ORIGINAL PAPER

DOI: 10.26794/2587-5671-2024-28-3-183-193
UDC 330.43:336.6(045)
JEL G01, O11, C46

Financial Contagion of the Russian Economy: Intersectoral Aspect

A.O. Ovcharov[a], A.M. Terekhov[b]
[a] Lobachevsky State University of Nizhni Novgorod, Nizhny Novgorod, Russia;
[b] Volga Branch of the Russian State University of Justice, Nizhny Novgorod, Russia

ABSTRACT

The study's **relevance** is due to the need to identify the scale and channels of the spread of crises in the economy based on the use of the financial contagion methodology. Understanding the mechanism of spreading financial contagion from one industry to another can help develop anti-crisis measures and ensure stable economic indicators. The **purpose** of the study is to assess the intersectoral financial contagion in the Russian economy during the spread of the coronacrisis, as well as to correlate the estimates obtained with the actual incidence of COVID-19 in the Russian Federation. The **novelty** of the research lies in the development of the methodology of financial contagion and its use in relation to sectors of the Russian economy, where they are considered transmitters and/or receivers of financial contagion. The **methodology** of advanced correlation analysis was used — the Forbes-Rigobon sliding test was implemented, which made it possible to assess the scale and intensity of financial contagion in the Russian economy. We used high-frequency **data** on 8 MICEX industry indices and on the incidence of COVID-19 in the period 2020–2021. The **result** was quantitative assessments of financial contagion, which showed that such industries as metallurgy, oil and gas sector, consumer sector, electric power industry had the highest susceptibility to financial contagion. Telecommunications, the financial sector, chemicals and petrochemicals, and transport have demonstrated resistance to the pandemic shock. The most powerful transmitters of financial contagion were the electric power industry, metallurgy, transport, and the financial sector. In general, the financial contagion in 2020–2021 between the sectors of the Russian economy spread unevenly, in some cases and in certain periods, the ups and downs of financial infectivity went in parallel with the ups and downs of the real incidence of COVID-19. The main **conclusion** was that during the pandemic, financial contagion spread with varying intensity, and individual industries manifested themselves either as receivers or transmitters of financial contagion. At the same time, there was no large-scale financial infection of the sectors of the Russian economy.

Keywords: financial contagion; crisis; Forbes-Rigobon test; sector; COVID-19; Russian economy; correlation

For citation: **Ovcharov A.O., Terekhov A.M. Financial contagion of the Russian Economy: intersectoral aspect. *Finance: Theory and Practice*. 2024;28(3):183-193. (In Russ.). DOI: 10.26794/2587-5671-2024-28-3-183-193**

INTRODUCTION

In recent years, the issue of financial contamination has become extremely popular among economists. This is because the use of financial contamination methodology is the key to understanding the nature of the spread of crises. Indeed, any financial crisis is not a one-stop event but a time-long process. Accordingly [1], there is a general pattern of the emergence and development of the crisis, which includes a combination of 5 elements (the author called them "building blocks" of the crisis): objective prerequisites, external or internal shocks, features of public policy, the actions of economic agents, and mechanisms to intensify the crisis. In our view, at least two of these "bricks" (shocks and reinforcement mechanisms) are directly related to financial contamination. Firstly, "infection" is always a reaction to a global shock, i.e., the shock triggers the processes of infection. For example, [2] showed that during the 2008–2009 global crisis, two types of shocks (liquidity compression and investors' escape to safe assets due to risk revaluation) played an important role in the global transmission of financial contamination. Secondly, the spread of the crisis occurs in different ways, which are often referred to as "channels of infection". The main channel is the financial channel (although the role of other channels, such as the trading channel, should not be underestimated), the "infection" through which can be transmitted mainly through increased uncertainty and volatility in the global financial markets with the subsequent reduction in the volume of cross-border banking lending.

As a rule, financial contamination investigations focus on the country aspect, i.e., assessing the presence and scale of "infection" from source to recipient country during periods of global shocks. However, it is also of interest to study the intra- and inter-sectoral effects of infection, the empirical studies of which are not so many. In this article, we set the challenge for the Russian economy to obtain estimates of the inter-sectoral financial contamination that spread during the crisis caused by the COVID-19 pandemic. To this end, we will review research on financial contagion in general and its appendices to cross-sectoral effects. Then, on the basis of an extensive empirical basis on the Russian industry stock indices, using a special econometric test, we will assess the scale and intensity of financial infection in the Russian economy during the period of COVID-19, and also correlate the estimates obtained with registered cases of morbidity in Russia (in other words, check whether there is a link between financial and real infection).

