ECONSTOR
Make Your Publications Visible.

A Service of
ZBW
Leibniz-Informationszentrum Wirtschaft
Leibniz Information Centre for Economics

Fungáčová, Zuzana; Jakubik, Petr

Working Paper

Bank stress tests as an information device for emerging markets: The case of Russia

BOFIT Discussion Papers, No. 3/2012

Provided in Cooperation with:
Bank of Finland, Helsinki

Suggested Citation: Fungáčová, Zuzana; Jakubik, Petr (2012) : Bank stress tests as an information device for emerging markets: The case of Russia, BOFIT Discussion Papers, No. 3/2012, ISBN 978-952-462-734-4, Bank of Finland, Institute for Economies in Transition (BOFIT), Helsinki, https://nbn-resolving.de/urn:nbn:fi:bof-201408071912

This Version is available at:
https://hdl.handle.net/10419/212727

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.

WWW.ECONSTOR.EU

Mitglied der Leibniz-Gemeinschaft

BOFIT Discussion Papers
3 • 2012

Zuzana Fungáčová and Petr Jakubík

Bank stress tests as an information device for emerging markets: The case of Russia

EUROJÄRJESTELMÄ
EUROSYSTEMET

Bank of Finland, BOFIT
Institute for Economies in Transition

BOFIT Discussion Papers
Editor-in-Chief Laura Solanko

BOFIT Discussion Papers 3/2012
10.2.2012

Zuzana Fungáčová and Petr Jakubík:

Bank stress tests as an information device for emerging markets: The case of Russia

This paper can be downloaded without charge from
http://www.bof.fi/bofit.

Suomen Pankki
Helsinki 2012

All opinions expressed are those of the authors and do not necessarily reflect the views of the Bank of Finland.

Contents

Abstract 4
1 Introduction 5
2 Main features of the Russian banking sector 6
3 Data and methodology 9
3.1 Data 9
3.2 Methodology 10
4 Empirical analyses 16
4.1 Results for the banking sector overall 16
4.2 Results by ownership 19
4.3 Results by size 21
5 Conclusions 23
References 25

Zuzana Fungáčová* and Petr Jakubík+

Bank stress tests as an information device for emerging markets: The case of Russia

Abstract

The recent financial crisis emphasised the need for effective financial stability analyses and tools for detecting systemic risk. This paper looks at assessment of banking sector resilience through stress testing. We argue such analyses are valuable even in emerging economies that suffer from limited data availability, short time series and structural breaks. We propose a top-down stress test methodology that employs relatively limited information to overcome this data problem. Moreover, as credit growth in emerging economies tends to be rather volatile, we rely on dynamic approach projecting key balance sheet items. Application of our proposed stress test framework to the Russian banking sector reveals a high sensitivity of the capital adequacy ratio to the economic cycle that shows up in both of the two-year macroeconomic scenarios considered: a baseline and an adverse one. Both scenarios indicate the need for capital increase in the Russian banking sector. Furthermore, given that Russia's banking sector is small and fragmented relative to advanced economies, the loss of external financing can cause profound economic stress, especially for medium-sized and small enterprises. The Russian state has a low public debt-to-GDP ratio and plays decisive role in the banking sector. These factors allow sufficient fiscal space for recapitalisation of problematic banks under both of our proposed baseline and adverse scenarios.

Keywords: stress testing, bank, Russia

JEL Classification: G28, P34, G21

* Zuzana Fungáčová: Bank of Finland, Institute for Economies in Transition (BOFIT), PO Box 160, FI-00101 Helsinki, Finland and Charles University in Prague, Institute of Economic Studies. Email: zuzana.fungacova@bof.fi.

+ Petr Jakubík: European Central Bank and Charles University in Prague, Institute of Economic Studies. Contact: European Central Bank, EU Neighbouring Regions Division, Kaisserstrasse 29, D-60311 Frankfurt am Main, Germany, Tel: +49 69 1344 5821, Fax: +49 69 1344 8647, Email: Petr.Jakubik@ecb.int or PetrJakubik@seznam.cz.

The views expressed in this paper are those of the authors and do not necessarily represent the views of the Bank of Finland, the European Central Bank or Charles University in Prague. Financial support from the Czech Ministry of Education (Grant MSMT 0021620841) and the Grant Agency of the Czech Republic (GACR 403/10/1235) is gratefully acknowledged.

1 Introduction

The recent global financial turmoil emphasised the importance of stress tests in evaluating financial sector resilience to adverse macroeconomic shocks.[1] Typically, financial sector supervisors and central banks have carried out macro stress tests in cooperation with key financial institutions. Unlike the stress tests financial firms perform for their own internal risk management purposes, however, the objective of macro stress testing is to identify potential sources of systemic risk and estimate the losses key financial institutions in a given country might suffer under adverse macroeconomic developments or various shocks. The recent crisis also demonstrated that stress testing can serve as an important macroprudential tool for restoring confidence in financial systems, increasing transparency and reducing market uncertainty.[2]

Even if the adverse macroeconomic shocks of the recent global economic recession were largely generated in advanced economies, they strongly impacted emerging markets. The decaying macroeconomic environment was felt strongest in banking sectors of emerging economies with strong linkages to the international financial system. The fact, that emerging markets can be highly vulnerable to this kind of adverse macroeconomic development stems from the much higher volatility of credit growth than in advanced economies. Thus, to properly assess potential banking sector vulnerabilities, stress tests should reflect the actual conditions of emerging markets if they are to serve as an effective information device. Moreover, an adverse scenario needs to be sufficiently severe to expose systemic fragility, yet remain plausible. The formulation of an appropriate scenario for stress testing is discussed in Berkowitz (2000), who argues for a probabilistic scenario structure and backtesting.

Stress testing has been employed widely by regulators and private financial institutions, yet no clear consensus on the applied methodology has arisen. Most currently applied techniques are based either on academic research (Blaschke et al., 2001; Jones et al., 2004) or developed from practice-based guides published by central banks and international organisations (IMF and World Bank, 2005; Čihák, 2007).

[1] Well before the current crisis, Borio, Furne and Lowe (2001) point out the importance of stress tests in understanding risk and how risk relates to the economic cycle.
[2] See e.g. Bank of England (2008), Board of Governors of the Federal Reserve System (2009a, 2009b), Committee of European Banking Supervisors (2010) and European Banking Authority (2011).

