

Measuring Non-Performing Loans During (and After) Credit Booms

Dobromił Serwa*

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Abstract

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

Keywords: non-performing loan ratio, credit boom, housing loans

JEL Classification: G21, G32, C63

*National Bank of Poland and Warsaw School of Economics; e-mail: Dobromil.Serwa@nbp.pl

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1 Introduction

The ratio of non-performing loans to total loans, the NPL ratio, is a standard and widely used statistic to measure the financial performance of a banking institution. This ratio 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 the efficiency of banking sectors (e.g., Lízal and Svejnar, 2002; Hasan and Wall, 2004; Podpiera, 2006), to determine bank equity (e.g., Aman and Miyazaki, 2009), to predict future bank failures (e.g., Jin, Kanagaretnam, and Lobo, 2011), and to construct early warning models for financial instability (e.g., Cihák and Schaeck, 2010; Whalen, 2010).

Supervisors, auditors, and economists using the NPL ratio face at least two obstacles. First, comparing this 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 the loans supplied by banks affects the NPL ratio since 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 inadvertently from time to time 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 flow of new loans to the portfolio, maturing of old loans, banks selling and buying credit tranches, and other external effects.

In this study we evaluate the distortion of the NPL ratio caused by the rapid credit growth such as the growth rate of credit in the loan portfolio that is higher than the sustainable growth rate for the analyzed banking institution or the financial system (e.g., Coricelli, Mucci, and Revoltella, 2006; Serwa, 2013). We show that the ‘bias’ caused by the prolonged credit boom may be significant; this fact alone calls into question the use of the NPL ratio in many countries with rapidly developing banking sectors. The NPL ratio observed during a boom can be as many as two times less than the ratio of an analogous portfolio in a stable period. After the end of the boom the quality of the loans decreases dramatically despite stable economic conditions and the NPL ratio increases beyond the original level from the beginning of the boom.

Next, we discuss three possible adjustments to the NPL ratio. Two simple adjustments are valid only for very short periods; the third adjustment performs better in the long term. Based on the theoretical model, the latter adjusted NPL ratio can be used to measure the quality of loans during extended credit booms. In such cases the adjustment can simulate future NPL ratio developments and compare the credit quality ratios across single portfolios, banks, or aggregated loans within different financial systems. We provide an example of this adjustment of the NPL ratio in the aggregate portfolio of housing loans in banks in Poland (cf., Głogowski, 2008; Marzec, 2010; Skała, 2013; and citations therein for econometric models of non-performing loans and loan losses within the Polish banking sector).

The aim of this study is to present the procedures for adjusting the NPL ratio in such a way that the adjusted ratio will be independent of the changing rate of credit growth.

Our new adjusted NPL ratio informs economists and analysts about the quality of loan portfolios with a higher precision than the standard NPL ratio. Moreover, the new adjusted ratio mirrors more closely the frequency of delinquencies in loan portfolios than the original ratio. Potential application of our adjusting procedure includes macroeconomic stress tests, impulse-response analyses, early warning models of financial instability, and comparisons of NPL ratios in different credit institutions, banking systems, or at 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 a practical example of how these measures can be used in the real banking sector. The final section provides conclusions.

2 Simple model of non-performing loans

We based our simulations on a highly stylized model of an aggregated loan portfolio. In this case each loan exists in a number of periods and can default with some exogenous probability at any given time. Similar and much more complex models can take into account the maturity structure of banking assets and 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 the 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 the banking sector. Nevertheless, none of these studies analyze the effect of a credit boom on the ratio of non-performing loans.

This current approach allows us to assess the effect of a credit boom on the quality of loans. To the best of our knowledge no earlier study has 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. Finally, let $\mathbf{B}_t = [b_{i,j,t}]_{n \times n}$ be the matrix of 'bad-quality' (non-performing) loan cohorts.

For each i and j the total volume of loans consists of both 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 the 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 $S_t^X = \sum_{i=0}^{n-1} \sum_{j=1}^n x_{i,j,t}$).