INTERSECTORAL ASPECT OF FINANCIAL CONTAGION

There is no generally accepted definition of financial contagion in contemporary literature. Most often, it is interpreted as the transfer of crisis processes from one country to another or from one sector of the economy to another sector. The mandatory attributes of such transmission are the initial shock, the source and recipient of the shocks, one or more transmission channels, and the presence of a chain reaction when all new markets and participants are involved in the infection process. Infection should be accompanied by a significant increase in inter-market links during the crisis period compared to the pre-crisis period. This was noted in particular by the World Bank, which stated that "infection" was defined by increases in correlation levels beyond those that could be explained by fundamental economic factors [3]. Let us reject the approach in which the phenomenon of contagion is linked to structural gaps leading to the intensification of economic relations in times of shock [4].

Most of the work on financial contamination examines only its country aspect, although other ways of transmission are possible:

a) inside the branch (sector);

b) between sectors of one country;

c) between different countries and industries (sectors).

The first option allows you to assess whether the presence, timing, and extent of "infection" differ depending on the economic

sphere. This approach assumes that the same business sector is both the source and recipient. Analysis of the results obtained separately by different industries allows us to rank them by the degree of resilience (resilience) to financial contamination. In the second case, the features of the transmission of "infection" by different sectors within the country are considered. In other words, cross-sectoral contamination assessments show similarities and differences in the resilience of each sector in a particular country. The third option is the most general approach to detecting "infection", which explores its scale, where the transmitter and recipient may be different countries and sectors of the economy. This approach was used, for example, in the paper [5] — the authors looked at the nature of financial contamination that spread to different sectors of the economies of 15 European countries during two periods of crisis: global financial and sovereign debt. The analysis was based on industry stock indices and multidimensional ADCC-GJR-GARCH models. The results showed that in both countries, all European countries experienced financial contagion, but the degree of penetration of the "contagion" into the economies of different countries was different. The financial and telecommunications sectors were the most affected in all countries. Industry was the most vulnerable to financial contamination during the global crisis, and consumer goods during the sovereign debt crisis.

In a number of papers, the effects of inter-branch contamination in coupled bonds of the species "branch 1 → industry 2" are investigated. An example is the link between energy and agriculture. These sectors make a major contribution to global economic growth and ensure global energy and food security. Obviously, the energy and agricultural markets are strongly linked in terms of supply, as natural gas and diesel fuel account for the bulk of the costs of agricultural production. Many authors note that any macroeconomic shocks affecting the business cycle affect the yields of agricultural goods through price shocks in the crude oil and natural gas markets (see, for example, [6]). Moreover, the evolution of bioenergy and the processes of financing commodity markets make the links between energy and agriculture even closer. Therefore, it is not surprising that researchers are interested in these issues from the point of view of the theory and methodology of financial infection. Thus, it has been found that during periods of crisis, it is actively spreading in agricultural futures markets from the oil and gas markets, with the dependencies of these markets being more intense and stable when they are "bears" rather than "bulls" [7]. Another study revealed a two-way and asymmetrical transfer of infection between these industries during periods of global financial and pandemic crises [8]. In particular, the most pronounced and variable are the effects of contamination in agriculture from ethanol rather than from crude oil or natural gas. Furthermore, the authors concluded that the development of bioenergy contributed to the emergence of cross-sectoral systemic risks, which predetermined the increased attention of regulators to these problems.

Interesting are studies in which the financial and real sectors of the economy are acting as elements of pairing links. Such studies very often confirm the high degree of interrelationship between the financial and real spheres, which increases the probability of their mutual infection [9]. For example, this was done in paper [10] — the authors studied the effects of contamination between the financial and mining sectors in 8 countries over the long period 2008–2019. The main conclusion was that financial crises have always had a strong impact on the mining industry. The banking sector was the main source of infection for her. However, in a number of economies (especially Australia, India, Russia, etc.), where the raw materials industry plays a strategic role and is an important factor determining economic growth, reverse "infection" has also been detected. The authors explain this by the fact that not only liquid and solid fuels, but at least some of the precious metals used in industry around the world, are

mined, consumed and exported in all countries where mining enterprises have infected banks. These enterprises are also key customers of the national banking sector and can have a stronger influence on its status and functioning.

