

The Use of the Signal Approach to Development of Early Warning Indicators of Financial Turmoil in Russia¹

A number of serious imbalances have emerged in the global economy to date. These are, primarily: a huge deficit of the US's balance of payments, China and the associated South-East Asian economies' big positive balance of the current account, a rapid accumulation of gold and forex reserves in these countries, Japan's huge financial imbalances, among others. The imbalances in question can affect not only the respective economies wherein they have unfolded, but other countries as well, thus derailing their financial stability.

Numerous research show that periods of financial turmoil that precede crises have certain elements in common. That is why, due to huge costs an economy incurs as a result of financial crises, researchers have focused on developing models which could help policy makers foresee possible challenges and properly react to them. Like in the medical science, in economics, it is easier to prevent problems, rather than cure them. That is why it is appropriate to undertake measures to preclude a crisis from emergence already at the stage of the rise of a financial turmoil.

In other words, to monitor the stability of the financial system of a given country, one needs a system of indicators, which would allow a regular evaluation of its healthy development. The need for design of early warning indicators of financial crisis was first realized after several financial crises that had unfolded in the 1990s. Meanwhile, considerable direct (recapitalization of the banking system) and indirect (fall in the economic activity) costs engendered by the crises have demonstrated importance of a constant monitoring of the financial system in order to expose, in a timely fashion, signs of the emergence of negative phenomena.

Let us note that the evaluation of the indicators of financial system's state of course appears insufficient for drawing a final conclusion of the financial system's state, as it in many ways is determined by factors that cannot be assessed in quantitative terms. That is why evaluation of early warning indicators of financial crisis should be considered just as one of elements of monitoring of the state of the financial system. Besides, one should not mechanically address the problem of examination of the indicators. That is to say, all marginal values that evidence a rise (fall) in the probability of the financial instability appear relatively provisional, as they are dependent on a concrete situation in a given economy. That is why, while concluding results of the monitoring, one always needs to analyze a current economic situation and, depending on that, to correct findings of the formal analysis.

To expose ties between specific indicators of financial stability and examination of the international experience of employment of early warning indicators of financial crisis, below, we provide a brief review of the literature on the subject. On its basis, we present the list of indicators which may potentially be employed to forecast the rise of the financial instability. Then we evaluate efficiency of specific indicators and give an assessment of their marginal values that appear specific for Russia's financial market. Finally, we provide results of the employment of the proposed methodology for the sake of analyzing financial stability in RF in the 4th quarter 2008.

International Record of Building of the Early Warning Indicators

In recent decades, numerous researchers have attempted to identify indicators that highlight on the financial system's state. While early works centered on examination of the fundamental economic indicators, the most recent research emphasized an important role of investors' expectations in forecasting financial crises.

¹ The paper is prepared basing on materials of the research: Trunin P.V., Kamenskikh M.V. "Monitoring finansovoy nestabilnosti v razvivayushchikhsya ekonomikakh (na primere Rossii)". Nauchnye trudy IEPP. M., 2007, № 111

I. Fisher provides a classical explanation of financial instability². He argued that the instability is strongly correlated with macroeconomic cycles and the dynamic of the aggregate debt in an economy. Propelled by accumulation of an excessively large debt in the real sector problems lead to a situation in which one has to repay the debt to restore the equilibrium. The debt repayment subsequently triggers a fall in deposits and assets sales on a cheap. All these factors send growth rates in prices and output nose-dive, as well as trigger a rise in unemployment and in the number of bankruptcies. So, Fisher believes that the main cause for financial turmoil is a negative dynamic of the fundamental indicators.

Let us note that until today Russian researchers have undertaken just a few attempts to build the national financial sector monitoring indicators. More specifically, Struchenevsky³ studies into the dynamic of macroeconomic parameters that describe the financial system's behavior in the period of normal development, pre-crisis periods, and directly in the times of financial crises in Russia. Plisetsky⁴ recaps on the international record of forecasting of financial crises with the use of an early warning system.