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

$$NPL_t = \frac{S_t^B}{S_t^X}. \quad (1)$$

In the next period $t + 1$ (e.g., the 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 removed 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. We assume that these good-quality loans are paid back at equal rates each period and the bad-quality loans are not paid back until their maturity. (As an extreme case we also construct a model where all loans are paid back only at their maturity. The main assumption of NPL ratio bias during a credit boom becomes even more pronounced in this case.)

The recursive formula for the value of loans in each period t takes the following form:

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

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 . 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 all loans.

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 of each loan in the portfolio (i.e., the probability of remaining a good-quality loan in period t by the good-quality loan observed at time $t - 1$). The recursive formula for the value of good-quality loans at time t is given as follows:

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

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 as follows:

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

We assume that the probability that non-performing loans will at some point 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 within 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 $q_{i,j,t}$ do not change with 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 shock shifts them away from this. At this point it will be possible to calculate a steady-state ratio for 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 a maturity of n periods (i.e., the maximum allowed maturity). One feature of this portfolio is a 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.

Loans originating at different periods and with different maturities usually have different probabilities of default. However, we need the assumption of a constant probability of default to construct a hypothetical NPL ratio reacting solely to the flow 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). 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 whereas 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.

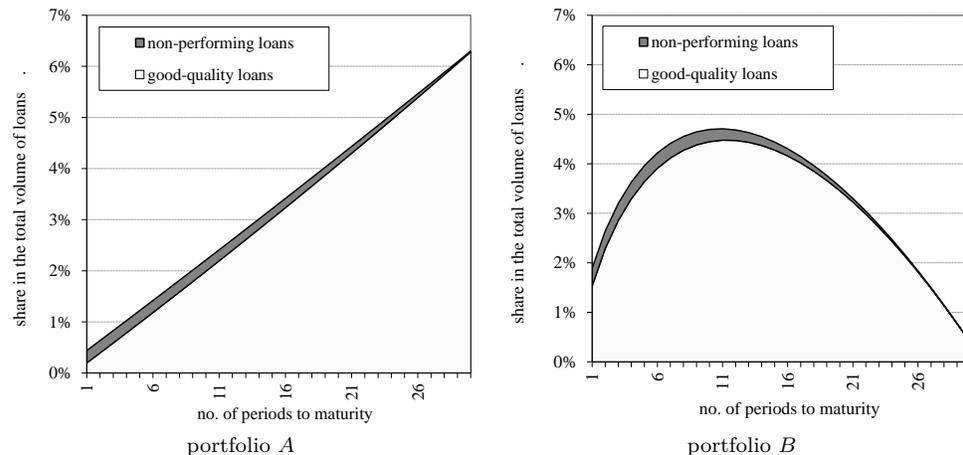
Since the derivation of exact values of performing and non-performing loans in portfolio *A* (i.e., $g_{i,j,t}$, $b_{i,j,t}$, and $x_{i,j,t}$ defined above) is rather complicated, we simulate all these values using the recursive formulas (2), (3) and (4) in the portfolio where all new loans have the maturity n , the probability $q_{i,j,t}$ always equals \bar{q} , and the growth rate of the total volume of loans is set to zero (i.e., the value of loans entering the portfolio equals the value of loans leaving the portfolio). When we simulate recursively the values of $g_{i,j,t}$, $b_{i,j,t}$, and $x_{i,j,t}$ over a large period of time (i.e., when $t \rightarrow \infty$) the

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values of performing and non-performing loans converge to their steady state values as observed in Figure 1 (left panel).

In the case of portfolio B , we assume that the new loans at time t are equally distributed amongst 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 at the steady state. The steady state values of loans in portfolio B have also been recursively simulated using a procedure analogous to that described above for portfolio A with the exception that the new loans have been equally distributed amongst different maturities from 1 to n periods. Under the assumption of a constant default probability \bar{q} , the quantities of short-term loans are generally larger than the quantities of loans with longer remaining maturities with the exception of 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 portfolios A and B with a 5% share of non-performing loans



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 that have recently experienced a credit boom, where housing is relatively expensive (e.g., affecting housing loans), 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 the lending policies of the bank. In fact, the parameter of

maximum maturity n can be set small to represent only short-term loans or it can be set large to represent both short and long-term loans.

