The Resilience of the Russian Regional Economies to the 2020 Pandemic

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Received February 25, 2022; revised July 14, 2022; accepted July 14, 2022

Abstract—This study is devoted to assessing the economic resilience of Russian regions to the 2020 pandemic and analyzing its factors. The resilience of the regional economies is evaluated using a set of per capita indicators, such as budget revenues and household incomes, production in the main sectors of the economy, and investment in fixed assets. Two alternative methods for assessing the resilience of a region to an external shock are applied, that is, the modified method of R. Martin and R. Lagravinese based on a comparison of regional trends with nationwide ones and the author’s approach based on a comparison of pandemic indicators with nonpandemic forecasts for the region. All particular resilience indicators are normalized and reduced to an integral indicator. The study revealed the most significant resilience to the pandemic of some underdeveloped Russian regions, which received substantial government support, and several border territories and Far Eastern regions, which benefited from the increase in metal prices. The lowest resilience was observed in more developed and larger economies and the centers of mining industry. The calculation of correlations between resilience indices and regional development indicators confirmed that the sectoral and institutional structure of the economy affect its resistance to the shock. By constructing an econometric model estimated by the ordinary least squares method, we confirmed the positive impact made by the share of employment in government-owned and municipal enterprises and the negative impact of the degree of openness, the size of the economy, and the share of the mining industry on the regional economic resilience. The conducted research is applicable for developing a balanced inter-budgetary, regional, and sectoral policy in the context of economic crises of a pandemic type.

Keywords: region, resilience, 2020 pandemic, assessment, factors

DOI: 10.1134/S2079970522700034

INTRODUCTION

The 2020 pandemic caused by the spread of the coronavirus infection was accompanied by a decrease in the mobility of the population and in the business activities of enterprises. It affected sectors of the Russian economy to varying degrees. The following sectors were mainly affected: oil production, due to a sharp drop in oil and gas prices and a reduction in their sales on the world market in the acute phase of the pandemic, and the automotive industry, transportation, and services (Zubarevich, 2021). At the same time, medical and pharmaceutical industries, the production of computers and equipment for remote work, and the IT sphere received a boost for development. The pandemic had has a mixed effect on the development of industry, trade, and construction. The specific sectoral effects of the pandemic largely determined the response of Russian regions to the shock of the pandemic. At the same time, the state took countermeasures to support the country’s economy: the transfers of federal center to the regions increased significantly and national projects were actively implemented, which was accompanied by additional state investments (Shirov, 2021). At the same time, support for the regions from the federal center was extremely uneven, which, taking into account the spillover effects of transfers and investments, also determined the uneven response of the regions to the pandemic shock.

Thus, the different spreading of infection and the severity of restrictive measures, as well as the presence of specific sectoral effects and unequal support from federal and regional authorities, were the main factors that affected the resilience demonstrated by the economies of federal subjects during the 2020 pandemic.

The purpose of this study was to assess and analyze the resilience shown by the Russian regions’ economies to the 2020 pandemic based on a set of indicators characterizing the development of the private and public sectors in the economy, various industries and areas of activity and to develop an integral indicator reflecting the resilience of regional economies. The
relationship between the indices reflecting the resilience of regional economies and several indicators of their pre-pandemic development was also analyzed.

LITERATURE REVIEW

The theory of economic resilience has been elaborated in the last 2 decades in (Foster, 2007; Hill et al., 2008; Martin, 2012; Fingleton et al., 2012; Lagravinese, 2015). In Russia, a certain contribution to its development was made by such researchers as (Klimanov et al., 2018, 2019; Kolomak, 2020; Malkina, 2020; Mikheeva, 2021; Zhikharevich et al., 2021) and others.

Resilient development is interpreted by the founders of the theory in two ways: on the one hand, as the ability of an economy to withstand external shocks (resistance); on the other hand, as its ability to return to a pre-existing equilibrium state (recovery) or enter new development paths in the post-crisis period (Martin, 2012). Some authors (Modica and Reggiani, 2015) distinguish between vulnerability of the economy measured by the speed and scale of shocks in the network and resilience itself estimated by the speed of the economy returning to equilibrium after a shock.

The resilience theory should be separated from the theory of sustainable development, where the emphasis is on the interaction of the economic sphere with other spheres (ecosystem, social sphere, public administration efficiency, etc.) and the study of positive and negative externalities of economic activities.

