Does Only Volume Matter? Stress-test for the Adequacy of International Currency Reserves for Russia

Oleg Solntsev, Renat Akhmetov, Vera Pankova, Elizaveta Cepilova

The Center for Macroeconomic Analysis and Short-term Forecasting (CMASF)

Introduction

- This study determines the adequate volume of international currency reserves of the Bank of Russia to prevent harmful fluctuations of the ruble exchange rate causing a threat to financial stability and the deficit of foreign exchange liquidity.

- The Bank of Russia does not directly intervene in the ruble exchange rate and uses only tools of temporary provision or absorption of foreign currency liquidity (for example, foreign exchange REPO operations). This means that in our study we focus on the role of the Bank of Russia as a lender of last resort in terms of providing currency liquidity (see Gopinath, Stein, 2018).

- The experience of the recent currency crises of 2008-2009 and 2014-2015 in Russia reflects that under stress conditions panic demand for foreign currency is showed by not only banks but also by non-financial companies and households. It implies that our models of demand for foreign currency should consider the behavior of several sectors of the economy in accordance with the approach of Čeh, Krznar (2009) and Gopinath, Stein (2018).

Literature review

- ***"Mercantilist motive"*** (Dooley et al., 2005, 2009; Aizenman, Lee, 2008). This is about the accumulation of foreign exchange reserves to prevent the appreciation or depreciation of exchange rate of the national currency in order to support industries of the economy (mainly export-oriented countries of East Asia - Japan, South Korea, China, Hong Kong, etc.), which receive competitive advantages in foreign markets due to the cheapness of their currencies. Within the context of this motive of international reserve accumulation, their volume is a consequence of the regulation of the exchange rate, and the question of the optimality or redundancy of reserves is not significant.

- ***"Precautionary motive"*** (Jeanne, Ranciere, 2011) – the desire to accumulate foreign reserves for the protection against the negative impact of crises such as sudden stops of capital inflows, capital flights and the increasing volatility of financial markets (Aizenman, Lee, 2007). Researchers working in this area suggest that reserves serve as insurance for the economy, which allows a reduction of possible losses in the level of GDP, the investment and welfare of the population in case of currency volatility (Čeh, Krznar, 2009). A number of studies have noted that the volume of international reserves is negatively correlated with the probability of crisis, i.e. the fact of accumulation of reserves reduces the possibility of crisis events (Garcia, Soto, 2006; Čeh, Krznar, 2009; Gourinchas, Obstfeld, 2012; Bussière et al., 2015). The feature of this approach is that researchers are concerned about the optimal level of reserves, since an excessive amount of hoarding is associated with costs, and it can lead to the inefficient use of national savings.

Novelty of the investigation

- Since we consider cases of panic demand for foreign currency, we simulate only the demand which significantly exceeds the trend values and we do not consider the aggregate demand for foreign currency in the Russian foreign exchange market. This panic demand is assumed as the effect of *"fire sales"* (Shleifer, Vishny, 2011; Cont, Schaanning, 2017) of assets denominated in rubles by economic agents (households and industries) in order to limit their losses.

- Two channels of demolishing the impact of panic demand for foreign currency liquidity on financial sector sustainability are modeled. The first one is the conversion of previously accumulated rubles into foreign currencies by bank customers. The second is a surge of activity in foreign currency customer accounts (due to increased mistrust), which means the transfer of foreign currency from bank to bank (including foreign banks) and withdrawals. It is assumed that the harmful impact through both of these channels on financial sector stability may be stopped by the short-term provision of foreign currency liquidity by the Bank of Russia. For example, a suitable tool in this case is foreign exchange REPO transactions, which removes the short-term shortage of currency liquidity.

- The currency crisis in this research is modeled as an iterative process, so it allows us to evaluate the results of providing by the Bank of Russia currency liquidity. The analysis is based on stress-testing methodology, which assumes assessing the consequences of the occurrence of rare, but probable negative shocks.

- In this way, our approach involves a quantitative assessment of the volume of the Bank of Russia's liquidity provision, which is necessary to prevent the destructive effects of an explosive depreciation in the exchange rate. The short-term consequences for the sustainability of the Russian banking sector that arise from the crisis are also estimated. The most significant indicators of banking sector instability are the number of banks which have lost financial stability (including the systemically important ones), the total deficit of equity in the banking system and the total shortage of the liquidity of banks.

