Comparative Analysis of σ-and β-Convergence of the Economic Growth of the Southern Russia Regions

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ABSTRACT
The article substantiates the strengthening of differentiation of economic growth in the Southern Russia regions during the introduction of international sanctions, reveals the trend of delayed and negative growth dynamics, which should be considered when developing a short-term forecast of economic growth in the Southern Russia macroregion. The calculated data of the GRP β-convergence regression model for SFD-12 and NCFD confirmed the hypothesis of absolute GRP β-convergence only in the period before the introduction of international sanctions (1998-2014). Calculations of unconditional convergence indicate the absence of a single trajectory of balanced growth for all regions of the South of Russia: there is a process of divergence, stratification of the population in terms of living standards, and increased social tension. The σ- and β-convergence model’s study confirms the club convergence effect’s presence and shows the need to form differentiated regional development strategies to reduce the gap between rich and poor Southern Russia regions. Cluster analysis of the socio-economic development of Southern Russia (NCFD and SFD) regions shows an unstable cluster and intra-cluster grouping of regions by economic and demographic indicators before and after the introduction of international sanctions. The convergence analysis in the conditions of increasing external shocks confirms the presence of different catch-up development rates in the Southern and North Caucasus macroregions. That can lead to a slowdown in the macroregion's economic growth and indicates the need for early formation of mechanisms to smooth out exogenous factors' negative effects on the region's trajectory of economic growth.

Keywords: β- and σ-convergence, Economic growth, Gross regional product, Regression model of convergence, Territorial clusters.

1. INTRODUCTION
In recent years, there has been an increase in the differentiation of socio-economic development of the South of Russia’s peripheral regions, which creates several problems for the state associated with the need to direct part of the resources to equalise the imbalances, and not to stimulate their development. The increase in the polarisation level of economic development in introducing anti-Russian sanctions leads to increased social tension and increased separatist sentiment and disintegration processes. The need to reduce the socio-economic development differentiation level is also noted in the Spatial Development Strategy of the Russian Federation for the period up to 2025 [1]. Therefore, the study of the vectors of convergence of economic growth in the South of Russia’s problem regions before and after introducing international sanctions allows us to develop timely preventive measures to reduce the impact of negative trends on the balanced development and country's economic security.

2. RESEARCH METHODOLOGY
The methodological aspects of the decomposition of economic growth are considered in the works of Russian researchers A. Iodchin [2, pp. 475-482], S. Drobyshevsky [3]. Also, the analysis of the influence of exogenous and endogenous factors on the dynamics of economic growth of the North Caucasus macroregion is presented in the scientific publication of the Institute of Socio-Economic Research of the Dagestan Federal Research Centre of the Russian Academy of Sciences [4, p. 249-253].

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In economic analysis, \( \sigma \)-convergence refers to the process of reducing the differentiation of indicators of development of a country or region. The presence of \( \sigma \)-convergence implies a decrease in interregional variance and an approximation of the analysed indicators' trajectories during the study period, which leads to the levelling of differences between these indicators by the end of the study period.

The economic content of \( \beta \)-convergence is expressed in the negative dependence of growth rates on the initial level of development of countries and regions, i.e., with the convergence of this type, less developed economies approach more developed ones. It should be noted that \( \sigma \)- and \( \beta \)-convergence are interrelated, but not equivalent categories: \( \sigma \)-convergence does not always indicate the presence of \( \beta \)-convergence.

The method of a quantitative assessment of \( \sigma \)- and \( \beta \)-convergence is formalised within the framework of endogenous economic growth models. The differentiation of statistical approaches to the definition of \( \sigma \)- and \( \beta \)-convergence should be noted. The analysis of \( \sigma \)-convergence is based on mathematical statistics using classical indicators: variance, standard deviation, and variation. The test of the hypothesis about the presence of \( \beta \)-convergence (a long-term trend of levelling the levels of regional development) is based on regression modelling.

