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The probability of default: a sectoral assessment

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Editorial

On 19-21 November 2009, the Bank of Greece co-organized with the Bank of Albania the 3rd Annual South-Eastern European Economic Research Workshop held at its premises in Athens. The 1st and 2nd workshops were organized by the Bank of Albania and took place in Tirana in 2007 and 2008, respectively. The main objectives of these workshops are to further economic research in South-Eastern Europe (SEE) and extend knowledge of the country-specific features of the economies in the region. Moreover, the workshops enhance regional cooperation through the sharing of scientific knowledge and the provision of opportunities for cooperative research.

The 2009 workshop placed a special emphasis on three important topics for central banking in transition and small open SEE economies: financial and economic stability; banking and finance; internal and external vulnerabilities. Researchers from central banks participated, presenting and discussing their work.

The 4th Annual SEE Economic Research Workshop was organized by the Bank of Albania and took place on 18-19 November 2010 in Tirana. An emphasis was placed upon the lessons drawn from the global crisis and its effects on the SEE macroeconomic and financial sectors; adjustment of internal and external imbalances; and the new anchors for economic policy.

The papers presented, with their discussions, at the 2009 SEE Workshop are being made available to a wider audience through the Special Conference Paper Series of the Bank of Greece.

Here we present the paper by Tatiana Malakhova (Bank of Russia) with its discussion by Vassiliki Zakka (Bank of Greece).

February, 2011

Altin Tanku (Bank of Albania)
Sophia Lazaretou (Bank of Greece)
(on behalf of the organisers)

THE PROBABILITY OF DEFAULT: A SECTORAL ASSESSMENT

Tatiana Malakhova
Bank of Russia

ABSTRACT

The paper illustrates the main problems faced by the Russian banking sector during the current world-wide economic and financial crisis. It also considers an approach to improve the stress-testing methodology applied by the central Bank of Russia including the estimation of default probabilities.

JEL Classification: C01, C10, C50

Keywords: probability of default, stress-testing, credit risk

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1. Introduction

Since the second half of 2007, the world economy has been experiencing a global financial crisis that struck primarily industrial economies. In the second half of 2008, the Russian economy was also significantly affected by the crisis.

Beginning 2008, the Russian banking sector as a whole demonstrated fairly rapid growth in its key performance indicators, even though global financial markets were in turmoil. However, in September, as a result of the worsening global crisis, the outflow of capital from emerging markets increased and oil prices fell. The Russian stock market, like those of other countries, experienced a dramatic fall in prices. Some credit institutions ran into liquidity problems and tensions in the interbank market escalated. Depositors' concerns led to a significant outflow of household bank deposits. By the end of the year, serial negative trends had led to lower income and domestic demand had declined in all key sectors of the economy. The rise in unemployment had also accelerated. As the crisis was deepening, GDP growth started to slow. Some banks which were systemically important before the crisis, found themselves on the brink of bankruptcy.

The deterioration of the general economic situation in the domestic market and the adoption by banks of more conservative methods of risk evaluation led to slower growth in retail credit. The growth of household loans diminished substantially: 35.2% in 2008 as against 57.8% in 2007; in 2009 (over 7 months) the volume of these loans actually contracted by 8.3%.

The credit crunch is one of the most adverse consequences of the financial crisis. At the same time, it works as a factor exacerbating the crisis. The main reasons for the sharp slowdown in credit growth are the deterioration of the financial standing of borrowers and banks' reluctance to assume additional risks. These circumstances prove the importance of complex credit risk assessment.

During the global crisis, the role of stress-testing in estimating changes in credit risk rises. A common measure of the credit risk of a borrower, particularly in the context of macroeconomic modelling, is the probability of default (PD). This is also a key

measure in the International Convergence of Capital Measurement and Capital Standards (Basel II).

This paper illustrates the main problems faced by the Russian banking system during the current crisis. In particular, it considers an approach to improve the stress-testing methodology applied by the central Bank of Russia including the estimation of default probabilities.

The rest of the paper is as follows. Section 2 presents the Bank of Russia's stress testing methodology. Section 3 concludes.

