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Contact: mmuri@yandex.ru; Lobachevsky State University of Nizhni Novgorod, 107, 7 per. Universitetskiy, 603000 Nizhni Novgorod, Russia

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Marina Yu. Malkina
Lobachevsky State University of Nizhni Novgorod, Russia
orcid.org/0000-0002-3152-3934

How the 2020 pandemic affected tax revenues in Russian regions?

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Abstract

Research background: The 2020 pandemic has proven to be stressful for regional tax systems. However, these systems reacted differently to lockdown and a decline in business activity, which was associated with both their structures and the specifics of their development.
Purpose of the article: The aim of the article is to assess the impact of the 2020 pandemic on tax revenues of Russian regions, as well as to analyze the factors contributing to the resilience of regional tax systems to epidemiological crises.
Methods: The study is based on monthly data from the Federal Tax Service of the Russian Federation on total tax revenues in 83 Russian regions for 2013–2020. For data up to March 2020, we construct stationary time series and plotted ARiMA regressions. Based on them, we forecast tax revenues for the period from April to December 2020, if there were no pandemic. The impact of the pandemic is calculated as the deviation of actual tax revenue from the forecast for the corresponding 9 months.
Findings & value added: We find that the impact of the pandemic on tax revenues varies over time and space. The crisis hit the fiscal system most negatively in the first three full months of the lockdown (April–June 2020). Some mining regions of the Urals, Western and Eastern Siberia, specializing in the extraction of oil and gas, as well as non-ferrous metals, turned out to be the most vulnerable to the pandemic. The most resistant to it are the central and southern regions of the European part of Russia. Calculation of Pearson's correlations shows that the greatest drop in tax revenues occur in regions with a larger share of the mining industry in gross value added and MET in tax revenues, with a higher GRP per capita and an increased level of general economic instability. The smallest decline in tax revenue, or even its growth, is observed in regions with a larger share of personal income tax and property tax in tax revenues, a higher share of trade and processing industries, social sphere and public administration in gross value added, a higher degree of economic diversification and a larger share of small business in total turnover. The obtained results are applicable to manage the resilience of tax systems to epidemiological crises.

Introduction

The 2020 pandemic triggered a global economic crisis. However, the diverse response of countries and regions to this crisis is associated with a number of reasons: the uneven spread and depth of coronavirus infection, the different severity of the restrictions imposed and the level of institutional support for businesses and households, as well as the structural parameters and characteristics of specific economies.

The impact of the pandemic on economic development is especially interesting to study on the data of territorial entities developing in a similar institutional environment. In Russia, the predominance of federal rules ensures the unity of institutional environment of its regions. At the same time, Russian regions differ significantly in terms of resource provision and their productivity, level of development and openness, the sectoral structure of the economy and the degree of sectoral diversification. In the context of the 2020 pandemic, the federal center provided unequal financial support to the regions and expanded their rights in establishing their own rules for dealing with the crisis. Therefore, we could expect different resilience of Russian regions to the crisis and the depth of the pandemic recession in them.

The 2020 pandemic shock hit the budgetary sphere of Russian regions. Their own tax and non-tax revenues decreased due to both the economic downturn and introduced tax incentives to support the population and enterprises during isolation and business contraction. At the same time, the growth of budgetary expenditures to support enterprises and the population (especially on healthcare, social benefits and investment programs) supported aggregate demand and business activity, but further worsened the state of regional budgets. To cope with the problem of lack of public resources, a fairly successful mechanism for debt financing of public expenditure was launched. Amid falling demand from the private sector, commercial banks placed their assets in government bonds. In turn, this fueled business activity in the country and discouraged fiscal cuts.

In this article, using the example of Russian regions, we try to identify how the 2020 pandemic, through various channels, affected the tax revenues of the regions, and why the reaction of the regional tax systems to the crisis was different. This allows us to answer the question of what characteristics of the regional economies support their resilience to pandemic crises. In addition, we compare the consequences of the pandemic crisis and conventional financial crises and recognise general and specific in their impact on the regional tax systems.

By building ARiMA models on pre-pandemic data, we predict what tax revenue would be in the pandemic months in the absence of a shock, and calculate their deviation from actual tax revenue. Next, we determine the correlation of the level of tax revenues during the 2020 pandemic with a number of indicators of regional economies, reflecting their sectoral and institutional structure and characteristics of development. On their basis, we draw conclusions about ways to increase the resilience of regional tax systems. The developed algorithm can be used to conduct similar studies in other countries with the aim of identifying the factors of stability of their fiscal systems under various kinds of crises.

Further research is organized as follows. The Literature review section analyses studies on the resilience of economies and budget systems and their determinants, with special emphasis on the Russian regions. We also provide a brief overview of relevant studies for the 2020 pandemic. The Data and Methods section contains a description of data and models for forecasting time series of tax revenues, methods for determining their level, as well as a description of the factors tested. In the Results section, we present the calculated indicators and disclose the impact of regional factors on change in tax revenues of Russian regions during the 2020 pandemic. In the Discussion section, we explain our results and compare them with the findings of other authors. The Conclusions section provides a brief summary of our research, reveals its limitations and outlines the prospects for further development.

