The Dynamics of Non-Performing Loans during Banking Crises: A New Database with Post-COVID-19 Implications

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Abstract

We present a new dataset on the dynamics of non-performing loans (NPLs) during 92 banking crises since 1990. The data show similarities across crises during NPL build-ups but much heterogeneity in the pace of NPL resolution. We document how high and unresolved NPLs deepen post-crisis recessions and use a machine learning approach to establish pre-crisis predictors of NPL problems. These predictors—a set of weak macroeconomic, institutional, corporate, and banking sector conditions—help shed light on post-COVID-19 NPL vulnerabilities.

JEL Classification Numbers: E32, E44, G21, N10, N20.

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I. Introduction

High levels of non-performing loans (NPLs)—those in or close to default—are a common feature of many banking crises. The literature acknowledges that high NPLs impair bank balance sheets, depress credit growth, and delay recovery from crises (Aiyar et al., 2015; Kalemli-Ozcan et al., 2015; IMF 2016). Yet, the analysis of NPL dynamics during banking crises has so far been constrained by data limitations. We know little about the patterns of NPL build-up and the factors that affect NPL resolution. Yet, these are important policy issues, as some countries are still dealing with the NPLs created by the Global Financial Crisis (GFC) and the European sovereign debt crisis, while a new wave of NPLs will likely be induced by the COVID-19 crisis.

This paper presents and analyzes a new dataset on NPL dynamics during banking crises. The dataset covers the yearly evolution of NPL-to-total loans ratios (hereafter, NPL ratios, or NPLs) for 92 banking crises in 82 countries since 1990. This includes all major regional and global crises during this period (e.g., the Nordic banking crisis, the Asian financial crisis, the GFC) and numerous standalone crises in transition and low-income economies. For each crisis, NPLs are reported over an 11-year long window that starts three years before the crisis and extends to seven years after the crisis.2

These data allow us to study NPL dynamics during banking crises in a comprehensive manner. We find that most banking crises (84 percent) exhibit elevated NPLs that exceed 7 percent of total loans. In nearly half of the crises, NPLs more than double compared to the pre-crisis period. The trajectory of NPLs typically follows an inverse U-shaped pattern (Figure 1). They start modest, rise rapidly around the start of the crisis, and peak some years afterwards, before finally stabilizing and declining. While there is much commonality across crises during the NPL build-up, experiences during NPL resolution vary. The decline in NPLs is rapid in some cases and protracted in others. In 30 percent of the crises, NPLs remain unresolved, that is, linger above 7 percent of total loans 7 years after the start of the crisis. In a few cases, NPLs decline and peak again, forming an M-shaped pattern (Figure 2).

2 The full dataset is available through the link: https://bit.ly/2SMc3uV. The dataset also covers pre-1990 crises when data are available. However, for the analysis we only use data on post-1990 crises, for two reasons. First, data coverage before 1990 may have selection bias driven by the characteristics of those countries that started reporting NPLs earlier. Second, to the extent that the structures of banking systems change over time, earlier data may be less informative for analyzing the vulnerabilities in future crises. This paper is accompanied by an Online Appendix that contains a detailed NPL literature review, a description of data definitions and sources, and a wide range of robustness tests.
The new data also allow us to add to the evidence on the link between NPLs and post-crisis economic growth. We use the local projection (LP) method (Jordà, 2005), and find a close relationship between adverse NPL dynamics and the severity of post-crisis recessions. Output in crises with high and unresolved NPLs is persistently lower than that in crises with low NPLs or high but resolved NPLs. Notably, we find that 6 years after a crisis, output is lower by 5 percent when NPLs are high. Among crises with high NPLs, lack of timely NPL resolution is associated with 10 percent lower output 6 years after the crisis.

Given the close relationship between NPL dynamics and post-crisis economic recovery, it is important to understand the “risk factors” of adverse NPL dynamics. We use a machine learning approach to study which pre-crisis conditions affect the likelihood of elevated NPLs, the duration and magnitude of NPL build-up, and the likelihood of timely NPL resolution. We document that countries with higher pre-crisis GDP per capita (which may proxy institutional strength) are less likely to experience high NPLs. Lower bank return on assets and shorter corporate debt maturities predict higher peak NPLs, while lower government debt, flexible exchange rates and stronger domestic macroeconomic conditions predict faster NPL stabilization and resolution. Finally, NPL stabilization and resolution take longer when a banking crisis follows a credit boom or macroeconomic overheating. Overall, these results indicate that better ex-ante macroeconomic, institutional, corporate, and banking sector conditions and policies can help reduce NPL vulnerabilities during a crisis.

We illustrate the relevance of our results on the determinants of NPLs using three exercises. The first exercise is backward-looking. We assess whether our findings on the determinants of NPLs could have predicted NPL dynamics in European crisis countries after the GFC. We establish that NPL outcomes in Europe were substantially worse than what the historic experience of advanced economies would have suggested. Our other exercises are forward-looking and aim to shed light on post-COVID-19 NPL risks. In the second exercise, we combine data on country macroeconomic exposure to COVID-19 and

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3 For example, Cerra and Saxena (2008) estimate output losses amounting to 7.5 percent of GDP over a 10-year period after a crisis, Reinhart and Rogoff (2009a, 2009b) find that the peak-to-trough output decline is on average 9 percent after a crisis, and Jordà et al. (2013) show a larger credit build-up is associated with a deeper recession.

4 Specifically, we use the “post rigorous least absolute shrinkage and selection operator” (“post-r-lasso”; Belloni et al., 2012; Belloni and Chernozhukov, 2013) model selection approach to determine the most informative combination of predictors for each NPL metric. This approach is particularly suitable to our analysis because of the large number of candidate NPL predictors relative to our sample size. See Section IV for further details.

5 We do so by means of out-of-sample predictions, i.e. we re-estimate the model based on pre-GFC data and consider how well this re-estimated model performs in explaining GFC NPL vulnerabilities.
on predicted NPL vulnerabilities to identify countries that are most at risk of an economic downturn accompanied by NPL problems in the wake of the COVID-19 pandemic. We compare advanced economies with emerging market and developing economies and find that while they are similarly exposed to the macroeconomic fallout of COVID-19, emerging market and developing economies are more exposed to the risk of adverse NPL dynamics given the macroeconomic fallout. Finally, in the third exercise, we return to the European crisis countries and compare how the determinants of NPL problems have changed between the GFC and the COVID-19 crisis. The results suggest some improvement in pre-crisis conditions, linked to the fact that the COVID-19 crisis did not follow a credit boom: credit to the private sector was lower and not growing as fast as before the GFC. This offers scope for milder NPL problems. However, other conditions, notably higher pre-crisis public debt and lower pre-crisis bank profitability, caution about possibly deeper NPL problems after the COVID-19 crisis.

