Macroeconomic and bank-specific determinants of credit risk: evidence from Russia[1]

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Abstract

During the latest crisis Russian banking system was faced with a significant deterioration in the loan quality. Russian government was forced to carry out massive recapitalization of the major national banks to maintain their stability. To evaluate the effectiveness of such a policy measure it's necessary to distinguish among the credit risk sources of affected banks. The main purpose of this paper is to separate the influence of macro- and microeconomic factors that led to an increase in bad loans of Russian banks. To address the research question we use single-equation approach on panel data covering Russian banks during the period 2004-2011. The resulting findings suggest that most of the negative influence on Russian banks' loan quality was caused by deterioration of macroeconomic conditions. However , taking into account a considerable heterogeneity of Russian banks we develop the framework which is aimed at identification banks whose risky strategy before the crisis led to prevailing part of microfactors' contribution to the overdue loans increase. This instrument can improve efficiency of government decisions on providing financial support to credit institutions.

JEL: E44, G21

Keywords: credit risk, Russian banking system, dynamic panel data model

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Contents

1. Introduction

During the latest crisis Russian banking system was faced with a significant deterioration in the loan quality. The growth of bad loans caused a sharp increase in banks' loan loss reserves. The later reduced opportunities for banks to earn profits and exerted pressure on banks' capital adequacy ratio. Under these conditions Russian government was forced to carry out massive recapitalization of the major banks to maintain their stability. In 2008-2009 Vnesheconombank (Russian Bank for development), granted Russian credit institutions more than 400 billion rubles in the form of subordinated loans. Besides, Bank of Russia provided Sberbank — the largest Russian bank — with the subordinated loan of 500 billion rubles.

The question inevitably arises, how justified was the decision of Russian government to provide financial support to credit institutions? To evaluate the effectiveness of such a policy measure it is necessary to distinguish among the credit risk sources of affected banks. In particular, state capital injections into banks with aggressive pre-crisis business strategies creates a distorting incentives for other banks and may lead to an exacerbation of moral hazard in middle-term perspective. On the contrary, government support is reasonable for those banks who suffer decrease in loan quality mainly due to the worsening of macroeconomic conditions.

The main purpose of our research is to separate the influence of macro- and microeconomic factors that led to an increase in bad loans of Russian banks using wide tools of panel data econometrics. The main hypothesis to be tested is the predominance of microeconomic factors of credit risk realization for most banks that received government support. Testing such a hypothesis involves estimation of panel data regression models explaining the dynamics of bad loans of Russian banks. We'll use as the independent variables those that reflect macroeconomic conditions and specific business strategies of banks.

There are a lot of studies considering determinants of bad loans at individual bank level. Most of them utilize data on largest banks or on the representative sample of banks within one country (among studies to be mentioned later there are researches on Italian, Indian, Greek, Spanish, Polish banks). A few papers consider cross-country data on individual bank level combining banking units of similar countries

(geographically or economically) into one panel (GCC, MENA countries). Existing studies on individual bank level are basically aimed at identifying macro- and microeconomic determinants of bad loans and provide empirical evidence for policy implications (such as influence of bank competition, capitalization, diversification, regulation environment, etc. on financial stability approximated by *ex post* credit risk). To the best of our knowledge the question of disentangling the relative importance of macro- and bank-specific factors of credit risk have not been raised yet[2]. However we believe that this question is of great importance in the context of last crisis in the Russian banking sector and in many other countries when governments were forced to recapitalize injured banks (as reported in (Laeven, Valencia, 2010), during the recent crisis direct fiscal costs to support the financial sector were about 5 percent of GDP in affected countsies).

2. Related literature review

The accumulation of credit risk is the most important factor in terms of maintaining financial stability in most countries, especially in developing ones. The empirical literature suggests that the excessive growth of distressed assets is a sign of an imminent banking crisis. For regulators aimed at ensuring financial stability it is important to predict and foresee the onset of bad debt crisis and to identify its determinants. This encouraged a large number of empirical studies on the econometric analysis of credit risk factors.

Empirical studies on determinants of credit risk can be divided into two main groups - studies at the level of the banking system as a whole (macroeconomic approach - see (Hoggarth, Sorensen, Zicchino 2005), (Babihuga 2007), Pesola (2007)), as well as studies on individual bank level (microconomic approach - see (Jimenez, Saurina 2005), (Espinoza, Prasad 2010), (Quagliariello, 2007), etc.). Studies on macroeconomic or aggregate data are focused on exploring the relationship between aggregate measure credit risk (percentage of adversely classified loans in the consolidated loan portfolio of banking sector or aggregate default rate in the corporate sector) and macroeconomic conditions using data in one

[2] except for (Bercoff, 2002) who, as reported in (Dash, Kabra, 2010), used survival analysis to separate inffluence of macroeconomic and bank specific factors. Though, this paper was not published yet that's why it isn't publicly available now. We were not able to get acquainted with its results and methodology.

(Hoggarth, Sorensen, Zicchino 2005) or several countries (Nkusu, 2011). The resulting econometric models can be applied to top-down stress-tests[3] of banking sector (Hoggarth, Sorensen, Zicchino 2005) or to investigate the feedback effects between loan quality and its macroeconomic determinants (Nkusu, 2011).

The other branch of empirical literature investigates determinants of credit risk on financial firm level data. These papers are of largest interest for us as they explain quality of loan portfolio of individual banks using microeconomic (bank level) and macroeconomic data. This directly corresponds to the topic of our research. Studies on individual bank level differ in choosing the measure of credit risk. The first indicator which is frequently used in empirical work is the ratio of loan loss provisions to total loan portfolio (Quagliariello 2007), (Głogowski 2008). Unfortunately it has a high proportion of noise compared to the real size of the credit risk (because of differences in management policies of banks over the credit cycle). Another credit risk indicator is the percentage of adversely classified / nonperforming loans at individual bank level. This measure is most often used in empirical research on credit risk determinants (Dash, Kabra, 2010), (Louzis,Vouldis, Metaxas, 2011), (Jimenez Saurina 2006), (Boudriga, Boulila Taktak, Jellouli, 2009), (Salas, Saurina, 2002), (Espinoza, Prasad, 2010). In (Quagliariello 2007) flow of new bad loans is also used instead of commonly used stock measure. As noted by (Quagliariello 2007) this indicator can be interpreted as a default rate. However the ratio of new bad loans (classified in the reference period) to the performing loans outstanding don't take into account recovery of loans, which were adversely classified in the past. The drawbacks of loan loss provisions and flow of new bad loans as the measures of credit risk induces us to use the percentage of nonperforming loans or its' proxy as the dependent variable in our research.

Banks' borrower and strategy heterogeneity may result in different sensitivity of credit risk indicators to macroeconomic conditions and microeconomic strategies. For example, the ratio of problem loans in savings and commercial banks in Spain have different sensitivity to GDP growth in (Salas, Saurina, 2002), the same holds in Greece for consumer and corporate loans in (Louzis, Vouldis, Metaxas, 2011). However most of the studies investigate determinants of credit risk using heterogeneous sample of

[3] (Sorge, 2004) provides a comprehensive review of stress-test methodologies

banks controlling for banks' different strategies by means of dummy variables and taking into account share of bank resources used in specific niches (retail, corporate, etc. – see below).

Most of reviewed studies provide an empirical confirmation that after controlling for common for all banks factors (systematic or macroeconomic), that determine business cycle phase, borrowers' financial conditions and their ability to repay debts, credit risk of individual bank is also determined by the riskiness of adopted business strategy (idiosyncratic or microeconomic factors). Indeed, even in the same macroeconomic environment banks have access to the borrowers of different credit quality depending on bank's market power, risk appetite, quality of screening, etc. In particular, banks' loan quality unevenness becomes apparent during the instability periods. For example, (Salas, Saurina, 2002) found that dispersion of problem loans ratio across banks rises substantially in the downward phase of the business cycle. To test the significance of bank-specific (microeconomic) factors of Greek banks' credit risk (Louzis, Vouldis, Metaxas, 2011) first estimated a «baseline model» which included only macroeconomic factors. Then the authors examined if the incorporation of bank-specific determinants helped to improve explanatory power of the model. (Salas, Saurina, 2002) considered significant effects of microeconomic variables in their problem loans equation by means of testing the hypothesis that all these variables have coefficients equal to zero.

3. Factors description

a. Macroeconomic factors

Most of the studies under review use GDP growth rates as the main indicator of macroeconomic conditions and debt sustainability of wide group of borrowers. An increase in GDP growth rates translates into higher income and improves debt servicing capacity of borrowers, which results in lower credit risk of banks. Some papers include solvency indicators of individual economic agents: households and corporate sector (Salas, Saurina, 2002), (Głogowski 2008), central government (Louzis, Vouldis, Metaxas, 2011). Debt service cost is usually approximated by real interest rates on loans. Some authors include asset prices (approximated by inflation rate, house price growth and stock market growth) to take into account influence of collateral inflation, asset bubbles and wealth effect on banks' credit risk

(Quagliariello 2007), (Nkusu 2011). In the studies on banking sectors of emerging markets authors stress the importance of taking into account foreign currency exposure because in these countries confidence to national currency can be limited in comparison to internationally recognized currencies (U.S. dollar, euro). This results in large proportion of FX loans. The credit quality of these loans is highly dependent on the exchange rate dynamics. To catch this effect (Głogowski 2008) and (Dash, Kabra, 2010) include real or nominal exchange rate of national currency into their models of credit risk.

b. Bank-specific factors

To investigate the relative importance of bank-specific factors for credit risk explanation existing studies consider the following list of factors: restrictiveness of banks' lending policy and risk appetite (approximated by loan or branch growth rates[4], lending rate, net interest margin, share of collateralized loans etc.), market power (approximated by market share or Lerner index), management efficiency (measured by cost to income ratio), bank performance (profitability), loan portfolio and income diversification (measured by bank size as a proxy for loan portfolio diversification, Herfindahl or entropy indexes for revenue diversification and industry and region loan portfolio concentration), solvency ratio (capital adequacy ratio). Some papers also introduce bank profile and ownership structure dummy variables to explain differences in risk profile of different groups of banks.

The lending policy of banks is expected to be highly correlated with the credit risk indicators. The possible explanation of this phenomenon is the following: rapid loans growth reflects decreasing lending standards as it corresponds with the reduction in time dedicated to consideration of loan applications, decline in monitoring quality, etc. and after a time (often during the economic contraction) it may result in problem loans increase. Several empirical studies find significant influence of pre-crisis credit expansion on the size of problem loans in banking sector (see, for example, Quagliariello (2007), Espinoza, Prasad (2010), Jimenez, Saurina (2005)).

High value of lending rate and net interest margin can be a sign of deliberately risky credit policy (high *ex ante* credit risk, built in risk premium) that can lead to rise of problem loans (*ex post* credit risk).

[4] (Głogowski 2008) points out that this indicator may be of limited usefulness because it may not reflect the accumulation of credit risk in case if level of financial depth was small at the starting point and economic agents rapidly increase use of financial services in an environment where access to them was limited before.

Besides, increase in interest rate raises debt service costs for borrowers thus leading to excess default rate. However, most authors didn't find significant influence of bank-specific lending rate on financial firm's credit risk.