2. The Bank of Russia stress-testing

The Russian banks saw an increase in credit risk in 2008. As the financial situation of borrowers deteriorated, they found increasingly difficult to service their credit. As a result, growth in overdue debt accelerated significantly, compared to 2007. The share of overdue debt in total loans rose in 2008 from 1.3% to 2.1% (see Table 1 and Figures 1 to 3).

The degree of credit risk of the Russian banks continues to be determined by the quality of loans to non-financial organizations, which, as of January 1, 2009, accounted for 62.9% of total loans extended. The share of overdue debts in loans to non-financial organizations rose from 2.1% at the beginning of 2009 to 5.3% as of August 1, 2009 (see Figure 4).

In 2008, the share of overdue loans in the retail portfolio (lending to households) grew less dramatically: from 3.2% to 3.7%. But, by August 2009 this indicator had risen to 6.0%.

In the framework of the Bank of Russia's stress-testing with the use of macroeconomic models, the most interesting is the estimation of a borrower's probability of default based on the sector in which the borrower does business. Estimation of the borrowers' probability of default by credit institutions is provided for in the Russian regulation. The credit institutions can estimate the PDs for own purposes. However, the results of such estimations are not reported to supervisors. The regulator (i.e. the Bank of

Russia) cannot estimate the PD directly under existing reporting because of lack of sufficient series of data.

To solve this problem, the Bank of Russia has elaborated a retrospective algorithm for calculating the PDs. Additionally, the Bank provides for the possibility of linking the PDs with key macroeconomic indicators, such as basic energy resources prices, exchange rates, tax rates, the rate of inflation, etc. This is also extremely relevant to improving the methodology of banking sector stress-testing.

The basic assumption assumed in modeling is that the probability of a borrower's default, according to a bank's estimate, can be expressed in terms of provisionary rates. Namely, to construct a dynamic series of PDs, the banks' own weighted average estimates of provisions are used.

On the basis of a representative sample of all domestic credit institutions, a linear regression can be constructed allowing access to PDs across industries, which can be presented in the following way:

$$\sum_{k\in\{2,3,4,5\}} LLP_i^k = \sum_{j\in branches} PD^j * Loans_i^j \ , \quad i \in \overline{1...N} \tag{1}$$

where

N – number of credit institutions operating at a reporting date;

LLP_i^k – loan loss provisions under the k-th group[1] of loans of the i-th credit institution;

PD^j – the bank's weighted average estimate of the probability of default of the j-th industry borrower (defined using linear regression);

$Loans_i^j$ – loans granted by the i-th bank to the j-th industry.

To get the weighted average estimate, the initial sample should include the most important banks in terms of loans provided to the industries under consideration. These banks will actually define the basic PD value.

[1] In the Russian Federation, in accordance with Bank of Russia Regulation №245-P, dated March 26, 2004, 'On the Procedure for Making by Credit Institutions Provisions for Possible Losses on Loans, Loan and Similar Debts', loan loss provisions (LLP) are created for loans in quality categories 2,3,4,5.

While calculating the PD, it is also necessary that the regression error derived by the estimation using the least-squares method in monetary terms would not "shift" to larger banks (for example, by assets). For this purpose, linearization of data was applied.[2] A data sample for the linear regression was taken as a percentage of assets. Thus, for each date during the period under consideration[3], a sample of credit institutions satisfying the above-mentioned criteria was generated.

The existing format of reporting allows us to divide borrowers into 5 main sectors: the industrial sector (X1), agriculture (X2), construction (X3), retail trade (X4) and other industries (X5).

For the purpose of initial data transformation, a regression model[4] was developed reflecting the dependence of the loan loss provision's size (Y) on the particular sector in which the borrower operates. For instance, the following equation was the result of modelling the PD values for QIV, 2008:

$$\bar{y} = 0.0734 * x_1 + 0.0406 * x_2 + 0.07445 * x_3 + 0.05335 * x_4 + 0.07644 * x_5 \qquad (2)$$

se	(0,014)	(0,022)	(0,018)	(0,013)	(0,012)
$t_н$	(5,15)	(3,84)	(4,06)	(3,96)	(6,32)

$F(5,351)=204,4,\ R^2= 0,74$

The equation statistical characteristics are presented indicating the significance of both the equation itself and its coefficients (where *se* is the standard error of the coefficients). The value of the coefficient of determination $R^2 = 0.74$ can be interpreted as showing that 74% of the dispersion of the indicator under consideration is influenced by the parameters included into the model. The Durbin-Watson[5] statistic suggests the absence of autocorrelation in the residuals.[6] Figure 5 depicts a histogram of the residuals