Literature review

In the context of our research, the works devoted to the problem of economic resilience to various shocks (Martin, 2012; Modica & Reggiani, 2015; Giannakis & Bruggeman, 2019) are of primary interest. The scholars identify three components of economic resilience: vulnerability, resistance and recoverability, and consider the possible trajectories of economy entering new paths of sustainable development after destabilizing shocks.

They investigate various factors of economic resilience. For example, Pietro *et al.* (2020), using an equilibrium model, demonstrate that the stability of economic systems depends on the nature of the external shock and characteristics of the economy itself, such as capital and labour intensity, openness, and specialization. The authors also highlight the importance of innovation, agglomeration effects, and education factors. Several researchers argue the importance of the sectoral structure of economy (Tan *et al*., 2017; Mai *et al*., 2019) and the level of its diversification (Dissart, 2003)

for achieving resilient development. Others confirm the impact of the involvement of economies in global production chains on their stability (Van Bergeijk *et al*., 2017).

A number of studies examine the stability of regional budget revenues and their sources, in particular, tax revenues. Lagravinese *et al*. (2018) define the instability of tax revenues as their temporary variability. Malkina (2020b) assesses the degree of instability of the budgetary systems of Russian regions based on the standard deviation of the residuals of temporary regressions of budget revenues per capita and as a percentage of GRP. This approach assumes that diversification of tax portfolios (Cornia & Nelson, 2010) or industry structure (Malkina, 2017) provides the stability of tax revenues.

It should be emphasized that most of the previous researchers studied the loss of stability of economic systems under the influence of global financial crises. The economic crisis caused by COVID 2019 is a completely new phenomenon that requires special reflection.

The 2020 pandemic has affected the economies of countries through the channels of supply, demand, finance and expectations (Mau (Ed.), 2020, pp. 252–253). It has an uneven impact on various industries and regions due to their different dependence on internal and external factors, institutional structures and resistance to shocks. By incorporating data on credit cards consumer spending into an input-output model, Darougheh (2021) concludes that the biggest recession during the pandemic is in end-user industries, especially in the service sector, while the production of intermediate goods act as an output stabilizer. In the study of Russian regions, Kolomak (2020) proposes the index of regional economic activity. Plotting a regression for this index shows that the 2020 pandemic has dealt the biggest blow to the economies of larger and more advanced regions. More urbanized Russian regions and those with developed small and medium-sized businesses turned out to be more resilient to the pandemic.

Some scientists investigate the fiscal effects of the 2020 pandemic. Clemens and Veuger (2020) assess the impact of the pandemic on the reduction of state government sales and income tax revenues in the USA. They find a relationship between tax revenues and spending on education and health, as well as various government support measures. Devereux *et al.* (2020) examine how tax deferral and incentive measures adopted by governments at different stages of the pandemic crisis (tax breaks for corporations, temporary VAT rate cuts) have impacted economic activity and budget revenues. Several authors attribute the severity of the pandemic shock to a combination of taxes and fees in tax systems (Chernick *et al*., 2020).

The impact of the pandemic on the Russian budgetary system is associated with the peculiarities of the Russian economy. One of the most important is its significant, albeit decreasing, dependence on the state of the world oil and gas market. Back in 2019, the share of oil and gas revenues in federal budget reached 39.3%. The collapse in oil prices in the midst of the 2020 pandemic (due to a significant reduction in international and domestic traffic, etc.), together with the oil production quotas established by agreement with OPEC, negatively affected the revenue side of Russian budgets. The federal budget has suffered the most, which, through the mineral extraction tax (MET), accumulates the lion's share of oil and gas revenues collected in the regions. In the first half of 2020 alone, its oil and gas revenues fell by 37.7% (Mau (Ed.), 2020, pp. 291–292). The sub-federal budgets of the mining regions have faced a reduction in income taxes, primarily profit tax.

Other important characteristics of the Russian economy that predetermine the depth of the pandemic recession and the speed of its recovery after the shock are the underestimation of the ruble, the debt model of consumer demand financing, the predominance of the state consumption channel, and the economic policy of dirigisme (Minakir, 2020, p. 9). In addition, several authors (Kuznetsova, 2020) emphasize the influence of the sectoral and institutional structure of regions on the change in tax revenues during the 2020 pandemic. The industries differ both in the elasticity of demand to various factors, and in the share of small and medium-sized businesses, the level of informal employment, and the ability to adapt to shocks (switching to remote work, etc.).

In general, the literature review points to insufficient research on the resilience of various economies to the 2020 pandemic shock. There are even fewer studies of the stability of the Russian economy and its regions. Finally, none of them analyzes the resilience of the tax systems of Russian regions to the 2020 pandemic shock and its specific factors. Our research aims to fill this gap. Understanding the specifics of the response of the Russian fiscal system to the coronavirus shock can also be useful to compare with its impact in other countries.

Assessing the magnitude of tax revenue losses due to a pandemic requires predicting them in the absence of a shock. To cope with this, scientists offer different methodological techniques: calculating expected changes in sales and using tax revenue elasticities (Chernick *et al*., 2020), building VAR models or artificial neural networks (Jena *et al*., 2021). In our research, we prefer constructing ARiMA models for stationary time series. The advantage of this approach is its ability to capture both the moving

average and the cyclical and seasonal components of income, as well as different frequency of tax payments.

