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The Relationship Between Industrial and Financial Stress in the Russian Economy in the Context of a Change in the Monetary Regime

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ABSTRACT

The **relevance** of the paper is defined by significant impact of financial shocks on various sectors of the Russian economy, which undermines the stability of the country's economic system. Therefore, it is essential to study the sources of financial shocks, the mechanisms of their distribution and ways to manage them. The **purpose** of the paper is to specify the impact of financial stress on industrial stress in the Russian economy and to determine the role of monetary policy in their interaction. The **novelty** of the research consists in the development of a methodology for constructing financial and industrial stress indices, the establishment of the mechanism of their interaction under different monetary regimes of the central bank. The construction of stress indices is carried out on the basis of the selected indicators of the financial market and industrial sector of the economy, the use of the principal component analysis for their aggregation, and mathematical transformation of the first principal component. The direction of interaction between financial and industrial stress in the Russian economy is determined using the Granger causality test. The construction of autoregressive distributed lag models (ARDL models) allows estimating the impact of financial stress, as well as monetary policy parameters (the scale of lending by the central bank to commercial banks and the deviation of the central bank's key rate from the market rate borrowing) on industrial stress in the Russian economy. The research **results** in estimates of the strength of the relationship between financial and industrial stress in the Russian economy in two periods: before the change in the monetary regime (2006 — end of 2014) and after the change in the monetary regime (end of 2014–2019). It is **concluded** that in the first period the impact of financial stress on industrial stress was faster and stronger. In the second period, the weakening and distancing of this influence in time is explained by the change of the monetary regime of the Bank of Russia, which indicates an increase in the effectiveness of the monetary policy tools of the Bank of Russia to counter "financial contagion" of the industrial sector.

Keywords: stress index; financial and industrial stress; monetary policy; monetary regime; Granger causality test; Russian economy

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INTRODUCTION

The problem of financial instability and its impact on the development of the real economy received a new research impulse after the Great Recession 2008–2009. Since then, there's been a lot of paper devoted to both the assessment of the level of financial stress and its relationship with the production sector.

Scientists developed a large number of indices on the state of the financial sphere. Some of the more popular ones include: 1) Financial Conditions Index (FCI) by the Federal Bank of Chicago, Bloomberg Agency, Goldman Sachs Investment Bank, etc.; 2) Financial Stress Index (FSI) of a number of central banks, such as the Bank of England, the Federal Reserve Bank of Saint Louis, the International Monetary Fund, the Financial Research Office of the US Treasury (OFR Financial Stress Index) and others; 3) Volatility Index (fear index) of Chicago Board options exchange (CBOE, VIX).

The construction of financial stress or financial conditions indices is based on key indicators of money, stock, currency markets [1]. They also take into account a number of macroeconomic indicators such as inflation, sovereign debt, etc. In some cases, institutional variables such as the level of political risk are also included in the private variables on which the composite index is based [2]. The construction of stress indices uses relative indicators such as spread of money and stock market yields, spread of short- and long-term treasury bonds yields, risk premium, etc. According to [3, p. 97], the spread between the real estate price index and the 30-year mortgage rate index in the USA can be regarded as the reliable predictor of the financial crisis.

In Russia, individual scientists and institutions have also developed analogues of financial market indicators suitable for domestic economy. They took into account both the specifics of the Russian crises and the features of the official information available for their construction. Examples of such indices are the composite leading indicators of the Centre for Macroeconomic Analysis and Short-term Forecasting (CMASF); Financial Stability Index of the Economic Policy Institute (EPI). Of special note are the two financial stress indices developed and calculated by the analytical credit rating agency ACRA: 1) ACRA FSI index based on analysis of financial market volatility and interest rate spread[1]; 2) structural index ACRA SFSI, based on the analysis of the financial condition of economic agents and the impact of various risks on it.[2]

Russian researcher M. I. Stolbov, using a dynamic factor model, developed a composite index of financial stress for Russia, accumulating the influence of twelve recognized metrics of financial instability, including credit gap indicators, debt service and real estate prices. In 2008–2018, this index demonstrated a statistically significant average negative relationship with Russia's industrial production index [4].