Our paper contributes to the literature on the determinants of NPLs along several dimensions. First, we present a new comprehensive dataset on the multi-year NPL dynamics during banking crises, which we further use to understand the determinants of a range of NPLs outcomes. Appendix A provides a comprehensive survey of 44 extant papers on the determinants of NPLs. Most papers (37 out of 44) use NPL data from a single country or region, thus offering less external validity than our analysis. The remaining 7 papers have wide geographic coverage, but restrictive data sources. Two papers (Boudriga et al, 2009; and Beck et al., 2013) use IMF FSI and World Bank WDI data, the coverage of which starts in 2000 but is extremely limited up to the GFC. The other five papers (Godlewski, 2004; Glen and Mondragón-Vélez, 2011; Nkusu, 2011; De Bock and Demyanets, 2012; and Balgova et al., 2017) use NPL data from Bankscope. Bankscope covers mostly publicly-traded or large banks, with limited coverage especially pre-2000, thus often being not representative of the financial system as a whole—especially when rural, regional and foreign-owned banks have different loan quality than publicly-traded or large banks (Bhattacharya, 2003). By contrast, we extend our dataset to 1990 (with pre-2000 data covering 59 out of the 92 banking crises) using hand-collected data from IMF Staff Reports and national sources. These hand-collected data cover 90 percent of the crises, and is cross-checked against FSI and WDI data to ensure consistency (see Section II and Annex B for more information on data construction).6 We use these data to summarize NPL dynamics into quantifiable metrics (peak NPLs, 6 A comparison with Balgova et al. (2017) helps understand the implications of additional data sources and methods of ensuring data consistency. Our data sources cover 5 additional crises and extend coverage for 8 other crises. More critically, (continued…)}
time to peak, time for NPL resolution, etc.) and provide key stylized facts and the analysis of determinants for each of these metrics. The latter analysis is based on a model selection methodology ("post-r-lasso"; Belloni et al., 2012; Belloni and Chernozhukov, 2013) which helps avoid ad hoc specification choices.

Second, we contribute to the literature on the link between post-crisis banking sector weakness and output recovery (Cerra and Saxena, 2008; Reinhart and Rogoff, 2009a, 2009b; Jordà et al., 2013). We document that high and unresolved NPLs are associated with a large and persistent decline in output after banking crises. To address the problem of simultaneity between growth and NPL outcomes in this analysis, we use predicted NPL outcomes based on pre-crisis data (as obtained in the model selection analysis) as a proxy for actual NPL outcomes. Finally, our paper contributes to the emerging literature on the effects of COVID-19 on the financial system (see e.g. Acharya and Steffen, 2020; Beck, 2020; Li et al, 2020). Our analysis highlights how NPL determinants in past crises can shed light on potential NPL problems after the COVID-19 crisis.

The findings of our paper have important policy implications. First, the close relationship between NPLs and post-crisis output growth points to the importance of macro-financial linkages in crisis recovery. Second, the identified risk factors of adverse NPL dynamics offer useful indicators for NPL risk monitoring. Our results also suggest that better *ex-ante* macroeconomic, financial, and institutional policies can alleviate the impact of banking crises. Third, our analysis illustrates that reliable NPL data are vital for NPL monitoring and for evidence based NPL resolution polices. Finally, our results highlight the risk of adverse NPL dynamics after the COVID-19 crisis and suggest that promptly addressing NPLs is crucial for post-pandemic recovery.

The paper proceeds as follows. Section II describes the dataset, its construction, and key stylized facts. Section III analyzes the relationship between NPLs and post-crisis output growth. Section IV studies the risk factors of NPL dynamics. Section V uses our findings to explain NPL dynamics in European
crisis countries after the GFC, and to shed light on NPL-related vulnerabilities after the COVID-19 crisis. Section VI concludes. The paper is complemented by an Online Appendix and the full dataset.

II. A Dataset on NPL Dynamics During Banking Crises

a. Data construction

We construct a dataset of NPL dynamics during systemic banking crises from 1990 to 2017. From the universe of 106 crises identified by Laeven and Valencia (2013, 2018), we document NPL data for 92 crises in 82 countries, each over an 11-year long window that starts three years before the crisis and ends seven years after the crisis. This window captures the fact that NPL buildup tends to precede the crisis, while NPL resolution is often protracted.

We draw NPL data from multiple sources and take steps to ensure consistency. We start with IMF’s Financial Soundness Indicators (FSI). The FSI data has the advantage of cross-country comparability thanks to detailed NPL classification guidelines. The shortcoming of the FSI is that the data start in 2001, with narrow country coverage early in the sample. When the FSI data are missing, we use hand-collected data from IMF Staff Reports. When both the FSI and Staff Report data are missing, we hand-collect data from the official statistics of the national authorities or other national sources. We use Bankscope data only when none of the above sources are available due to two reasons. First, Bankscope only covers publicly traded or large banks, and thus omits the conditions of small banks. Second, the coverage is weak pre-2000s, with large fluctuation across years in some countries. Sample breaks that result from changing bank coverage can confound NPL dynamics observed in Bankscope.

We take multiple steps to ensure data consistency when we combine different data sources into a single time series. First, when extending the data from a more prioritized source with a less prioritized source, we require a coverage overlap. We then multiplicatively rescale the less prioritized source to match the

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7 Laeven and Valencia (2013, 2018) identify 108 banking crises. Because our goal is to analyze the dynamics of NPLs over the years, we combine crises in the same country with close timing into one episode (Brazil 1990 and 1994; and Democratic Republic of Congo 1991 and 1994). This results in a sample of 106 episodes.

8 Another commonly used cross-country NPL database is World Bank’s Global Financial Development Database (GFDD). This is sourced from the FSI (with more historical data for some countries) and has few minor discrepancies with the FSI. Note that, in the IMF definition, the term “country” may cover entities that are not states as understood by international law and practice.

9 For example, if the coverage expands to include a bank with particularly high NPLs in a given year, this will create the appearance of an increase in NPLs even though none has actually occurred.
more prioritized source in the first overlapping year. Second, countries may have different NPL definitions: while the 90 days past-due principal and interest definition is the most common, some countries opt for stricter guidance that includes loans less than 90 days past-due. In the same vein, the definition of NPLs may differ across data sources. To avoid creating definition-related data breaks, we only combine data sources when their definitions are consistent (see Appendix B for further details on NPL definitions and data sources). While this conservative approach limits sample coverage, it ensures cross-country comparability of the data.

Figure 2 plots the resulting NPL time series for each banking crisis.

b. Stylized facts

Most banking crises exhibit elevated NPLs. NPLs typically start modest before a crisis, rise substantially during the crisis, and remain elevated for a long time (Figure 3). In 84 percent of the crises, peak NPLs exceeds 7 percent of total loans (Figure 4 Panel A). In our baseline analysis, we use the 7 percent threshold to define high NPLs (This threshold is convenient because no crisis has a peak NPL ratio close to 7 percent: these are mostly either below 5 or over 9 percent. We further investigate the robustness of our results to alternative thresholds.) In crises with high NPLs, the peak NPL ratio is 22 percent on average. In a few exceptional cases peak NPLs exceed 50 percent. Peak NPLs are more than twice the pre-crisis NPLs in almost half of the crises; and more than four times the pre-crisis NPLs in 20 percent of the crises (Figure 4 Panel B).

NPLs keep rising for 2.3 years on average following the start of the crisis. In nearly 30 percent of the crises, NPLs keep rising for four years or more (Figure 5). Notably, in 30 percent of the crises, NPLs remain above 7 percent 7 years after the crisis—in other words, high NPLs are not resolved within our time window (Figure 6). For countries that manage to bring NPLs to below 7 percent, there is much heterogeneity in the time needed to achieve such a reduction, with an average of 6 years from the crisis start date (Figure 7).

