Measuring non-performing loans

during (and after) credit booms

Dobromił Serwa

National Bank of Poland, Financial System Department

Warsaw School of Economics, Institute of Econometrics

This version: 10.07.2013

Abstract:

We evaluate the distortion of the ratio of non-performing loans (NPL) caused by the rapid credit growth and show that the bias in the ratio caused by the prolonged credit boom may be significant. Then, we discuss an adjustment to the NPL ratio based on a theoretical model of a loan portfolio. This adjustment is robust to credit booms and busts, and it can be employed to compare credit quality ratios across distinct portfolios and banks, and to simulate future NPL ratio developments. Our estimates for the portfolio of housing loans in Poland show that the new adjusted index of non-performing loans is robust to different model specifications.

JEL: G21, G32, C63

Key words: non-performing loan ratio, credit boom, housing loans

The support and constructive comments from Sławomir Zajączkowski, Marta Gołajewska, Piotr Kasprzak, Jorge Martínez, Michał Rubaszek, and colleagues from the Financial System Department of the NBP, Capital Markets and Financial Structure Division of the ECB, and participants of the MARS network seminar are gratefully acknowledged. This research has been financed by the grant from National Science Centre in Poland.

1. Introduction

The ratio of non-performing loans to total loans, the NPL ratio, is a standard and widely used statistic measuring financial performance of banking institutions. It is frequently employed to assess and compare the quality of loan portfolios (e.g., Meeker and Gray, 1987; Mendoza and Terrones, 2008; Festić, Repina, and Kavkler, 2009), to analyze lending policies and efficiency of banking sectors (e.g. Lízal and Svejnar, 2002; Hasan and Wall, 2004; Podpiera, 2006), to price bank equity (e.g., Aman and Miyazaki, 2009), to predict bank failures (e.g., Jin, Kanagaretnam, and Lobo, 2011), and to construct early warning models of financial instability (e.g., Čihák and Schaeck, 2010; Whalen, 2010).

Supervisors, auditors, and economists using the NPL ratio face at least two obstacles. First, comparing the ratio between banks or between financial systems in different countries is complicated when credit dynamics or business cycle phases differ. It is well known that the dynamics of loans supplied by banks affect the NPL ratio, because the new loans are generally of better quality than the older loans in bank portfolios (e.g. Tornell and Westermann, 2002, p.22).

Second, the NPL ratio may vary in time inadvertently due to reasons not related directly to the changing economic conditions or credit risks. These reasons include altering maturities in the successive cohorts of loans in the portfolio, the flows of new loans to the portfolio, maturing of old loans, actions of banks selling and buying credit tranches, and other external effects.

In this study we evaluate the distortion of the NPL measure caused by the rapid credit growth. We show that the "bias" caused by the prolonged credit boom may be significant and this fact puts into question the use of the NPL measure in many countries with rapidly developing banking sectors. The NPL ratio observed during a boom can be even twice lower than the ratio of an analogous portfolio in a stable period. After the end of the boom, the quality of loans decreases dramatically despite stable economic conditions and the NPL ratio increases beyond the original level from the start of the boom.

Next, we discuss three possible adjustments to the ratio of nonperforming loans. Two simple adjustments to the NPL ratio are valid only in very short periods and the third one performs better also in a longer term. Based on the theoretical model, the latter adjusted NPL ratio can be employed to measure the quality of loans during extended credit booms, to simulate future NPL ratio developments, and to compare credit quality ratios across single portfolios, banks, or aggregated loans in different financial systems. We provide an example of the adjustment to the NPL ratio in the aggregate portfolio of housing loans in banks in Poland.

Possible applications of our adjusting procedure include macroeconomic stress tests, impulse-response analyses, early warning models of financial instability, and comparisons of NPL ratios in different credit institutions, banking systems, or in different times.

In the next section, we present a highly stylized theoretical model describing the dynamics of good and bad quality loans in a bank portfolio. Using this model, we present the effect of an extended credit boom on two typical credit portfolios. Section 3 discusses the use of alternative measures of non-performing loans controlling for credit dynamics. Section 4 presents an example of the use of these measures in a real banking sector. The final section concludes.

2. Simple model of non-performing loans

We base our simulations on a highly stylized model of an aggregated loan portfolio, where each loan exists a number of periods and can default with some exogenous probability any time. Similar and much more complex models, taking into account the maturity structure of banking assets, have been constructed by a number of researchers. Heitfield and Sabarwal

(2004) estimate a competing risks model of default and prepayment on subprime automobile loans. Gordy and Howells (2006) analyze pro-cyclicality of Basel II regulatory policies in theoretical portfolios of loans. Chatterjee, Corbae, Nakajima, and Ríos-Rull (2007) construct a theoretical model of unsecured consumer credit, where borrowers have an option to default. Drehmann, Sorensen, and Stringa (2010) build a stress testing framework for a banking sector. Nevertheless, none of these studies analyze the effects of credit booms on the ratio of non-performing loans.

Our approach allows us to assess the effect of a credit boom on the quality of loans. To our best knowledge, no earlier study measured the direct impact of rapid credit growth on the ratio of non-performing loans by taking into account the maturity structure of loans in a theoretical model.

Let $\mathbf{X}_t = [x_{i,j,t}]_{n\times n}$ be the matrix of aggregated loan cohorts observed at time t, supplied to borrowers i periods (e.g. years or quarters) ago, and maturing in j periods, where $i = 0, 1, \dots, n-1$ and $j = 1, 2, \dots, n$, respectively. Similarly, let $\mathbf{G}_t = [g_{i,j,t}]_{n\times n}$ be the matrix of "good-quality" (performing) loan cohorts observed at time t, supplied to borrowers i periods ago, and maturing in j periods, and $\mathbf{B}_t = [b_{i,j,t}]_{n\times n}$ be the matrix of "bad-quality" (non-performing) loan cohorts.

For each i and j the total volume of loans consists of bad and good-quality loans, $x_{i,j,t} = g_{i,j,t} + b_{i,j,t}$. The aggregate portfolios of good-quality, bad-quality and total loans are the sums of respective loans observed at time t, i.e. $S_t^G = \sum_{i=0}^{n-1}\sum_{j=1}^{n} g_{i,j,t}$, $S_t^B = \sum_{i=0}^{n-1}\sum_{j=1}^{n} b_{i,j,t}$, and $S_t^X = \sum_{i=0}^{n-1}\sum_{j=1}^{n} x_{i,j,t}$.

The ratio of non-performing loans in such a framework can be defined as:

$$NPL_t = \frac{S_t^B}{S_t^X}. \tag{1}$$

In the next period $t+1$ (e.g. next year), the remaining maturities of all types of loans decrease by one period and no other changes in maturities (e.g. re-scheduling of some loans) are allowed in the model. When the remaining maturity of a loan falls to zero, this loan is taken from the balance sheet. The new tranches of loans $z_{j,t+1}$ with various maturities j ($j = 1, 2, \dots, n$) are added to the portfolio. All new loans are assumed to be of a good quality. The good-quality loans are assumed to be paid back at equal rates each period and the bad-quality loans are not paid back until their maturity.[1]

The recursive formula for the value of loans in each period t takes the form[2]:

$$S_t^X = \left(\sum_{j=1}^{n} z_{j,t}\right) + \left(\sum_{i=1}^{n-1}\sum_{j=1}^{n-1} x_{i,j,t-1}\right) - \left(\sum_{i=1}^{n-1}\sum_{j=1}^{n-1}\frac{g_{i,j,t-1}}{j+1}\right), \tag{2}$$

where the last sum in (2), $\sum_{i=1}^{n-1}\sum_{j=1}^{n-1}\frac{g_{i,j,t-1}}{j+1}$, is the part of loan portfolio paid back by the borrowers at time t.

