

Original Paper



<https://doi.org/10.15826/jtr.2022.8.3.120>

Stress Index of the Tax System of the Russian Federation in Terms of Tax Revenues

Marina Yu. Malkina¹  , Rodion V. Balakin^{1,2} 

¹ Lobachevsky State University of Nizhni Novgorod, Nizhni Novgorod, Russian Federation

² Research Financial Institute, of the Ministry of Finance of the Russian Federation,
Moscow, Russian Federation

 mmuri@yandex.ru

ABSTRACT

Economic systems are increasingly exposed to external shocks of various nature, which test their resilience. The tax system, which is directly linked to the level of business activity, is one of the first to experience stress, so the ways it reacts to shock are of particular research interest. The 2020–2021 coronavirus pandemic made such studies more acute. The purpose of the paper is to develop and test new approaches in studying the resilience of the tax system in terms of tax revenues by analyzing the dynamics and structure of the tax system stress index in the Russian Federation in pre-pandemic, pandemic and recovery periods. The tax system stress index for tax revenues is calculated as the difference between the moving standard deviation and the moving average growth rate of tax revenues. We have developed a method for decomposing the stress index by source with determining the contribution of each tax to the average growth rate and to the standard deviation of the growth rate. We have also calculated the Russian Federation tax revenue stress index from December 2015 to March 2022 and identified its sources. It was found that the stress indices for almost all taxes (except for excises and state duties) are significantly positively correlated with each other. The main contribution to the growth of the stress index during the crisis and its decline within the recovery period is made by profit tax and a group of taxes on natural rent, which significantly negatively correlate with oil prices. Under the pandemic crisis in Russia, the stress index on revenue form special tax regimes also increased significantly. It was found that the personal income tax has a stabilizing effect on the tax system stress index in the crisis and post-crisis periods. During the pandemic in Russia, the damping role of excises also came to the fore, which is explained by institutional factors and changes in tax rates. The research findings can be advantageous for the authorities to make an impact on the most vulnerable components of the tax system of the Russian Federation in order to increase its resilience to crises.

KEYWORDS

tax system of the Russian Federation, taxes, tax revenues, growth rates, standard deviation, stability, stress index, decomposition

JEL H2, E3

УДК 336.2

Индекс стресса налоговой системы Российской Федерации по налоговым доходам

М.Ю. Малкина¹  , Р.В. Балакин^{1,2} 

¹ Нижегородский государственный университет им. Н.И. Лобачевского, г. Нижний Новгород, Российская Федерация

² Научно-исследовательский финансовый институт Министерства финансов РФ, г. Москва, Российская Федерация

 mmuri@yandex.ru

АННОТАЦИЯ

Экономические системы все чаще подвергаются воздействию внешних шоков разной природы, испытывающих их устойчивость. Налоговая система, непосредственно связанная с уровнем деловой активности, одна из первых испытывает стресс, поэтому ее реакции на шок представляют особый исследовательский интерес. Пандемия коронавируса 2020–2021 актуализировала подобные исследования. **Целью** статьи является разработка и апробирование новых подходов к исследованию устойчивости налоговой системы по налоговым доходам посредством анализа динамики и структуры индекса стресса налоговой системы в РФ в допандемическом, пандемическом и восстановительном периодах. Индекс стресса налоговой системы по налоговым доходам рассчитывается как разница скользящего стандартного отклонения и среднего темпа прироста налоговых поступлений. Разработана методика декомпозиции индекса стресса по источникам с выделением вклада каждого налога в средний темп прироста и в стандартное отклонение темпа прироста. Оценена динамика индекса стресса налоговых доходов РФ и выявлены его источники в период с декабря 2015 г. по март 2022 г. Установлено, что индексы стресса практически по всем налогам (кроме акцизов и государственной пошлины) значимо положительно коррелируют друг с другом. Основной вклад в рост индекса стресса во время кризиса и его снижение в восстановительный период вносят налог на прибыль и группа налогов на природную ренту, которые существенно коррелируют с ценами на нефть. Во время кризиса пандемии в России также сильно увеличился индекс стресса поступлений по специальным налоговым режимам. Обнаружено, что налог на доходы физических лиц оказывает стабилизирующее влияние на уровень индекса стресса в кризисный и посткризисный периоды. В период пандемии в России также проявилась демпфирующая роль акцизов, что объясняется институциональными факторами и изменением ставок налога. Полученные результаты могут быть полезными органам управления для воздействия на наиболее уязвимые составляющие налоговой системы РФ с целью повышения её устойчивости в периоды кризисов.

КЛЮЧЕВЫЕ СЛОВА

налоговая система РФ, налоги, налоговые доходы, темпы прироста, стандартное отклонение, устойчивость, индекс стресса, декомпозиция

1. Introduction

The tax system is an important part of the country's economic system, and its state is directly related to the processes in both the real and financial sectors of the economy. It sensitively and most promptly responds to economic crises and shocks of various nature (pandemic, environmental, sanctions, and others). State tax

revenues fit into modern business cycles and have some degree of procyclicality, which destabilizes the tax system overall. The procyclicality of tax revenues can be prevented by the rules of the tax system, the ones that concern rates, exemptions, base calculation, tax benefits, deferrals, credits, etc., which are either designed as automatic stabilizers or discretely adjust

in a cycle. On such occasions, tax revenues are less responsive to business cycles and shocks in the economy, making the tax system more resilient.

In turn, the resilience of the tax system to global crises and external shocks is also important for the resilience of the economic system as a whole. It contributes to the smooth financing of the public sector, which affects the stability of the provision of public goods to the population (Shon & Kwak [1]) and mitigation of fluctuations in business activity in the country (Fricke & Süßmuth [2]). The stability of tax revenues has an impact on aggregate demand and aggregate supply in the country. It is particularly important to study the reaction of the tax system to the economic crises and external shocks and to identify the sources of its resilience with the aim of managing state tax revenues in conditions of increased turbulence.

The correct measurement of the degree or level of tax revenues resilience plays an important role in their managing. One approach to such measurement, often used to analyse financial systems, is to determine their stress level.

The stress of the tax system is a state of its increased reaction to various adverse external and internal influence factors that destabilize the system and hamper its stable functioning. The tax system stress depends not only on macroeconomic processes in the country, but also on changes in the tax behaviour and tax culture of economic agents, as well as in the institutional environment, etc.

However, in most cases, the stress is ultimately expressed either in a change in the system revenue, or in an increase in its uncertainty or risk.

In our study, we adhere to the point of view that the lower the growth rate of tax revenues (the greater the loss in tax revenues) and the higher its volatility (uncertainty of tax revenues), the higher the stress of the tax system is. To do this, we use the methodology for determining the level of system stress previously proposed by Malkina & Ovcharov for other systems [3] and adapt it to the tax system. Assessment of the Russian tax system stress

in dynamics makes it possible to establish its connection with pre-crisis, crisis and recovery processes in the Russian economy.

