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ECONOMETRIC MODELLING OF THE FINANCIAL REGULATION MECHANISM IN REGIONAL DEVELOPMENT

A conceptual approach to forming of a system of models of the financial regulation mechanism in regional development has been suggested. The models for estimation of interregional socioeconomic differentiation, of regional development convergence, for forecasting the dynamics of regional development, for generation of solutions regarding balanced regional development are presented.

Keywords: *regional development; fiscal policy; econometric modelling.*

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ЕКОНОМЕТРИЧНЕ МОДЕЛЮВАННЯ МЕХАНІЗМУ ФІНАНСОВОГО РЕГУЛЮВАННЯ РОЗВИТКУ ТЕРИТОРІЙ

У статті запропоновано концептуальний підхід до формування комплексу моделей механізму фінансового регулювання розвитку територій. Розроблено моделі оцінювання міжрегіональної соціально-економічної диференціації, конвергенції регіонального розвитку, прогнозування динаміки розвитку територій, генерації управлінських рішень щодо збалансованого територіального розвитку.

Ключові слова: *регіональний розвиток; фіскальна політика, економетричне моделювання.*
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ЭКОНОМЕТРИЧЕСКОЕ МОДЕЛИРОВАНИЕ МЕХАНИЗМА ФИНАНСОВОГО РЕГУЛИРОВАНИЯ РАЗВИТИЯ ТЕРРИТОРИЙ

В статье предложен концептуальный подход к формированию комплекса моделей механизма финансового регулирования развития территорий. Разработаны модели оценки межрегиональной социально-экономической дифференциации, конвергенции регионального развития, прогнозирования динамики развития территорий, генерации управленческих решений относительно сбалансированного территориального развития.

Ключевые слова: *региональное развитие; фискальная политика; эконометрическое моделирование.*

Problem statement. Large-scale geoeconomic transformations have caused new problems in regional development, new kinds of risk interaction, social and economic consequences which are hard to predict and which are of destructive, catastrophic nature leading to conflicts escalation. Under these conditions the transition towards a new state policy takes place, a policy aimed primarily at solving social and economic problems.

The world economic crisis, coupled with a number of social upheavals, forced people to acknowlege the issue of irregularities in regional economic development, as well as the social impact of its aggravation under the conditions of resonance regional interaction, from a different angle. Underestimating of system risks in the activities of donor regions as a result of synchronization of periodic development of the leading national economies has led to the deficit of reserves for prevention of social crises, stimulation of business activities of core regions, and exacerbation of the recession phase. This situation is very typical for the economy of Ukraine, as well as for some

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EU countries. Under a cyclic crisis recipient regions are forced to cut down social programs, which leads to a number of social crises, while in donor regions the practicability of spending financial resources on balancing social-economic programs of regional development is becoming an issue. The problem of inequalities in regional development becomes dominant for the development of separate regions, states (territories), including Ukraine.

The growth of economies openness, a differentiated level of regional competitiveness increase their gap in the levels of economic development objectively, lead to sustainable spatial economic concentration, reinforce the development of certain regions and the weakness of others. Under these conditions creating a common economic space is impossible without governmental regulation of regional development processes. Among the instruments of governmental regulation the most efficient ones, as the practice of successful regional management demonstrates, are financial ones: accumulating funds for financial support of regions, budget financing of the development of separate sectors of regional economies, fiscal policy. It should be noted that the existing fiscal (tax) policy inevitably leads to limiting the interests of donor regions, slowing down their economic growth, while the absence of stimuli for less developed regions raises their subsidization. Economic misbalance causes political misbalance, forming the threats in border regions, absence of motivation for interregional interaction, strengthening centrifugal tendencies.

The aforementioned facts emphasize how important proper modelling of the financial regulation mechanism of regional development is, allowing us choose the most efficient tools for smoothing out interregional socioeconomic differences through the prism of the strategy of anti-cyclic policy and stable development of national economy as a whole.

Recent research and publications analysis. Theoretical and methodological aspects of modelling and forecasting the socioeconomic regional development are explored in the works of the following researchers: R. Barro and X. Sala-i-Martin (1991), A.A. Bondarev (2004), A.R. Buhtizin (2008), V.P. Chernov and F.A. Ushchev (2010), P.-P. Combes et al. (2008), J. Cuadrado-Roura et al. (2000), V.M. Geyets et al. (2006), G.V. Gorelova et al. (2005), P.-O. Gourinchas and H. Rey (2013), C.V. Ketova (2008), J. Lopez-Rodriguez (2008), I.G. Lukyanenko (2004), N.N. Lychkina (2009), R.G. Nyzhegorodzev (2008), V.S. Ponomarenko et al. (2011), S.V. Soloduhin and V.V. Khoroshun (2012), V.A. Vasyliev and V.I. Suslov (2010, 2011), P.V. Zaharchenko (2010), F.D. Zastavniy (2006). In particular, the emphasis has been made to such aspects of the problem as: interregional economic interaction on the basis of a complex of optimizing interregional interbranch models; development of system dynamic models for estimation, analysis and forecasting of socioeconomic regional development; application of casual and non-casual approaches to modelling of budget regulation mechanisms for regional development.