2.2 Effects of a credit boom

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

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

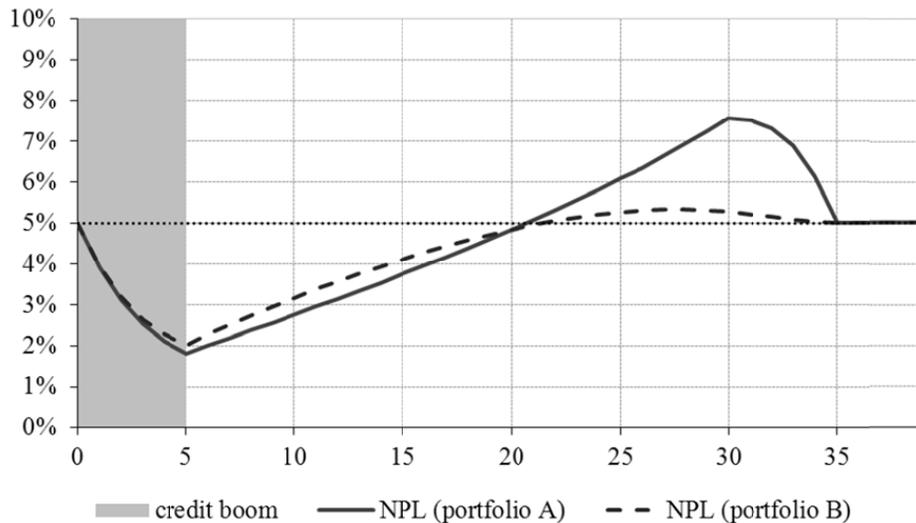
We can observe the ratios of non-performing loans (NPL ratios) for the two predefined loan portfolios in Figure 2. The NPL ratios decrease by more than a half in the first five periods of the credit boom. Both the NPL ratios return to pre-boom levels after the next 15 periods and reach their maximum values in the 27th (portfolio *A*) and 30th period (portfolio *B*), respectively. The NPL ratios return to their pre-boom level of 5% after 35 periods since all loans originated during the boom have now 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 whereas older and lower quality loans outweigh new ones during the phase of a credit slow down.

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 ratio of non-performing loans for loan portfolios *A* and *B* with high probabilities of default is 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 a five-period credit boom where the level of credit increases by 30% in each period, the ratios of non-performing loans fall to less than a half of the initial level (i.e., half of 40%). Again, the ratios return to the initial level after 15 periods. The maximum level of non-performing loans is reached in the 25th (portfolio *A*) and 30th (portfolio *B*) periods, 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 within 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 growth rates that were 20 percentage points greater during both boom and normal periods (50% and 20%, respectively) to account for countries with high inflation rates or rapid GDP growth. In such cases and the results were very similar. We obtain qualitatively similar results also for 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 (results are available upon request). We also provide computer programs that enable the user to simulate the performance of the NPL ratio

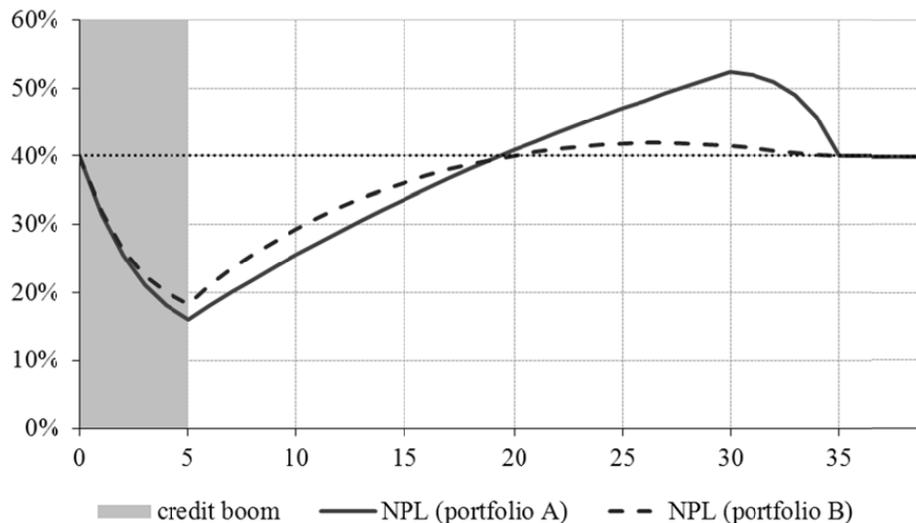
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Figure 2: Ratios of non-performing loans in portfolios A and B during and after the credit boom – borrowers with a low probability of default