There is large body of literature providing convincing evidence in favor of contradictory hypotheses on bank's market power – stability relationship (market power – fragility, market power – stability). However authors use data on different sets of countries and different measures of market power and risk. The most commonly used indicators of competition in bank-level panel studies are the Lerner index and concentration ratios such as Herfindahl-Hirschman index (HHI). In measuring bank individual risk authors prefer non-performing loan ratio (NPL), which is of primary interest in our research, and Z-scores (Roy, 1952). The positive relation between Lerner index and NPL as well as between HHI in loan (deposit) market and NPL are found in (Berger, Klapper, Turk-Ariss, 2008) which partially confirms "competition-stability" view for the sample of 30 developed countries. From the opposite side, (Jimenez, Lopez, Saurina, 2007) reveal the strong evidence of "competition-fragility" nexus using the sample of Spanish banks.

There is no consensus in the literature about the relation between credit risk and bank efficiency. On the one hand, high values of cost efficiency indicator may reflect reduction of resources allocated to risk management and borrower's monitoring , which leads to loan quality deterioration («skimping» hypothesis, put forward by (Berger, DeYoung, 1997)). On the other hand, low cost efficiency indicates low quality of bank management, thus leading to problem loans increase (assumed that inefficient managers are unable to cope with credit risk management - («bad management» hypothesis, (Berger, DeYoung, 1997)). Besides low values of this variable may induce banks to take on more risk in order to improve profitability at the expense of the quality of loan portfolio. The investigation of causality direction between cost efficiency and problem loans provide more empirical evidence in favor of «bad management» hypothesis (Berger, DeYoung, 1997), (Louzis, Angelos, Metaxas, 2011), (Quagliariello, 2007), (Podriera, Weill, 2008).

A number of authors consider influence of bank's past performance measured by profitability (ROA – return on assets, ROE – return on equity) on future problem loans ratio. In particular

(Quagliariello, 2007) and (Głogowski 2008) examine if «income smoothing» hypothesis holds. This hypothesis implies that banks earn more in time of economic expansion in order to cushion inevitable detereoration of loans' quality during contraction. If this proposition holds than lagged profitability should have positive sign of influence on credit risk. (Louzis, Angelos, Metaxas, 2011) test the same direction of influence explaining it by «procyclical credit policy hypothesis». Their reasonong is that bank management aimed at increasing market share of financial firm may inflate earnings by means of more liberal lending policy («negative NPL extension of credit») thus seeding the seeds of future problems. This hypothesis also predicts positive sign of profitability influence.

Empirical evidence suggests that income sources and loan portfolio diversification are effective means of lowering credit risk. First, involvement in operations not associated with credit risk taking (payment transactions, broking, etc. – income diversification) allows banks to earn less risky income thus, reducing incentives to finance speculative projects. Second, having opportunity to lend money to a diversified range of borrowers banks can successfully reduce their impaired loans (minimizing risk of individual borrower). (Salas, Saurina, 2002) found empirical confirmation of borrower diversification hypothesis.

It is widely accepted in literature that low capital adequacy ratio is associated with higher probability of bank's default, because it may induce management to involve in more risky projects («moral hazard» hypothesis, (Berger, DeYoung, 1997)). The confirmation of this statement was found in (Salas, Saurina, 2002) and (Berger, DeYoung, 1997).

(Głogowski 2008) mention that the level of credit risk differs between types of loans and classes of borrowers. It is obvious that banks' percentage of problem loans can be influenced by the composition of its loan portfolio (weight of retail / corporate loans). Different types of borrowers have unequal debt sustainability under the same macro-environment *ceteris paribus*. For example, (Louzis, Angelos, Metaxas, 2011) report that corporate loans default rates are more sensitive to worsening of macroeconomic conditions. (Głogowski, 2008) outlines that in many countries mortgage loans exhibit lowest default rates. To take these differences into account (Głogowski 2008) explores significance of bank business profile by introducing corresponding dummy variables (retail, corporate, universal banks,

etc.).

The other important determinant of management quality and riskiness of the strategy is the type of bank ownership. (Boudriga, Boulila Taktak, Jellouli, 2009) found that foreign ownership has a positive impact on loan quality as it promotes imports of human capital, management skills and technologies and provides opportunity to raise funds cheaply on international markets. (Boudriga, Boulila Taktak, Jellouli, 2009). State banks are reported to have more incentives to involve in risky projects since they are more prone to «too big to fail problem». (Micco, 2004) investigated bank performance in 119 countries and concluded that state-owned bank in developing countries have higher ratio of nonperforming loans. However, (Hu, Li, Chiu, 2004) found nonlinear U-relationship between problem loans and the percentage of government shareholdings in bank capital.

(Głogowski, 2008) proposed an idea of specific transformations of factors to improve their explanatory power. First, in this paper households income and debt susutainability characteristics were multiplied by individual bank's share of retail loans. This allows to account ind individual bank's exposure to particular source of risk. Second, (Głogowski, 2008) took bank-level loan growth and capital adequacy ratio in deviations from sector median. This variables transformation helps to identify bank-specific type of risk excluding common for all banks effects.

c. Selected explanatory factors

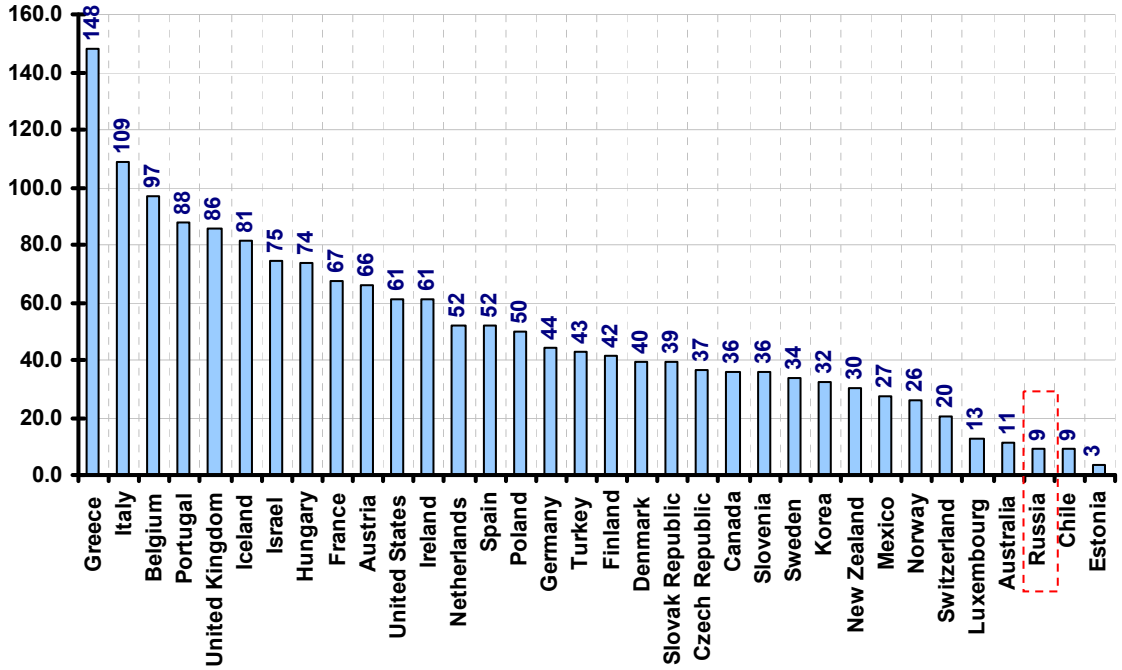
Overview of credit risk determinants used in existing empirical studies allowed us to identify several groups of factors included in bad loans equations (a detailed list of factors and expected direction of their influence see in Appendix, Tables 2a-2b):

- macroeconomic factors including
    - national economy characteristics;
    - households debt and income indicators;
    - corporate sector indicators;
    - prices of collateral;
    - external sector and exchange market conditions;
- banking sector factors including

- lending policy indicators;
- interest rates;
- efficiency indicators;
- performance characteristics;
- diversification indicators;
- market power index.

Our list of factors doesn't contain any indicators reflecting Russian government debt sustainability indicators. At the same time it is widely known that government finance squeeze in developed European countries have imposed considerable risks on banks with government bonds of risky countries (PIIGS and some others) in their portfolios. However, Russian government has relatively low level of debt to GDP ratio in comparision with most OECD countries (figure 1). That is why we did not consider risks originating from government finance deterioration.

Figure 1. Central government debt to GDP in 2010, %.



Source: OECD, CMASF calculations

Rissian banks issue a high proportion of foreign currency loans (before the 2008 crisis the share of FX loans in total loans was more than 20 percent). Borrowers' ability to repay for these loans is sensitive to the ruble exchange rates (especially national currency depreciations noticeably affects debt burden and

debt service costs thus increasing default rate on these loans). That's why following (Głogowski, 2008) we take into empirical consideration nominal and real exchange rates and balance of payment indicators which can lead currency market dynamics (see Table 2a in Appendix).

Following (Berger, Hannan, 1998) we extend their ideas about individual Herfindahl-Hirschman indexes calculated on the bank level. For this purpose we use weights of different kinds of assets (liabilities) in total bank's assets and then multiiply them by the banking industry concentration ratios in the respective markets of assets (liabilities). These indicators ($B\text{-}HHI_{EA}$ and $B\text{-}HHI_{EL}$, see Table 2b in Appendix) represent bank involvement into different assets or liabilities markets and serve as asubstitute for Lerner index.

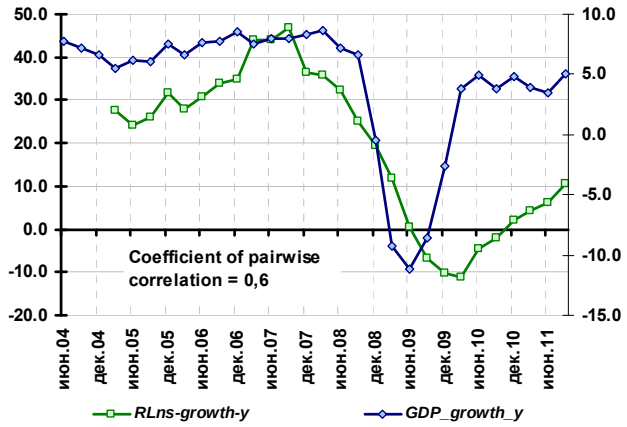
Since the main purpose of our research is to separate the relative importance of macro- and bank-specific factors of credit risk we started our empirical study from investigating correlation between these groups of factors. It is obvious that if we include both types of factors as explanatory variables into equation of credit risk and at the same time dynamic of bank-specific factors can at least partially be explained by macroeconomic conditions we'll get a bias in our estimation of relative contribution of both groups of factors. In particular, if bank-specific factors are correlated with macroeconomic ones we will overestimate the relative importance of microeconomic factors. In this case macro factors will have direct effect on bank risk through their own coefficients in credit risk equation and indirect effect through the influence on banking actions.

The possible and the easiest solution of this problem is to avoid inclusion into equation those bank-specific factors that are tightly correlated with macro conditions. It is clear that this correlation can be maintained only by link between dynamics common for all banks (sample mean) and mactoeconomic environment. Our correlation analysis suggests that only average loan growth rates, growth of loans to deposits ratio, the share of non-interest income in total income and profitability after loan loss provisioning (ROAa) are closely correlated with macroeconomic factors approximated by GDP growth rates (figure 2). That is why we are not able to include these variables on individual bank level. Instead of this we can include these bank-specific factors in deviations from banking sector mean (that are uncorrelated with macrofactors due to construction) – see Table 2b in Appendix. Other bank-specific

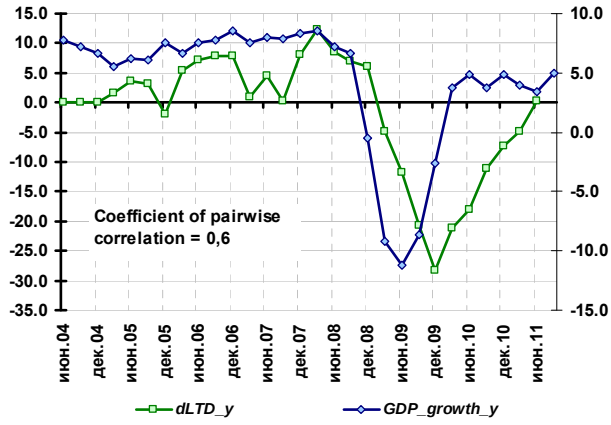
factors (that are uncorrelated with macroecomonic factors) were included in levels. This approach allowes us to avoid bias in our assessment and to estimate contribution of each group of factors consistently.