Unresolved issue. Despite considerable interest to the issue, there still remain insufficiently studied approaches that allow evaluating the balance of economic space, which impact the dynamics of interregional socioeconomic differentiation, as well as the conformity of the fiscal policy attributes, its influence on the convergence processes of regional development, ensuring stable development of separate regions and of national economy as a whole.

Key research findings. The suggested mechanism of financial regulation of territories is viewed as a sum of mutually dependent modules, tuned for the realization of corresponding management functions (Klebanova et al., 2012). Under the mechanism modelling we mean the development of a coordinated complex of the models for assessment, analysis, and forecast of socioeconomic regional development as a result of fiscal policy that allow solving the problem of ensuring balanced territorial development. A conceptual chart of the mechanism is shown in Figure 1. Below is the description of the modules of this mechanism.

The purpose of *the first module* of the mechanism is *the estimation of interregional socioeconomic differentiation*. This module solves such problems as forming the information space of attributes of socioeconomic regional development, grouping the regions by the level of SERD.

The purpose of *the second module* is *the convergence analysis of regional development.* This module considers the following issues: analysis of absolute and relative convergence, long-term convergence, estimation of irregularities in socioeconomic development as a threat to economic security (Klebanova, Kavun and Guryanova, 2012).

The aim of *the third module* is *forecasting the crisis dynamics of regional development*. This module highlights such issues as: cycle-forming factor analysis, assessment of resonance interaction of economic indicators (Daradkeh, Guryanova, Kavun and Klebanova, 2012).

The role of *the fourth module* of the mechanism is *forming the inertial scenarios of changing attributes of SERD*. The main objectives of this module are: forecasting the attributes of the budget system and socioeconomic regional development; dynamic analysis of misbalances in regional development; definition of origins of misbalances in regional development.

The purpose of *the fifth module* of the mechanism is in *development and analysis of alternative scenarios of managing SERD*. The objectives of this module are: grouping regions for generating solutions regarding the elimination of misbalances in regional development; forming of alternative options in fiscal policy; forecasting the dynamics of SERD; choosing the variant of financial regional policy (Klebanova, Guryanova et al., 2012; Brumnik, Klebanova, Guryanova, Kavun and Trydid, 2014).

The suggested mechanism allows evaluating threats to national economy sustainability, to find the origins of inequality in regional development, to make a choice of effective tools for financial regulation of regional development that would ensure the stable development of national economy as a whole while smoothing interregional socioeconomic differentiation.

The basis modules in the suggested mechanism (Figure 1) are the modules in interregional socioeconomic differentiation estimation, of the analysis of regional development convergence, of forecasting the crisis dynamics in regional development. Data of the State Statistics Committee on socioeconomic development of Ukraine and its 25 regions over the past 12 years are the information base for this research.

The model basis of the first module includes the model for estimation of the level of descriptiveness of SERD indicators; model for groupping of regions by their develiomen level; models for estimation the stability of regional cluster entities (Guryanova, 2013).