It should be noted that the banking sector is very often viewed as a transmitter or a receiver of infection. For example, credit shocks have been shown to have a strong and negative impact on added value, employment, and the procurement of production resources in non-financial companies. "Infection" in such companies spreads through their commercial credit chains [11]. However, the reverse effect is also possible, i.e., shocks can occur in the real sector and spread to the banking sector, which in turn can intensify them, thereby further deteriorating the financial conditions in the actual sector. Such interactions are illustrated, inter alia, by the example of the Brazilian economy [12]. The authors found that while the oil and gas sector receives the highest amounts of loans from banks, the companies in the sector are not the transmitters of infection to the banks. On the contrary, the metal mining and processing sector, the tertiary sector, and the food and beverage sector lead as the riskiest segments of the economy for banks, although banks interact less with companies from these sectors. The authors explain this as a "network effect" (a complex combination of interbank links, corporate banking, and feedback between companies and banks) that can either weaken or intensify real-sector shocks and thus play an important role in "infection" processes. The study also concluded that state banks are the most susceptible to shocks from firms in any sector of the economy.

Thus, as one sector faces one or another shock, other sectors are affected by strong economic links that disperse and exacerbate the negative effects of the initial sectoral shocks. Intertwined with real flows, the associated cross-sectoral financial flows make a major contribution to the transmission mechanism of the "infection" [13]. Sectoral shocks can spread across the economy due to intricate interconnections, presenting cross-sectoral systemic hazards [14]. Understanding how shock-induced financial contagion spreads from one industry to another could assist in the development of anti-crisis tools and the maintenance of steady economic performance.

MATERIALS AND METHODS

When conducting a study of inter-sectoral financial contamination in the Russian economy, it was assumed that the main channel of such "infection" is the stock market. Therefore, the empirical basis was provided by the data on the industry equity indices of MOEX, namely:

- oil and gas (OG);
- metallurgy and mining (MM);
- transport (TN);
- finance (FN);
- consumer sector (CN);
- chemistry and petrochemistry (CH);
- telecommunications (TL);
- electricity (EU).

These data were taken from Investing.com.[1] In addition, data on COVID-19 infection dynamics were used to identify the link between financial and actual infection.[2] To obtain reliable estimates were considered crisis (associated with the spread of COVID-19 in the territory of the Russian Federation) and calm (pre-crisis) periods. A total of 4728 observations (591 date) were used for the period from 01.09.2019 to 30.12.2021.

It should be noted that branch stock indices do not reflect all the diversity of interrelationships in the economy, as they only record the level of capitalization of the largest companies in a particular sector. Other indicators that characterize the development of a particular industry from different sides can also be used in the "infection" assessment. It is theoretically possible to construct its own integrated industry indicator by aggregating private indicators. However, we have rejected this approach in favor of stock indices for the following reasons. Firstly,

[1] Investing.com: Russia — Indexes. URL: https://ru.investing.com/indices/russia-indices (accessed on 05.02.2024).

[2] Coronavirus (COVID-19): Coronavirus infection statistics in Russia in days. URL: https://coronavirus-monitorus.ru/#stat (accessed on 05.02.2024).

our analysis of publications on the problem of financial contamination allows us to conclude that most often researchers use stock indices when identifying it in the country or in sectoral aspects. In other words, the legitimacy of using such an empirical basis has been confirmed by real research. Secondly, the methodology of financial infestation to obtain reliable estimates involves the use of high-frequency data — that is what data on stock indices are (we used daily statistics on them in our calculations), which cannot be said of many other indicators. High frequency allows for the formation of a large sample and reliable estimates of "infection". Thirdly, the choice of alternative indicators involves finding an appropriate empirical basis and ensuring industry comparability of data, which is difficult to implement in practice. After all, stock indices are the indicators that are most sensitive to external shocks that trigger the processes of financial contamination. Increased volatility of these indices is a precursor to a possible "infection", i.e., based on the dynamics of stock indices, it is possible to suspect their existence.

The distinction between calm and crisis periods was based on the analysis of MOEX yield fluctuations. The starting point of the crisis period was the start of volatility growth, which is clearly recorded in February 2020. Note that the end of 2021 is not the end date of the pandemic. Our estimates did not extend to 2022 due to the development of another crisis (related to the start of a special military operation in Ukraine), the consequences of which could merge with the effects of the pandemic shock.

Research hypotheses:

1. During the period of the COVID-19 pandemic, financial infection spread between the branches of the Russian economy, and it was two-way, i.e. a particular industry could act as both a receiver and a transmitter.

2. There is a link between financial infections and cases of COVID-19 in the Russian Federation.

Testing of these hypotheses was carried out by methods of correlation analysis. A special Forbes-Rigobon test, first presented in the paper [15] and used in many studies to study the country effects of infection, was used to estimate cross-sector financial contagion. We applied this approach to cross-sectoral effects and improved it in that we received "pointed" but dynamic assessments of infection. The fact is that the traditional use of any tests for "infection" implies the contemporaneity of its occurrence and the identification itself on the principle of "there is infection" or "no infection". In reality, financial contamination, as well as biological, is a prolonged process that can intensify and weaken, stop and emerge again. This fact was taken into account by the "slip" method — we performed multiple calculations of the test statistics with the sample shift for one date and with the constant "window", the value of which was equal to the period of the acute phase of the crisis.