Methodology – The general scheme of the analysis of the sufficiency of international reserves
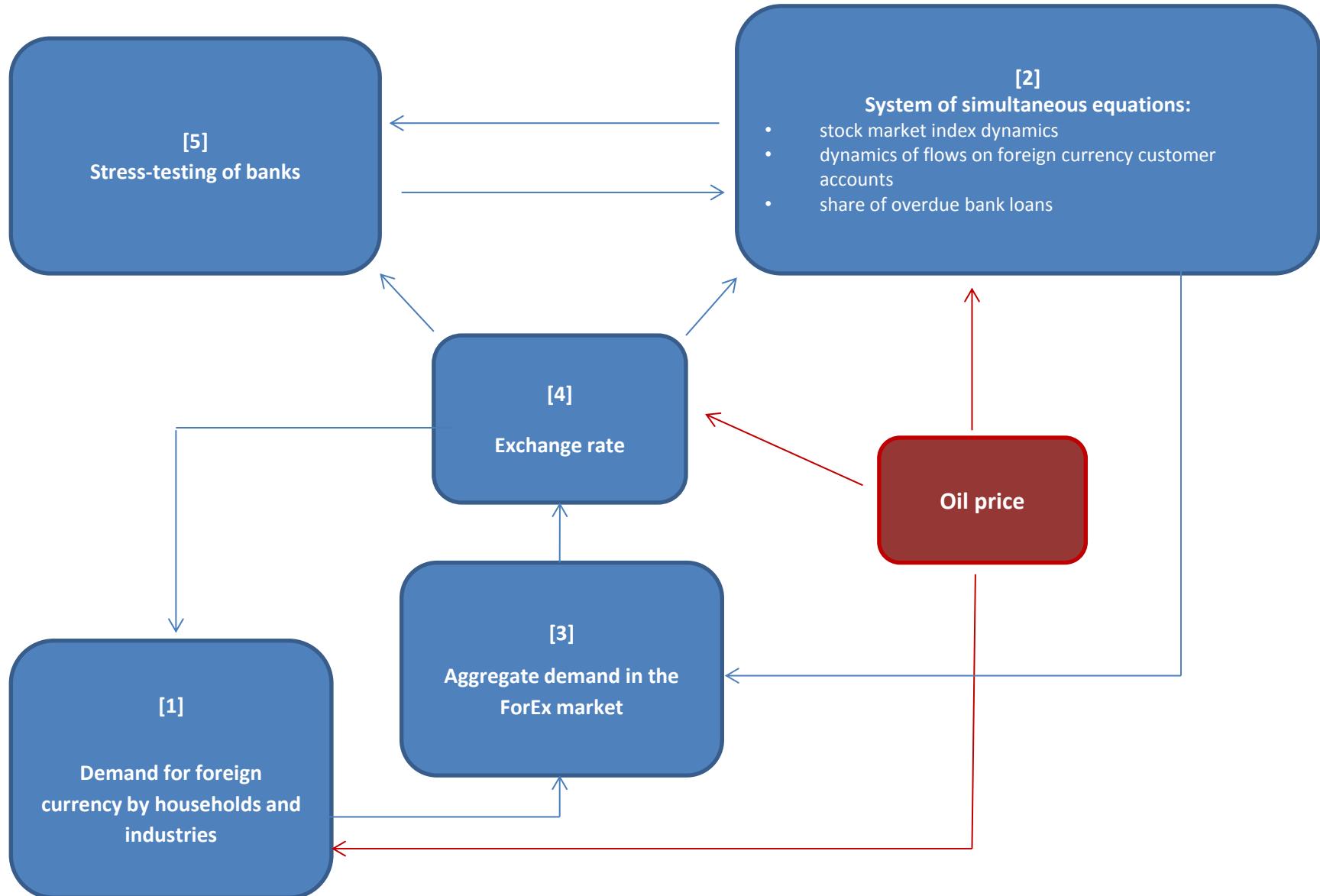
Methodology – The general scheme of the analysis of the sufficiency of international reserves

- **The first block** describes the analysis of the behavior of households and industries with stress in the foreign exchange market and a fall of oil prices. In this block we construct the model which corresponds to the first channel of the harmful impact on the foreign currency liquidity of banks (the conversion of previously accumulated rubles into foreign currencies by bank customers). The model includes such individual characteristics of industries as profit, debt burden denominated in rubles and debt burden denominated in foreign currency, the volume of exports and imports, which determine the demand for foreign currency liquidity for each of the industries. If there is a sharp decrease in the exchange rate, then all industries have a panic demand for currency, which leads to a further amplification of the exchange rate (the "fire sales" mechanism).

- **The second block** presents a system of simultaneous equations, which examines the influence of the exchange rate and oil price stresses on stock market dynamics, the share of overdue bank loans, the indicator of the dynamics of foreign currency customer accounts in the banking system (i.e. the second channel). The exchange rate and oil price shocks are exogenous parameters for a system of simultaneous equations.