Figure 2. Correlation between selected banking factors (measured as sample average) and macroeconomic conditions (approximated by GDP growth rates)

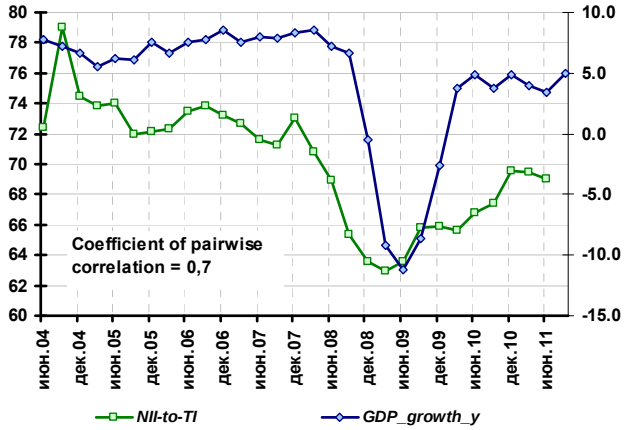
Real loans growth rate, per year (%) and GDP growth rate, per year (%) - right scale



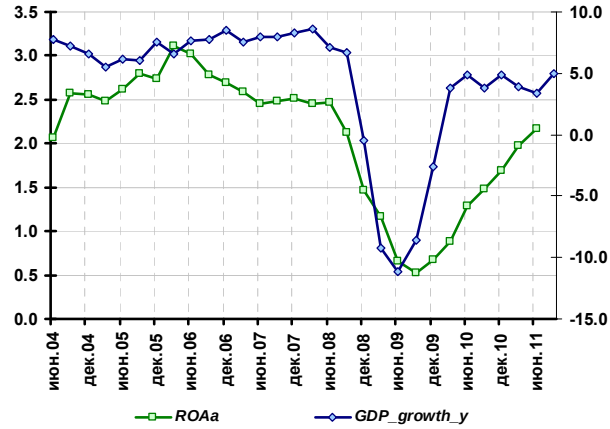
Growth of loans to deposits ratio, per year (perc. p.) and GDP growth rate, per year (%) - right scale



Non interest income to total income (%) and GDP growth rate, per year (%) - right scale



Return-on-assets after loan loss provisioning (%) and GDP growth rate, per year (%) - right scale



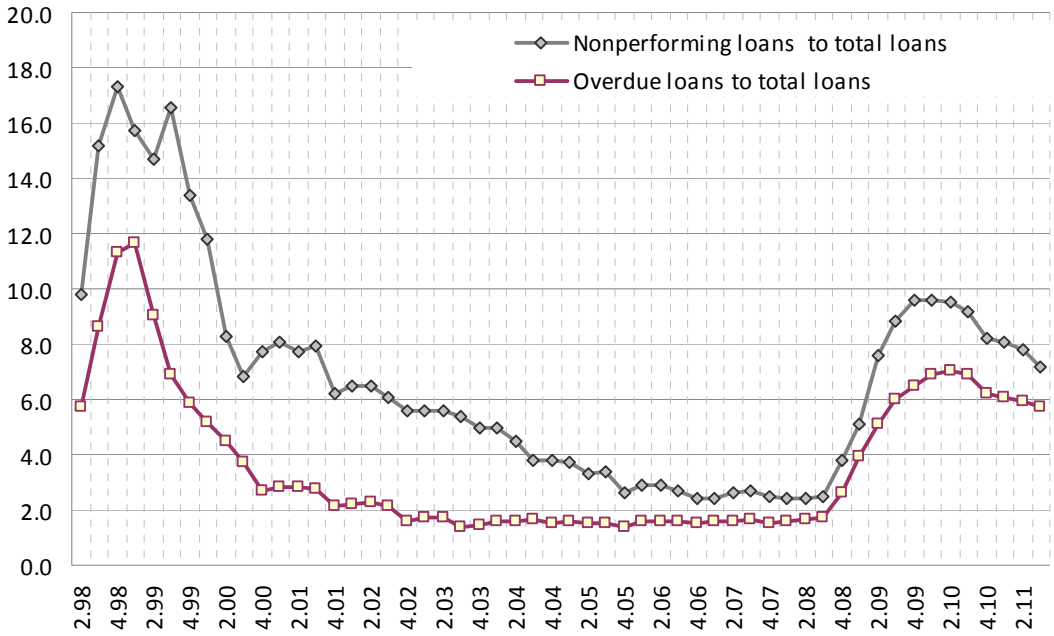
Source: Bank of Russia, Federal State Statistic Service, authors' calculations

As we have previously noted, we intend to use the percentage of nonperforming loans[5] as the dependent variable in our research. Unfortunately, Russian banks are not required to publish theit financial accounts in line with international reporting standards. On the basis of Russian accounting

[5]The entire loan becomes nonperforming if payment of interest or principal is past due by 90 days or more

standards it is impossible to estimate this indicator. But for international comparisons IMF uses an approximation for Russian banks' nonperforming loans defined as the share of problem and bad loans, that is, loans of IV and V quality categories according to Regulation of the Bank of Russia № 254-P. However, Bank of Russia doesn't disseminate form 115 of individual banks records (only form 101 and 102 which will be the statistical base of our research – see below). That is why we use the ratio of overdue loans[6] to total loans as the only available substitute for nonperforming loans as the dependent variable. Figure 3 demonstrates that there is a close dependence between these indicators

Figure 3. Percentage of nonperforming loans and overdue loans in Russian banking system



Source: Bank of Russia, authors' calculations

4. Data description including dealing with the outliers

We exploit two types of determinants of banks' loan portfolio quality. They are as follows:

1. bank variables:
   - on micro level collected from Bank of Russia[7];
   - on macro level as banking sample average;

[6] Percentage of overdue loans includes only the overdue payments of loan, not the intire loan as i n case of nonperforming loans

[7] Publicly available financial accounts – balance sheet statistics (form 101) and profit & loss accounts (form 102), http://www.cbr.ru/credit/forms.asp

2. macroeconomic variables collected from Federal State Statistics Service website[8].

We use monthly bank-level data from balance sheet statistics (form 101) and quarterly bank-level data from profit & loss accounts (form 102) reported by Russian commercial banks over the period 2004Q1 – 2011Q2 (Table 1)[9]. All the quarterly bank specific indicators aggregated on the basis of form 102 (interest income, interest and operating expenses, etc.) are taken in annual terms, i.e. as moving sum of each indicator values for the four previous quarters, to avoid the problems associated with seasonality. To ensure comparability of the forms 101 and 102 we reorganize monthly bank-level indicators coming from the form 101 to quarterly basis.

Table 1. Sources and data structure for Russian commercial banks

Data Sources:	**Balance sheet statistics (form 101)**	**Profit & Loss accounts (form 102)**
Variables	*Assets*: households and corporate loans, granted inter-bank loans, purchased securities, total assets, etc. *Liabilities*: funds, deposits, attracted inter-bank loans, foreign liabilities, etc. *Capital and performance*: total equity, loan loss provision, profit	*Income*: interest income, operating income, etc. *Expense*: interest expenses, operating expenses, etc.
Duration	monthly	quarterly
Availability	from January 2004	from 2004Q1

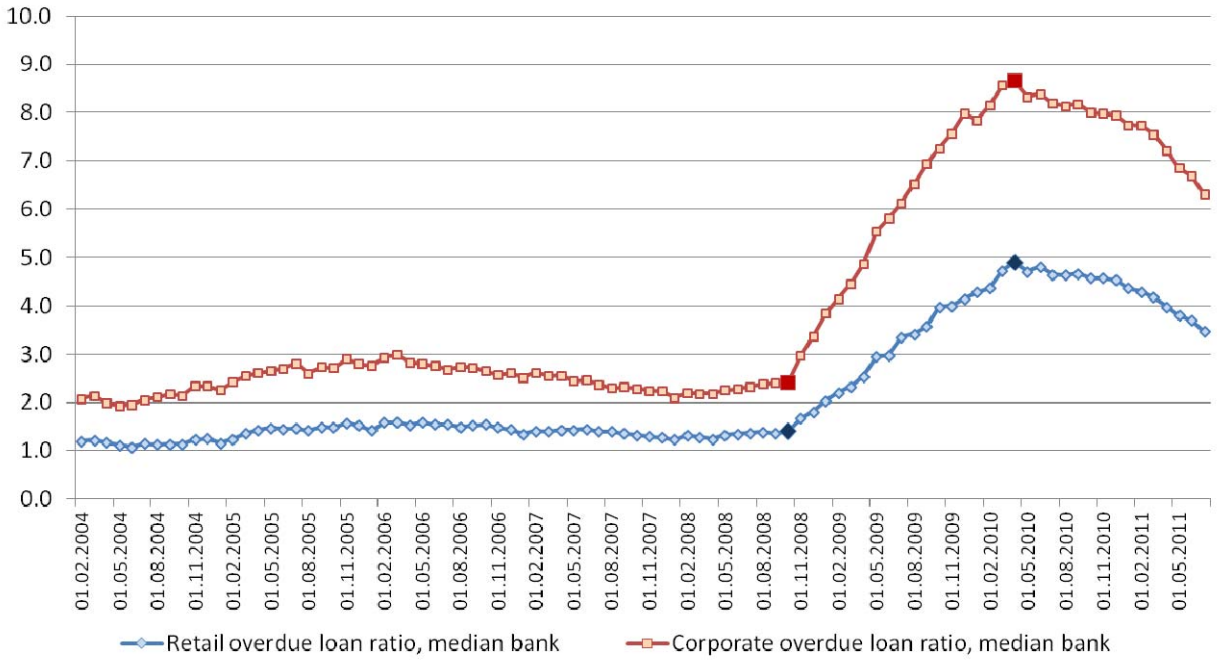
The reporting of financial accounts has one special feature in Russia – it is not necessary for bank to make its individual data publicly available. Accordingly, from quarter to quarter sample size of banks, who agreed to publish their accounts, can vary widely – from 705 to 1024 financial institutions at the beginning of 2004 and at the end of 2010Q1, respectively. Following the aim of our research we exclude from the sample those banks, whose lending strategy is concentrated on banking owners business (affiliated banks) instead of being based on market conditions. This issue is closely related to the problem of financial accounts falsification undertaken by Russian banks to satisfy supervisory standards. To deal with this problem and its possible negative effects on our estimation results we suggest the following procedure of such banks identifying to be further excluded.

[8] Data on GDP, inflation, exchange rates, unemployment, etc: http://www.gks.ru/dbscripts/Cbsd/DBInet.cgi
[9] Earlier data is unavailable

First of all, we distinguish between banks with primarily corporate and retail lending strategy due to their different risk profile reflecting in return-on-asset ratio (ROAb[10]) being equal approximately 5-7% for the group of retail banks and only 2-3% for corporate banks, (Mamonov, 2011). If at a given point of time the share of corporate (retail) loans in bank's loan portfolio exceeds 80% we assume it to be a corporate (retail) bank[11]. Otherwise, if both share of corporate and retail lending exceeds 20% we classify such bank as universal financial institution.