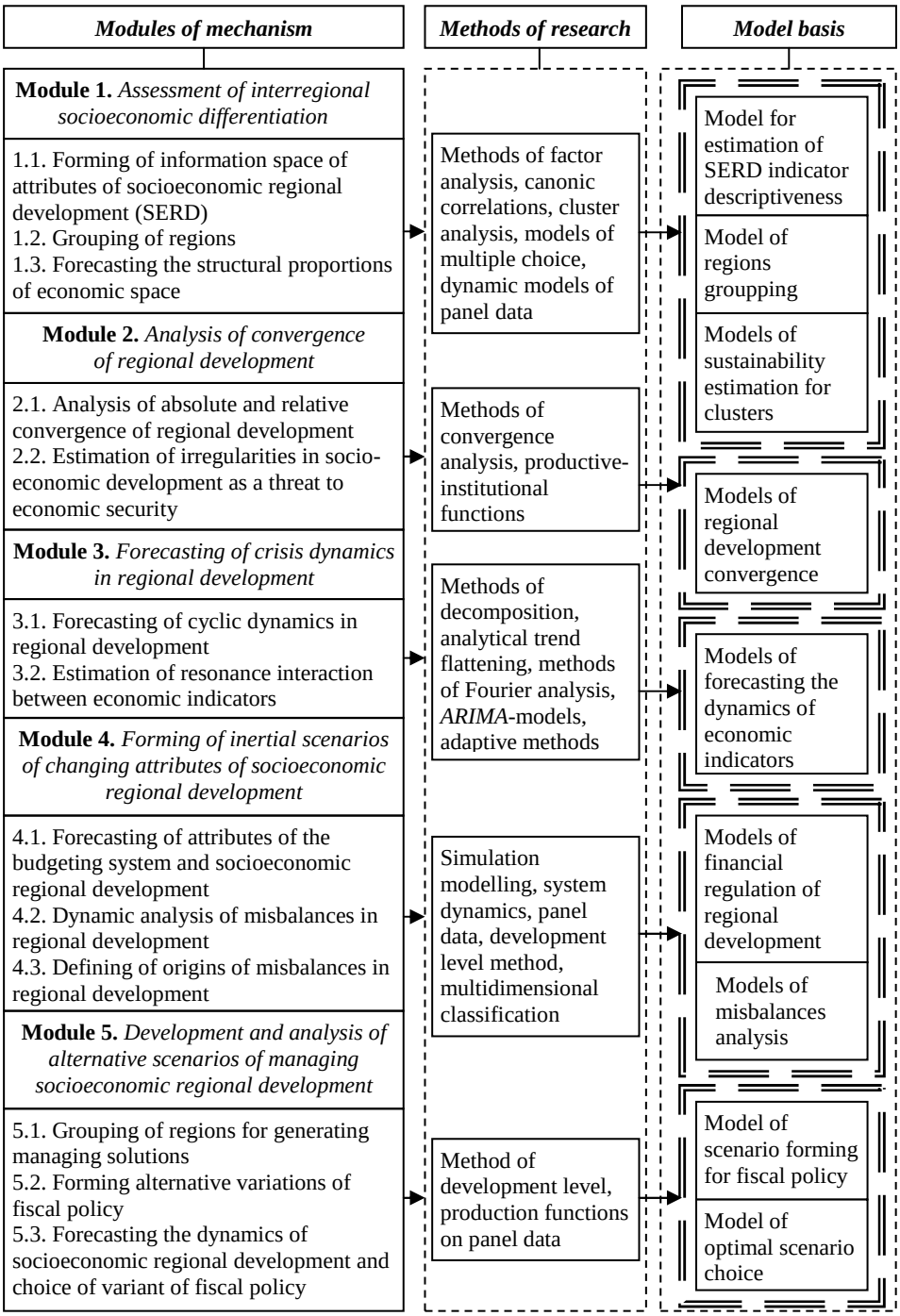

Figure 1. **Conceptual chart of financial regulation mechanism of regional development,** *authors' development* (Klebanova, Kizim, Guryanova et al., 2011; Klebanova, Guryanova, Daradkeh and Kavun, 2013)

The suggested structural model of estimation of the descriptiveness of SERD indicators is based on a synthesis of the method of prime components and of canonical analysis, which allows finding latent factors, explore causalities between indicators, form a system for diagnostics of SERD attributes. The subset of diagnostic attributes consisting of 43 indicators is provided, characterising SERD with such components as: "Demographics", "Population employment", "Population income", "Public utility", "Education", "Medical services", "Public transportation and communication", "Law violation", "Ecology", "Industry", "Agriculture", "Investments", "Economic potential", "Organizational potential", "International economic activity", "Finances", "Science and innovation".

The suggested model for estimation of socioeconomic regional differentiation is based on the methods of cluster analysis and spatial econometrics. Cluster analysis allows singling out groups of regions, similar to SED attributes. The paper uses the synthesis of hierarchical agglomeration and iterative methods. For the purposes of comparing groups, the following functionals of quality are used:

$$F_1 = \sum_{l=1}^{k} \sum_{i \in S_l} d^2(x_i, \bar{x}_l); \tag{1}$$

$$F_2 = \sum_{l=1}^{k} \sum_{i,j \in S_l} d_{ij}^{\ 2}; \tag{2}$$

$$F_3 = \sum_{l=1}^{k} \sum_{j=1}^{p} \sigma_{lj}^2. \tag{3}$$

The optimal partition is the one where $F_i \to \min_{S \in A}$ and A is the multitude of all possible variants of fragmentation. The results allow us to conclude that there are substantial disproportions in economic development: the groups with high and low levels of SED count respectively for 36% and 64% of the regions.

The methods of spatial econometrics are used for the research on spatial autocorrelation of the rate of socioeconomic regional development, analysis of territorial organization of separate clusters. The research on global and local spatial effects is based on measures of spatial autocorrelation (Fischer, Getis et al., 2010) and demonstrates the existence of positive spatial autocorrelation of SERD rates: regions with low level of socioeconomic development are mainly surrounded by low developed regions, which in turn leads to further polarization and rising threats in border regions.