Here, we employ a top-down approach to assess the resilience of the Russian banking sector to negative macroeconomic shocks. Our baseline and adverse macroeconomic scenarios are projected on individual bank balance sheets via simple econometric models that link non-performing loans and credit growth with selected macroeconomic indicators. We calculate credit, interest and contagion risks for both the baseline and adverse scenarios. Using this information, we calculate the impact on bank capital for each bank, the sector as a whole, and groupings of banks broken down in terms of their size and ownership.

Our study contributes to the current literature in two ways. First, we use a unique data sample based on the balance sheets of banks that hold a total of about 94% of banking sector assets. This is important because the stability of Russia's bank-based financial system remains highly dependent on bank health and the fact that the Russian economy is so big that its stability might affect financial stability in other countries. Second, our applied methodology reflects the recent trend towards dynamic approaches. We employ a two-year time horizon to capture the deleveraging/releveraging process driven by swings in lending (Jakubík and Schmieder, 2008; Schmieder, Puhr and Hasan, 2011). The impact of the deleveraging/releveraging process on the capital adequacy ratios of banks, although commonly omitted in the literature, is crucial in assessing Russia as credit growth in emerging markets tends to be more volatile than in advanced economies. This is also reflected in the higher volatility of capital needs due to higher volatility of credit exposures. Admittedly, this emerging economy phenomenon to some extent reflects lower levels of financial intermediation and catching-up needs, but it can also stem from the aggravated boom/bust cycles typical of these economies.

Our paper is structured as follows. Section 2 describes the main features of the Russian banking sector. Section 3 provides description of data sources and stress test methodology. Section 4 presents and discusses our results. Conclusions are provided in Section 5.

2 Main features of the Russian banking sector

Despite the large number of banks operating in Russia (955 at the end of 2010) and significant growth during the past decade (see Table 1), Russia's banking sector remains small and underdeveloped compared to economies of similar size. Indeed, banking sector assets only correspond to about 75% of GDP and only 40% of Russians have a bank account. Moreover, banking sector assets are concentrated in the major banks; the five largest banks hold almost half of the sector's total assets, and the 200 largest banks some 94%. Other banks are typically quite small, even if they might have regional significance. Growth in credit to companies and households contributed to increasing financial intermediation by

banks in Russia during the past decade, but the ratio of domestic credit to GDP in Russia is still below 50% (over 100% in the Eurozone and China).

Table 1 Development of the main banking sector indicators (annual growth rates, %)

	2004	2005	2006	2007	2008	2009	2010
Total assets	27.3	36.6	44	44.1	39.2	5	14.9
Capital (own funds)	16.2	31.2	36.3	57.8	42.7	21.2	2.4
Corporate loans	38	31.3	39.8	51.5	34.3	0.3	12.1
Household loans	116.4	96.2	78.3	57.8	35.2	-11	14.3
Individual deposits	30.4	39.4	38	35.4	14.5	26.7	31.2
Corporate deposits	36.9	43.7	52.6	47.2	24.4	8.9	16.4

Source: Central Bank of Russia

Unlike most countries in Central and Eastern Europe, no major bank privatisation occurred in Russia. Its banking sector remains predominantly state-controlled to this day. Sberbank and VTB, Russia's two largest banks, held IPOs in 2007 that lifted the private shareholdings in these banks to 40% and 23%, respectively. In October 2010, the Russian government approved a programme to sell shares in numerous large state enterprises including banks over the next five years. In February 2011, VTB conducted a second public offering that resulting in the sale of a further 10% stake. Even so, the Russian state still owns about 75% of VTB. Similarly, the Central Bank of Russia (CBR), which currently holds a 57.6 % stake in Sberbank, plans to retain a 50%-plus-one-share majority in the giant bank even after selling 7.6% of its shares in the near future. Although referred to as a "privatisation programme," the state will retain controlling voting shares in major banks and other "strategic" enterprises.

Like in other economies, Russia saw state control increase during the recent financial crisis. However, at the start of the crisis, state-controlled banks already accounted for over half of the Russian banking sector and all of the country's five largest banks were state-controlled. These big banks acquired other banks during the crisis, further strengthening their market positions. Foreign participation in the Russian banking sector remains low, but has been increasing over the years. The number of banks with foreign ownership rose

from 174 in 2000 to 220 at the end of 2010. About half of these banks are majority foreign-owned. Three of Russia's "Top 10" banks are foreign-owned (see Table 2).[3]

Table 2 "Top 10" banks based on total assets and their market share (end of August 2011)

Bank	% of total banking sector assets	Ownership
Sberbank	27 %	State (CBR)
Bank VTB	9.7 %	State
Gazprombank	5.4 %	State (Gazprom)
Rosselhozbank	3.7 %	State
VTB-24	3 %	State
Alfa-bank	2.5 %	Domestic Private
Bank of Moscow	2.3 %	State*
UniCredit Bank	2.3 %	Foreign
Rosbank	1.7 %	Foreign
Raiffeisenbank	1.6 %	Foreign

Source: www.banki.ru
Note: * through VTB

Russia's banking sector succumbed to the financial crisis in the second half of 2008. While banks were not directly exposed to the financial instruments that triggered the crisis, they and the rest of the Russian economy were hit with the double-whammy of reduced access to foreign financing and a severe drop in oil prices.

The Russian government and CBR swiftly responded by implementing measures aimed at maintaining stability of the financial system. The emphasis was on liquidity support to the banks and maintaining stability of the ruble. The implemented measures included a temporary decrease in bank reserve requirements, CBR guarantees for interbank lending to qualified banks, non-collateralised central bank loans, widening the range of acceptable collateral for Lombard and repurchase operations, as well as auctions allocating free budgetary funds to the banks.

The deposit insurance framework was enhanced by increasing the deposit insurance limit, and Russia's deposit insurance agency assumed responsibility for restructuring individual troubled banks. Recapitalisation of banks was accomplished directly by the government in the form of capital support to state-controlled banks, or indirectly in the form of

[3] Several foreign banks have recently decided to abandon their retail operations in Russia (Barclays, Banco Santander, HSBC). Moreover KBC is selling its stake in Absolut Bank and Rabobank plans to concentrate on other countries. Last year Morgan Stanley sold its local mortgage unit and Swedbank decided to curtail its operations as well. On the other hand, China Construction Bank has decided to enter the Russian market.

unsecured subordinated loans from the CBR and development bank Vneshekonombank (VEB). In theory, both state-controlled and private banks had access to these subordinated loans, but the level of reliance on these loans depended on bank ownership. Private banks were recapitalised largely from other sources, while most of the capital increase of state-controlled banks was supplied in the form of subordinated loans. VEB was also given resources to help refinance foreign debt of Russian firms. These measures helped stabilise Russia's banking system and boosted the state's presence in banking as the government took over troubled banks via state-controlled firms or banks to preserve trust in the banking sector and avert bank runs.