Let $q_{i,j,t}$ be the exogenous probability that a single unit of a loan, originated i periods ago and maturing in j periods, becomes non-performing at time t, given that it was performing well at time $t-1$. We treat $q_{i,j,t}$ as an average default probability for loans originated i periods ago and maturing in j periods.

Let $p_{i,j,t} = 1 - q_{i,j,t}$ be the "survival" probability for each loan in the portfolio, i.e. the probability of remaining a good-quality loan by the loan that was performing well in the previous period. The recursive formula for the value of good-quality loans at time t is given below:

$$g_{i,j,t} = g_{i-1,j+1,t-1} \cdot p_{i,j,t} \cdot \left(1 - \frac{1}{j+1}\right) + z_{i,j,t}\ , \tag{3}$$

[1] As an extreme case, we also construct a model where all loans are only paid back at their maturity. The main result about the bias of the NPL ratio during a credit boom becomes even stronger then.
[2] We simplify the analysis by treating the interest on loans that is included in the total volume of loans in each period as a part of the tranche of new loans with respective maturities, i.e. all interest rates are exogenous to the model. Alternatively, one can assume that the interest is not included in the total volume of loans.

where $\frac{1}{j+1}$ is the share of loans paid back by borrowers and excluded from the bank portfolio. The value of bad-quality loans is equal:

$$b_{i,j,t} = g_{i-1,j+1,t-1} \cdot q_{i,j,t} + b_{i-1,j+1,t-1}. \quad (4)$$

We assume that the probability for non-performing loans to become performing is null. The aggregated values of good, bad, and total loans (S_t^G, S_t^B, and S_t^X) can be calculated accordingly.

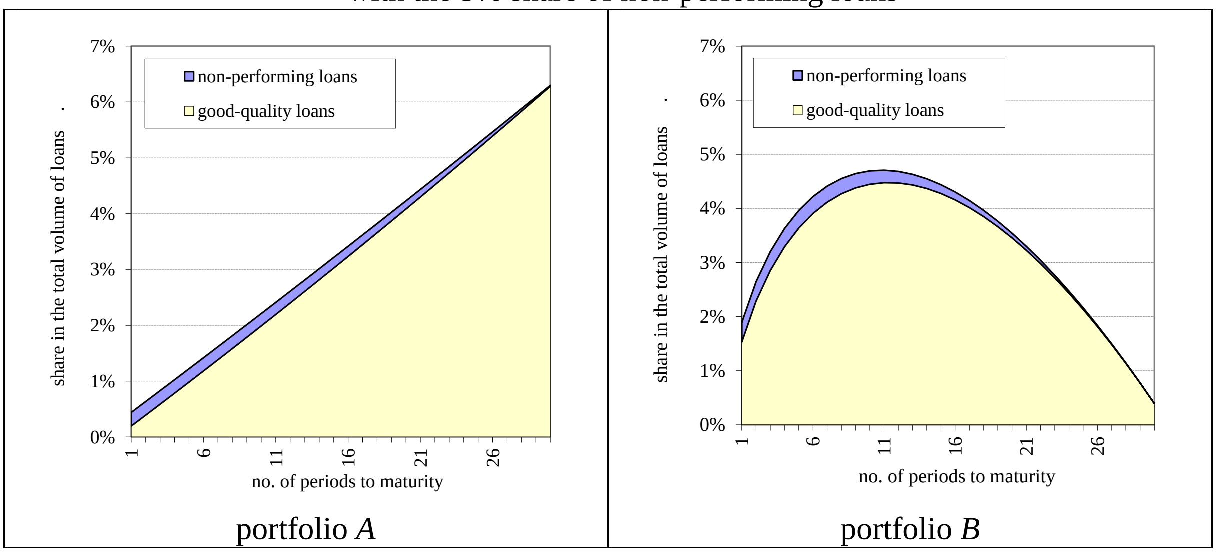
Typically, the values of good, bad, and total loan cohorts ($g_{i,j,t}$, $b_{i,j,t}$, and $x_{i,j,t}$) change in each period. However, it is possible to construct theoretical credit portfolios where the values of good and bad loans with different maturities will not change over time, given that the total amounts of loans S_t^G, S_t^B, and S_t^X remain constant and the probabilities $p_{i,j,t}$ and $q_{i,j,t}$ also do not change in time. We will term such stable-in-time quantities of credit as steady-state values of loans. The values of good and bad quality loans will usually tend to return to their steady-state if some shocks shift them away from it. Then, it will be possible to calculate a steady-state ratio of non-performing loans.

2.1 Two example portfolios

In this subsection we construct two example portfolios to analyze the performance of the NPL ratio during and after a possible credit boom. We consider two portfolios in the steady-state (cf. Figure 1). In the first portfolio (denoted portfolio *A*), all new loans are supplied with maturity of n periods, i.e. the maximum allowed maturity. One feature of this portfolio is the large share of loans with the longest maturities and a small share of loans with very short remaining maturities when the aggregate value of loans S_t^X remains constant in time (i.e. when the growth rate of the loan portfolio is zero). If we assume that the probability of default for each loan remains constant in time and across maturities, $q_{i,j,t} = \bar{q}$, then the share of non-performing loans will be low for longer maturities and high for short maturities.[3] This may be interpreted as the situation when good-quality loans with different maturities are equally vulnerable to default shocks. The ratio of nonperforming loans will not be the same for all maturities because all new loans are of good quality and older portfolios have a larger share of non-performing loans. However, the distribution of good-quality and bad-quality loans in the portfolio with respect to maturity will remain constant in time.

In case of portfolio *B*, we assume that the new loans at time t are equally distributed among different maturities from 1 to n periods. Under the condition that the aggregate value of loans S_t^X is constant in time, the quantities of loans with different maturities will also remain constant in time in a steady-state. Under the assumption of constant default probability $\bar{q}$, the quantities of short-term loans will generally be larger than the quantities of loans with longer remaining maturities, except from the loans with very short maturities (cf. Figure 1, right panel). The share of non-performing loans will also tend to be higher for shorter maturities than for longer ones.

Figure 1: Distribution of loans with different maturities in the portfolios A and B with the 5% share of non-performing loans



---

[3] Loans originating in different periods and with different maturities have usually different probabilities of default. However, we need the assumption of $q_{i,j,t} = \bar{q}$ to construct a hypothetical NPL ratio reacting solely to flows of loans in the portfolio and not to the external economic conditions or the financial standing of borrowers (see subsections 2.2 and 2.3 for details).

The two portfolios A and B represent rather typical cases. Credit portfolios tend to have a distribution similar to portfolio A in banks and financial systems which recently experienced a credit boom, where houses are relatively expensive (e.g. affecting housing loans) and interest rates are very low, or when specific long-term loans (e.g. investment loans) are considered. Portfolio B represents portfolios where both new short-term and long-term loans are equally popular, possibly due to macroeconomic conditions (e.g. high interest rates), wealth effects (less expensive consumption goods), or lending policies of banks. In fact, the parameter of maximum maturity n can be set small and represent only short-term loans, or it can be fixed large to represent both short and long-term loans.