10 Using scaling to combine two series with similar trends avoids creating artificial trends and data breaks in the combined series, which may occur with an interpolation or splicing method.
11 The crisis date is taken from Laeven and Valencia (2013, 2018), who define it as the first date when two conditions are met: (1) significant signs of financial distress in the banking system, as indicated by significant bank runs, losses in the banking system, and/or bank liquidations, and (2) significant banking policy intervention measures in response to significant losses in the banking system.
12 The time to resolution is truncated at 8 years after the crisis date (or at 2017 for post-2010 crises).
The rise and fall in the NPL ratio may be driven by a change in NPLs outstanding (i.e. the numerator), or in total loans (the denominator), or both. Our data show that most changes in the NPL ratio are driven by changes in NPLs outstanding rather than in total loans. Appendix Figure B1, Panel A plots the contribution of the numerator during the accumulation period (i.e. from the start of the crisis to when the NPL ratio peaks). It shows that the numerator explains 94 percent of the post-crisis rise in NPL ratios. Panel B of the same figure plots the contribution of the numerator during the reduction period (i.e. from when the NPL ratio peaks to when it falls below 7 percent). Here, the numerator explains 85 percent of the reduction in NPL ratios from their peak to resolution.13

Because banking crises are rarely single-country events, it is useful to compare NPL dynamics within and across different waves of banking crises.14 The Nordic banking crisis of the early 1990s was an example of effective NPL resolution in advanced economies. NPL ratios peaked at 9-10 percent in Finland, Norway and Sweden soon after a housing downturn, and NPLs were resolved within 3 years in all three countries (see Figure 2). Among Asian countries affected by the Asian financial crisis of the late 1990s, NPLs peaked rapidly (within 1 year) and were resolved slowly (over more than 7 years) in Malaysia and Thailand but peaked slowly (after 3 to 4 years) and were resolved rapidly (within 2 years of the peak) in Japan and Korea. During the same period, in countries outside Asia, NPLs tended to peak fast and be resolved within 7 years.

There was much heterogeneity in the dynamics of NPLs during the GFC. In Europe, Latvia achieved the fastest NPL reduction: NPLs peaked 2 years after the crisis and were resolved a year later. Outside Europe, Mongolia and Nigeria experienced the sharpest rise in NPLs. On average, NPL resolution after the GFC was slow compared to prior crises. As of end-2017, 9 out of 27 countries affected by the GFC were still saddled with elevated NPLs.15 Overall, emerging and developing economies tend to have higher peak NPLs than advanced economies (Table 1, Panel C). At the same time, NPLs in advanced economies take longer to peak and to be resolved. This pattern holds also within crisis waves.16

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13 During the NPL accumulation period, in 38 percent of the crises, the denominator increases and the rise in NPL ratio is solely driven the rising numerator. In another 56 percent of the crises, the denominator falls and the contribution of the numerator is larger than that of the denominator. During the NPL reduction period, in 37 percent of the crises, the denominator falls and the decline in NPL ratio is solely driven by the falling numerator. In another 48 percent of the crises, the denominator rises, the numerator falls, and the contribution of the numerator is larger than that of the denominator.

14 See Appendix Table D1 for the definition of crisis waves.

15 These include Cyprus, Greece, Ireland, Italy, Portugal, Kazakhstan, Nigeria, Russia, and Ukraine.

16 NPLs in non-Asian countries during the Asian financial crisis are a notable exception. In this group, NPLs in emerging and developing economies take longer to peak and to be resolved than those in advanced economies.
NPLs are usually higher and more volatile during banking crises compared to normal times. The mean NPL ratio over the 11-year window around banking crises is 11 percent with a standard deviation of 11 percent. By contrast, the mean NPL ratio in normal times (i.e. outside the 11-year window) is 6 percent with a standard deviation of 6 percent. The difference in the means is economically and statistically significant.17

III. POST-CRISIS NPLs AND OUTPUT

We now proceed to formal econometric analysis based on our dataset. In this section, we study the relationship between NPL dynamics in banking crises and post-crisis output. We ask whether post-crisis output is lower in countries with elevated NPLs, and further lower in countries where elevated NPLs remain unresolved. We use the local projection (LP) method of Jordà (2005), which has been used in the literature to study output paths following financial distress (see e.g. Jordà, Schularick and Taylor, 2013; Romer and Romer, 2017).

a. Specification

We start by assessing whether elevated NPLs affect the path of post-crisis output. We estimate the following impulse response system of equations:

\[ y_{i,t+h} = \alpha^h + \theta^h H_i + \sum_{k=0}^{1} \Gamma_k^h X_{i,t-k} + u_{i,t}^h, \]  

(1)

where the subscripts \( i \) and \( t \) index crises and time respectively, and the superscript \( h = 1, \ldots, 6 \) denotes the horizon (number of years after \( t \)) being considered. The dependent variable \( y_{i,t+h} \) is real GDP (in logs, relative to \( t \), multiplied by 100) for crisis \( i \) at time \( t+h \), which captures the cumulative change in real GDP in the first \( h \) years of the crisis. \( H_i \) is a dummy that equals 1 if peak NPLs are above 7 percent (or 5 or 10 percent, in a robustness exercise). \( \alpha^h \) is a constant, which captures the average output loss for crises with low NPLs while \( \theta^h \) captures the average output loss for crises with high NPLs relative to those with low NPLs. \( X_{i,t-k} \) are contemporaneous and 1-year lagged control variables at the crisis date \( h = 0 \). The controls include bilateral exchange rate against the USD, the government debt to GDP ratio, and credit to the private sector to GDP ratio, all measured in first differences. These controls capture broad external, fiscal, and financial conditions that the literature has found to be related to post-crisis output.

17 We use data for normal time NPL ratios from IMF FSI and Bankscope. The F-test rejecting equal means is significant at the 1 percent level. Similar results hold when controlling for country and/or year fixed effects.
output dynamics. The controls also include the pre-crisis NPL ratio and real GDP growth to capture the historical relationship between NPLs and output, and crisis wave fixed effects to account for unobserved common factors in contemporaneous crises with high NPLs.\textsuperscript{18}

We then analyze whether the resolution of elevated NPLs improves growth outcomes. We estimate:

\begin{equation}
    y_{i,t+h} = \alpha^h + \lambda^h R_i + \sum_{k=0}^{1} I^h_{k} X_{i,t-k} + u_{i,t+h},
\end{equation}

where $R_i$ is a dummy variable that equals 1 for countries with timely NPL resolution. We define timely resolution as bringing NPLs under 7 percent within 7 years after the crisis (or under 5 or 10 percent, in a robustness exercise). Here, $\alpha^h$ captures the average output loss following crises where high NPLs were not resolved in a timely manner and $\lambda^h$ captures the difference in output loss between crises with and without timely NPL resolution.

The relationship between NPLs and output in (1) and (2) may or may not reflect a causal link. For example, a sluggish recovery may exacerbate NPL problems. Or both NPLs and output may be affected by common factors pertaining to the post-crisis period. To alleviate concerns of reverse causality and omitted variables, we replace the dummy for high NPLs $H_i$ in equation (1) and the dummy for timely NPL resolution $R_i$ in equation (2) with their predicted values based on pre-crisis country fundamentals. These predicted values are estimated using a model selection framework that is described in detail in Section IV.\textsuperscript{19}

\textbf{b. Results}

The results of the analysis are documented in Figure 8 and Table 2, and are highly consistent across specifications. First, output is on average lower in banking crises with elevated NPLs compared to those with low NPLs. Estimates of equation (1) using a high NPL dummy of 7 percent yield a difference in real GDP levels of 1.3 and 3.5 percent in the first two post-crisis years, widening to above 5 percent after the third year (Panel A).