As well, a number of research was conducted in RF to build early indices designated for foreseeing a future economic dynamic. However, such works rested primarily on the qualitative analysis and were aimed at forecasting the situation in the real sector, rather than in the financial one. For example, Smirnov⁵ puts forward a system of early indicators for Russia, which formed the basis for his calculations, which would enable one to arrive at certain conclusions regarding the economic dynamic in the country. In his paper, Ostapkovich⁶ considers indicators different countries employed to build an aggregate early index.

All the research papers that center on exposing the financial turmoil harbinger indicators can be classified into three groups, depending on the methodology employed, to identify the best indicators in question.

1. *Qualitative analysis*. The approach suggests a graphic comparison of the dynamics of the fundamental economic indicators on the eve of a financial crisis and in a normal state. The most renowned research in this direction by far have been works by J. Aziz, R. Salgado, J. Caprio, D. Klingebiel, F. Caramazzi⁷.
2. *Econometric modeling*. Under this approach, one builds econometric models to identify correlation between a given indicator and the probability of the financial crisis. Most often, the authors of these models (G. Corsetti, P. Pesenti, N. Rubini, A. Demirguc-Junt, M. Krueger, among others)⁸ employed logit-analysis or probit-analysis, under which they test a regression model that mirrors correlation between the probability of a financial crisis and a series of economic indicators. The tested model is employed for forecasting the probability of the financial crisis.
3. *Non-parametric testing*. Under this approach, researchers design various numerical characteristics that allow an early identification of an economy's exposition to financial

² Fisher I. The Debt-Deflation Theory of Great Depression // *Econometrica*. 1933. Vol. 1 (October). P. 337–357.

³ Struchenevsky A.A. Empirichesky analiz finansovykh krizisov v Rossii // *Ekonomichesky zhurnal VSHE*. 1998. Vol. 2 № 2. pp. 197-209

⁴ Plisetsky D. Systema monitoring finansovogo sektora ekonomiki // *Bankovskoye delo* № 9. 2004. Pp 6-10.

⁵ Smirnov S. Systema operezhayuschikh indikatorov dlya Rossii // *Voprosy ekonomiki*. 2001. № 3

⁶ Ostapkovich D. O sisteme indikatorov tsyklichnosti ekonomiki // *Voprosy statistiki*. 2000. № 12

⁷ See: Aziz J., Caramazza F., Salgado R. Currency crises: in search of common elements // IMF working paper 00/67. March 2000; Caprio J., Klingebiel D. Bank insolvencies. Cross-country experience. World Bank Policy Research Working paper. 1620. 1996.

⁸ Corsetti G., Pesenti P., Roubini N. Paper tigers? A model of the Asian crisis // NBER Working Paper No 6783. November 1998.; Demirguc-Kunt A. Detragiache E. Financial liberalization and financial fragility. Prepared for the 1998 World Bank Annual Conference on Development Economics. 1998.

crisis. It was such authors as G. Kaminsky, S. Lizondo, H. Edison, J. Hawkins, M. Klau⁹, whose contribution to this direction of research was most notable. In the frame of this approach one can single out two main directions – building threshold values of early warning indicators of the financial crisis on the basis of various criteria and designing aggregate financial stability indices.

We believe that the qualitative analysis bears a great deal of subjectivity in interpretation of the indicators' dynamic. That is why it is imperative to develop some quantitative characteristics which would allow a greater objectivity of the monitoring of financial stability. An analysis of the global record in the financial stability monitoring allows one to argue that there exist two main ways of designing such characteristics.

The first way is econometric modeling, i.e. testing binary choice models with different financial instability indicators that are employed as exogenous variables. But, because of a number of reasons, we consciously rejected such an analysis.

First, our examination of the international record of building econometric models to assess the probability of the rise of financial instability, showed that, despite consideration of the same crisis episodes, different authors produce fairly different findings, both in terms of the best early warning indicators and in terms of selection of threshold values of the indicators. Choosing this or that econometric model to employ results of its testing for the purpose of the financial stability monitoring would not be far less subjective an exercise than a plain qualitative analysis of the indicators dynamic. Plus, none of the examined papers displayed any advantage borne by econometric testing vis-à-vis non-parametric methods.