The formally sliding Forbes-Rigobon test (FR_n) for the transmission of infection from industry *i* to industry *j* for the transmission of infection from industry:

$$FR_n(i \to j) = \frac{\ln\left(\frac{1+\hat{v}^n_{y/x}}{1-\hat{v}^n_{y/x}}\right) - \ln\left(\frac{1+\hat{p}^n_x}{1-\hat{p}^n_x}\right)}{2\cdot\sqrt{\frac{1}{T_y-3}+\frac{1}{T_x-3}}},$$

where $\hat{p}_x$ — estimates of the standard yield correlation factor of two Russian sector stock indices for the pre-crisis period *x*; $\hat{v}_{y/x}$ — assessment of the correlation factor adjusted for heteroscedasticity during the crisis period *y*; T_x and T_y — number of observations in pre-crisis and crisis periods, respectively; $n = 1, 2 \ldots N$, N — number of infection assessments.

In the calculations, the actual values of the test statistics were compared to the critical value (FR_{cr}), which for the significance level α = 0.05 is 1.645. In cases where $FR_n > FR_{cr}$, i.e. when "infection" was recorded, the difference between actual and critical values was treated as the intensity of the spread of the infection from *i* to *j* during the pandemic crisis.

In addition, average estimates of infection were obtained in each link ($\overline{FR}_{i\to j}$) for the entire period

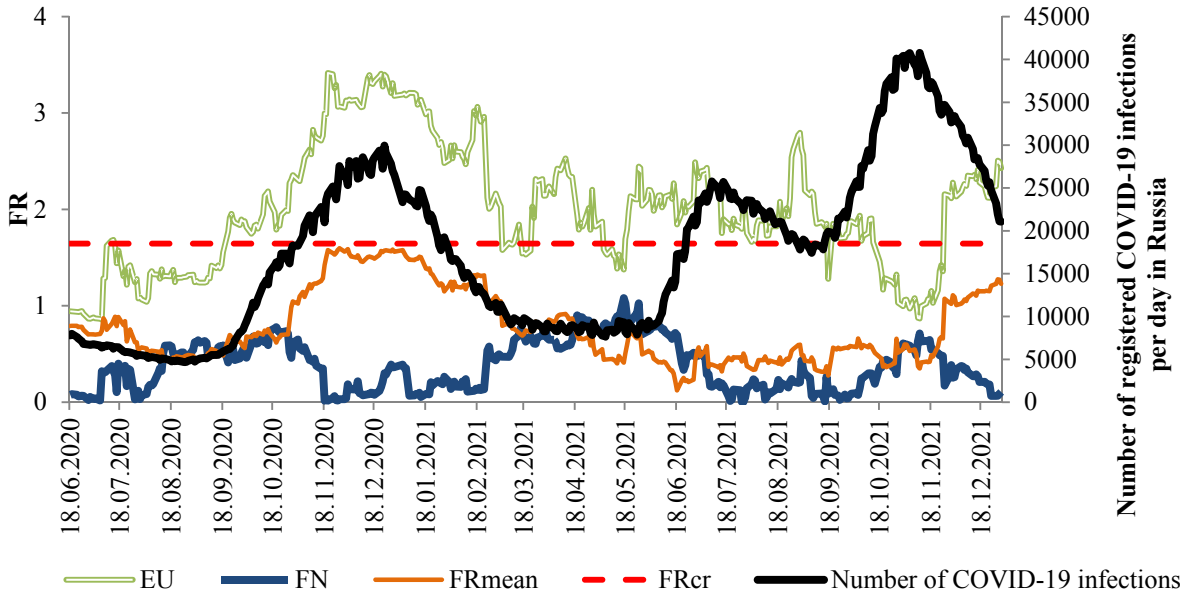

Fig. 1. **The Transport Sector as a Recipient of Financial Contagion and the Incidence of Coronavirus in the Russian Federation**

Source: Compiled by the authors.

under review and industry-wide average assessments of financial infection (FR_{aver}). To identify the relations of the assessments received with the wave-shaped course of the incidence of COVID-19 in the Russian Federation were also calculated Pearson's pair correlation coefficients. Interpretation of statistical correlation was made in accordance with the Cheddock scale.