To understand the nature of stress in the tax system, it is important to identify both its external factors, for example, changes in oil prices, economic growth or inflation, and internal sources. In this study, we do not touch upon the former issue, leaving it for a separate study. We are interested in internal sources of stress, its decomposition into individual taxes, tax groups and duties. Based on our understanding of the tax system stress in terms of tax revenues, it is important to separate contribution of each source to tax revenue growth rate and its volatility. According to the portfolio approach (developed by Markowitz [4], Sharpe [5], and applied to the tax system by Seegert [6]), the risk of a “tax portfolio” depends on its structure, the risk of each tax, and correlations of various taxes revenues with each other. The suggested additive decomposition of the tax revenue growth rate and its standard deviation by source (individual taxes and tax groups) captures the combined influence of these factors.

The purpose of the paper is to develop and test new approaches to the study of the resilience of the tax system in terms of tax revenues by analysing the dynamics and structure of the tax system stress index in the Russian Federation in the pre-pandemic, pandemic and recovery periods.

The hypothesis of the study is to confirm the existence of the drivers and dampeners of tax system stress in terms of tax revenues, which makes it possible to manage the resilience of tax revenues in the cycle and during unpredictable external shocks. This enables regulators to find the most vulnerable spots in the tax system, create more flexible tax and budgetary rules that allow to form state reserves and redistribute stress in time, space or between the levels of the budget system.

Further research follows way. The Literature Review section examines the various authors’ approaches to the analysis of economic and tax systems resilience, particularly in the context of the current

pandemic crisis, to measuring the stress of the financial system, and discusses the results of their use. The Data and Research Methodology section expands on the sources of information, describes in detail the author's methodology for assessing and decomposing the tax system stress index by tax revenues. The Results section reports the calculated and decomposed tax system stress indices by tax revenues in the Russian Federation for the period from 2015 to March 2022, and explains their dynamics in the pre-pandemic, pandemic and recovery periods. In the Discussion section, the research findings are analysed and compared with the results previously obtained by various authors, including us, and the limitations of the study and the prospects for its further development are revealed. The Conclusion section summarizes the results and main implications of the study.

2. Literature review

An analysis of the resilience of economic systems to external and internal shocks is of particular relevance during periods of crisis. Thus, such studies became increasingly widespread after the financial crisis of 2008–2010 (e.g. Martin et al. [7] and Xiao et al. [8]). The economic crisis caused by the spread of coronavirus infection in 2020–2021 was no exception. Researchers studying the stress resistance of economic systems are interested in general and specific manifestations of crisis phenomena in the economy under the influence of shocks of various nature (financial, epidemiological, sanctions, etc.).

Goswami et al. [9] and Devereux et al. [10] study the factors affecting the degree of response of various economies to the crisis and the speed of their subsequent recovery.

Pietro et al. [11] examine the resilience of the European Union countries and regions (the so-called NUTS) to three recessionary shocks, each of which activated different economic adjustments and mechanisms. Using a spatial general equilibrium model, this paper measures the vulnerability, resistance and resilience of European economies and identi-

fies key features that affect their ability to withstand and recover from unexpected external shocks. As a result, it was established that the reactions of different economies vary depending on the nature of the external shock, their pre-crisis characteristics, as well as the mobility of production factors.

Brada et al. [12] assess economic resilience as the system ability to absorb and recover from economic shocks. The authors examine 199 regions of Central and Eastern Europe after the 2008 global financial crisis. They find evidence of strong positive spatial effects leading to the formation of high-efficiency and low-efficiency clusters. Analysing the experience of regional recovery after the 2008 financial crisis, the authors modelled the impact of the COVID-19 pandemic on the regions' ability to return to pre-crisis employment levels.

Lagravinese et al. [13] study the impact of business cycles on the so-called buoyancy of tax revenues and how to manage it.

Based on a panel sample of 146 countries for 1981–2016, Ngangnon [14] shows that the instability of tax revenues negatively affects the share of non-resource taxes, but this influence decreases as GDP per capita grows.

The works devoted to the resilience of financial systems during the 2020–2021 pandemic are of particular interest. They examine the impact of the coronavirus crisis on macroeconomic, financial performance and tax revenues in various countries: Indonesia (Zamzam et al. [15]); Nigeria (Adesola & Owoniya [16]), Czech Republic (Koziel [17]), Azerbaijan (Suleymanzade [18]).

Shipalana & O'Riordan [19] explore the impact of the 2020 pandemic on financial stability in Africa. Experts estimate that the pandemic could have caused Africa to lose up to 20–30% of its fiscal revenues, which would have resulted in a number of African countries being unable to service their debt or even defaulting, which, combined with the decline in local currencies, could have caused a deep depression on the continent.

Based on a mixed-frequency data and using several machine learning techniques, Lahiri & Yang [20] predicted New York State tax revenues. Their estimates showed a sharp, over 16%, year-over-year decline in actual tax revenues in May 2020, followed by several upward revisions to the forecast. The projected recovery in tax revenue to -1% in March 2021 came close to the actual annual value of -1.6%.

A number of authors note that tax revenues during the pandemic were influenced not only by the crises per se, but also by policies to counteract them, including a package of tax breaks and exemptions.

Cheng [21], using the Malaysian economy as an example, proposes an expanded two-phase package of fiscal measures to support people and businesses during the pandemic and to overcome its consequences.

Corrick et al. [22] provide an overview of the consequences of the 2020 pandemic for the mining industry and evaluate the efficiency of various tax incentives. They have developed short-term tax policy options (including the ones for small and medium-sized enterprises in the industry) and described measures to be avoided.

Klimanov et al. [23] analyse how the COVID-19 pandemic affected regional budgets and the fiscal resilience of the regions of the Russian Federation. First, the authors analyse the state of Russian regional budgets before and under COVID-19 conditions. Second, they examine the growth in the regional debt dependence attributable to their increased spending commitments amid the pandemic. Third, the authors discuss anti-crisis fiscal measures that have been taken to combat the negative impact of COVID-19. They show that the economic crisis of 2020 is ambivalent for Russia because the pandemic in its acute phase was accompanied by a collapse in oil prices. The authors also estimated the volume of shortfalls in regional budget revenues in the first year of the pandemic.

Malkina [24; 25] investigated the impact of the 2020 pandemic on the budget revenues of Russian regions from different

taxes. The researcher based on the forecasting of non-pandemic trends concludes that the pandemic led to the loss of 13.9% of total tax revenues in the Russian Federation and 6.2% of tax revenues of regional budgets. Extractive regions were the hardest hit by the pandemic, because the largest contribution to the decline in tax revenues of the consolidated and federal budgets was made by the mineral extraction tax, the revenues on which fell sharply due to the decline in oil and gas revenues. The author also substantiates that the equalizing function of the Russian tax distribution system manifested itself in the formation of regional budgets revenues.

Kakaulina [26] forecasts the reduction in personal income tax revenues to the consolidated budgets of the constituent entities of the Russian Federation in 2020–2023 due to the COVID-19 pandemic. The author identifies three factors for forecasting the reduction in tax revenues: the amount of damage caused by the COVID-19 pandemic to the economic system as a whole; the sensitivity of the revenue base to the crisis; the sensitivity of regional tax revenues to changes in the revenue base.

Lykova [27] emphasizes the growth of excise tax revenues in Russian Federation under the conditions of the pandemic and the economic crisis caused by it. The author notes that the increase in the tax rates for some categories of excisable goods combined with the increase in the share of tax deductions to the regional budgets led to the growth of excise revenues in the regional budgets in 2020 by 6.5%, or 35.9 billion roubles. The author comes to the conclusion that the regions, which are generally considered to be quite prosperous and stable, show relatively less tax stability during the current economic crisis. In addition, the most economically active regions, which are highly dependent on their own tax revenues and the global economic situation, experience significantly greater difficulties than passive regions that rely on federal transfers.