Secondly, because the binary choice models are non-linear, it appears hard to test the contribution of each regressor into growth of the probability of emergence of a financial instability in the event the actual value of the indicator significantly biases from the average one.

Finally, to obtain statistically significant tests, a fairly big number of crisis episodes is needed. Until the crisis of the fall 2008, there had been only 4 episodes by which statistical data are available – namely, the August 1995 crisis on the interbank market, the stock market crisis in October 1997, a huge financial crisis in August 1998, and the crisis in confidence in the national banking system in May 2004. The existence of just 4 episodes clearly appears insufficient to test the binary selection model. Its testing on the panel data (i.e. with the use of data on cross-country crisis episodes), in our view, is undesirable, as it would significantly diminish the power of the criterion, according to which the probability of emergence of the financial instability is assessed. The fact of the matter is that, despite their common features, crises display numerous peculiarities determined by specificities of the respective economies. That is why the dynamic of the financial stability indicators on the eve of a crisis differs from country to country.

So, due to the above reasons, we have opted for nonparametric methods. When compared with them, the econometric analysis methodology appears far more complex and requires fulfillment of a great number of premises with regard to the employed data. Meanwhile, the methodology we use is transparent, while its findings are easy to interpret. They, of course, have their limitations – more specifically, if the methods are implemented, it is harder to employ standard statistical tests. But we, anyway, believe that the balance of pros and cons of the nonparametric approach testifies to the fact that it appears more preferred over the other methods. Let us note that most papers that deal with forecasting of the unfolding of financial turmoil with the use of such methods employ the so-called “signal” approach¹⁰, first proposed by Kaminsky, Lizondo,

⁹ Kaminsky G., Lizondo S., Reinhart C. Leading Indicators of Currency Crises // IMF Staff Papers. 1998. Vol. 45 (March). P. 1–48; Edison H. Do indicators of financial crises work? An evaluation of an early warning system. Board of Governors of the Federal Reserve System International Finance Discussion Paper No. 675. July 2000; Hawkins J., Klau M. Measuring Potential Vulnerabilities in Emerging Market Economies. BIS Working Paper 91. October 2000.

¹⁰ For the brief description of this approach, see: Drobyshevsky S., Trunin P., Paliy A., Knobel A. Nekotorye podkhody k razrabotke indikatorov monitoring finansovoy stabilnosti. Nauchnye trudy. № 103P. – M.: IEPP, 2006.

and Reinhart¹¹ back in 1998. However, it has not been tried by far to evaluate Russia's financial system. That is why we decided to adapt it to develop a system of leading indicators of financial instability on Russia's market, as well as to build an aggregate financial instability index for Russia.

Methodology of the Signal Approach

While realizing the signal-based approach, it is assumed there is the necessity to test zero hypothesis of the economy being in a normal state vis-à-vis an alternative hypothesis of the possibility of some financial turmoil within the upcoming three to six months. As in the course of testing of any statistical hypothesis, a threshold (critical value¹²) should be picked. If a value of a given indicator goes beyond the preset threshold, the indicator is believed to send a signal. To select an optimal threshold value for each indicator, one needs to set up some criterion. It is the indicator that takes into account the balance between "bad" signals and "good" ones, which is used as such a criterion¹³. To build the indicator, let us break all its values into four groups (see *Table 1*). Needless to say, in the ideal case all its values will fit into cells A and D.