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

Figure 3: Ratios of non-performing loans in 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 portfolios A and B, respectively.

and distributions of loans in the portfolios under different scenarios. These GAUSS programs are available at the following URL: <http://akson.sgh.waw.pl/~dserwa/art/npl.html>.

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 only the NPL ratio is considered. The quality of loans seems to improve significantly during booms; successive deterioration may simply indicate a return to the long-run equilibrium. In this 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 does 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 for the most part prove to be insufficient for correcting the bias caused by a rapid credit growth.

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

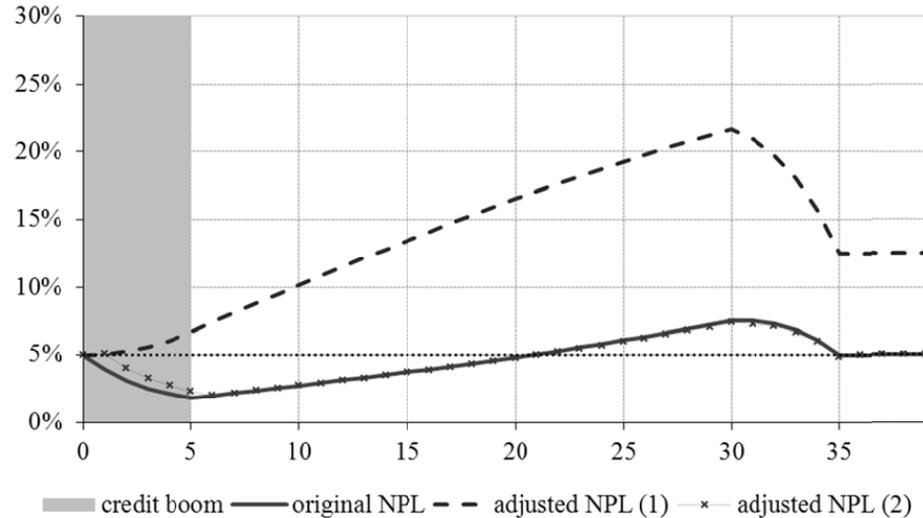
3.1 Three possible adjusted NPL ratios

First, we consider a simple correction to the NPL ratio where the denominator of formula (1) is assumed to remain constant during the boom and is thus 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 a somewhat pessimistic picture of the portfolio, almost as if there were no boom. One advantage of such an adjustment is that one only needs to know the rate of growth of the total amount of credit in the portfolio to compute the ratio. The second adjustment also affects the denominator of formula (1) and causes it to be lagged by one period, $NPL(2)_t = S_t^B / S_{t-1}^X$. In this way there is greater control exercised over short-lived booms since this ratio uses lower values of total loans from the previous period and new loans begin to deteriorate with some delay.

Figure 4 presents the 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 an adjusted ratio is one that represents the ratio of bad-quality loans

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



close to its original value (5% in this exercise) in 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 should be noted that this adjustment fails to mimic the 'no-credit-boom' scenario after the first six years independently of whether the boom continues or not. $NPL(1)_t$ increases 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 of 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 a boom period. Each adjustment increases between periods 5 and 30 while the desired level of the NPL ratio remains constant.

Therefore, we propose a third correction for the non-performing loan ratio that takes into account the changing dynamics of credit. This 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 probability of default is the same as in the original portfolio. 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; however, the probability of default for each of these loans is fixed and constant in the sample (e.g., equal to their initial values prior to the boom). Comparing such an adjusted ratio with the original ratio would provide information on how the growth rate of loans (and not the economic conditions) affected the original NPL ratio.