For evaluating the structural proportions of economic space in mid-term perspective, the options of saving, smoothing out, or reinforcing disproportions, devised here are the models for estimating the stability of regional cluster formations. This estimation requires forecasting the attributes of socioeconomic regional development and discerning of the cluster state of regional systems. To solve the first problem, we have developed a complex of model panel data of SERD attributes (in brackets is the value of t-statistics, coefficient of determination, Fisher's criteria):

$$\begin{gathered} x_{7,3_{it}} = \mu_i + 1.262554 x_{7,3_{i,t-1}} - 0.33377 x_{7,3_{i,t-2}} \\ (t_{a1} = 21.60786, t_{a2} = -5.966959, R^2 = 0.97819, F = 880.597); \end{gathered} \tag{4}$$

$$x_{14,2_{it}} = \mu_i + 0.267317x_{14,2_{i,t-1}} + 0.319985x_{14,2_{i,t-2}}$$
$$(t_{a1} = 2.043419, t_{a2} = 2.621649, R^2 = 0.84479,\ F = 1077.737); \quad (5)$$

$$x_{10,1_{it}} = \mu_i + 0.877753x_{10,1_{i,t-1}} - 3.197484x_{10,1_{i,t-2}}$$
$$(t_{a1} = 13.04861, t_{a2} = -3.464478, t_{a3} = 4.747707, R^2 = 0.747993, F = 345.9324);) \quad (6)$$

$$x_{5,3_{it}} = \mu_i + 0.714818x_{5,3_{i,t-1}} - 0.321037x_{5,3_{i,t-2}}$$
$$(t_{a1} = 19.6398, t_{a2} = -8.571705, R^2 = 0.838296, F = 1026.458); \quad (7)$$

$$x_{7,1_{it}} = \mu_i + 0.420728x_{7,1_{i,t-1}} + 0.132141x_{7,1_{i,t-2}}$$
$$(t_{a1} = 6.334255, t_{a2} = 1.891239, R^2 = 0.604101, F = 302.1272); \quad (8)$$

$$x_{3,1_{it}} = \mu_i + 0.914184x_{3,1_{i,t-1}} + 0.236649x_{3,1_{i,t-2}}$$
$$(t_{a1} = 13.15922, t_{a2} = 2.968103, R^2 = 0.963743, F = 5262.991); \quad (9)$$

$$x_{3,2_{it}} = \mu_i + 0.964418x_{3,2_{i,t-1}}$$
$$(t_{a1} = 22.62615, R^2 = 0.727507, F = 4260.702), \quad (10)$$

where μ_i is the value of the fixed effect for the *i* region; $X_{7,3}$, $X_{14,2}$, $X10,1$, $X_{5,3}$, $X_{7,1}$, $X_{3,1}$, $X_{3,2}$ – diagnostic attributes of SERD levels.

To solve the issue of recognition we used *logit*- and *probit*-analysis, which helps ensuring the acceptable quality of classification under the conditions of small selection (shown in brackets is the value of *t*-statistic, pseudo R^2, information criteria of Akaike, Schwarz, the mean absolute percentage error of forecast):

$$y_i = \begin{cases} 1, if \Lambda(z) = \dfrac{e^{\begin{array}{l}-12.0132+0.075007x_{7,3_i}+0.032994x_{14,2_i}+0.000755x_{10,1_i}+\\+0.033656x_{5,3_i}+0.036623x_{7,1_i}-0.00394x_{3,1_i}+0.000134x_{3,2_i}\end{array}}}{1+e^{\begin{array}{l}-12.0132+0.075007x_{7,3_i}+0.032994x_{14,2_i}+0.000755x_{10,1_i}+\\+0.033656x_{5,3_i}+0.036623x_{7,1_i}-0.00394x_{3,1_i}+0.000134x_{3,2_i}\end{array}}} \geq 0.5 \\ 0, if \Lambda(z) = \dfrac{e^{\begin{array}{l}-12.0132+0.075007x_{7,3_i}+0.032994x_{14,2_i}+0.000755x_{10,1_i}+\\+0.033656x_{5,3_i}+0.036623x_{7,1_i}-0.00394x_{3,1_i}+0.000134x_{3,2_i}\end{array}}}{1+e^{\begin{array}{l}-12.0132+0.075007x_{7,3_i}+0.032994x_{14,2_i}+0.000755x_{10,1_i}+\\+0.033656x_{5,3_i}+0.036623x_{7,1_i}-0.00394x_{3,1_i}+0.000134x_{3,2_i}\end{array}}} < 0.5 \end{cases} \quad (11)$$

$$(t_{a0} = -7.24746,\ t_{a1} = -3.026762,\ t_{a2} = 1.886637,\ t_{a3} = 4.561631,$$
$$t_{a4} = 4.443112,\ t_{a5} = 3.993964,\ t_{a6} = -5.09814,\ t_{a7} = 2.007267,$$
$$m.a.p.e. = 13.5,\ AIC = 0.89,\ SIC = 0.99,\ R^2 = 0.803);$$