\textsuperscript{18} See Appendix Table D1 for the definition of crisis waves. In the regression sample, all crises with low NPLs are in the GFC crisis wave.

\textsuperscript{19} Specifically, for equation (1), we predict the likelihood of high NPLs using predictors and estimates reported in Table 3 Panel A. For equation (2), we predict the likelihood of timely NPL resolution using predictors and estimates reported in Table 3 Panel D. The cutoff value for the high NPL and NPL resolution dummies are defined such that the average predicted likelihood of high NPLs and NPL resolution match their empirical counterparts.
Second, among crises with elevated NPLs, output is on average higher in countries that achieve timely NPL resolution compared to those that do not (Panel B). These differences are again large: estimates based on equation (2) using a 7 percent NPL ratio as a threshold of NPL resolution yield a difference in real GDP levels of 1.8 percent in the first post-crisis year, widening to close to 10 percent in the fifth and sixth years. Notably, output recovers to the pre-crisis level within 4 years of a crisis start when there is timely NPL resolution. When timely resolution is not achieved, on the other hand, output remains substantially below its pre-crisis level through the 6 year projection horizon.

Our findings are robust to replacing dummies based on actual NPL outcomes with the likelihoods of high NPLs and NPL resolution estimated from pre-crisis data, as obtained in Section IV (Appendix Figure C1), as well as to using alternative thresholds of elevated NPLs and NPL resolution (Appendix Figure C2).20

Overall, our analysis documents that high and unresolved NPLs are associated with more severe recessions. Even without formally establishing causality, this finding points to the importance of elevated and unresolved NPLs in understanding the severity of post-crisis recessions following banking crises.

IV. PREDICTORS OF NPL DYNAMICS

In this section, we study what best predicts NPL dynamics in banking crises. We ask which pre-crisis factors best explain the likelihood of elevated NPLs, the length and magnitude of the NPL run-up, and the timeliness of NPL resolutions.21

a. Methodology

Economic intuition and the existing literature on NPLs offer a vast set of candidate predictors of NPL dynamics (which are further discussed below and listed in Appendix Table A1). Given the limited number of historic banking crises, indiscriminately including all the candidate predictors in the empirical analysis would inflate standard errors and lead to overfitting. Instead, we use a model

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20 These results are not driven by crises in which the change in NPL ratio is primarily due to changes in the denominator (i.e. total loans) (see footnote 13 for details). We obtain similar results when we drop such crises from the sample.

21 The fact that we measure all predictor variables before the crisis, while all dependent variables reflect NPL outcomes during a crisis, helps alleviate endogeneity concerns. Nevertheless, we do not ascribe a causal interpretation to our findings. The main goal of our exercise is to identify predictors useful for risk monitoring.
selection approach to determine the most informative combination of NPL predictors. From a policy perspective, having a narrow set of predictors also has the practical merit of reducing data requirements for risk monitoring.

For model selection, we use the “post rigorous least absolute shrinkage and selection operator” ("post-r-lasso"; Belloni et al., 2012; Belloni and Chernozhukov, 2013) approach. This approach is particularly useful when the number of candidate predictors is large relative to the sample size. Post-r-lasso is implemented in two steps. In the first step, the number of predictors is reduced by appending the least squares fitting criterion with a penalty parameter that shrinks the absolute sum of the coefficients of all predictors. The penalty parameter leads to lower variance than those in the least-squares estimator at the expense of a downward bias in coefficients. In the second step, after obtaining the most informative set of predictors, their coefficients are re-estimated without the penalty parameter to remove the bias. We use ordinary least squares (OLS) regression, unless the dependent variable is binary or truncated, in which case we use logistic and Tobit regressions respectively.\textsuperscript{22}

We consider a number of metrics of NPL dynamics introduced in Figure 1. We start with the likelihood of elevated NPLs, defined as NPLs exceeding 7 percent of total loans. For crises with elevated NPLs, we consider peak NPL ratio, the time it takes for NPLs to peak after the start of the crisis ("time to peak") and the time for NPLs to be resolved, that is, to decline to under 7 percent ("time to resolve"). We also examine the likelihood of timely NPL resolution ("NPL resolution dummy"), defined as whether NPLs decline to under 7 percent within 7 years from the start of the crisis.

We let the model selection algorithm choose from a rich set of candidate predictors capturing domestic and external macroeconomic, banking, and corporate conditions, and country institutional characteristics. The post-r-lasso method entails a trade-off between the sample size and the number of candidate predictors, since observations with missing predictor data are dropped from the sample. Because of this trade-off, we consider three alternative specifications. The first specification includes the largest sample of crises and the smallest set of predictors based mostly on macroeconomic variables. This specification is then expanded to include additional predictors at the expense of smaller samples: by adding banking sector variables, and then also corporate sector variables. Appendix Table

\textsuperscript{22} Our findings are robust to using probit instead of logistic regressions. We use Tobit regressions for “time to peak” and “time to resolve” because these measures are truncated at 8 years after the crisis date (or 2017 for post-2010 crises).
D2 lists all variable definitions, and Table D3 reports the candidate predictors included in each specification.23

b. Candidate NPL predictors

Candidate predictors in the first “macroeconomic” specification include measures of domestic and external macroeconomic conditions, and of institutional strength. We capture pre-crisis domestic macroeconomic conditions using GDP growth, domestic credit to the private sector, and unemployment and inflation rates. The relationship between these conditions and NPLs is theoretically ambiguous. On the one hand, low GDP growth and high unemployment may predict higher NPLs because of their adverse impact on borrowers’ wealth and debt service capacity (Williamson, 1987; Bernanke and Gertler 1989; Bernanke and Gilchrist 1999; Kiyotaki and Moore 1997). On the other hand, high credit and GDP growth, and declining unemployment may reflect a credit boom that lowers credit quality, leading to higher NPLs (Schularick and Taylor, 2012; Calomiris and Chen, 2018; Kirti, 2018). Although inflation may make it easier to service local currency debt by reducing its real value, it may also lead to higher nominal and real interest rates, which raise debt service costs. High inflation may also be associated with macroeconomic instability that exacerbates NPLs. Similar ambiguity is present for the impact of macroeconomic conditions on NPL resolution. Favorable pre-crisis macroeconomic conditions may aid NPL resolution if they leave more resources for borrowers and lenders to resolve the debts. However, strong growth fueled by a credit boom may imply lower credit quality, challenging NPL resolution.

We also consider pre-crisis government debt-to-GDP ratio. Higher public debt may be associated with higher NPLs and longer NPL stabilization and resolution time, for two reasons. First, high public debt reduces the government’s fiscal space, limiting its ability to cushion the economic fallout from the banking crisis. Second, high public debt may induce a sovereign-bank nexus where banks increase their domestic sovereign bond purchases due to government pressure or in a gamble for resurrection, thereby crowding out new credit to the private sector (Acharya et al. 2018; Ari, 2017).

We capture pre-crisis external conditions using the change in the bilateral nominal exchange rate against the USD and two dummy variables for an exchange rate peg and for whether that peg was

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23 We further expand these specifications with additional candidate predictors as part of robustness tests, which are described in detail in Section IV.d.
broken, all measured in the 5-year period prior to the crisis. Exchange rate flexibility may cushion the decline in economic activity during banking crises, helping stabilize and reduce NPLs. While a depreciation reduces the borrowers’ ability to serve foreign currency denominated debts, it may still facilitate timely NPL resolution as currency mismatch-related losses of borrowers are typically easy to verify.