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 with 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 must set the maturity structure of the loan portfolio for each analyzed period. In practice we must know the approximate term structure of all new loans in each period and the initial term structure of all loans in the portfolio. Second, we calibrate the 'survival probability' of loans in the portfolio for each period to fit the values of the original NPL ratio, given the true growth rates of the loan portfolio.

Third, we assume that the growth rates of the portfolio are 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 of 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 $\mathbf{G}_t = [g_{i,j,t}]_{n \times n}$ and $\mathbf{B}_t = [b_{i,j,t}]_{n \times n}$ 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.

For the purposes of 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 determine 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 once 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 with time, the probability p_t must also be calculated separately for each period. Finding p_t is not trivial since 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 determine the optimal survival probability for each period (we provide the GAUSS code to perform the search of the optimal survival

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probability for each period).

In the third step the investigator uses 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's aggregate of nonperforming and total housing loans held at commercial banks in Poland. Housing loans in Poland were growing at a 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. (The annual rate of growth adjusted for exchange rate changes exceeded 60% already in 2007.) At the same time the NPL ratio (called the '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 an economic slowdown in Poland and the instance of 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 quarterly data from the cyclical publication of the National Bank of Poland (2012, Box 6, p. 64-67) for our simulation. Our sample begins with the fourth quarter of 2004 and ends with the fourth quarter of 2011. Several important regulatory changes were implemented in 2003 and earlier that had a significant impact on the determination of the impaired loan ratio. In December 2003 the issue of writing off uncollectible claims without the necessity of surrender was regulated. In line with this regulation banks began to write off old volumes of loss loans. Additionally, new regulations concerning the classification of credit exposure came into force in January 2004. Delinquency periods with regard to the payment of principal or interest, which constitutes a criterion for the classification of claims, have been changed (National Bank of Poland, 2004, p. 38 and 40). This regulation could potentially affect the survival probabilities of loans in our analysis and therefore we decided to use only the time series beginning at the end of 2004.

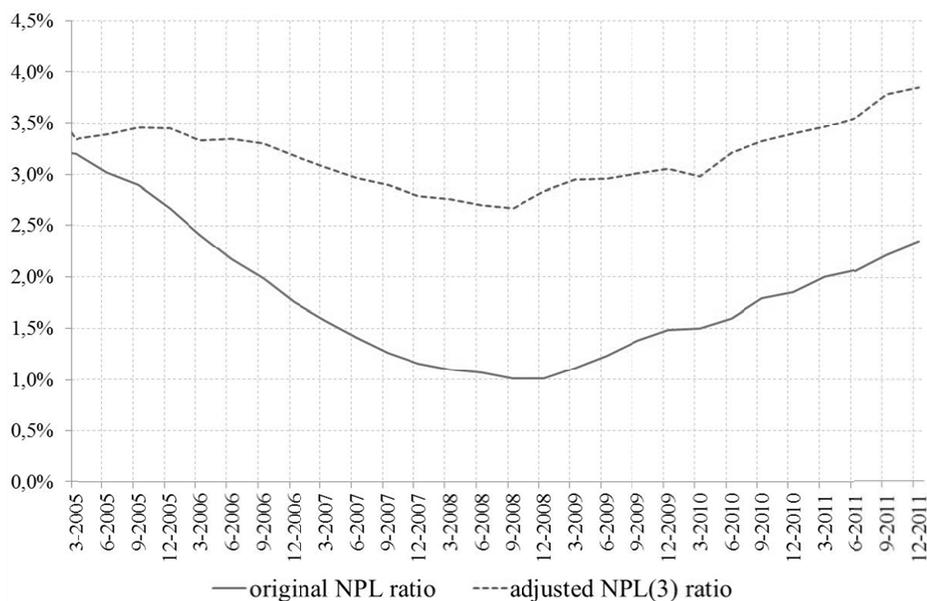
We use an index of the 'impaired loan ratio for housing loans' (i.e., non-performing housing loan ratio) and the quarterly growth rate of housing loans in the Polish household sector. In line with the official classification we define non-performing loans as those with identified impairment or loans classified to substandard, doubtful, and loss loans according to Polish Accounting Standards.