Thus, the purpose of our study is to assess the impact of the 2020 pandemic on tax revenues in the Russian regions and to identify factors that contribute to the resilience of regional tax systems to epidemiological crises.

Data and methods

The study is based on the monthly data of the Federal Tax Service of the Russian Federation on total tax revenues in 83 Russian regions for 2013–2020. In addition, we employ regional statistics data provided by the Federal State Statistics Service of the Russian Federation.

We assume that data from January 2013 to March 2020 reflects the impact of economic cycles, but does not capture the impact of the 2020 pandemic. Data from April to December 2020 reflects the impact of both cycles and pandemic. Turning points can be diagnosed visually by analyzing tax revenue time series.

Figure 1 also shows a decrease since April 2020 in annual tax revenues in Russia and the contribution of different regions to this change. It also demonstrates that the overall situation with tax revenues in Russia strongly depends on that in capital cities (Moscow and St. Petersburg) and in some mining regions (Khanty-Mansy Autonomous Okrug). These three out of 85 regions together provided more than 37% of all tax revenues in the country in 2019.

The research algorithm covers the following stages:

1) For pre-pandemic data on monthly tax revenues in regions (covering the period 01.2013–03.2020), conducting an augmented Dickey-Fuller test and determining the level of the time series (d) at which they become stationary. Time series of tax revenues for all regions are brought to a stationary form by calculating either the first (second) difference of variables, or the first (second) difference of their natural logarithms. Specifically, we use the simple difference method for regions that have zero or negative tax revenues in certain months. In all other cases, we prefer the logarithmic method.

2) Modeling pre-pandemic regional time series using ARiMA (p, d, q) regressions:

$$\Delta^d X_t = c + \sum_{i=1}^{p} \varphi_i \cdot \Delta^d X_{t-i} + \sum_{j=1}^{q} \theta_j \cdot \varepsilon_{t-j} + \varepsilon_t, \qquad (1)$$

where:

X_t – tax revenues (or their logarithm) in the analyzed region in month t;

Δ^d – time series difference operator of order d; c, φ_i;

θ_j – estimated coefficients of the model; ε_t – residuals.

The orders of p and q are determined based on the sample autocorrelation functions (ACF) and the partial autocorrelation function (PACF). When fitting the models, we take into account the significance of the coefficients with $p<0.10$ and the minimization of Akaike and Bayesian (Schwarz) information criteria (AIC and BIC). If these criteria contradict each other, we are guided by the Hannan-Quinn (HQ) criterion.

3) Plotting, based on the obtained regressions, monthly forecasts of tax revenues for April–December 2020 (X_{tf}). Logarithmic values are converted to their original values by taking an exponent. We believe that tax revenues could have such values, following the logic of previous economic processes, had it not been for the pandemic.

4) Calculation of the tax revenues index for each k-th region as the ratio of actual tax revenues to their non-pandemic forecast on an accrual basis for 9 months of 2020:

$$I_k = \frac{\sum_{t=1}^{T} X_{kt_f}}{\sum_{t=1}^{T} X_{kt}}. \qquad (2)$$

This index reflects both direct and indirect impact of the pandemic and methods of combating it on the tax revenues of the regions.

5) Determination of the correlation between the tax revenue index and a number of regional indicators:

- the structure of tax revenues in the regions (the shares of different taxes and tax groups in the total tax revenues);
- the sectoral structure of the economy (the shares of the enlarged industries, determined according to OKVED-2014, in the total gross value added of the regions in 2017);
- the level of economic diversification, determined by the index of two structures similarity:

$$SSI_k = 1 - \sqrt{\sum_{n=1}^{N} (s_{n/k} - s_n)^2}\ , \qquad (3)$$

where $s_{n/k}$ – the share of n-th industry in the total gross value added (GVA) of the k-th region;

s_n – the share of the same industry in the country's GVA;

N – number of industries.

- indicators of the level of regional development: logarithm of gross regional product (GRP) per capita, capital and labour intensity of GRP (determined, respectively, as the ratio of the value of fixed assets and the amount of actually worked time to GRP), and the scale of the regional economy (share of the region's GRP in the total GRP of all regions);
- an indicator of the general instability of regional economies, determined on the basis of the Mahalanobis distances taken from (Malkina, 2020a);
- the share of small businesses in the total turnover of the regions;
- the degree of openness of the regional economies, determined by the shares of exports and imports in their GRP.

Research hypothesis: interregional differences in the response of tax revenues to the 2020 pandemic are due to the different level, structure and nature of development of regional economies.

Results

Using the methodology presented in Data and Methods, we built ARiMA models for stationary time series describing the fluctuations in tax revenues in 83 Russian regions for January 2013–March 2020.

Figures 2, 3 and Table 1 show sequentially the construction of such a model for the Russian Federation. Since the data on tax revenues for the Russian Federation does not have negative values, we take their natural logarithms. Next, we follow point 1 of the methodology. The augmented Dickey-Fuller test indicates that time series are stationary at the level of the first differences, d=1 (Figure 2a). The sample and partial autocorrelation functions (ACF and PACF) allow us to determine the possible operators p and q in our model (Figure 2b).