Institutional strength—in the form of robust corporate governance, rule of law, and an efficient legal system—may limit the increase in NPLs during a banking crisis and contribute to timely NPL resolution. We use a country’s GDP per capita as a high-level proxy for institutional strength. As indicators for specific institutional factors are unavailable for many of the crises in the dataset, we consider those in an extended specification in Appendix Table D6.

The second “banking” specification adds predictors reflecting pre-crisis banking sector conditions. Most variables pertain to bank profitability: bank return on assets and equity, net interest margins, operating expense-to-net interest income ratio, and noninterest-income-to-total-income ratio. Banks’ cost efficiency and profitability may reflect low monitoring and high risk-taking and be associated with higher NPLs or reflect good management and imply lower NPLs (Berger and DeYoung, 1997). High profitability may also help banks absorb capital losses associated with NPL recognition, thus facilitating NPL resolution. We also include measures of bank concentration. A concentrated banking sector may better internalize the negative externalities of elevated NPLs on the wider economy, leading to lower peak NPLs and timelier resolution. Higher concentration may also make banks more profitable thus reducing their risk-taking incentives, leading to lower NPLs; or may have the opposite effect if banks are “too big to fail” (Kareken and Wallace, 1978; Keeley, 1990; Carletti, 2008). 24

The third and final “corporate” specification adds predictors reflecting pre-crisis corporate conditions. We use the non-financial corporate debt-to-assets ratio to capture corporate leverage, earnings before interest and taxes (EBIT)-to-total interest expense ratio to capture corporate debt service capacity, the share of short-term debt in total debt, and current asset-to-liability ratio to capture the maturity profile of debt and the rollover risk, and the share of foreign assets in total assets to capture international competitiveness. A more indebted corporate sector may experience higher NPLs, while a more

24 We cannot include bank capitalization directly as a predictor due to the lack of available data. Data for macroprudential policy measures and the share of banks with foreign ownership are available for a subset of crises. We consider these in extended specifications in Appendix Table D6.
internationally competitive corporate sector may be more resilient to adverse shocks, thereby reducing NPLs (Kalemli-Ozcan, Laeven, and Moreno, 2015). If firms are unable to roll over loans, however, shorter corporate debt maturities may induce faster recognition and stabilization of NPLs.

c. Results

Table 3 documents the results of the model selection analysis. The likelihood of elevated NPLs is lower in countries with higher GDP per capita, which is a proxy for institutional strength (Panel A). An increase in GDP per capita by one standard deviation reduces the likelihood of elevated NPLs by 19 percentage points.\textsuperscript{25} Conditional on elevated NPLs, peak NPLs are lower in countries with higher bank return on assets and longer corporate debt maturity (Panel B)—reflecting stronger banking and corporate sectors conditions. A one standard deviation increase in bank return on assets or in corporate debt maturity reduces peak NPL ratio by 5 and 4 percentage points, respectively.

A depreciation of the exchange rate against the USD by one standard deviation is associated with NPLs peaking 10 to 13 months sooner (Panel C). Abandoning an exchange rate peg prior to the crisis is also associated with a sooner NPL peak. These results may reflect the effect of floating exchange rates in facilitating post-crisis macroeconomic adjustment. Also, pre-crisis depreciations may be indicative of an overall timelier policy response. Note, however, from Panel B, that while depreciations and floating exchange rates predict a shorter NPL time-to-peak, they do not predict lower peak NPL ratios, possibly reflecting currency mismatch-associated losses in firms and banks.\textsuperscript{26} NPLs peak sooner in countries with higher pre-crisis GDP growth, consistent with favorable macroeconomic conditions raising banks’ and borrowers’ debt management capacity. A one standard deviation increase in pre-crisis GDP growth reduces the time to peak by one year. NPLs also peak sooner in countries with a lower pre-crisis government debt-to-GDP ratio, reflecting more fiscal space. One standard deviation lower government debt reduces time to peak by approximately 11 months.

In contrast, NPLs peak later in countries with higher pre-crisis domestic credit growth and lower unemployment. This may reflect the adverse impact of credit booms and macroeconomic overheating. An increase in domestic credit growth or a reduction in unemployment by one standard deviation increases time to peak by approximately 9 and 5 months, respectively. Also, NPLs peak later in

\textsuperscript{25} We standardize the candidate predictors data to Z-scores (i.e. zero mean and unit standard deviation across crises).

\textsuperscript{26} Our results are robust to interacting exchange rate depreciations with proxies for currency mismatches, including corporate foreign assets and deposit dollarization (Yeyati, 2006).
countries with higher GDP per capita. A one standard deviation increase on GDP per capital extends time to peak by 15 months. This may reflect higher corporate debt maturity in more developed countries, which would lead to NPLs materializing slower. Consistent with this interpretation, GDP per capita is no longer selected in the corporate specification (3), where it is replaced by corporate debt maturity. A one standard deviation increase in corporate debt maturity extends time to peak by 7 months. Together with the results in Panel B, this implies that short-term corporate debt leads to faster NPL stabilization but higher peak NPLs.

NPLs are resolved sooner, and the likelihood of NPL resolution is higher, in countries with lower pre-crisis government debt and credit growth, consistent with credit boom risks and fiscal space constraints (Panels D and E). One standard deviation lower pre-crisis government debt shortens the resolution time by over a year and increases the probability of NPL resolution by 15 percentage points. Similarly, one standard deviation lower credit growth reduces the resolution time by 15 to 16 months and increases the probability of NPL resolution by 25 percentage points.

The likelihood of NPL resolution is higher for more favorable domestic macroeconomic conditions but lower after macroeconomic overheating. A one standard deviation increase in pre-crisis GDP growth raises the likelihood of NPL resolution by 10 percentage points, while a one standard deviation reduction in pre-crisis unemployment lowers it by 11 to 12 percentage points. The likelihood of NPL resolution is also higher after exchange rate depreciation, consistent with floating exchange rates facilitating macroeconomic adjustment. Notably, exchange rate depreciation is the predictor of timely NPL resolution that has the strongest marginal effects: a one standard deviation larger depreciation against the USD increases the likelihood of NPL resolution by 34 percentage points.

The likelihood of NPL resolution is lower in countries with better pre-crisis corporate liquidity, possibly because unviable firms can use liquid assets to repay part of bank debt and thus postpone liquidation. A one standard deviation increase in the corporate current asset-to-liability ratio reduces the likelihood of NPL resolution by 14 percentage points. Finally, the likelihood of NPL resolution is higher in countries with high bank non-interest-to-total income ratio, which is a proxy for profitability and good management. A one standard deviation higher non-interest-to-total income ratio increases the likelihood of NPL resolution by 21 percentage points.