- **The third block** connects with the calculation of the aggregate panic demand in the foreign exchange market, which is obtained as a result of the impact of the initial shock through the two channels mentioned above.

- **The fourth block** is a model for the dynamics of the exchange rate which is explained by the aggregate panic demand for foreign currency liquidity, by the reduction of oil prices and by the monetary policy rate.

- **The fifth block** is about the stress-testing of the banking system with the simultaneous depreciation of the national currency (ruble) and falling oil prices. The stress-test involves the "fire sales" mechanism for securities. If banks face a foreign currency liquidity shortage due to an imbalance of foreign assets and liabilities, they will try to sell their securities (on the asset side) in order to buy an foreign currency.

Description of stress scenarios

Initial Shock / Scenario	Significant shock	Maximum shock
Exchange rate growth, %	4.3	23.0
Oil price growth (Brent), %	-6.2	-16.4

- **The scenario with the significant currency stress** assumes the depreciation of the ruble by 4.3%, which corresponds to 99 percentile of the appropriate distribution, and the decline in oil prices by 6.2%, which corresponds to 1 percentile of the appropriate distribution.

- **In the scenario with the maximum currency stress,** the dynamics of the corresponding indicators implies their initial change is two times higher than the maximum / minimum growth rate.

Stress-test results for 2018 conditions

Indicators	The significant stress with the immediate provisions by the Bank of Russia	The significant stress with the late provisions by the Bank of Russia	The maximum stress with the immediate provisions by the Bank of Russia	The maximum stress with the late provisions by the Bank of Russia
The amount of highly liquid foreign currency reserves needed to overcome shocks, $ bln.	32.1	92.3	48.4	140.1
The growth rate of the USD/RUB, %	4.3	42.1	23.0	82.7
The volume of "fire sales" of securities carried out by banks to cover the shortage of liquid funds, bln. rubles	600	1049	785	1558
Number of banks that become unstable due to the disability to cover the liquidity and capital shortages	68	79	71	91
Uncovered shortage of capital of the banking system, bln. rubles	1767	2335	1984	7912
Uncovered shortage of liquidity of the banking system, bln. rubles	172	212	184	243

The change in the USD/RUB exchange rate and the volume of highly liquid foreign currency reserves required to the elimination of the shock effects depending on the iteration of crisis amplification
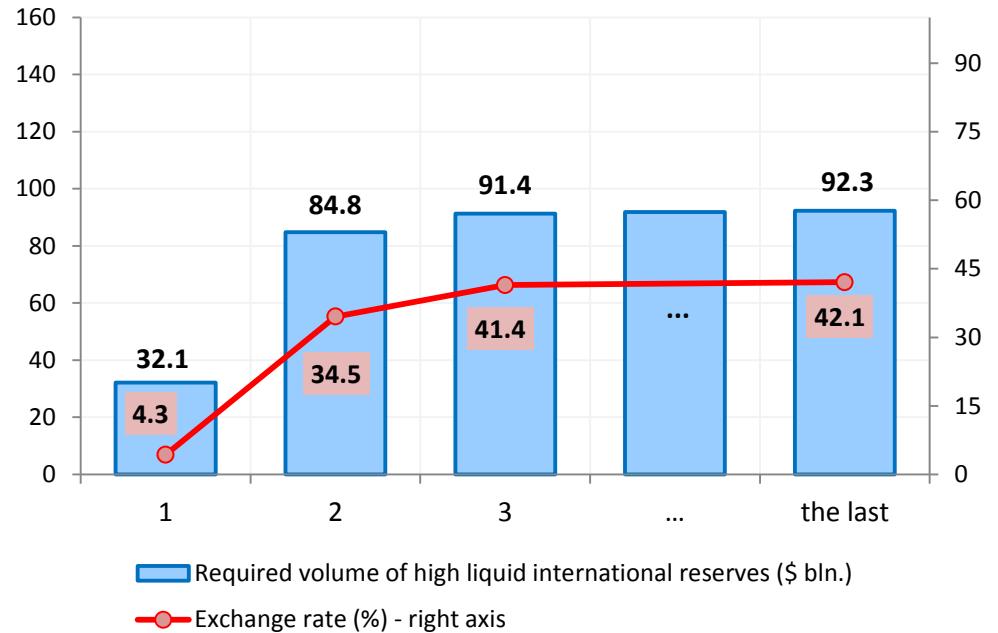