Pinskaya et al. [28] note that the sustainability of the Russian tax system during the pandemic is also influenced by

the system of support measures for the population and businesses and the change in fiscal rules during the coronavirus crisis.

Pogorletskiy & Söllner [29] argue that pandemic crises per se cause significant changes in the rules of tax policy. These changes have long-term implications for the tax system.

A number of studies are devoted to the development and analysis of stress indicators for the economy in general or tax revenues in particular.

Shon & Kwak [1] conducted a comprehensive analysis of methods and models for quantitative assessment of financial instability of economic systems based on financial stress indices applied in the modern literature. The authors summarize the indicators of financial instability, show their relationship to stress tests, and analyse the vulnerability of economic systems to shocks of different nature.

Szendrei & Varga [30] propose a new stress indicator, the Factor-based Index of Systemic Stress, FISS. This index is based on the determination of the main components of the indicators characterizing the financial system. As a result, the authors conclude that the FISS should be a key element of the macroprudential toolkit for the Hungarian economy.

Stress indices are also used at the micro level to assess the financial resilience of business entities.

Atkeson et al. [31] examine the distribution of financial soundness among a wide range of companies over most of the last century (from 1926 to 2012).

Malkina & Balakin [32; 33] assess the risks of the Russian tax system. The authors understand the instability of the tax system as the degree of its reaction to changing macroeconomic factors within the economic cycle. They conclude that minimizing the negative impact of external shocks on the tax system is possible by changing its rules, managing the sectorial structure of the economy and increasing the degree of its diversification.

It is important to note that the macroeconomic stress indices used in the literature mostly concern the analysis of financial markets or the state of the banking system

and are almost never used for the analysis of tax revenues. In the present study, applying and adapting the methodology [1], we propose for the first time the stress index of the tax system in terms of tax revenues (tax system stress index). Using it, we analyse the dynamics of the stress of total tax revenues and revenues from individual taxes to the consolidated budgets of the constituent entities of the Russian Federation (regional budgets) in the context of changes in the macroeconomic situation, development of crisis and economic recovery during the coronavirus pandemic. We also carry out the decomposition of stress index by source, which allows us to identify taxes and tax groups that are amplifiers and dampeners of the tax system stress in the pandemic conditions.

3. Data and research methodology

This study is based on the data retrieved from the statistical reporting form 1-NM of the Federal Tax Service of the Russian Federation (FTS RF)¹. We used information on tax revenues in general and on individual taxes (tax groups) in monthly terms for the period from January 2013 to March 2022. The data is presented in terms of five taxes and duties administered by the FTS RF:

- 1) corporate income (profit) tax;
- 2) personal income tax;
- 3) value added tax;
- 4) excise taxes;
- 5) state duty;

as well as two consolidated groups of taxes:

6) natural taxes (mineral extraction tax, regular payments for the extraction of minerals (royalties) when implementing production sharing agreements; water tax; fees for the use of fauna objects and for the use of objects of aquatic biological resources). The main contribution in this group belongs to the mineral extraction tax;

7) property taxes (personal property tax, corporate property tax, transport

¹ Report on the accrual and receipt of tax revenues, fees, insurance premiums and other obligatory payments to the budget system of the Russian Federation. URL: https://www.nalog.gov.ru/rn77/related_activities/statistics_and_analytics/forms/

tax, gambling tax, land tax and property tax levied on real estate property located within the boundaries of the cities of Veliky Novgorod and Tver).

In order to exclude the influence of seasonality and different frequency of tax payments, we calculated the moving annual values of tax revenues with a one-month shift. First, we computed the annual revenues from January 2013 to December 2013 on an accrual basis, then the annual revenues from February 2013 to January 2014, and so on: each new value was determined with a shift of one month and covered 12 adjacent months. Thus, we obtained a smoothed series of annual tax revenues. Accordingly, the growth rate of annual tax revenues was determined with a lag of 12 months and a step of 1 month. The first value was calculated for December 2014 and represented the relative increase in tax revenues in 2014 compared to 2013; the last growth rate was determined for March 2022.

Below is the methodology for calculating the tax system stress index:

1. The moving growth rate of annual tax revenue from the *k*-tax (t_{kj}) or from all taxes (t_j) referring to the *j*-month, calculated with a one-month shift:

$$t_{kj} = \frac{T_{kj}}{T_{kj-12}} - 1 \quad \text{or} \quad t_j = \frac{T_j}{T_{j-12}} - 1, \quad (1)$$

where

$$T_{kj} = \sum_{j=J-11}^j T_{kj} \quad \text{and} \quad T_j = \sum_{j=J-11}^j T_j -$$

the amount of revenues, respectively, from the *k*-tax and all taxes for 12 consecutive months, ending with *J*-month;

$$T_{kj-12} = \sum_{j=J-23}^{J-12} T_{kj} \quad \text{and} \quad T_{j-12} = \sum_{j=J-23}^{J-12} T_j -$$

the amount of revenues, respectively, from the *k*-tax and all taxes for 12 consecutive months, ending with *J*-12-month;

2. Moving average growth rate for 12 consecutive months, ending with *J*- month:

$$\tau_{kj} = \frac{\sum_{j=j-11}^j t_{kj}}{12} \quad \text{or} \quad \tau_j = \frac{\sum_{j=j-11}^j t_j}{12}. \quad (2)$$

3. The moving standard deviation of the tax revenue growth rate for 12 consecutive months ending with *J*-month:

$$\sigma_{kj} = \sqrt{\frac{\sum_{j=j-11}^j (t_{kj} - \tau_{kj})^2}{12}} \quad (3)$$

$$\text{or} \quad \sigma_j = \sqrt{\frac{\sum_{j=j-11}^j (t_j - \tau_j)^2}{12}}.$$

4. Stress index of tax system in terms of tax revenues:

$$SI_{kj} = \sigma_{kj} - \tau_{kj} \quad \text{or} \quad SI_j = \sigma_j - \tau_j. \quad (4)$$

Lower growth rates of tax revenue reduce the budget system provision and limit the available resources for financing public goods and national projects. Higher volatility of these rates increases the uncertainty of budget revenues and characterizes a quantitative measure of their risk. According to our approach, both factors increase the stress of tax system in terms of tax revenues. In other words, the proposed stress index shows the risk of tax revenues adjusted for the measure of their growth. This index can be measured in fractions (points) or as a percentage. In our work we use the first approach.