Table 1

The Signal-Based Approach to the Testing of Harbinger Indicators

	Crisis is there for 3 months	No crisis over 3 months
Signal in place	A	B
No signal	C	D

Using *Table 1*, it is easy to clarify the methodology of picking the marginal values. Let us identify an unconditional probability of the looming financial turmoil (1) for each indicator as the ratio of observations that were followed by the financial turmoil within 3 months to all observations.

$$P(C) = \frac{A + C}{A + B + C + D} \quad (1)$$

Should the indicator send a great number of "good" signals, it can be expected that the probability of the rise of a financial instability on condition of the signal generation $P(C | S)$ would be greater than the unconditional probability $P(C)$. Meanwhile,

$$P(C | S) = \frac{A}{A + B} \quad (2)$$

That is to say, in order to make sense out of the use of the indicator in question for forecasting the emergence of financial instability, the following correlation should be complete:

$$P(C | S) > P(C) \quad (3)$$

¹¹ Kaminsky G., Lizondo S., Reinhart C. Leading Indicators of Currency Crises // IMF Staff Papers. 1998. Vol. 45 (March). P. 1–48.

¹² We will be testing single-sided hypotheses, that is, we assume that either a rise, or a fall of a given indicator may evidence growth in the probability of the emergence of financial instability.

¹³ The signal is "bad", providing its generation is not followed by financial turmoil. Accordingly, the "good" signal is transmitted on the eve of the financial instability.

Let us label this condition as the one necessary for selection of an optimal threshold value. Besides, while picking the threshold values, we minimized the “bad” signals to “good” ones ratio:

$$N/S = \frac{B/(B+D)}{A/(A+C)} \quad (4)$$

So, we considered all possible threshold values for each indicator over a maximum possible time period and opted for the threshold value under which the value of the indicator (4) was minimal, while condition (3) was observed with. Let us note that in a number of cases it may happen that the “bad”-to-“good” signal ratio accounts for zero, because the proportion of “bad” signals is zero, while the indicator is too insensitive, i.e. it does not send signals on the eve of a considerable number of crises. That is why, while selecting indicators and their threshold values, it is also imperative to remain attentive to the proportion of crises a given indicator heralds (let us denote it as *PC*) in the overall number of crises. The review of the literature, as well as the qualitative analysis of various macroeconomic indicators allowed setting the following list of indicators, which, potentially, can signal about a looming financial instability:

- Economic growth rate:
 - GDP growth rate;
 - Dynamic of industrial output;
- Balance of payments:
 - Balance of the current account of the balance of payments;
 - Gold and foreign exchange reserves;
 - Foreign public debt;
 - Terms of trade (export prices);
 - Import and export;
 - Real effective exchange rate;
 - Net capital outflow;
 - Capital flight
- Interest rates:
 - Real interest rate;
 - Spread between the domestic interest rate and the LIBOR rate;
 - Credit interest rate to deposits interest rate ratio.
- Monetary indicators:
 - Consumer price index (CPI);
 - Domestic credit in real terms;
 - Money multiplier;
 - Deposits in real terms;
 - Money supply to gold and foreign exchange reserves ratio;
 - «Excess» money supply in real terms.
- The index of pressure on the forex market.

In most cases we employed increase rates of the indicators or considered their ratio to GDP, which enabled us to ensure the data consistency. At the same time, in a number of cases, for the sake of analysis we employed an indicator expressed on levels, as it was the form in which they demonstrated the greatest prognostic power. *Table 2* comprises the description of modifications applied to the indicators, as well as periodicity of the data and their source.

Table 2

Some characteristics of the Financial Stability Eearly Warning Indicators

Indicator	Modification of the variable	Periodicity	Source
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GDP growth rate	Growth rate in real terms vs the same period of the prior year (SPPY)	Quarterly	Rosstat
Dynamic of industrial output	Increase rate to the prior period	Monthly	Rosstat
Balance of the current account of the balance of payment	Level	Quarterly	CBR
Gold and forex reserves	Increase rate to the prior period	Monthly	CBR
Foreign debt	% of GDP	Quarterly	CBR
Terms of trade* (prices for Brent)	Level	Monthly	IFS**
Import and export	Increase rate to SPPY	Monthly	IFS
The Rb. real effective exchange rate	Increase rate to the prior year	Monthly	CBR
Net capital outflow***	Level	Quarterly	CBR, IET calculations
Capital flight	Level	Quarterly	CBR, IET calculations
Real interest rate on the interbank market	Level	Quarterly	CBR, IET calculations
Spread between the domestic interest rate and LIBOR rate	Level	Monthly	CBR, IFS, IET calculations
The credit rate to deposit rate ratio	Level	Monthly	CBR, IET calculations
CPI	Increase rate to SPPY	Monthly	Rosstat
Domestic credit	Increase rate in real terms to the prior period	Monthly	CBR
Money multiplier	Level	Monthly	CBR, IET calculations
Deposits****	Increase rate to SPPY	Monthly	CBR, Rosstat, IET calculations
Money supply to gold and forex reserves ratio	Level	Monthly	CBR, IET calculations
«Excess» money supply in real terms *****	% of GDP	Quarterly	CBR, Rosstat, IET calculations
Index of pressure on the forex market *****	Index	Monthly	CBR, IET calculations