Other researchers, Yu. A. Danilov, D. A. Pivovarov and I. S. Davydov [5], constructed Russian Financial Conditions Index (FCI) based on a number of financial market indicators such as: general and industrial indices of the Moscow Stock Exchange, interbank loan rate, spread of Federal Loan Bond (FLB) and interbank market rates, Russian Volatility Index (RVI), residential property price index and exchange rate of the ruble to the USD. Negative influence of financial conditions index on Russia's real GDP with a two-quarters lag is proved.

Scientists propose different methods of constructing stress indices that differ in the way of rationing, weighting and aggregation of private indicators. The most commonly used methods are: factor analysis, principal

[1] URL: https://www.acra-ratings.ru/criteria/129 (accessed on 27.10.2021).

[2] URL: https://www.acra-ratings.ru/criteria/520 (accessed on 27.10.2021).

component analysis (PCA), equivalent variance method, economic weights, cumulative distribution functions (CDF), logit model construction and others. For example, principal component analysis is used in calculations of the stress index of the Russian agency ACRA[3] and in some foreign studies [2, 6]. In some cases, econometric and economic-mathematical methods are proposed for the construction of stress indices: multi-dimensional (multivariate) GARCH models and portfolio approach [1]. Application of portfolio or so-called credit weighting — with share of "managed" wealth — allows to conduct additive decomposition of stress by sources: market types or financial spheres [7].

A number of studies focus on the impact of financial stress indicators on the production sector and its individual industries, as well as the functioning of commodity markets. According to [8], financial and geopolitical shocks affect commodity prices and cause significant volatility in energy and metal markets in the short term. Using the non-linear vector autoregression (VAR) model and quantile regressions, article [9] investigates the influence of the financial stress index (FSI) of developed countries on the the exchange market pressure index (EMPI) in Brazil, China, Mexico, Russia and South Korea.

A special issue in the study of financial stress is the identification of causal relationships in its interaction with the real economy. Thus, article [10] shows that the financial stress index of the Financial Research Office of the US Ministry of Finance (OFR FSI) not only predicts financial shocks in the economy well, but also, according to Granger's causality test, is the predictor for the Chicago Fed National Activity Index. In the work of V. Baranova [11] based on the ACRA financial stress index, the construction of a threshold structural VAR model and the conduct of an extended Granger — Toda-Yamamoto causality test, proves negative impact of financial shocks on business activity in the Russian economy.

In the article on the economy of Luxembourg [12], the authors consider the two-way links between financial stress and economic activity. In addition to the Granger test, they use a spectral method that takes into account frequency, nonlinearity, and causality cycles. The study of American economy [13] with coherent and wavelet analysis shows that the impact of financial stress on the real economy (economic growth, unemployment and inflation, 10-year treasury rate) is noticeable over long periods of study and manifests itself during severe financial shocks. The study of Czech economy [14] using the structural VAR model also proved that the financial stress in 2004–2014 had an impact on output, prices and interest rates, with the maximum reaction occurring about a year and a half after the shock.

To identify periods of financial stress on the real economy sector, researchers propose different methodological techniques. In particular, in the paper [15] dating of periods of crisis is carried out on the basis of an autoregression model with two Markov switching and one threshold vector autoregression. In the study of Turkish economy [16] structural autoregression models SVAR were used. The authors identified significant impacts of stress indices of changes in consumer prices and industrial production in the country, but also found the reverse impact of industrial stress on financial stress.

Another important field of application of financial stress indices is the study of cross-border spread of systemic risk [17]. The main channels of transmission of financial contagion from the developed to the emerging markets are changes in exchange rates [9] and capital flows between countries [18]. A number of papers explore the influence of the news background on the transmission of negative

[3] URL: https://www.acra-ratings.ru/criteria/129 (accessed on 27.10.2021).

impulses from one financial market to another. For example, in the article by E.A. Fedorova, etc. [19] based on sentiment analysis (tonality analysis) of news reports about Russia in foreign media, it has been proved that the crisis macroeconomic processes not only directly, but also indirectly (through formation of negative news background and investor sentiment) influence the dynamics of the stock index of the Moscow Stock Exchange.

The impact of financial stress on the real economy depends on counter-acting measures taken by monetary and fiscal authorities to respond to the crisis. The preference for certain tools of monetary regulation in the anti-crisis policy of the government is explained by their ability to react promptly to the situation. Thus, according to a study of the American economy [20] for both crises (the financial crisis of 2008 and the pandemic of 2020), the negative impact of the external shock decreased after the US Federal Reserve announced the introduction of new quantitative easing measures, which maintained investor confidence and refocused investor behavior. Another paper [21] concludes on the positive impact of non-conventional monetary policy on the "calming" of financial markets and prevent a decrease in the real economy.