Within modern resilience theory, three independent concepts have been formed (Boschma, 2015). According to the “engineering” concept (Fingleton et al., 2012; Rose, 2004), resilience is understood as the ability of a system to return to a stable equilibrium and the previous development path after a shock. According to the “ecological” concept (Reggiani et al., 2002; Swanstrom et al., 2009; Zolli and Healy, 2012), resilience is interpreted as the tendency of an economic system to reach a new equilibrium state by changing the sectoral and institutional structure, as well as to a new growth path after the impact of an external shock. According to the evolutionary concept (Boschma, 2015; Christopherson et al., 2010; Clark et al., 2010; Pike et al., 2010; Simmie and Martin, 2010), resilience includes not only the short-term ability of regions to withstand shocks but also their long-term ability to develop new growth paths accompanied by continuous adaptation and reconfiguration of socioeconomic and institutional structures.

One of the important problems in the theory of resilience is measuring its level. Economists with different concepts have proposed several ways to measure resilience, the most popular of which are discussed in (Martini, 2020). Resilience measures include: (1) R. Martin’s index of resilience (Martin et al., 2016), which compares the rate of change in the economy measured by the sum of exports and imports and the GRP); the scale of the public sector in production and employment; the level of economic openness (measured by the ratio between the sum of exports and imports and the GRP); the quality of public administration (Ezcura and Rios, 2019) and anti-crisis regulation measures related to fiscal and monetary policy, etc. (Martin et al., 2016). Although most authors agree that the sectoral structure of a region’s economy has a determining influence, some also emphasize that the characteristics of the crisis itself are of great significance, as well (Lagravinese, 2015).

In accordance with the defining determinants of resilience, three concepts of resilience are distinguished (Mai et al., 2021): structural, agency, and political—economic. In the structural concept, resilience is associated with the composition and the right combination of industries and the diversification level of the economy (Fingleton et al., 2012; Groot et al., 2011; Kluge, 2018; Ray et al., 2017). The agency concept focuses on the influence of the institutional environment, cultural values, and government regulation. Therefore, it often uses an evolutionary approach to the analysis of postcrisis development paths (Boschma, 2015; Simmie and Martin, 2010). The agency theory is very popular among researchers of the Chinese economy, where government spending plays an important stabilizing role during a crisis (Faroudst et al., 2012; Tan et al., 2020). The political—economic concept is based on the scheme of three circuits of capital accumulation and Harvey’s spatial fix concept (Harvey, 2001). It substantiates the importance of investment in fixed capital and the creation of jobs for
the “reproduction of space” in the region (Mai et al., 2021).

Investigations into the impact of the sectoral structure of the economy on the resilience of European regional economies during financial crises led the authors (Lagravinese, 2015; Martin, 2012) to the conclusion that regions with a greater share of manufacturing and construction in the sectoral structure of the economy are more vulnerable to financial shocks. At the same time, they found greater resilience of regions with a developed service sector due to its increased flexibility and adaptability to crises. They also noted the positive impact exerted by the share of employed in the public sector on the regional resilience.

In studying the impact of sectoral diversity on the level of economic resilience, some researchers (Cainelli et al., 2019; Xiao et al., 2018) found that it is not the level of economic diversification per se but the so-called related variety, that is, the complementarity of various industries, that contributes to better adaptation of economies to external shocks. Such a diversified industrial structure promotes better interaction between industries, facilitates the transfer of skills and technologies between them, and promotes the joint development of products and services (Cainelli et al., 2019).

It should also be noted that there are few modern studies on the regional resilience to the 2020 pandemic caused by the spread of coronavirus infection. In a study of the Chinese northeastern provinces (Hu et al., 2022), the main factors of regional resilience and recovery in the context of the 2020 pandemic are the structure of the secondary sector of the economy, the level of sectoral diversification, the level of innovation, the regional specialization, the openness of the economy, and government policy aimed at containing COVID-19. Another study on the influence of the 2020 pandemic on the Italian provinces (Arbolino and Di Caro, 2021) revealed a significant impact of government funds allocated under the Cohesion Program in the European Union to achieve the resilience of regional labor markets.

Thus, in previous studies, scientists have developed theories and concepts of the resilience of economic systems, and proposed methods for measuring it, studied the factors that promote resilience of the country and regional economies to various shocks, mainly of a financial nature. The influence of the modern pandemic on the resilience of regional economic systems has not been sufficiently studied in the literature. Moreover, we have not found a study that assessed the impact of the 2020 pandemic on the resilience of the Russian regional economies using a set of indicators of their development. The present study aims to fill this gap.

DATA AND METHODS

The information base of the study was the official annual data of the Federal State Statistics Service and the Federal Treasury of the Russian Federation both for the whole country and for 85 federal subjects of the Russian Federation (hereinafter referred to as regions). The entire study period was divided into two subperiods: the pre-pandemic period 2015–2019 and the pandemic period 2020.

