Using non-performing loan rates to compute loan default rates: Evidence from European banking sectors

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Abstract: This research is the first attempt to calibrate default rates of loan portfolios with the use of raw data on nonperforming loans and some additional information on the maturity structure of the loan portfolios. We apply a simple model of loan quality, controlling for loan maturities and dynamics of loan supply. Results for nine national aggregate indices of nonperforming housing loans in the Czech Republic, Greece, Ireland, Hungary, Latvia, Poland, Portugal, Romania, and Spain reveal strong differences in the dynamics of calibrated default probabilities between countries. Calibrated default rates are correlated with macroeconomic factors, but the linkages depend on the markets investigated.

1. Introduction

In this paper we propose a simple method to derive default rates of loan portfolios from the time series of non-performing loans. The non-performing loan (NPL) ratio, i.e. the ratio of non-performing loans to total loans in the portfolio, is a standard measure of loan quality widely used in research analyzing performance of banking sectors and their customers (e.g., Meeker and Gray, 1987; Lízal and Svejnar, 2002; Hasan and Wall, 2004; Podpiera, 2006; Mendoza and Terrones, 2008; Aman and Miyazaki, 2009; Festić, Repina, and Kavkler, 2009; Čihák and Schaeck, 2010; Whalen, 2010; Jin, Kanagaretnam, and Lobo, 2011). The well-known problem of this measure is the 'mechanistic' dependence of its values on the rate of growth of the loan portfolio, which often forbids cross-sectional and inter-temporal comparisons (e.g. Tornell and Westermann, 2002, p.22; Coricelli, Mucci, and Revoltella, 2006;). Another drawback of the NPL rate as a measure of loan quality is that it is a backward-looking variable, i.e. it evaluates the historical performance of the loan portfolio. Non-performing loans often stay in the portfolios for several quarters or even years, affecting the NPL ratio but having no impact on the current financial performance of credit institutions. In contrast, most analysts are interested in the present standing of the portfolio and the present performance of the debtors. One alternative variable that describes the current performance of loans and does not automatically depend on the dynamics of the loan portfolio is a default rate (DR) of that portfolio.

Default rate quantifies the rate at which borrowers default on the amount of funds they owe to the bank in a given (e.g., most recent) period. Default rate is often weighted with the values of analyzed loans so that defaults of large loans weigh more in this measure. Moreover, the historical default rate may be considered as a realization of a popular forward-looking measure of credit risk, namely a probability of default (PD). Therefore, default rates are often used to predict values of loan portfolios.

One important problem is the lack of publicly available data on PDs and DRs of loan portfolios, while time-series of NPL ratios at the aggregate country level are published by international central banks and financial supervisory authorities. In this study, we aim at deriving time-series of default rates from historical data of NPL rates. We apply a simple method to calibrate the term-structure of loan portfolios proposed by Serwa (2013) to analyze changes in the quality of loans in nine European banking sectors.

We focus here on the aggregate portfolios of housing loans because these loans are relatively most uniform in comparison to other types of banking loans. Moreover, the housing loans are long-term contracts and even bad quality mortgages remain in the loan portfolio for long periods and influence the NPL ratio in the long-run. Analyzing the aggregate default rates of housing loans provides a valuable information about the average financial performance of households involved in mortgages.

In the next section, we describe the method to calibrate the default rates, given minimum information on the term structure of the loan portfolio. In Section 3, we present empirical results of estimated default rates for nine country-aggregates of housing loans. The last section concludes.

2. Term-structure of loans and default rates

Our description of the model of a loan portfolio strictly follows the one by Serwa (2013). Let n be the maximum maturity of a loan contract in a given portfolio. The loan portfolio $\boldsymbol{X}_t$ at time t consists of aggregated loan cohorts $x_{i,j,t}$ supplied to borrowers i periods ago and maturing in j periods, where $i = 0,\ 1,\ \ldots,\ n-1$ and $j = 1,\ 2,\ \ldots,\ n$, respectively. The non-performing loans are part of this portfolio and the aggregated bad-quality (non-performing) loan cohorts are denoted as $b_{i,j,t}$. The tranches of good-quality loans $g_{i,j,t}$ are computed as $g_{i,j,t} = x_{i,j,t} - b_{i,j,t}$.

The non-performing loan ratio is the share of bad loans in the portfolio:

$$NPL_t = \frac{\sum_{i=0}^{n-1}\sum_{j=1}^{n} b_{i,j,t}}{\sum_{i=0}^{n-1}\sum_{j=1}^{n} x_{i,j,t}}\ . \tag{1}$$

We introduce the following simplifying assumptions to operationalize derivation of default rates. The important characteristics of loan contracts cannot be changed while loans are present in the analyzed portfolio. Loans are only removed from the portfolio after reaching maturity. The good-quality loans pay interest while the non-performing loans do not. The interest paid on loans in each period is not included in the portfolio. All new loans added to the portfolio at time t are of good quality. The good-quality loans are repaid by borrowers in equal tranches between each period, $g_{i,j,t}/j$, and the bad-quality loans are not repaid until maturity. Assuming other repayment schedules does not change our general results. The above assumptions are the same as in Serwa (2013).

The recursive formula for the value of non-performing loans is as follows:

$$b_{i,j,t} = b_{i-1,j+1,t-1} + DR_{i-1,j+1,t-1} \cdot g_{i-1,j+1,t-1}\ , \tag{2}$$

where $DR_{i-1,j+1,t-1}$ is the average default rate between time $t-1$ and t for the loans that have belonged to the portfolio since $i-1$ periods and have been expected to mature in $j+1$ periods at time $t-1$. Since we aim at constructing a single index of default rate, we compute an average default rate for all cohorts of loans. To simplify computations, we assume that $DR_{i,j,t} = DR_t$

is the same for all maturities and cohorts at time t. Now, the aggregate value of all non-performing loans is equal:

$$\sum_{i=0}^{n-1}\sum_{j=1}^{n} b_{i,j,t} = \sum_{i=0}^{n-1}\sum_{j=1}^{n-1} b_{i,j,t-1} + DR_t \cdot \sum_{i=0}^{n-1}\sum_{j=1}^{n-1} g_{i,j,t-1} \qquad (3)$$

and the aggregate value of good-quality loans equals:

$$\sum_{i=0}^{n-1}\sum_{j=1}^{n} g_{i,j,t} = \sum_{j=1}^{n-1} g_{0,j,t} + (1 - DR_t) \cdot \sum_{i=0}^{n-1}\sum_{j=1}^{n-1} g_{i,j,t-1} \cdot \frac{j}{j+1}. \qquad (4)$$

Deriving DR_t from (3) and (4) is complicated by the fact that data for neither $\sum_{i=0}^{n-1}\sum_{j=1}^{n-1} b_{i,j,t-1}$, $\sum_{i=0}^{n-1}\sum_{j=1}^{n-1} g_{i,j,t-1}$, or $\sum_{j=1}^{n-1} g_{0,j,t}$ are publicly available.

One idea to overcome the problem of unobservable cohorts of loans in the portfolio is to calibrate the term structure of the loan portfolio using the information about the maximum available maturity of loans, the growth rate of loans, the non-performing loan ratio, and the distribution of new loans entering the portfolio in each period. Then the rate of default can be recursively computed from equation (3):

$$DR_t = \frac{\left(\sum_{i=0}^{n-1}\sum_{j=1}^{n} b_{i,j,t}\right) - \left(\sum_{i=0}^{n-1}\sum_{j=1}^{n-1} \tilde{b}_{i,j,t-1}\right)}{\sum_{i=0}^{n-1}\sum_{j=1}^{n-1} \tilde{g}_{i,j,t-1}}, \qquad (5)$$

where $\tilde{b}_{i,j,t-1}$ and $\tilde{g}_{i,j,t-1}$ are the approximated values of true $b_{i,j,t-1}$ and $g_{i,j,t-1}$, respectively, derived from equations (3) and (4) for the time $t-1$. The initial values of $b_{i,j,0}$ and $g_{i,j,0}$ as well as the new loans $g_{0,j,t}$ should be either known or assumed. In the latter case, Serwa (2013) proposed to use some artificial distributions of 'initial' loans in the portfolio and to perform robustness analysis afterwards.