Notes:

*Originally, this indicator constitutes the export prices to import prices ratio. However, because of the absence of export and import prices in Russia's statistics of balance of payment, this calculation is impossible. We considered, as an analogous indicator, the price dynamic for Brent. As oil forms one of main Russia's exports, the index of changes in its price, under the premise of a relatively unchanged prices for imports, may serve a fairly trustworthy indicator of the country's trade conditions.

** The IMF data base – International Financial Statistics (IFS)

*** Net capital outflow is the balance of the capital flows account for banks and non-financial corporations, as well as net errors and omissions. Capital flight is characterized by the sum of trade credits and advance payments, export gains not repatriated on time, and net errors and omissions. A positive value of the indicators means capital inflow, while a negative one – capital outflow.

**** We consider the amount of demand deposits, time deposits, saving deposits, and deposits denominated in foreign exchange.

***** An “excess” money supply in real terms constitutes a bias of the tested money supply from the observed money supply (in the form of the proportion of money supply in GDP), i.e. as a balance of the regression equation of

the following form : $\frac{M_t}{GDP_t} = a_0 + a_1 Y_t + a_2 \Delta p_t + a_3 t + \varepsilon_t$,

where M_t – money supply M_2 ; GDP_t – nominal GDP; Y_t – volume of GDP (in real terms); Δp_t – consumer price index; t – time. The balances ε_t are interpreted as an indicator of an “excess” lending in an economy.

***** The index constitutes the average weighted value of the three indicators:

- 1) the monthly increase exchange rate of the domestic currency, \dot{E} ;
- 2) the increase rate in gold and foreign exchange reserves (with an inverse sign), \dot{R} ;
- 3) the interest rate level (for Russia – interest rate on the interbank lending market), i .

The two latter items mirror the monetary authorities' policy on the forex market in the event a speculative attack on the national currency occurs. It is assumed that under the fixed (regulated) exchange rate such an attack would lead to a fall in the nation's gold and forex reserves. On the other hand, under any forex regime, the central bank can raise interest rates to protect the national currency. It is considered while being included in the formula for the sake of calculation of the index of the third item. So, the index of "pressure on the forex market" is calculated as:

$$I = \frac{w_1 \dot{E} + w_2 (-\dot{R}) + w_3 i}{3}.$$

Weights w_1, w_2, w_3 are selected in such a manner, so that to ensure that variances of all the three values are equal,

i.e. $D(w_1 \dot{E}) = D(w_2 \dot{R}) = D(w_3 i)$. Accordingly, taking $w_1 = 1$, $w_2 = \sqrt{\frac{D(\dot{E})}{D(\dot{R})}}$, $w_3 = \sqrt{\frac{D(\dot{E})}{D(i)}}$.

Application of the above methodology of selecting early warning indicators of financial instability in RF allowed obtaining the results presented in *Table 3*. The threshold values were built on the basis of evaluation of the data over the period between January 1994 and December 2006 (with account of their availability across individual indicators).