[2] A linearization of the data was performed by dividing the initial indicators by a constant: Y/const=X1/const*PD1+X2/const*PD2+… +Xn/const*PDn, where the assets value of a particular credit institution was taken as a constant.
[3] The period from 2005 to 2008 was chosen as a retrospective period for consideration. Modelling was based on quarterly dynamics.
[4] The calculations are obtained using the Statistica software package.
[5] The value of the Durbin-Watson statistic for this model is 2.15.
[6] Residuals are defined as the difference between the initial sequence of data and the one resulting from the model.

with the imposed normal distribution. The residuals produced are characterized by a relatively symmetric distribution and are close to the normal distribution.

Thus, the resulting model reflecting the dependence of the size of provisions on the sector in which a borrower is active appears to be adequate. Similar results were obtained for other reporting dates of the period in question.

Figure 6 illustrates the distribution over time of the PDs of borrowers by sector based on the results of the regressions. It is interesting to note that in 2008 (in particular, from the third quarter afterwards) the PD of the enterprises both in the construction sector and in the industrial sector has increased markedly. This can be attributed mainly to the global financial crisis.

To verify the results obtained, we compare the calculated PDs with the indicators of overdue loans granted to a particular sector. This analysis also confirms the adequacy of the models constructed. For example, as shown in Figure 7, the PD in the construction sector increases along with the share of overdue loans in the total amount of loans extended to borrowers in this sector.

The retrospective calculation of the PDs represents only the initial stage in developing the stress-testing methodology applied in the Russian Federation. However, the use of such estimates opens other opportunities to analyze the factors influencing the PDs. It thus seems feasible to use the simulated values of borrowers' PDs as a basis for assessing the influence of macroeconomic indicators on the change in these values.

For this purpose, a list of macroeconomic indicators for each sector is defined that can subsequently be used as a basis to build a binary regression of PD dependence on these variables. To this end, a logistical regression (binary distribution) can be applied, i.e.:

$$PD^{j} = \frac{1}{1 + e^{-(a_0 + a_1 * \Delta X_1^j + \ldots + a_n * \Delta X_n^j)}} \qquad (3)$$

where

PD^{j} – the weighted average bank's estimate of the probability of default of the j-th industry borrower;

ΔX_i^j – the change of the i-th macroeconomic indicator influencing the j-th industry;

a_i – influence of the macroeconomic indicator on PD.

Having estimated the parameters of such a binary regression, we can construct the distribution of PDs conditional on the macroeconomic indicators. This distribution can be more actively used in a credit institutions' risk management system, with due account of macroeconomic conditions. Then, case stress-testing will be reduced to simulation involving the changes in the macroeconomic indicators and an instant PD recalculation that will also immediately allow the expected losses resulting from credit risk to be calculated.

3. Conclusion

The Bank of Russia is now in the process of selecting macroeconomic indicators influencing the PDs. Later, after a full verification of the results obtained, the calculated PD values may be used by the regulator and they will also equally recommend for credit risk assessment and the calculation of expected losses under condition of stress by the credit institutions that do not calculate this indicator independently.

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Table 1.The dynamic of overdue debts of the Russian banking sector

	2008 year				2009 year		
	QI	QII	QIII	QIV	QI	QII	July
Overdue debts, total, %	4,4	3,5	6,0	15,2	15,0	8,9	9,4
Overdue debts in the portfolio of corporate loans	4,4	4,5	8,1	23,5	19,4	10,5	11,4
Overdue debts in the portfolio of individual loans	4,6	2,6	3,3	4,2	7,0	5,1	3,9