However, when building model (point 2 of the methodology), we initially take the maximum allowable number of lags (10) for MA and AR orders. Then we fit the initial model, excluding the most insignificant lag variables successively, provided that one or all of the information criteria (AIC, BIC of HQ) are improved. Ultimately, we obtain the model presented in Table 1. In it, all lagged variables are significant at a P-value<0.00001, and the values of information criteria are minimal among all alternatives.

Figure 3 shows the actual (solid line) and estimated (dashed line) tax revenues in the Russian Federation in the pre-pandemic period. The quality of the constructed ARiMA model is confirmed by the proximity of estimates to actual values. Further, on the basis of the ARiMA model, non-pandemic forecasts for April-December 2020 are constructed (right side of the dashed line in Figure 3), and they are compared with the actual tax revenues during the pandemic (gray line with dots). The synchronicity (parallelism) of the forecast and pandemic indicators again testifies to the adequacy of the model.

A similar procedure was applied for all regions of the Russian Federation. Based on the obtained regressions, we predicted the monthly values of tax revenues in April–December 2020, if there were no pandemic (point 3 of the methodology). Next, we calculated the ratio of the actual tax revenues to their forecasts on an accrual basis (point 4 of the methodology).

According to our assessments, the maximum deviation of actual tax revenues from their forecasted values in the country is observed in April-June 2020. The largest drop in tax collection in Russian regions also occurs in the first three months of the pandemic. More precisely, for 14 regions the maximum decline is observed in April, for 31 regions — in May, for 22 regions — in June, for 6 regions — in July, and for the remaining 10 regions — in the other 5 months of 2020.

In total, the consolidated budget of Russia has lost more than 21% of tax revenues in the 9 pandemic months of 2020. However, the situation in the regions was different (see the map presented in Figure 4). In four regions: Murmansk Oblast (administrative code 51), Nenets Autonomous Okrug (83), Sakhalin Oblast (65) and Astrakhan Oblast (30), the shortfall in tax revenues due to the pandemic exceeded 50%. In another 5 regions it was within 40–50%, in 5 regions — 30–40%, in 7 regions — 20–30%, in 14 regions — 10–20%, in 20 regions — 0–10%. At the same time, in 27 out of 83 regions there was an excess of tax revenues over the forecast for the entire period, but in most of them (15 regions) it did not exceed 0-10%.

The most vulnerable to the pandemic were some mining regions of the Urals, Western and Eastern Siberia, the main producers of oil and gas, as well as non-ferrous metals. A significant shortfall in tax revenues was also

observed in the Sakhalin Oblast (the largest gas producer in the Far Eastern Federal District). The deviation of actual from projected tax revenues in such regions is shown in Figures 5 a-i. At the same time, the coal-mining Chukotka Autonomous Okrug (administrative code 41) even demonstrated moderate growth in revenues.

The least susceptible to the pandemic shock were some regions of the European part of Russia (in particular, Smolensk, Tula and Nizhny Novgorod regions, administrative codes 67, 71 and 52). Leading positions are also held by two constituent entities of the Far Eastern Federal District: Amur (28) and Magadan (49) Oblasts.

To elucidate the factors that predetermine the resilience of regional tax systems to the 2020 pandemic, we calculated Pearson's correlations between the level of tax revenues (the ratio of actual to forecast values) and a number of indicators of regional structure and development (point 5 of the methodology). The results are presented in Table 2. In addition, Figure 6 a-i shows the most pronounced non-linear relationships between the tested variables and the tax revenue level in the regions in the 2020 pandemic.

The tax systems of Russian regions with a large share of personal income tax (PIT) in total tax revenues show the greatest stability. This group includes the lagging North Caucasian republics and some republics of southern part of Siberian Federal District. Tax systems of some Far Eastern regions, characterized by high volatility in the pre-pandemic period, have also shown increased resilience during the pandemic due to the high share of PIT in tax revenues.

The stability of tax revenues is also supported by a high proportion of property taxes and duties (which, together with PIT, negatively correlate with the level of economic development). At the same time, the most vulnerable to the pandemic are the tax systems of extractive regions with a large share of the mineral extraction tax (MET) in total tax revenues.

The level of tax revenues in regions during the pandemic is also explained by their sectoral structure. The share of the extractive industry in GVA shows a significant negative correlation with this level. The largest positive relationship with the level of tax revenues is demonstrated by the trade sector, followed by manufacturing and infrastructure sectors, social sphere and public administration. At the same time, we provide evidence that the degree of economic diversification (SSI) has a moderately positive effect on the resilience of the fiscal system to pandemic shocks.

The 2020 pandemic most affected the tax systems of the more developed regions (with higher GRP per capita and its capital intensity) and least affected the tax systems of lagging regions (with increased labor intensity of GRP). The regions with generally unstable economies (Malkina, 2020a),

on average, were more sensitive to this shock. At the same time, the impact of the size of the economy and the degree of its openness on tax revenues was mixed.

Finally, we observe a positive, albeit weak, relationship between tax revenue and the share of small businesses in the regions.

Discussion

Our study confirms the hypothesis put forward about the relationship between the peculiarities of regional structure and development and the sensitivity of regional tax systems to the pandemic shock.

The most vulnerable to the pandemic crisis are highly developed and generally unstable economies specializing in the extractive industry. The most resistant to it are diversified economies with a large share of trade and the secondary sector in the GVA, as well as the sectors of social and public administration.

