_{lj}^2, \ k$ –number of clusters; S_l - set of elements which form the l-th cluster; $d^2(x_i, \bar{x}_l)$ – distance between the i-th element and the cluster centroid; d_{ij}^2 – distance between the i-th and the j-th elements; p – number of variables used in clustering; σ_{lj}^2 – dispersion of the j-th variable in the l-th cluster.
. A partition is considered optimal when $F_i \rightarrow \min(S \in A)$, where A - the set of all admissible partitions.

In the second module, the formation of a system of indicators of research and diagnostic classes of the level of financial decentralization is carried out. The construction of a system of diagnostic indicators of the level of financial decentralization was carried out in accordance with the block diagram of the indicator system filter described above. When forming diagnostic classes of the level of financial decentralization, standardized values of the following indicators were used: financial decentralization by expenditure, financial decentralization by income, indicators of the level of economic development and homogeneity of the economic space, indicators of territorial scale. To build diagnostic classes, hierarchical agglomerative (Ward's method) and iterative (k-means method) cluster analysis procedures were used, as well as the two-way join method, that is described in detail in the work of Kizim at al. (2007).

The content of the third module is a comprehensive assessment of the financial decentralization level. The need to build a system of complex (across the entire system of indicators) and local (for individual components) integral assessments of the level of financial decentralization is caused by the different direction of changes in indicators. This fact complicates the analysis and requires to represent the initial indicator set in the form of a synthetic assessment, which is the result of a convolution of indicators that describe the development of individual subsystems.

The block diagram of an algorithmic model for the formation of an integral assessment of the level of financial decentralization is based on one of the methods for constructing a reference object - a taxonomic indicator of the development level (Geetz at al., 2006). The indicator of the development level is calculated as follows: $d_i^* = 1 - \frac{c_{i0}}{c_0}, \ c_0 = \bar{c}_0 + 2S_0, \bar{c}_0 = \frac{1}{n}\sum_{i=1}^{n} c_{i0}, S_0 = \frac{1}{n}\sqrt{\sum_{i=1}^{n}(c_{i0} - \bar{c}_0)^2}, \ \ c_{i0} = \sqrt{\sum_{j=1}^{m}(Z_{ij} - Z_{0j})^2}$. To construct the pattern, the initial indicator set must be divided into stimulants and disstimulants. Those indicators that have a positive, stimulating effect on the level of financial decentralization are called stimulants, as opposed to disstimulants. The procedure for grouping indicators from the diagnostic set φ4 into stimulants and disstimulants is based on expert assessment. The coordinates of the pattern are determined as follows: $z_{0j} = \begin{cases} \max_i z_{ij}, if \ j \in I \\ \min_i z_{ij}, \ if \ j \notin I \end{cases}$,

where I – stimulants set. Because of different dimensions of initial indicators, the distance matrix is calculated on

the basis of the standardized values: $z_{ij} = \frac{x_{ij} - \overline{x_j}}{s_j}$. The values of the final integral indicator vary in the range from 0 to 1. The closer the values of the integral indicator to 1, the higher the level of financial decentralization.

The purpose of the fourth module is to build a model of production and institutional functions. The model allows you to determine the "threshold" level of financial decentralization, the excess of which will lead to a slowdown in economic growth. The industrial and institutional functions are sufficiently effective tool for studying the impact of the development of financial mechanisms of decentralization on economic growth. They are widely used in modeling production and fiscal effects (Klebanova et al., 2013). A general model specification can be represented as follows:

$$Y = \gamma \cdot D \cdot K^{q \cdot (a + b \cdot q)} L^{q \cdot (n + m \cdot q)},$$

where Y – output (GDP), $D = e^{\beta t}$ – trend operator, t – time period, K – capital, L – number of employees, $\beta, \gamma, a, b, m, n$ – model parameters, q – tax burden parameter.

The output elasticity is determined by the non-linear function of the tax burden for each production factor. This reflects the possibility of strengthening or weakening the influence of factors in different states of the institutional environment.