Figure 1: Credit risk in the Russian credit institutions

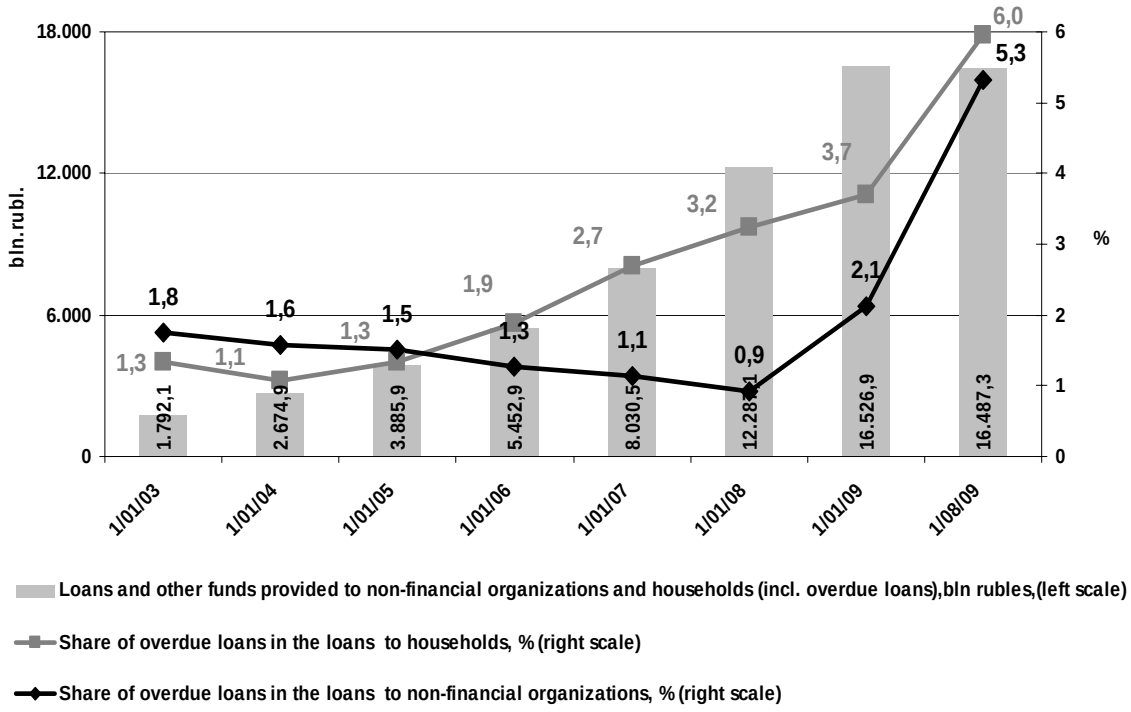


Figure 2. Lending and overdue debts: corporate loans

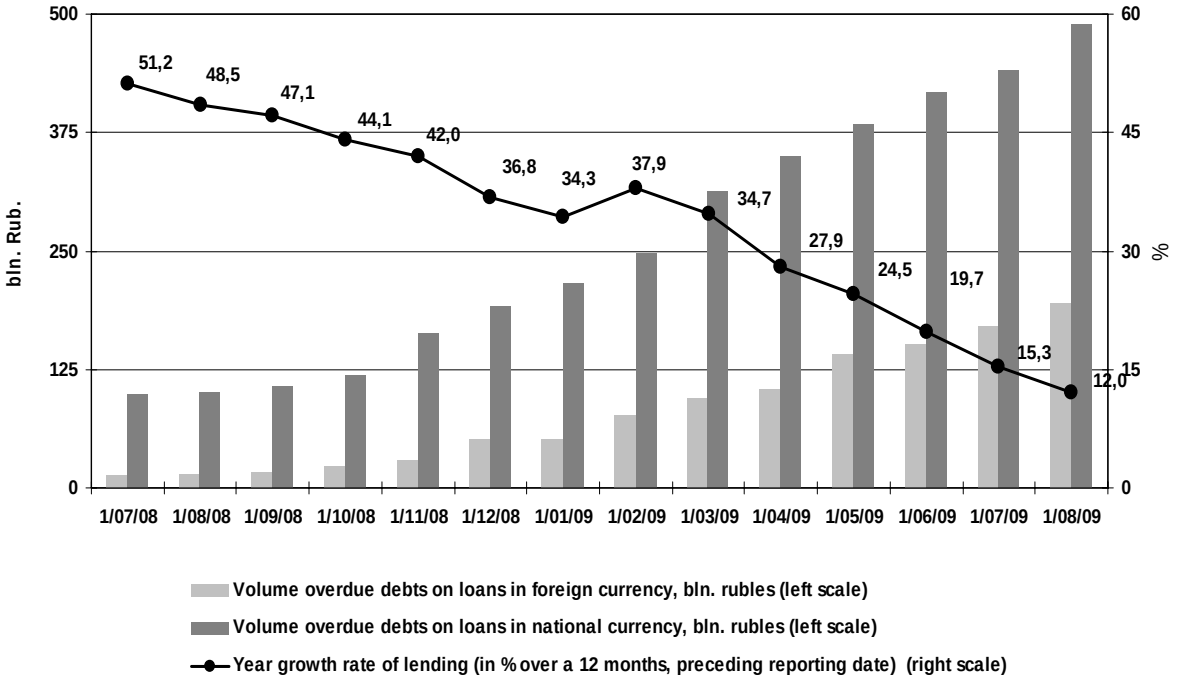


Figure 3. Lending and overdue debts: retail portfolio