We consider two distributions of new loans with respect to their maturity. The first approach assumes that all new loans are equally distributed. The second approach controls for the situation when new long-term loans are more frequent than new short-term loans and the distribution of new loans is triangular.

The initial distribution of good and bad loans in the portfolio is calibrated to match the initial ratio of non-performing loans. We calculate recursively the long-term levels of $b_{i,j,t}$ and $g_{i,j,t}$ for t approaching infinity assuming the 'steady state' growth rate of the whole portfolio, the constant distribution of new loans with respect to maturity, and the constant rate of default of loans. In practice 500 recursive computations of $b_{i,j,t}$ and $g_{i,j,t}$ from equations (3) and (4) lead to stable 'steady state' values of these variables for all i and j independently of the initial values.

3. Default rates of housing loans in nine European economies

We consider nine European banking sectors for which we were able to obtain the time series of non-performing loan ratios, the growth rates of loans, and the values of maximum available (but 'realistic') maturity for all loans in the sample. We focus on the aggregate portfolios of housing loans in each country, because these loans have long maturities and they are more homogenous than other types of loans. The analyzed countries are the Czech Republic, Greece, Hungary, Ireland, Latvia, Poland, Portugal, Romania, and Spain. The sample begins in 2002 and ends in 2009 for the Czech Republic and it starts in 2004 and ends in 2010 for Hungary (both samples contain annual data). For other countries the data are quarterly and samples equal: 2005Q1-2011Q4 for Greece, 2009Q3-2011Q3 for Ireland, 2007Q3-2011Q4 for Latvia, 2004Q4-2011Q4 for Poland, 1998Q1-2012Q2 for Portugal, 2008Q3-2011Q4 for Romania, and 1999Q1-2012Q1 for Spain.

Figures 1 to 9 present fluctuations of the nonperforming loan ratios in time and the intermediate changes in the business cycles of respective economies. For most of the countries, one can observe rising unemployment and slowing income growth during the global financial crisis of 2008-2009. In the calm periods wage growth is higher and the unemployment rate is lower. However, it is difficult to distinguish between crisis and non-crisis periods by observing nonperforming loan ratios because they contain combined information about credit growth rates and credit default rates. These two combined factors provide rather noisy messages on credit risk. For instance, the pace of credit growth in many countries was still high at the beginning of the resent global financial crisis while the economic fundamentals were already weak and the credit risk was rising.

In turn, the loan default rates should possibly react more rapidly to changing economic conditions than did the NPL ratios. Figures 10 to 18 present changes in default rates in time for each analyzed country. These default rates have been calibrated using the model presented in Section 2. The default rates shown in these figures are valid for the two scenarios, i.e. when all new loans are equally distributed across remaining maturities (DR1) and when more new loans have longer-term maturities (DR2). It can be seen that the differences between the two estimates are relatively small and they do not affect the general conclusions (other distributions of new loans in the portfolio are also possible, but they do not change the results significantly).

There are strong differences in the volatility and 'roughness' of the calibrated default rates for different countries. For some countries, like Hungary, Latvia or Spain, the estimates are relatively smooth. However, the series for Portugal and Poland are coarse. It is possible that the latter default rates contain more economic information or they simply contain more random noise. It is clear from the figures that the large increases of default rates are observed during the global financial crisis of 2008-2009 (for Greece later as well) for all countries. For some countries, like Spain, the crisis period is also the most volatile in terms of changes in the default rates. Surprisingly, default rates vanish to very small values in calm periods for some markets. The rates of default are also rather small for most portfolios, therefore the calibrated indices should be treated as proxies of credit risk rather than precise estimates of credit risk. Our new measures are likely to provide a valuable information on changes of credit risk over the business cycle rather than the information on the levels of risk.

We investigate how our measure of credit risk is correlated with macroeconomic factors. Results are shown in Table 1. We find that default rates were often strongly correlated with macroeconomic variables in the investigated samples. However, the pattern of correlations is not perfectly clear and strongly depends on the investigated countries. Interestingly, the default rates measured at time t were more correlated with the unemployment rates in the upcoming quarter (measured at time $t+1$) rather than those measured in the present quarter (at time t) in six out of nine cases. For the growth of wages, correlations were more negative (i.e. made more sense) between present defaults and the future growth of wages in five out of nine cases. Similarly, correlations were more negative between present defaults and the future interest rates in five out of nine cases. We could expect a negative link between present default rates and future interest rates if central banks adjusted the interest rate to worsening or improving economic conditions proxied by default rates. We conclude that there is no strong evidence that default rates can predict macroeconomic variables well, but at least the contemporaneous linkages of credit risk and macroeconomic factors are strong in many countries.

4. Conclusions

Deriving probabilities of default from raw indices of nonperforming loans is a difficult task when only limited information is available. Depending on the country, the computed default rates are volatile or smooth but they are always more irregular than original non-performing loan ratios. It may suggest that economic fluctuations and their effects on the loan quality are volatile. Banks tend to smooth their economic performance (and the non-performing loan ratio) by controlling their loan supply. Obviously, there are several factors that influence changes in the nonperforming loan ratios independently of the changing rates of default. For example, selling some parts of a loan portfolio will significantly affect the term-structure of the aggregate loan portfolios. Changing accounting regulations, and changing policies of banks with respect to new loan supply and old non-performing loans would also affect our results. In practice, more information about the structure of the loan portfolio improves precision of calibrated default rates.

Further analyses should compare our proxy of credit risk for a loan portfolio with the true values of default rates in bank loan portfolios. Currently, this task is complicated by the fact that only few banks publish estimates of PDs cyclically.

One direct extension of our results could be regression analyses of macroeconomic factors affecting credit risk in different countries. Possibly, the combined macroeconomic variables in regression models may explain a large share of credit risk volatility. This may lead to more efficient models used to predict credit risk.

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Figure 1: The NPL ratio and macroeconomic data for the Czech Republic