As a next step we try to assess the scope of financial accounts falsification on the bank-level basis within each lending strategy. For this purpose we compare the magnitude of corporate overdue loan ratio at the peak of the crisis with its pre-crisis (normal) level (see Figure 4 as an example for the median bank in our sample).

Figure 4. Percentage of overdue loans in retail and corporate loan portfolios



Source: Bank of Russia, authors' calculations

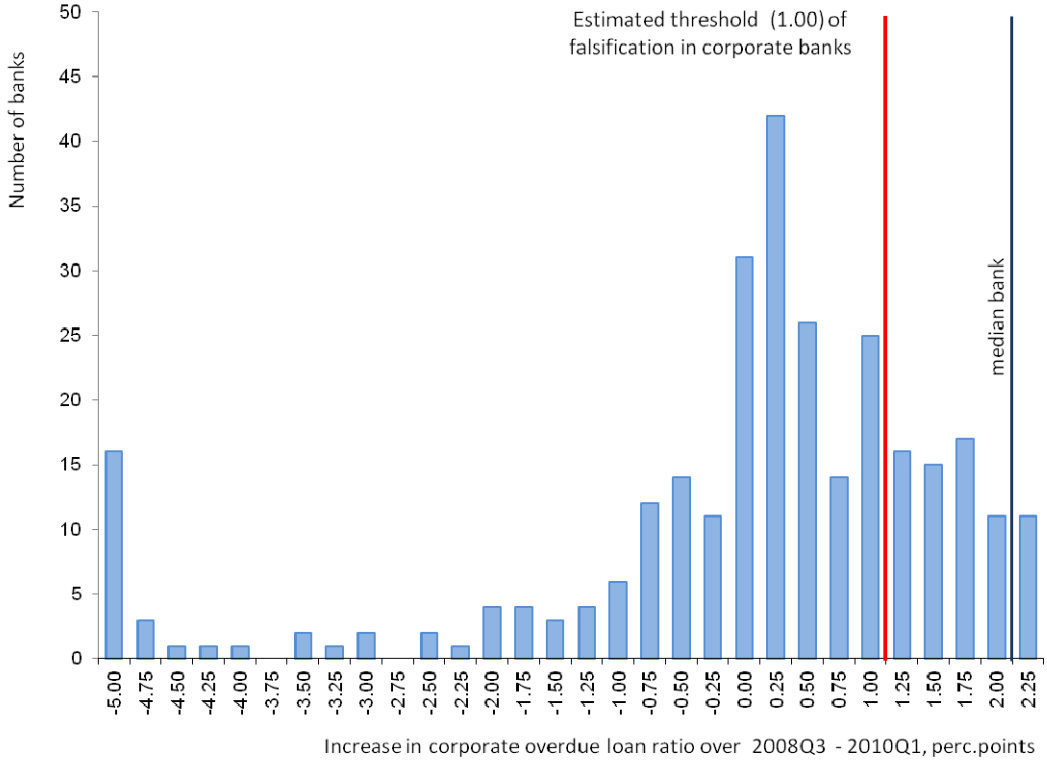
Corporate banks. If a corporate bank provide customer lending on market conditions and does not falsify its accounts than it must experience a sizable increase in overdue loans due to both macroeconomic deterioration and (or) specificities of its business strategies. Such banking institutions are of great interest for our further research. Otherwise, a corporate bank is a falsifier and should be excluded

[10] before loan loss provisioning

[11] One should notice that the average banking industry share of corporate loans decreased significantly during observed time period from 85% in 2004Q1 to 76% in 2011Q2 exhibiting a little upward tendency during the 2008-2009 financial crisis

from the sample as an outlier. Figures 5 and 6 demonstrates corporate banks distribution density of the increase of corporate overdue loan ratio over Q3 2008 – Q1 2010, that exhibits significant hump in the distribution located around 0-1 percentage points of the ratio increase. Correspondingly, we assess the threshold of corporate lending quality falsification at approximately 1 percentage points – the lower values indicates banks-falsifiers to be excluded from our sample. Note that the median value is two times higher (2.07 p.p.). There are 222 corporate banks located below the falsification threshold accounting 21% in banking system corporate loan portfolio (excluding "the big four" – Sberbank, VTB, Gazprombank, Rosselhozbank).

Figure 5. Absolute frequency of deviations of problem loans issued to corporate sector at the peak of the crisis (2010Q1) compared to pre-crisis level[12] (2008Q3), percentage points

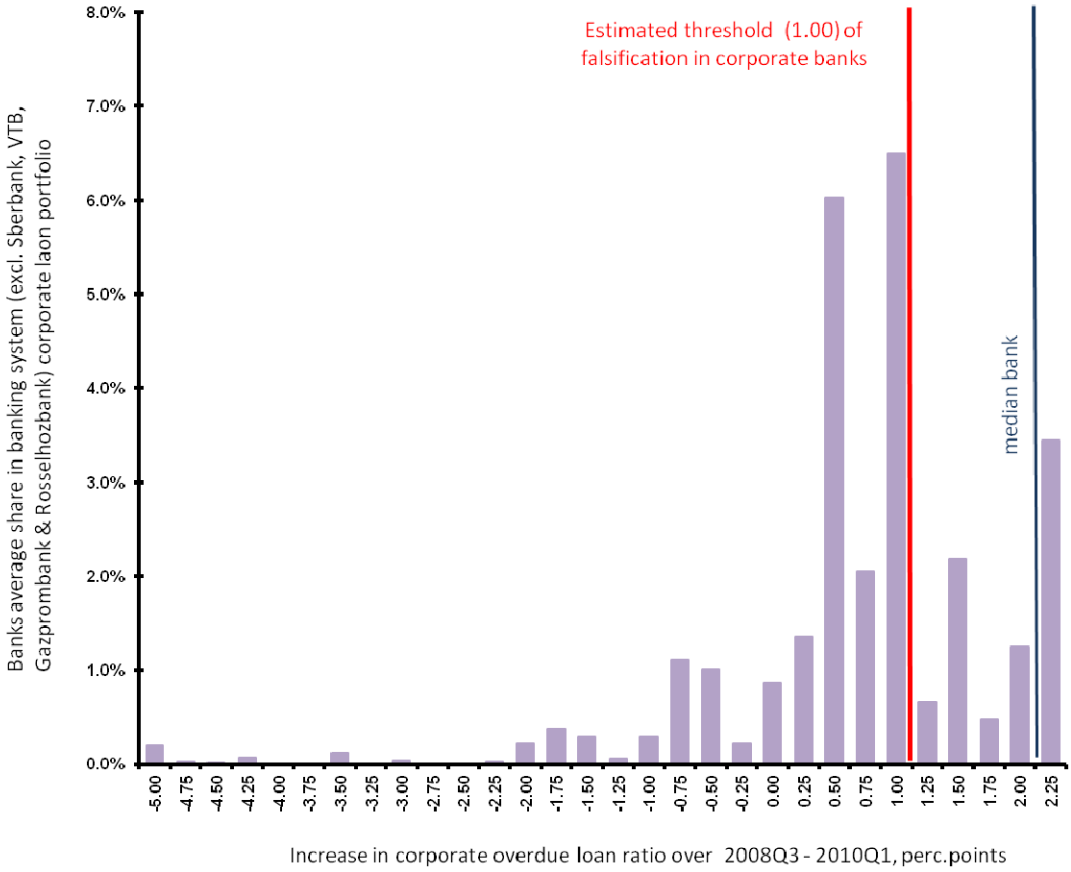


Note: estimated upper threshold of banks suspected in falsifications of quality of their corporate loan portfolios is 1 percentage point

Source: Bank of Russia, authors' calculations

[12] values above 2.25 are hidden for illustrative purposes

Figure 6. Absolute frequency of deviations of problem loans issued to households at the peak of the crisis (2010Q1) compaed to pre-crisis level[13] (2008Q3), truncated from above, percentage points



Source: Bank of Russia, authors' calculations

Retail banks. We found no significant humps in increase of retail overdue loan ratio during the latest crisis. But following the logic of customer lending based on market conditions we qualify retail banks as falsifiers if they exhibited increase in "bad" retail loan ratio lower then 0 provided that share of retail loan in loan portfolio of such a bank is not lesser than 10% (for the sake of outliers absence). We found that there are 85 retail banks satisfying this condition holding only 3% of banking system retail loan portfolio (excluding Sberbank and VTB24 – the leaders of retail banking market in Russia).

Besides, we reorganize our sample excluding observations below 1st and above 99th percentiles in all variables representing relative indicators on the bank level to deal with the problem of significant outliers.

Ultimately, after all excluding procedures we have observations from about 14244 to 19464 of

[13] values above 2.25 are hidden for illustrative purposes

quarterly bank level data due to unbalanced panel.

Our resulting sample covers up to 730 commercial banks representing approximately 90% of total assets of Russian banking system.

5. Model specification and methodology

Following (Salas, Saurina, 2002), we assume that the share of overdue loans in loan portfolio is closely related to its values in previous periods, because overdue loans cannot be immediately written-down and may remain on banks' balance sheets up to several years. In other words overdue loan ratio shows a tendency to persist over time. It necessitates the use of dynamic specification of econometric equations describing the relation between overdue loans and its bank specific and macroeconomic determinants instead of common static equations. Dynamic specifications were also estimated in (Jimenez, Saurina, 2005), (Quagliariello, 2007), (Espinoza, Prasad, 2010).

Nonetheless, we use both static and dynamic approaches to ensure robustness of our conclusions concerning the contribution of micro- and macroeconomic factors to overdue loan ratio. The first one stands for the preliminary conclusions, while the second one brings us to the ultimate results.

5.1. Static specification

Following static approach we write the overdue loan ratio equation as:

$$OL_{i,t} = \xi + \sum_{j=1}^{N_1} \beta^{(j)} \cdot M_{t-k}^{(j)} + \sum_{s=1}^{N_2} \gamma^{(s)} \cdot BI_{t-k}^{(s)} + \sum_{h=1}^{N_3} \theta^{(h)} \cdot BS_{i,t-k}^{(h)} + \sum_{m=1}^{N_4} \delta^{(m)} \cdot \left(BS_{i,t-k}^{(m)} - BI_{t-k}^{(m)}\right) + \mu_i + \nu_{i,t} \quad (1)$$

where

lower-case letters refers to bank i, quarter t ($t = Q1\ 2004 ... Q2\ 2011$) and quarter time lag k ($k = 0, 1, ..., 4$). Number of banks varies significantly in different specifications (from 619 to 645 after all outliers excluding procedures described in Section 4) depending on the choice of covariates and due to the unbalanced panel of banks.

$OL_{i,t}$ – overdue loan ratio (combining retail and corporate borrowers) of bank i in quarter t;

upper-case letters j, s, h and m refers to different sets of macroeconomic (M), banking industry

(*BI*), bank specific (*BS*) determinants and deviations of bank specific from banking industry (*BS–BI*) variables, respectively (see their description in Section 3)[14]. N_1, N_2, N_3 and N_4 are their respective quantities which vary in different specifications.

$\mu_i + \nu_{i,t}$ – composite error term, such that μ_i represents individual effect of bank *i* and $\nu_{i,t}$ is idiosyncratic component which is $i.i.d.\left(0, \sigma_\nu^2\right)$;

$\xi, \beta, \gamma, \theta, \delta$ – vectors of parameters to estimate.