The following indicators were used to assess the resilience of the Russian regions economies:

1. revenues of the subfederal budget of the Russian regions (BR), including their own tax and nontax revenues (BR_own) and transfer incomes (BR_trans), most of which are transfers from the federal center to the regions, RUB mln;
2. the income of the population (household income) (Income_p), as well as their main part, wages (wage), RUB;
3. the production indicators in the main sectors of the economy:
   a. industrial output, which includes four types of economic activities, that is, Mining; Manufacturing; Electricity, gas, steam and air conditioning supply; Water supply; sewerage, waste management and remediation activities (Industry), RUB mln;
   b. the volumes of own-account construction, including those carried out for own needs (Construct), RUB mln;
   c. the turnover of wholesale and retail trade (Trade), RUB mln;
   d. the volume of paid services rendered to the population (Services), RUB thous.;
   e. road transport freight turnover (Transport), mln t-km;
4. investment in fixed assets (Invest), RUB mln.

In order to eliminate the scale effect, all variables were calculated per capita (most of them based on the indicator of the average annual population in the region). Wage and investment variables were calculated per employee in the regional economy.

In order to assess the resilience of the regional economy in terms of some indicator during the pandemic we used two alternative approaches.

I. A modified approach by R. Martin (2012) and R. Lagravinese (2015) based on a comparison of changes in the growth rates for indicators in the region and the country as a whole. Our modification of this approach is to calculate average growth rates in the pre-pandemic period based on geometric rather than arithmetic averages.

For each i-th indicator \( (k = 1, K) \) for each i-th region \( (i = 1, N) \) and the country as a whole \( (i = R) \) we calculated the following:

- the average growth rates in the pre-pandemic period
\[ g_{ik}^{\alpha} = \frac{\alpha + \beta t + e_t}{y_{T-1}^{ik}} - 1, \]  
\[ g_{ik}^{\beta} = \frac{\alpha + \beta t + e_t}{y_{T-1}^{ik}} - 1, \]  
\[ \text{where } t = 1, T. \text{ In our case, } t \in (2015, 2020) \text{ is the entire studied period, and } T = 2020 \text{ is the pandemic year.} \]

With this approach, for regions that have experienced a greater decline in the indicator than the national average, Re \( s_{ik} < 0 \), and for regions that have shown greater resilience, Re \( s_{ik} > 0 \).

II. The author's approach based on calculating relative deviations of regional indicators during a pandemic from their nonpandemic forecasts.

For each \( k \)th indicator \((k = 1, K)\) for each \( i \)th region \((i = 1, N)\), the following calculations are carried out:

- based on pre-pandemic values of the indicator, \( t \in (2015, 2019) \), time regressions of a linear type are constructed

\[ y_{T-1}^{ik} = \frac{\alpha + \beta t + e_t}{y_{T-1}^{ik}} - 1. \]  

where \( \alpha \) and \( \beta \) are estimated regression coefficients and \( e_t \) are regression residuals;

- based on these regressions, predictive nonpandemic values of indicators for the pandemic period \( (\hat{y}_{T}^{ik}) \) are calculated;

- the resilience index shows the relative deviation of actual indicator values during a pandemic \( (y_{T}^{ik}) \) from their nonpandemic forecasts, that is,

\[ \text{Re } s_{ik} = \frac{y_{T}^{ik}}{\hat{y}_{T}^{ik}} - 1. \]  

Further, for both approaches, integral resilience indices are calculated assuming the equivalence of the indicators. This calculation is carried out in two steps, that is,

- normalization of the resilience indices of each \( k \)th indicator using a linear scale \((0, 1)\)

\[ \text{Re } s_{ik}^{N} = \frac{\text{Re } s_{ik} - \min (\text{Re } s_{ik})}{\max (\text{Re } s_{ik}) - \min (\text{Re } s_{ik})}; \]  

- calculation of the integral resilience index as the arithmetic mean of particular normalized resilience indices.

Based on the integral resilience indices, a conclusion is made about the relative resilience of the regional economy during the pandemic. At the same time, the first approach (I) assesses the region’s resilience during the pandemic relative to the general situation in the country, while the second approach (II) assesses the region’s resilience during the pandemic relative to the region’s own pre-pandemic development trends. Both approaches complement each other and provide a complete picture of the impact made by the pandemic on the regional economy.

RESULTS AND DISCUSSION

Table 1 presents the weighted average growth rates of indicators before and during the pandemic \((g)\), their minimum \((\text{Min})\) and maximum \((\text{Max})\) values in the regions, and the weighted standard deviation of regional growth rates \((\text{SD})\). It should be noted that in most cases the region’s share in the national population was used as the weight. For the indicator of wages and investment calculated per employee, the share of the population in total employment served as the weight.