Parameters of production and institutional functions are estimated based on the linearization of the model (transforming the nonlinear model to a linear form):

$$lnY = ln\gamma + \beta \cdot t + a \cdot q \cdot lnK + b \cdot q^2 \cdot lnK + n \cdot q \cdot lnK + m \cdot q^2 \cdot lnL,$$

let's denote:

$$z_1^* = lnY, a_0 = ln\gamma, z_2^* = q \cdot lnK, z_3^* = q^2 \cdot lnK, z_4^* = q \cdot lnL, z_5^* = q^2 \cdot lnL$$

By substitution, we obtain a linear view of the model, the parameters of which are estimated according to statistical procedures:

$$z_1^* = a_0 + \beta \cdot t + a \cdot z_2^* + b \cdot z_3^* + n \cdot z_4^* + m \cdot z_5^*.$$

In general, the estimation of the model parameters makes it possible to study the extremum points of the function. This curve reaches a local maximum at the point q*, for which the following conditions are satisfied:

$$\frac{\partial Y(q^*)}{\partial q} = 0; \frac{\partial^2 Y(q^*)}{\partial q} < 0$$

When analyzing the effectiveness of the development of financial decentralization mechanisms, it is proposed to consider the integral indicator of the level of development of fiscal decentralization as an assessment of the institutional factor. The proposed specification of the model is: $Y = \gamma \cdot D \cdot K^{cv \cdot (a + b \cdot cv)} L^{cv \cdot (n + m \cdot cv)}$, where Y – output (GDP); $D = e^{\beta t}$ – trend; t – time period; K – Investments in fixed assets; L – number of employees; $\beta, \gamma, a, b, m, n$ – model parameters; cv – integral indicator of the level of development of the mechanism of financial decentralization.

It is necessary to note that the impact of production resources may be increased or decreased depending on the level of financial decentralization. So, some countries are already decentralized more than they need and would get more effect from re-centralization. This is due to the strong impact of "shocks" on individual regions in the context of growing globalization and openness of the economy, the need for financial assistance to such regions;

growth of uneven regional development, heterogeneous potential of adaptation of regional systems to unstable conditions of functioning. Increasing instability also leads to the increase of social spendings level (pensions, social security, unemployment benefits, retraining, etc.), and, as a result, given the high level of tax autonomy and decentralization, to an increase in the budget deficit and public debt. In addition, in some cases, decentralized countries can have a greater effect from the re-centralization of the health and education system, economies of scale and effective coordination of resource allocation.

Other countries are excessively centralized and have a low level of tax autonomy, which causes imbalances in the fiscal system at different management levels. The development of financial decentralization would increase the productivity of resources and overall economic efficiency, as subnational authorities can increase the efficiency of the public services sector due to their proximity to the population and greater awareness of the needs and problems of the respective territories. In other words, investments made by subnational governments are more efficient and more conducive to economic growth than those ones made by central government. In addition, in the conditions of mobility of labor and financial capital, the application of a competitive development model for the subnational level is an incentive for local authorities to improve the quality of life of the population and create favorable conditions for doing business in the region.

Thus, the implementation of the proposed conceptual approach to building a set of models for evaluating the effectiveness of financial decentralization makes it possible to form diagnostic classes of financial decentralization; to determine the "threshold" value of the level of financial decentralization, the excess of which will slowdown the economic growth; identify groups of macroregions that will have a higher effect from the development of financial decentralization or re-centralization of public finances.

4. Results and analysis

The implementation of the first module of the proposed conceptual approach was carried out on the indicators of socio-economic development and competitiveness of more than 100 objects (macro-regions). For the implementation of the models the following programs were used: Statistica, R, Deductor Studio (Guryanova at al., 2018). The initial system of indicators was formed on the basis of the analysis of literary sources devoted to the problem of assessing the level of socio-economic development and competitiveness of territories. The selected indicators are included in the "core" of the indicator systems, occurring in more than 60% of the researched cases. Such indicator system includes both quantitative indicators (GDP per capita, unemployment rate, per capita consumption, inflation) and qualitative indicators (Global competitiveness index (GCI), Global innovation index (GII), Human development index (HDI), ICT development index (ICTDI), Index of economic freedom (IoEF)). The information base of the research has been generated from the World Bank's website (http://data.worldbank.org), World Economic Forum website (http://reports.weforum.org/), Global Innovation Index website (https://www.globalinnovationindex.org/), United Nations Development program website (http://hdr.undp.org/en/content/human-development-index-hdi), ICT Development index (https://www.itu.int/net4/ITU-D/idi/), Index of economic freedom website (https://www.heritage.org/index/explore?view=by-region-country-year). Data for 108 macro regions was considered for the period 2014-2018. The source dataset included 3888 items.