2.2 Effects of a credit boom

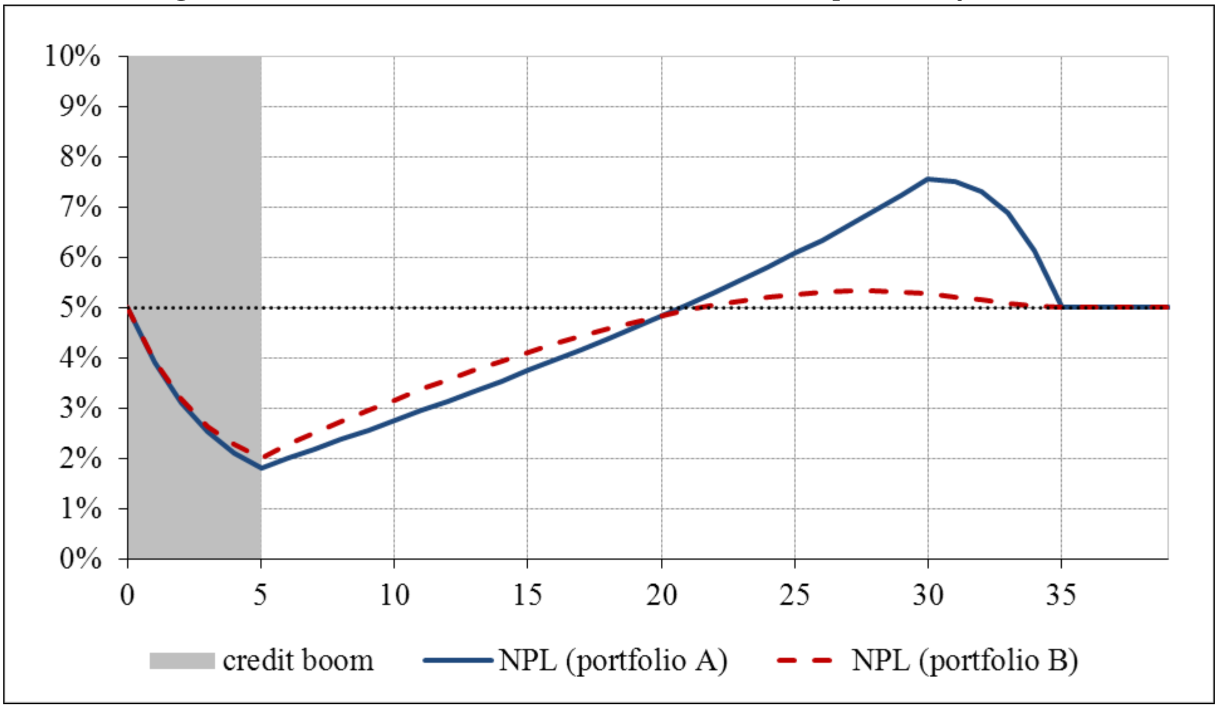
Now, a credit boom is introduced in the model and the ratio of non-performing loans is measured. We assume that the economic conditions for borrowers and the probability of default do not change in time. The maximum maturity for loans is set to 30 periods.

If the volume of credit remained constant in time, the ratio of nonperforming loans would be equal 5% and would also remain constant. However, during the boom the value of credit grows by 30% in the first 5 periods, then the growth rate changes to 0% in the periods from 6 to infinity.

We can observe the ratios of non-performing loans (NPL ratios) for the two predefined loan portfolios in Figure 2. In the first five periods of the credit boom, the NPL ratios decrease by more than a half. Both NPL ratios return to the pre-boom levels after the next 15 periods and reach their maximum values in the 27th (portfolio A) and in the 30th period (portfolio B), respectively. After 35 periods, the NPL ratios return to the pre-boom 5% level, because all loans originated during the boom have already matured. The explanation for the swing in the

NPL ratio is that the new and better-quality loans dominate the portfolios of banks during the credit boom, and older and worse-quality loans outweigh the new ones during the credit slow-down phase.

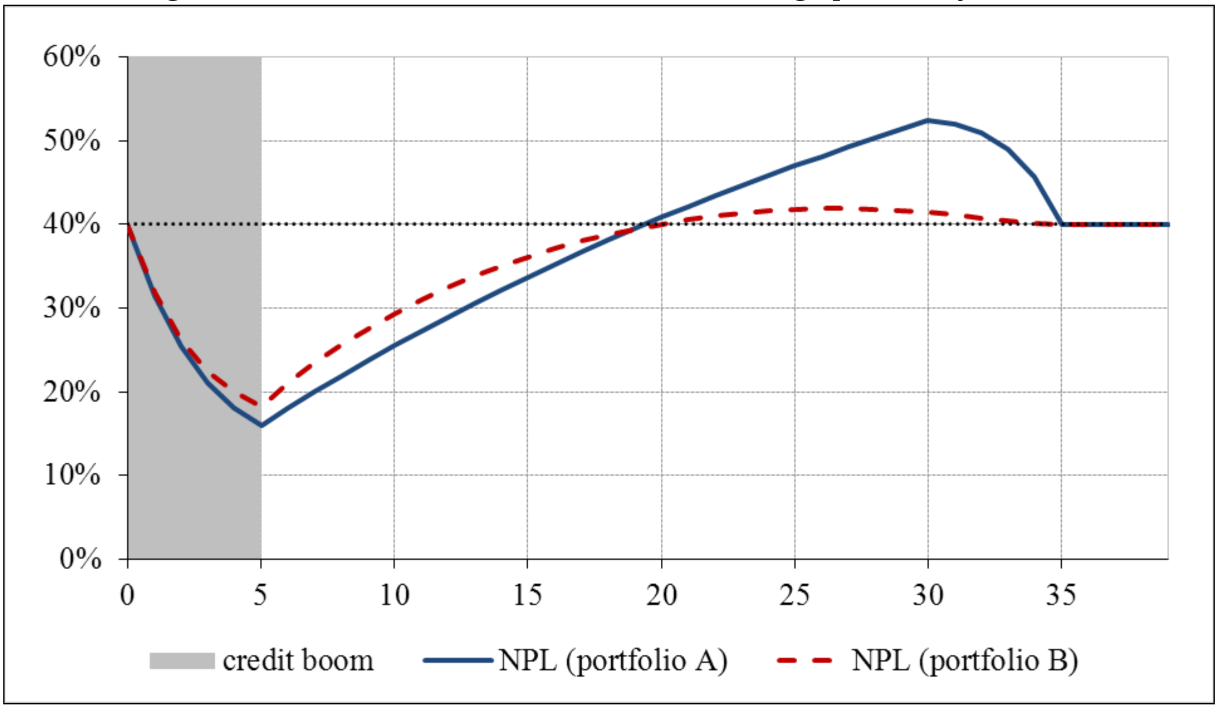
Figure 2: Ratios of non-performing loans in the portfolios A and B
during and after the credit boom – borrowers with a low probability of default



Note: The ratios of non-performing loans in the portfolios *A* and *B*, respectively.