Overall, our model selection analysis documents a set of pre-crisis macroeconomic, institutional, banking and corporate sector conditions that are predictive of NPL dynamics during a banking crisis.
The (pseudo) adjusted R\(^2\) value is 0.42 in the regression explaining the likelihood of elevated NPLs, and ranges from 0.11 to 0.14 in regressions explaining peak NPLs, 0.03 to 0.23 in regressions explaining time to peak, 0.04 to 0.12 in regressions explaining resolution time, and 0.16 to 0.28 in regressions for the likelihood of NPL resolution.

d. Robustness tests

We subject model selection to a number of robustness tests. In the first test, we augment our specifications with crisis wave fixed effects, as contemporaneous crises may share similar features. Appendix Table D4 documents the results. The results remain qualitatively similar. The selected predictors are identical for the likelihood of successful NPL resolution, while additional predictors are selected for peak NPLs and the resolution time, and fewer predictors are selected for time to peak.\(^{27}\)

In the second robustness test, we consider alternative definitions of the NPL dynamics metrics. We use a 5 percent (instead of 7 percent) threshold for elevated NPLs, measure peak NPLs as a multiple of NPLs at the crisis date (instead of absolute percentage value), measure time to resolve NPLs relative to the year when they first exceed 7 percent (instead of the crisis year), and consider NPLs resolved if they fall below 25 percent of peak NPLs (instead of the absolute 7 percent threshold). Table 4 compares the resulting predictors with those selected in the baseline (Appendix Table D5 documents the full robustness results). Some patterns emerge from this comparison. First, there is substantial overlap between the predictors under the baseline and the alternative definitions. This offers comfort on the robustness of the baseline predictors. Second, the predictive power is generally higher, and the set of predictors is generally richer under the baseline definitions, suggesting the relative superiority of the baseline definitions from a forecasting perspective.

In the third robustness test, we consider additional candidate predictors for which available data are more limited. Specifically, we enrich the banking specification with the share of foreign-owned banks, and the macroeconomic specification by including the nominal and real effective exchange rates, indicators of institutional and governance quality, and indicators of macroprudential policy measures, all taken in turn. As the inclusion of these candidate predictors significantly reduces the sample size, some variation in the model selection results is to be expected. Nevertheless, the robustness of the

\(^{27}\) Since all crises with low NPLs in the regression sample are in the GFC crisis wave, crisis wave fixed effects absorb all of the variation for the likelihood of elevated NPLs and no predictors are selected for this NPL metric.
baseline specifications is supported by the fact that the additional predictors are selected only in a few instances (see Appendix Table D6 for the full set of results). Notably, real effective exchange rates are never selected while nominal effective exchange rates yield similar results to the bilateral exchange rate against the USD, as used in our baseline specification. Among institutional and governance indicators, government effectiveness, which captures the quality and credibility of policy formulation and implementation, is selected as a predictor of a lower likelihood of high NPLs instead of GDP per capita. Finally, a higher share of foreign-owned banks is found to be associated with a lower probability of successful NPL resolution, likely because it correlates with lower financial depth and weaker market development, which are important for the resolution of bad loans.

In the fourth and final robustness test, we assess whether the model selection results are driven by advanced or emerging market and developing economies. To do so, we extend the macroeconomic, banking and corporate specifications by adding the interaction of each candidate predictor with a dummy variable for advanced economies (see Appendix Table D7 for the results). The results for peak NPLs and the likelihood of successful NPL resolution remain identical, with no interaction variable selected. For the likelihood of elevated NPLs, only interaction terms are selected, indicating that the findings in our baseline specification are driven by advanced economies. Interaction variables are also selected in some specifications for time to peak and time to resolve, suggesting that the selection of the government debt to GDP ratio and domestic credit to private sector as NPL determinants is to an extent driven by crises in advanced economies.

V. APPLICATION: NPLS IN EUROPE AFTER THE GFC AND AFTER COVID-19

In this section, we apply our results on the predictors of NPL dynamics to topical economic issues. We consider two questions. First, how well do our predictors perform out-of-sample for predicting NPL problems that occurred after the GFC? Second, what do out predictors imply for NPL problems after the COVID-19 pandemic? We address both of these questions with a special focus on European countries that experienced high NPLs after the GFC as dealing with NPLs in those countries proved to be one of major and unforeseen post-GFC policy challenges.28

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28 Specifically, we study Greece, Ireland, Italy, Portugal, Spain, Hungary and Slovenia. These represent a set of EU countries for which full NPL data series before and after the GFC and on the predictors of NPLs are available.
a. NPLs in Europe post-GFC: The Quality of Out-of-Sample Predictions

Our analysis so far has offered a number of stylized facts about NPL dynamics and identified a set of predictors. In this section, we apply these findings to post-GFC NPL dynamics in European crisis countries. We ask to what extent NPL dynamics (i.e., NPLs that proved very high and persistent) could have been anticipated, and whether NPL resolution has been on par with the international experience. To answer these questions, we use our model selection method (Section IV) to make out-of-sample predictions of the post-GFC NPL dynamics in the European crisis countries and compare these predictions to actual outcomes. To clarify, out-of-sample prediction implies that we re-estimate the regressions of Table 3 after excluding observations from the European crisis countries during the GFC.

Figure 9 plots the predicted NPL dynamics against actual outcomes. Panel A shows predicted average peak NPLs of 7 percent, which is substantially lower than the actual value of 19.9 percent. Panel B shows that predicted time to peak is also shorter than actual: 2.5 years versus 5.6 years. The predicted time to NPL resolution is close to the actual outcome at just under 8 years. Predicted resolution likelihood is 37 percent—implying 2 or 3 out of the 7 countries should have resolved NPLs within 7 years—compared to the actual 14 percent, or just 1 out of 7 countries.

Thus, our results suggest that the extent of post-GFC NPL problems in European crisis countries exceeded that which could have been anticipated based on historic crisis experiences and pre-crisis conditions, especially in view of these countries’ relatively high per capita GDP. In other words, the extent of post-GFC problems in Europe was unprecedented for advanced economies. This result is likely attributable to the facts that the post-GFC banking crisis in Europe has coincided with and spilled over to sovereign debt distress in several countries, which in turn caused a negative feedback loop to banking and economic conditions, and that many crisis management policies in Europe proved insufficiently effective (Ari, 2017; Acharya et al., 2018; Brunnermeier and Reis, 2019).

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29 The predictions report averages across the countries in our sample and use the macroeconomic conditions specification. We are not able to use the banking and corporate specifications as doing so would reduce the number of observations for estimation and thus also the precision.

30 This may in part be due to the fact that the time to resolution variable is truncated at 8 years.

31 To replicate the actual value of NPLs in the European crisis countries in our model, we would need to set GDP per capita to a value below the global mean.
b. NPL vulnerabilities after COVID-19

We now proceed to a forward looking analysis and ask what our results imply for NPL vulnerabilities after the COVID-19 pandemic. Although the COVID-19 crisis did not stem from the banking sector, it represents for many countries a substantial shock to the banking system. The extent of a country’s post-pandemic NPL vulnerabilities will, in a simplified form, reflect two factors: the extent of the economic contraction that affects borrowers’ ability to repay, and the banks’ ability to contain and resolve NPLs.

We perform two forecasting exercises. In the first exercise, we identify countries that are most at risk of adverse NPL outcomes post-COVID-19, along the two dimensions discussed above. We capture the economic impact of COVID-19 as the difference in the IMF’s country GDP growth forecasts for 2020 between the October 2019 forecast vintage (pre-COVID-19) and the October 2020 forecast vintage (after the COVID-19 shock). We capture post-pandemic NPL risks based on their predicted values, as estimated using pre-crisis fundamentals in the model selection exercise of Section IV. We thus consider the values of peak NPLs, time to peak, time to resolve NPLs, and the likelihood of successful NPL resolution, as predicted based on pre-crisis economic conditions.