$$y_i = \begin{cases} 1, if(z) = \dfrac{1}{\sqrt{2\pi}} \times e^{\dfrac{-(\begin{array}{l}-6.90131+0.0432x_{7,3_i}+0.01793x_{14,2_i}+0.00043x_{10,1_i}+\\+0.01907x_{5,3_i}+0.02159x_{7,1_i}-0.00229x_{3,1_i}+0.00008x_{3,2_i})^2\end{array}}{2}} \geq 0.5 \\ 0, if(z) = \dfrac{1}{\sqrt{2\pi}} \times e^{\dfrac{-(\begin{array}{l}-6.90131+0.0432x_{7,3_i}+0.01793x_{14,2_i}+0.00043x_{10,1_i}+\\+0.01907x_{5,3_i}+0.02159x_{7,1_i}-0.00229x_{3,1_i}+0.00008x_{3,2_i})^2\end{array}}{2}} < 0.5 \end{cases} \quad (12)$$

$$(t_{a0} = -7.81418,\ t_{a1} = 3.23784,\ t_{a2} = 1.78283,\ t_{a3} = 4.89633,$$
$$t_{a4} = 4.49099,\ t_{a5} = 4.25636,\ t_{a6} = -5.53726,\ t_{a7} = 2.21265,$$
$$m.a.p.e. = 13.8,\ AIC = 0.89,\ SIC = 0.99,\ R^2 = 0.803).$$

The results based on those models allowed concluding that in the mid-term perspective the existing disproportions will remain.

The second module of the suggested mechanism is the module of the convergence analysis of regional development (Figure 1). We have conducted a test of the hypothesis on the convergence of regional development in Ukraine based on the models of Barro, Sala-i-Martin, Solow-Swan, Cuadrado-Roura, conditional β-convergence, spatial lag of minimally conditional convergence, conditional convergence with spatial error, models of σ-convergence.

Statistical evaluation of the models' parameters of unconditional β-convergence yielded the following results:

$$\frac{1}{T}\ln\left[\frac{Y_i(T)}{Y_i(0)}\right] = 0.130911 + 0.005322 \times \ln Y_i(0) + \varepsilon_i \quad (13)$$
$$(t_c = 1.694718,\ t_\beta = 0.522164,\ R^2 = 0.0117152),$$

where $Y_i(T)$, $Y_i(0)$ – GRP per capita of the i region in the corresponding period of time; $\beta = -\frac{(1-e^{-bT})}{T}$ – the rate of convergence; ε_i – magnitude of error, which is a random component.

Assessments of the models' parameters of unconditional β-convergence are statistically insignificant, which allowed us conclude about the absence of one single direction of equal growth for all regions. Similar results have been received basing on the modifications of the model of unconditional β-convergence.

In the model of conditional β-convergence it is assumed that convergence occurs within the groups of regions with similar structural characteristics. For the group of regions with a high level of development the following regression has been calculated:

$$\Delta y_{it} - \Delta\overline{y_t} = \alpha_i - 0.300652 \times (y_{i,t-1} - \overline{y}_{i,t-1}) + \varepsilon_{it} \quad (14)$$
$$(t_\beta = -3.373375,\ R^2 = 0.2615),$$

where $y_{i,t}$ – the logarithms of GRP per capita of the i region in the t time period; $\Delta y_{it} = y_{it} - y_{i,t-1}$; $\Delta\overline{y_t} = \frac{\sum_{i=1}^{25}\Delta y_{it}}{25}$; α_i – the value of the fixed effect for the i region.

The demonstrated results allowed us conclude about the existence of a rather strong effect of conditional convergence: 30% of the deviation in the levels of economic development is eliminated during one period. For a group of regions with low level of development the convergence rate amounts to 45%.

The spatial model of conditional β-convergence allows us check the hypothesis of the impact of spatial effects, explained by heterogeneity and spatially correlated reaction, on macroeconomic "shocks". Statistical assessment of the models parameters yielded the following results:

$$\ln\left[\frac{Y_i(T)}{Y_i(0)}\right] = 2.8861 - 0.1849 \times \ln Y_i(0) + 0.2224 \times z_{1i} + 0.1121 \times z_{2i} -$$
$$- 0.0396 \sum w_{ij} \ln Y_j(0) + 1.7916 \times \sum_{j=1}^{25} w_{ij} \ln\left[\frac{Y_i(T)}{Y_i(0)}\right] + \varepsilon_i \quad (15)$$

$$(t_{a1} = 3.74376,\ t_{\beta} = -1.81929,\ t_{z1} = 3.55713,\ t_{z2} = 2.54537,$$
$$t_{\gamma} = -2.19478,\ t_{\lambda} = 2.17974,\ R^2 = 0.551),$$

where z_{1i}, z_{2i} are the fictional variables reflecting the relation of the *i* region to one of the highlighted clusters; w_{ij} – the elements of the matrix of spatial balance.

The parameters of exogenous and endogenous spatial lag are statistically significant, which allowed us make the following conclusion: the rising rate of economic development of close regions leads to the increase in regional business activities.