Next, we show that the above results do not depend on the quality of loans in the portfolio or the probability of default $\bar{q}$. The ratios of non-performing loans for the loan portfolios *A* and *B* with high probabilities of default are presented in Figure 3. The probability of default $\bar{q}$ is calibrated in such a way that the ratio of non-performing loans equals 40% in the steady state. During the five-period credit boom, when the level of credit grows 30% in each period, the ratios of non-performing loans fall to less than a half of the initial 40% level. Again, the ratios return to the initial level after ca. 15 periods and grow further. The maximum level of non-performing loans is reached in the 25th (portfolio A) and 30th (portfolio B) period, respectively.

Figure 3: Ratios of non-performing loans in the portfolios A and B
during and after the credit boom – borrowers with a high probability of default.



Note: The ratios of non-performing loans in the portfolios A and B, respectively.

The annual credit growth rate of 30% during a credit boom may be considered rather low in comparison to recent growth rates for certain types of loans in many emerging markets in Europe or elsewhere. Nevertheless, this rate is large enough to reveal the important effects of booms on portfolios of loans, i.e. large swings in the NPL ratio. We also experimented with 20 percentage points higher growth rates during both boom and normal periods (50% and 20%, respectively) to account for countries with high inflation rates or rapid GDP growth, and the results were very similar.[4] We obtain qualitatively similar results also for the loan portfolios with very low and intermediate probabilities of default (where the corresponding NPL ratios equal 1% and 15%, respectively), and with shorter maturities (e.g. 5 periods/years).[5]

[4] We also provide computer programs which enable the user to simulate performance of the NPL ratio and distributions of loans in the portfolios under different scenarios. The GAUSS programs are available on the web page http://akson.sgh.waw.pl/~dserwa/art/npl.html.

[5] Results available upon request.

One conclusion from this exercise is that the quality of loan portfolios in many emerging banking sectors experiencing rapid credit growth may be significantly misjudged, when solely the NPL ratio is considered. The quality of loans seems to improve significantly during booms and the successive deterioration may simply indicate return to the long-run equilibrium. In the next section we propose a possible adjustment to the non-performing loan ratio that controls for changes in credit growth and fluctuations in the term structure of loans in bank portfolios.

3. Index adjusted for credit booms

It is clear from the above discussion that a more adequate measure of credit risk is needed in banking systems experiencing credit booms. In this section we discuss possible adjustments to the original ratio of non-performing loans, presented in formula (1). Our aim is to propose an adjustment that would not require excessive amount of information about the term structure of loan portfolios and that would be feasible to compute. The first two adjustments consist of manipulating the denominator of the NPL ratio and they turn out to be insufficient to correct the bias caused by the rapid credit growth.

The third adjustment employs a method to compute the hypothetical value of the NPL for the low and sustainable (e.g. zero percent) rate of credit growth. This measure appears to outperform other two proposed adjustments, but requires additional information about the loan portfolio.

3.1 Three possible adjusted NPL ratios

First, we consider a simple correction to the NPL ratio in which the denominator part of the formula (1) is assumed to remain constant during the boom and equal to its “pre-boom” level, $NPL(1)_t = S_t^B / S_{pre-boom}^X$. In this way, most of the new good-quality loans are not taken into account and the adjusted NPL ratio presents the (somewhat pessimistic) picture of the portfolio, as if there were no boom. One advantage of such an adjustment is that one only needs to know the rate of growth for the total amount of credit in the portfolio to compute the ratio. In the second adjustment, the denominator part of the formula (1) is lagged by one period, $NPL(2)_t = S_t^B / S_{t-1}^X$. In this way short-lived booms are expected to be controlled for, because the ratio uses lower values of total loans from the previous period and new loans also start to deteriorate typically with some delay.

Figure 4: The NPL ratio and the adjusted NPL ratios during a credit boom.

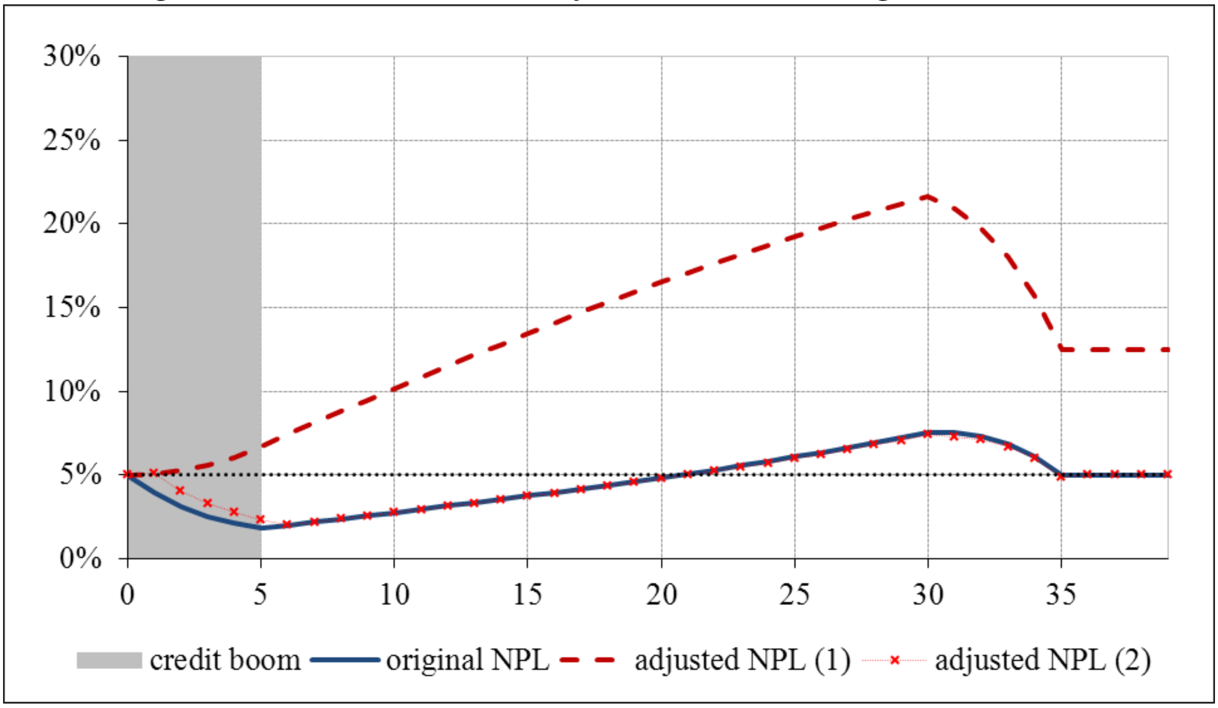


Figure 4 presents performance of these adjusted measures in comparison to the original NPL ratio under the same boom scenario as in the previous subsection. Since the idea of the adjusted ratio is to show the ratio of bad-quality loans close to its value (5% in this exercise) from the "no-credit-boom" hypothetical scenario, the adjusted ratio $NPL(1)_t$ compares favorably only during the first five or six periods (years) with the original ratio. It must be noted that this adjustment fails to mimic the "no-credit-boom" scenario after the first six years independently of whether the boom is continued or not. $NPL(1)_t$ grows to very high levels and significantly exceeds the desired 5% level in later periods.

The second adjustment $NPL(2)_t$ fails to correct the bias in the original NPL ratio already after the first two periods and it performs in a very similar way to the original NPL ratio in later periods. Moreover, both adjustments $NPL(1)_t$ and $NPL(2)_t$ do not control for the significant growth of non-performing loans after the boom period. They both increase between periods 5 and 30 while the desired level of the NPL ratio remains constant.