The Fig.1 represents the results of the macro-regions grouping by the level of socio-economic development and competitiveness based on hierarchical agglomerative cluster analysis methods (Ward method) (Fig. 1a) and Kohonen self-organizing maps (Fig. 1b). The optimal number of clusters was determined according to GAP statistics, the "elbow" method, the silhouette method. The results showed that it is optimal to split the original population into three clusters.
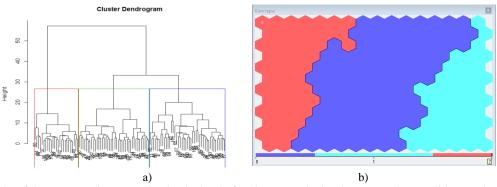
Fig. 1. The results of the macro-regions grouping by the level of socio-economic development and competitiveness based on hierarchical agglomerative cluster analysis methods (Ward method) and Kohonen self-organizing maps.

Source: developed by the authors

The initial set of objects is divided into three classes according to the level of socio-economic development and competitiveness: a cluster of macro-regions with high, medium, low levels of socio-economic development (SED). The analysis of the obtained results has shown that cluster of objects with a low level of socio-economic development consists of 37 macroregions (34% of the total), the medium level cluster has 46 macroregions (43%), the last 25 macroregions are included into the high level cluster (23%). The analysis of the cluster composition showed that 27 of the 28 countries of the European Union belong to clusters with high and medium levels of SED and competitiveness in the global coordinate system. The exception is Romania, which belongs to a cluster of countries with a low level of socio-economic development. Ukraine is included in the same cluster. However, a comparison of classification results based on the Ward method and Kohonen's self-organizing networks makes it possible to say that Ukraine belongs to the group of macroregions that are prone to migration to a medium cluster.

This cluster includes such Eastern Europe countries as Poland, Slovakia, Slovenia, etc. The Czech Republic, Estonia, Italy, and Malta are inclined to move to a higher cluster - a cluster of regions with a high level of socio-economic development.

Thus, the EU countries are mainly in the group of macro-regions with high and medium levels of SED and competitiveness. Ukraine is a macro-region prone to migration from a low level group to a medium level group. The above facts allow to make a conclusion about a fairly high level of comparability of data sets for Ukraine and EU countries when investigating trends in the development of financial decentralization mechanisms.

In the second module, the system of indicators and diagnostic classes of the level of financial decentralization was applied. The initial system of indicators was formed on the basis of the analysis of literary sources. Taking into account the information availability of data series and their methodological continuity in open databases, the final indicator system includes the following groups of markers: indicators of the level of development of the public sector ($x1$ - the percentage of state budget expenditures in GDP (%), $x2$ - the percentage of state budget revenues in GDP (%)); indicators of decentralization by expenditures ($x3$ - the percentage of local budget expenditures in total expenditures (%), $x4$ - the percentage of expenditures of local budgets in GDP (%)); $x4$ - the percentage of local budget expenditures in GDP (%)); indicators of leveling federalism ($x5$ - the percentage of transfers in regional incomes (%); $x6$ - the percentage of transfers in regional expenditures (%)); income decentralization indicators ($x7$ - the share of local budget revenues in total revenues (%); $x8$ - the share of local budget revenues in GDP (%)); indicators of fiscal federalism ($x9$ - the proportion of tax revenues in local budget revenues (%); $x10$ - the proportion of tax revenues to local budgets in total tax revenues (%)); indicators of the level of economic development and homogeneity of the economic space ($x11$ - GDP per capita (euro), $x12$ –economic density (euro

/ km^2)); indicators of scale (x13 - area (km2), x14- population (thous. people)). To form diagnostic classes of the level of financial decentralization, standardized values of indicators of financial decentralization by expenditure, financial decentralization by income, indicators of the level of economic development and homogeneity of the economic space, indicators of territorial scale were used. The hierarchical agglomerative (Ward's method) and iterative (k-means method) cluster analysis procedures, as well as two-input combination method were applied.