Table 3

Results of Employment of the Signal Approach¹⁴

Indicator	Threshold value	<i>N/S</i>	<i>PC</i>	<i>P(C S)</i>	<i>P(C S) – P(C)</i>
Balance of the current account of the balance of payments*	– 1.5 USD bn	0	0.5	1	0.85
Real interest rate on the ILM	4.4%	0	0.5	0.75	0.67
Money supply to gold and forex reserves ratio*	3.7	0.12	0.5	0.63	0.46
The Rb. real effective exchange rate	+ 6.5%	0.08	0.25	0.5	0.42
“Excess” money supply in real terms	2.2% of GDP	0.09	0.5	0.5	0.42
Spread between the domestic interest rate and the LIBOR rate	40 p.p.	0.17	0.5	0.35	0.27
GDP growth rate*	– 5.2%	0.31	0.25	0.4	0.23
Terms of trade (prices for Brent)	12.1 USD/barrel	0.18	0.25	0.29	0.22
Capital flight*	– 8.3 USD bn.	0.55	0.25	0.25	0.1
Gold and forex reserves	– 2.2%	0.45	0.75	0.16	0.08
Export	– 1.4%	0.5	0.5	0.14	0.07
Domestic credit	1.6%	0.52	0.5	0.13	0.06
Index of pressure on the forex market	1.7	0.52	1	0.15	0.06
CPI	222%	0.56	0.25	0.12	0.05
Deposits	– 0.9%	0.6	0.5	0.11	0.04
Import	+ 40.5%	0.84	0.25	0.09	0.01
Money multiplier	2.02	0.9	1	0.08	0.01
Credit interest rate to deposit rate ratio	1.73	0.95	1	0.09	0
Net capital outflow	+ 2.8 USD bn.	0.88	1	0.07	-0.01

Evaluation of the findings allows one to conclude that employment of all the indicators, except for net capital outflow, enables one to forecast the rise of financial instability with the probability

¹⁴ By asterix we noted the indicators for which the best results were gotten under calculations with the use of a six-month signal window prior to the crisis.

rate being greater than the unconditional one. In other words, the employment of the proposed methodology gives a possibility to predict a financial instability, at least, better than with the use of frequency of the past financial crises, as the forecast, which, in our view forms a necessary condition of the indicator's efficiency. In addition, we propose to set a lower threshold of the excess of the conditional probability over the unconditional one at the level of 5 p.p. as the criterion of efficiency of an indicator. In this case, it will be 13 indicators that would for the group of efficient indicators, whose analysis would enable one to predict financial instability. *Table 4* provides data on the state of the system of functional leading financial instability indicators on the eve of the past crisis episodes in RF.

Table 4

**The State of the Financial Instability Leading Indicators
on the Eve of Crisis Episodes in RF**

Crisis episode	The number of indicators across which there are the pre-crisis statistics	The number of indicators that set the signal within 3 months prior to the crisis	The proportion of indicators that set the signal in the overall number of indicators, as %
The interbank market crisis, Aug 1995	12	5	42
The stock market crisis, Oct 1997	13	6	46
The financial crisis, Aug 1998	13	9	69
The confidence crisis in Russia's banking system, May 2004	13	5	38

It can be noted from *Table 4* that it was the financial crisis of August 1998, whose approaching was signaled by the greatest number of indicators. It should have been expected, as the magnitude of the crisis by far has been the greatest one. As concerns the other episodes, some 40% of indicators would set respective signals. But it may well happen that a proportion of indicators that signal the looming financial instability does not form the best aggregate indicator of financial stability in a country. In other words, as the number of the examined indicators is sufficiently big, there arises the problem of aggregation of the information provided by the examination of the dynamics of individual indicators. We considered some variants of such aggregation, i.e. of the building of aggregate financial stability indices.

The first one merely represents a sum of all the signals set at moment t :

$$I_t^1 = \sum_{j=1}^{13} S_t^j \quad (5)$$

It is clear, however, that this index falls short of factoring in numerous factors. For example, the probability of financial instability can grow, but that does not mean that all indicators would simultaneously set the signal. That is why to monitor a gradual accumulation of problems in the economy, it is suggested employing the following index, too:

$$I_t^2 = \sum_{j=1}^{13} S_{t-s,t}^j, \quad (6)$$

where $S_{t-s,t}^j$ equals 1, should indicator j set signal at least once in s months prior to moment t . Parameter s is set exogenously; proceeding from our premise that the crisis symptoms should manifest themselves, as a minimum, over three months prior to its start, we will assume that s equals 3.