Figure 10 depicts the resulting two-factor country rankings as a set of scatterplots, where the impact of COVID-19 on GDP is plotted on the vertical axis and predicted NPL vulnerabilities on the horizontal axis. Panels A to D show vulnerabilities for the different NPL outcomes. Each point represents a country, with advanced economies shown in black, emerging market economies in grey, and developing economies in white. Each scatterplot is divided into four quadrants using the medians on each axis. Countries in the upper right quadrant (upper left for successful NPL resolution measure) have a larger economic impact and worse predicted NPL vulnerabilities, and consequently are more at risk of adverse post-COVID-19 NPL dynamics.

Two results stand out. First, there is substantial variation in predicted NPL outcomes, meaning that our predicted metrics help differentiate countries that are more and less exposed to NPL problems. Second, the distinction between countries at different levels of economic development is illuminating. Whereas

32 The scatterplots are based on the macroeconomic specification (which is the specification with data available for the largest set of countries), with the explanatory variables taken for 2018-2019, that is, in the two years preceding the crisis, consistent with our method for Section IV. The scatterplots for the banking and the corporate specifications are provided in Appendix E, where the distribution of countries is similar to the macroeconomic specification, highlighting the robustness of our results. The only difference is in the banking specification, which suggest a risk of high peak NPLs in advanced economies on the back of low bank profitability.
according to IMF forecasts, advanced economies are expected to undergo a broadly similar economic contraction due to COVID-19 compared to emerging market and developing economies, the likelihood that this translates into high NPLs in the advanced economies is lower, consistent with their higher level of institutional development that helps address the rise in NPLs (Panel A). By contrast, should NPLs materialize, advanced economies have a higher risk of not being able to resolve NPLs in a timely manner, consistent with the higher complexity of the banking systems there.

In the second exercise, we consider the sample of European crisis countries from Section V.a and evaluate how the risk of adverse NPL outcomes changed between the GFC and the COVID-19 crisis. To shed light on this question, we compare the predictors of adverse NPL dynamics documented in Section IV before the GFC and before the COVID-19 crisis. Unsurprisingly, some key predictors for these countries have changed little, for example, GDP per capita and the fixed exchange rate regime. Yet, several other important predictors have changed as documented in Figure 11. Notably, European crisis countries entered the COVID-19 pandemic with substantially higher government debt and lower bank profitability than those before the GFC. Based on our analysis, these factors induce worse NPL outcomes. At the same time, unlike the GFC, the COVID-19 crisis was not preceded by a credit boom. Private debt was not accelerating as fast, and corporate indebtedness is overall lower pre-COVID-19 than it was before the GFC. These factors may assist NPL resolution after COVID-19. Therefore, our analysis presents a mixed picture for the overall balance of vulnerabilities.

VI. CONCLUSION

During the Great Moderation of early 2000s, banking crises appeared to be a phenomenon of the past. Yet the GFC brought back the debate on the causes and consequences of banking crises, including the challenge of dealing with persistently high NPLs. Now, the deep recession associated with the COVID-19 pandemic is bound to lead to high NPLs and weaken bank balance sheets. Despite the historical prevalence of NPL problems, and the evidence that high and unresolved NPLs impede economic activity, cross-country studies of NPLs are often constrained by data limitations. This paper aims to fill this gap, by documenting and analyzing a new dataset on NPL dynamics during 92 banking crises since the 1990s.

We find that most banking crises are followed by elevated NPLs. While there is much cross-country commonality in NPLs paths, there is also much heterogeneity, especially during NPL resolution, with many countries failing to resolve their NPLs in a timely manner. We document that elevated and
unresolved NPLs substantially impede post-crisis recovery. This points to the importance of understanding the “risk factors” behind adverse NPL outcomes. Using a model selection exercise, we identify key risk factors including high credit growth, high government debt, fixed exchange rates, low bank profitability, and high corporate indebtedness. These findings suggest that sound *ex ante* macroeconomic and macro-prudential policies can play a role in preventing NPL problems during banking crises. Notably, monetary and prudential policies can help curb high credit growth and limit bank risk-taking, while prudent fiscal policies create the fiscal space needed for crisis interventions and help avoid adverse sovereign-bank feedback loops. Exchange rate flexibility can help cushion real and financial shocks and support the economic recovery. Strong institutional environment, including robust corporate governance and effective bank supervision and regulation, also mitigates NPL problems.

Reliable NPL data are vital for anticipating and gauging the extent of NPL problems and formulating policy responses. Although NPLs are common in many banking crises, there are significant gaps in data coverage especially for the pre-2000 period. Also, cross-country comparisons are hampered by a lack of a harmonized NPL definition. Furthermore, bank-level NPL data are still mostly unavailable publicly except for large and publicly listed banks. Granular bank- or loan-level data are essential to advance our understanding of the causes of NPLs and of the effectiveness of policy interventions.

Our data and results offer valuable insights to NPL vulnerabilities and strategies in the context of the COVID-19 crisis. Given the importance of NPL resolution for economic recovery, and many countries’ historical difficulties in implementing NPL-related interventions, designing effective post-pandemic NPL resolution tools is today a critical financial policy issue. Much research is still needed; and the new data and stylized facts presented in this paper may assist such research.
References

Accornero, Matteo, Piergiorgio Alessandri, Luisa Carpinelli, and Alberto Maria Sorrentino, 2017, “Non-performing loans and the supply of bank credit: evidence from Italy”, Bank of Italy Occasional Paper Series, 374.

Acharya, Viral V., Eisert, Tim, and Christian Eufinger, Christian Hirsch, 2018, “Real Effects of the Sovereign Debt Crisis in Europe: Evidence from Syndicated Loans”, The Review of Financial Studies, 31(8): 2855–2896.

Acharya, Viral, and Sascha Steffen. 2020, "Stress tests” for banks as liquidity insurers in a time of COVID.” VoxEU. org, March 22.

Aiyar, Shekhar, Wolfgang Berghaler, Jose M. Garrido, Anna Ilyina, Andreas (Andy) Jobst, Kenneth Kang, Dmitriy Kovtun, Yan Liu, Dermot Monaghan, and Marina Moretti, 2015, “A Strategy for Resolving Europe’s Problem Loan,” IMF Staff Discussion Note 15/19, International Monetary Fund, Washington.

Ari, Anil, 2017, “Sovereign Risk and Bank Risk-Taking,” IMF Working Paper, WP/17/280

Balgova, Marta, Alexander Plekhanov, and Marta Skrzypinska, 2017, “Reducing non-performing loans: Stylized facts and economic impact”, mimeo.

Basel Committee on Banking Supervision, (BCBS), 2017, “Prudential Treatment of Problem Assets – Definitions of Non-Performing Exposures and Forbearance”.

Beck, Thorsten. 2020. "Finance in the times of coronavirus," in: Economics in the Time of COVID-19, an e-book.

Beck, Roland, Petr Jakubik, and Anamaria Piloiu, 2013, “Non-performing loans: what matters in addition to the economic cycle?” Working Paper Series 1515, European Central Bank.

Belloni, Alexandre, Daniel Chen, Victor Chernozhukov, and Christian Hansen, 2012, “Sparse Models and Methods for Optimal Instruments with An Application to Eminent Domain”, Econometrica, 80(6): 2369-2429.