The grouping procedure was carried out on the data series that describe 22 macro regions of the EU for the period 2005-2016. The initial data array included 2816 elements. The resulting classification dendrogram is shown in Fig. 2.
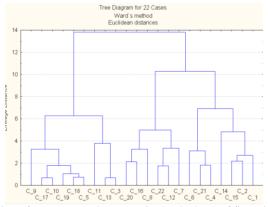

Fig. 2. Classification of European Union countries by the level of financial decentralization
Source: developed by the authors

As can be seen from fig. 2, the initial set should be divided into two clusters, the composition of which was determined using the "k-means" method. The average values of the variables in each cluster are presented in Fig. 3
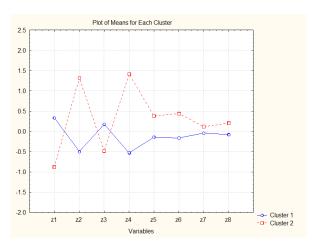

Fig. 3. The average values of the variables in each cluster

* Legend: z1 - the percentage of state budget expenditures in GDP (%), z2 - the percentage of local budget expenditures in GDP (%), z3 - the percentage of state budget revenues in GDP (%); z4 - the percentage of local budget expenditures in GDP (%); z5 - per capita GDP (euro), z6 - area (km2), z7 - economic density (euro / km2); z8 - population (thousand people).
Source: developed by the authors

According to the Fig. 3 the macroregions that formed the first cluster are characterized by a higher level of expenditures and revenues of the state budget in GDP compared to macroregions from the second cluster, low autonomy of bottom levels of the budget system, low economic development, low economic density, smaller scale and population. Thus, this cluster consists of macroregions with a low level of financial decentralization. The second cluster is characterized by a high level of regional independence from the center and minimization of redistributive processes in the fiscal system, a higher level of economic development. The results of the classification show that a higher level of decentralization is observed in countries with a high level of development, economic density, area and population.

The classification results on the basis of a two-way join (Fig. 4) also confirm rather strong differentiation in terms of decentralization by income and expenditure, the level of economic development. Clusters are less homogeneous in terms of area and population.
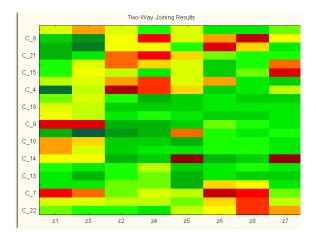

Fig. 4. The two-way join classification results
Source: developed by the authors

Thus, based on the obtained results, it can be concluded that a high level of financial decentralization is shown by the countries with a high level of economic development, where there is a high quality of political institutions and a high level of administrative decentralization, which leads to an increase in the efficiency of the public sector and, as a result, economic growth.

The third module deals with integral assessment of the level of financial decentralization. The initial data series describe more than 20 EU countries for time period 2005-2016. The source array included 2816 elements. Income decentralization indicators, expenditure decentralization indicators, indicators of leveling (budgetary) federalism and tax autonomy were taken into account. The values of the integral indicator of the financial decentralization level (cv_i) are presented in the Table 2.

Table 2. The values of the financial decentralization integral indicator (fragment)

№	Country	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
1	Austria	0.35	0.35	0.35	0.35	0.33	0.33	0.26	0.27	0.26	0.28	0.27	0.34
2	Belgium	0.49	0.49	0.49	0.48	0.48	0.46	0.35	0.35	0.34	0.36	0.35	0.53
3	Czech Republic	0.24	0.24	0.24	0.23	0.19	0.18	0.21	0.21	0.22	0.23	0.23	0.26
4	Denmark	0.57	0.55	0.54	0.53	0.53	0.52	0.40	0.43	0.40	0.44	0.43	0.54
5	Estonia	0.17	0.16	0.16	0.17	0.13	0.13	0.10	0.10	0.09	0.11	0.11	0.17

6	Finland	0.68	0.68	0.67	0.66	0.64	0.62	0.62	0.62	0.59	0.61	0.61	0.63
7	France	0.39	0.39	0.40	0.40	0.40	0.37	0.40	0.40	0.39	0.43	0.41	0.41
8	Germany	0.64	0.64	0.65	0.65	0.62	0.61	0.62	0.64	0.62	0.67	0.65	0.70
9	Greece	0.03	0.06	0.06	0.06	0.12	0.11	0.20	0.20	0.21	0.22	0.22	0.13
18	Slovakia	0.20	0.19	0.18	0.17	0.18	0.18	0.16	0.16	0.16	0.16	0.14	0.17
19	Slovenia	0.32	0.32	0.33	0.34	0.34	0.35	0.45	0.46	0.45	0.46	0.44	0.33
20	Spain	0.56	0.57	0.58	0.57	0.55	0.57	0.45	0.44	0.42	0.47	0.46	0.58
21	Sweden	0.83	0.83	0.84	0.85	0.82	0.80	0.86	0.87	0.85	0.90	0.89	0.85
22	Great Britain	0.32	0.32	0.32	0.31	0.30	0.30	0.27	0.26	0.25	0.27	0.27	0.29