5. Decomposition of tax system stress index by *k*-sources (taxes and tax groups).

5.1. Decomposition of the growth rate of total tax revenues by source:

$$t_j = \frac{T_j}{T_{j-12}} - 1 = \frac{\sum_{k=1}^K T_{kj}}{T_{j-12}} - 1 =$$

$$= \sum_{k=1}^K \frac{T_{kj}}{T_{kj-12}} \cdot \frac{T_{kj-12}}{T_{j-12}} - 1 = \quad (5)$$

$$= \sum_{k=1}^K (t_{kj} + 1) \cdot \alpha_{kj-12} - 1 = \sum_{k=1}^K t_{kj} \cdot \alpha_{kj-12},$$

where

$$\alpha_{kj-12} = \frac{T_{kj-12}}{T_{j-12}} -$$

share of *k*-tax (tax group) in total tax revenues a year ago, with

$$\sum_{k=1}^K \alpha_{kj-12} = 1.$$

Thus, the contribution of each tax to the growth rate of total tax revenues is defined as the product of its own growth rate and its share in tax revenues in the base period:

$$t_j(k) = t_{kj} \cdot \alpha_{kj-12}. \tag{6}$$

For the average growth rate, the same rule is followed as for the growth rate in a particular period (formula 5):

$$\tau_j = \frac{\sum_{j=11}^j \sum_{k=1}^K t_{kj} \cdot \alpha_{kj-12}}{12} = \sum_{k=1}^K \tau_{kj} \cdot \alpha_{kj-12}. \tag{7}$$

Accordingly, the contribution of each tax to the average growth rate of tax revenues is determined by the formula:

$$\tau_j(k) = \tau_{kj} \cdot \alpha_{kj-12}. \tag{8}$$

5.2. Decomposition of the standard deviation of the growth rate of total tax revenues by source:

$$\begin{aligned} \sigma_j &= \frac{\sigma_j^2}{\sigma_j} = \frac{Var(t_j)}{\sigma_j} = \\ &= \frac{CoVar\left(t_j; \sum_{k=1}^K t_{kj} \cdot \alpha_{kj-12}\right)}{\sigma_j} = \tag{9} \\ &= \frac{\sum_{k=1}^K CoVar(t_j; t_{kj} \cdot \alpha_{kj-12})}{\sigma_j}, \end{aligned}$$

where $Var(t_j) = CoVar(t_j; t_j)$ – variance, aka the covariance of the moving growth rates of tax revenues. After replacing t_j with the equation from formula (6) and applying the rule for sum covariance, we obtain an additive decomposition of the standard deviation of the growth rate by sources (taxes).

Then the contribution of each tax to the standard deviation of the growth rate of tax revenues is determined by the formula:

$$\sigma_j(k) = \frac{CoVar(t_j; t_{kj} \cdot \alpha_{kj-12})}{\sigma_j}. \tag{10}$$

In other words, it depends on the share of this tax in tax revenues in the base period and the relative covariance of its growth rate with the growth rates of other taxes.

5.3. Decomposition of the tax system stress index by source:

$$SI_j = \sigma_j - \tau_j = \sum_{k=1}^K (\sigma_j(k) - \tau_j(k)). \tag{11}$$

The application of this methodology made it possible to obtain time series of stress indices for tax revenues as a whole, as well as for individual taxes for the period from 2015 to March 2022 and to identify the impact of the crisis caused by the pandemic on the Russian tax system stress in terms of tax revenues. This methodology also allowed us to estimate the contribution of each tax to the change in the tax system stress index under the influence of external shocks and to answer the question of which taxes act as amplifiers and which dampeners of overall stress.

4. Results

First, we present the dynamics of the tax system stress index calculated according to formulas 1–4 for the total tax revenues in the country (Fig. 1). Then, in order to clarify its specific components, we separately consider the tax system stress indices on revenues from individual taxes (Fig. 2).

As can be seen from Figure 1, the tax system stress index was rising during the imposition of the 2015–2016 sanctions and the 2020–2021 pandemic crisis. This index begins to grow rapidly as early as June 2019, that is, long before the pandemic. It is noteworthy that, according to our methodology, the index for June 2019 reflects stress from July 2018 to June 2019. However, it did not exceed the zero threshold throughout the larger pre-pandemic study period (with the exception of a few cases in early 2017, which were due to crisis events in 2014–2016). In June 2020, the stress index again reached positive values and continued to rise until July 2021 (with a slight decrease in March 2021), reflecting the impact of the pandemic. During the recovery period it began to decrease, and by January–February 2022 the stress index returned to the negative zone.

The data on the tax system stress index for revenues from particular taxes (Fig. 2) allow us to draw several conclusions. First of all, stress indices for almost

all taxes (except excises and state duty) show a strong positive correlation. The highest correlation (with Pearson's correlation coefficient of 0.97) is demonstrated by the profit tax and the group of taxes on natural resource rents. For these taxes, as well as for the tax system as a whole, the increase in the stress index began as early as the second half of 2019 (namely, for the group of natural taxes in June 2019, for the profit tax in September 2019), that is, before the pandemic hit.

From June 2019 to August 2021, the stress index on revenues from the group of natural resources taxes increased by 0.82 points (which is the maximum value among all taxes), and on revenues from the profit tax by 0.39 points. In addition, for the group of natural taxes, there is the largest among all taxes negative relationship between the stress index and oil price with a lag of 6 months (their linear Pearson correlation coefficient is $R = -0.65$). This indicates a significant influence of the world oil market conditions on the state of the Russian tax system.

Close correlation of stress indices with each other (with Pearson's linear correlation coefficients from 0.7 to 0.9) is noted for profit tax, personal income tax, VAT, group of taxes on natural resource rent and special tax regimes. At the same level there is a correlation of the property taxes stress index with the profit tax stress index

and the stress index for the taxes on natural rent. All this indicates similar dynamics of stress indices for major taxes.

The increase in the stress index for the above tax revenues begins from March 2019 to March 2020, which is largely due to the changing global oil market conditions. Indeed, in November 2018, the average monthly price of Brent crude oil fell to \$54 per barrel, compared to \$83 in August 2018, which affected subsequent tax revenues. The stress index for property tax revenues began to rise earlier than for other tax revenues (as early as March 2019). It is also noteworthy that this index shows a medium strength relationship with stress indices for special tax regimes (0.65), personal income tax (0.50), and VAT (0.48).

For personal income tax and special tax regimes, as in the case of the previously mentioned natural resources taxes and profit tax, the growth of the stress index began in the second half of 2019 (for personal income tax in July 2019, for special regimes in October 2019). Later than others among the designated taxes there is a growth of the stress index for VAT revenue, which had its manifestation with the introduction of restrictions on mobility of the population and business activity of enterprises, i.e., since March 2020. This can be explained by the fact that due to its indirect nature, VAT is more related to economic activity and the formation of value added.