Random "shocks" that influence regional economy can counteract the trend of decreasing interregional socioeconomic differentiation and increase the dispersion of the SERD attributes. After the statistical evaluation of the parameters of the model of σ-convergence, we have received the following results:

$$\sigma_{it}^2 = 1.145645 \times \sigma_{i,t-1}^2 \sigma_e^2$$
$$(t_{b^2} = 6.610856,\ R^2 = 0.9284), \tag{16}$$

where $\sigma_{it}^2 = \dfrac{\sum_{i=1}^{N}(Y_{it} - \overline{Y_{it}})^2}{N}$; $\overline{Y}_{it} = \dfrac{1}{N} \times \sum_{i=1}^{N} Y_{it}$; σ_e^2 – the retained dispersion.

The assessment of the parameter b_i is statistically significant and has values higher than 1. It means that the reduction tendency in GRP per capita levels is not typical for any region of Ukraine.

We have explored the impact of a cyclic crisis on the convergence-divergence dynamics of regional development. We have examined such hypotheses as: neutral influence (differentiation remains); convergence (decline in the rate of economic growth in regions with high levels of SED occurs faster than in the regions with low levels of development, differentiation is diminished); divergence (decline of the growth rate occurs faster in the regions with low levels of SED, differentiation increases). The results allowed us conclude about a fairly strong influence of cycle formations on regional economic dynamics. The assessment of the convergence rate, taking into account the factor of cyclic development, was carried out using the model of conditional convergence:

$$\ln\left(\frac{Y_{it}}{Y_{i,t-1}}\right) = \alpha_i - 0.083831 \times \cos\left(\frac{2\pi}{3}(t-1)\right)$$
$$+ 0.008969 \times \sin\left(\frac{2\pi}{3}(t-1)\right) - 0.032602 \times \ln Y_{it-1} + \varepsilon_{it} \tag{17}$$
$$(t_b = -3.455222,\ R^2 = 0.306861),$$

where α_i – the value of the fixed effect for the *i* region.

The yielded results allow us state that the rate of long-term convergence is 3%. The rate of short-term convergence, tied to the impact of cyclic development, as mentioned above, is 30% for the group of regions with high level of socioeconomic development, 45% – for the group of regions with low SED level. The cyclic crisis affects primarily the regions with high level of development, those which can be characterized by a considerable dependence of economic activity on the situation at world markets. The cyclic crisis also heavily influences the regions suffering from economic depression.

The considerable sensitivity of economic indicators of regional systems to the influence of external shocks, and spatial clustering reacting to external shocks, reveals itself in high volatility of the attributes of regional development in the periods of cyclic growth and decline. Anomalous dispersion is one of the indicators that help us estimate the crisis forming in the development of economic systems. We have conducted the analysis of indicators of σ-convergence/divergence using the attributes of such structural components as "Demographics", "Population employment", "Population income" etc. To choose the typical representative attributes for each of the structural components of SED we have used the "center of gravity" method. The results give evidence that anomalous dispersion is typical for the attributes of innovation and investment and international economics activity. This means the possibility of crisis formation in regional subsystems.

To evaluate the influence of irregularities in socioeconomic development on economic growth we have used the productive-institutional functions (PIF). Statistical assessment of the PIF parameters delivered the following results:

$$Y = 27353.53\exp^{0.1507t} K^{q(0.0436-0.0014q)} L^{q\cdot(-0.2376+0.0059q)}$$
$$(t_\beta = 2.79,\ t_\alpha = 1.19,\ t_b = -1.41,\ t_n = -2.09,\ t_m = 2.07,\ R^2 = 0.9974), \quad (18)$$

where Y – GDP volume, bln UAH; t – time; K – cost of fixed assets, bln UAH; L – number of employed population, mln persons; q – evaluation of irregularities in socioeconomic regional development.

The PIF model allows us define the extreme value of the coefficient of irregularities of regional SED, exceeding of which would lead to economic growth decline. The analysis of the received date allowed us to conclude that the misbalance in economic space becomes a threat to stable development of economic systems.

The third module of the mechanism (Figure 1) presents the forecasting of cyclic dynamics of territorial development. We have defined the features of structural components of the prediction system of economic regional dynamics, formed an information space for the attributes of research of cyclic dynamics of economic systems. We have evaluated the cycle formations in the dynamics of macroeconomic indicators. One of the main indicators, regarding which a hypothesis on cyclic development has been proposed, is the volume of industrial production. A research of the timeline of the volume of industrial production using the *ADF*-test showed that the timeline is stationary in the first margins with the 99% probability. To confirm the hypothesis of the existence of a short-term cyclic component in the timeline we used the adaptive models of prediction, with and without short-term cyclic fluctuations. For building the model of the trend we have considered different classes of the growth graph. The research of the discovered first retained figures of the line $s_1(t)$ using the method of spectral analysis demonstrated the existence of the following most important periodic components (Table 1).