The purpose of this study is to reveal features of the influence of financial stress on industrial stress in the Russian economy and to determine the role of monetary policy as for the period 2006–2019 under review, so separately for periods before and after the monetary regime change (transition to inflation targeting and floating ruble exchange rate).

DESCRIPTION OF DATA

Official data from Rosstat, the Central Bank of the Russian Federation, and the financial agency Investing.com were used to construct stress indices. The calculations involved monthly data from January 2006 to December 2019 (i.e. before the 2020 pandemic crisis).

Industrial stress index (ISI) is calculated on the basis of a number of private indicators reflecting the output of the country's main industries, such as: mining of coal, oil, gas, production of food and chemicals, metallurgical production.

Financial stress index (FSI) is formed from the three main financial indicators: exchange rate of ruble to USD, Moscow Stock Exchange index, average Brent oil futures contract price.

The Census X-13 seasonal smoothing procedure was implemented in the EViews package for all private indicators. By calculating the growth rates of the seasonally smoothed indicators, their stationary time series were formed, which were the basis for the calculation of stress indices.

The analysis of the relationship of the stress indices with the main parameters of monetary policy used a number of additional indicators of the Bank of Russia for the same period of time in the monthly representation:

1) Bank of Russia claims on credit institutions — CB_LOANS.[4] We used the natural logarithm of the seasonally adjusted indicator — LN_CB_LOANS;

2) key interest rate of the Bank of Russia — CB_R,[5] for which the average for each month was calculated based on daily values;

3) average weighted interest rate of credit institutions on loans to non-financial institutions in rubles for up to 1 year, including demand loans (excluding "Sberbank") — RATE.[6] Deviation of credit rate from key interest rate was also used — ΔRATE.

[4] URL: https://www.fedstat.ru/indicator/44591 (accessed on 27.10.2021). Description of "Claims on credit institutions" indicator is presented on the website of the Bank of Russia: Methodological comment. URL: https://cbr.ru/statistics/macro_itm/dkfs/Methodological_commentary_1/ (accessed on 27.10.2021).

[5] Key interest rate of the Bank of Russia. URL: https://www.cbr.ru/hd_base/KeyRate/ (accessed on 27.10.2021). Up to 2013 refinancing rate data was used. URL: http://www.cbr.ru/statistics/idkp_br/refinancing_rates1/ (accessed on 27.10.2021).

[6] Interest rates on loans and deposits. URL: http://www.cbr.ru/statistics/bank_sector/int_rat/ (accessed on 27.10.2021).

Finally, we have identified two research periods:

1) 2006 — October 2014;

2) November 2014–2019.

This division is explained by the change in the monetary regime of the Russian economy in 2014, that is:

official transition of the Bank of Russia to inflation targeting policy since the beginning of 2014;

transition in November 2014, in the midst of the crisis caused by sanctions for the Russian economy, to the ruble floating regime.

As our previous paper [22] showed, this transition has been enabled by the Bank of Russia to respond more quickly to changes in demand for money, which strengthened endogeneity of money supply and its attachment to the needs of the economy.

METHODOLOGY

Stress index construction method

During the calculation of the industrial and financial stress indices, we used the method first proposed in our work [23].

The growth rates of seasonally smoothed private indicators, reflecting the development of the industrial or financial sphere, were aggregated with the principal component analysis (PCA):

$$PC_t = \sum_{i=1}^{n} \alpha_i \cdot (X_{it} - \bar{X}_i) / \sigma_i , \qquad (1)$$

where PC_t — the value of the first principal component in the time period t; α_i — specific weight (load) of i-indicator in PC, calculated empirically by maximizing PC variance; X_{it} — value of the i indicator in the time period t; $\bar{X}_i$ — inter-temporal average of i-indicator; σ_i — its inter-temporal standard deviation.

Further on the first principal component, the stress index (SI_t) is calculated in dynamics as the difference between the moving standard deviation σ_{PCit} and the moving average value μ_{PCit} of the first principal component for every seven months with a one-month shift:

$$SI_t = \sigma_{PCit} - \mu_{PCit} . \qquad (2)$$

This method allows to get time series of indices of industrial and financial stress (ISI_t and FSI_t).