The above two indexes do not fully use the information obtained while building the threshold values of the leading indicators, as they fail to take into account their individual forecast accuracy rates. It would be a logical way to factor this information in by weighing individual indicators with the use of values that equal the excess of the conditional probability of the rise of financial instability, in the event they have set the signal, over the unconditional one:

$$I_t^3 = \sum_{j=1}^{13} S_t^j (P^j(C|S) - P^j(C)) \quad (7)$$

After calculating the values the indices posted between July 1995 and December 2006, we tested probabilities $P(C | \underline{I} \leq I_t < \bar{I})$ of the rise of financial instability under different values posted by the indices:

$$P(C | \underline{I} \leq I_t < \bar{I}) = \frac{A}{A+B}, \quad (8)$$

where \underline{I} – the lower margin of the interval for which the probability of the rise of financial instability is computed; \bar{I} – the upper margin of this interval; A equals the number of cases when the index value found itself within the interval $[\underline{I}; \bar{I})$ and a crisis burst out within the next three months; B equals the number of cases when the index value was in the same interval, but no crisis occurred over the next three months.

To test the prognostic power of the indices, we suggest testing the bias of empirical probabilities of the rise of financial instability P_t from actual probabilities, under which we will understand values of the dummy variable R_t , which takes form 1 within three months prior to the crisis and 0 – in the other cases. Accordingly, the following indicator can be calculated for each index:

$$Q^k = \frac{1}{T} \sum_{t=1}^T (P_t^k - R_t)^2, \quad (9)$$

where $k = \{1,2,3\}$ depicts an index for which the prognostic power is calculated, while T equals the number of observations.

Table 5 gives values of indicator Q :

Table 5

Prognostic Power of Various Financial Stability Indicators

Indicator	Prognostic power (Q)
Unconditional probability	0.134
Balance of the current transactions account of the balance of payments	0.130
I^1	0.093
I^2	0.105
I^3	0.074

It can be noted from Table 5 that it is the aggregate index, which factors in each indicator's "operational capacity", that allows one to forecast a looming financial instability. It forecasts it more accurately than any leading indicator, and its employment appears notably more efficient than the value of the unconditional probability of financial instability. Meanwhile, it appears appropriate to employ all three aggregate indices to examine the situation in the financial sector.

Monitoring of Financial Stability in RF in the 4th Quarter 2008

Results of the employment of the quantitative analysis methodology are presented in *Table 6*. It contains the values of the leading indicators registered between the 2nd and the 4th quarters 2008, their threshold values. As well, the *Table* reflects whether or not they set the signal.

Table 6

The State of the System of Financial Instability Indicators in the 2nd-4th Quarters 2008

Indicator	Threshold value	2 nd Q. 2008		3 rd Q 2008		4 th Q 2008	
		Value	Signal	Value	Signal	Value	Signal
Balance of the current account of the balance of payments	- 1.5 USD bn.	25.8 USD bn.	0	27.6 USD bn.	0	8.1 USD bn.	0
Real interest rate on the ILM	4.4%	- 0.7%	0	- 0.2%	0	0.0%	0
Money supply to gold and forex reserves ratio	3.7	1.07	0	1.02	0	1.08	0
The Rb. real effective exchange rate	+ 6.5%	0.5%	0	- 0.4%	0	- 3.6%	0
"Excess" money supply in real terms	2.2% of GDP	1.1% of GDP	0	- 0.1% of GDP	0	- 5.4% of GDP	0
Spread between the domestic interest rate and the LIBOR rate	40 p.p.	1.47 p.p.	0	4.06 p.p.	0	8.02 p.p.	0
GDP growth rate	- 5.2%	+ 7.5%	0	+ 6.2%	0	+ 1.1%	0
Trade conditions (prices for Brent)	12.1 USD/barrel	140.1 USD/barrel	0	98.8 USD/barrel	0	44.3 USD/barrel	0
Capital flight	- 8.3 USD bn.	- 10.1 USD bn.	1	- 11.9 USD bn.	0	- 13 USD bn.	1
Gold and forex reserves	- 2.2%	+ 4.2%	0	- 4.4%	1	- 6.3%	1
Export	- 1.4%	+ 63.4%	0	+ 53.9%	0	- 31.8%	1
Domestic credit	1.6%	+ 3.8%	1	+ 1.5%	0	+ 14.4%	1
Index of pressure on the forex market	1.7	0.02	0	3.33	1	5.5	1