In estimating static version of our models we apply both well-known fixed and random effects estimators and also pooled OLS approach. The best error term specification are chosen according to *F*-test on individual effects, Breush-Pagan *LM*-test on random effects and Hausman test.

5.2. Dynamic specification

We rewrite our static eq. (1) in two ways. First, we add the quarterly lags of dependent variable in the right hand side of equation to account for persistency of overdue loan ratio. Second, following (Blundell, Bond, 1998) we combine dynamic equation in levels with its analogue in first differences which exclude bank's fixed effects and help us to get consistent estimation results. Ultimately, we write a system of equations as:

$$\begin{cases} OL_{i,t} = \xi + \alpha_1 OL_{i,t-1} + \alpha_1 OL_{i,t-2} + \sum_{j=1}^{N_1} \beta^{(j)} M_{t-k}^{(j)} + \sum_{s=1}^{N_2} \gamma^{(s)} BI_{t-k}^{(s)} + \sum_{h=1}^{N_3} \theta^{(h)} BS_{i,t-k}^{(h)} + \sum_{m=1}^{N_4} \delta^{(m)} \left(BS_{i,t-k}^{(m)} - BI_{t-k}^{(m)} \right) + \mu_i + \nu_{i,t} \\ \Delta OL_{i,t} = \alpha_1 \Delta OL_{i,t-1} + \alpha_1 \Delta OL_{i,t-2} + \sum_{j=1}^{N_1} \beta^{(j)} \Delta M_{t-k}^{(j)} + \sum_{s=1}^{N_2} \gamma^{(s)} \Delta BI_{t-k}^{(s)} + \sum_{h=1}^{N_3} \theta^{(h)} \Delta BS_{i,t-k}^{(h)} + \sum_{m=1}^{N_4} \delta^{(m)} \Delta \left(BS_{i,t-k}^{(m)} - BI_{t-k}^{(m)} \right) + \Delta \nu_{i,t} \end{cases} \quad (2)$$

These equations are estimated via the one-step system GMM estimator as inclusion of dependent variable lags into the set of covariates leads to inconsistency of FE estimator. Besides, the estimation of dynamic specification of overdue loan equation can also solve the problem of endogenity of some variables included in the right hand side of the equations. In case of bank-level panel data the endogenous variables are those bank-specific covariates, which are simultaneously determined with the dependent variable. For example, we use real interest rate on banks loans to customers as an explanatory

[14] As we mentioned in Section 3, we include the fourth type of covariates into regressions if pairwise correlation between banking industry determinant and macroeconomic environment (proxied by real GDP growth) is more than 0.5 to deal with the possible problem of multicollinearity which lead to overestimated contribution of microeconomic factors to fitted values of dependent variable (overdue loan ratio).

variable of overdue loan ratio in dynamic specification at the same quarter *t* because there are short-term loans in retail (consumer lending) and corporate (small and medium business) segments. These types of loans may become overdue instantly – within one quarter – in the case of macroeconomic deterioration. But at the same time the interest rates are affected by increasing of overdue loans because banks' managers have the incentives to compensate for their declining interest incomes by means of higher price charged on loans.

6. Estimation results

In this section we provide estimation results of both static and dynamic specifications of overdue loan ratio equation. Here we interpret the resulting empirical links between overdue loan ratio (an indicator of bank instability) and indicators of market power and an indicator of bank operating efficiency. Then we estimate the contribution of micro- and macroeconomic factors to the overdue loan ratio within each of the presented equations. Finally, we generalize our conclusions and provide policy implications.

First of all, we present descriptive statistics of dependent variable and covariates which were finally included in both static and dynamic equations (see Table 3 in Appendix). It shows that the number of macro- and microeconomic determinants equals 8 and 11, respectively, and one specific variable which is the product of micro- and macroeconomic factors. Besides, after all excluding procedures, described in Section 4, we have no significant outliers in bank-level data, but considerable heterogeneity of banks is still remain. For example, the maximum real interest rate on loan is tenfold larger than the median value (7.14%). The same result is for the ROE (before loan loss provisioning) which reflects that banks in our sample pursue different lending strategies. Retail lending (about 4% of sample) is the highest yielding segment of Russian banking market while corporate strategy (29% of banks) is traditionally less profitable.

Parameters estimates of fixed effects regressions (static specification) are presented in the four panels of Table 4 in Appendix. Most coefficients are of high significance and are robust to changes in specifications. In the absence of dependent variable lags in the right hand side of the equations we

achieve about 55% to 58% of goodness of fit calculated on the basis of least squares dummy variables (LSDV) approach. There is a strong evidence in favor of presence of individual effects in our sample according to F-test, which are fixed rather than random in all specifications as Hausman test shows. In Table 6 in Appendix we present matrix of pairwise correlations between different factors included in one of the fixed effects models (FE2a). It demonstrates no significant pairwise correlation between the explanatory variables.

Econometric estimation of FE models has shown that quality of loan portfolios of all banks is tightly correlated with macroeconomic conditions. First, GDP growth rates demonstrate significant and robust to specification inverse influence on the percentage of overdue loans. During the periods of economic expansion credit risk tends to be lower while contraction periods are followed by loan quality deterioration. Second, disinflation enters into equation significantly. The latter indicates that sudden stop of income and asset price inflation can reduce borrowers' debt sustainability. Third, our results confirm hypothesis of significant influence of exchange rates devaluation on the quality of loans denominated in foreign currency. Fourth, retail banks are more exposed to business cycle since changes in unemployment level is a source of additional push up effect on credit risk[15].

Our results provide strong evidence in favor of detrimental effect running from bank-level interest rates to its loan quality. An increase in one standard deviation of real interest rate (approx. 7.5 percentage points across the sample of banks) causes rise of overdue loans in 1.6 percentage points in the next one quarter. It is the largest negative effect among all bank specific variables.

We found that increasing bank-level concentration (HHI_A[16]) representing banks' involvement into different markets of assets[17] leads on average to declining of overdue loan ratio confirming the "competition-fragility" view. An increase in one standard deviation of HHI_A (approx. 294 basis points) causes decrease of overdue loans in 0.40-0.45 percentage points in the next two quarters. The later reflects that improvement in the loan quality is not an immediate process. Thus, if a bank has an

[15] This phenomenon can be explained by low share of mortgage loans in total loans to households (about one-quarter). Non-mortgage loans which take the prevailing share of households loans are considered as more risky than corporate ones.
[16] bank-level averaged HHI across different markets of assets
[17] We consider the main four domestic markets of banking assets including retail lending, corporate lending, inter-bank lending and private & public securities markets. The mean values of HHI concentration ratios for these markets are 1520, 1148, 300 and 2330 points, respectively.

opportunity to expand its share on more concentrated banking markets then this bank can extract additional profits creating more financial buffers to absorb different kinds of shocks. This result remains robust when we employ traditional HHI calculated for Russian loan market.

Our results also reveal the possible opposite effect of banks' profitability on its loan quality. It shows that increases in profitability may be achieved by banks' engaging in riskier lending strategies which imply higher credit risks in future (procyclical credit policy, income smoothing). Thus, we found that an increase in one standard deviation of ROEb (15.8 percentage points) leads to a moderate rise of overdue loan ratio in only 0.10-0.15 percentage points in the next four quarters. Nonetheless, this negative effect is about four times lower than the positive effect of increasing concentration.

In addition, we found that banks providing lending strategy too rapidly should face loan quality deterioration in future. In other words, if a banks' yearly increase in loan-to-deposit ratio deviates from banking system more than in 70 percentage points it causes 0.13 percentage points increase in overdue loan ratio in next four quarters. Again, this negative effect is much lower than the positive concentration effect associated with lending expansion.

One of the most interesting result concerns the revealed magnitude of negative effect running from inefficiency to loan quality. We found that an increase in one standard deviation of operating cost-to-income ratio (0.18) raises overdue loan ratio in 0.70-0.75 in the next four quarters in favor of "bad management" hypothesis. It implies that if a bank achieves success in expanding its shares in different concentrated markets but becomes inefficient due to the "quiet life" effect its managers will face with the loan quality deterioration in near future as the positive effect of increased concentration is neutralized by the negative one coming from inefficiency.

Another interesting result suggests that if a bank tends to deviate from the banking system in expanding its share of non-interest income (e.g. increasing diversification) too rapidly it have to face with the loan quality deterioration. This is because such banks' managers switch their efforts from lending strategy to other kinds of activities (securities, fee & commission income, etc.) which may cause the worsening of credit monitoring of remaining borrowers.

We next describe the estimation results obtained in dynamic version of overdue loans equation

using one-step system GMM (see Table 5 in Appendix). As we expected there is a strong inertia in dependent variable and it made us to include two quarter lags of overdue loan ratio to take into account all possible autocorrelation in the depended variable. Again, we provide the correlation matrix of explanatory variables for the sake of pairwise multicollinearity concerns (see Table 7).

In dynamic specification of overdue loans equations both GDP and exchange rate devaluation demonstrate the same influence on the dependent variable as in the static version. One of the new factor in this specification is loan-to-deposit ratio at the banking system level. It reflects common for all banks disparity between attracted and allocated financial resources. The increase of this disparity at the macro level can be the result of macroeconomic overheating led to over-optimistic expectations of managers, which intensified rivalry for market share and profitability. This herd behavior results in problem loans increase with large lag – a year and a half. Apart from this we found a positive effect of income diversification at the level of banking system as a whole on average loan portfolio quality. This is explained by lowering pressure to involve in risky projects due to emergence of other sources of income. Besides we obtained negative influence of collateral price growth rates (approximated by house prices) on credit risk. The effect is simultaneous and is likely to reflect credit squeeze due to banks' reduction of risk perception as a result of collateral price drop during economic contractions. As our estimates show, resulting credit rationing only exacerbates the problem of defaults on loans.

To ensure the robustness of our previous findings we changed lag structure of bank specific explanatory variables in dynamic specifications and achieve basically the same results. As in the static version both the profitability of bank business strategy and real interest rates charged on loans lead to an increase in credit risk[18]. The distinctive feature of dynamic version is the attempt to account for possible nonlinear relationship between overdue loan ratio and bank concentration of liabilities (HHI_L[19]), efficiency and capitalization. In all three cases we found more or less strong support for the existing of

[18] At the same time we didn't obtain confirmation that rapid income diversification negatively affects banks' exposure to credit risk at the bank level. Moreover, we found some evidence in support of the contrary view on the banking system level. Ultimately, we treat this result with caution.

[19] The analogue of individual concentration of assets (HHI_A) calculated for the six markets of liabilities – retail accounts and deposits, corporate accounts and deposits, borrowed funds from inter-bank market, borrowed funds from the Bank of Russia, banks' securities issued, and banks' foreign liabilities. The mean values of HHI concentration ratios for these markets are 2719, 699, 435. 5999, 414 and 426 basis points, respectively.

facing upward parabolic relationships. Firstly, the inflection points of HHI_L estimated in different specifications from 1588 to 1644 divide our sample in proportion 2:1 which implies that approximately $^2/_3$ of the observations lie below the inflection points. Increasing concentration up to some extent positively affects loan portfolio quality because the more a bank involves into different liabilities markets the more it has to pay for funds. The later necessitates loan quality improvement to provide more interest income ("market power-stability" effect). But after some point of concentration there is a "quiet life" effect, e.g. a bank deepens ties with its depositors considerably and begins to extract additional (quasi-monopoly) rent by lowering payments for funds which allow it to weaken borrowers monitoring procedures. The later may result in loan quality deterioration ("market power-fragility" effect). Thus, our results confirm the theoretical findings of (Martinez-Miera, Repullo, 2010) concerning nonlinear relationship between competition and risk. Efficiency estimates results show that about $^2/_3$ of data lie below the inflection point (0.69-0.70) in the third and fourth equations[20] representing "skimpers" in Russian banking system. Thus, the other part of the sample consists of "bad managers". Also, our analysis revealed that the vast majority of observations (reflecting 90% of Russian banks) lie below the inflection point (39%) of equity-to-asset ratio, e.g. more capitalized banks tend to be less risky.