the significant stress scenario for conditions of 2018
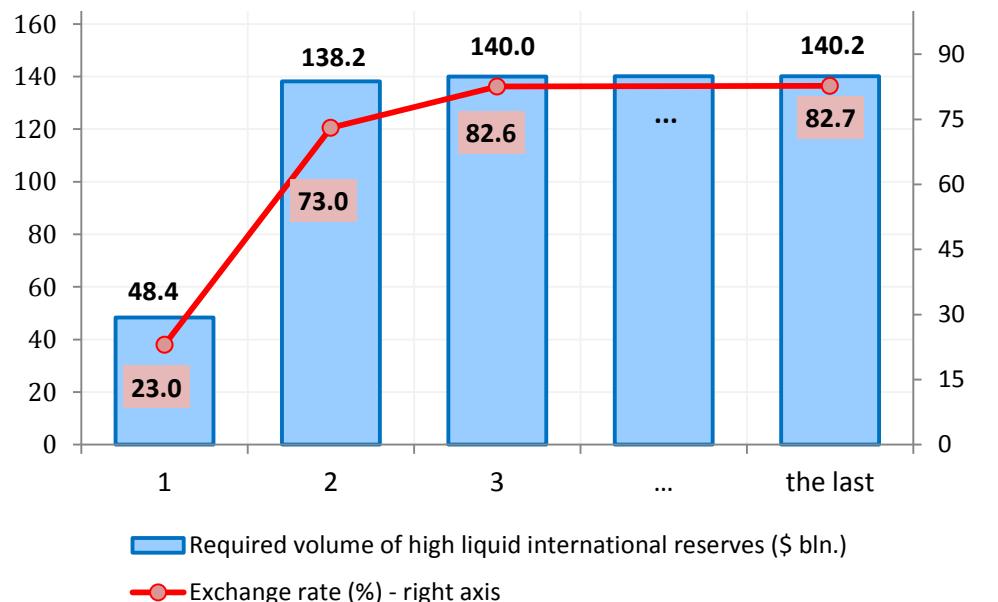
the maximum stress scenario for conditions of 2018

Conclusions

- The stress testing reveals that the current volume of highly liquid international reserves is sufficient for the elimination of harmful consequences of the ruble depreciation by the Bank of Russia, even in the case of maximum stress.

- However, the current volume of highly liquid international reserves is inadequate, if the reaction of the Bank of Russia will be tardy. In this case, the Bank of Russia will have to sell a significant volume of government securities of foreign issuers. It can lead to a devaluation of these securities and additional losses for the reserves of the Bank of Russia. In this connection, the Bank of Russia should change the structure of the currency international reserves in favor of highly liquid assets, by reducing the share of securities and increasing the share of short-term deposits in foreign banks with high credit ratings.

- As for the volume of ***international currency reserves*** for Russia (including less liquid components), ***it is sufficient*** to overcome the maximum possible stress in the foreign exchange market and to subsequently maintain the solvency of the Russian economy.
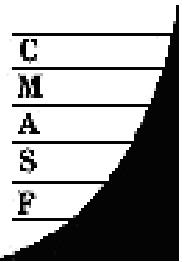
Thank you for attention!

Appendix. Modelling of the demand of companies of the real sector of the economy for foreign currency (1/2)

The demand of companies for foreign currency was estimated on the basis of the analysis of 15 key types of economic activity (industries) by the optimization for each of these agents under the following assumptions:

1) The future annual expenses of the agents, if possible, should not exceed the volume of future annual income.

2) In case of a deterioration of the economic situation (ruble depreciation and fall in export prices) and, as a result, a revaluation of the flow of forthcoming payments on foreign currency debt and changes in exports and imports, the expenses of companies may exceed their incomes. Consequently, companies should try to restore their balances, reducing their potential losses due to purchasing of foreign currency in advance at the expense of available funds generated by profits of the previous period.

3) Firms can use up to 100% of the profit of the previous period to purchase foreign currency without loss for production process. A further increase in purchases of foreign currency leads to the reduction of current assets of companies:

$$\Delta Current\_assets = \begin{bmatrix} 0, if\ purchase \leq profit \\ purchase - profit, otherwise \end{bmatrix}$$

Appendix. Modelling of the demand of companies of the real sector of the economy for foreign currency (2/2)

4) Further, in the case of a reduction in current assets, enterprises gain a loss. Moreover, as the scale of reduction of current assets increase incomes decline even faster. We assume that the relationship between these two indicators at the firm level has a parabolic form specific to each industry. In process of constructing an aggregated loss function for each industry we assume the level of industry concentration:

$$loss_i = \Delta Current\_assets_i * (FE_i + b * Herfindahl_i * \Delta Current\_assets_i),$$