Source: developed by the authors

The table shows a significant heterogeneity of the EU countries in terms of financial decentralization. The maximum value of the financial decentralization level is observed in Sweden (0.85). The minimum value is observed in Greece (0.13). The coefficient of variation of the financial decentralization level is 50%, which reflects significant variations in data set. Similarly, local integral indicators of income decentralization, expenditure decentralization, budgetary federalism and tax autonomy were found (cv_{1i}, cv_{2i}, cv_{3i}, cv_{4i}). The coefficients of variation for the indicators v_{1i}, cv_{2i}, cv_{3i}, cv_{4i} are respectively 19,69%; 23,8%; 10,34%; 21,38%. In terms of the level of development of budgetary federalism, the sample is homogeneous. The most significant differences are observed in the indicators of the level of financial decentralization of income and tax autonomy. Among all EU countries, the Czech Republic, Spain, Italy, and Sweden are the closest ones to the coordinates of the "pattern point".

The above values of the integral indicator were used to build a model of the production-institutional function (the fourth module of the conceptual approach). It should be noted that the previously presented model of production and institutional functions can be developed using spatial, dynamic or panel data. The paper presents a spatial model which has the most accurate approximation level. The resulting model is: $Y = exp^{16.72962} K^{cv(0.5156+2.6142 \cdot cv)} L^{cv(1.0203-4.0936 \cdot cv)}$. Student criterion value equal to t_y=21.29, t_a= 2.41, t_b= 3.29, t_m= 9.15, t_n=-3.67 This allows us to conclude that the model parameters are statistically significant with a 93-99% confidence level. The value of the coefficient of determination, correlation index, Fisher criteria are the following R^2 =0.92, R=0.96, F =48.96. They indicate the statistical significance of the model as a whole. Thus, the model can be used for further analysis.

The "threshold" values of the level of financial decentralization found on the basis of the model suggest that EU countries have significant potential for economic growth due to the development of financial decentralization mechanisms. In particular, for a number of Eastern European countries the level of financial decentralization is significantly lower than optimal. It should be noted that the above approach is quite universal and can be used to assess the effectiveness of sectoral decentralization.

5. Conclusions

Thus, the conceptual approach to the formation of a set of models for assessing the effectiveness of the development of financial decentralization mechanisms was proposed. The approach includes the following modules: classification of countries by level of socio-economic development and competitiveness, the formation of a comparable research base; formation of a system of indicators and diagnostic classes of the financial decentralization level; development of integrated assessment models for the financial decentralization level; development of models of production and institutional functions.

The modeling results showed that a high level of financial decentralization is peculiar to countries with a high level of economic development, in which there is a high-quality institutional environment and administrative decentralization. These factors are the core drivers of efficiency increase in the public sector and, consequently, of economic growth. At the same time, there is a gap between the growth rates of income and expenditure powers of budgets of various levels and GDP growth rates for countries with a high level of competitiveness and socio-economic development, which reduces the level of budget and debt security.

The simulation results led to the conclusion that there is a significant heterogeneity of the EU countries in terms of the level of development of financial decentralization. The coefficient of variation of the financial decentralization complex indicator is about 50%. The data sample is homogeneous in terms of leveling (budgetary) federalism indicator. It indicates a low differentiation of indicators of social policy between the EU countries. The most significant differences are observed in the indicators of the financial decentralization of income and tax autonomy. Among all EU countries, the Czech Republic, Spain, Italy, and Sweden are the closest ones to the coordinates of the "pattern point".

The developed models of production and institutional functions make it possible to determine the "threshold" value of the level of financial decentralization, the excess of which will lead to a slowdown in economic growth. The groups of countries have been determined that will have a higher effect from the development of financial decentralization or re-centralization of public finances. The proposed approach is quite universal and can be used to assess the effectiveness of sectoral decentralization.

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