3 Data and methodology

The state's extensive participation in the Russian banking sector has strong implications for the risk assessment for the sector. As borne out by the recent financial crisis, the Russian state has the will and resources to bail out troubled banks. Russia's interbank market, on the other hand, remains underdeveloped and dominated by the biggest banks. Most banks were shut out of the interbank market during the crisis, highlighting the lack of mutual trust in the banking community. Moreover, as most transactions are overnight, liquidity risk can be quite significant in Russian conditions, especially for smaller banks.

3.1 Data

To assess risks in the Russian banking sector more rigorously, we conduct a top-down macro stress test analysis. Unlike the bottom-up approach, the same models and assumptions are applied to all banks in our estimations.[4] Analysis is based on the balance sheet data of Russian banks as of end-2009. The 200 largest banks, which together hold about 94% of the Russian banking sector assets, are included in the analysis to assess banking sector vulnerabilities over a two-year horizon, i.e. we provide projections for 2010 and 2011. Our data come from the financial information agency Interfax, which collects and organises bank data from the CBR. Aggregate indicators covering the development of the

[4] Some central banks use a combined top-down/bottom-up approach, e.g. the Dutch central bank (see Van den End, Hoeberichts and Tabbae, 2006).

Russian banking sector originate from the CBR and at the time of writing were available for 2010. Data describing the macroeconomic environment are taken from Rosstat.

3.2 Methodology

Our methodology links bank balance sheet data and the macroeconomic environment under different scenarios. Adverse macroeconomic shocks are translated into capital adequacy ratios to assess financial sector resilience. Risks on bank balance sheets (credit, market, contagion and income risks) are consistently covered within a single framework. Drehmann, Sorensen and Stringa (2008), who point out the importance of off-balance sheet items as a potential source of risk, saw their assertion recently confirmed by the global financial crisis. Since these items are insignificant in the case of Russian bank balance sheets, however, we do not include them in our analysis.

We conduct the investigation in a dynamic framework in line with recent literature (Schmieder, Puhr and Hasan, 2011). For each item of assets, liabilities, income and expenditure, there is an initial (i.e. last actually known) stock, to which the impact of the shock in one year is added. This final stock is then used as the initial stock for the following year. The changes in flow and stock variables are modelled in a consistent manner. Thus, losses reflected in a fall of profit (a flow indicator) will also be reflected in the same amount in total assets (a stock indicator). The dynamic nature of the analysis provides more realistic insights into banking sector vulnerabilities than sensitivity analyses or the commonly used static stress tests (Cihak, 2007).

Our stress test analysis is performed in five steps:

(i) Creation of macroeconomic scenarios
(ii) Forecasting stress parameters by “satellite” models
(iii) Deduction of losses from bank capital
(iv) Iterative interbank contagion
(v) Computation of post-shock and post-contagion capital adequacy ratios.

In step one, we create two macroeconomic scenarios for 2010-11. These are generated on the basis of publicly available professional consensus forecasts (baseline scenario) and expert judgement (adverse scenario). The scenarios include real GDP, inflation, the exchange

rate between the Russian ruble and the US dollar and short-term interest rate.[5] These variables are then used to project housing prices and the development of key credit variables, including nonperforming loans (NPLs) and total loans.

In the next step, econometric models for aggregate data linking NPL ratio growth, total banking loans growth and housing prices to past GDP growth and other lagged economic and financial variables are employed to forecast credit growth, nonperforming loan ratio growth and growth rate of housing prices for the baseline and the adverse scenario. These are estimated independently as follows:

$$gnpl_{t_{c,h}} = \alpha + \beta_{1_{c,h}} realGDP_{t-1} + \beta_{2_{c,h}} realGDP_{t-2} + \ldots + \beta_{k_{c,h}} realGDP_{t-k} + \lambda_{c,h} X + \varepsilon_{1t_{c,h}} \quad (1)$$

$$gLoans_{t_{c,h}} = \theta + \gamma_{1_{c,h}} realGDP_{t-1} + \gamma_{2_{c,h}} realGDP_{t-2} + \ldots + \gamma_{k_{c,h}} realGDP_{t-k} + \chi_{c,h} Y + \varepsilon_{2t_{c,h}} \quad (2)$$

$$gHousep_t = \mu + \delta_1 realGDP_{t-1} + \delta_2 realGDP_{t-2} + \ldots + \delta_k realGDP_{t-k} + \tau Z + \varepsilon_{3t} \quad (3)$$

where the lag structure is determined by statistical significance and X,Y and Z are vectors of other control variables such as nominal GDP, the NPL ratio, housing prices and household credit growth.

These "satellite" models help us project credit growth and the NPL ratios for both the household (index h) and corporate (index c) sector consistently with the considered macroeconomic scenarios. The same growth rates are applied to all banks in the analysis.

In the third step, we use our projected values and balance sheet data to calculate credit and market risks (including both foreign-exchange and interest-rate risks) for each bank over the two-year horizon. The value of risks is then deducted from total bank capital.

Market risk is evaluated based on the changes in interest rates and exchange rates. With respect to interest-rate risk, we consider changes in present values of investment securities available for sale (trading book), in particular corporate, foreign government, federal and municipal bonds. Their present value is influenced by changes in short-term interest rates that originate from the macroeconomic scenario under consideration. Again, the parallel move in the yield curve is assumed. As data on duration are not available at the level of individual banks, we estimate average duration for available securities on the Russian market. We split securities into corporate bonds, federal loans, municipal bonds and foreign government bonds. Based on CBR (2010) data for the sector, the same durations are assumed for all banks (1.7 for corporate bonds, 4.3 for federal loan and municipal

[5] The parallel shift of the yield curve is assumed for simplification in further calculations.

bonds and 1 for foreign government bonds). Finally, the sum of the changes in values for all mentioned segments based on standard Macaulay duration is calculated for the interest-rate risk of every bank. Exchange-rate risk for each bank is calculated as the product of the net-open foreign exchange position and the change in the exchange rate resulting from the macroeconomic scenario under consideration. Hedging against foreign exchange risk is not taken into account (as this information is not available) so that foreign exchange risk might be overestimated in some cases. The same caveats also apply to the interest-rate risk calculation.