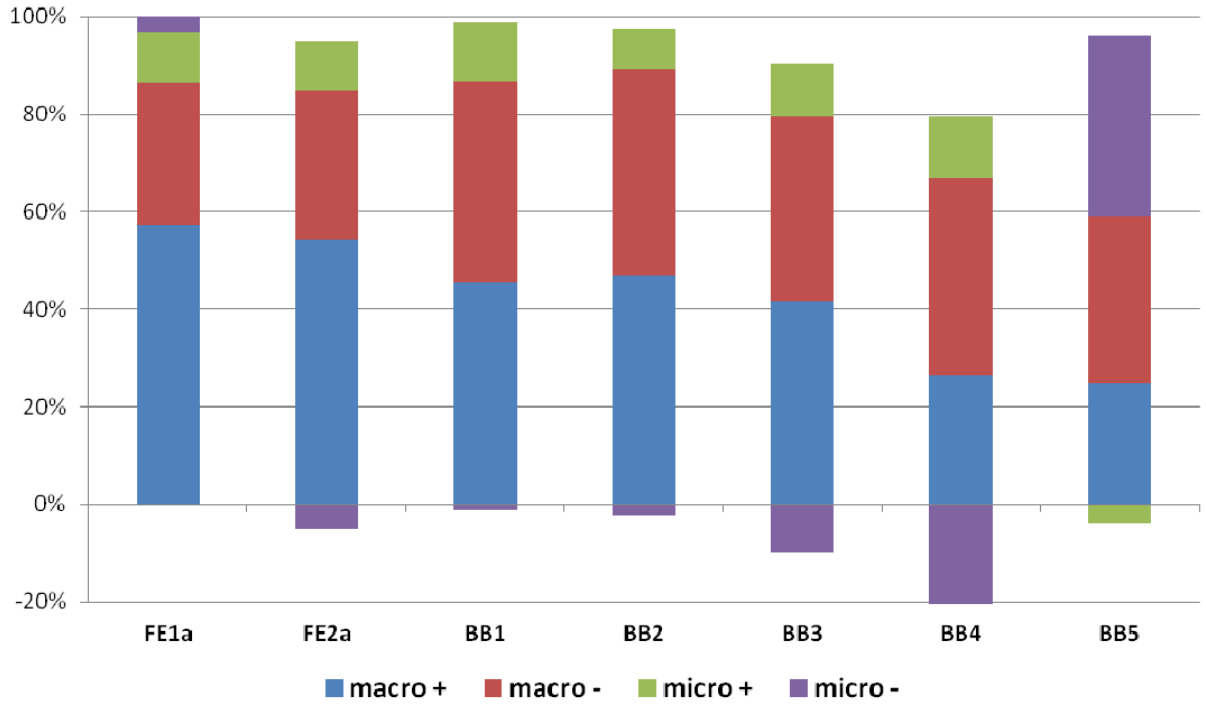
We next provide factors decompositions in various estimated equations for the median bank in our sample. As depicted in Figures 8a and 8b (see Appendix) reflecting fixed effects estimation results the overdue loan ratio was mainly influenced by deterioration of macroeconomic factors ("macro +" on the figures) namely the decline of GDP and weakening of exchange rates during the crisis of 2008-2009. Also to some lesser extent a set of microeconomic factors ("micro +") – basically higher real interest rate – caused an increase in overdue loans. The same is true for the dynamic estimation results (see Figures 8c and 8d in Appendix) what provides robustness to our conclusions. Factors from both macro- and microeconomic sides which are to be responsible for overdue loans decrease ("macro –" and "micro –", respectively) didn't play significant role after and before the latest crisis.

We also aggregate factors decompositions results from all of the estimated equations. We calculated the increases in all groups of factors over the period of overdue loans growth, namely 2008Q3

[20] the fifth equation in Table 5 implies only $^1/_3$ of data lying below the inflection point (0.50).

– 2010Q1. As depicted in Figure 7 macroeconomic factors were of highest influence on loan quality deterioration in all estimated equations.

Figure 7. The contribution of increases in different factors to the fitted values of overdue loan ratio of median bank in different equations over the period 2008Q3 – 2010Q1



Notes: FE (fixed effects) equations are presented in Table 4; BB (Blundell-Bond) equations are presented in Table 5

Source: authors' calculations

7. Conclusions and policy implications

Our study is aimed at investigation the relative importance of macroeconomic and bank-specific factors of problem loans increase in Russian banking sector during the latest crisis. To learn the answer we employed econometric estimation of static and dynamic specifications of overdue loans equation on the panel data on the level of individual banks. We conducted factor decomposition of fitted values of depended variable in our estimated specifications and compared contribution of four groups of factors (macro+, micro+, macro-, micro-) before and at the peak of the crisis. The main result is that macroeconomic determinants were the most important and this finding is robust to the specification of econometric model. Thus we point out that worsening of macroeconomic conditions in 2008-2009 made the prevailing contributions into problem loans increase of median bank in Russia.

This finding is of great importance for regulators and policymakers. Our study suggests that in

order to lower credit risk in Russian banking system it is necessary to reduce procyclicality of financial intermediation. Regulators should limit the size of adopted risks during the cyclical upturns by means of macroprudential policy and other applicable measures. For example, as noted in (Moiseev, 2009), current regulations of loan loss reserves in the Russian banking sector only exacerbates the problem of its procyclicality. In line with current prudential norms banks should build up large amount of reserves only during the crisis as it corresponds with borrowers' credit quality deterioration. Large reserves accumulation leads to sharp drop in profit and negatively affects banks' capital. On the contrary, during the expansionary phase of the business cycle banks are not required to accumulate reserves as existing regulation don't take into account future risks of borrowers (only current financial condition matters, which is always good during the boom periods). One of the possible solutions of this problem is introduction of dynamic prudential norms (reserves, capital, loan-to-value ratio, etc.). The most well-known countercyclical instrument is dynamic (statistical) provisions introduced in 2000 in Spain. The main feature of this regulation is that it necessitates banks to build up more reserves during the expansion in comparison with visible level of risks thus reducing their costs during the crisis. This approach is aimed at smoothing of provisions over the business cycle as it takes into account future loan losses and hidden risks. The main shortcoming of dynamic reserves is that they reduce banks' profit during the upturns as the expenses on provisioning are made before profit is calculated. This negative feature is overcome in another dynamic prudential norm, such as dynamic capital regulation when countercyclical reserves are made from after-tax profit and are treated as a part of bank's capital.

The other important macroeconomic factor that contributed much into problem loans increase is the weakening of the ruble exchange rate during the last crisis. In order to limit its negative effect Bank of Russia should reduce attractiveness of foreign currency loans both for banks and for borrowers (especially for those with low share of income denominated in foreign currency). For example, Bank of Russia can introduce additional reserve requirement on FX loans. Regulator have already made some steps in right direction (in terms of reducing attractiveness of foreign currency loans), as it now reduced its interference on foreign exchange market in comparison to pre-crisis period and promotes floating exchange rate regime. The resulting increase in exchange rate uncertainty has already led to reduction in

the share of foreign currency loans, as Bank of Russia is no longer guarantees exchange rate peg. Regulator should also use its emerged possibility to influence on interest rate on limiting banks' lending rate increase that occurred during the last crisis. As it was found in our study, rise in interest rate on loans became the important push-up factor of problem loans growth. To take interest rate under control during instability periods Bank of Russia should expand its toolkit of available liquidity instruments and to provide access to it to a greater number of banks.

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9. Appendix.

Table 2a. Desctiption of credit risk determinants: macroeconomic factors

Variable	Notation	Sign	Comment
Consumption plus investment expenditure to disposable income, per year, %	M-C+I-Y-T	+	
The share of consumer spending in disposable income, per year, %	M-ConsExp-Income	+	including product with bank-level share of households loans
Increase in the share of consumer spending in disposable income, per year, %	M-ConsExp-Inc-gr-y	+	
Loans to households / households income, per year, %	M-HHLns-Income	+	
Real households income, growth rate, per year, %	M-HHReaIinc-growth-y	-	
Total loans plus corporate external debt to GDP ratio, %	M-TotDebt-GDP	+	
Corporate external debt to total debt, %	M-d-Ext-Debt	+	including product with bank-level share of corporate loans
Enterprise debt to current capital, %	M-EntDebt-CurCap	+	
Enterprise profit / debt, %	M-EntProfit-Debt	-	
Gross profit to corporate debt, %	M-GrosProfit-Debt	-	
GDP growth rates, per year, %	M-GDP-growth-y	-	
Inflation, growth rate, per year, %	M-Iinflat-y	+	
Desinflation (reduction of inflation), pecentage points	M-Desinflat-y	-	
Unemployment level, %	M-Unempl	+	including product with bank-level share of households loans
Growth of unemployment level, per year, pecentage points	M-Unempl-growth-y	+	
MICEX index, growth rate, per year, %	M-MICEX-y	+/-	Lagged more than a year - «+», less than a year «-»
MICEX index, growth rate, per 2 years, %	M-MICEX-2y	+	Lagged more than a year
MICEX index,, deviation from previous year mean, pecentage points	M-MICEX-dev-y	+/-	Lagged more than a year - «+», less than a year «-»
House price, growth rate, per year, %	M-Housing-y	+/-	Lagged more than a year - «+», less than a year «-»
House price, growth rate, per 2 years, %	M-Housing-2y	+	Lagged more than a year
Real effective exchange rate index, per year	M-REER-y	+/-	Lagged more than a year - «+», less than a year «-»
Real effective exchange rate index, per 2 years	M-REER-2y	+	Lagged more than a year
Real effective exchange rate index, deviation from previous year mean, pecentage points	M-REER-dev-y	+/-	Lagged more than a year - «+», less than a year «-»
Weakening of nominal exchange rate of ruble to US dollar, %	M-Weaken-Exrate	-	0<Lag<1 year, including product with individual share of FX

			loans
Standard deviation of nominal exchange rate of ruble to US dollar on Forex market, %	M-Volat-Exrate	+	including product with individual share of FX loans
Accumulated capital inflow in banking sector	M-BankCap-Inflow	+	Lagged more than a year
Terms of trade index, per year, %	M-TOT-y	-	including product with individual share of FX loans
Oil price growth rate, per quarter, %	M-Brent-growth-q	-	
Current account balance to GDP, %	M-CAB-GDP	-	
Decrease in current account balance to GDP, in relation to previous year mean, pecentage points	M-CAB-GDP-dev-y	-	

Source: authors' analysis

Table 2b. Desctiption of credit risk determinants: bank-specific factors (individual bank level and banking system level indicators)