RESULTS AND DISCUSSION

We conducted calculations for all links in selected sectors in both direct and reverse directions, but illustrate our calculations with the example of only one industry — transport. *Fig.1* shows the results of dynamic tests that characterize the transfer of financial contamination from other sectors to transport, i.e., transport in this case is considered the recipient of the "infection". Two different impacts are shown — the strongest (from the power sector) and the weakest (by the financial sector), as well as the average level of test statistics (it can be interpreted as the overall susceptibility of the sector to "infection" from all other sectors) and coronavirus incidence itself. *Fig. 2* shows the results of the assessments in a similar way, but only in cases where transport was considered to be a transmitter of financial infection.

An analysis of the results for the transport sector makes it possible to conclude its susceptibility to infection from other sectors (excluding the financial sector), with the intensity of infection varying and occurring at different time intervals. For example, the period from June 2020 to December 2021 is the most pronounced "infection" of the transport sector by electricity. The rest of the sectors had a strong impact on transport, leading to infection, but only for relatively short periods of time. At the same time, peak values of test statistics were observed in the oil and gas sector at the end of 2020 and in the consumer sector — at the beginning of 2021. As a source of infection, the transport industry has shown itself stronger than a recipient. At the same time, the most obvious "infection" was recorded in relation to the oil and gas sector (between 28.10.2020 and 11.06.2021 and from 30.01.2021 to the end of the period under review). The peak value falls at the beginning of March 2021. The "infection" from the transport sector to the metallurgy and electricity sectors was less pronounced, although

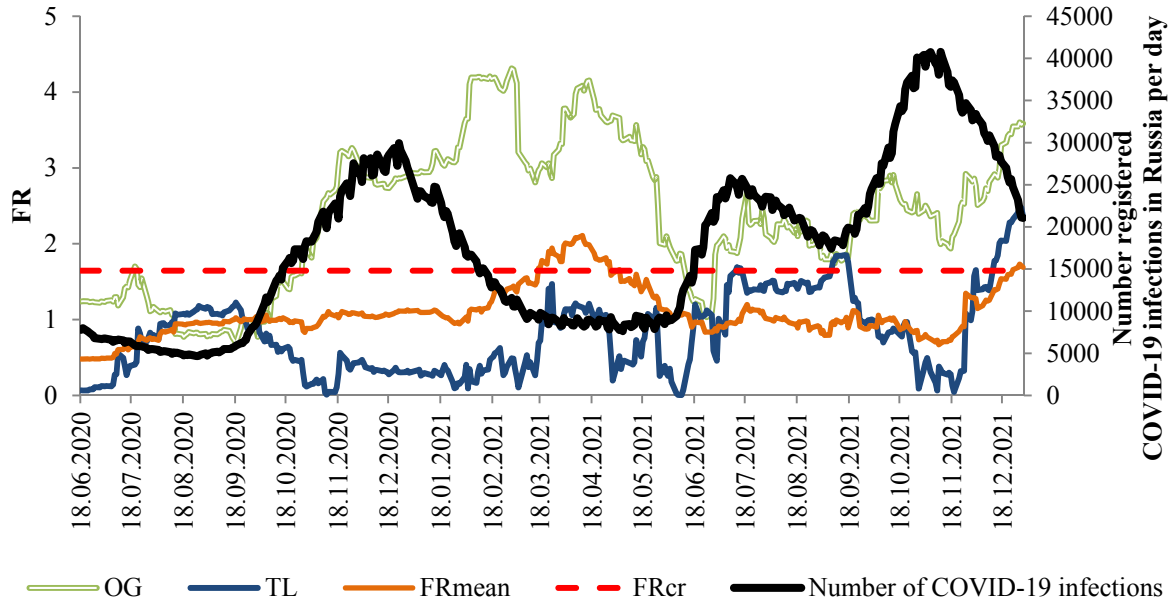

Fig. 2. **The Transport Sector as a Transmitter of Financial Contagion and the Incidence of Coronavirus in the Russian Federation**

Source: Compiled by the authors.

it spread with gaps over a long period of time. Transmissions to other sectors were minor and were recorded at relatively short intervals and on separate dates.

Quantitative estimates of the presence and intensity of infection were obtained for each industry. Without going into a detailed description of the results, note that the maximum peaks of the test statistics (the highest intensity of contamination) were observed in such recipient industries as metallurgy, the oil and gas sector, the consumer sector, and electricity. Telecommunications, the financial sector, chemicals and petrochemicals, and transport have demonstrated a weak susceptibility to "infection", indicating the resilience of these industries to the pandemic shock. The most powerful transmitters of the infection were electricity, metallurgy, transportation, and the financial sector, and their influence on other industries was manifested at different time intervals during the coronacrisis.