Credit risk is traditionally the key risk for banks. This is particularly true for the Russian banking sector, which is mainly involved in commercial banking. The Russian economy was strongly affected by the crisis and experienced a sharp fall in economic output in 2009. As a result, NPLs in the local banking sector rose considerably. This increase in credit risk took place against the backdrop of a pronounced local boom-bust cycle. Annual credit expansion rates exceeded 40% before the crisis, collapsed to -2.5% during the crisis in 2009, and then rebounded to over 12% growth in 2010. Credit risk built up during the boom period in which lending standards were lowered materialised during the bust period when credit growth collapsed, leading with some time lag to a sharp rise in nonperforming loans. This is in line with the evidence from other countries. For example, Jiménez and Saurina (2006) look at the Spanish data and show that credit granted during "good times" has a greater likelihood of ending up in default than loans made during recessions.

Due to the crucial impact of credit risk on bank balance sheets, macroeconomic credit-risk modelling often links credit risk and macroeconomic environment. Some researchers highlight the nonlinear relationship between macroeconomic shocks and credit risk (e.g. Cihak, 2007; Jakubík, 2007). Moreover, the non-linear logistic function originally introduced in credit-risk modelling by Wilson (1997a, 1997b) is often employed in credit-risk modelling.[6] If appropriate data is available, probability of default can be modelled directly (Hamerle, Liebig and Scheule, 2004). However, this information is rarely available, so NPL data are employed in credit-risk modelling. This is also the case here.

For the analysis, we calculate credit risk for each bank, distinguishing between corporate and household loan portfolios. Expected credit losses are calculated as the product of the average probability of default (PD) for the loan portfolio, the exposure at default

[6] See Boss et al. (2006), Boss et al. (2009), Virolainen (2004) and Jokivuolle, Virolainen and Vahamaa (2008) among others.

(EAD) and the loss given default (LGD). Due to the lack of LGD data for individual banks, we use the sector averages for corporate, household and other exposures (59% for corporate exposures, 55% for households and 58% for others) based on estimation performed by rating agencies as initial values for 2009.[7] The LGD projection uses a simple econometric model for housing prices. The exposure at default can be expressed as the difference between outstanding loans and NPLs. Projected NPLs depend on new NPLs (determined by PD estimates), outflows (as write-offs or selling-out of existing NPLs) and the current stock of NPLs. This is expressed formally as:

$$NPL_{t+1} = NPL_t + PD_t \cdot (Loans_t - NPL_t) - r \cdot NPL_t, \tag{4}$$

where r represents the average write-off (or sell-out) rate of existing NPLs. In practice, this parameter can be unstable over time. For instance, in times of crisis, banks may increase the pace of write-offs to clean up their portfolios. This parameter is hard to model, so we set a constant value based on common practices in the Russian banking sector and anecdotal evidence. We employ the value 10% for corporate and other exposures, and 20% for household exposures.[8]

The estimated regression models for growth in the NPL ratio (gnpl) and credit growth (gLoans) are then used to indirectly derive the probability of default for loans to corporations and households separately. The growth of the NPL ratio can be expressed by the growth rate of NPLs' stock and credit growth, i.e.:

$$gnpl_t = \frac{gNPL_t + 1}{gLoans_t + 1} - 1 \approx gNPL_t - gLoans_t \tag{5}$$

where

$$gNPL_t = \frac{NPL_t - NPL_{t-1}}{NPL_{t-1}} \qquad gLoans_t = \frac{Loans_t - Loans_{t-1}}{Loans_{t-1}}$$

The expected probability of default (PD) is derived from the NPL ratio and credit growth projections. Probability of default is calculated as:

[7] Moody's Global Banking report for Russia was used for calibration - see Moody's (2010).
[8] These numbers imply that banks on average keep bad loans on their balance sheets for ten years in the case of corporate and other exposures, and five years in case of household exposures, before they write off or sell them.

$$PD_t = (gNPL_{t+1} + r)npl_t \quad (6)$$

Equation (6) suggests that the portfolio-average PD depends on the average write-off rate (r), the initial level of the NPL ratio and the growth rate of NPLs, calculated as:

$$gNPL_t = (gnpl_t + 1)(gLoans_t + 1) - 1 \quad (7)$$

To account for unexpected losses, we use the Basel II formula as it considers changes in risk-weighted assets (RWA). This allows us to project RWA so that the deleveraging/releveraging effects that characterise the high volatility of Russian credit growth can be taken into account by satellite models for credit growth.[9] RWA change also affects bank risk profile.

For the calculation of credit risk, we assume all banks behave as if they were complying with the Basel II framework, even if it is not fully implemented in Russia. Hence, the loan portfolio is split into corporate loans, retail loans and other loans. Credit risk is computed using separate formulas as indicated in the Basel II framework. For the capital requirement for corporate loans, we proceed as follows:

Correlation (R) = 0.12 × (1 – EXP(-50 × PD)) / (1 – EXP(-50)) + 0.24 × [1 – (1 – EXP(-50 × PD))/(1 – EXP(-50))] (8)

Maturity adjustment (b) = (0.11852 – 0.05478 × ln (PD))^2 (9)

Capital requirement (K) = [LGD × N [(1 - R)^-0.5 × G (PD) + (R / (1 - R))^0.5 × G (0.999)] – PD x LGD] x (1 - 1.5 x b)^ (-1) × (1 + (M – 2.5) × b) (10)

In the case of capital requirement for retail loans, we use the following:

Correlation (R) = 0.03 × (1 – EXP (-35 × PD)) / (1 – EXP (-35)) + 0.16 × [1 - (1 - EXP(-35 × PD))/(1 - EXP(-35))] (11)

Capital requirement (K) = LGD × N[(1 - R)^-0.5 × G(PD) + (R / (1 - R))^0.5 × G (0.999)] – PD × LGD , (12)

[9] This approach is in line with Schmieder et al. (2011). It was previously also applied by Jakubík, Schmieder (2008).

where N denotes normal distribution function and G inverse normal distribution function. For "other loans," the same formula as for corporate loans is applied. The capital requirement for market and operational risk are assumed to grow at the same rate as the capital requirement for credit risk.

Expected losses are calculated separately for credit and market risk, and then deducted from total capital. Unexpected losses are covered by the Basel II formula so as to take into account the change in risk-weighted assets:

$$\text{Expected losses (EL)} = \text{EAD} * \text{PD} * \text{LGD} \quad (13)$$

$$\text{Risk-weighted assets (RWA)} = \text{K} \times (1/\text{MCAR}) \times \text{EAD}, \quad (14)$$

where EAD denotes exposure at default and MCAR is the minimum capital adequacy ratio (10% for Russia).