Our result on the positive impact of the share of property tax on the sustainability of tax revenues during the pandemic is consistent with data from the United States (Chernick *et al*., 2020). However, a number of industries officially recognized as the most affected by the coronavirus received an official deferral of property tax receipts, which affected their collection. In general, autonomous taxes (including state duties) proved to be more resilient to the crisis than income taxes.

At the same time, in Russia, unlike the United States (Chernick *et al*., 2020), personal income tax plays the role of stabilizer during the crisis. There are several explanations for this. First, Russia is characterized by a large and growing share of the public sector in the economy, which lives under soft budget constraints. The state significantly increased investment activity during the crisis, which also led to an increase in personal income in some sectors and generated a multiplier effect. Second, in the 2020 pandemic, the state directly supported certain segments of the population (families with children) and increased payments to health workers etc. Third, transfers from the federal budget to the regions grew by 36%, which, although uneven (Zubarevich & Safronov, 2020), supported the public sector and contributed to the growth of wages in it.

Our study shows the greatest sensitivity to the pandemic of the primary sector, mainly mining, while agriculture served as a kind of tax stabilizer. This finding partially contradicts the study on Indian provinces (Goswami *et al*., 2021), which indicates the largest decline in provinces with more developed secondary and tertiary sectors of the economy, while provinces

with a predominance of the primary sector (mainly agriculture) are more resistant to the pandemic shock.

Our research also suggests that a broader presence of the trading sector in the region's economy is helping to mitigate the impact of the pandemic crisis. A large share of trade is characteristic of the capital cities and less developed regions of southern part of Russia. During the pandemic, several factors contributed to the development of trade. First, the consumer hype in the first months of the pandemic was associated with the expectation of a long quarantine. Second, during the summer holidays, there was an increase in domestic demand due to a decrease in external demand. Third, the change in consumer preferences led to an increase in purchases of certain goods (computer and telecommunications equipment for remote work, building materials, suburban real estate, etc.). Fourth, the growth in consumer demand was facilitated by a decrease in the attractiveness of savings due to a significant decrease in the key interest rate of the Bank of Russia and the devaluation of the ruble. Fifth, the belated hype of consumers was associated with inflationary expectations.

The conclusion that advanced regions (with a large GRP per capita) are more susceptible to the pandemic is consistent with (Kolomak, 2020). On the one hand, most of these regions are home to the lucrative extractive industries that have been hit hardest by the pandemic. On the other hand, the final demand in high-income regions fell more than in low-income regions. This conclusion is supported by the UK study (Hacıoğlu-Hoke *et al*., 2021), where the effect of larger spending cuts in wealthier regions is explained by a dominant fall in spending in the upper quintile of the population.

Our finding that tax revenues are positively associated with the share of small businesses contradicts the widespread belief that small businesses are significantly more affected by the pandemic shock (Shafi *et al*., 2020; Dai *et al*., 2021), albeit it again coincides with (Kolomak, 2020). This Russian phenomenon can be explained by the fact that Russian SMEs received significant government support during the pandemic (Mau (Ed.), 2020, p. 304), and they have shown greater flexibility and better adaptation to remote work.

Finally, our research shows the importance of sectoral diversification of the economy in achieving its resilience to crises. However, this conclusion is unequivocal only for economies characterized by a high level of specialization. At the same time, for economies with a significant variety of industry structure, the impact of diversification on resilience is ambiguous (Figure 6 g) and depends on the nature of the relationship between the profitability of different industries (Malkina, 2017).

Conclusions

We investigate the impact of the 2020 pandemic on tax revenues of the Russian regions and determine the factors of resilience of regional fiscal systems to epidemic shocks. Based on monthly data on tax revenues in 83 Russian regions for 2013–March 2020, we construct ARiMA models. With their help, we predict tax revenue in the remaining 9 months of 2020, if there were no pandemic. Comparison of forecast and actual tax revenues on a cumulative basis for April-December 2020 reveals the unevenness of the impact of the pandemic in space and time.

The study of the correlations of the level of tax revenues during the 2020 pandemic with indicators of development, structural and institutional features of regional economies has led to a number of new results. Some highly developed mining Russian regions with a large share of mineral tax in tax revenues and generally heightened sensitivity to various shocks are among the most vulnerable to the 2020 pandemic. Less developed regions with large shares of personal income tax and property taxes, a high degree of economic diversification, and an increased share of trade, manufacturing, infrastructure, social and public administration sectors in the gross value added proved to be the most resilient to the pandemic shock. Contrary to expectations, the share of small businesses in the region's turnover positively correlates with the level of tax revenues in Russian regions.

The results obtained indicate the importance of the sectoral and institutional structure of the economy and the level of economic diversification for increasing its resistance to epidemiological shocks. Meanwhile, it should be emphasized that diversification is not limited to simple industry diversity, but is also associated with cross-sectoral effects. If industries are technologically linked together, this can increase the volatility of tax systems and their vulnerability to shocks. The study also shows the importance of active government regulation in times of crisis, but long-term effects of increased public investment and transfers have yet to be explored. In the pandemic crisis, we see the impact of changing consumer behavior on the fiscal system revenues. Spillovers, such as price changes in major energy and metals markets, are mingled with the direct effects of the pandemic (associated with limited activity). Moreover, indirect effects can be even stronger than direct ones, which brings the epidemiological crisis closer to the financial one. However, their main difference is that pandemic crisis primarily affects the industries associated with transportation, the service sector and the regions in which they are concentrated.