Table 1. **Distribution of dispersion between harmonics,** *authors'*

Duration of cycle (*T*), months	*48*	*96*	*32*	*19.2*	*24*	*16*	9.6	13.71	7.38	2.9	10.7
Harmonics contribution to process dispersion, %	*43.31*	*22.90*	*6.23*	*6.03*	*2.88*	*2.01*	1.31	1.02	1.00	0.96	0.72

Thus, the research on the dynamics of the industrial production volume shows a significant influence of mid-term cyclic components. These periodic components explain the 84.38% of process dispersion. The model of cyclic component of the timeline looks as follows:

$$\begin{aligned} S_{1t} = {} & 0.134086\cos\left(\frac{2\pi}{48}(t-1)\right) + 0.153038\sin\left(\frac{2\pi}{48}(t-1)\right) \\ & + 0.08508\cos\left(\frac{2\pi}{96}(t-1)\right) - 0.121026\sin\left(\frac{2\pi}{96}(t-1)\right) + \\ & 0.063453\cos\left(\frac{2\pi}{32}(t-1)\right) + 0.043461\sin\left(\frac{2\pi}{32}(t-1)\right) - \\ & - 0.02045\cos\left(\frac{2\pi}{19.2}(t-1)\right) + 0.073107\sin\left(\frac{2\pi}{19.2}(t-1)\right) + \\ & + 0.017753\cos\left(\frac{2\pi}{24}(t-1)\right) - 0.049395\sin\left(\frac{2\pi}{24}(t-1)\right) \\ & - 0.00765\cos\left(\frac{2\pi}{16}(t-1)\right) + 0.04319\sin\left(\frac{2\pi}{16}(t-1)\right) + u_t. \end{aligned} \quad (19)$$

The calculated values of the periodic component of the line and the value of the second residual component allowed us conclude about the existence of a pronounced descending wave, which can be explained by a long-term cycle. The assessment of the influence of long-term cyclic components was performed basing on the linear harmonic trends. When reconstructing the timeline, the second residual component was examined using the *ARIMA*-models. The average absolute percent of error in the combined model constituted 5.0377%, indicating the credibility of the modelling results. Predictive values of the industrial production volume for 3 years into the future, received from the combined model, are demonstrated in Figure 2.

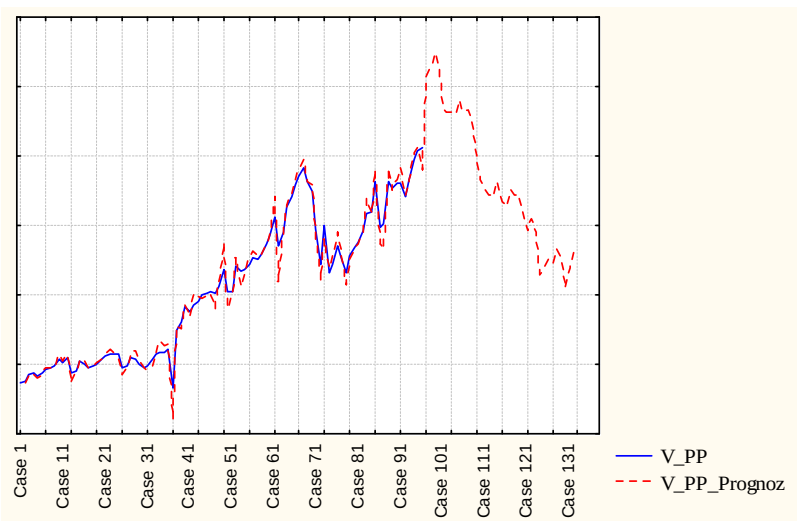

Figure 2. **Factual (V_PP) and predictive (V_PP_Prognoz) values of the industrial produce volume,** *authors'*

The analysis of the derived data shows the decline phase in the dynamics of the analyzed attribute. Similar results have been received upon examining the cyclic components of such macroattributes as retail turnover ($s_2(t)$)), average monthly wages ($s_3(t)$), volume of construction works ($s_4(t)$), aggregate M3 ($s_5(t)$). The models of the cyclic components of the timelines of these indicators look as follows:

$$\begin{aligned} S_{2t} = {} & 0.050306\cos\left(\frac{2\pi}{48}(t-1)\right) + 0.114825\sin\left(\frac{2\pi}{48}(t-1)\right) - \\ & - 0.226513\cos\left(\frac{2\pi}{96}(t-1)\right) - 0.082921\sin\left(\frac{2\pi}{96}(t-1)\right) + \\ & + 0.018279\cos\left(\frac{2\pi}{32}(t-1)\right) + 0.069207\sin\left(\frac{2\pi}{32}(t-1)\right) + \\ & + 0.018115\cos\left(\frac{2\pi}{19.2}(t-1)\right) + 0.057173\sin\left(\frac{2\pi}{19.2}(t-1)\right) - \\ & - 0.003333\cos\left(\frac{2\pi}{24}(t-1)\right) - 0.045562\sin\left(\frac{2\pi}{24}(t-1)\right) - \\ & - 0.019862\cos\left(\frac{2\pi}{16}(t-1)\right) + 0.021522\sin\left(\frac{2\pi}{16}(t-1)\right) + u_t; \end{aligned} \tag{20}$$