Areas such as metallurgy and power are both sources of contamination for other industries and recipients of some of them. At the same time, the transmission of "infection" by these industries is due to the fact that their products are used in the production processes of most enterprises. The financial exposure of these and other industries was due to the fall in demand for their products and services. For example, the decline in output during the pandemic was largely caused by the fall in consumer demand for metallurgy products, electricity, and energy resources. In particular, the decline in consumer demand was attributable to a decrease in the purchasing power of the population, as well as failures in the logistics chains, which led to a reduction in consumption, primarily of imported products, which could not be replaced by domestic production.

In the petrochemical sector, in the first half of 2020, there was a decrease in demand for products for automotive and aviation, as well as the construction industry, which was partially offset by increased demand for packaging, personal protective equipment, and sanitary and medical products. In this regard, the effects of the COVID-19 pandemic have affected the petrochemical industry to a lesser extent. Our

Table 1

Average Estimates of Intersectoral Financial Contagion ($\overline{FR}_{i\to j}$)

OG	1.326	2.371	1.446	1.227	1.068	0.714	1.976
1.105	MM	0.915	0.926	1.556	0.760	1.408	1.825
1.751	1.018	TN	0.381	0.845	0.733	0.959	2.006
0.919	0.795	0.870	FN	1.147	1.380	0.902	0.835
0.976	2.086	0.924	0.885	CN	0.896	1.143	1.006
0.854	0.924	0.611	1.706	0.651	CH	0.870	0.658
0.472	0.587	0.808	1.098	0.965	0.793	TL	1.563
0.596	0.570	1.169	1.338	0.898	0.736	1.596	EU

Source: Calculated by the authors.

assessments of financial contamination have confirmed this. The overall stability of chemical production may be attributable to the steady growth in demand for mineral fertilizers during the crisis. The main consumer of mineral fertilizers is agriculture, which showed steady growth during the pandemic [16]. Due to the fact that the production of mineral fertilizers is little dependent on other industries, and in Russian conditions the shortage of raw materials for the chemical industry is practically impossible, it is little susceptible to external shocks. In our case, the "infection" of the industry during the coronavirus period is recorded only from the finances and in short periods from the electricity.

The impact of the coronavirus on the results of the telecommunications market in 2020 has led to its slight decline. The decline was mainly attributable to the fall in roaming revenue (due to the reduction in travel by mobile operators) and the decline in sales of premium smartphone models (due to the restriction of imports).[3] Our calculations have shown that the industry is clearly distinguished both as a source of financial contamination and as a receiver in interactions with the electricity industry. This is due, on the one hand, the 100 percent dependence of the operation of the industry on electricity sources, and on the other — the increase in the consumption of electricity due to the growth of the number of subscribers of enterprises in this sphere [17].

In conclusion, estimates can be presented in the form of cross-sectoral estimates of the intensity of "infection" obtained on an average of the total sample volume for each "sector 1 — sector 2" link, both in direct and in reverse direction. These averages are shown in *Table 1*. The values of the statistics that indicate the presence or absence of "infection" in a straight direction are displayed in the cells located at the bottom left of the table, in the opposite direction — at the top right. For example, a value of 2,086 represents the high average intensity of the "infection" that spread during the pandemic from metallurgy to the consumer sector. On average, we did not record a reverse "infection" (from the consumer sector to the metallurgy industry), since the test statistics (1.556) were less than the critical value of 1.645. From *Table 1*, it can be seen that large-scale financial infestation of sectors of the Russian economy during the pandemic did not occur (average statistical "infection" showed only 7 links — highlighted in red). Moreover, we found a two-way approach in the only case — in the link "oil and gas — transport".

Our analysis of the results obtained from the results of the Forbes-Rigobon dynamic

[3] Russian telecommunication market: impact of the pandemic and development prospects. URL: https://delprof.ru/press-center/open-analytics/telekommunikatsionnyy-rynok-rossii-vliyanie-pandemii-i-perspektivy-razvitiya/ (accessed on 05.02.2024).

Table 2

The Value of the Coefficients of Paired Correlation (*r*) between the Number of COVID-2019 Contagion and the Values of Test Statistics in the Bundles $FR_i \rightarrow FR_j$