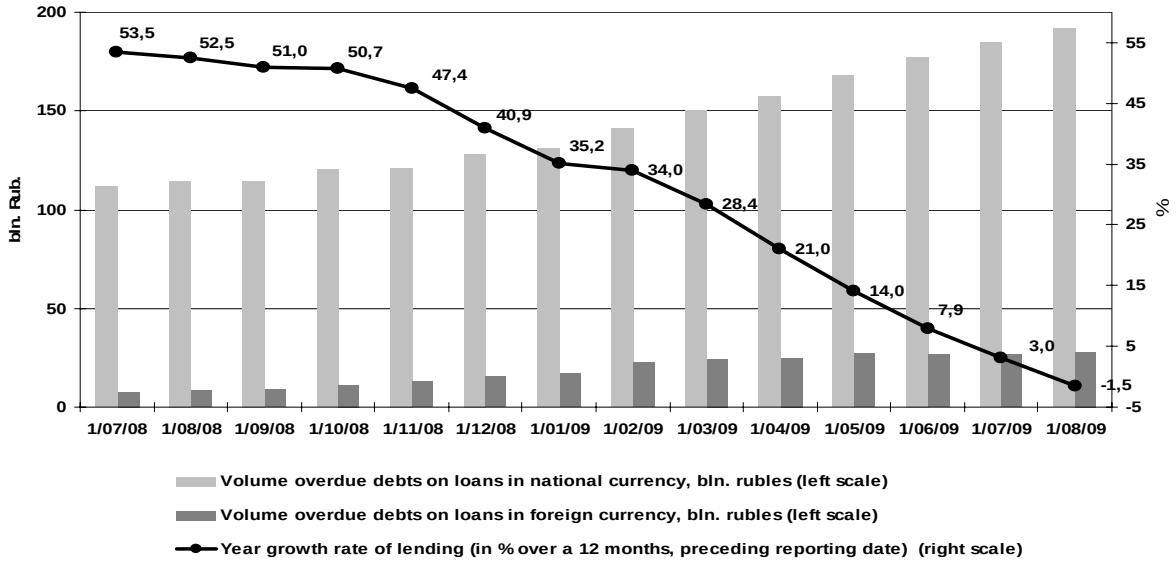


Figure 4. Overdue debts and the share of NPL

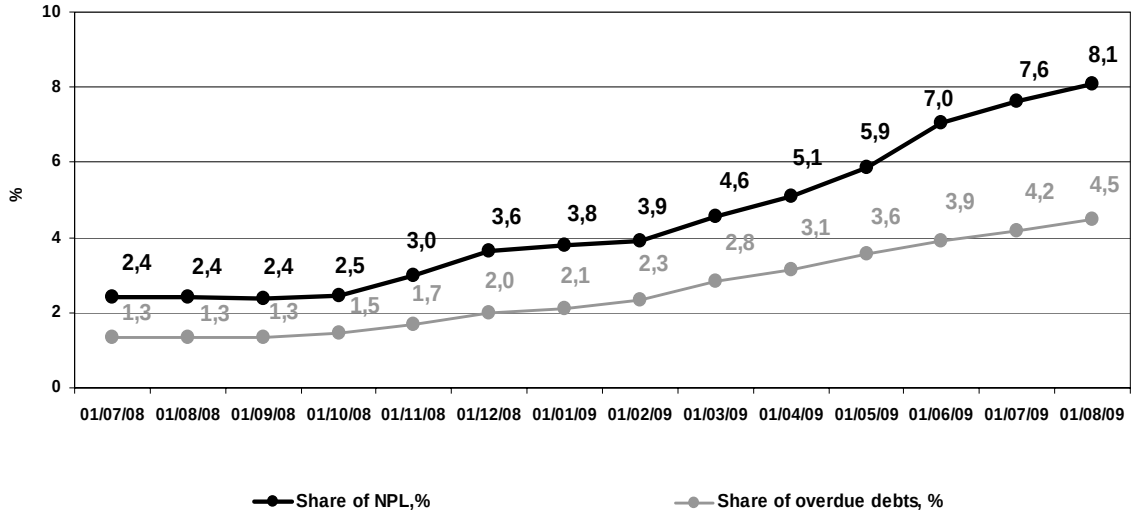


Figure 5
Bar chart of residuals

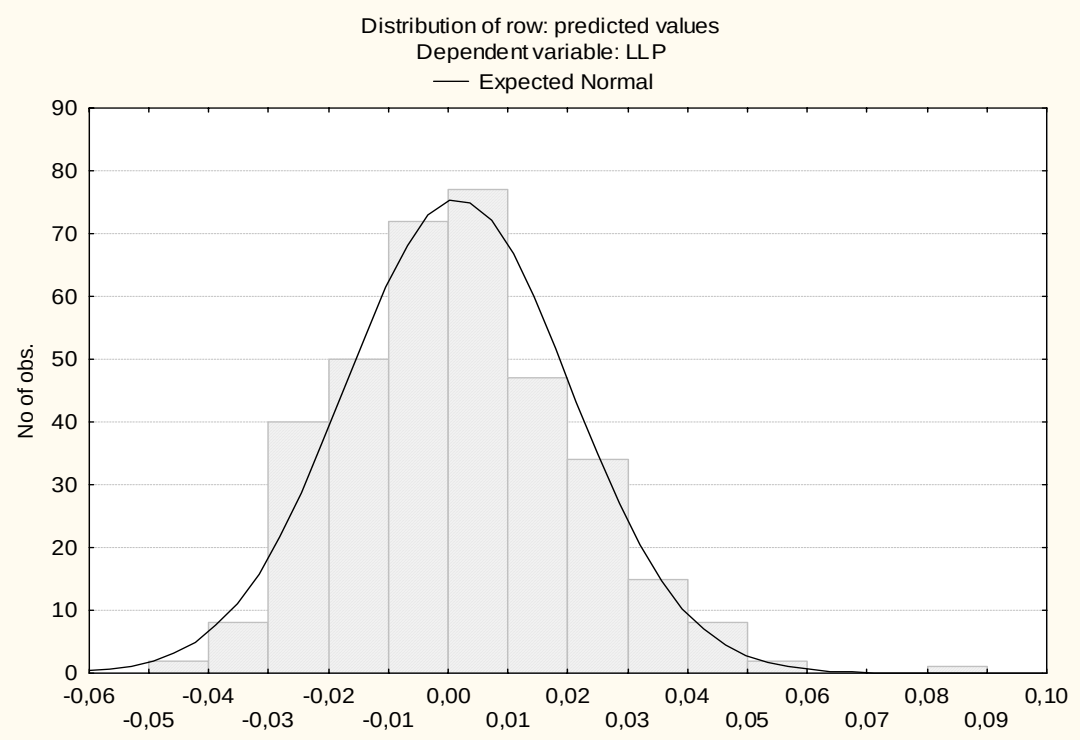


Figure 6. The probability of default by sector