Losses stemming from the described credit and market risk calculations can to some extent be covered by available net income. Therefore, bank income is taken into account as the first line of defence against the losses. In particular, it is assumed that banks will use all available income to sustain their capital adequacy ratio at the same level when hit by a financial shock. If income is insufficient to fully absorb the losses emerging in the macroeconomic scenario under consideration, the losses are deducted from bank capital. Net income is computed as a sum of net interest income and non-interest income. The change in interest rate based on considered scenario and average net-interest income over last three years is considered to project the total net-interest income. Non-interest income is projected as an average over last three years.

In the fourth step of our analysis, we take into account possible interbank contagion. After losses are deducted from bank capital, a mapping of capital ratios into the probability of default of the respective bank (bank-specific PD) is used to determine the likelihood of the bank under consideration defaulting on its interbank liabilities to other banks. To consider interactive rounds of interbank contagion, we approximate bilateral interbank exposures, which are unavailable, using the maximum entropy principle proposed by Upper and Worms (2002). Losses are computed using the default on interbank liabilities. Approximated bilateral interbank exposures are then multiplied by a bank-specific PD derived from an expert-based mapping (see Table 3 below) of post-shock capital adequacy ratios into PDs. The LGD on a bank default is assumed to be 10%.

Table 3 Mapping of bank CAR into PD

CAR >=	PD
14.00%	0.00%
12.00%	0.01%
10.00%	0.05%
8.00%	5.00%
7.00%	15.00%
5.00%	50.00%
3.00%	80.00%
<3.00%	100.00%

The resulting losses are deducted from the capital of the affected banks. Ten iterations of such interbank contagion rounds are taken into account.

In the last step of our analysis, post-shock and post-contagion CARs that take into account the shock and interbank contagion are computed as average of the banking sector and bank-by-bank capital adequacy ratios. Possible recapitalisation costs that would arise if the capital adequacy ratio of a bank falls below the minimum regulatory requirement (10%) are computed as a proportion of GDP. Recapitalisation for the top 200 banks is scaled up to reflect their share of total banking sector assets.

4 Empirical analyses

In this section, we present the results for the banking sector as a whole and the results for banks categorised on the basis of ownership and size.

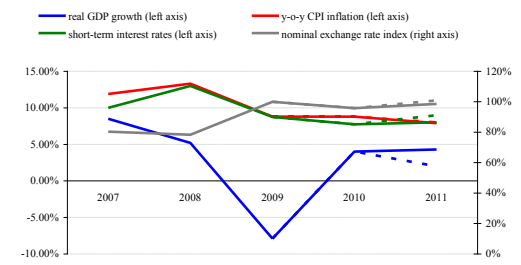
4.1 Results for the banking sector overall

The results of stress test analysis suggest that the Russian banking sector is quite sensitive to changes in the macroeconomic environment. High credit risk and cyclicality typical of emerging markets combined with the low level of financial intermediation appear to dampen economic development under our baseline scenario. While this likely reflects the low level of financial intermediation and catching-up needs of Russia, it also is an indica-

tion of aggravated boom/bust cycles. The CAR improvements in the Russian banking sector seen during 2009 and 2010 seem to be largely driven by deleveraging.

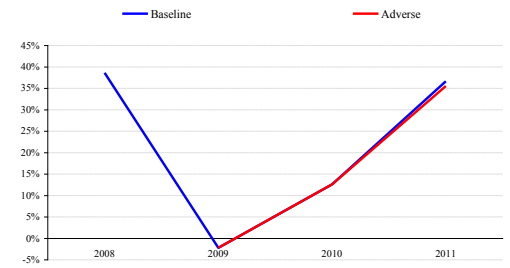
Results of the macro stress test

Macroeconomic scenarios
(%)

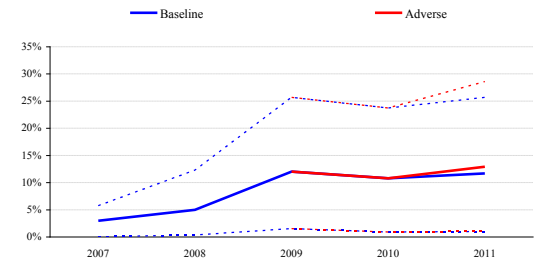


Note: An increase in the nominal exchange rate index means depreciation.
Solid line referes to "Baseline", dashed line to "Adverse" sceanrio.

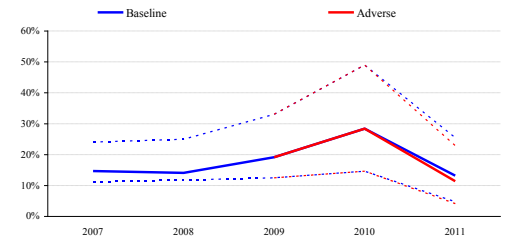
Credit growth for both scenarios
(%, year-on-year)



NPL ratios for the scenarios
(% of total loans)



Capital adequacy ratios after interbank contagion
(%)



Sources: Bank of Finland Institute for Economies in Transition and ECB calculations.
Notes: Capital adequacy and non-performing loan ratios refer to the average (solid lines) and the 10th and 90th quantile (dashed lines) for the 200 largest banks by total assets.

Banks on average appeared to be adequately capitalised at the end of 2010. The macroeconomic recovery that started in 2010 continues in 2011 under the baseline scenario. This is reflected in an acceleration of credit growth that, after the decline during the crisis, turns positive in 2010. The rate of credit growth is predicted to more than double in 2011, which might constitute a threat for certain banks. Even if the NPL stock stabilises, certain banks might not be able to bear an acceleration in credit growth that puts downward pressure on their capital adequacy ratios. Based on our calculations and provided that banks are unable to raise additional capital from other sources, the CAR for 67 banks out of 200 included in our sample would fall below the regulatory minimum of 10% in 2011 and the total recapitalisation costs would reach 0.6% GDP in 2011. On the other hand, profitability of the banking sector in 2010 outpaced even pre-crisis levels, which would help improve the

situation of some banks in 2011. Moreover, state-controlled banks could be recapitalised easily by the government and state support for domestic private banks could also be provided via state-controlled companies as in 2008 and 2009. In addition, some banks will have to increase their registered capital anyway when new minimum capital requirements of RUB 180 million (about €4.6 million) enter into force at the beginning of 2012.[10]

Under our adverse scenario, which assumes only sluggish growth in 2011, the situation deteriorates further. As the macro data for 2010 and much of 2011 are already known, it is clear that this scenario is only hypothetical. The NPL ratio increases under the scenario to about 13%, while the average CAR for all banks included in our analysis remains above the regulatory minimum.[11] Some 80 banks out of the 200 in our sample would need recapitalisation in 2011.[12] Total recapitalisation costs during 2011 would reach as high as 0.8% of GDP.