Modeling relationships between stress indices and monetary policy parameters

The relationship between stress indices and their relationship to monetary policy parameters (LN_CB_LOANS and ΔRATE) is verified using the Granger causality test.

In order to achieve that, the time series should be checked for stationarity using the Augmented Dickey Fuller (ADF) test. If the null hypothesis of a unit root time series is not supported at a certain level of significance, then it can be argued that the studied series is stationary or integrated of a zero order $I(0)$. Otherwise, a statement about the stationary of the series in the first differences and further is taken, the Engle-Granger test for time series cointegration is conducted, and the VECM (vector error correction) model is built.

For stationary time series, a vector autoregression model (VAR) is built. The lag order in the model (k) is selected based on the information criteria of Akaike, Schwarz and Hannan-Quin. Granger causality test is performed for VAR model of k-order. For each equation of the model, the null hypothesis is tested that X is not a cause for Y, and Y is not a cause for X.

The relationship of the studied time series is further investigated on the basis of the construction of the autoregression and distributed lag model (ARDL-model) for the two selected periods:

$$Y_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i Y_{t-i} + \sum_{j=0}^{k} \beta_j X_{t-j} + e_t . \qquad (3)$$

Based on the estimated coefficients and degree of their importance, it is concluded that the influence of financial stress and monetary policy parameters on industrial stress in the Russian economy has increased/decreased.

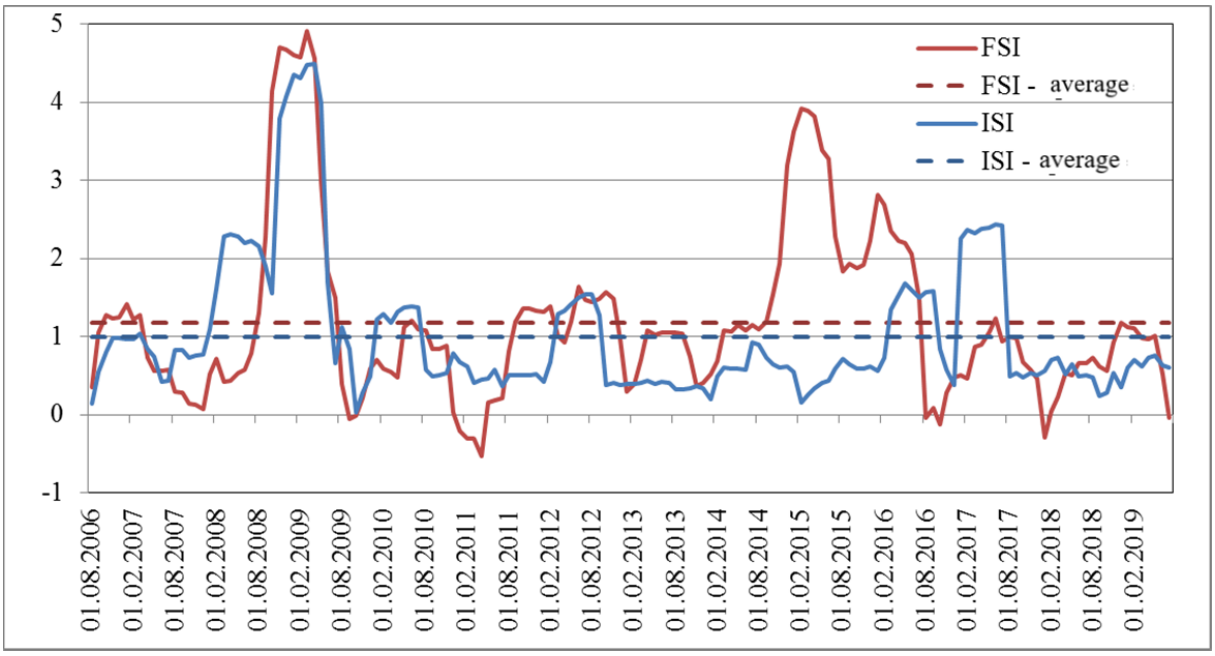

Fig. 1. **Dynamics of Industrial and Financial Stress Indices**

Source: Completed by authors.