$loss_i$ – losses of industry i in case of sell of current assets

FE_i – industry-specific fixed effect i.e. reduction in income, which is proportional to the withdrawal of current assets;

$Herfindahl_i$ – Herfindahl index for industry i

5) The panic demand of firms and the households for foreign currency reinforces the initial ruble depreciation. It leads to a reassessment of the value of foreign trade transactions and payments on the foreign currency debt, and a possible further deterioration of the expenditure to income ratio. Then the "fire sales" mechanism of ruble assets is launched. At each round of "fire sales" households and industries re-shape their demand for foreign currency to meet the following condition:

$$Debt\_ser_{for} * cur_\$ + Debt\_ser_{dom} + import * cur_\$ + invest$$
$$\leq export * prices_{export} * cur_\$ + other\ income - loss + purchase_{cur} * cur_\$$$

The export share in output by industries, %
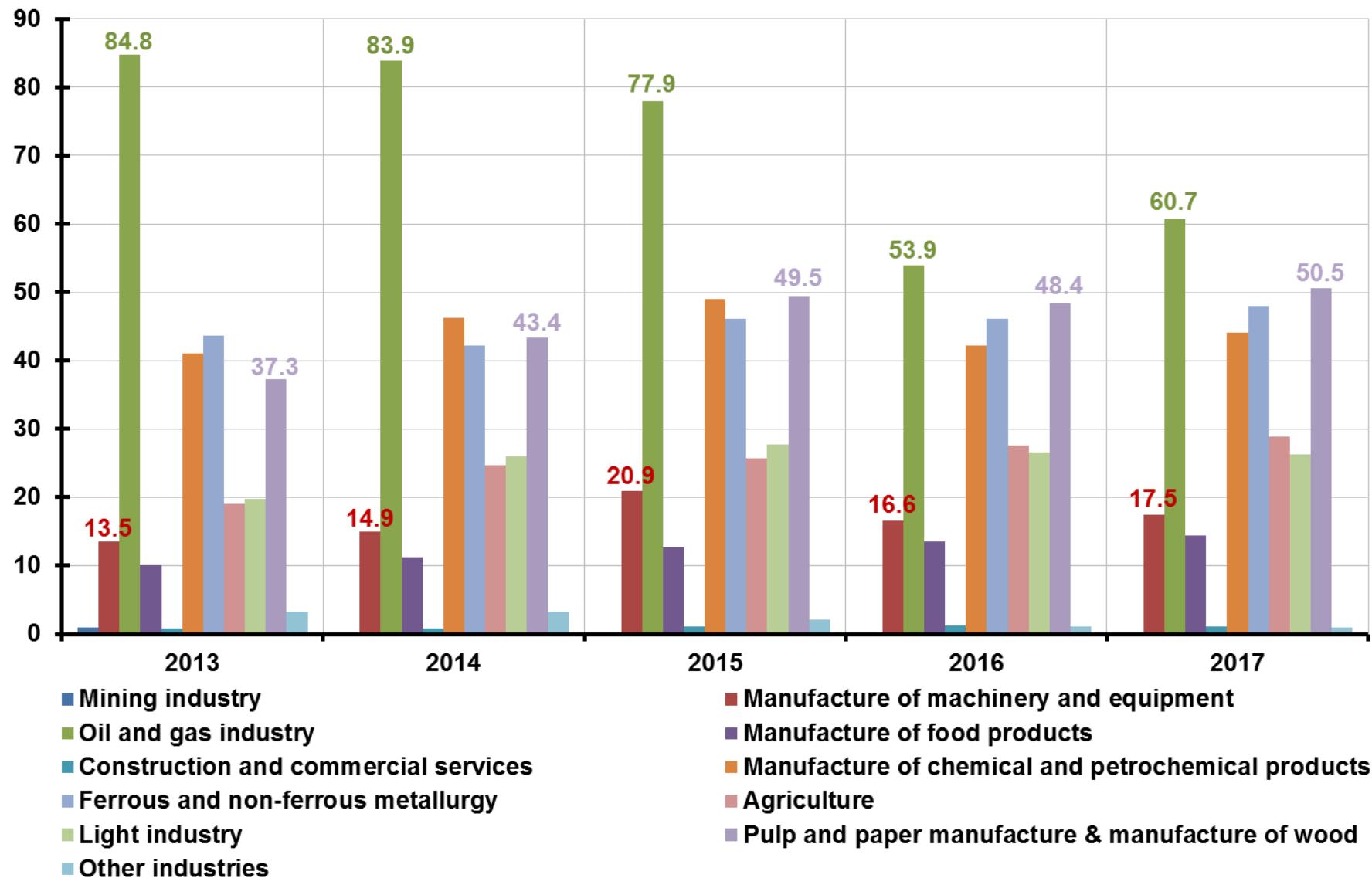
The import share in tangible costs by industries, %