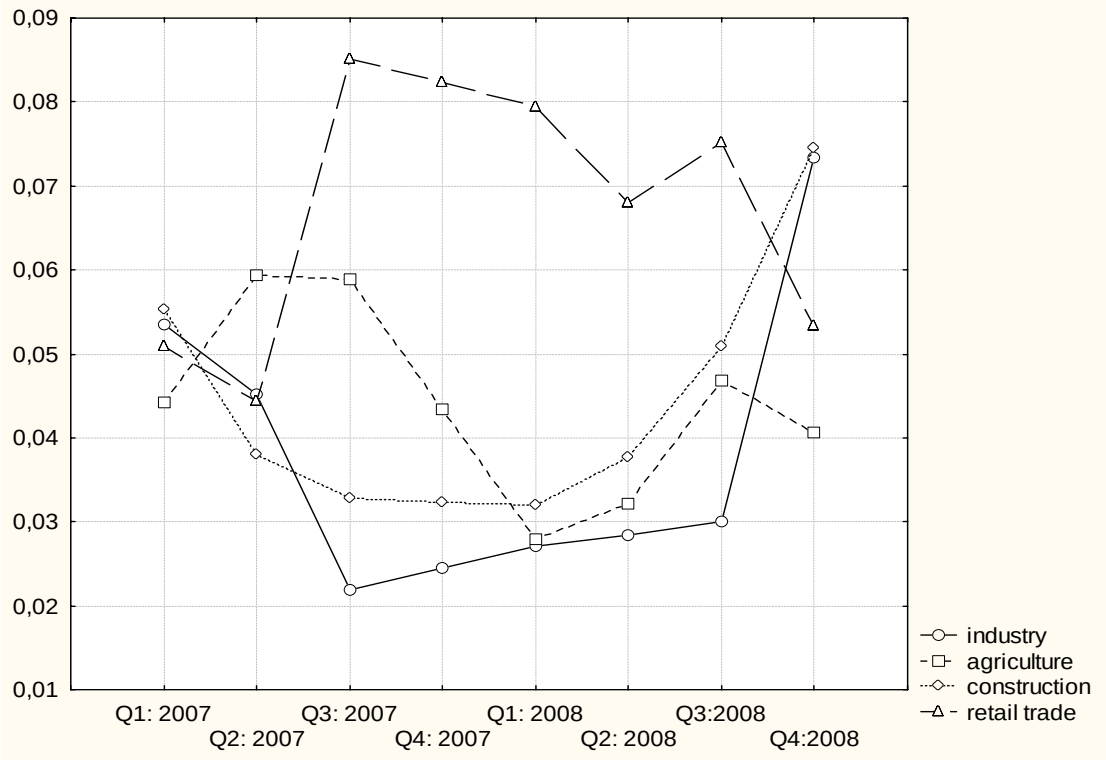
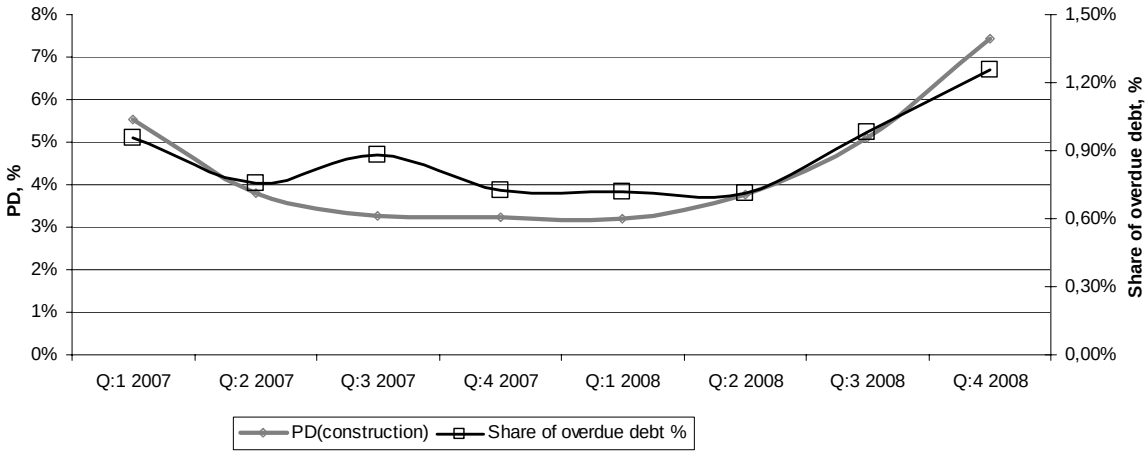


Figure 7. Verification of the results



Discussion

Vassiliki Zakka[7]
Bank of Greece

I will start my discussion of the excellent paper of Tatiana Malakhova from the end. This is because, from what I understood, it is there where the incentive for the research that culminated in the paper lies. This incentive is none other than the need for an adequate stress test of the credit risk of the banks and the banking system as a whole.