We believe the weighted approach in this case to be more correct than the unweighted one because it takes into account the uneven distribution of economic activities across the country. An unweighted approach assumes all regions are equal, which can be misleading. In particular, this approach shows that the average growth rate of transport freight turnover during the pandemic decreased slightly (from 2.8 to 2.6%) and remained in the positive zone, while the weighted approach clearly indicates its significant fall and exit into the negative zone (from 2.7 to \(-1.3\)%). In the case of the unweighted approach, the extreme growth of the indicator in some small regions (for example, in the republics of Chechnya and Ingushetia) has a disproportionately large impact on the change in the overall indicator in the country. Similarly, the weighted approach shows negative industrial growth in 2020 \((-3.6\%)\), while the unweighted one shows the low but positive growth \((1.4\%)\).

Table 1 shows different impacts of the pandemic on the change in the analyzed regional indicators. The only indicator whose growth rate did not slow during the pandemic is budget revenues per capita \((BR)\). This trend is mainly due to the active state fiscal policy, a significant increase in federal transfers in the face of the decline in the regions’ own incomes. In fact, average regional growth rates in the own revenues of consolidated budgets of the RF federal subjects per capita \((BR \text{ own})\) during the pandemic dropped from 9.5% (pre-pandemic level) to \(-1.8\%\) (2020 pandemic). However, this drop was more than offset by additional transfers to the regions from the federal center, due to which the growth rate of transfer incomes \((BR \text{ trans})\) over the considered period rose from 11.2 to 59.0% (see Table 1). It should also be noted that interbudgetary transfers were designed not only to compensate for the shortfall in own revenues of the regional budget.
systems but also to cover the growth of budget expenditures in the context of the pandemic.

For nominal population incomes \((\text{Income}_p)\), there is a decrease in growth rates relative to the pre-pandemic level but these rates remain in the positive zone. At the same time, the main part of personal income, wages \((\text{wage})\), suffered the least, which is also explained by the active state fiscal policy, intensive spending on the social sphere and healthcare, and support for employment in the most affected industries during the pandemic.

For main productive sectors of economy, an uneven decline in growth rates is observed. The service sector, industry, and transport, which generally experienced a drop in per capita indicators in 2020 compared to 2019 were the hardest hit by the pandemic. The growth rate of paid services to the population \((\text{Services})\) decreased the most, by 18 percentage points, that is, from 6.1% in the pre-pandemic period to −11.9% during the pandemic. The most affected were tourism and hotel services, services of cultural, physical culture and sports institutions, as well as transport services.

The decline in industry \((\text{Industry})\) also proved to be significant, its annual growth rate decreased by 15 percentage points (p.p.). This is followed by trade \((\text{Trade})\) where the growth rate decreased by 8.2 percentage points. A much better state of affairs is noted in construction \((\text{Construct})\) where the growth rate lost only 2.2 percentage points and retained a fairly high level (4.6%). A similar situation is observed for the investment indicator \((\text{Invest})\), whose growth rate also decreased by less than a third. The relative well-being of the construction industry and the overall situation with investments amid the pandemic can be attributed to the dirigisme policy of the Russian state and the active implementation of national projects accompanied by an increase in public investment and support for the construction industry during the coronavirus crisis.

In addition to the specific sectoral effects of the pandemic and its unequal impact on incomes in the private and public sectors of the economy, attention should be paid to different regional effects of the pandemic. Table 1 shows the significantly increasing scatter in the growth rates of regional indicators (which can be assessed both by the range of variation and by the standard deviation). The only area where there has been some convergence in growth rates is construction (for example, the inter-regional coefficient of variation in growth rates in the construction industry has decreased from 2.75 to 2.64). We should also note the extreme pre-pandemic growth rate in construction volumes per capita (153.4%) for the city of Sevastopol.

Thus, the pandemic affected the economies of the Russian regions in different ways, which may be explained not only by their specific industrial structure but also by the different spread of infection, as well as restrictive and stimulating measures taken by regional authorities.