Legend:
- Mining industry
- Oil and gas industry
- Construction and commercial services
- Wholesale and retail trade
- Ferrous and non-ferrous metallurgy
- Agriculture
- Pulp and paper manufacture & manufacture of wood
- Manufacture of machinery and equipment
- Manufacture of food products
- Transport and communications
- Manufacture of chemical and petrochemical products
- Energy industry
- Light industry
- Other industries

The import share in fixed investment by industries, %
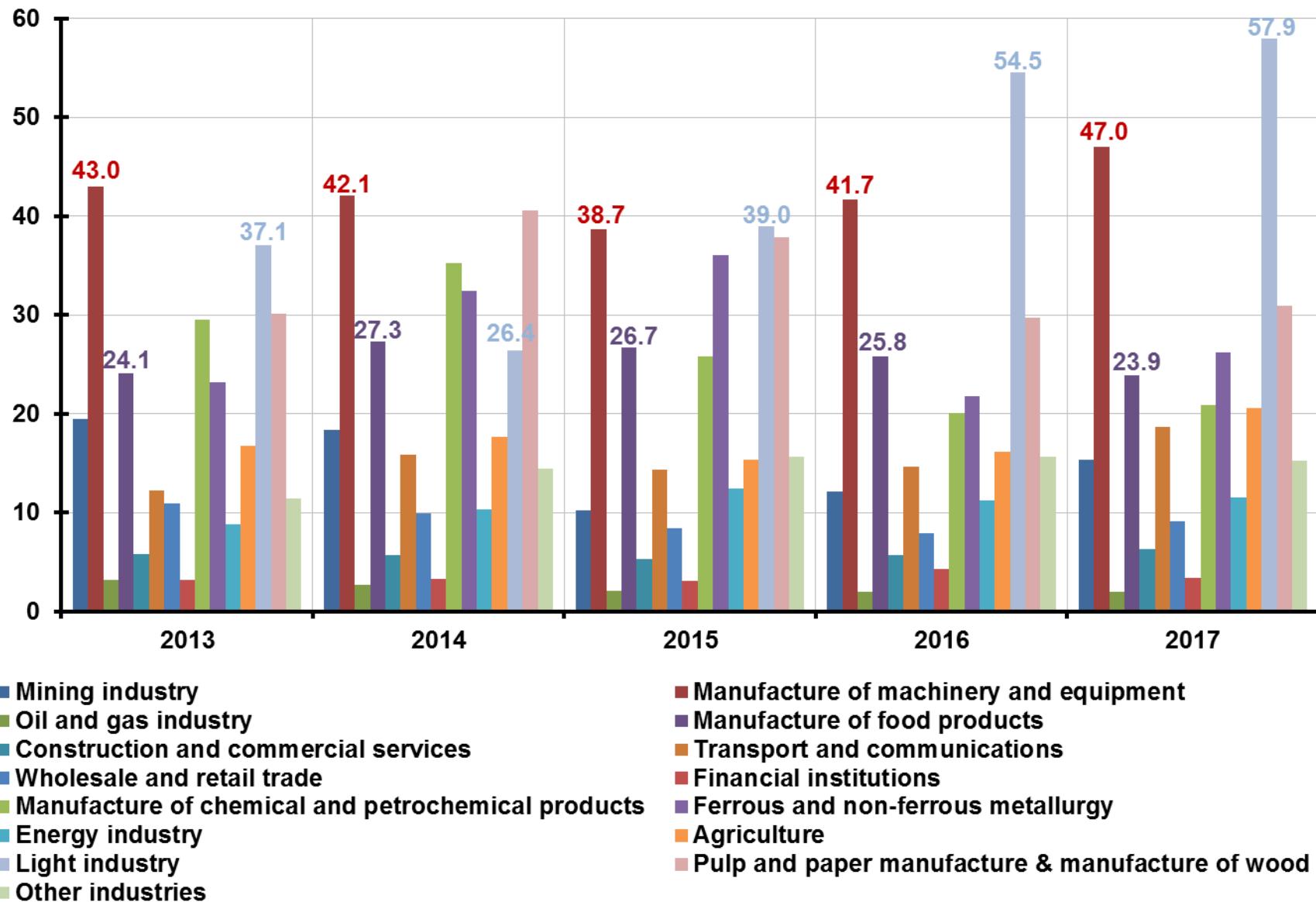
Legend:
- Mining industry
- Oil and gas industry
- Construction and commercial services
- Wholesale and retail trade
- Manufacture of chemical and petrochemical products
- Energy industry
- Light industry
- Other industries
- Manufacture of machinery and equipment
- Manufacture of food products
- Transport and communications
- Financial institutions
- Ferrous and non-ferrous metallurgy
- Agriculture
- Pulp and paper manufacture & manufacture of wood