Therefore, we propose another correction of the non-performing loan ratio that takes the changing dynamics of credit into account. The idea rests on constructing a hypothetical portfolio where the growth rate of loans is set to some low sustainable level (e.g. zero percent) and the probabilities of default of loans are the same as in the original portfolio.[6] If the true loan portfolio behaves in line with our simple theoretical model presented in section 2, the adjusted $NPL(3)_t$ will fit exactly the 5% horizontal line in the exercise above. However, this third ratio requires much more information about the loan portfolio than the two former indices.

3.2 Constructing the NPL index robust to credit booms

The construction of the adjusted $NPL(3)_t$ is more demanding than that of the indices $NPL(1)_t$ and $NPL(2)_t$. First, we set the maturity structure of the loan portfolio for each analyzed period. In practice, we need to know the approximate term structure of new loans in each period and the initial term structure of all loans in the portfolio.

[6] Another alternative would be to consider the adjusted NPL ratio for the artificial portfolio whose growth is identical with the growth rate of the original loan portfolio, but the probabilities of default for each loan are fixed constant (e.g. equal to their initial values prior to the boom) in the sample. Comparing such an adjusted ratio with the original ratio would provide information on how the growth rate of loans (and not economic conditions) affected the original NPL ratio.

Second, we calibrate the "survival probabilities" of loans in the portfolio for each period to fit the values of the original NPL ratio and given the true growth rates of the loan portfolio.

Third, we assume that the growth rates of the portfolio equal some fixed low value, e.g. zero percent. We also set the starting value of the adjusted $NPL(3)_t$ to equal the original NPL ratio in the first period. Then, we use the "survival probabilities" computed in the second step and the assumed growth rate of loans to simulate the term structure of bad and good quality loans in the subsequent periods. Finally, using the simulated values of "bad" and "good" loans, we compute the NPL ratio for each period, i.e. the adjusted $NPL(3)_t$ ratio.

We provide more details on each of these construction steps below.

In the first step, an investigator sets the aggregate values of "good" and "bad" loans in the matrices $\mathbf{G}_t = \left[g_{i,j,t}\right]_{n\times n}$ and $\mathbf{B}_t = \left[b_{i,j,t}\right]_{n\times n}$ for each analyzed period t. Since the exact term structure of loans in the portfolio is usually not known to the investigator, (s)he can assume some initial term structure of loans for the first period, assume the term structure of new loans for the subsequent periods, and use the information about the growth rates of loans to simulate the term structure of loans in the subsequent periods.

In our investigations, we compute the steady-state values of all loans in the portfolio by repeating the recursive calculations of formulas (3) and (4) for the whole portfolio a large number of times (e.g. 300). The term structure of loans in the first period is approximated in this way.

In the second step, one needs to find the "survival" probabilities $p_{i,j,t}$ for the loans in the portfolio, so that the ratio of "bad-quality" loans to total loans matches exactly the observed NPL ratio of the portfolio. For simplicity, we again assume that all loans have the same survival probabilities, i.e. $p_{i,j,t} = p_t$ for all i and j. Since the ratio of non-performing loans changes in time, the probability p_t also needs to be calculated separately for each period. Finding p_t is not trivial, because its value affects the term structures of "good" and "bad-quality" loans (bad loans do not pay interest) in equation (3). However, one may use some standard search algorithms like the "golden section search" to find the optimal survival probability for each period.[7]

In the third step, the investigator employs the initial term structure of loans calculated in the first step and the "survival" probabilities calculated in the second step. The investigator sets the constant ("sustainable") growth rate of loans for the subsequent periods (as if there were no boom) and uses the recursive formulas (3) and (4) to calculate the hypothetical term structures of "good" and "bad" loans in these periods. Finally, (s)he uses (1) to obtain the adjusted $NPL(3)_t$ ratio.

4. Example from the Polish banking sector

In this section we analyze the country aggregate of nonperforming and total housing loans in commercial banks in Poland. The housing loans in Poland were growing at the relatively high rate in recent years and this rate of growth was significantly affecting the non-performing loan ratio. The annual growth rate of housing loans increased from 20% in 2004 to more than 60% at the end of 2008.[8] At the same time the NPL ratio (called "impaired loan ratio" in the local terminology) decreased from 3.2% in the last quarter of 2004 to 1% at the end of 2008. The global financial crisis caused economic slowdown in Poland and the new mortgages also decelerated. The growth rate of housing loans was circulating around 20% between 2009 and 2011. The ratio of non-performing loans was steadily increasing in that period up to the level of 2.4% in December 2011.

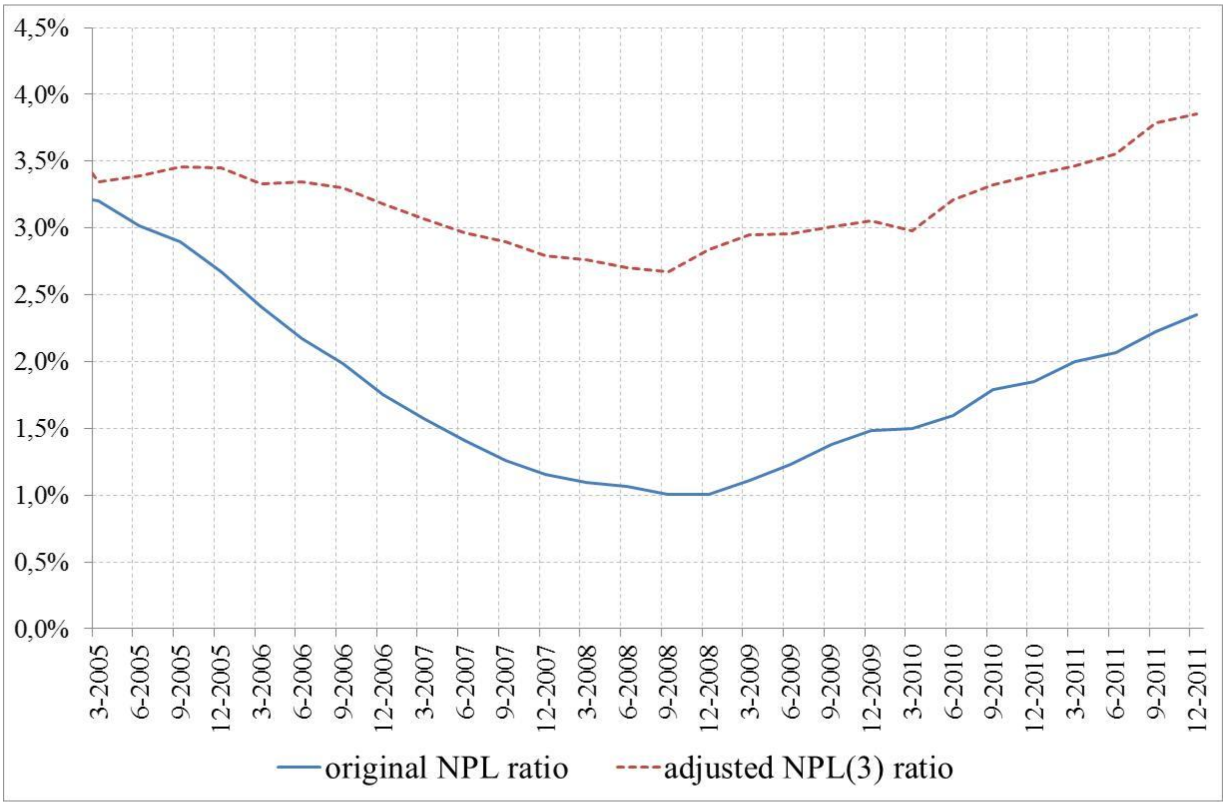
We use the quarterly data from the cyclical publication of the National Bank of Poland (2012, Box 6, p. 64-67). Our sample starts in the fourth quarter of 2004 and ends in the last

[7] We provide the GAUSS code to perform the search of the optimal survival probability for each period.
[8] The annual rate of growth adjusted for exchange rate changes exceeded 60% already in 2007.

quarter of 2011.[9] We use an index of the ”impaired loan ratio for housing loans” (i.e. non-performing housing loan ratio) and the quarterly growth rate of housing loans in the Polish household sector.