It should be noted that some banks in Poland have been forcing defaulted borrowers to convert their foreign exchange denominated loans (FX loans, hereafter) into Polish

złoty (local currency) denominated loans. In this way the NPL ratio for FX loans became lower than the NPL ratio for local currency loans in our sample. If we were considering only the FX loans or only the local currency loans and banks subsequently changed their policies toward defaulted FX loans in the sample our results could be biased. Nevertheless, we analyze the portfolio of both FX and local currency loans in our investigation and therefore the ratio of non-performing loans is not significantly affected by currency conversions in the portfolio.

We assume that the maximum maturity of new housing loans is 30 years for the whole sample. We also set the distribution of new loans to be triangular at the beginning of the sample (i.e., in the last quarter of 2004), with short maturities assigned to most loans and longer maturities assigned to fewer loans. However, in 2005 and onward most new loans were assigned longer maturities and only few loans had short maturities. We also performed a 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 within Poland



In line with the algorithm described in Section 3, we set the 'sustainable' rate of quarterly growth of loans at 2%. This rate of growth affects the level of the NPL ratio, as higher sustainable growth rates decrease the adjusted NPL ratio and lower growth rates increase the adjusted NPL ratio. Since the 'sustainable' rate of growth for loans may differ between countries, sectors, or even types of loans, this parameter should be

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set carefully when the quality of several different loan portfolios is compared. However, the main findings of our sample are robust for any reasonable rate of sustainable growth.

Figure 5 presents the adjusted NPL ratio for 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 for the housing loans, the adjusted NPL ratio is much higher than the original NPL ratio. The new NPL ratio declines throughout the years 2006, 2007, and in the first three quarters of 2008. After this it begins to grow in a similar way to the original NPL ratio.

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

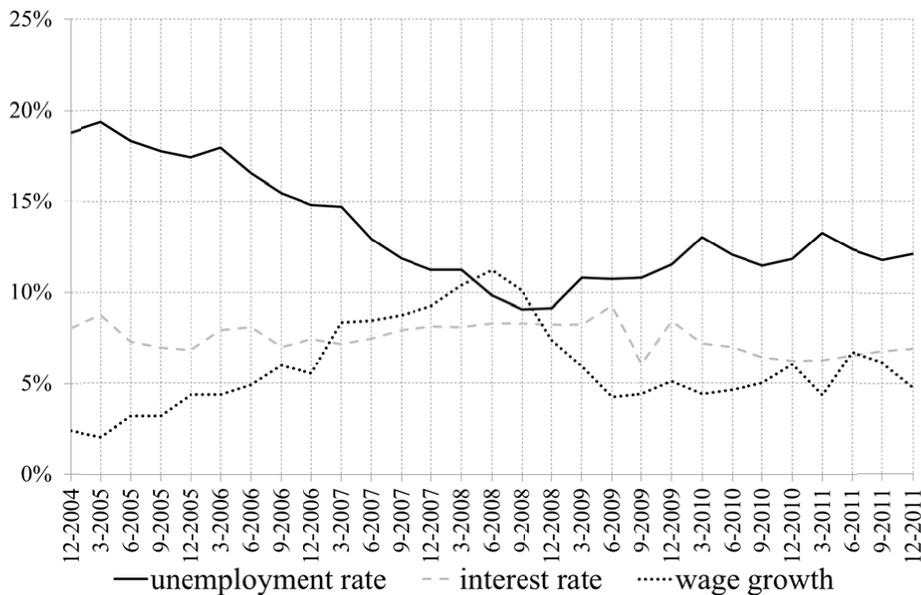
Macroeconomic factors play an important role in modeling the credit risk of loan portfolios since they allow for more a precise prediction of changes in the aggregate economic credit risk that banks cannot easily protect against (e.g., Ali and Daly, 2010; So and Thomas, 2010; Jokivuollea and Virénb, 2013). For example, the unemployment rate and the growth rate of wages describe the general ability of the population to repay their loans to banks whereas the bank interest rates characterize the restrictive or relaxed lending policies of banks. It is interesting to observe how the changing NPL ratios match the economic conditions evolving in Poland throughout the analyzed period. Figure 6 presents three variables representing the 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 that affect the quality of housing loans. The NPL ratios change in our sample are in line with the unemployment rate and in the opposite direction of the growth rate of wages. The interest rate remains relatively stable throughout the entire sample. More 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 these changing economic conditions and begins to increase in the fourth quarter of 2008. The original NPL ratio shows a delayed response as it begins to grow in the first quarter of 2009.