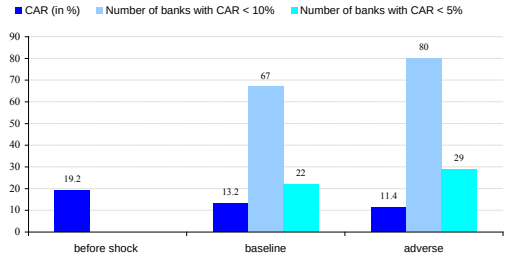
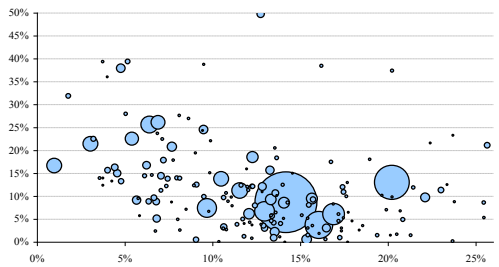
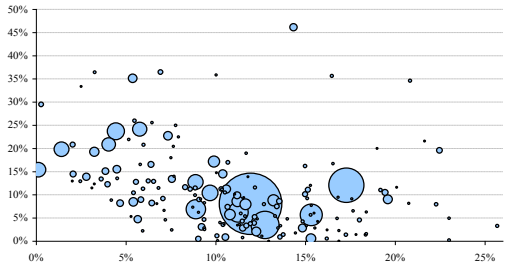
Taking into consideration Russia's low public debt-to-GDP ratio (just below 10% at the end of 2010), the government is fully able to recapitalise banks under each scenario without facing significant fiscal strains. Despite this, our analysis highlights some weaknesses in the Russian banking sector. The currently large average capital buffer (18.1% at the end of 2010) was partly the result of a substantial slowdown in credit growth (from over 40% of annual nominal credit growth in pre-crisis period to decrease of about 2.5% in 2009). As the economy recovers, high credit growth can put downward pressure on the CAR from the increase in risk-weighted assets and banks tightening credit conditions. Thus, economic recovery could be dampened as access to external financing worsens, especially for medium-sized and small firms. Here, the capacity of the Russian banking sector to maintain pre-crisis credit growth without generating additional risk would be limited. This reinforces the views that Russia's banking sector is under-dimensioned for the size of the economy and that private sector actors still face serious constraints in access to bank financing. Even today, Russian corporations tend to rely on financing obtained from global markets if they can get it.

[10] Minimum capital requirements at the time of writing were RUB 90 million. In December 2011, however, the president signed a new law that incrementally raises the minimum capital requirements for existing banks to RUB 300 million (about €7.4 million) by 2015.

[11] This number has been adjusted to obtain the value comparable with the commonly used practices and does not correspond to officially reported numbers provided in section 2.

[12] These results are in line with the stress test results conducted by the Central Bank of Russia (CBR, 2011), whereby about a third of all Russian banks would need to be recapitalised under our adverse scenario. The CBR results are based on bank-level data as of end-2010.

Individual results of macro stress tests

CAR, baseline and adverse scenario in 2011 (%)	
	
CAR and NPL ratios for baseline scenario in 2011 Note: CAR (%) is on the horizontal axis and NPLs (% of total loans) are on the vertical axis.	CAR and NPL ratios for adverse scenario in 2011 Note: CAR (%) is on the horizontal axis and NPLs (% of total loans) are on the vertical axis.
	

Sources: Bank of Finland Institute for Economies in Transition and ECB calculations.

4.2 Results by ownership

One of the distinctive features of the Russian banking sector is the substantial role of the state. While state-controlled banks are tacitly assured of being bailed out in case of financial distress, this tells us nothing about how vulnerable these banks actually are to macroeconomic downturns. To investigate this question, we divide banks in our sample into three categories according to ownership. Foreign-owned banks are those where foreign ownership share exceeds 50%. State-controlled banks are identified based on the data from Vernikov (2009) updated at BOFIT. The last group consists of private domestic banks.

Our analysis reveals that all types of banks are highly sensitive to macroeconomic development in the country. In line with the above-described results for the entire banking sector, the CAR of banks in all subgroups drops significantly in 2011 (even under the baseline scenario). The average CAR of foreign-owned and domestic private banks drop to near the regulatory minimum. The situation of state-controlled banks seems a bit better as the starting level of CAR was higher for these banks; their average CAR does not fall below

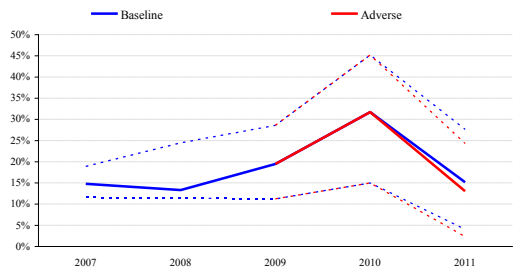
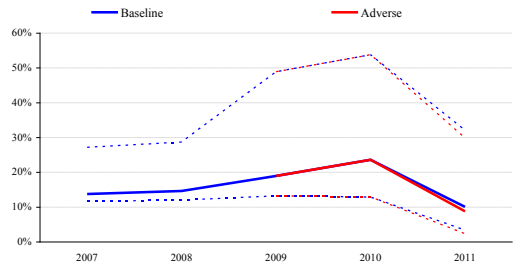
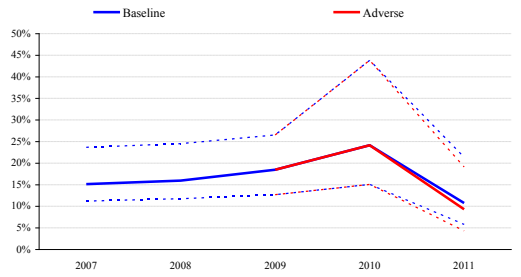
15% under baseline scenario in 2011. Moreover, state-controlled banks can rely on relatively stable household deposits and access to CBR financing as necessary.

Foreign-owned banks seem most vulnerable. Almost half of foreign-owned banks under the baseline scenario and over half under the adverse scenario see their CARs fall below the regulatory minimum without infusions of fresh capital. The recapitalisation costs here amount to almost 0.3% of GDP under the baseline scenario, and even higher under the adverse scenario for 2011. Prior to the European debt crisis, at least, the working assumption was that these banks have strong parent companies that would have little trouble providing additional capital infusions under normal circumstances.