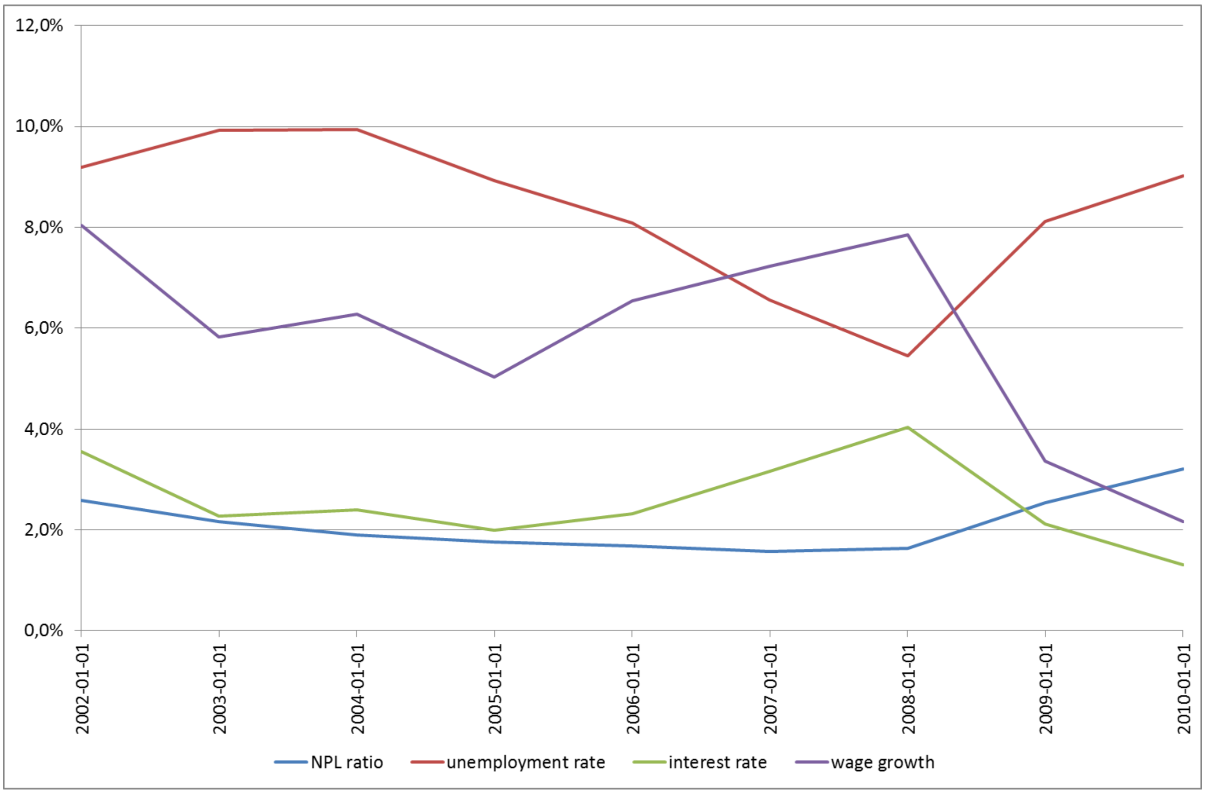

Figure 2: The NPL ratio and macroeconomic data for Greece

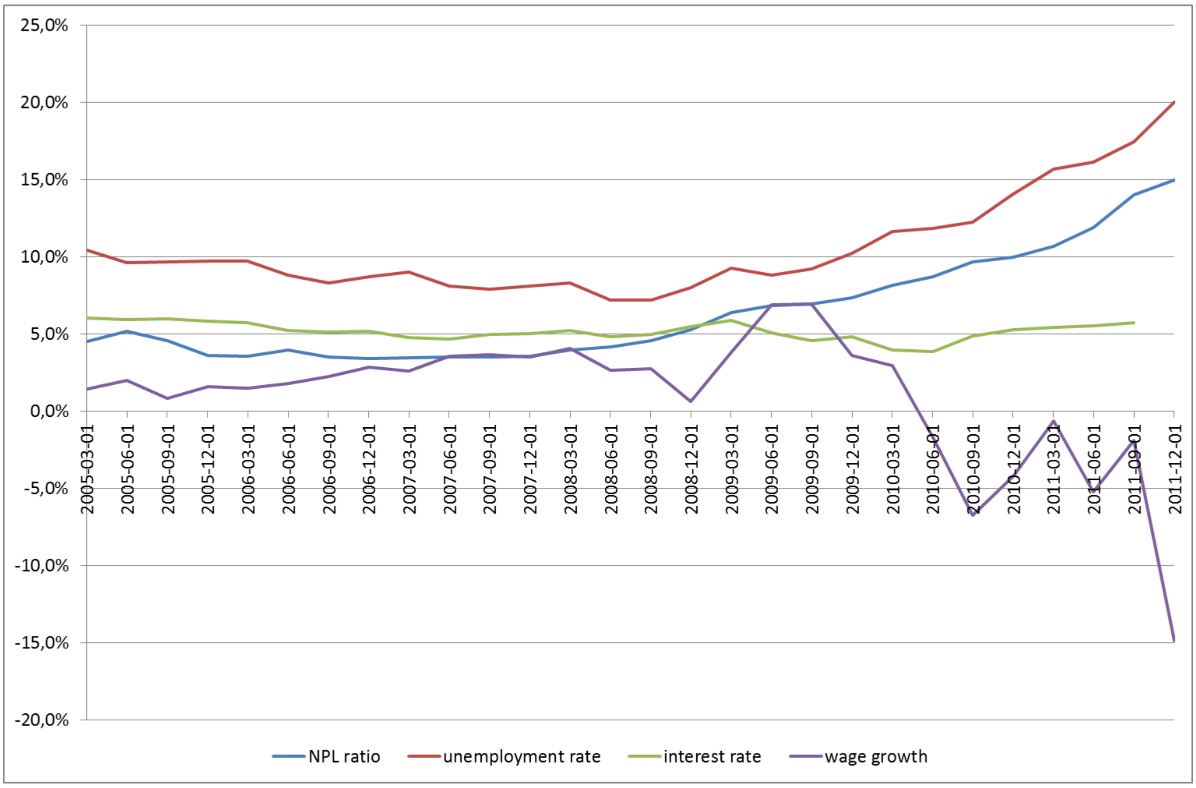

Figure 3: The NPL ratio and macroeconomic data for Ireland

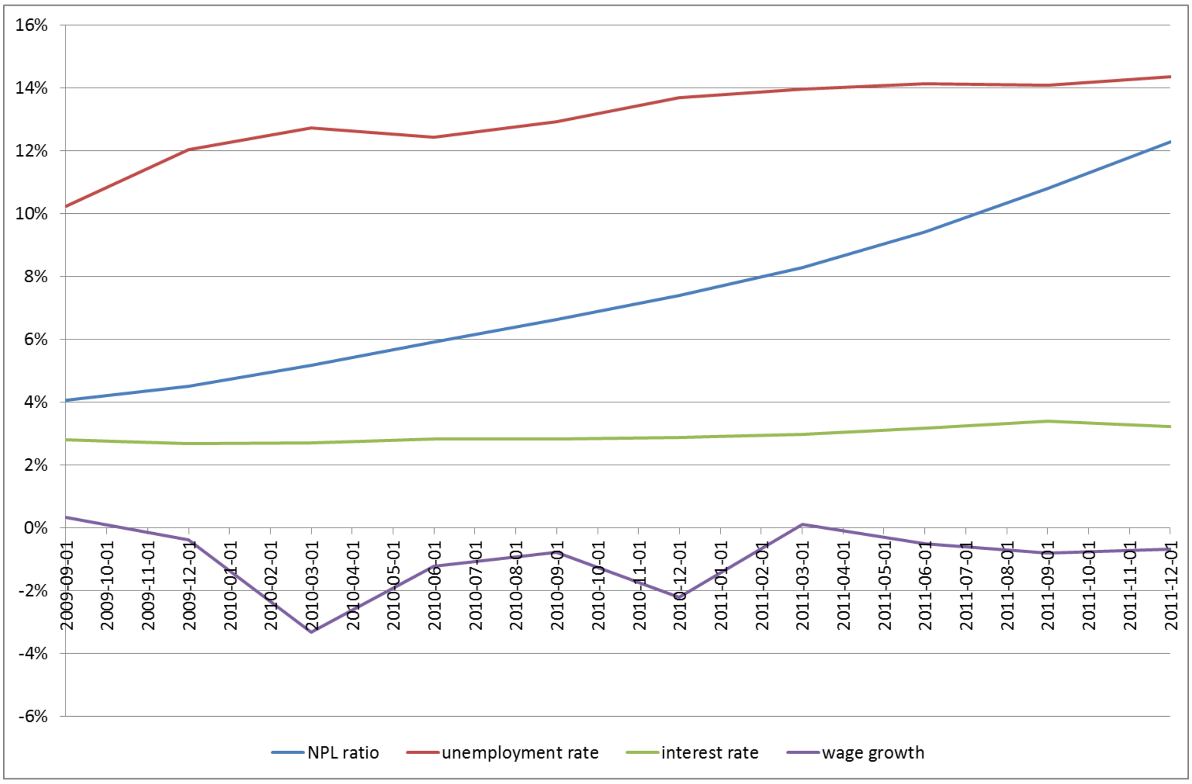

Figure 4: The NPL ratio and macroeconomic data for Hungary

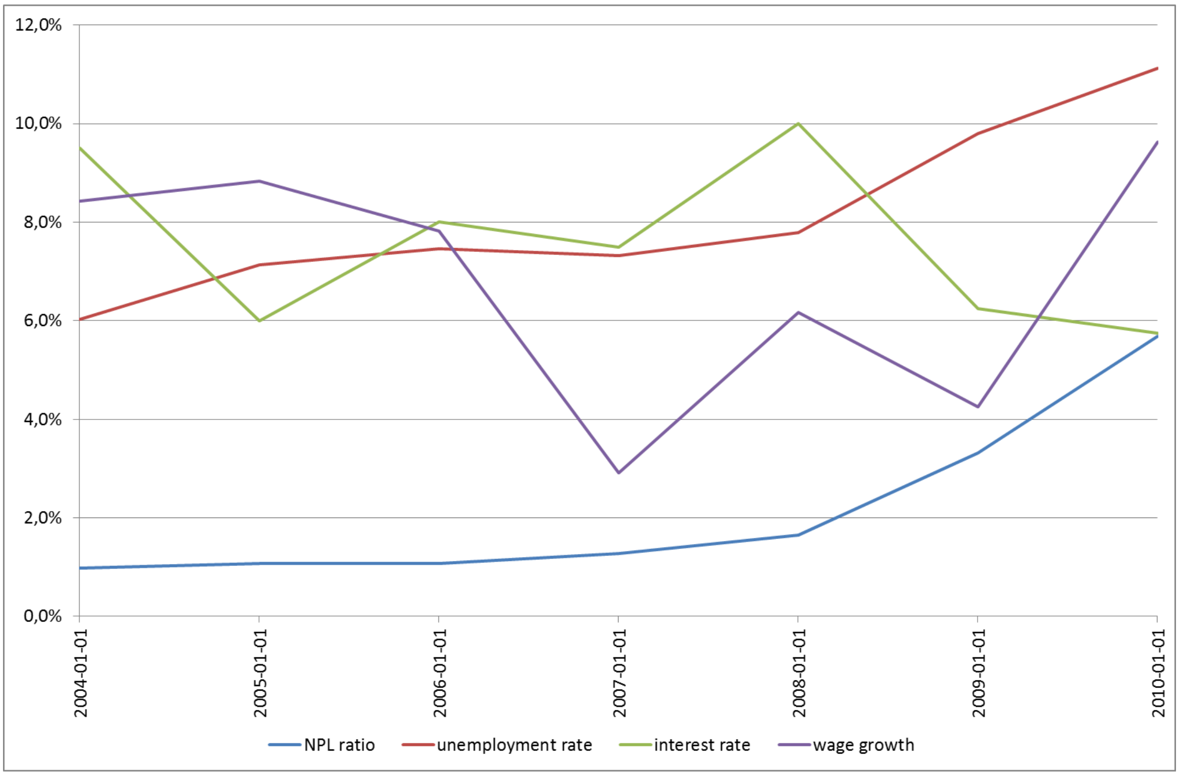

Figure 5: The NPL ratio and macroeconomic data for Latvia