The structure of corporate external debt by industries, %

	Mining industry	Manufacture of machinery and equipment	Oil and gas industry	Manufacture of food products	Transport and communications	Construction and commercial services	Wholesale and retail trade	Financial institutions (except credit institutions)	Manufacture of chemical and petrochemical products	Ferrous and non-ferrous metallurgy	Energy industry	Agriculture	Light industry	Pulp and paper manufacture & manufacture of wood	Other industries
2013	4.6	0.5	54.9	0.1	11.2	0.9	0.2	2.6	6.6	14.7	1.6	0.1	0.0	0.0	2.1
2014	5.4	0.5	50.8	0.1	12.7	1.1	0.2	2.1	7.6	14.7	2.6	0.0	0.0	0.0	2.2
2015	6.2	0.6	46.6	0.0	14.0	1.0	0.2	1.5	9.1	16.1	2.3	0.0	0.0	0.0	2.3
2016	4.2	0.5	50.0	0.0	14.9	1.1	0.2	1.3	9.2	14.3	2.1	0.0	0.0	0.2	1.8
2017	6.1	0.6	44.6	0.0	13.8	0.9	0.2	1.8	10.1	18.2	2.3	0.0	0.0	0.5	0.7

Appendix. The system of simultaneous equations (SSE) [1]

- SSE allows to estimate the interactions of the following indicators: the dynamics of the Moscow Exchange Stock Index (IMOEX), the share of overdue bank loans and the dynamics of foreign currency customer accounts in banking system.
- Shocks of oil price and the exchange rate are exogenous parameters in the SSE. The impact of this shocks leads to a fall of the stock index, an increase in the level of overdue bank loans and a surge of activity in foreign currency customer accounts.
- The indicator of foreign currency customer accounts mobility is calculated as growth rate of the volume of foreign currency customers' accounts in Russian banking system minus 3 standard deviations of this growth rate for a sample of banks at a given period. This indicator can be considered as a measure of the risk of outflow of foreign currency deposits for a bank.

Analyzed period: 11/2014 - 06/2018

	Coefficients
Equation #1: Moscow Exchange Stock Index (IMOEX), growth rate, %	
Oil price (Brent), growth rate, %	0.045***
Indicator of dynamics of foreign currency customer accounts in banking system ("-" – increase of activity, "+" – decrease of activity), %	0.077**
Indicator of "fire sales" of stocks on the Moscow stock exchange, bln. rub.	-0.011***
MIACR rate (lag = 1 month), %	0.148***
Equation #2: Share of overdue bank loans for banking system, %	
Moscow Exchange Stock Index (IMOEX), growth rate, %	-0.141***
MIACR rate (lag = 1 month), %	0.835***
Exchange rate USD/RUB, growth rate, %	0.093***
Equation #3: Indicator of dynamics of foreign currency customer accounts in banking system ("-" – increase of activity, "+" – decrease of activity), %	
Share of overdue bank loans for banking system, %	-0.438***
Moscow Exchange Stock Index (IMOEX), growth rate, %	0.175***
Exchange rate USD/RUB, growth rate, %	-0.078***

*The system was estimated with GMM (HAC) ** - significance at the 5%. level; *** - Idem, 1%.*

Appendix. The system of simultaneous equations (SSE) [2]

- To this end, the indicator of "fire sales" of stocks on the Moscow stock exchange is included in the equation of the dynamics of IMOEX. This indicator is designed in such a way that in the months of simultaneous 1) excess of the trade volume on the Moscow stock exchange of its average level and 2) drop in IMOEX by more than 5%, the indicator is equal to the value of this excess, and in all other cases it is equal to zero.

- The SSE is estimated in the period November 2014 – June 2018. The rationale behind the choice of this time span is that we have an attempt to evaluate the effects solely for the floating exchange rate regime. The Central Bank of Russia transited to the floating exchange rate regime in November 2014, accordingly the Bank of Russia does not intervene to influence the ruble exchange rate under normal conditions and there is no need to keep additional international reserves for interventions.

- The volume of "fire sales" of securities calculated in the block for the stress-testing of banks is used to forecast the dynamics of the Moscow Exchange Stock Index (IMOEX). It helps to account for secondary effects of national currency depreciation (shock).