RESULTS AND THEIR ANALYSIS

Fig. 1 presents dynamics of calculated indices of industrial and financial stress. First of all, the average financial stress index exceeds the average industrial stress index, although the principal component method largely eliminates the variation of indicators.

In addition, *Fig. 1* demonstrates a closer relationship of stress indices before changing the monetary regime than after changing it. Indeed, in August 2006 — October 2014, the linear correlation of industrial and financial stress indices is $R = 0.783$. In the period from November 2014 to December 2019, there is no lag-free relationship between the two indices.

In the first study period there is a simultaneous increase in industrial and financial stress during the crisis 2008–2009. In the second period, some autonomy of two types of stress is evident. In 2014 — the first half of 2016 there is a significant predominance of financial stress over industrial. Further until mid-2017, by contrast, industrial stress is stronger than financial. A year-and-a-half later both stress levels are below average.

The alternation of two types of stress in the second period of the study can be explained by the immediate reaction of financial markets in the context of floating exchange rate to shocks associated with the tightening of sanctions regimes of the Russian economy. At the same time, proactive public policies aimed at import substitution and encouraging public investment have led to a delayed response from the industrial sector to external shocks. It is also possible that the change in the interaction between the two types of stress was due precisely to the change in the monetary regime.

In this paper we analyze the policy of the Bank of Russia in both periods. *Fig. 2* shows the average weighted key interest rate, loan rate and the Bank of Russia claims on credit institutions.

It is easy to notice that in the first period of the study (before the change of monetary regime) during the crises there is an increase in both average lending rates and the official key interest rate (which is a response to increased risks, including inflation). During the crises, refinancing of credit institutions has increased, which is due to the Central Bank's desire to

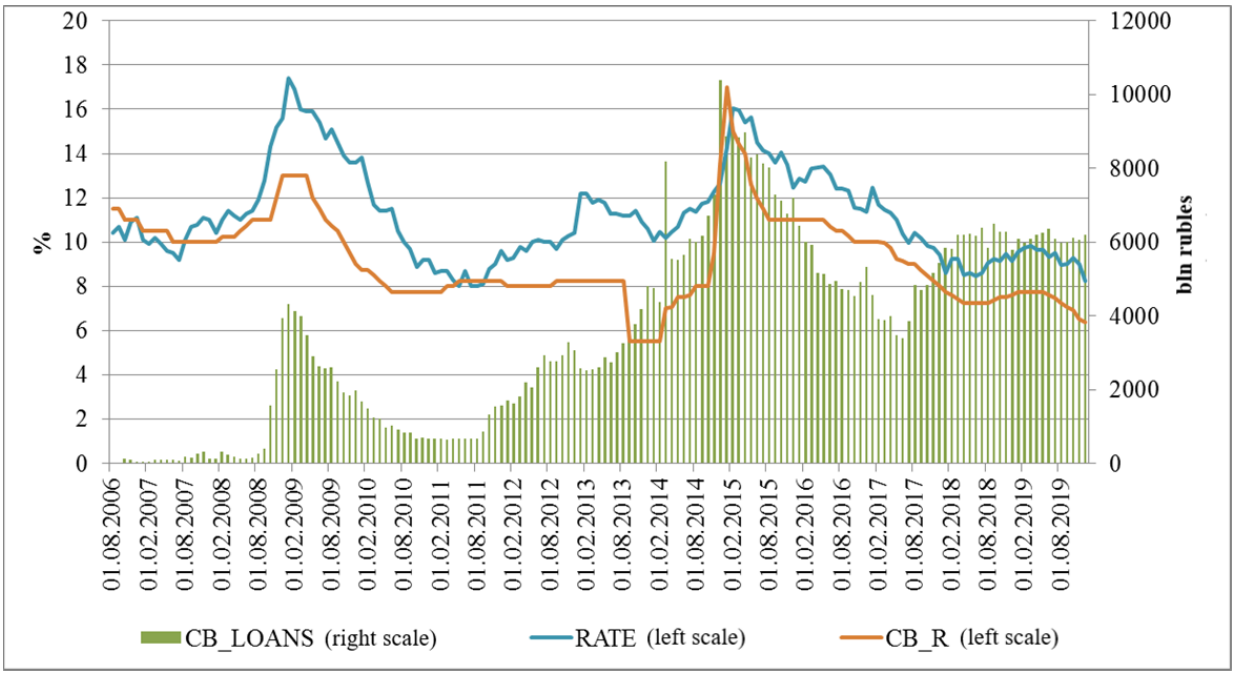

Fig. 2. **Dynamics of Interest Rates and the Amount of Loans of the Bank of Russia to Credit Institutions**

Source: Compiled by the authors based on data of the Bank of Russia.

counteract the crisis. In the second period we see a change in the scale of lending to commercial banks by the Central Bank.