Similar recapitalisation costs as in the case of foreign-owned banks would be necessary for domestic private banks. Some 30% of these banks under the baseline scenario and 40% in the adverse scenario would have CARs lower than the regulatory minimum required by Russian regulator (10%). For some of these banks, it could be challenging to increase their capital. Nevertheless, they can become interesting targets for acquisition by other banks. Russia's state-controlled banks have grown recently by acquiring other banks, a trend that undoubtedly strengthens the role of state-controlled banks in all segments of the market.

Under our adverse scenario, the situation worsens for foreign-owned and domestic private banks. The average CAR falls below the regulatory minimum for these subgroups of banks in 2011.

Results of macro stress test for ownership subgroups

STATE-CONTROLLED BANKS	FOREIGN-OWNED BANKS
CAR after interbank contagion (%)	CAR after interbank contagion (%)
	
DOMESTIC-PRIVATE BANKS	
CAR after interbank contagion (%)	
	

Sources: Bank of Finland Institute for Economies in Transition and ECB calculations.
Notes: Capital adequacy and non-performing loan ratios refer to the average (solid lines) and the 10th and 90th quantile (dashed lines) for the 200 largest banks by total assets.

4.3 Results by size

The fact that the Russian banking sector is so concentrated increases the relative importance of its largest banks. It is therefore prudent to analyse the results of our stress tests for different sized banks. We divide the banks in our sample into three categories (large, medium and small) based on total assets. We apply two different sets of criteria to divide the banks into these subgroups,[13] but both produce the results we now describe.

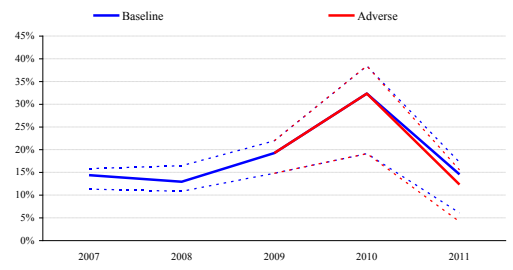
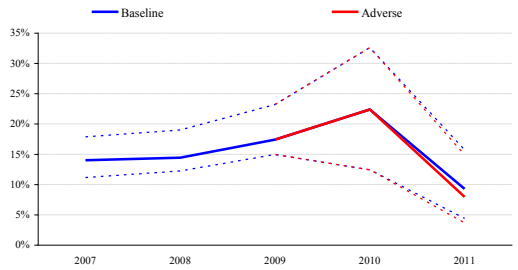
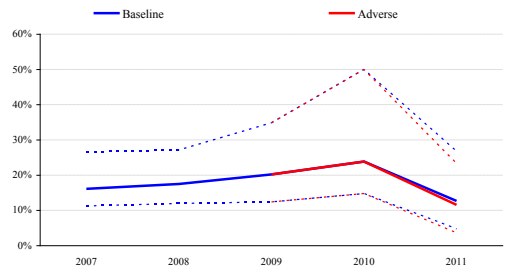
Our analysis suggests medium-sized banks are the most vulnerable. Even under the baseline scenario, about half of medium-sized banks end up with CARs lower than the regulatory minimum and the average CAR for all medium-sized banks drops below the minimal level. On the other hand, the average CAR of both large and small banks does not fall below the 10% minimum even under the adverse scenario. Large and small banks tend

[13] The large banks are Russia's ten largest banks by assets. Medium-sized banks are defined as either the eleventh to thirtieth largest banks, or alternatively, as the eleventh to fiftieth largest banks. The remaining banks in the Top 200 are considered as small banks.

to be a bit better capitalised than medium-sized banks, but their CAR declines are also not as sharp. Medium-sized banks are systemically important, since they are large enough to precipitate major bank runs. The recapitalisation costs that would be necessary for medium-sized banks under adverse scenario provided that they were not able to raise new capital otherwise, would reach approximately 0.3% of GDP.

Unlike medium-sized banks, small banks seem largely resilient to deterioration in the macroeconomic environment. A possible explanation for this phenomenon might be that they typically operate within a small region and focus on some specific businesses they know well. Such a strategy likely makes it easier to manage risk. Moreover, small banks on average hold substantial capital buffers. On the other hand, in comparison to large banks it is more difficult and more costly for medium-sized banks to acquire capital which makes them more vulnerable than large banks.

Results of macro stress test for size subgroups

LARGE BANKS	MEDIUM-SIZED BANKS
CAR after interbank contagion (%)	CAR after interbank contagion (%)
	
SMALL BANKS	
CAR after interbank contagion (%)	
	

Sources: Bank of Finland Institute for Economies in Transition and ECB calculations.
Notes: Large banks are defined as the ten largest banks by assets, medium-sized as the eleventh to thirtieth largest banks and the rest are considered to be small. Capital adequacy and non-performing loan ratios refer to the average (solid lines) and the 10th and 90th quantile (dashed lines) for the 200 largest banks by total assets.

5 Conclusions

A healthy financial sector is necessary for sustainable economic growth. Hence, it is crucial to assess risks and potential vulnerabilities of the banking sector. Our paper proposes a top-down stress test methodology that employs relatively limited information. This is especially important in emerging markets where short time series, structural breaks and limited data availability with absence of reliable market data can make banking sector analyses quite challenging. Moreover, credit growth in emerging economies tends to be rather volatile, especially when compared to advanced economies. This aspect of emerging economies has an important implication for choice of stress testing methodology as such volatility influences risk-weighted assets (RWA) in bank portfolios. While a commonly used static framework assuming constant balance sheet items over the projected horizon can be sufficient for an advanced economy, it can substantially bias the results for emerging economies where the amount of total loans can as much as double over a short period of time. Thus, a dynamic approach projecting key balance sheet items may better capture the high volatility of credit growth typical of emerging economies.

Moreover, proper analysis of banking sector vulnerabilities is essential to address potential financial instability in an adequate and timely manner. Stress tests constitute an important part of financial stability assessment that helps regulators and policymakers respond appropriately to changing macroeconomic conditions.

Russia's financial system is bank-based. Important sources of risk in the sector can be easily overlooked in aggregate banking sector numbers. Hence, we employ individual bank level data to detect possible banking sector vulnerabilities. A top-down macro stress test approach is applied here to assess stability of the Russian banking sector. We consider the 200 largest banks which constitute 94% of the banking sector's assets. Using stress test framework we consistently evaluate risks on bank balance sheets (credit, market, contagion and income risks). Moreover, the employed dynamic approach allows us to capture impact of re/de-leveraging effect on banks' balance sheets which is especially important for emerging markets like Russia. We analyse the banking sector as a whole, as well as the resilience of subgroups based on bank size and ownership. The applied two-year horizon is shown to better explicate the long-term nature of credit risk that the commonly used one-year horizon.