As is widely known, credit risk is the risk of loss as a result of the counterparty not fulfilling his/her obligations. It is therefore a function of:

- The probability of the counterparty not fulfilling, i.e. defaulting on his/her obligations, which is termed the Probability of Default, in short, PD
- The portion of the exposure that cannot be recovered in the event of default, which is termed Loss Given Default, in short, LGD.

The LGD is particularly relevant in cases of secured lending, where part of the exposure can surely be recovered through liquidation of the collateral. These two parameters, together of course with the size of the exposures or 'Exposure At Default' (EAD), give the expected loss, which should be covered by provisions and, under specific assumptions regarding the distribution of losses, the 'unexpected' loss or rather probable, within a confidence interval, loss that should be covered by capital. Therefore, by stressing the PD and the LGD we would end up with the provisions and capital that a credit institution needs to remain viable under stressed conditions.

In order to stress test for credit risk we should of course stress both the parameters of credit risk. However, it is true that the PD is more frequently stressed. Therefore, a

[7] Supervision of Credit and Related Financial Institutions Department. Email to vzakka@bankofgreece.gr

paper that explores a stress testing methodology for the probability of default is very pertinent. Alternatively, if we are only interested in provisions, we could stress directly not the two parameters, i.e. PD and LGD, but the Expected Loss.

In any case, certain interrelationships between the parameters should be borne in mind. For example, the definition of the PD has a significant effect both on its size as well as on the size of the LGD. For example, if the PD is defined as the probability that a debtor will be more than 90 days late on his payments, it is certain that the estimated PD will be higher than if the definition is for the probability of the debtor being more than 180 days late. On the other hand, if the definition of default is for obligations that are late by more than 90 days, the LGD could be lower than if the definition of default was for 180 days, since a number of 'defaulting' debtors may have paid in full even though they never reached the 180 days limit.

Moreover, the relationship between the PD and Non-Performing Loans should be explored. There are lags between the PD, which refers to a rate of loans becoming 'non-performing', and the NPLs which is the stock of defaulted loans through the years. The write-off policy of the banks affects the relationship quite significantly as well.

Returning to the PD, it is true that in calculating expected and probable losses we can use the average PD for the whole portfolio of loans. However, especially regarding the calculation of probable losses, it is better move to a more granular approach. We could estimate the PD per portfolio (corporate, retail, possibly mortgage) and per sector as is the case for the paper by Malakhova, or could go even further per sector and size in the sense that a debtor's size is a factor that influences the PD, as well as its response to changes in the economic environment.

The following question arises: Which is the best segmentation? There is no easy answer to that. It is certain that the segmentation should be as granular as possible. In any case, the decisive questions would be: Does the behaviour of debtors in one segment differ from those in another under similar macroeconomic conditions? Does a change in the macroeconomic factors affect debtors in the different segments in a different way? The sector segmentation seems to be quite appropriate because it is common knowledge that some sectors are more 'sensitive' to changes in the economic conditions than others.

Insufficiency of data is a serious constraint on achieving segmentation as granular as possibly is. Therefore, a compromise between granularity and adequacy of data should be made. Closely related to the adequacy of the data is the issue of the size of the population and the different samples which should be large enough to produce reasonably accurate statistical estimations.

Other issues like the homogeneity in the segment should be addressed. For example, in segmentation by sector, in many cases debtors in the same sector may be quite different not only in terms of size but also in terms of the market they try to cover, the product mix etc.

Setting aside the limitations that exist in practice, since the data are never enough, the samples are not always representative and the distributions are not normal, the proposed methodology however can provide valuable input in our thinking of estimation of the PDs in the context of stress testing.

Special Conference Papers

3rd South-Eastern European Economic Research Workshop
Bank of Albania-Bank of Greece
Athens, 19-21 November 2009

1. Hardouvelis, Gikas, Keynote address: "The World after the Crisis: S.E.E. Challenges & Prospects", February 2011.
2. Tanku, Altin "Another View of Money Demand and Black Market Premium Relationship: What Can They Say About Credibility", February 2011.
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8. Kalluci, Irini "Analysis of the Albanian Banking System in a Risk-Performance Framework", February 2011.
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11. Malakhova, Tatiana "The Probability of Default: a Sectoral Assessment", including discussion by Vassiliki Zakka, February 2011.
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