Appendix. Modeling the volume of the aggregate panic demand for foreign currency

- **Dependent variable** – panic demand for foreign currency
- **Analyzed period: 11/2014 - 10/2018**
  - We determine the currency microcrisis as follows: more than 2.5% excess of the exchange rate of its trend level followed by 5% excess of currency demand of its trend level is considered as the beginning of the crisis (only if the crisis period has an economic interpretation).
  - The end of the crisis is considered as the day of the last crisis event, after which within 15 working days there are no significant excesses of the exchange rate and currency turnover on the Moscow Exchange (2.5% and 5%, respectively).
  - A month is considered a crisis month, if there is at least one day of crisis.

Variables	Estimated coefficients
Total demand of industries and households for foreign currency, bln. $	0.262**
	(0.923)
Indicator of dynamics of foreign currency customer accounts in banking system, %	-5.804***
	(1.542)
Number of observations	9
R2-adjusted	0.86

Appendix. Modeling the effect of panic currency demand on the ruble exchange rate

- **Dependent variable -** average daily exchange rate USD/RUB in the Moscow Exchange, growth rate
- **Analyzed period: 11/2014 - 10/2018**

Variables	Estimated coefficients
Panic demand, mln. dollars, ln	0.002*** (0.001)
Oil price (Brent), growth rate	-0.110 (0.079)
Weighted average actual rates on Moscow banks' ruble loans for one-day (lag =1 day), %;	-0.002** (0.031)
Number of observations	97
R2-adjusted	0.12

Appendix. Stress testing of the banking system(1/2)

- Each bank's need for additional capital is estimated by sequentially calculating the following indicators:

- 1) Volume of securities portfolio – volume of government (*GovSec*) and corporate securities (shares and bonds, *CorpSec*), which are at the disposal of each bank for possible sale in order to cover the deficit of liquid funds. Besides, there are two types of securities – for trading and for investment. The correction of the appropriate market index (stock or bond) causes the revaluation of only trading securities and there are no changes for investment securities.

$$GovSec_{i,t} = GovSec_{i,t_0} *(1 - GSIndexgr_t)$$

$$CorpSec_{i,t} = CorpSec_{i,t_0} *(1 - CSIndexgr_t)$$

- 2) Liquidity shortfall (*LiqSh*), which is defined as the volume of liquid assets – *LA* (absolutely liquid assets of a bank – *AbsLA*, and the most liquid foreign assets – *FA*), minus funds necessary for the bank to meet the minimum liquidity requirements (*LiqRatio*), as well as funds to cover possible outflow of currency as the result of depreciation (*FCDout*). The latter are calculated taking into account the indicator of dynamics of foreign currency customer accounts in banking system obtained from the system of simultaneous equations (SSE).

$$LA_{i,t} = AbsLA_{i,t} + \alpha FA_{i,t}$$

$$LiqSh_{i,t} = LA_{i,t} - FCDout_{i,t} - LiqRatio_{i,t}$$

Appendix. Stress testing of the banking system(2/2)

- 3) Volume of "fire sales" of government and corporate securities (*FireSales*) should cover the deficit of liquid funds of a bank resulting from the occurrence of currency depreciation and capital shock.

$$FireSales_{i,t} = \begin{bmatrix} -LiqDef_{i,t} \, , if \; GovSec_{i,t} + CorpSec_{i,t} \geq \left| LiqDef_{i,t} \right| \\ 0, if \; else \end{bmatrix}$$

- 4) Capital adequacy ratio, which is determined by the predictive values of equity (*Capital*) and risk-weighted assets (*RWA*). In this case, the capital is adjusted for changes in the value of securities as a result of "fire sales". In turn, risk-weighted assets are adjusted for the increase in the value of the bank's assets denominated in foreign currency (*FCA*) as a result of the national currency depreciation. Capital adequacy ratio is equal to 8% under standard (non-crisis) conditions. At the same time, it is expected that the bank's capital adequacy ratio should be at least 10% in order to maintain an additional buffer for damping probable shocks.

$$Capital_{i,t} = Capital_{i,t_o} + \Delta GovSec_{i,t} + \Delta CorpSec_{i,t}$$

$$RWA_{i,t} = RWA_{i,t_o} + \Delta FCA_{i,t}$$

$$H1_{i,t} = Capital_{i,t} \, / \, RWA_{i,t}$$

$$\overline{\Delta Capital}_{i,t} = \frac{10\% - H1_{i,t}}{H1_{i,t}} \cdot Capital_{i,t}$$