$FR_i \rightarrow FR_j$	r	$FR_i \rightarrow FR_j$	r	$FR_i \rightarrow FR_j$	r	$FR_i \rightarrow FR_j$	r
OG→MM	–0.06	TN→FN	0.32	CN→CH	0.30	TL→FN	–0.48
OG→TN	0.36	TN→CN	0.71	CN→TL	0.05	TL→OG	0.03
OG→FN	0.38	TN→CH	–0.05	CN→EU	0.46	TL→TN	0.22
OG→CN	0.33	TN→TL	0.08	CN→OG	0.35	TL→CN	0.20
OG→CH	0.26	TN→EU	0.22	CN→MM	0.56	TL→CH	0.13
OG→TL	–0.14	TN→OG	0.25	CN→TN	0.65	TL→MM	–0.09
OG→EU	0.47	TN→MM	–0.02	CN→FN	0.09	TL→ EU	0.09
MM→TN	0.11	FN→CN	–0.09	CH→MM	0.07	EU→FN	0.13
MM→FN	0.07	FN→CH	0.28	CH→OG	–0.06	EU→TN	0.24
MM→CN	0.55	FN→TL	–0.60	CH→TL	–0.26	EU→OG	0.61
MM→CH	0.74	FN→EU	–0.08	CH→EU	0.14	EU→CN	0.55
MM→TL	–0.21	FN→OG	0.16	CH→TN	–0.18	EU→MM	0.55
MM→EU	0.72	FN→TN	0.26	CH→FN	0.00	EU→CH	0.81
MM→OG	–0.04	FN→MM	–0.03	CH→CN	–0.02	EU→TL	–0.03

Source: Calculated by the authors.

Note: green highlighted links with high statistical connectivity, blue with noticeable, red with moderate, pink with weak.

surveys has led to the conclusion that in some cases and at certain periods, the ups and downs of financial infection were parallel to the uprisings and falls of the actual incidence of COVID-19. This can even be revealed visually — in *Fig. 1*, for example, it is visible that the wave of infection in the EU → TN link and in the FR_{aver} → TN link from September 2020 to March 2021 corresponds to the wavy nature of the flow of COVID-19 in the Russian Federation. Similar features are typical for other bonds, in particular for EU → CH, MM → CH etc.

In order to verify the hypothesis of the existence of a link between financial and actual infection, we have obtained estimates of the correlation between the previously calculated FR_n test statistics and the number of coronavirus cases in the Russian Federation (*Table 2*).

Table 2 shows that out of 56 links, only 20 show a tangible link with actual morbidity. It should be noted that the consumer sector is most frequently present in these links, which is quite natural. Coronavirus incidence and quarantine measures have led to a decline in consumer activity, which could affect the resilience of the sector itself. It was vulnerable to the pandemic shock and the subsequent "infection". In general, the majority of links, unlike the real infection did not show a clear waveform infection, so it can be said that most often inter-branch financial infection in the Russian Federation was not due to declines and rises in the incidence of COVID-19.

CONCLUSION

The article discusses the current problem of financial infection in the appendix to the inter-sectoral effects. These effects represent the transmission of shocks from one sector

of the economy to another, which disrupts stable connections in the economic system. The prevalence of "infection" in relation to the Russian economy was studied during the pandemic crisis — the task was to assess the scale and intensity of inter-sectoral financial infection in 2020–2021, as well as to correlate the estimates obtained with the actual COVID-19 infectiousness in the Russian Federation. For this purpose, high-frequency data on 8 MOEX industry indices and a special dynamic test for financial infection were used.

The results of the study were quantitative estimates of financial contamination obtained in each mating of type "industry 1 — industry 2", both in direct and in reverse direction. The main conclusion was that during the pandemic period, financial contamination spread with varying intensities and individual industries showed themselves either as its recipient or as its transmitter. The most active transmitters were electricity, metallurgy, transport, financial sector. The first two industries were also the main recipients of the infection, while the latter two, as well as the telecommunications and petrochemical industries, showed a weak susceptibility to "infection", indicating the resistance of these four sectors to the pandemic shock. At the same time, it should be borne in mind that the financial contagion in 2020–2021 has spread unevenly between the industries, in different periods of time it has arisen and finished. Average estimates of test statistics showed that overall, no large-scale financial contamination of the sectors of the Russian economy occurred.

Another result was the assessment of the link between financial and actual infection. Calculations showed that the incidence of COVID-19 was most often significantly correlated with financial infection, when it was channeled by the consumer sector. In most cases, the links were weak, which led to the conclusion that there was no intersectoral financial infection in the Russian Federation due to fluctuations in the incidence of the coronavirus.

ACKNOWLEDGEMENTS

The reported study was funded by the Russian Science Foundation, project No. 24-28-00124, https://rscf.ru/en/project/24–28–00124/. Lobachevsky State University of Nizhni Novgorod, Nizhny Novgorod, Russia.