Table 2 shows particular resilience indicators of Russian regions \((\hat{\text{Res}})\) and the normalized integral resilience index calculated based on the approach I (according to formulas 1–3 and 6). The Table presents their regional mean, minimum and maximum values in regions, as well as an indicator of interregional

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**Table 1.** Some indicators of regional development in the prepandemic and pandemic periods, %

| Indicator   | Before the pandemic | During the pandemic |
|-------------|---------------------|---------------------|
|             | \(g\) | \(\text{Min}\) | \(\text{Max}\) | \(\text{SD}\) | \(g\) | \(\text{Min}\) | \(\text{Max}\) | \(\text{SD}\) |
| \(\text{BR}\) | 9.8 | −2.1 | 21.0 | 2.8 | 9.8 | −20.3 | 54.5 | 9.1 |
| \(\text{BR}_{\text{ Own}}\) | 9.5 | −4.6 | 18.8 | 2.8 | −1.8 | −24.4 | 56.2 | 7.1 |
| \(\text{BR}_{\text{ Trans}}\) | 11.2 | −1.7 | 47.0 | 7.2 | 59.0 | −28.1 | 297.5 | 77.3 |
| \(\text{Income}_p\) | 4.0 | −0.8 | 14.2 | 1.9 | 1.1 | −4.7 | 7.3 | 2.0 |
| \(\text{wage}\) | 8.7 | 4.6 | 10.3 | 1.3 | 7.6 | 2.3 | 17.1 | 2.4 |
| \(\text{Industry}\) | 11.4 | −8.6 | 34.7 | 3.9 | −3.6 | −34.1 | 89.2 | 12.2 |
| \(\text{Construct}\) | 6.8 | −22.0 | 153.4 | 18.6 | 4.6 | −41.9 | 47.5 | 12.2 |
| \(\text{Trade}\) | 8.7 | −1.0 | 14.7 | 3.8 | 0.4 | −8.7 | 20.2 | 4.8 |
| \(\text{Services}\) | 6.1 | 0.9 | 12.8 | 1.6 | −11.9 | −21.4 | 0.4 | 6.2 |
| \(\text{Transport}\) | 2.7 | −31.6 | 39.1 | 9.2 | −1.3 | −57.6 | 107.8 | 27.4 |
| \(\text{Invest}\) | 8.8 | −7.6 | 53.9 | 9.1 | 6.0 | −47.0 | 133.8 | 13.3 |

For Chukotka Autonomous Okrug, prepandemic transport growth rates were calculated for 2017–2019 due to the high instability of this indicator in the previous period.

*Source.* Hereinafter, the author’s calculations are based on the data retrieved from Statistics / FSSS. 2021. https://rosstat.gov.ru/statistic (accessed January 2022), and Consolidated budgets of the federal subjects of the Russian Federation and budgets of territorial state extra-budgetary funds / Federal Treasury of the Russian Federation. 2020. https://roskazna.gov.ru/ispolneniebyudzhetov/konsolidirovanny-byudzhety-subektov/ (accessed January 2022).
inequality (SD). It should be recalled that in the approach I, the regional resilience during a crisis is assessed relative to the general national (average regional) trend.

It should also be noted that in the approach I positive values of the average indices for some indicators do not imply greater regional resilience for these indicators. They are possible when a smaller drop was experienced by small regions and a larger drop was experienced by larger regions, whose influence is underestimated in an unweighted approach. Negative average values of the indices point out a greater fall in smaller regions, whose influence in this case is overestimated. At the same time, the calculation of weighted average resilience indices in this approach does not make sense, since they are close to national values that are actually taken as a reference point (that is, the zero level).

Therefore, in the approach I, we are more interested not in the average regional value but in the interregional scatter of the index, which can be estimated both based on the range of variation (Max−Min) and standard deviation (SD) of the corresponding index. The results convincingly testify to a greater level of interregional differences in the resilience indices of transport, investment, construction, and budget revenues. At the same time, the calculation of weighted average resilience indices in this approach does not make sense, since they are close to national values that are actually taken as a reference point (that is, the zero level).

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Next, the results obtained using the approach II (formulas 4–6) to be considered. Table 3 presents the regional mean, minimum, and maximum values of particular and integral resilience indices, as well as the range of variation and interregional standard deviation of these indices.

In contrast to the approach I, in the approach II, the average values of the indices are much more meaningful, as they reflect the average regional resilience for the corresponding indicator. According to these results, the lowest resilience in the regions, on average, was demonstrated by the sectors of paid services to the population, industry, and trade, as well as regional own budget revenues. The greatest resilience of the regions during the pandemic was provided by interbudgetary transfers, which supports the earlier conclusion about the role of the federal center during the pandemic.