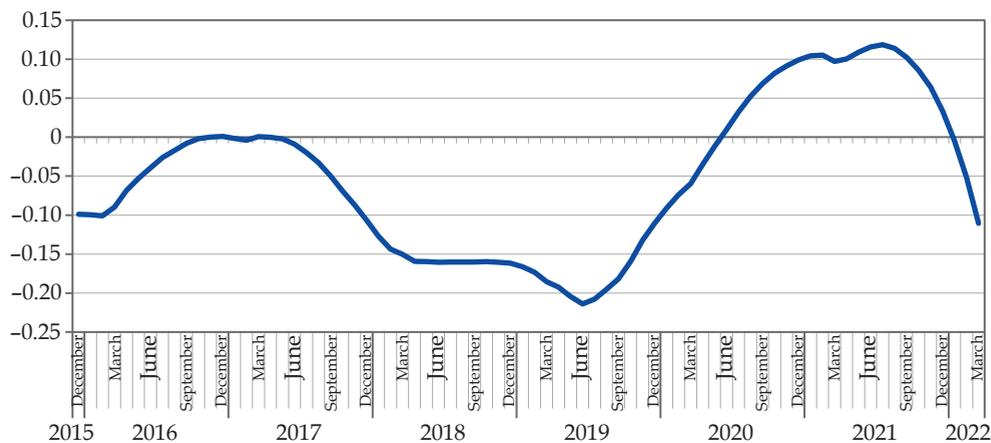


Figure 1. Russian tax system stress index for total tax revenues (points)

Source: authors' elaboration based on the data of the Federal Tax Service of the Russian Federation (hereinafter referred to as the FTS RF)

Special tax regimes show the second highest (after the group of natural resources taxes) increase in the stress index by 0.60 points (continuing from October 2019 to May 2021). This is explained by the fact that this group includes taxes from small businesses, which were at risk during the

pandemic (in particular, the service sector, where small businesses operating under simplified taxation schemes predominate, was affected). In addition, a package of stimulating fiscal measures was applied to small businesses, which also affected the revenues of the tax system and its stability.

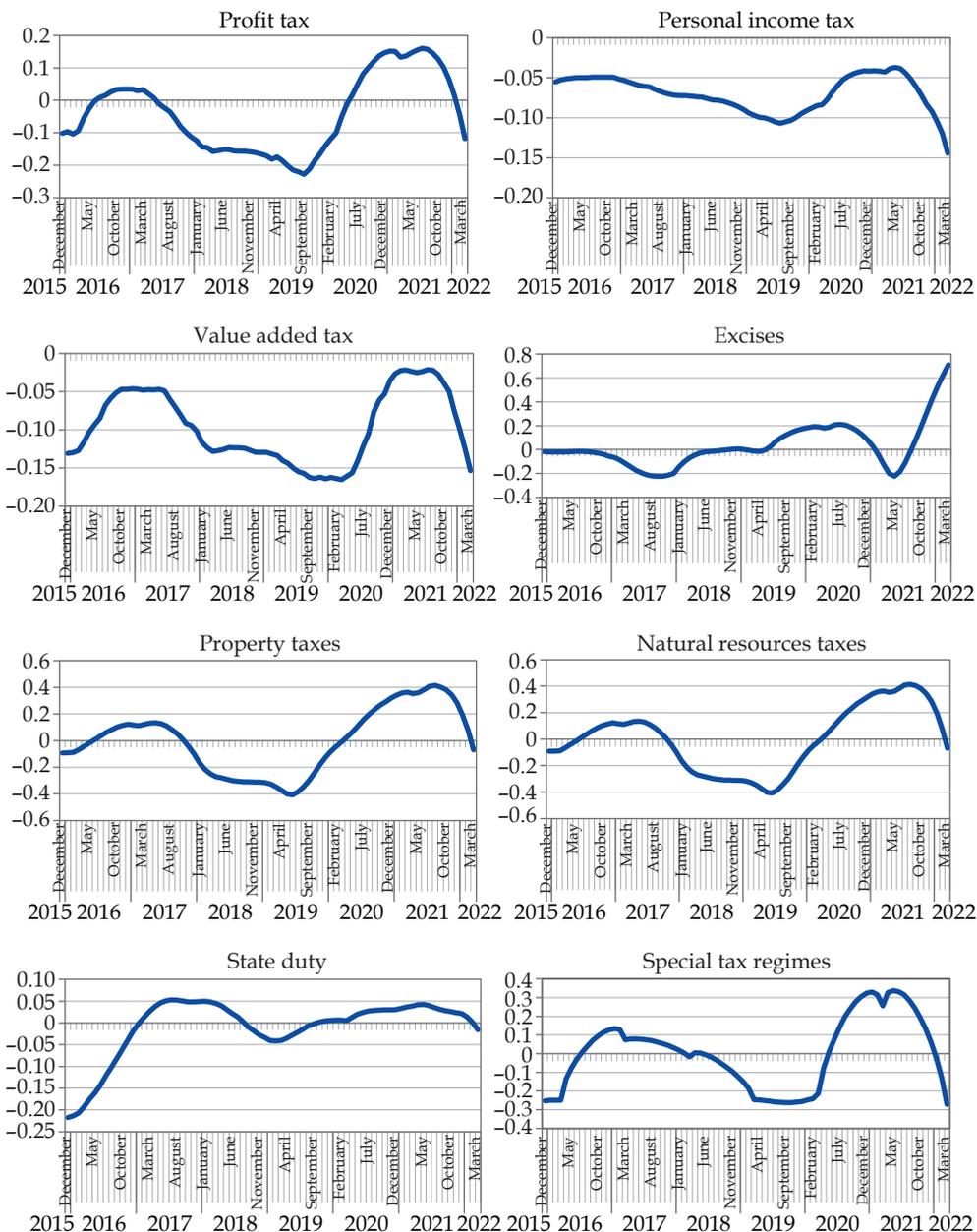


Figure 2. Russian tax system stress index for the revenues from individual taxes and duties (points)

Source: authors' elaboration on the basis of the FTS RF data

It should be noted that, on average, from March 2020 to February 2021 the revenues from special tax regimes decreased by 24%. Finally, a significant increase in the stress of tax revenues under special tax regimes can be explained by the fact that one of the special tax regimes applies to production sharing agreements. Specifically for the Sakhalin region, where this regime is applied, the growth of the stress index over the period under consideration amounted to 1.64 points, and the revenues in this region decreased by 81%.

For the property tax group, the stress index increase from March 2019 to December 2020 was 0.18 points. For VAT for the year from March 2020 to March 2021, the stress index rose by 0.14 points, which is lower than for total tax revenues (0.33 points), but higher than for personal income tax, property taxes, and state duties for the same period.

Among all taxes and tax groups, the personal income tax shows the smallest increase in the stress index: in virtually two years (from July 2019 to May 2021) the stress increased by only 0.07 points.

An important feature of all the taxes analyzed above is that at the end of the study they had already passed the maximum point of the stress index, therefore, there is certain correction in the dynamics of these taxes. The group of property taxes demonstrates the decrease in the stress index first among all the taxes. The decrease in the stress index for this group began as early as December 2020, mainly due to an increase in the growth rate of revenues, which is explained by the low base effect. Indeed, in the second quarter of 2020 (from April 1 to June 30, 2020), certain categories of taxpayers working in pandemic-stricken sectors of the Russian economy, as well as socially oriented non-profit and religious organizations, were exempted from paying property taxes and advance payments.

In accordance with the list of the Government of the Russian Federation, such industries include transport, activities in the field of culture, leisure and entertainment, fitness and sports, travel agencies and other organizations providing servi-

ces in tourism, hospitality, catering, organizations of additional education, non-governmental educational institutions, the organization of conferences and exhibitions, the provision of household services to the public (repairs, laundry, dry cleaning, hairdressing and beauty salon services), activities in health care, retail trade in non-food products, media and printing production.

For VAT the reduction of the stress index began in March 2021, and for personal income tax and special tax regimes in May 2021. The maximum decrease in the stress index is demonstrated by special tax regimes: from May 2021 to February 2022, their stress index decreased by 0.46 points (while during the crisis it increased by 0.6 points). For natural resource rent taxes, the stress index decreased by 0.34 points from August 2021; for profit tax, it decreased by 0.2 points from July 2021 to the end of the period under review. For other taxes, the decrease is no more than 0.1 points. It should be also noted that profit tax, property tax and special tax regimes returned to the zone of negative stress index, while the stress index for VAT and personal income tax did not reach positive values even during the pandemic.