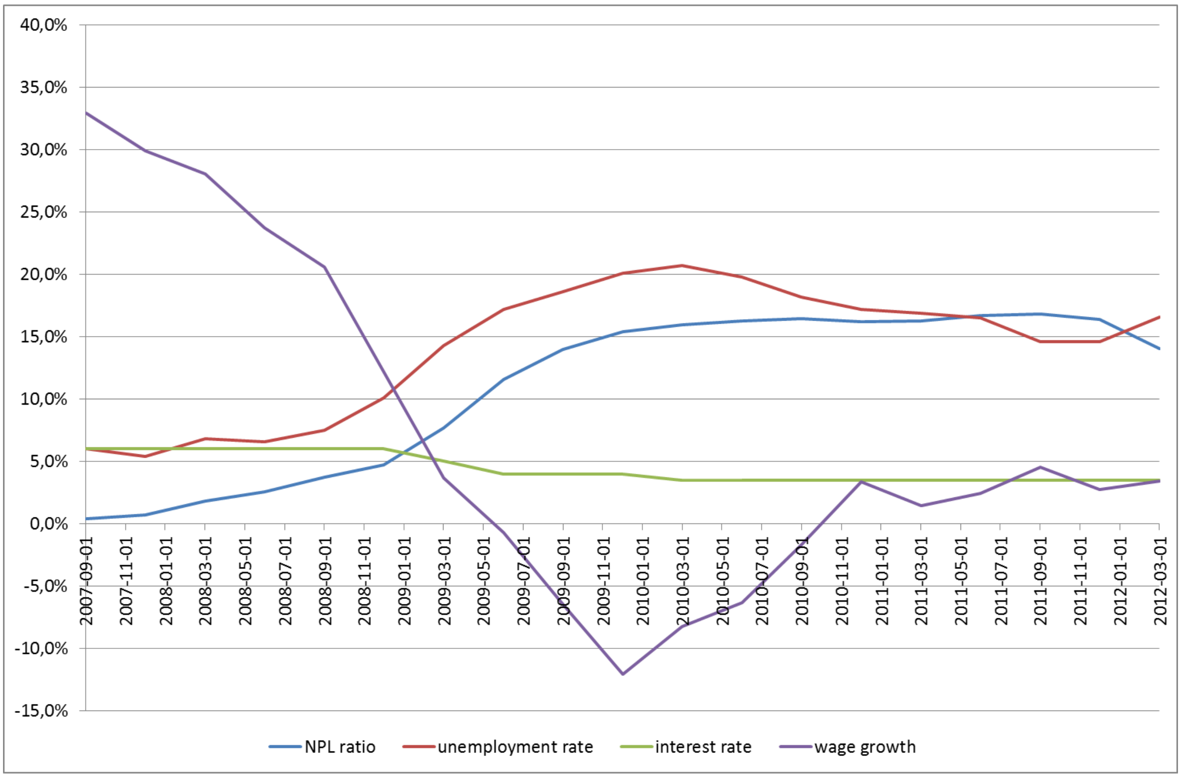

Figure 6: The NPL ratio and macroeconomic data for Poland

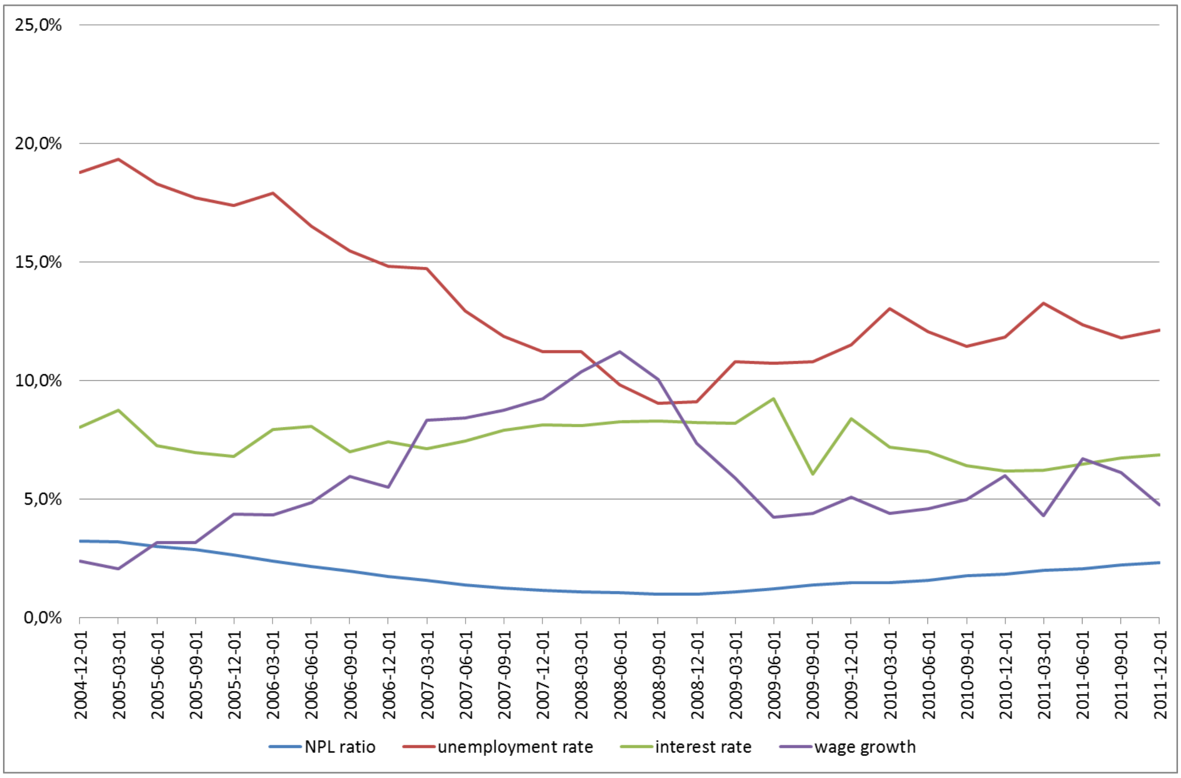

Figure 7: The NPL ratio and macroeconomic data for Portugal

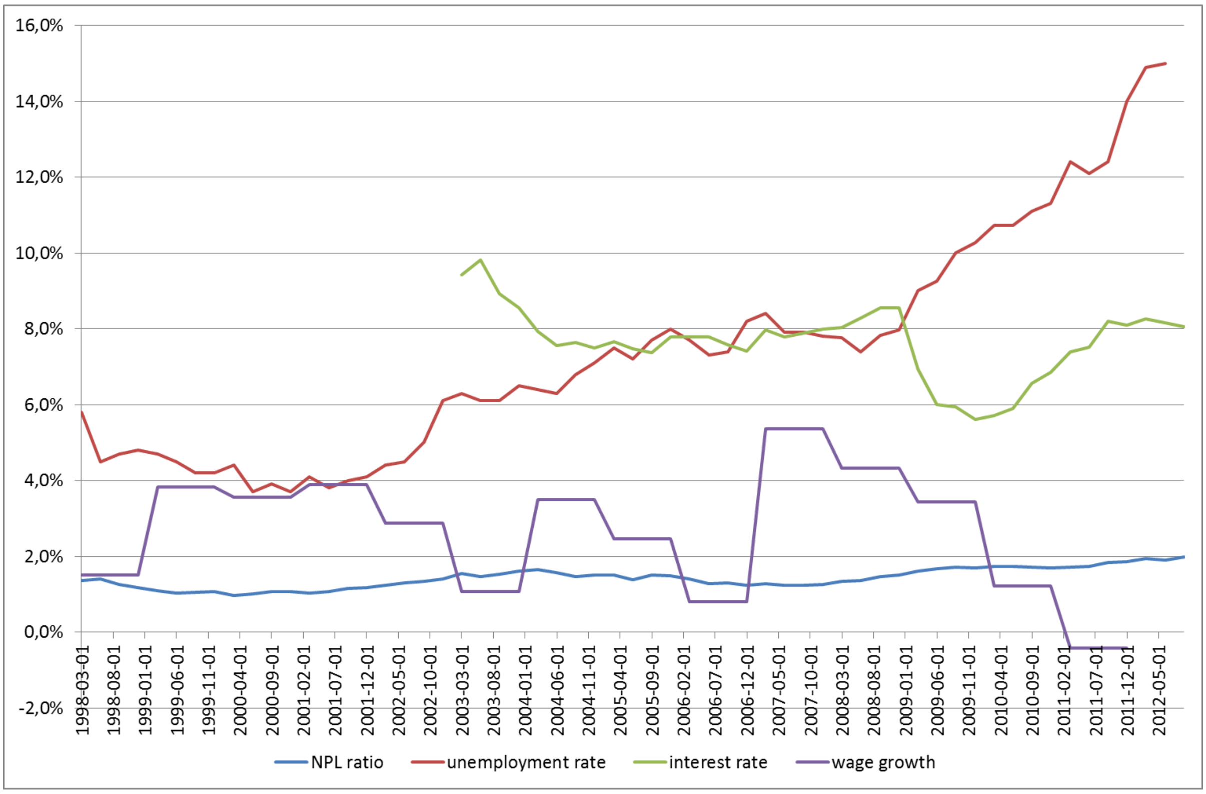

Figure 8: The NPL ratio and macroeconomic data for Romania

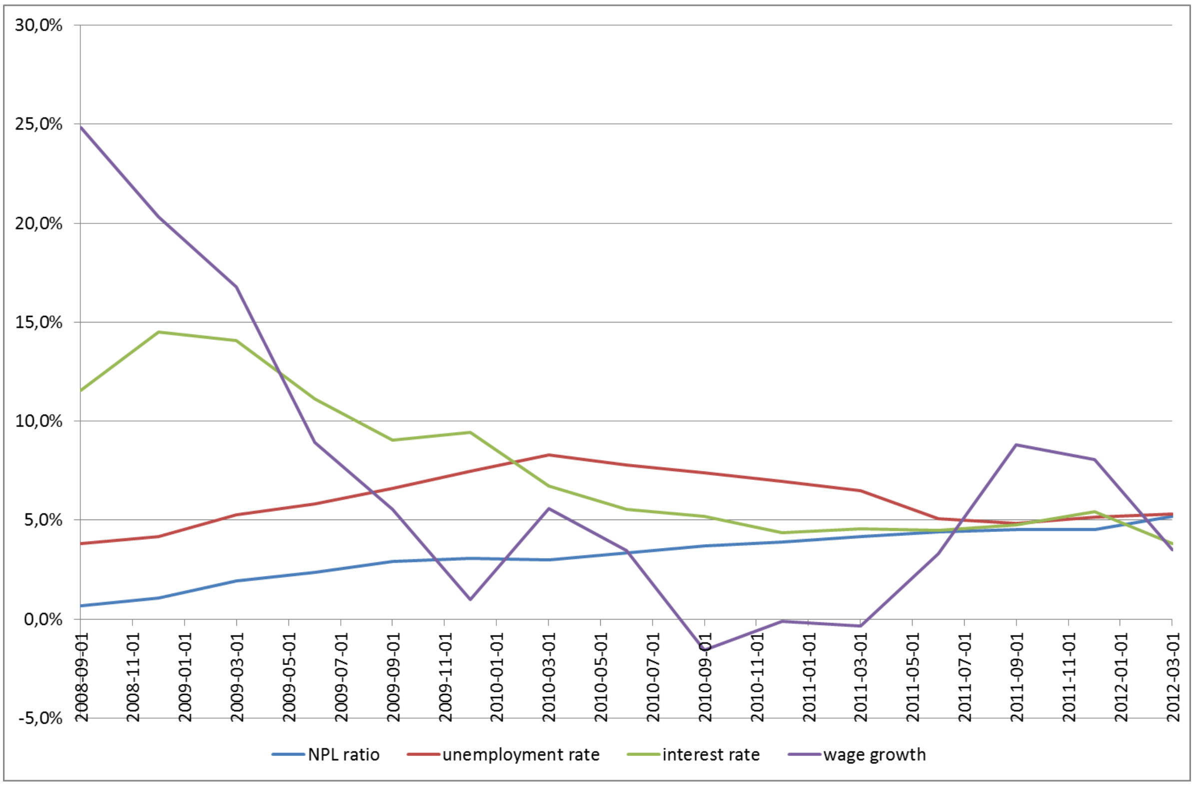

Figure 9: The NPL ratio and macroeconomic data for Spain