### Table 2. Indicators of regional economies resilience during the pandemic calculated based on the approach I

| Indicator of resilience | Res | Min | Max | Max−Min | SD |
|-------------------------|-----|-----|-----|---------|----|
| BR                      | 0.705 | −13.07 | 14.97 | 28.05 | 4.695 |
| BROwn                   | 0.199 | −2.411 | 6.376 | 8.787 | 1.131 |
| BRTS                    | −0.402 | −1.948 | 2.776 | 4.724 | 0.601 |
| IncomeP                 | 0.306 | −5.893 | 2.771 | 8.664 | 1.165 |
| Wages                   | 0.547 | −4.324 | 8.656 | 12.98 | 1.847 |
| Industry                | 0.209 | −3.681 | 7.498 | 11.18 | 1.673 |
| Construct               | −1.118 | −48.40 | 3.044 | 5.339 | 0.951 |
| Trade                   | 0.290 | −2.294 | 0.763 | 1.641 | 0.528 |
| Services                | 0.120 | −0.878 | 1.661 | 3.539 | 1.173 |
| Transport               | −1.065 | −25.12 | 7.498 | 11.18 | 1.673 |
| Invest                  | −0.105 | −31.15 | 48.85 | 80.00 | 8.990 |
| Integral index          | 0.518 | 0.301 | 0.663 | 0.362 | 0.063 |

Res and SD stand for the unweighted mean and standard deviation of resilience indices in regions.

At the same time, there is an obviously great resilience of several less developed republics in the south and central part of Russia, as well as some border regions. The leaders in resilience according to the approach I are the republics of Kalmykia (Res = 0.663), Chechnya (Res = 0.628), Dagestan (Res = 0.620), and Khakassia (Res = 0.615), as well as Murmansk oblast (Res = 0.615). The relatively higher resilience during the pandemic of the less developed Russian regions can be explained by their higher level of federal budget support, while for several Far Eastern regions it can be attributed to a favorable situation on the metal market.

In contrast to the approach I, in the approach II, the average values of the indices are much more meaningful, as they reflect the average regional resilience for the corresponding indicator. According to these results, the lowest resilience in the regions, on average, was demonstrated by the sectors of paid services to the population, industry, and trade, as well as regional own budget revenues. The greatest resilience of the regions during the pandemic was provided by interbudgetary transfers, which supports the earlier conclusion about the role of the federal center during the pandemic.

1 In the article the borders of Russia are considered in accordance with the Constitution of the Russian Federation adopted by popular vote on December 12, 1993, with amendments approved during the All-Russian vote on July 1, 2020.
coronavirus crisis. On average, the relatively high regional resilience was shown by transport, mainly due to greater increase in its growth rates in small republics, as well as construction and investment.

With regard to the dispersion of the resilience indices in regions, similar to the approach I, the largest interregional differences are demonstrated by transport, construction, and investment. However, unlike the approach I, the approach II reveals much larger differences in the dynamics of interbudgetary transfers across regions. This is due to the relatively more even federal support of the regions amid the pandemic, which led to a significant deviation of the transfer incomes per capita from their pre-pandemic trend in a number of regions. The smallest interregional differences in growth rates changes during the pandemic were found for per capita household incomes, trade turnover, and paid services to the population.

Figure 2 shows the integral regional resilience indices calculated based on the approach II. The lowest resilience amid the pandemic was shown by the city of Sevastopol (Res = 0.210), the Republic of Sakha
As we can see, four of the five areas with the lowest resilience match the results of approach I. Among the least resilient, we again see some mining regions and capital cities. In the approach II, this conclusion becomes even more obvious.

The greatest resilience to the pandemic in the framework of the approach II was confirmed for the republics of Kalmykia (Res = 0.589), Chechnya (Res = 0.552), and Murmansk oblast (Res = 0.536). Within the approach II, the five most resilient areas also include the Jewish Autonomous Oblast (Res = 0.553) and Amur oblast (Res = 0.513). Again, we see an amazing result, that is, a greater resilience of some outlying regions of Russia.

Figure 3 shows a significant correlation between the two regional indices of resilience. This is due to their having a common methodological basis. The first index shows the deviation of the region from the all-Russian trend, and the second, from its own pre-pandemic trend.

Next, we attempted to identify links between resilience indices and some indicators characterizing the economic development of Russian regions before the pandemic. A number of indicators were tested, from

(Yakutia) (Res = 0.222), the city of Moscow (Res = 0.293), Kaliningrad oblast (Res = 0.298), and the Republic of Bashkortostan (Res = 0.298). As we can