Analysis of stress indices relationship in the Russian economy in 2006–2019

Testing the stationarity of time series for two calculated stress indices (ISI and FSI) and monetary policy parameters (LN_CB_LOANS and ΔRATE) with Augmented Dickey Fuller test (ADF-test) leads to mixed results (*Table 1*).

For the test with a constant, the stationarity in the series levels is only confirmed for the financial stress index at the significance level $\rho < 0{,}05$ and for the industrial stress index at the significance level $\rho < 0{,}1$. For the test without a constant, the stationarity in the series is confirmed for the loans rate deviation from the Bank of Russia rate (ΔRATE) with $\rho < 0{,}05$ and for the logarithm of the Bank of Russia claims on credit institutions (LN_CB_LOANS) with $\rho < 0{,}1$. The time series are stationary in the first differences. The Engle-Granger cointegration test does not confirm the presence of a long-term dependency, which makes the construction of a VECM-model impractical. Therefore, taking into account the proximity of the time series to the stationary state in the series levels, the construction of the VAR model is applicable.

Next, for the time series studied, we conducted a Granger causality test. The Table 2 presents short-term time series dependencies in the period 2006–2019, obtained with VAR-models. The order of lag in them was determined using Akaike, Schwarz and Hannan-Quin information criteria.

Based on the results obtained, we constructed a chain of causal relationships between the investigated variables in 2006–2019 (*Fig. 3*).

Thus, financial stress causes both industrial stress and monetary changes. First of all, the traditional financial crisis is accompanied by a fall in oil prices and stock indices, and devaluation of the ruble. Increasing volatility of financial markets, growth of speculative expectations and inflationary threats lead to an increase in interest rates. Worsening forecasts and increasing credit risk have contributed to a decline in commercial bank lending to private sector.

Table 1

Results of ADF Unit Root Test for 2006–2019

Variable	*P*-value			*P*-value for first difference		
	Without constant	With constant	With constant and trend	With constant	Without constant	With constant and trend
ISI	0.1137	0.0542	0.0789	0.0001	0.0000	0.0018
FSI	0.1221	0.0149	0.0618	0.0001	0.0000	0.0011
ΔRATE	0.0484	0.2138	0.2116	0.0000	0.0000	0.0000
LN_CB_LOANS	0.0947	0.9697	0.2340	0.0000	0.0000	0.0025

Source: Calculated by the authors.

Table 2

Results of Short Run Granger Causality Test in 2006–2019

Dependent variable	Independent variable	Chi squared	*p*-value	Conclusion	Lag order
ISI	FSI	7.048	0.008	ISI<=FSI	1
FSI	ISI	0.163	0.686	–	1
ISI	ΔRATE	4.496	0.034	ISI<= ΔRATE	1
ΔRATE	ISI	0.005	0.943	–	1
ISI	LN_CB_LOANS	17.822	0.022	ISI<= LN_CB_LOANS	8
LN_CB_LOANS	ISI	4.171	0.841	–	8
FSI	ΔRATE	1.390	0.499	–	2
ΔRATE	FSI	14.518	0.001	ΔRATE <= FSI	2
FSI	LN_CB_LOANS	2.154	0.341	–	2
LN_CB_LOANS	FSI	10.849	0.004	LN_CB_LOANS <= FSI	2

Source: Calculated by the authors.

In such circumstances, the central bank tries to counteract the negative processes in the economy and, with the increase in the key interest rate, expands the refinancing of credit institutions, including backed by long-term non-market liabilities. In the short term, with the decline in demand for loans and the growth of borrowers' defaults, the active money emission does not have a significant positive effect on the economy. Fueling speculative demand for money, it

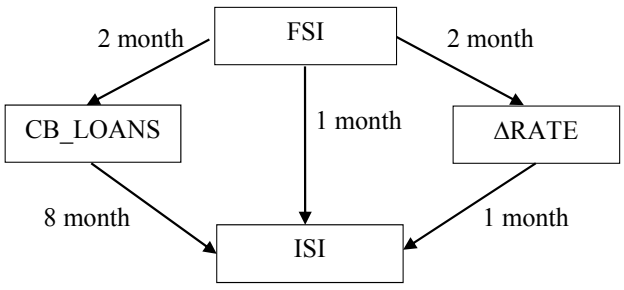

Fig. 3. **Causal Relationships in the Model**

Source: Compiled by the authors.