We assumed the maximum maturity of new housing loans to equal 30 years in the whole sample. We also set the distribution of new loans to be triangular at the beginning of the sample (in the last quarter of 2004), with short maturities assigned to most loans and longer maturities assigned to fewer loans. However, starting from the year 2005 most new loans were assigned longer maturities and only few loans had short maturities. We also performed the robustness check to assess how our assumptions affect the values of the adjusted $NPL(3)_t$ ratio.

Figure 5: Original “impaired loan ratio” for housing loans and the adjusted NPL ratio in Poland



[9] In the year 2003 and earlier several important regulatory changes were implemented, which had a significant impact on a fall of the impaired loan ratio. Therefore, we decided to use only the time series starting at the end of 2004.

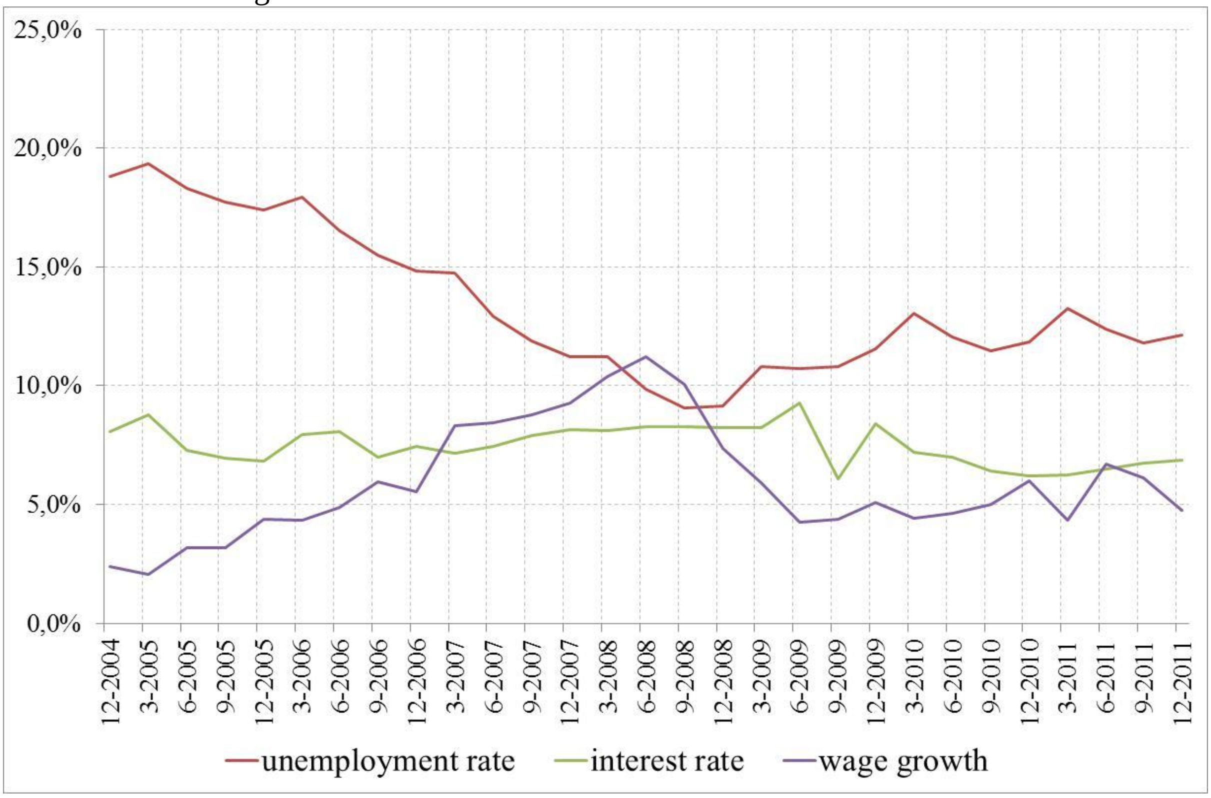
In line with the algorithm described in Section 3, we set the “sustainable” rate of quarterly growth of loans to equal 2%. This rate of growth affects the level of the NPL ratio, as the higher sustainable growth rates decrease the adjusted NPL ratio and the lower growth rates increase the adjusted NPL ratio. Since the “sustainable” rate of growth of loans may differ between countries, sectors or types of loans, this parameter should be set carefully when the quality of several different loan portfolios is compared. However, in our example the main findings are robust to any reasonable rate of sustainable growth.

Figure 5 presents the adjusted NPL ratio in the period between 2005 and 2011. Since the sustainable level of credit growth is assumed to be much lower than the original rate of growth of housing loans, the adjusted NPL ratio is much higher than the original NPL ratio. The new NPL ratio declines in the years 2006, 2007 and in the three quarters of 2008 and then begins to grow in a similar way to the original NPL ratio.

The main result from this analysis is that most of the (2.2 percentage points) decrease in the original NPL ratio in the years 2005-2008 comes from the credit boom and the effect of improving economic conditions is less than a half (and less than 1 percentage point). The difference between the original NPL ratio and the simulated ratio is 1.5 percentage points at the end of the sample. This result is in line with the parallel analysis of the NPL ratio (employing a similar algorithm based on our methodology) described in National Bank of Poland (2012, Box 6, p. 64-67).

It is interesting to observe how the changing NPL ratios match the economic conditions evolving in Poland in the analyzed period. Figure 6 presents three variables representing economic situation of the borrowers in Poland. It is clear that the unemployment rate, the growth rate of wages, and the lending interest rates are all important factors affecting the quality of housing loans. In our sample, the NPL ratios change in line with the unemployment rate and in the opposite direction to the growth rate of wages, while the interest rate remains relatively stable in the whole sample. Importantly, the turning point (and the maximum) for the growth of wages is June 2008 and the unemployment rate reaches its minimum in September 2008. The adjusted NPL ratio reacts immediately to the changing economic conditions and starts to increase in fourth quarter of 2008, while the original NPL ratio shows a delayed response as it starts to grow in the first quarter of 2009.