There is no close correlation between the stress indices on revenues from excise taxes and state duty and the stress indices on revenues from other taxes. It is only evident the average degree of correlation of the stress index on revenues from state duties with the stress indices on revenues from special tax regimes (0.51) and property taxes (0.47).

At the same time, state duties and excise taxes show a rather interesting stress index trajectory. The stress index for excise revenues begins to rise in September 2017, and with a slight adjustment in early 2019, its growth continues until July 2020. The stress index then goes rapidly downward and by May 2021 reaches its low point, down 0.43 points in 10 months. In other words, the previous period's (April 2019 July 2020) increase of 0.23 points in the excise tax revenue stress index was almost halved by its subsequent decline.

Thus, excises turned out to be the only tax that demonstrated a decrease in the stress index during the pandemic. This is partly explained by a rather active policy of the Russian Government regarding excise taxes: from 2020 fuel tax rates were raised, tobacco rates were increased by 20% (in addition, any electronic cigarettes and tobacco heating devices became excisable). But then the stress index began to skyrocket: from May 2021 to February 2022, it rose by 0.85 points, and by the time the study ended (March 2022) the stress index on excise tax revenues was the highest of all other taxes.

The state duty shows an increase in the stress index since the beginning of the study (December 2015). The stress index reaches its maximum in July 2017, then decreases until February 2019 and then increases again by 0.08 points until May 2021. A further decrease in the stress index (from June 2021 to February 2022) allows its previous increase to be offset by half (-0.04 points). However, on the whole, at the end of the period under study the stress index on state duty revenues appears to be 0.22 points higher than the

initial level. Such dynamics of the stress index can be explained by the impact of institutional changes (introduction of new tariffs of duties) and less direct linkage of the duty with economic processes.

According to the portfolio approach, the tax system stress index as a whole depends on the stress indices of each tax, on the structure of tax revenues (the share in them of individual taxes) and the relationship between the revenue growth rates for different taxes (or rather, the correlation of stress indices on individual taxes or tax groups). The developed methodology of decomposition of the tax system stress index (formulas 5–11) allows us to capture the joint influence of all these factors.

Figures 3 and 4 present a dynamic decomposition of the tax system stress index separately for the two stress components: the growth rate of tax revenues and their standard deviation. Figure 5 combines the results of the decomposition of the tax system stress index on tax revenues by source. In addition, Figure 6 shows the average structure of the stress index during periods of negative and positive values of the overall stress index.

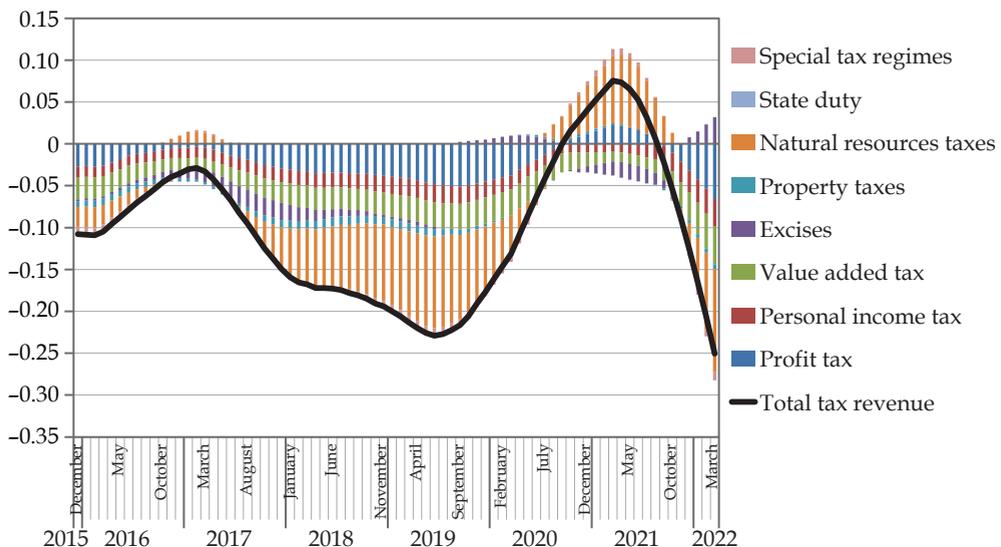


Figure 3. Source decomposition of the tax revenue growth rate of the Russian tax system stress index (points)

Source: author’s elaboration based on the data of the FTS RF

Note. Since the growth rate of tax revenues reduces risk, their components are taken with the opposite sign

The figures show that during the period of economic recovery and stress reduction, the profit tax, VAT and the group of natural resources taxes grow at the highest rate. For example, from June 2017 to June 2020, total tax revenues rose by 34 percent, with VAT revenues up 48 per-

cent, the natural resources tax group up 42 percent, and profit tax revenues up 40 percent. In other words, these three out of the four most productive tax revenues (that is, excluding the personal income tax) increased at a faster rate than the total tax revenues.

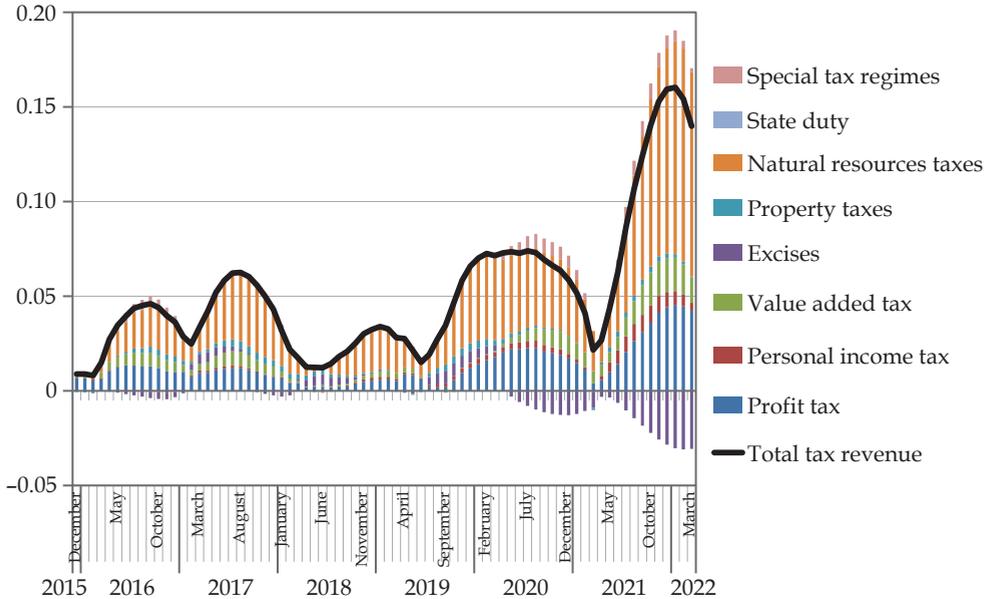


Figure 4. Source decomposition of the standard deviation of the tax revenue growth rate of the Russian tax system stress index (points)