When compared with the 3rd quarter 2008, the probability of the rise of the financial crisis grew notably in the next quarter. Negative trends were on the rise in Russia's financial sector – five out of 13 indicators gave signals in different months of the quarter – namely, gold and forex reserves, the index of pressure on the forex market, domestic credit in real terms, export, and capital flight. Such a big number of indicators setting the signal was noted for the first time since March 2004 (prior to the crisis of confidence in Russia's banking system). But at the time such a situation was noted just over one month, while results of the most recent monitoring evidenced that as many as five indicators signaled the upcoming turmoil in November and December. Such a state of the system of financial stability indicators was noted just on the eve of the 1998 crisis. Meanwhile, let us note that it was the indicators that carried the least weight in the financial

instability index that set the signal. However, there is every reason to believe that the situation in Russia's financial sector may further aggravate over time.

The period of late 2008-early 2009 has highlighted a significant magnitude of the economic crisis that battered the country. Meanwhile, thanks to the accumulated reserves and the national monetary authorities' timely reaction, the government has by far avoided a mass bankruptcy of credit organizations and exodus of their customers. But the state of the system of financial stability indicators speaks in favor of hard times facing Russia's financial system in the medium-term.

We fixed the state of the system of leading indicators which corresponds to some 40% probability of growth in the magnitude of financial instability over the upcoming 1-2 quarters. This result evidences that the probability of the further aggravation of the situation in the financial sector and, consequently, in the real sector may remain high over the first half 2009.

Conclusions

The findings referenced to in the present paper allow one to argue that both theoretical and practical research prove there is a possibility for building indicators that enable experts to conduct a timely forecasting of the rise of financial instability. International experience demonstrates that the financial stability indicators can be successfully employed to forecast the rise of financial instability.

Our examination of approaches to forecasts of financial turmoil allowed us to compile a theoretically substantiated list of indicators whose efficiency was first tested on the Russian financial market. The list comprises such indicators as the real exchange rate, GDP growth rate, dynamic of the domestic lending and money supply, change in consumer prices, terms of trade, among others. The statistical testing of the said indicators offers the possibility to forecast the rise of financial instability with a probability rate being in excess of an unconditional probability of the rise of financial instability.

Development of a system of the financial instability leading indicators for a specific country, rather than a group of countries, allows a considerable increase in the indicators' efficiency, which appears particularly important, should economic agents employ the suggested methodology for the sake of decision making. The fact of the matter is, while analyzing a given country's financial market, it becomes plausible to consider its specificity and adjust threshold values of the leading indicators accordingly. For Russia, it is the balance of the current account of the balance of payments, the real interest rate, the money supply to gold and forex reserves ratio, the Rb. real effective exchange rate and "excess" money supply in real terms that became the most efficient indicators.

The paper suggests original aggregate financial stability indices in RF, using which one can get a quantitative assessment of the probability of the rise of financial instability.

Employment of the suggested methodology for the sake of evaluation of financial stability in the 4th quarter 2008 demonstrated that five out of thirteen indicators set the signal of a high probability of the rise of the crisis. Those were: gold and forex reserves, the index of pressure on the forex market, domestic credit in real terms, export, and capital flight. Such a shape of the harbinger indicator system matches corresponds to some 40% probability of the rise of financial instability within the future one-two quarters. Given the negative trends in the economy, we estimate the probability of aggravation of the financial crisis in RF in 2009 as being a high one, particularly if the state of affairs in the foreign trade area is going to worsen further on.