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

Figure 6: Economic conditions for borrowers within Poland



Note: All data was retrieved from the Ecowin database. The 'interest rate' is the rate of interest for new housing loans indexed within the local currency.

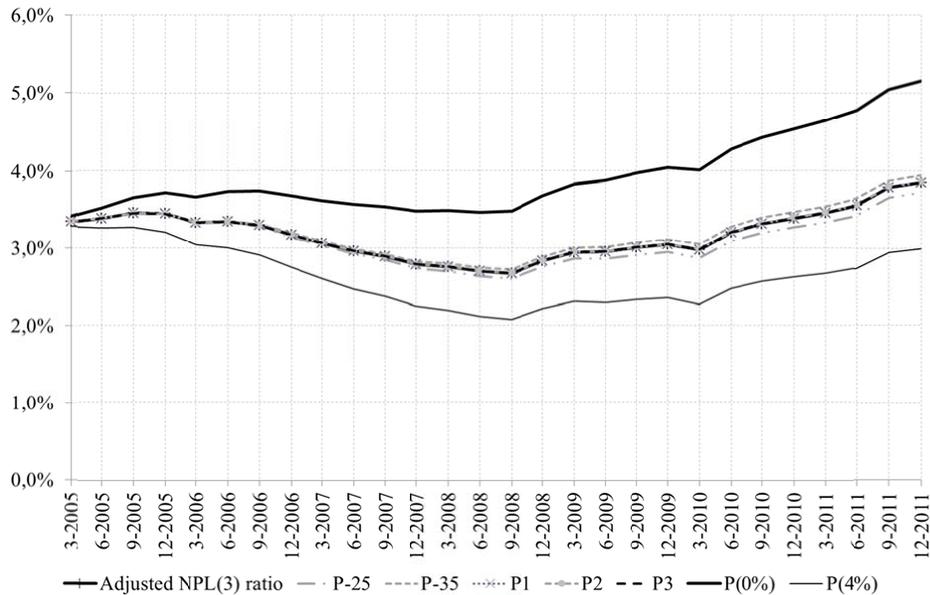
structure of loans in the portfolio for each period. Banks may modify their policies regarding maturities of new loans and the approximation should take this fact into account.

We perform a number of simulations to determine 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 several different distributions of new loans in the portfolio: (1) all new loans 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 a few loans have the longest maturity of 30 years); and (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 for different assumptions about the structure of the loan portfolio (i.e., the distribution of new loans and the