Simultaneously, it should be considered that convergence, even in neoclassical growth models, takes place only under an extreme condition of homogeneity of the economies under consideration (unconditional convergence of growth trajectories to equilibrium ones). For heterogeneous economies, neoclassical models predict conditional convergence, i.e., the convergence of each economy’s growth trajectory to the individual or group trajectory of equilibrium growth. Growth theory is not limited to neoclassical models; several alternative theories go beyond the neoclassical paradigm, which does not give any definite predictions about economic inequality dynamics. There are several strong proofs that \( \sigma \)-convergence implies \( \beta \)-convergence, but \( \sigma \)-convergence does not follow from \( \beta \)-convergence. According to Caselli F. [11, pp.679-741], the empirical analysis of \( \beta \)-convergence only allows us to determine whether the behaviour of economies has some properties resulting from a particular modification of the neoclassical growth model, and nothing more.

This section of the study’s primary purpose is to model and analyse intersubjective inequality dynamics according to the \( \sigma \)- and \( \beta \)-convergence criteria. The quantitative assessment was based on the calculation of the coefficient of variation according to the following formula:

\[
\sigma_t = \sqrt{\frac{\sum_{i=1}^{n}(M_i - M_{cp})^2}{M_{cp}}} \tag{1}
\]

where \( M_i \) - the value of the considered indicator (GRP) for the i-region; \( M_{cp} \) - the average value of the considered indicator (GRP) for all macroregion subjects; \( n \) - the total number of macroregion subjects.

The definition of \( \beta \)-convergence involves comparing the growth rates for the regions under consideration over time. Based on the \( \beta \)-convergence model, two of its characteristics can be calculated: the speed (\( \nu \)) and time (\( \tau \)) of intersubjective inequality reducing by two times.

The calculation of speed (\( \nu \)), time (\( \tau \)), and \( \beta \)-convergence is based on the following economic equations:

\[
\frac{\ln M_i - \ln M_{io}}{\tau} = \beta_0 + \beta_1 (\ln M_{io}) + \varepsilon, \tag{2}
\]

\[
\nu = \frac{\ln(1+T\beta_1)}{T}, \tag{3}
\]

\[
\tau = \frac{\ln 2}{\nu}, \tag{4}
\]

where \( \beta_0 \), \( \beta_1 \) - the parameters of the equation of convergence; \( i \) - number of the object; \( T \) - period; \( M_{io} \) - the value of this indicator for the object in the initial period; \( M_i \) - the value of this indicator for the facility over the past period; \( \varepsilon \) - the residual term.

It should be noted that there is a distinction between conditional and absolute convergence. Absolute convergence, or unconditional convergence, is observed when
developing countries (regions) tend to grow faster than rich ones because a small initial GDP size allows for a high growth rate. Conditional convergence indicates a decrease in each country's GDP growth rate as it approaches a stable state. In a formalised form, the absolute $\beta$-convergence can be represented as follows:

$$y = \beta_0 + \beta_1 x,$$  

(5)

where $\frac{\ln M_t - \ln M_{t0}}{T} x = \ln M_{t0}$.

The estimation of $\beta$-convergence parameters is carried out based on regression analysis. The conclusion about the presence of $\beta$-convergence is made based on the analysis of the sign for the parameter of $\beta_1$ equation (5): a negative sign for the parameter $\beta_1$ indicates the presence of $\beta$-convergence, in the opposite case, there is a $\beta$-divergence.

3. STUDY RESULTS

This study's unique feature is a comparative analysis of $\sigma$- and $\beta$-convergence results before (1998-2014) and after introducing international sanctions (1988-2018). As objects of study selected all the South of Russia regions except the Chechen Republic, the Republic of Crimea and Sevastopol which do not have the required statistics for the study period. In this study, regression modelling of $\beta$-convergence was carried out separately for the North Caucasus Federal District and 12 subjects of Southern Russia (SFD-12), including the Krasnodar Territory, Stavropol Territory, Rostov, Volgograd, Astrakhan Regions, the Republics of Adygea, Kalmykia, Dagestan, Ingushetia, North Ossetia – Alania and Kabardino-Balkar, Karachay-Cherkess Republics.