Figure 6: Economic conditions for the borrowers in Poland

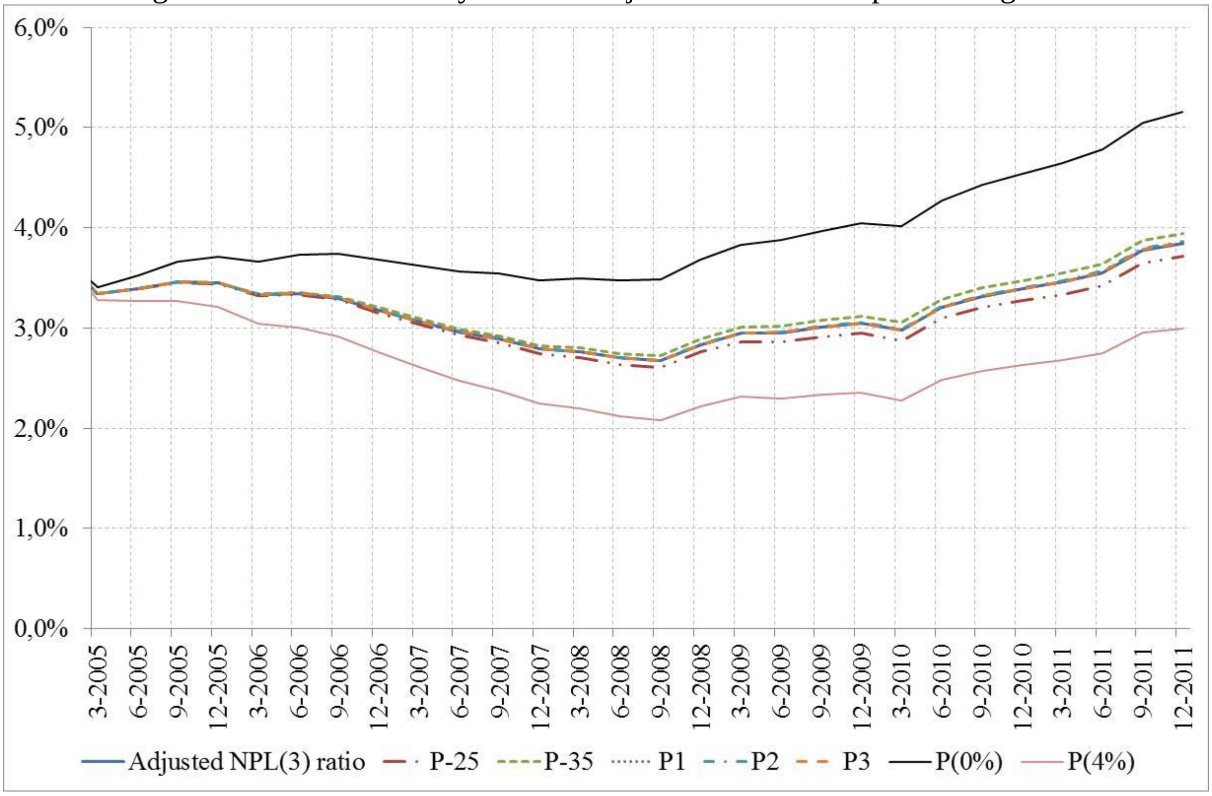


Note: All data come from the Ecowin database. The "interest rate" is the rate of interest for new housing loans indexed in the local currency.

4.1 Robustness check

The adjusted $NPL(3)_t$ ratio is by definition robust to credit booms when the original loan portfolio behaves in line with our theoretical model. However, this ratio depends on the number of parameters whose exact values are usually not known by the investigator. For example, the investigator often needs to approximate the term structure of loans in the portfolio for each period. Banks may modify their policies regarding maturities of new supplied loans and the approximation should take this fact into account.

Figure 7: Robustness analysis of the adjusted ratio of non-performing loans



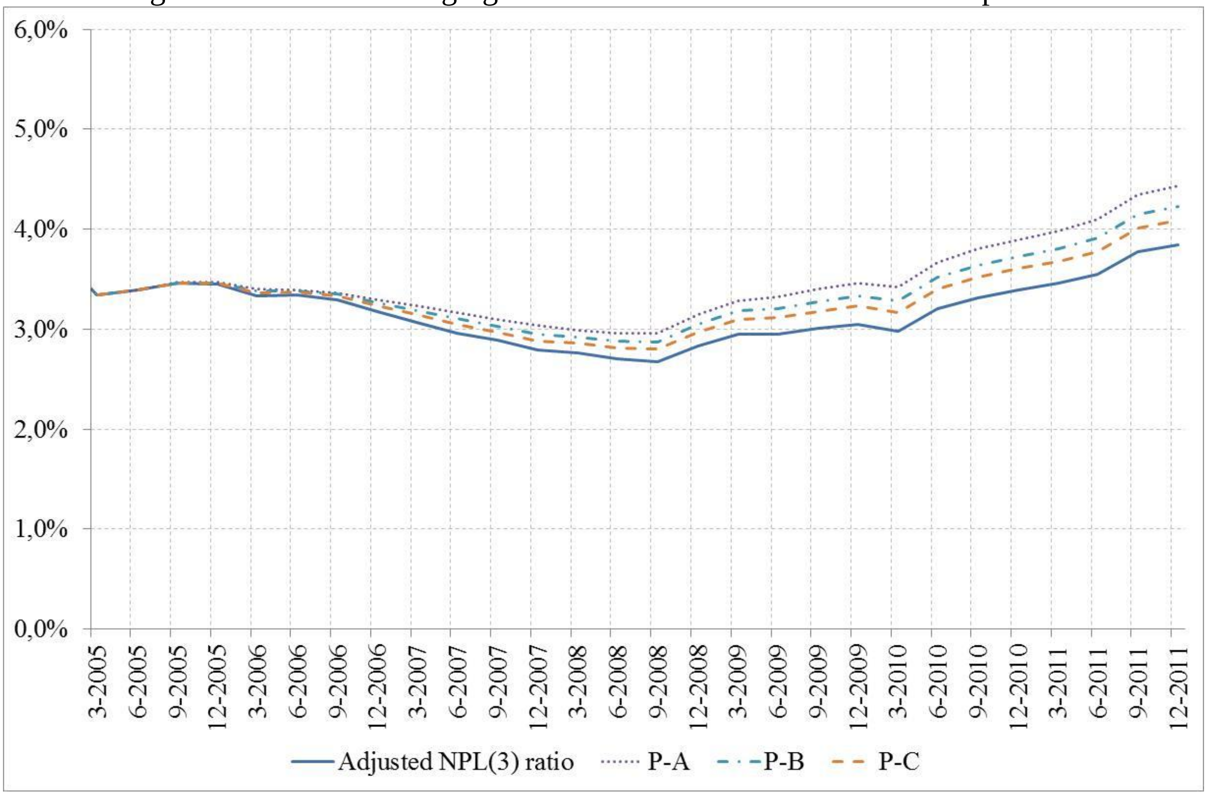
Note: "P-25" ("P-35") is the adjusted NPL ratio when the 25-year (35-year) maximum maturity is assumed. "P1" ("P2" and "P3", respectively) is the adjusted index when all new loans have the maximum maturity (most new loans are with the shortest maturity, and all new loans are uniformly distributed with respect to their maturity, respectively). "P(0%)" ("P(4%)") denotes the adjusted NPL ratio with the 0% (4%) "sustainable" growth rate of loans.