Despite the convincing results consistent with the logic of economic processes, our study has certain limitations. First, we based our research on

a time series of total tax receipts. A more detailed approach based on a separate analysis of revenue from different taxes would lead to more accurate forecasts. Second, it is desirable to clarify the separation of the trend, cyclical and seasonal components in the models, as well as to justify the periods on the basis of which we build the forecast. Third, building multivariate models that take into account the impact of key macroeconomic variables, such as oil prices, exchange rates, industry restrictions and support, would help distinguish between direct and indirect effects of the pandemic on tax revenues. Expansion of the study is also possible by including in the model factors related to the spread of coronavirus and the depth of infection in the regions. Addressing these issues requires a deeper approach in the future.

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Annex

Table 1. ARiMA model for Russian Federation, dependent variable (1-L) ln(X_{RF}), using observations 2013:02–2020:03 (T = 86)

	Coefficient	**Std. error**	**P-value**
const	0.0095	0.0020	<0.00001***
phi_2	-0.9787	0.0713	<0.00001 ***
phi_4	-0.8868	0.1090	<0.00001 ***
phi_6	-0.6911	0.1208	<0.00001 ***
phi_8	-0.6851	0.0983	<0.00001 ***
phi_10	-0.7944	0.0631	<0.00001 ***
theta_1	-0.9436	0.1125	<0.00001 ***
theta_2	1.0505	0.1553	<0.00001 ***
theta_3	-0.4728	0.1453	0.00114 ***
theta_4	0.6495	0.1205	<0.00001 ***
theta_5	-0.3817	0.1152	0.00092 ***
Mean dependent var.	0.0144	S. D. dependent var.	0.3303
Mean of innovations	0.0051	S. D. of innovations	0.0977
Log-likelihood	66.530	Akaike criterion	-109.06
Schwarz criterion	-79.609	Hannan-Quinn criterion	-97.208

Note: Estimated using Kalman filter (exact ML). Standard errors based on Hessian.

Source: author's own calculations based on data from the FTSRF.

Table 2. Pearson correlation between tax revenue level during the 2020 pandemic and explanatory variables

Variable	**Coefficient**	**Variable**	**Coefficient**
Share in total tax evenue:		Share in GVA:	
CIT	0.24	Agriculture	0.20
PIT	0.55	Mining	-0.50
VAT	-0.14	Manufacturing	0.25
Excises	0.15	Electricity, gas and water supply	0.26
PT	0.44	Wholesale and retail trade; repair	0.36
MET	-0.59	Public administration and military security	0.21
Duty	0.40	Healthcare and education	0.22
Special Tax Modes	-0.06	Financial, insurance and real estate activities	0.19
ln(GRP_pc)	-0.38	Information and communication activities	0.22

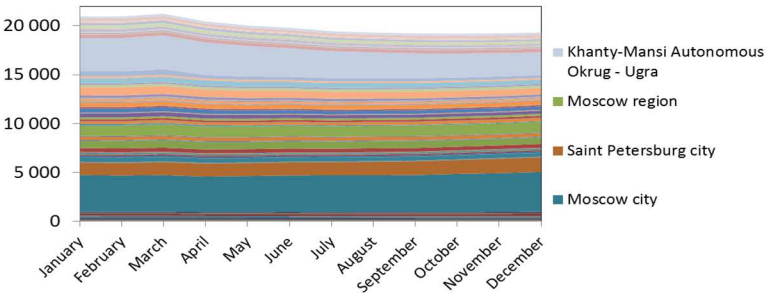
Table 2. Continued

Variable	Coefficient	Variable	Coefficient
Labour intensity of GRP	0.34	Instability	-0.22
Capital intensity of GRP	-0.15	Net Exports (Exports-Imports) share in GRP	-0.15
Share in total GRP	-0.10	Share of small business in turnover	0.25
Diversification (SSI)	0.41		

Note. Abnormal values of the Amur and Magadan regions are excluded as outliers

Source: author's own calculations based on data from FTSRF

Figure 1. Tax revenues in the Russian Federation in 2020 on an annualized basis (for the 12 months) and their regional structure (billion roubles)

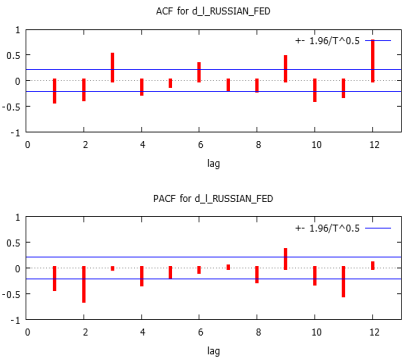


Source: author's own calculations based on data from the Federal Tax Service of the Russian Federation (FTSRF).