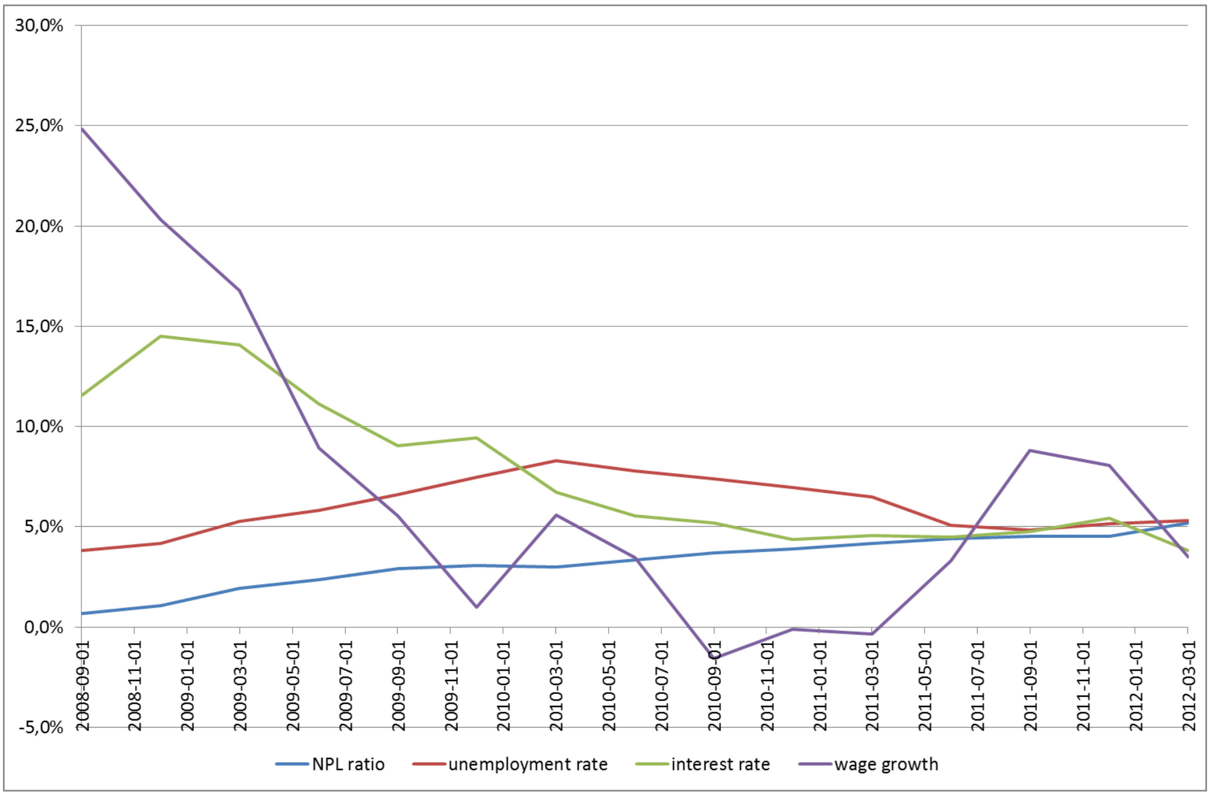

Figure 10: Calibrated default rates for the Czech Republic

Figure 11: Calibrated default rates for Greece

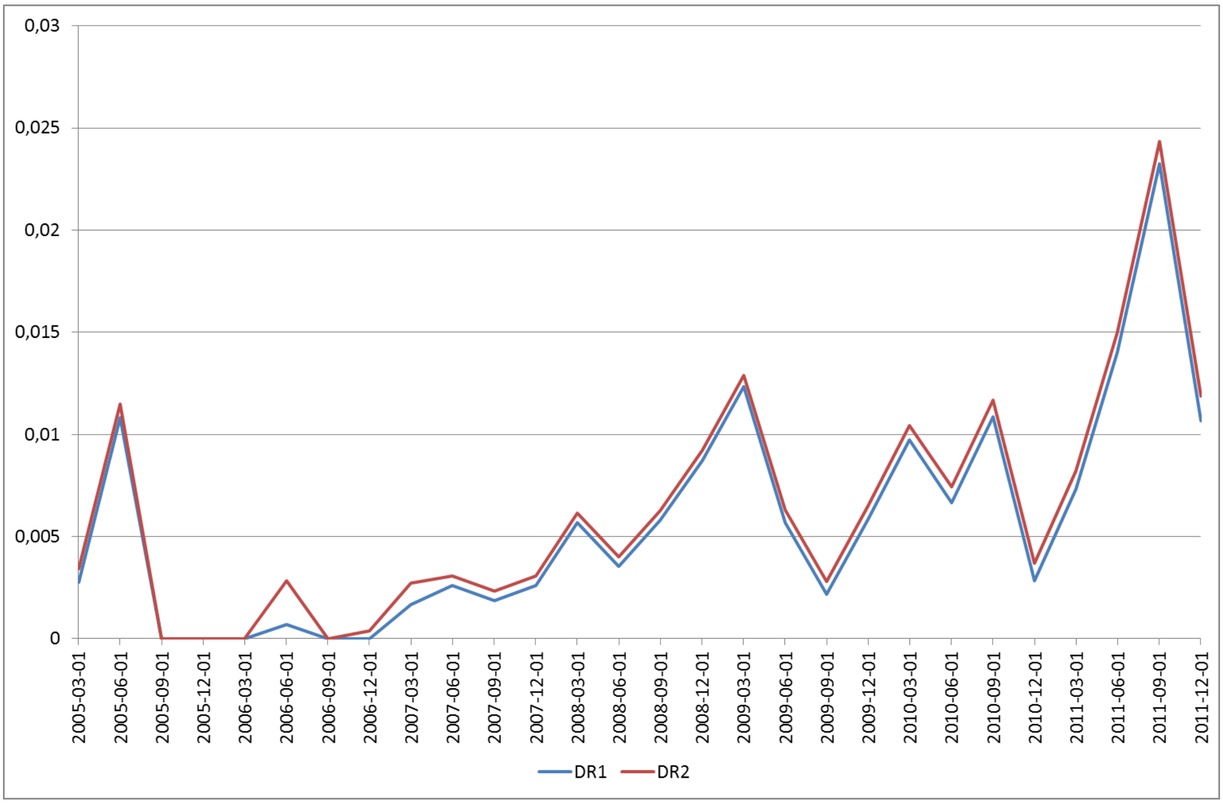

Figure 12: Calibrated default rates for Ireland

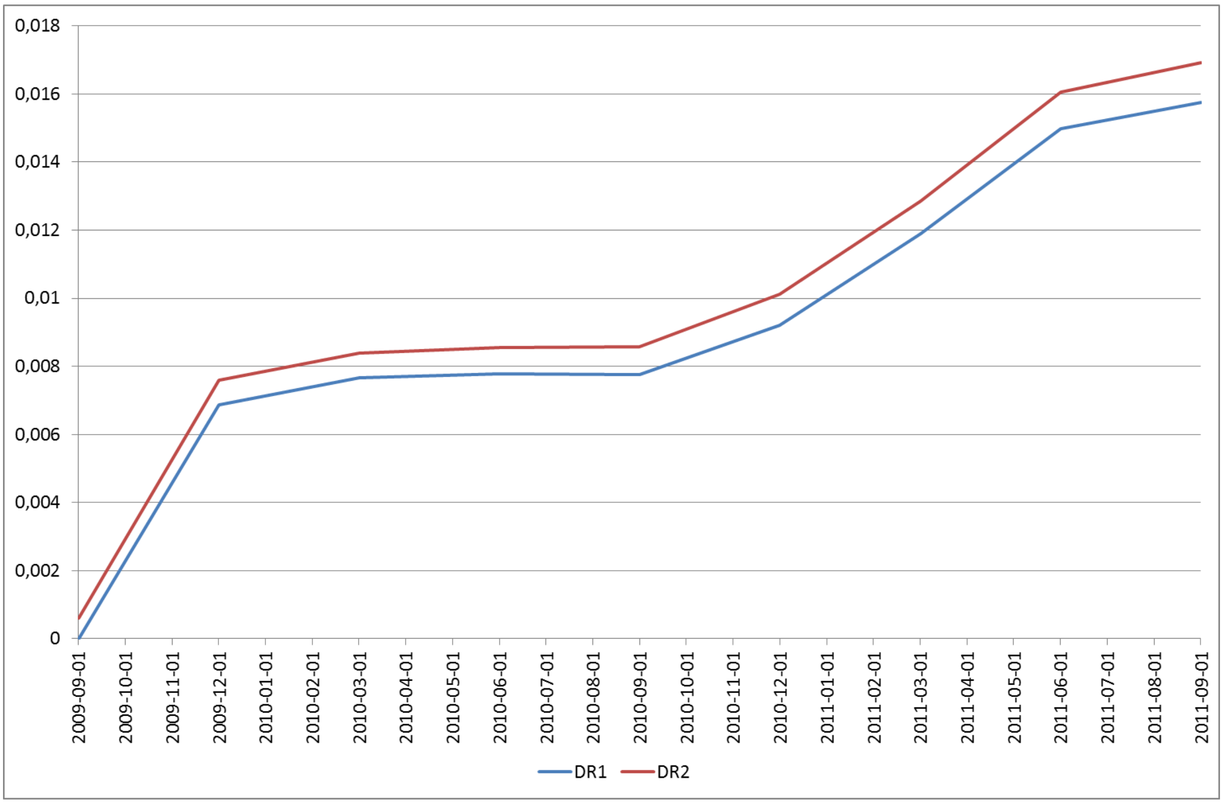

Figure 13: Calibrated default rates for Hungary

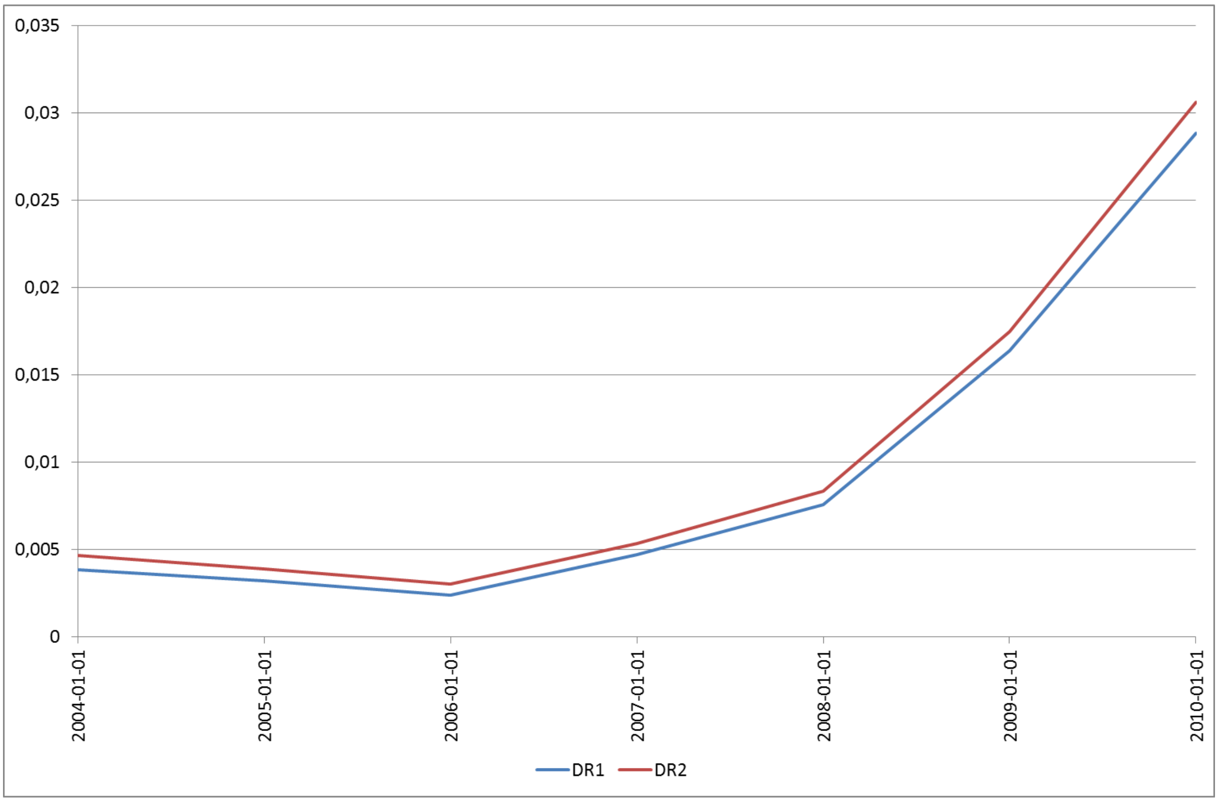