We perform a number of simulations to check how robust the adjusted $NPL(3)_t$ ratio is to different assumptions about the loan portfolio. First, we check how the new NPL index depends on the term structure of new loans. We present developments of the adjusted $NPL(3)_t$ ratio when the maximum maturity is set to 25 and 35 years, respectively. Second, we consider different distributions of new loans in the portfolio: (1) all new loans to have a maximum maturity, (2) the distribution of new loans entering the portfolio is triangular with respect to the remaining time to maturity, i.e. most loans are supplied with the shortest one-period maturity and only few loans have the longest maturity (e.g. 30-year), (3) the uniform (rectangular) distribution of new loans with respect to their maturity. In all cases we leave the distribution of the portfolio of loans at the beginning of sample the same as in the main calculation of the adjusted index. Third, we analyze changes in the adjusted $NPL(3)_t$ ratio when the "sustainable" rate of growth is switched to 0% or 4%.

Figure 7 presents the robustness check for the analysis described above. Our simulations show that the adjusted NPL ratio is robust to different assumptions about the structure of the loan portfolio, i.e. the distributions of new loans and the maximum maturity of loans. Obviously, the rate of the "sustainable" growth affects the level of the adjusted NPL ratio, but this parameter needs to be set by the investigator according to her preferences. For example, setting the rate to 0% (or some other number) for all series of original NPL ratios (e.g. from different banks) allows for comparison of all adjusted NPL ratios. Importantly, the shape of the adjusted index is very similar for 0%, 2% and 4% growth rates. In all cases the turning point for the non-performing loans is September 2008. After this date the ratios increase gradually due to worsening economic conditions.

Slightly worse performance of the adjusted NPL ratio can be observed in Figure 8, where different distributions of the loan portfolios with respect to maturities of loans at the beginning of the sample are examined. In the first case (P-A), the portfolio is constructed by assuming that all new loans have the maximum allowed maturity and the portfolio is in the steady-state (the same as Portfolio A discussed in subsection 2.1). In the second case (P-B), the distribution of new loans is rectangular, most new loans have longer maturities, and the portfolio P-B is in the steady-state at the beginning of the sample. In the third case (P-C), the distribution of new loans is uniform and the portfolio is in the steady state at the beginning of the sample. All three cases simply implicate different distributions of loans with respect to their maturities at the beginning of the sample. The distribution of new loans in the subsequent periods of the sample remain the same as in the main calculation of the adjusted NPL ratio. The figure shows that the adjusted $NPL(3)_t$ ratio depends to some extent on the initial distribution of loans, as the indices P-A, P-B, P-C differ from the adjusted NPL(3) ratio up to 0.5 percentage points toward the end of the sample. One way to minimize the bias is to use the P-C index, whose values stay in the middle of the range of the investigated indices. In general, the bias does not prohibit the use of the adjusted NPL(3) ratio even when the distribution of loans in the portfolio is unknown.

Figure 8: Effects of changing the initial distribution of loans in the portfolio



Note: "P-A" ("P-B" and "P-C", respectively) is the adjusted NPL ratio for the portfolio where all new loans have with the maximum maturity in the steady-state at the beginning of the sample (most new loans are with the shortest maturity in the steady-state at the beginning of the sample, and all new loans are uniformly distributed with respect to their maturity in the steady-state at the beginning of the sample, respectively).

5. Conclusions

In this study we find that the effect of a rapid credit growth on the ratio of nonperforming loans to the total volume of loans is significant and can be observed several years after the credit boom. This fact complicates the use of the standard NPL ratio in time-series and panel-data analyses of financial sectors.

The simple adjustment, consisting of reducing the total volume of loans by subtracting the new loans, can only be useful during the first few periods after the start of the boom. A more complex method proposed in this paper requires information on the maturity structure of good and bad quality loans. This new method enables constructing the adjusted NPL ratio that is comparable in time, across banks, markets, and financial systems.

We present an example of using the adjusted NPL ratio for an aggregated portfolio of housing loans in Poland. The results suggest that the new ratio points to a larger credit risk than the original ratio. The new adjusted index is also robust to different model specifications including the term structure of loans and the maximum maturity of loans.

We envisage many potential applications of the new adjusted index of loan quality. First, the algorithm to build artificial loan portfolios may be used to forecast the future loan quality (e.g. when the economic conditions are approximated by the specific values of the "survival" probabilities of loans). The typical purpose is to perform macro or microprudential stress-tests or analogous simulations.

Second, impulse-response analyses taking into account the credit portfolio quality (e.g. in the new generation of dynamic general equilibrium models) could constitute a prospective application of our method. Moreover, taking into account the enriched maturity structure of loans allows for new forms of dynamics of credit around the equilibrium.

Third, the ability of our new measure to identify turning points in the performance of the lending market earlier than the traditional NPL ratio warrants its use as an early warning tool against financial instability.

From the supervisory policy perspective, the non-performing loan ratio is a highly pro-cyclical measure of credit quality. The adjustment employing the constructed theoretical portfolio controls for this fact and poses a new possible tool to assess the changing quality of loans over business cycles (e.g., Gordy and Howells, 2006). The adjusted ratio of non-performing loans may also be used to compare the quality of loans in different times, in different portfolios, institutions, or banking systems.

References

Aman H., Miyazaki H. (2009) Valuation effects of new equity issues by banks: evidence from Japan, Applied Financial Economics, 19, 635—645.

Chatterjee S., Corbae D., Nakajima M., Ríos-Rull J. (2007) A Quantitative Theory of Unsecured Consumer Credit with Risk of Default, Econometrica, 75, 1525-1589.

Cihák M., Schaeck K. (2010) How well do aggregate prudential ratios identify banking system problems?, Journal of Financial Stability, 6, 130-144.

Drehmann M. Sorensen S., Stringa M. (2010) The integrated impact of credit and interest rate risk on banks: A dynamic framework and stress testing application, Journal of Banking & Finance, 34, 713-729.

Festić M., Repina S., Kavkler A. (2009) The Up-Coming Crisis and the Banking Sector in the Baltic States, Swiss Journal of Economics and Statistics, 145, 269-291.

Gordy M., Howells B. (2006) Procyclicality in Basel II: Can we treat the disease without killing the patient?, Journal of Financial Intermediation, 15, 395-417.

Hasan I., Wall L. (2004) Determinants of the Loan Loss Allowance: Some Cross-Country Comparisons, The Financial Review, 39, 129-152.

Heitfield E., Sabarwal T. (2004) What Drives Default and Prepayment on Subprime Auto Loans?, The Journal of Real Estate Finance and Economics, 29, 457-477.

Jin J., Kanagaretnam K., Lobo G. (2011) Ability of accounting and audit quality variables to predict bank failure during the financial crisis, Journal of Banking & Finance, 35, 2811-2819.

Lízal L., Svejnar J. (2002) Investment, Credit Rationing, and the Soft Budget Constraint: Evidence from Czech Panel Data, The Review of Economics and Statistics, 84, 353-370.

Meeker L., Gray L. (1987) A note on Non-Performing Loans as an indicator of asset quality, Journal of Banking and Finance, 11, 161-168.

Mendoza E., Terrones M. (2008) An anatomy of credit booms: evidence from macro aggregates and micro data, NBER Working Paper Series, 14049.

National Bank of Poland (2012) Financial Stability Report, July 2012.

Podpiera R. (2006) Does Compliance with Basel Core Principles Bring Any Measurable Benefits? IMF Staff Papers, 53, 306-326.

Tornell A., Westermann F. (2002) Bomm-bust cycles in middle income countries: facts and explanation, NBER Working Paper Series, 9219.

Whalen G. (2010) Are Early Warning Models Still Useful Tools for Bank Supervisors?, OCC Working Paper Series, 2010-3, Office of the Comptroller of the Currency, Washington DC.