Figure 2. Preparation for building ARIMA model for the Russian Federation (using the Gretl program)

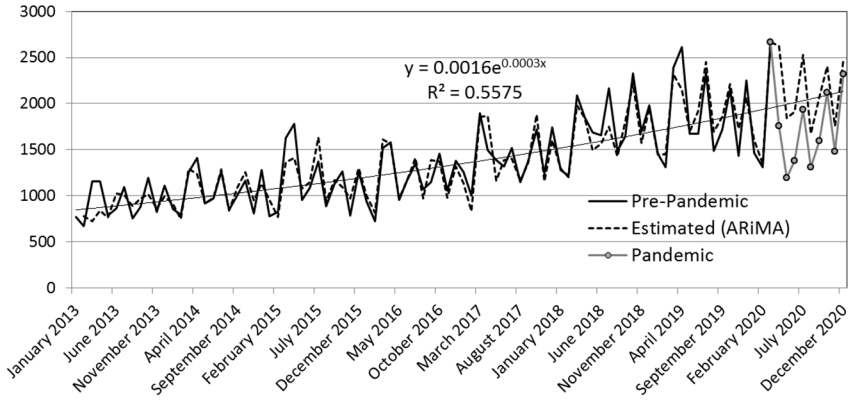
```
Augmented Dickey-Fuller test for d_l_RUSSIAN_FED
including 10 lags of (1-L)d_l_RUSSIAN_FED (max was 12)
sample size 75
unit-root null hypothesis: a = 1

   test with constant
   model: (1-L)y = b0 + (a-1)*y(-1) + ... + e
   1st-order autocorrelation coeff. for e: 0.124
   lagged differences: F(10, 63) = 41.926 [0.0000]
   estimated value of (a - 1): -8.79477
   test statistic: tau_c(1) = -9.41807
   asymptotic p-value 2.356e-017

   with constant and trend
   model: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
   1st-order autocorrelation coeff. for e: 0.121
   lagged differences: F(10, 62) = 41.357 [0.0000]
   estimated value of (a - 1): -8.79914
   test statistic: tau_ct(1) = -9.35847
   asymptotic p-value 2.775e-017
```

a) determining the level of the time series (d) at which they become stationary



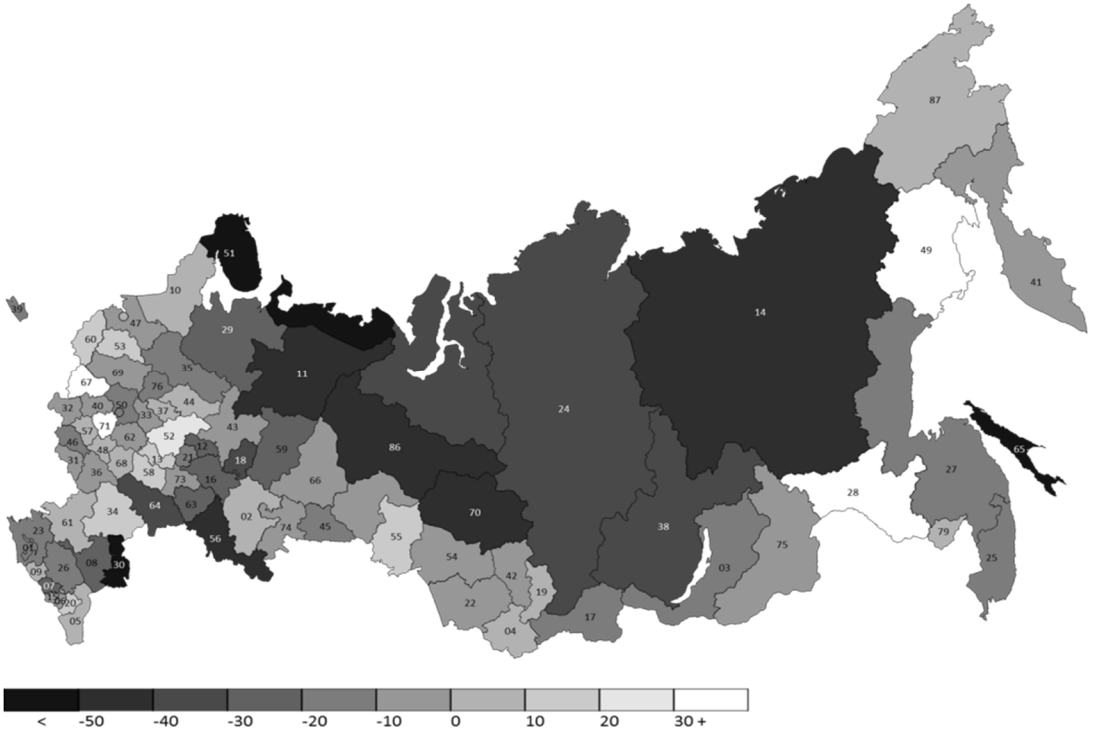
b) Choosing the order of p and q with help of the ACF and PACF

Figure 3. Actual and forecast tax revenues in RF before and during the 2020 pandemic (billion roubles)



Source: author's own calculations based on data from FTSRF.

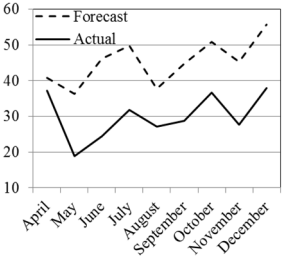
Figure 4. Change in the tax revenue of Russian regions during the 2020 pandemic (%)



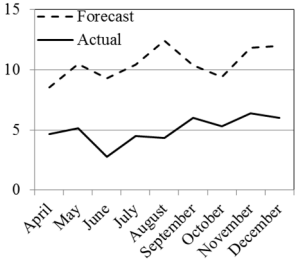
Note: Regions are designated according to their administrative codes

Source: author's own calculations based on data from FTSRF.