Variable	Notation		Sign	Comment
	banking system level	individual bank level		
Real loans, growth rate, per year, %	BI-RLns-growth-y	B-dev-RLns-growth-y	+	Lagged more than a year, bank-level indicator is in deviations from sector mean
Real loans, growth rate, per 2 years, %	BI-RLns-growth-2y	–	+	Lagged more than a year
Growth of loans to assets ratio, per year, pecentage points	BI-d Lns-TA-y	B-dev-Lns-TA-y	+	Lagged more than a year, bank-level indicator is in deviations from sector mean
Growth of loans to assets ratio, per 2 years, pecentage points	BI-dLns-TA-2y	–	+	Lagged more than a year
Loans to deposits ratio, %	BI-LTD	B-LTD	+	Lagged more than a year
Growth of loans to deposits ratio, per year, pecentage points	BI-dLTD-y	B-dev-dLTD-y	+	Lagged more than a year, bank-level indicator is in deviations from sector mean
Growth of loans to deposits ratio, per 2 years, pecentage points	BI-dLTD-2y	–	+	Lagged more than a year
Real lending rate, %	BI-RIR	B-RIR	+	Lagged
Cost-to-income ratio (excluding loan loss reserves)	BI-CIR	B-CIR	-/+	Lagged, skimping / bad management hypothesis,
Non interest income to total income (excluding currency	BI-NII-to-TI	B-dev-NII-to-TI	-	Lagged, bank-level indicator is in deviations from sector

market expences)				mean. Diversification hypothesis
Return-on-assets (excluding net expences on loan loss reserves)	BI-ROAb	B-ROAb	+	Procyclical credit policy / income smoothing hypothesis
Return-on-assets (including net expences on loan loss reserves)	BI-ROAa	B-dev-ROAa	+	Bank-level indicator is in deviations from sector mean
Return-on-equity (excluding net expences on loan loss reserves)	BI- ROEb	B-ROEb	+	Procyclical credit policy / income smoothing hypothesis
Return-on-equity (including net expences on loan loss reserves)	BI-ROEa	B-dev-ROEa	+	Bank-level indicator is in deviations from sector mean
Market power (Herfindahl-Hirschman index)	BI-HHI	$B\text{-}HHI_A$ $B\text{-}HHI_L$	-/+	Competition-stability / competition-fragility hypothesis
Share of foreign currency loans	BI-FXloans	B-FXloans	+	
Share of foreign liabilities to total liabilities	BI-Foreign	–	+	Lagged more than a year
Net interest margin to total assets	BI-NIM-to-TA	B-NIM-to-TA	+	
Capital to assets ratio	–	B-EQ-to-TA	-	Moral hazard hypothesis
Bank's share in total assets	–	B-d-TA	-/+	Diversification, Too-big-to-fail hypothesis
Bank profile and ownership structure dummy variables	–	B-Retail, B-Corp, B-Univ, B-State, B-Foreign, B-Metropol, B-Region	+/-	

Source: authors' analysis

Table 3. Descriptive statistics of dependent variable and its determinants included into static and dynamic specifications of equation

	Variable name	Obs	Mean	Std. Dev.	Min	Max	Percentiles		
							1st	50th	99th
Dep. var	Overdue loan ratio	14804	3.38	4.66	0.00	50.57	0.01	1.66	23.17
MACRO	M-GDP-growth-y	30	4.37	5.30	-11.15	8.59	-11.15	6.60	8.59
	M-Desinflat-y	30	-1.86	2.15	-7.65	0.00	-7.65	-0.72	0.00
	M-Weaken-Exrate	30	-1.60	3.67	-14.07	0.00	-14.07	0.00	0.00
	M-CAB-GDP	30	7.40	3.36	1.45	14.70			
	M-Housing-y	30	17.37	17.07	-11.05	54.37			
	BM-LTD	30	118.63	10.62	97.40	137.95	97.40	119.37	137.95
	BM-NII-to-TI	30	70.21	3.84	62.97	79.01	62.97	71.42	79.01
	BM-HHI-LOANS	30	1224	92	1049	1397	1049	1203	1397
	M-Unempl · B-Retail-loan-share	18485	221.64	193.52	0.00	916.59	1.23	166.29	782.77
MICRO	B-dev-dLTD-y	14244	-7.40	70.70	-459.50	407.79	-280.39	-4.50	216.00
	B-dev-Lns-TA-y	14759	-0.28	13.42	-77.79	76.77	-39.34	-0.21	36.52
	B-RIR	15909	7.14	7.46	-3.90	50.01	-3.03	5.49	35.60
	B-ROEb	15201	18.78	15.80	-34.87	94.52	-12.10	16.17	66.33
	B-EQ-to-TA	19022	22.22	15.29	3.88	95.15	6.01	17.23	77.29
	B-CIR	16797	0.59	0.18	0.07	1.20	0.20	0.59	0.97
	B-HHI_A	19464	1174	294	74	3843	342	1163	2143
	B-HHI_L	19404	1303	545	113	3582	394	1249	2683
	B-dev-NII-to-TI	16824	64.75	16.63	7.69	100.00	26.28	65.22	96.37
	B-dum-Retail	28710	0.04	0.19	0.00	1.00			
	B-dum-Corp	28710	0.29	0.45	0.00	1.00			

Table 4. Estimation results of static specification of overdue loans equation

Independent variables		Dependent variable – Overdue loan ratio, OL			
		FE1a	**FE1b**	**FE2a**	**FE2b**
MACRO	M-GDP-growth-y (-1)	–0.143*** (0.007)	–0.151*** (0.007)	–0.146*** (0.007)	–0.162*** (0.006)
	M-Desinflat-y (-1)	–0.074*** (0.020)	–0.097*** (0.019)	–0.078*** (0.023)	–0.096*** (0.021)
	M-Weaken-Exrate (-1)	–0.018** (0.009)	–0.033*** (0.009)	–0.018* (0.009)	
	M-Unempl (-1) · B-Retail-loan-share (-1)	0.004*** (0.001)		0.003*** (0.001)	
	BM-HHI-LOANS (-2)/10000			–12.318* (6.538)	–17.686*** (5.387)
MICRO	B-HHI_A (-2)/10000	–14.455*** (2.648)	–12.915*** (2.334)		
	B-CIR (-4)	3.951*** (0.407)	4.551*** (0.400)	3.948*** (0.410)	4.401*** (0.400)
	B-RIR (-1)	0.214*** (0.009)	0.210*** (0.008)	0.216*** (0.009)	0.210*** (0.008)
	B-ROEb (-4)	0.007** (0.004)	0.011*** (0.003)	0.007* (0.004)	0.011*** (0.004)
	B-dev-dLTD-y (-4)	0.002*** (0.001)		0.002*** (0.001)	
	B-dev-NII-to-TI (-1)	0.038*** (0.005)		0.040*** (0.005)	
	B-dum-Retail			0.138 (0.274)	–0.196 (0.251)
	B-dum-Corp			–0.338** (0.156)	–0.293** (0.144)
Intercept		1.060** (0.420)	1.218*** (0.387)	1.131 (0.849)	2.173*** (0.720)
No. Observations (banks)		8474 (619)	9113 (645)	8474 (619)	9113 (645)
R^2_{adj} (LSDV)		0.5741	0.5532	0.5729	0.5514
F-stat (p-value)		0.0000	0.0000	0.0000	0.0000
Bank fixed effects		yes	yes	yes	yes

Notes: *, **, *** denote an estimate significantly different from zero at the 10%, 5%, 1% level. Standard errors are in parentheses

Table 5. Estimation results of dynamic specification of overdue loans equation

Independent variables		Dependent variable – Overdue loan ratio, OL				
		BB1	**BB2**	**BB3**	**BB4**	**BB5**
Inertia	OL (-1)	0.891*** (0.036)	0.890*** (0.035)	0.891*** (0.037)	0.869*** (0.037)	0.898*** (0.038)
	OL (-2)	0.064** (0.030)	0.053* (0.029)	0.070** (0.030)	0.068** (0.033)	
MACRO	M-GDP-growth-y	–0.069*** (0.008)	–0.070*** (0.007)	–0.075*** (0.008)	–0.069*** (0.008)	–0.051*** (0.014)
	M-Weaken-Exrate	–0.027*** (0.009)	–0.028*** (0.009)	–0.029*** (0.008)	–0.025*** (0.009)	–0.041*** (0.012)
	BM-LTD (-6)	0.019*** (0.005)	0.018*** (0.005)	0.017*** (0.004)	0.010* (0.006)	
	BM-NII-to-TI (-2)				–0.050* (0.026)	
	M-CAB-GDP (-1)					–0.035 (0.026)
	M-Housing-y					–0.010* (0.006)
MICRO	B-dev-NII-to-TI (-2)	–0.011 (0.018)				
	B-dev-Lns-TA-y (-6)					0.002 (0.010)
	B-RIR	0.022* (0.012)	0.024** (0.012)	0.025** (0.011)	0.042*** (0.014)	
	B-ROEb (-1)					0.038*** (0.014)
	B-EQ-to-TA (-2)	–0.032** (0.014)	–0.021* (0.012)		–0.108** (0.046)	
	B-EQ-to-TA-squared (-2)				0.001** (0.001)	
	B-HHI_L (-4)	–36.501** (16.630)	–29.799** (14.802)		–50.013** (20.448)	
	B-HHI_L-squared (-4)	0.011** (0.005)	0.009** (0.004)		0.016*** (0.006)	
	B-CIR (-4)			–5.241*** (2.008)	–17.063*** (6.323)	–17.561* (10.156)
	B-CIR-squared (-4)			3.703* (2.183)	12.367** (5.294)	17.533** (8.871)
Intercept		1.251 (1.396)	0.694 (1.262)		12.840** (4.271)	3.894 (2.697)
No. Observations (banks)		9609 (683)	10065 (697)	9847 (682)	9169 (624)	7789 (606)
No. Instruments		559	559	558	559	304
F-stat (p-value)		0.000	0.000	0.000	0.000	0.000
Hansen test (p-value)		0.182	0.136	0.134	0.306	0.639
AR1 / AR2 test (p-values)		0.000 / 0.200	0.000 / 0.111	0.000 / 0.183	0.000 / 0.150	0.000 / 0.338
Difference-in-Hansen test (p-value)		0.752	0.886	0.564	0.931	0.365
Inflection point of B-HHI_L		1644	1588		1613	
Inflection point of B-CIR				0.708	0.690	0.501
Inflection point of B-EQ-to-TA					39.13	
Banks fixed effects		yes	yes	yes	yes	yes

Notes: *, **, *** denote an estimate significantly different from zero at the 10%, 5%, 1% level. Standard errors are in parenthese

Table 6. Pairwise multicollinearity in fixed effects estimation (FE2a model)

	OL	M-GDP-gr (-1)	M-Desinf (-1)	M-Weak-Exr (-1)	M-Unm(-1) · B-Ret (-1)	BM-HHI (-2)	B-CIR (-4)	B-RIR (-1)	B-ROEb (-4)	B-dev-dLTD-y (-4)	B-dev-NII-TI (-1)	B-dum-Retail	B-dum-Corp
OL	1.00												
M-GDP-gr (-1)	-0.28	1.00											
M-Desinf (-1)	-0.21	0.17	1.00										
M-Weak-Exr (-1)	-0.07	0.38	-0.19	1.00									
M-Unm (-1) · B-Ret (-1)	0.15	-0.13	-0.07	-0.05	1.00								
BM-HHI (-2)	0.05	-0.10	-0.12	0.18	0.04	1.00							
B-CIR (-4)	0.15	-0.16	-0.27	0.06	-0.05	0.00	1.00						
B-RIR (-1)	0.31	-0.14	-0.36	0.06	0.18	0.02	0.22	1.00					
B-ROEb (-4)	0.05	-0.01	-0.01	-0.04	0.05	-0.05	-0.25	-0.08	1.00				
B-dev-dLTD-y (-4)	0.14	-0.11	0.01	-0.08	-0.17	-0.02	0.12	-0.02	0.13	1.00			
B-dev-NII-TI (-1)	-0.05	-0.01	0.00	0.00	0.01	0.01	-0.01	-0.06	-0.02	0.00	1.00		
B-dum-Retail	0.10	-0.02	-0.01	-0.01	0.54	-0.02	-0.05	0.11	0.01	-0.07	0.00	1.00	
B-dum-Corp	-0.09	0.00	-0.01	0.01	-0.68	-0.01	0.09	-0.07	-0.05	0.15	-0.01	-0.13	1.00