### Table 3. Indicators of the regional economies resilience during the pandemic calculated based on the approach II

| Indicator     | Res   | Min  | Max  | Max–Min | SD   |
|---------------|-------|------|------|---------|------|
| BR            | 0.083 | −0.267 | 0.419 | 0.686   | 0.119 |
| BR_own        | −0.056 | −0.307 | 0.741 | 1.048   | 0.129 |
| BR_trans      | 0.578 | −0.401 | 3.293 | 3.694   | 0.483 |
| Income_p      | 0.001 | −0.150 | 0.077 | 0.227   | 0.031 |
| Wage          | 0.016 | −0.033 | 0.121 | 0.153   | 0.024 |
| Industry      | −0.069 | −0.404 | 0.860 | 1.264   | 0.187 |
| Construct     | 0.025 | −0.485 | 0.799 | 1.284   | 0.213 |
| Trade         | −0.030 | −0.205 | 0.166 | 0.370   | 0.057 |
| Services      | −0.123 | −0.266 | −0.018 | 0.248 | 0.053 |
| Transport     | 0.148 | −0.600 | 4.201 | 4.801   | 0.740 |
| Invest        | 0.030 | −0.562 | 1.687 | 2.249   | 0.261 |
| Integral index| 0.413 | 0.210 | 0.589 | 0.379   | 0.070 |

Res and SD stand for the unweighted mean and standard deviation of the regional resilience indices.

**Fig. 2.** Assessments of the level of the RF regions’ resilience to the 2020 pandemic (approach II).
which, ultimately, we selected only those for which significant correlations were confirmed (Table 4).

From these data, it can be concluded that the greatest resilience amid the pandemic was shown by small and less developed regions with a large share of agriculture and the labor intensity of gross regional product (GRP). The conclusion about the greater resilience of agricultural regions corresponds with the results obtained for 27 EU countries in 2008–2015, covering the Great Recession and the recovery period after it (Giannakis and Bruggeman, 2019). In addition, according to our research, regions with a high share of the public sector in the economy and a significant share of spending on the social sphere turned out to be more successful during the pandemic. It should be recalled that (Lagravinese, 2015) also found a positive effect of the share of public officers in the number of employees on the resilience of Italian regions in 1970–2011.

The most vulnerable regions to the pandemic were more developed, larger, more urbanized regions with higher-skilled labor, as well as mining regions and open economies. These conclusions are also confirmed by several studies by other authors. In particular, (Huynh et al., 2021) found a negative impact of the openness of the economy on the resilience of stock markets that reflected the economy performance amid the pandemic.

The share of employees in small-sized businesses turned out to be a factor of lack of resilience due to the specific impact of the lockdown on the activities of service enterprises. The negative relationship of resilience with the share of organizations having own Internet servers is surprising and hardly explainable. Common sense suggests that under the conditions of the lockdown, enterprises that already had digital

### Table 4. Correlations of integral resilience indices with indicators of regional economic development

| Indicator (according to 2019 data) | Denotation | Pearson’s linear coefficient | $Res_1$ | $Res_2$ |
|-----------------------------------|------------|------------------------------|---------|---------|
| Logarithm of GRP per capita        | ln(GDP$_{pc}$) | $-0.376$ | $-0.362$ |
| Share of the region in GRP         | $Share_{GRP}$ | $-0.403$ | $-0.401$ |
| Share of exports and imports in GRP (degree of economic openness) | $Openness$ | $-0.319$ | $-0.434$ |
| Share of TEA Agriculture, forestry, hunting, fishing and fish farming in GRP | $Agriculture$ | $0.385$ | $0.346$ |
| Share of TEA Mining in GRP         | $Mining$ | $-0.211$ | $-0.194$ |
| Share of TEA Government and military security; social security in GRP | $Government$ | $0.273$ | $0.233$ |
| The total share of TEAs Education and Activities in the field of health and social services in GRP | $Educat&Health$ | $0.252$ | $0.221$ |
| The level of economic diversification * | $DIV$ | $0.075$ | $0.073$ |
| Labor intensity of GRP (amount of hours actually worked / GRP)** | $Labour_intens$ | $0.392$ | $0.353$ |
| Share of employees in public sector | $State_employees$ | $0.452$ | $0.463$ |
| Share of employees in small-sized enterprises | $Small_share$ | $-0.287$ | $-0.323$ |
| Share of employees with higher and secondary specialized education | $Educated_share$ | $-0.343$ | $-0.382$ |
| Share of urban population | $Urban_share$ | $-0.280$ | $-0.278$ |
| Share of organizations that used servers | $Servers_share$ | $-0.377$ | $-0.386$ |

Data for the Republic of Crimea and Sevastopol were not used in the calculations. TEA is type of economic activity according to All-Russian Classifier of Types of Economic Activity.
* The indicator of economic diversification was calculated based on the index of similarity of two structures and was borrowed from (Malkina, 2020).
** Labor intensity indicator was calculated based on data for 2017.
Source. Calculated according to (Regions of Russia. Socioeconomic indicators / Rosstat. 2021. https://rosstat.gov.ru/folder/210/document/13204 (accessed January 2022)).
assets and experience in using digital technologies in the pre-pandemic period should have been in favorable position. Therefore, this negative result at the regional level can be attributed to the indirect influence of the specific sectoral effects of the pandemic. Finally, no relationship was found between the level of diversification of regional economies and their resilience to the coronavirus crisis.