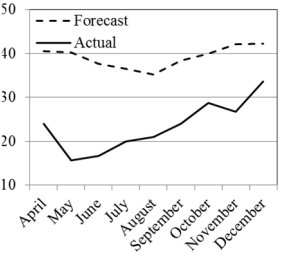
Figure 5. Actual and forecast tax revenues in some mining Russian regions during the 2020 pandemic (billion rubles)



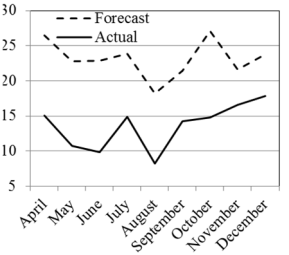
a) Irkutsk region (code 38)



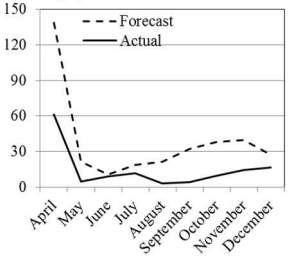
b) Nenets Autonomous Okrug (83)



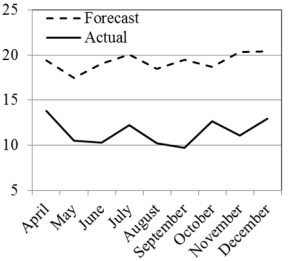
c) Orenburg region (56)



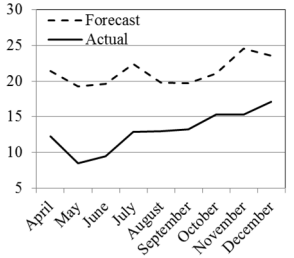
d) Komi Republic (11)



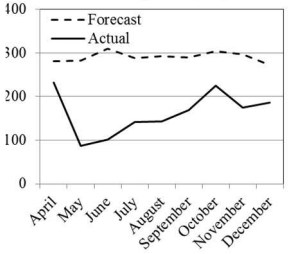
e) Sakhalin region (65)



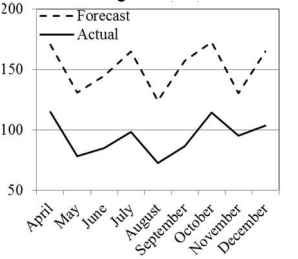
f) Tomsk region (70)



g) Udmurt republic (18)



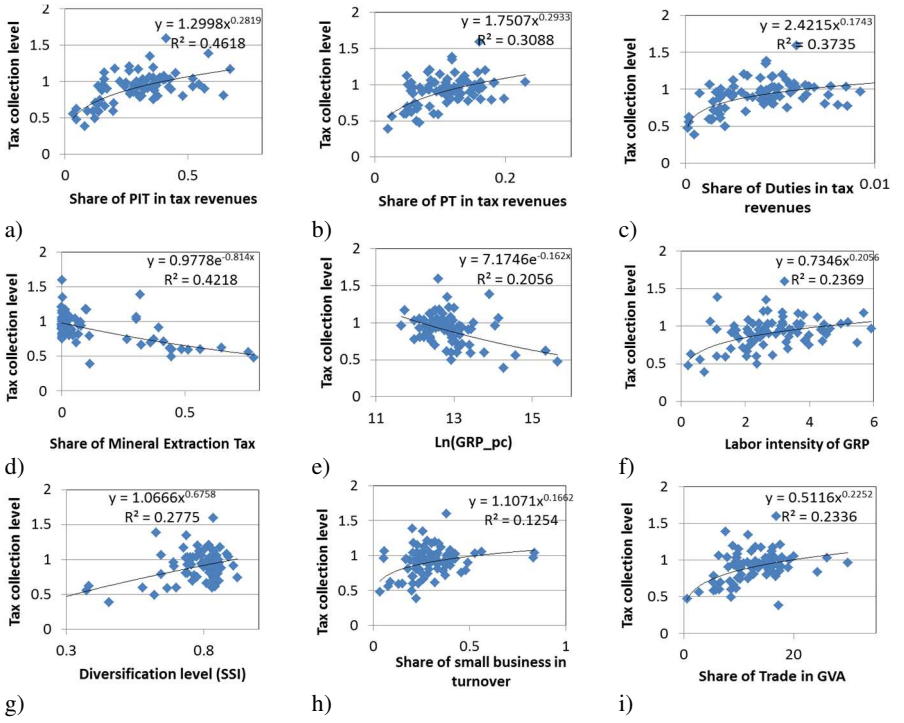
h) Khanty-Mansi Autonomous Okrug - Ugra (86)



i) Yamalo-Nenets Autonomous Okrug (89)

Source: author's own calculations based on data from FTSRF.

Figure 6. Some relationships between tax revenue level during the 2020 pandemic and characteristics of regional tax systems



Note. Abnormal values of the Amur and Magadan regions are excluded as outliers.

Source: author's own calculations based on data from FTSRF.