Figure 14: Calibrated default rates for Latvia

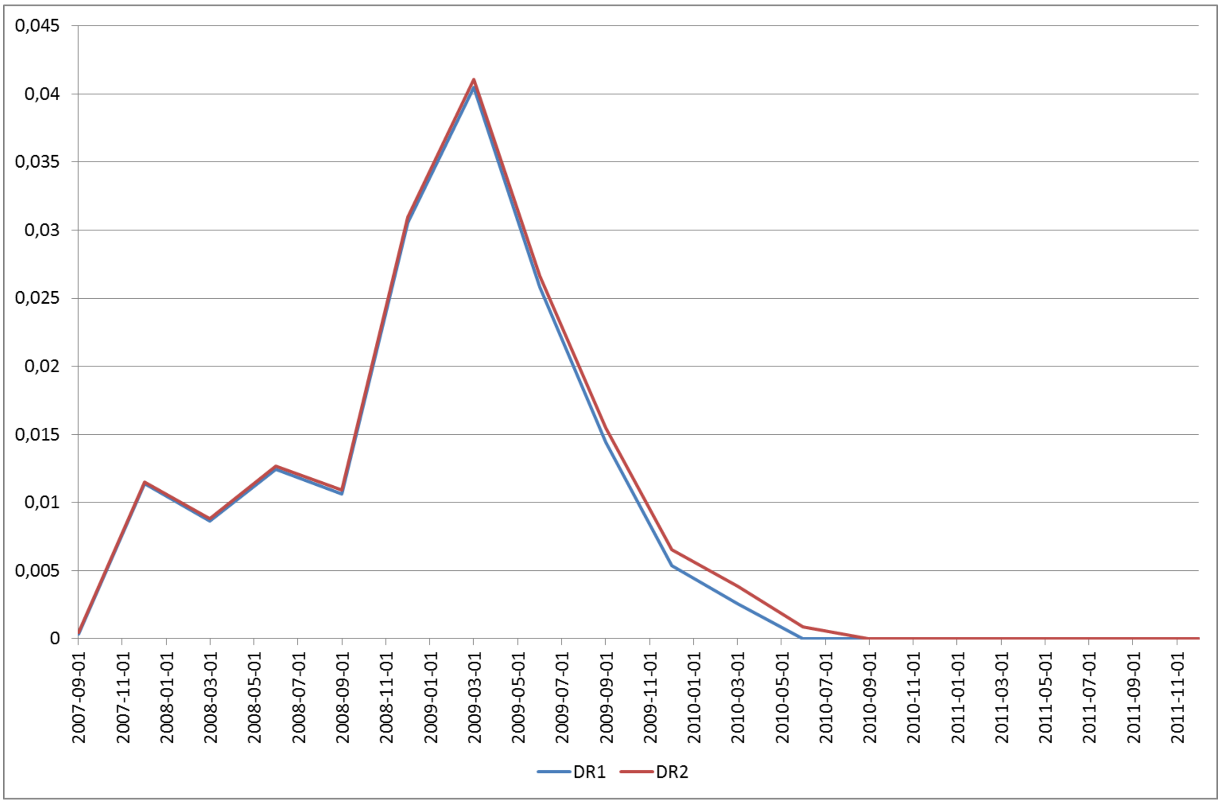

Figure 15: Calibrated default rates for Poland

Figure 16: Calibrated default rates for Portugal

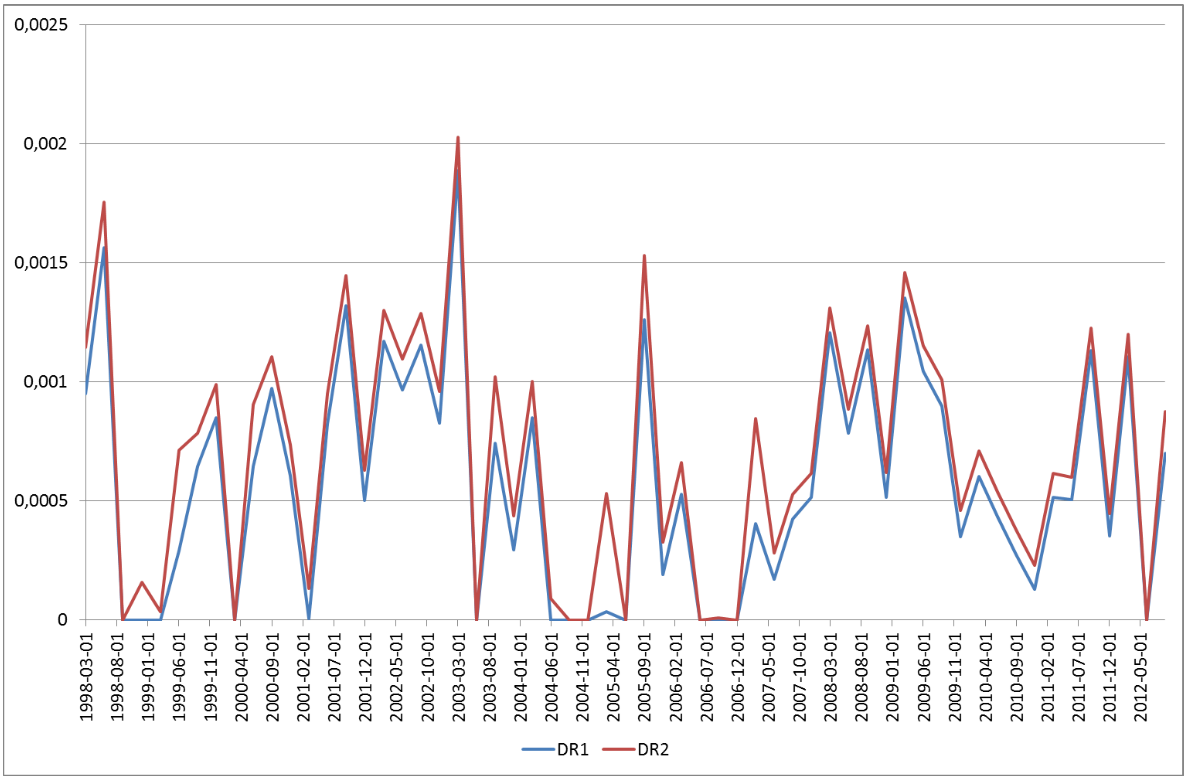

Figure 17: Calibrated default rates for Romania

Figure 18: Calibrated default rates for Spain

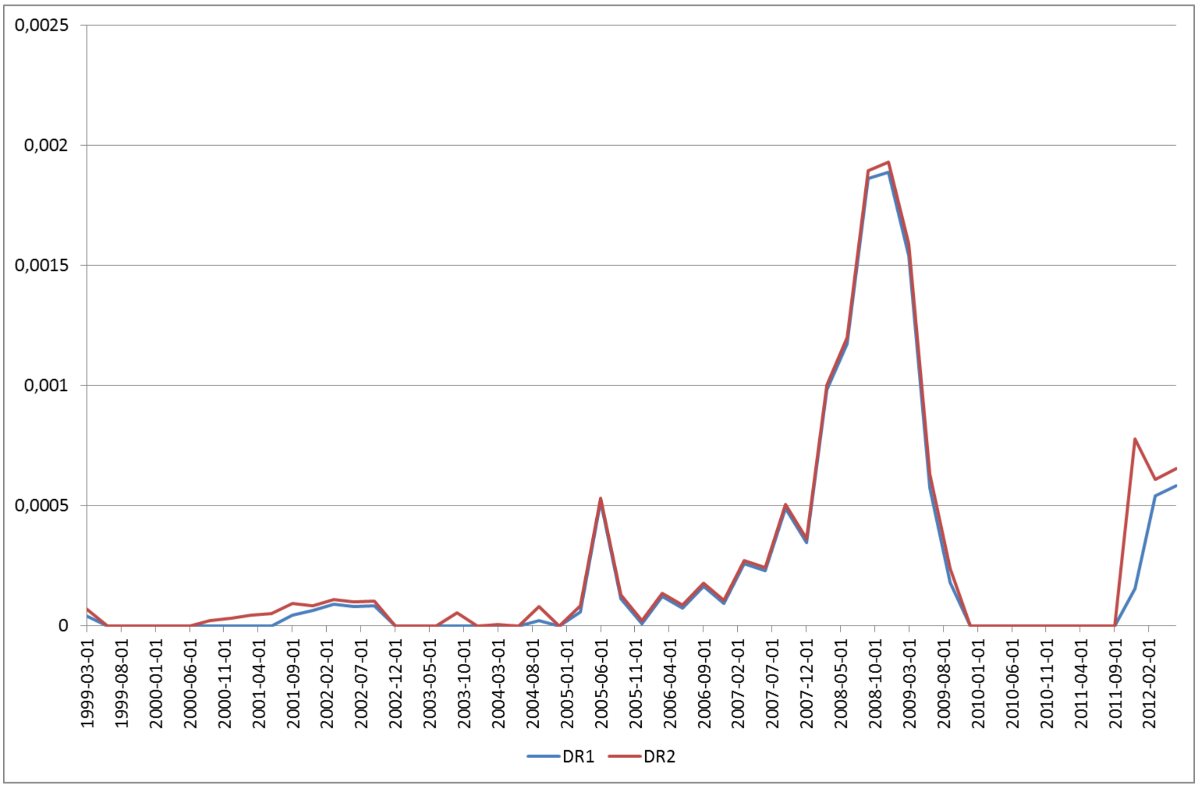

Table 1: Correlations of loan default rates with nonperforming loan ratios and macroeconomic variables

	NPL (t)	NPL (t+1)	unemployment rate (t)	unemployment rate (t+1)	wage growth (t)	wage growth (t+1)	interest rate (t)	interest rate (t+1)
Czech Rep.	0,32	0,87	-0,40	0,40	-0,10	-0,91	0,39	-0,72
Greece	0,75	0,77	0,62	0,65	-0,40	-0,62	0,10	0,04
Ireland	0,92	0,93	0,94	0,87	-0,07	0,15	0,79	0,91
Hungary	1,00	0,98	0,95	0,86	0,19	0,40	-0,53	-0,30
Latvia	-0,42	-0,26	-0,20	0,04	0,09	-0,12	0,45	0,24
Poland	0,17	0,14	0,17	0,20	-0,30	-0,18	0,00	0,08
Portugal	0,10	0,10	-0,07	-0,01	0,07	-0,01	0,10	0,10
Romania	0,03	0,20	-0,15	-0,16	0,16	0,01	0,10	-0,02
Spain	0,33	0,41	-0,01	0,06	0,10	0,15	0,42	0,37

Note: Default rates are measured at time t while the other variables are measured at time t or t+1 (as denoted in the first row).