Source: author’s elaboration based on the data of the FTS RF

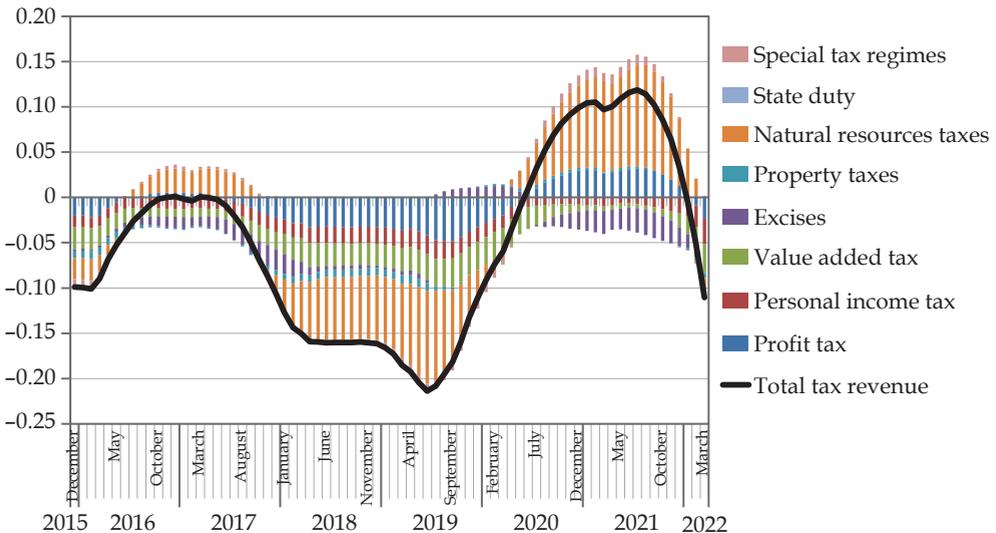


Figure 5. General decomposition of the Russian tax system stress index in terms of tax revenues by source (points)

Source: author’s elaboration based on the data of the FTS RF

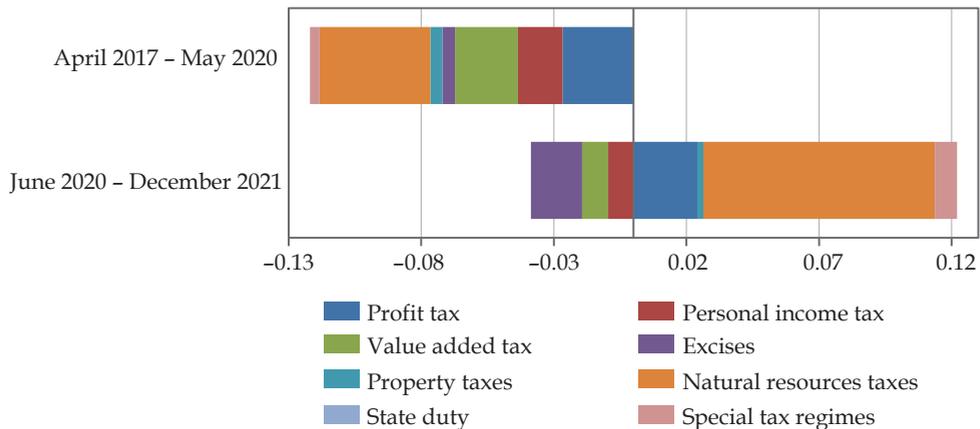


Figure 6. The average structure of the Russian tax system stress index in the periods of its negative and positive values (points)

Source: author's elaboration based on the data of the FTS RF

The same conclusion is confirmed by the data on the correlation coefficient for the growth rate of total tax revenues and specific taxes: the profit tax and the group of natural resources taxes show a correlation coefficient with total revenues at the level of $R=0.97$, VAT - at the level of 0.85. However, we should note that the other taxes also demonstrate high correlation coefficients: special tax regimes - at the level of 0.82, personal income tax - 0.77, excises - 0.71, property taxes - 0.68. The only tax, which growth rate weakly correlates with the growth rate of total tax revenues - the state duty ($R=0.14$).

It should be noted that during an economic downturn, stress also grows mainly due to natural resources taxes and profit tax. Revenues from them decrease, and their volatility increases at a faster rate (it is worth reminding that, along with special tax regimes, profit tax and natural resources taxes during the crisis show the maximum growth of the stress index).

During the coronavirus crisis, the dampening role of excises unexpectedly manifested itself. Institutional (changes in excise rates for various goods) and structural factors played an important role in this. Thus, in July 2020, when the stress index went into positive zone and excise taxes went into negative zone, 32% of excise revenues came from tobacco products,

22% from motor gasoline, 17% from diesel fuel, 10% from spirits, 9% from beer, and 8% from petroleum raw materials.

A year later, in July 2021, with total revenues from excise taxes at about 600bn rubles, almost 500bn rubles of returns were on excise taxes on crude oil, i.e. in their absence the revenues from excise taxes could have been twice as much. In January 2022, when the stress index returned to the positive zone, the negative revenues from excise taxes on crude oil were already 4.73 times higher than the total revenues from excise taxes. This situation is explained by the fact that an additional investment surcharge on the excise tax on petroleum crude was imposed for 10 years beginning in 2021, which increased the amount of the reverse excise tax introduced in 2019².

It should also be noted that the personal income tax almost always, regardless of the study period, plays a weak damping role. This is due to the most stable growth rates of revenues from this tax. Indeed, the standard deviation of the growth rate of personal income tax is the lowest among all the taxes and tax groups under consideration. And it is 3.35 times less than the standard deviation of the growth rate of total tax revenues.

² <https://www.interfax.ru/business/793221>

5. Discussion

The study confirms the earlier hypothesis that certain taxes play the role of amplifiers or dampers of tax revenue stress on the tax system of the Russian Federation. We have obtained convincing evidence that the stress enhancers in the Russian tax system are the mineral extraction tax and the profit tax, and to add to the above, in the pandemic conditions special tax regimes because of the greater vulnerability to the Covid19-related crisis of small business.

The main stress damper is the personal income tax. The changes of the institutional conditions impact significantly the stress of the tax system on revenues from specific taxes, often redistributing it over time.

This was demonstrated by property taxes, for which a number of exemptions were introduced during the pandemic, and excise taxes, which experienced rate changes and refunds during the pandemic and recovery periods.

Indeed, among all the taxes, the maximum values of the stress index growth during the pandemic are demonstrated by the group of natural resources taxes (+0.29 p.p. in just four months from March to June 2020), followed by special tax regimes and profit tax (+0.12 p.p. over the same period). Stress for VAT and property taxes is comparable with the stress on total tax revenues. Stress on personal income tax is lower than for the whole tax system. Besides, personal income tax is the only tax for which the stress index at the end of the period under consideration turned out to be lower than at the beginning.

Decomposition of the tax system stress by tax revenues from different sources presented even more convincing evidence that mineral extraction tax and profit tax in Russia can be regarded as amplifiers of the overall tax system stress (their contribution to the overall tax system stress during its growth period was +105.7% and +29.1% respectively), and personal income tax as a stress damper (its contribution was -11.5%).