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

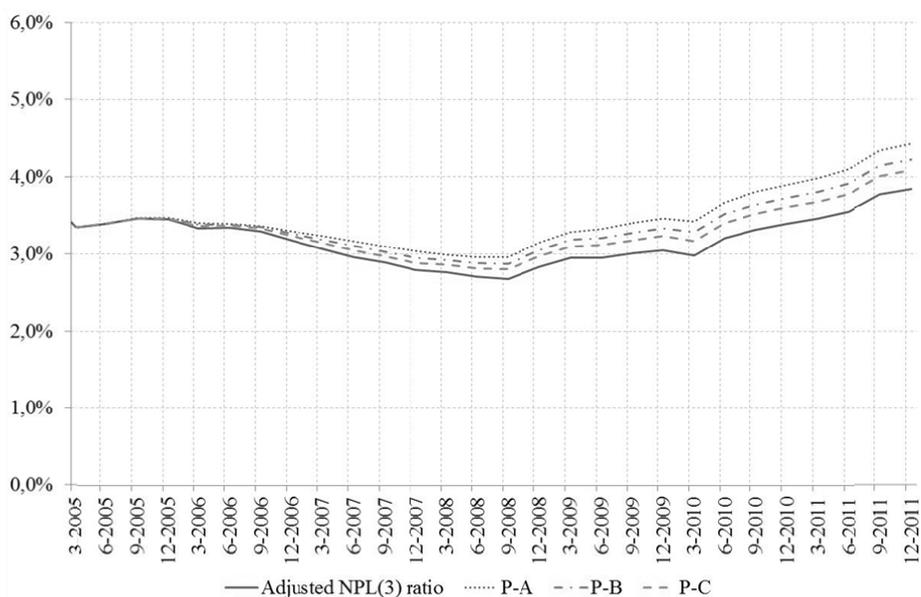


Note: "P-25" ("P-35") is the adjusted NPL ratio when the 25-year (35-year) maximum maturity is assumed. "P1" ("P2" and "P3", respectively) is the adjusted index when all new loans have the maximum maturity (most new loans are established with the shortest maturity and all new loans are uniformly distributed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

maximum maturity of loans). Obviously, the rate of the 'sustainable' growth affects the level of the adjusted NPL ratio; however, the investigator must set this parameter 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.

A slightly worse performance of the adjusted NPL ratio can be observed in Figure 8, where different distributions of the loan portfolios with respect to the maturities of the loans at the beginning of the sample is 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 at a 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 at a 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 at a steady state at the beginning of the sample. All three

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



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

cases simply implicate different distributions of loans with respect to their maturities at the beginning of the sample. The distribution of new loans in subsequent periods of the sample remains the same as the main calculation of the adjusted NPL ratio. This figure shows that the adjusted $NPL(3)_t$ ratio depends to some extent on the initial distribution of loans since the indices P-A, P-B, and P-C differ from the adjusted $NPL(3)_t$ ratio upwards of 0.5 percentage points towards the end of the sample. One way to minimize bias in this case is to use the P-C index whose values remain at the middle of the range of investigated indices. In general, the bias does not prohibit using the adjusted $NPL(3)_t$ ratio even when the distribution of loans in the portfolio is unknown.

5 Conclusions

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

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The simple adjustment, which involves reducing the total volume of loans by subtracting the new loans, can only be useful during the first few periods after the start of a 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 construction of an NPL ratio that is comparable in time and all across banks, markets, and financial systems.

We present a case for using the adjusted NPL ratio with 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 this new adjusted index of loan quality. First, the algorithm to build artificial loan portfolios may be used to forecast future loan quality (e.g., when the economic conditions are approximated by the specific values of the 'survival' probabilities of loans). The typical purpose of this is to perform macro or micro prudential stress tests or analogous simulations. For example, different scenarios for survival probabilities in loan portfolios may be considered and the potential effects of these scenarios on bank profitability or loan losses may be estimated.

Second, impulse-response analyses that take 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 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 a supervisory policy perspective, the non-performing loan ratio is a highly pro-cyclical measure of credit quality. The adjustment employing a 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 at different times and in different portfolios, institutions, or banking systems. One potential application of our adjusted ratio is related to the introduction of countercyclical capital buffers aimed at curbing procyclical lending policies within banks. When lending policies that are too generous trigger credit booms, the adjusted NPL ratio should help identify the increased credit risk of such banks (despite the overall excellent economic conditions) and could help to establish the required capital buffers.

Finally, neither the original nor the adjusted NPL indices take into account the role of collateral in the loan portfolio. In the case of housing loans, collateral plays an important role since it affects the recovery rate of defaulted loans and bank returns from the portfolio. In turn, the adjusted NPL ratio is mostly related to the frequency

of defaults in the loan portfolio. Therefore, a more detailed analysis of a bank's financial standing should also incorporate additional measures including the recovery rate or the adjusted net interest income (i.e., net interest income less charges to provisions for impaired loans) from the loan portfolios apart from our NPL measure.

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