Table 3

ARDL Model for ISI

Variable	Coefficient	Standard error	*t*-statistic	*p*-value
Period: 2006M10–2014M10				
ISI (–1)	0.982	0.087	11.337	0.000
ISI (–2)	–0.184	0.081	–2.279	0.025
FSI (–1)	0.659	0.083	7.935	0.000
FSI (–2)	–0.532	0.089	–6.008	0.000
LN_CB_LOANS	–0.084	0.042	–1.989	0.050
ΔRATE	0.051	0.031	1.648	0.103
Const	1.133	0.535	2.116	0.037
Period: 2014M11–2019M09				
ISI (–1)	0.403	0.113	3.572	0.001
FSI (–1)	0.181	0.053	3.382	0.001
LN_CB_LOANS	–1.649	0.362	–4.555	0.000
ΔRATE	0.091	0.048	1.915	0.061
Const	25.822	5.655	4.567	0.000
Model criteria			Period: 2006M10–2014M10	Period: 2014M11–2019M09
R-squared			0.911	0.762
Adjusted *R*-squared			0.905	0.745
S.E. of regression			0.314	0.325
F-statistic			153.672	45.593

Source: Calculated by the authors.

carries threats of further inflation and ruble devaluation and pushes for another rise in the key interest rate. But, in the long term, active monetary policy, together with a reduction in interest rates, can have a stabilizing effect on the real economy.

To clarify the direction and strength of influence of the financial stress index (FSI) and monetary policy parameters on the industrial stress index (ISI), we have constructed ARDL models separately for periods before and after the change of monetary regime (*Table 3*).

ARDL model estimates show positive and statistically significant impact of financial stress on industrial stress in both periods. However, in the second period this influence is noticeably less. The positive deviation of the weighted average interest rate on commercial loans from the key interest rate of the Bank of Russia also directly and statistically significantly affects industrial stress. The increase in the estimated coefficient at ΔRATE indicates an increase in the sensitivity of industry to the relative

level of interest rates. A negative sign for LN_CB_LOANS confirms the positive impact of the central bank's active lending to commercial banks on reducing industrial stress. Significant increase in absolute value of the coefficient estimates with LN_CB_LOANS in the second period indicates an increase in the impact of refinancing policy on the reduction of stress in the economy under the new monetary regime.

CONCLUSION

By implementing an index approach using the principal component analysis, conducting a series of econometric tests and building models of the ARDL type, we proved the significant relationship between financial and industrial stress in the Russian economy and the significant impact of the first stress on the second. In this case, the transformation of the interaction character of two types of stress under the influence of the change in the monetary regime of the Bank of Russia in late 2014 was found. With the transition to inflation targeting and a floating ruble exchange rate, the impact of financial stress on industrial stress has been significantly reduced. This could be due to both the change of the monetary regime and the new industrial policy of the Russian state, including the policy of import substitution, but identifying its effects requires independent research.

The influence of monetary tools (key interest rate and volumes of refinancing of credit institutions by the Bank of Russia) on industry has increased, which indicates an increase in the monetary and credit policy efficiency and greater adequacy of the new monetary regime to the needs of the economy.

In the current circumstances, the Central Bank should reduce inflation risks and dampen negative impulses from the financial sector to the real economy by adjusting the key interest rate to the market situation. The positive impact will be felt in the short term. However, high interest rates, reducing inflationary stress, impose other stresses on the real sector, suppressing business activity and economic growth. Therefore, amid crisis, it is advisable for the Central Bank to increase refinancing of the banking sector, which will have a corrective positive impact on the industrial sector, but most likely in the long term.

The new realities of 2022–2023 indicate that in the context of stringent sanctions regimes, the Central Bank has to introduce non-market regulatory tools and abandon a number of market-based tools (as for currency regulation). At the same time, both main tools of monetary policy (interest rate and refinancing of credit institutions) continue to play a regulatory role in the management of stress in the economy.

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