The results of the $\sigma$-convergence estimation are presented in table 1.

| Table 1. Comparative analysis of $\sigma$-convergence of Southern Russia regions |
|-----------------------------------|-----------------|-----------------|-----------------|
| **The regression equation**       | **Note**        | **The regression equation**       | **Note**        |
| **1998-2014**                     |                  | **1998-2018**                     |                  |
| SFD-6                             | Y = -0.001X + 0.3071 R² = 0.462 | Convergence | Y = -0.0019X + 0.3017 R² = 0.1705 | Convergence |
| NCFD-6                            | Y = -0.0162X + 0.4674 R² = 0.685 | Convergence | Y = -0.02X + 0.62 R² = 0.765 | Convergence |
| SFD                               | Y = -0.0017X + 0.3976, R² = 0.21 | Convergence | Y = -0.0006X + 0.3814R² = 0.0205 | Divergence |
| NCFD                              |                  |                  |                  |

Source: author's calculations.

Note: SFD - 12 – Southern Federal District, NCFD - North Caucasus Federal District.
4. RESULTS DISCUSSION

The $\sigma$-convergence assessment results on the example of Russia's 12 southern regions during the introduction of international sanctions show divergence.

Analysis of the $\beta$-convergence by the Fisher criterion over the period 1998–2018 (Table 3) shows the excess tabular values over the calculated ones. Hence, the conclusion that there is an absolute convergence of economic growth dynamics in 12 regions of Southern Russia is unfounded.

5. CONCLUSIONS

Based on the design data of tables 2, 3 and the regression model of $\beta$-convergence of the GRP, it is possible to draw the following conclusions: for the SFD and NCFD-12 period 1998–2014 confirmed the hypothesis of absolute $\beta$-convergence of the GRP.

The unconditional convergence model implementation allows concluding that there is no uniform trajectory of proportional growth for all Southern Russia regions. The study of the model of $\sigma$- and $\beta$-convergence indicates the effect of cluster convergence, the need to form differentiated strategies for regional development.

The conclusion that there is an unconditional convergence in the period 1998-2018 is unfounded, which in our

<table>
<thead>
<tr>
<th>Macro region</th>
<th>Parameter</th>
<th>The parameter value</th>
<th>Standard mistake</th>
<th>Criteria Student</th>
<th>P-value</th>
<th>F-table (0.05)</th>
<th>F-calc (0.05)</th>
<th>Rate of $\beta$-convergence (v)</th>
<th>Time reducing the backlog in 2 times, (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SFD-12</td>
<td>$\beta_0$</td>
<td>-0.178</td>
<td>1.50</td>
<td>-0.119</td>
<td>0.9079</td>
<td>4.84</td>
<td>0.5715</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$\beta_1$</td>
<td>-0.173</td>
<td>0.2289</td>
<td>-0.755</td>
<td>0.4671</td>
<td></td>
<td>0.068</td>
<td>-0.105</td>
<td>6.6</td>
</tr>
<tr>
<td>NCFD - 6</td>
<td>$\beta_0$</td>
<td>2.171</td>
<td>1.5676</td>
<td>1.384</td>
<td>0.238</td>
<td>6.61</td>
<td>5.3553</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$\beta_1$</td>
<td>-0.57</td>
<td>0.2465</td>
<td>-2.3141</td>
<td>0.0817</td>
<td></td>
<td></td>
<td>-0.157</td>
<td>4.4</td>
</tr>
<tr>
<td>SFD-6</td>
<td>$\beta_0$</td>
<td>2.171</td>
<td>2.3079</td>
<td>0.404</td>
<td>0.7068</td>
<td>7.71</td>
<td>0.831</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$\beta_1$</td>
<td>-0.312</td>
<td>0.3422</td>
<td>-0.911</td>
<td>0.413</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: author's calculations.

Note: SFD-12 – NCFD+SFD, SFD-6 – Southern Federal District (Republic of Crimea, Sevastopol), NCFD-6 – North Caucasian Federal District.
view is a manifestation of the influence of exogenous factors associated with international sanctions.

Thus, the analysis of the economic space of Southern Russia based on the concept of convergence in the conditions of growing external shocks confirms the presence of the different speed of catching-up development in the SFD and NCFD that may lead to a slowdown in the economic growth of the macroregion and suggests mechanisms to mitigate the negative effects from the impact of external shocks on region's economic dynamic.

REFERENCES
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