$$\begin{aligned} S_{3t} = {} & 74.7203\cos\left(\frac{2\pi}{96}(t-1)\right) - 32.1492\sin\left(\frac{2\pi}{96}(t-1)\right) + \\ & + 58.7979\cos\left(\frac{2\pi}{32}(t-1)\right) + 25.7822\sin\left(\frac{2\pi}{32}(t-1)\right) - \\ & - 15.9164\cos\left(\frac{2\pi}{48}(t-1)\right) + 35.7875\sin\left(\frac{2\pi}{48}(t-1)\right) - \\ & - 17.1555\cos\left(\frac{2\pi}{19.2}(t-1)\right) + 1.5842\sin\left(\frac{2\pi}{19.2}(t-1)\right) + \\ & + 18.6619\cos\left(\frac{2\pi}{16}(t-1)\right) + 16.5033\sin\left(\frac{2\pi}{16}(t-1)\right) + \\ & + 3.238\cos\left(\frac{2\pi}{24}(t-1)\right) - 13.4948\sin\left(\frac{2\pi}{24}(t-1)\right) + u_t; \end{aligned} \tag{21}$$

$$\begin{aligned} S_{4t} = {} & -0.015492\cos\left(\frac{2\pi}{48}(t-1)\right) + 0.158615\sin\left(\frac{2\pi}{48}(t-1)\right) + \\ & + 0.156447\cos\left(\frac{2\pi}{32}(t-1)\right) - 0.018247\sin\left(\frac{2\pi}{32}(t-1)\right) - \\ & - 0.151984\cos\left(\frac{2\pi}{96}(t-1)\right) - 0.033406\sin\left(\frac{2\pi}{96}(t-1)\right) + \\ & + 0.072323\cos\left(\frac{2\pi}{16}(t-1)\right) + 0.052395\sin\left(\frac{2\pi}{16}(t-1)\right) + u_t; \end{aligned} \tag{22}$$

$$S_{5t} = -0.186805\cos(\frac{2\pi}{48}(t-1)) - 0.041769\sin(\frac{2\pi}{48}(t-1)) + \\ + 0.124393\cos(\frac{2\pi}{96}(t-1)) + 0.072022\sin(\frac{2\pi}{96}(t-1)) + \\ + 0.079623\cos(\frac{2\pi}{32}(t-1)) - 0.089214\sin(\frac{2\pi}{32}(t-1)) - \\ - 0.044653\cos(\frac{2\pi}{19.2}(t-1)) - 0.076730\sin(\frac{2\pi}{19.2}(t-1)) + \\ + 0.040183\cos(\frac{2\pi}{16}(t-1)) - 0.016382\sin(\frac{2\pi}{16}(t-1)) - \\ - 0.003819\cos(\frac{2\pi}{24}(t-1)) + 0.041842\sin(\frac{2\pi}{24}(t-1)) + u_t. \quad (23)$$

The analysis of resonance events in the dynamics of macroeconomic indicators during the researched period allowed us pinpoint the convergence in the phases of decline in the dynamics of such attributes as the volume of industrial production, retail turnover, average monthly wages, and the coefficient of migration, which indicates the forming of a crisis situation.

The research of patterns in cyclic dynamics in the development of regional systems was performed basing on the data of socioeconomic development of representative regions in the groups of regions with high and low levels of development. The examination of mid-term periodic components of the timelines allowed us single out the phases of economic cycles.

Thus, the suggested complex of models allows us explore the cyclic components which have the most profound impact on the dynamics of the attributes of regional economic development, and to predict the crisis situations in economic systems.

Conclusion. The conducted analysis of regional development allowed pinpoint as one of the running tendencies the growing irregularities and fragmentation of economic space in the country. The resulting misbalance threatens the integrity of the national economy as well as the stability of its budget systems. A conceptual approach to the forming a system of models within the financial regulation mechanism of regional development is suggested. The models for estimation of interregional socioeconomic differentiation, regional development convergence, forecasting the dynamics of regional development, generation of solutions on balanced regional development have been designed. The devised set of models allows estimating the sustainability of regional cluster entities, measure their territorial ties, the impact of cycles on the regional development dynamics. The system of models is based on such methods of econometric modelling as: criterion reduction method, cluster analysis, panel data, probit-analysis, logit-analysis, spatial econometrics, models of absolute and relative convergence, Fourier analysis, production-institutional functions, time series analysis. The main theses, conclusions and recommendations have been taken into account when preparing changes and additions to the program of economic and social aspects of regional development, as well as the plans for realization of the Strategy of economic and social regional development.

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