The conclusion about the greater stress on tax revenues from the mineral

extraction tax and profit tax largely correlates with the conclusions obtained earlier in our study of the risk of the Russian tax system [34] using alternative methods.

The new study differs from the previous one in several ways.

First, it uses moving annual tax revenues rather than monthly data, which eliminates the effects of seasonality and frequency of tax payments.

Second, it deals with the growth rate of tax revenues as a baseline, rather than the return on individual taxes as the ratio of tax revenues to gross domestic product or regional gross value added.

Third, it is a dynamic rather than a static approach applied, which allows us to track the stress of the tax system over time and further incorporate the stress index into other models.

Fourth, we apply a different method to account for the trade-off between return and risk of tax revenues. Usually for this purpose coefficients of variation are used as the ratio of risk and return [1; 6; 14; 34], while we take the difference between risk and return, which is closer to the representation of the Arrow-Pratt-type portfolio utility functions.

It is noteworthy that the change in the stress index of the tax system for different taxes occurs at different times, although it describes similar dynamics. Thus, for most taxes, the increase in the stress index occurs during the 2015–2016 sanctions shock, then the stress index decreases, and its growth resumes in 2019–2020 (the exception is excise taxes, for which the increase in stress index began later). First, stress increases for property taxes, then for a group of natural resources taxes and personal income tax, and then for profit tax and special tax regimes.

One of the significant factors of the leading dynamics of the tax system stress on the revenues from most taxes was the decline in world oil prices. Therefore, it is impossible to state unequivocally that the pandemic was the only reason for the growth of tax stress in the period under consideration. However, it was definitely an important reason for its subsequent growth. Later than others (in March 2020)

the VAT stress index began to grow. In this case we can speak more confidently about the pandemic as a cause of tax system stress.

Our study did not seek to distinguish between the impact of the pandemic and other factors (e.g., oil prices or sanctions) on fiscal stress, nor did it seek to determine the relationship of the factors themselves (e.g., the pandemic and the oil shock). We leave this task for the future, which will require other methods.

The conducted study has no direct analogues for comparison, as there was introduced a new methodology for assessing the resilience of the tax system by tax revenues through the construction and decomposition of the tax system stress index, which has been tested on the examples of the pre-pandemic, pandemic and recovery periods of the Russian economy. Its use also allowed us to obtain new results concerning the different speed and degree of tax response to the shock, their interaction and the influence of institutional factors (the rules) on smoothing or intensification of the stress. At the same time, specific conclusions about the impact of the pandemic on individual tax revenues in the Russian Federation are generally consistent with the results of other authors [23–27].

While the approaches and results are undoubtedly novel, this study has a number of limitations.

First, we did not distinguish between the effects of economic growth and inflation on the increase in tax revenues. It is possible that deflation of indicators and exclusion of the influence of price growth will adjust the conclusions obtained concerning the strength of the stress in different periods.

Second, our stress index, which has something in common with Arrow-Pratt's portfolio utility function, does not include a risk attitude (or risk perception) parameter, which requires a justification for introducing an appropriate coefficient for the standard deviation of the tax revenue growth rate. We also leave all of these issues for future research, which may lead to more sensitive conclusions.

6. Conclusion

The paper proposes a methodology for assessing the tax system stress in terms of tax revenues and its decomposition by source (individual taxes, duties and tax groups). The peculiarity of the methodology is the exclusion of the influence of seasonality, as well as different periodicity of tax payments. The tax revenues stress index is presented as the difference between the moving standard deviation and the moving average value of the growth rate of tax revenues for 12 contiguous months with the step of one month, which allows to take into account both return and risk of tax revenues. The developed method has been tested on the example of tax revenues to the consolidated budget of the Russian Federation in 2013 up to March 2022. Its application made it possible to estimate the dynamics of the tax system stress in the pre-pandemic, pandemic and recovery periods, to reveal the synchronous changes and correlation of the stress indices on individual tax revenues, their connection not only with the pandemic, but also with the drop in oil prices.

Decomposition of the tax system stress by tax revenues confirmed the acceleration role of mineral extraction tax and profit tax, as well as the damping role of personal income tax in the dynamics of overall stress. At the same time, it demonstrated the peculiarity of the pandemic crisis, which small businesses were most vulnerable to, which significantly increased the stress on revenues from special tax regimes. Finally, it showed the important role of institutional rules, which was evident in the analysis of the stress on excises and property taxes revenues.

The conducted research has theoretical and practical significance. It clearly demonstrates that increasing the flexibility of tax rates, the formation of insurance reserve funds, the implementation of the tax rule in the budget system support redistribution of risks and management of the tax revenue stress over time. A detailed study of these issues is the subject of future research.

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Information about the authors

Marina Y. Malkina – Dr. Sci. (Econ.), Professor, Chief Researcher, Head of the Center for Macro- and Microeconomics of the Institute of Economics and Entrepreneurship of the Lobachevsky State University of Nizhni Novgorod (7 per. Universitetsky, Nizhni Novgorod, 603000, Russian Federation); ORCID: <https://orcid.org/0000-0002-3152-3934>; e-mail: mmuri@yandex.ru

Rodion V. Balakin – Cand. Sci. (Econ.), Senior Researcher, Center for Macro- and Microeconomics, Institute of Economics and Entrepreneurship of the Lobachevsky State University of Nizhni Novgorod, Center for Tax Policy of the Research Financial Institute of the Ministry of Finance of the Russian Federation (7 per. Universitetsky, Nizhni Novgorod, 603000, Russian Federation); ORCID: <https://orcid.org/0000-0002-0494-9702>; e-mail: balakin@nifi.ru

For citation

Malkina M.Yu., Balakin R.V. Stress Index of the Tax System of the Russian Federation in Terms of Tax Revenues. *Journal of Tax Reform. 2022;8(3):251–269*. <https://doi.org/10.15826/jtr.2022.8.3.120>

Article info

Received August 5, 2022; Revised September 21, 2022; Accepted October 17, 2022

Информация об авторах

Малкина Марина Юрьевна – доктор экономических наук, профессор, главный научный сотрудник, руководитель Центра макро- и микроэкономики Института экономики и предпринимательства Нижегородского государственного университета им. Н.И. Лобачевского (603000, Российская Федерация, г. Нижний Новгород, пер. Университетский, 7); ORCID: <https://orcid.org/0000-0002-3152-3934>; e-mail: mmuri@yandex.ru

Балакин Родион Владимирович – кандидат экономических наук, старший научный сотрудник Центра макро- и микроэкономики Института экономики и предпринимательства Нижегородского государственного университет им. Н.И. Лобачевского, Центра налоговой политики Научно-исследовательского финансового института Министерства финансов РФ (603000, Российская Федерация, г. Нижний Новгород, пер. Университетский, 7); ORCID: <https://orcid.org/0000-0002-0494-9702>; e-mail: balakin@nifi.ru

Для цитирования

Malkina M.Yu., Balakin R.V. Stress Index of the Tax System of the Russian Federation in Terms of Tax Revenues. *Journal of Tax Reform. 2022;8(3):251–269*. <https://doi.org/10.15826/jtr.2022.8.3.120>

Информация о статье

Дата поступления 5 августа 2022 г.; дата поступления после рецензирования 21 сентября 2022 г.; дата принятия к печати 17 октября 2022 г.