It should be noted that we also tested other variables, in particular, those related to the rate of infections and recoveries, deaths and excess deaths, the severity of restrictions, and the number of support measures. However, they did not show significant relationships with the tested indicators of resilience, thus we do not present them here.

Pairwise correlations indicate the direction and strength of the relationship. However, they can lead to a biased assessment due to the failure to take into account the influence of other factors. Therefore, in order to obtain more reliable results on the significant resilience factors, multiple econometric models should be built. We have tested a number of linear and nonlinear models. The choice of the most relevant ones was carried out based on the Akaike and Schwartz information criteria, the significance of the regression coefficients and the model as a whole, the absence of multicollinearity (according to the VIF criterion) and heteroscedasticity (according to the White test), as well as compliance with the requirement for the normality of the distribution of residuals (according to the Pearson $\chi^2$ test). Eventually, we selected a model estimated by the ordinary least squares method. It is presented in Table 5.

Thus, the constructed econometric dependencies confirmed the positive impact on the resilience of regional economies made by the share of employees in state and municipal enterprises and the negative impact by the degree of openness and scale of the economy, as well as the share of the mining sector therein. The variance of these factors taken together explains more than 37% of the variance of the dependent variable (regional economies resilience estimated based on the approach II).

### CONCLUSIONS

We studied the impact of the 2020 pandemic on the economic resilience of Russian regions. Resilience was assessed based on the average per capita income of the population and the consolidated budgets of the RF federal subjects, the production in a number of industries, and the level of investment. Two alternative approaches were used to assess the resilience. Within the framework of the approach I (R. Martin and R. Lagravinese), resilience is estimated through the change in the regional growth rates relative to the country-wide trend. Within the framework of the approach II (the author’s), resilience is estimated as a deviation of the region’s indicators from their prepanademic trend. This research revealed that the pandemic differently affected various industries and sectors of the economy. In particular, the greatest resilience was shown by the budget revenues, which is explained by large-scale injections of federal aid into the regions. The active implementation of national projects prevented a significant drop in the growth rates in construction and investment in fixed assets. In addition, support for healthcare, social security, and employment in the most affected sectors prevented serious losses in population incomes. Industry, services, and transport were the hardest hit during the pandemic.

The pandemic affected regional economies in different ways, which is explained primarily by the difference in their sectoral structures. Based on the calculation of the integral resilience indices, a conclusion has
been made about greater resilience to the pandemic displayed by some underdeveloped regions of Russia, which, moreover, received significant federal support. Some border regions and regions of the Far East also turned out to be more stable, which can be explained by a significant increase in metal prices. The lowest resilience was shown by developed and large economies and centers of the mining industry. The lower resilience of developed and extractive regions confirms the conclusion made earlier in a work on assessing the resilience of Russian regions in the pre-pandemic period (Malkina, 2020). The results we obtained based on the two indices are somewhat different but in general show similar trends and a high degree of association.

The calculated correlations of the resilience indices with several development indicators of Russian regions and constructed econometric model complemented the picture of different resilience of Russian regions during the coronavirus crisis. In particular, a greater vulnerability to the pandemic was found for the economies of large developed urbanized regions with a higher quality of human capital, as well as regions with a developed mining industry and a high degree of openness. At the same time, a large level resilience to the pandemic has been proven for the economies of underdeveloped agrarian regions with a high labor intensity of GRP, a large share of the public sector, and a relatively higher level of social spending. This investigation indicates the prevailing impact of sectoral effects and interbudgetary policy on the economic resilience of the Russian regions to the 2020 pandemic.

The limitation of the study is due to the impossibility at this stage to assess the long-term consequences of the pandemic, in particular, to describe the recovery trajectories of the regions, since the resolution of the epidemiological situation has not yet been reached and the impact of the pandemic is still ongoing. This, in turn, determines one of the directions for further research on the problem. In addition, in the future it is also planned to improve approaches to the assessment of resilience in terms of selecting indicators and justifying the methods for their aggregation and normalization, as well as better specification of econometric models of resilience and the inclusion in them of factors related to the epidemiological situation and regulatory policy in the regions.

FUNDING

The study was carried out within the framework of the basic part of the state assignment of the Ministry of Education and Science of the Russian Federation, project 0729-2020-0056.

CONFLICT OF INTEREST

The author declares no conflict of interest.

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