Table 7. Pairwise multicollinearity in one-step system GMM estimation (BB4 model)

	OL	OL (-1)	OL (-2)	M-GDP-growth-y	M-Weaken-Exrate	BM-LTD (-6)	BM-NII-to-TI (-2)	B-RIR	B-EQ-to-TA (-2)	B-EQ-to-TA-sq (-2)	B-HHI_L (-4)	B-HHI_L-sq (-4)	B-CIR (-4)	B-CIR-sq (-4)
OL	1.00													
OL (-1)	0.89	1.00												
OL (-2)	0.79	0.89	1.00											
M-GDP-growth-y	-0.22	-0.15	-0.07	1.00										
M-Weaken-Exrate	-0.01	0.05	0.08	0.38	1.00									
BM-LTD (-6)	0.21	0.16	0.10	-0.51	-0.28	1.00								
BM-NII-to-TI (-2)	-0.38	-0.38	-0.36	0.42	-0.03	-0.57	1.00							
B-RIR	0.33	0.32	0.30	-0.14	0.06	0.22	-0.38	1.00						
B-EQ-to-TA (-2)	0.09	0.10	0.10	-0.02	0.03	0.03	-0.09	0.13	1.00					
B-EQ-to-TA-sq (-2)	0.09	0.10	0.10	-0.01	0.03	0.03	-0.09	0.11	0.95	1.00				
B-HHI_L (-4)	0.15	0.17	0.18	-0.07	0.09	0.12	-0.41	0.21	0.04	0.05	1.00			
B-HHI_L-sq (-4)	0.15	0.18	0.19	-0.07	0.09	0.12	-0.42	0.22	0.06	0.08	0.98	1.00		
B-CIR (-4)	-0.09	-0.08	-0.08	0.08	0.05	-0.04	0.08	-0.07	-0.18	-0.17	-0.23	-0.24	1.00	
B-CIR-sq (-4)	-0.10	-0.09	-0.09	0.10	0.05	-0.07	0.13	-0.07	-0.16	-0.14	-0.25	-0.25	0.97	1.00

Figure 8a. Factors decomposition of overdue loans ratio of median bank (excluding intercept), model FE1a

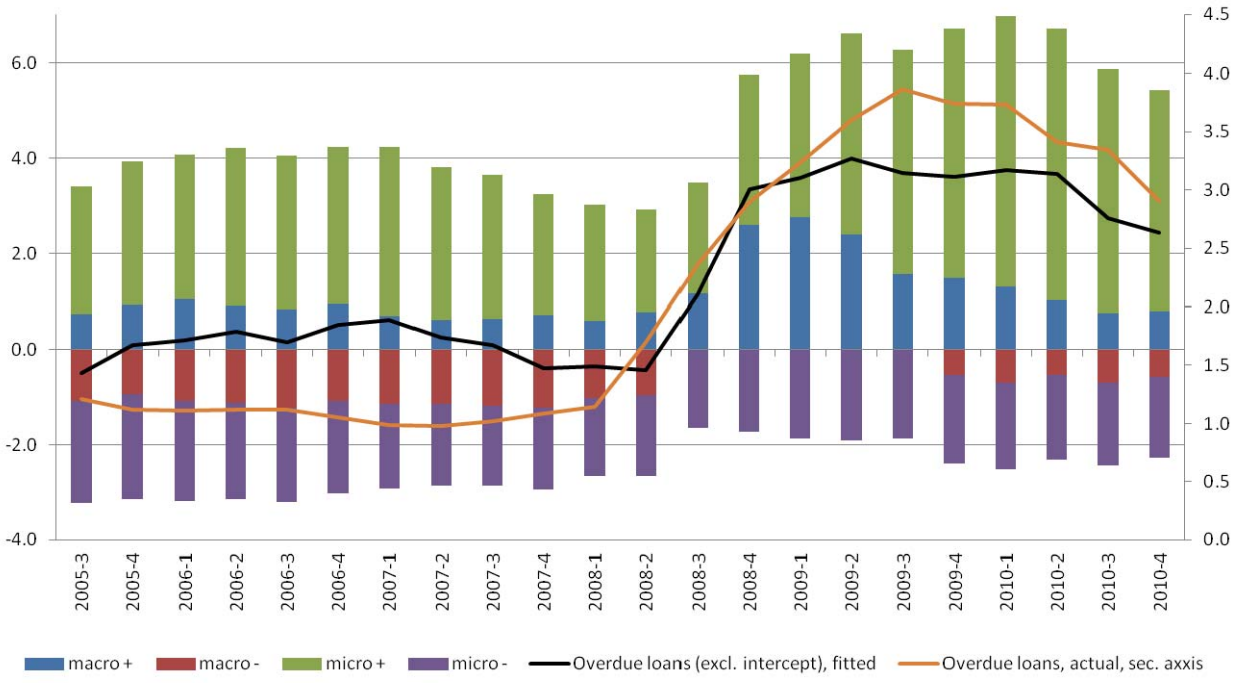

Figure 8b. Factors decomposition of overdue loans ratio of median bank (excluding intercept), model FE2a

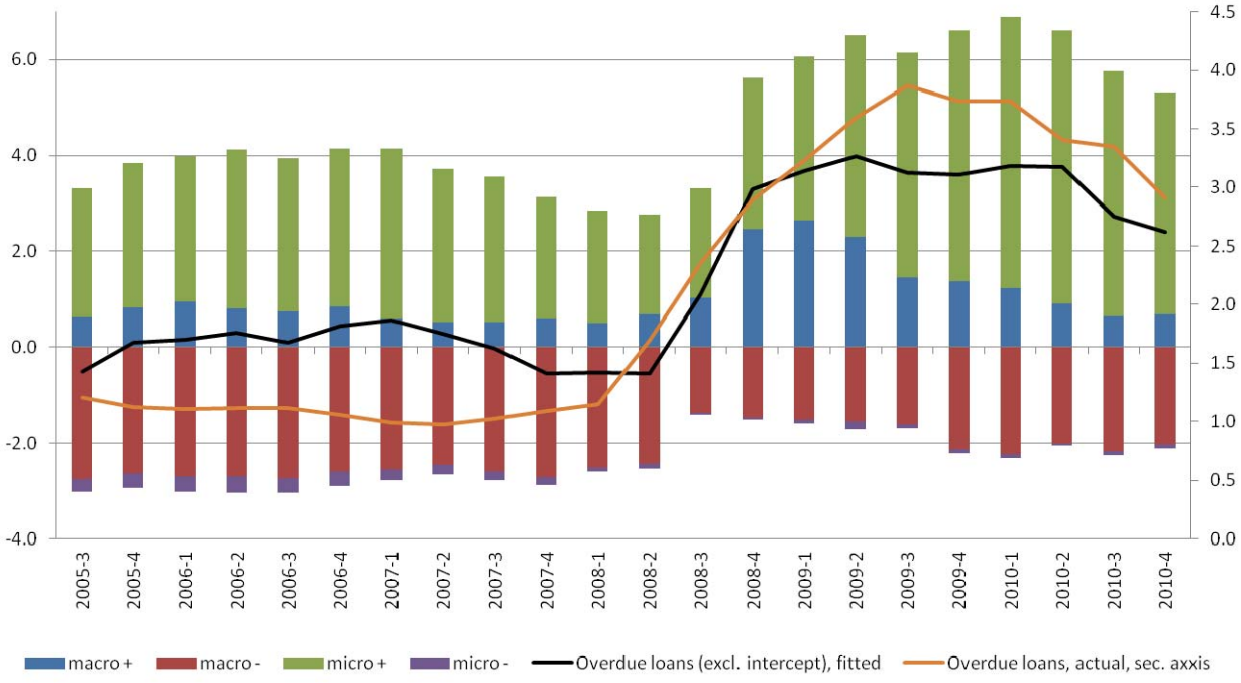

Figure 8c. Factors decomposition of overdue loans ratio of median bank (excluding intercept and inertia), model BB2

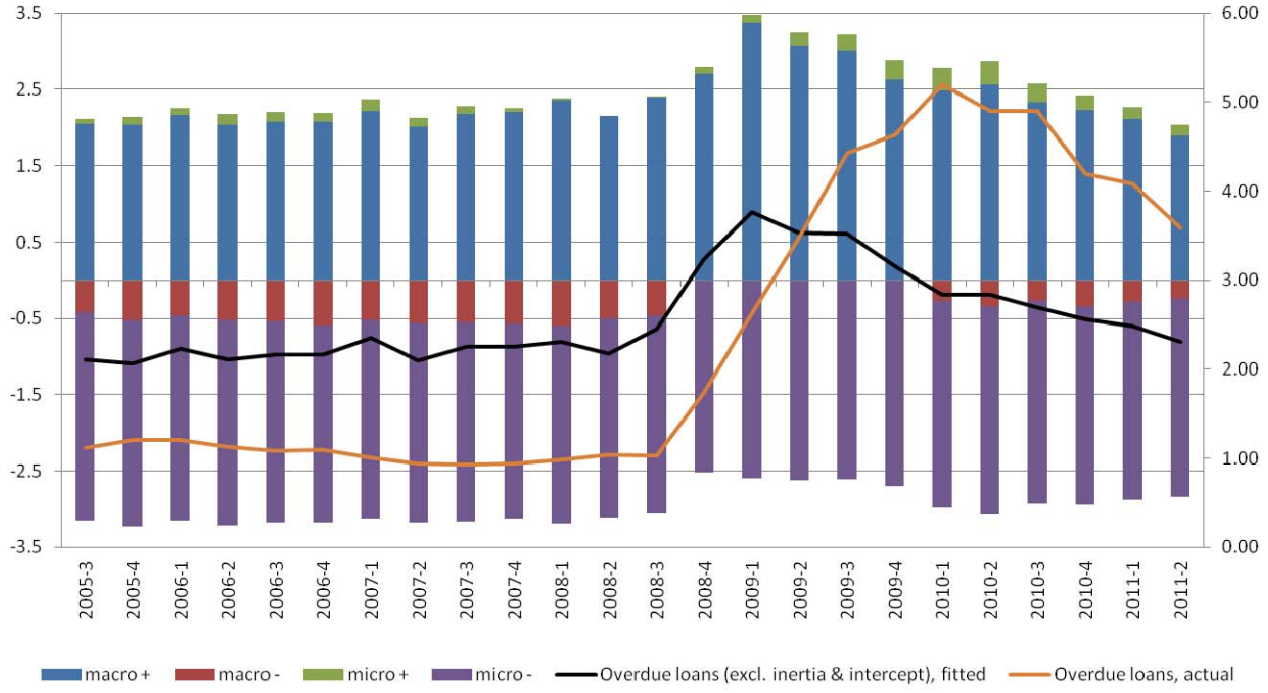

Figure 8d. Factors decomposition of overdue loans ratio of median bank (excluding intercept and inertia), model BB5