Our analysis backs up the view that the Russian banking sector is under-dimensioned for the size of the economy and that the private sector is likely to face difficulties in obtaining external financing when macroeconomic conditions deteriorate. We show that medium-sized banks are on average more vulnerable than large and small banks. Furthermore, the Russian banking sector remains dominated by state-controlled banks that are less vulnerable to global financial problems than foreign-owned banks. In any case, the government still has sufficient fiscal space to recapitalise the banks in a downturn. This was illustrated in summer 2011 with the massive public rescue of Bank of Moscow with a $14 billion bailout package. Serious problems of Bank of Moscow and some other banks which were however not spotted by the regulators point out to weaknesses in bank supervision.

As a policy note, Russian banks in general should be expected to bolster their capital as economic growth recovers. Here, it is important to keep in mind that we assume no increase in bank capital in our calculations. In general, when considering the situation in pre-crisis years, bank capital was growing at about 38% on average in the period 2001−2007. If the banking sector returns to growth, only some banks for which we have identified CARs below the minimum requirement would actually face this situation. Nevertheless, the limited ability of the banking sector to finance the real sector could curtail Russian economic growth over the medium and long term.

References

Bank of England (2008). Financial Stability Report, October.

Berkowitz, J. (2000). "A Coherent Framework for Stress Testing," *Journal of Risk* 2, 1-11.

Blaschke, W., M. Jones, G. Majnoni and M. Peria (2001). "Stress Testing of Financial Systems: An Overview of Issues, Methodologies, and FSAP Experiences," IMF Working Paper No. 01/88.

Board of Governors of the Federal Reserve System (2009a). "The Supervisory Capital Assessment Program: Design and Implementation."

Board of Governors of the Federal Reserve System (2009b). "The Supervisory Capital Assessment Program: Overview of Results."

Borio, C., C. Furfine and P. Lowe (2001). "Procyclicality of the Financial System and Financial Stability Issues and Policy Options," BIS Papers 1, Bank for International Settlements.

Boss, M., G. Krenn, J. Pann, C. Puhr and M. Summer (2006). "Systemic Risk Monitor: A Model for Systemic Risk Analysis and Stress Testing of Banking Systems," Financial Stability Report 11, 83-95, Oesterreichische Nationalbank.

Boss, M., G. Fenz, J. Pann, C. Puhr, M. Schneider and E. Ubl (2009). "Modeling Credit Risk through the Austrian Business Cycle: An Update of the OeNB Model," Financial Stability Report 17, 85-101, Oesterreichische Nationalbank.

Čihák, M. (2007). "Introduction to Applied Stress Testing," IMF Working Paper 07/59.

Committee of European Banking Supervisors (2010). "Aggregate outcome of the 2010 EU wide stress testing exercise coordinated by CEBS in cooperation with the ECB."

Central Bank of the Russian Federation (2010). *Обзор финансового рынка* (Financial Market Review), No.2 (69).

Central Bank of the Russian Federation (2011). Banking Supervision Report 2010.

Drehmann, M., S. Sorensen and M. Stringa (2008). "The Integrated Impact of Credit and Interest Rate Risk on Banks: An Economic Value and Capital Adequacy Perspective," Working Paper 339, Bank of England.

European Banking Authority (2011). "2011 EU-Wide Stress Test Aggregate Report," July.

Hamerle, A., T. Liebig and H. Scheule (2004). "Forecasting Credit Portfolio Risk," Discussion Paper Series 2: Banking and Financial Supervision 1, Deutsche Bundesbank.

IMF and World Bank (2005). *Financial Sector Assessment: A Handbook*, International Monetary Fund and the World Bank.

Jakubík, P. (2007). "Macroeconomic Environment and Credit Risk," Czech Journal of Economics and Finance 57(1-2), 41-59.

Jakubík, P. and Ch. Schmieder (2008). "Stress Testing Credit Risk: Comparison of the Czech Republic and Germany," Financial Stability Institute, Bank for International Settlements.

Jiménez, G. and J. Saurina (2006). "Credit Cycles, Credit Risk, and Prudential Regulation," *International Journal of Central Banking*, 65-98, June.

Jokivuolle, E., K. Virolainen and O. Vahamaa (2008). "Macro-Model-Based Stress Testing of Basel II Capital Requirements," Bank of Finland Research Discussion Paper 17, Bank of Finland.

Jones, M., P. Hilbers and G. Slack (2004). "Stress Testing Financial Systems: What to Do When the Governor Calls," IMF Working Paper No. 04/127.

Moody's (2010). Moody's Global Banking – Russia, Banking System Outlook.

Schmieder, Ch., C. Puhr and M. Hasan (2011). "Next Generation Balance Sheet Stress Testing," IMF Working Paper 11/83, April.

Upper C. and A. Worms (2002). "Estimating Bilateral Exposures in the German Interbank Market: Is there a Danger of Contagion?" Bundesbank Discussion Paper 09/02.

Van den End, J. W., M. Hoeberichts and M. Tabbae (2006). "Modelling Scenario Analysis and Macro Stress-testing," DNB Working Paper 119, De Nederlandsche Bank.

Vernikov, A. (2009). "Russian Banking: The State Makes a Comeback," BOFIT Discussion Paper 24/2009, Bank of Finland.

Virolainen, K. (2004). "Macro Stress Testing with a Macroeconomic Credit Risk Model for Finland," Discussion Paper 12, Bank of Finland.

Wilson, T. C. (1997a). "Portfolio Credit Risk I," *Risk Magazine* 10(9), 111-117.

Wilson, T. C. (1997b). "Portfolio Credit Risk II", *Risk Magazine* 10(10), 56-61.

BOFIT Discussion Papers

A series devoted to academic studies by BOFIT economists and guest researchers. The focus is on works relevant for economic policy and economic developments in transition/ emerging economies by BOFIT economists and guest researchers.

2012

No 1 Walid Marrouch and Rima Turk-Ariss: Bank pricing under oligopsony-oligopoly: Evidence from 103 developing countries

No 2 Ying Fang, Shicheng Huang and Linlin Niu: De facto currency baskets of China and East Asian economies: The rising weights

No 3 Zuzana Fungáčová and Petr Jakubík: Bank stress tests as an information device for emerging markets: The case of Russia

www.bof.fi/bofit

BOFIT Discussion Papers
http://www.bof.fi/bofit_en • email: bofit@bof.fi
ISBN 978-952-462-734-4, ISSN 1456-6184, online