REFERENCES

3. Rustamov E. Financial crises: Sources, manifestations, consequences. *Voprosy ekonomiki*. 2012;(4):46–66. (In Russ.). DOI: 10.32609/0042–8736–2012–4–46–66
4. Chudik A., Fratzscher M. Identifying the global transmission of the 2007–2009 financial crisis in a GVAR model. *European Economic Review*. 2011;55(3):325–339. DOI: 10.1016/j.euroecorev.2010.12.003
5. Morales L., Andreosso-O'Callaghan B. The global financial crisis: World market or regional contagion effects? *International Review of Economics & Finance*. 2014;29:108–131. DOI: 10.1016/j.iref.2013.05.010
6. Jokipii T., Lucey B. Contagion and interdependence: Measuring CEE banking sector co-movements. *Economic Systems*. 2007;31(1):71–96. DOI: 10.1016/j.ecosys.2006.05.001
7. Alexakis C., Pappas V. Sectoral dynamics of financial contagion in Europe — the cases of the recent crises episodes. *Economic Modelling*. 2018;73:222–239. DOI: 10.1016/j.econmod.2018.03.018
8. Pal D., Mitra S.K. Correlation dynamics of crude oil with agricultural commodities: A comparison between energy and food crops. *Economic Modelling*. 2019;82:453–466. DOI: 10.1016/j.econmod.2019.05.017
9. Ji Q., Bouri E., Roubaud D., Shahzad S.J.H. Risk spillover between energy and agricultural markets: A dependence-switching CoVaR-copula model. *Energy Economics*. 2018;75:14–27. DOI: 10.1016/j.eneco.2018.08.015
10. Zhu B., Lin R., Deng Y., Chen P., Chevallier J. Intersectoral systemic risk spillovers between energy and agriculture under the financial and COVID-19 crises. *Economic Modelling*. 2021;105:105651. DOI: 10.1016/j.econmod.2021.105651

11. Anufriev M., Panchenko V. Connecting the dots: Econometric methods for uncovering networks with an application to the Australian financial institutions. *Journal of Banking & Finance*. 2015;61(S 2): S 241-S 255. DOI: 10.1016/j.jbankfin.2015.08.034
12. Fijorek K., Jurkowska A., Jonek-Kowalska I. Financial contagion between the financial and the mining industries — empirical evidence based on the symmetric and asymmetric CoVaR approach. *Resources Policy*. 2021;70:101965. DOI: 10.1016/j.resourpol.2020.101965
13. Cingano F., Manaresi F., Sette E. Does credit crunch investment down? New evidence on the real effects of the bank-lending channel. *The Review of Financial Studies*. 2016;29(10):2737–2773. DOI: 10.1093/rfs/hhw040
14. Silva T.C., da Silva Alexandre M., Tabak B.M. Bank lending and systemic risk: A financial-real sector network approach with feedback. *Journal of Financial Stability*. 2018;38:98–118. DOI: 10.1016/j.jfs.2017.08.006
15. Nguyen L.X.D., Mateut S., Chevapatrakul T. Business-linkage volatility spillovers between US industries. *Journal of Banking & Finance.* 2020;111:105699. DOI: 10.1016/j.jbankfin.2019.105699
16. Zhang W., Zhuang X., Wang J., Lu Y. Connectedness and systemic risk spillovers analysis of Chinese sectors based on tail risk network. *The North American Journal of Economics and Finance* 2020;54:101248. DOI: 10.1016/j.najef.2020.101248
17. Forbes K.J., Rigobon R. No contagion, only interdependence: Measuring stock market comovements. *The Journal of Finance*. 2002;57(5):2223–2261. DOI: 10.1111/0022–1082.00494
18. Siginevich D.A. Petrochemical industry in the context of the COVID-19 pandemic. *Innovatsii i investitsii = Innovation & Investment*. 2020;(7):234–238. (In Russ.).
19. Drobyshevskaya L.N., Churbanova A.S. Impact of the pandemic on the telecommunications companies' financial results. *Ekonomika i biznes: teoriya i praktika = Economy and Business: Theory and Practice*. 2020;(10–1):104–108. (In Russ.). DOI: 10.24411/2411–0450–2020–10776

ABOUT THE AUTHORS

Anton O. Ovcharov — Dr. Sci. (Econ.), Prof., Department of Accounting, Lobachevsky State University of Nizhni Novgorod, Nizhny Novgorod, Russia
https://orcid.org/0000-0003-4921-7780
Corresponding author:
anton19742006@yandex.ru

Andrey M. Terekhov — Cand. Sci. (Econ.), Assoc. Prof., Department of Humanities and Socio-Economic Disciplines, Volga Branch of the Russian State University of Justice, Nizhny Novgorod, Russia
https://orcid.org/0000-0002-2356-4533
terehoff.t@yandex.ru

Conflicts of Interest Statement: The authors have no conflicts of interest to declare.

The article was submitted on 05.02.2024; revised on 07.05.2024 and accepted for publication on 15.05.2024. The authors read and approved the final version of the manuscript.

Translated by V. Timonina