Belloni, Alexandre, and Victor Chernozhukov, 2013, “Least Squares After Model Selection in High-Dimensional Sparse Models”, Bernoulli, 19(2): 521–547.

Berger, Allen N., and Robert DeYoung, 1997, “Problem loans and cost efficiency in commercial banks,” Journal of Banking and Finance, 21(6): 849-870.

Bhattacharya, Kaushik, 2003, “How good is the BankScope database? A cross-validation exercise with correction factors for market concentration measures.” BIS Working Paper 133.

Boudriga, Abdelkader, Neila Boulila Taktak and Sana Jellooui, 2009, “Banking supervision and nonperforming loans: a cross-country analysis”, Journal of Financial Economic Policy, Emerald Group Publishing, vol. 1(4), pages 286-318, November.
Brunnermeier, Markus K., and Ricardo Reis, 2019, “A Crash Course on the Euro Crisis,” NBER Working Paper 26229.

De Bock, Reinout, and Alexander Demyanets, 2012, "Bank Asset Quality in Emerging Markets; Determinants and Spillovers", IMF Working Papers 2012/071, International Monetary Fund.

European Central Bank (ECB), 2017, Guidance to Banks on Non-Performing Loans.

Ghosh, Amit, 2015, “Banking-Industry Specific and Regional Economic Determinants of Nonperforming Loans: Evidence from US States”, Journal of Financial Stability, 20: 93-104.

Glen, Jack, and Camilo Mondragón-Vélez, 2011, “Business cycle effects on commercial bank loan portfolio performance in developing economies.” Review of Development Finance, 1(2), 150-165.

Godlewski, Christophe J., 2004, “Capital regulation and credit risk taking: Empirical evidence from banks in emerging market economies.” Available at SSRN 588163.

International Monetary Fund (IMF), 2006, Financial Soundness Indicators Compilation Guide, International Monetary Fund, Washington.

International Monetary Fund (IMF), 2016, “Fostering Stability in a Low-Growth, Low-Rate Era,” Global Financial Stability Report, October, Chapter 1, International Monetary Fund, Washington.

International Monetary Fund (IMF), 2019, “Vulnerabilities in a Maturing Credit Cycle,” Global Financial Stability Report, October, Chapter 1, International Monetary Fund, Washington.

Jordà, Òscar. 2005. “Estimation and Inference of Impulse Responses by Local Projections”, American Economic Review, 95 (1): 161-182.

Jordà, Òscar, Moritz Schularick, and Alan M. Taylor, 2013, “When Credit Bites Back”, Journal of Money, Credit, and Banking, 45(2): 3-28.

Kalemli-Ozcan, Sebnem, Luc Laeven, and David Moreno, 2015, “Debt overhang, rollover risk and investment in Europe”, mimeo.

Kaminsky, Graciela, L., and Carmen M. Reinhart, 1999, “The Twin Crises: The Causes of Banking and Balance-of-Payments Problems”, American Economic Review, 89 (3): 473-500.

Laeven, Luc, and Fabian Valencia 2013, “Systemic Banking Crises Database”, IMF Economic Review, 61(2): 225-270.

Laeven, Luc, and Fabian Valencia, 2018, “Systemic Banking Crises Revisited,” IMF Working Paper, 18/206, International Monetary Fund, Washington.

Li, Lei, Philip E. Strahan, and Song Zhang.2020, “Banks as lenders of first resort: Evidence from the Covid-19 crisis.” Review of Corporate Finance Studies, forthcoming.
McFadden, Daniel L., 1974, “Conditional logit analysis of qualitative choice behavior,” pp. 105-142 in P. Zarembka (ed.), Frontiers in Econometrics. Academic Press.

Nkusu, Mwanza, 2011, "Nonperforming Loans and Macrofinancial Vulnerabilities in Advanced Economies", IMF Working Papers 11/161, International Monetary Fund.

Podpiera, Jiří, and Laurent Weill, L., 2008, “Bad Luck or Bad Management? Emerging Banking Market Experience,” Journal of Financial Stability, 4, pp.135-148.

Reinhart, Carmen M., and Kenneth S. Rogoff, 2009a, “The Aftermath of Financial Crises.American Economic Review,” 99, pp. 466–72.

Reinhart, Carmen M., and Kenneth S. Rogoff, 2009b, “This Time Is Different: Eight Centuries of Financial Folly,” Princeton, NJ: Princeton University Press.

Romer, Christina D. and David H. Romer, 2017, “New Evidence on the Aftermath of Financial Crises in Advanced Countries”, American Economic Review, 107(10): 3072–3118.

Yeyati, Eduardo Levy, 2006, “Financial Dollarization: Evaluating the Consequences”, Economic Policy, vol. 21(45): 61-118.
Figure 1: A typical NPL trajectory
Figure 2: A new dataset on NPL dynamics

Global Financial Crisis
Figure 2: A new dataset on NPL dynamics (cont’)

Asian Financial Crisis: Asian countries

Asian Financial Crisis: other countries

Nordic Banking Crisis
Figure 2: A new dataset on NPL dynamics (cont’)

Transition countries: EU accession

Transition countries: non-accession
Figure 2: A new dataset on NPL dynamics (cont’)

Low-income countries

- Bolivia 1994
- Burkina Faso 1996
- Cameroon 1995
- Cape Verde 1993
- Central African Republic 1995
- Guinea 1993
- Haiti 1994
- Kenya 1992
- Moldova 2014
- Nicaragua 1990
- Nicaragua 2000
- Nigeria 1991
- Togo 1993
- Uganda 1994
- Yemen 1998
- Zambia 1995

T-2 T T+2 T+4 T+6
Figure 2: A new dataset on NPL dynamics (cont’)

Other crises

Note: T refers to the starting year of a banking crisis (Laeven and Valencia, 2013, 2018). The vertical axis plots NPL to total loans ratio (%). The red line indicates the year with peak NPLs.
Source: IMF FSI, IMF Staff Reports, Bankscope, national sources, and authors’ calculations.
Figure 3: NPLs during banking crises around the world

Panel A: Pre-crisis NPLs

Panel B: NPLs in crisis start year
Figure 3: NPLs during banking crises around the world (cont’)

Panel C: Peak NPLs

Panel D: NPLs 7 years after crisis start

Note: This figure shows NPLs (as a percentage of total loans) 3 years before the start of a crisis (Panel A), in the crisis start year (Panel B), peak NPLs, and NPLs 7 years after the start of a crisis (Panel D). For countries with more than one crisis, the figure shows NPLs in the crisis with highest NPLs.

Source: IMF FSI, IMF Staff Reports, Bankscope, national sources, and authors’ calculations.
**Figure 4: Distribution of peak NPLs**

**Panel A: Peak NPLs**

Source: IMF FSI, IMF Staff Reports, Bankscope, national sources, and authors’ calculations.

**Panel B: Peak NPLs relative to NPLs at crisis date**

Source: IMF FSI, IMF Staff Reports, Bankscope, national sources, and authors’ calculations.
Figure 5: Time to peak

Source: IMF FSI, IMF Staff Reports, Bankscope, national sources, and authors’ calculations.

Figure 6: NPL resolution within 7 years

Source: IMF FSI, IMF Staff Reports, Bankscope, national sources, and authors’ calculations.
Figure 7: Time to NPL resolution

Source: IMF FSI, IMF Staff Reports, Bankscope, national sources, and authors’ calculations.
Figure 8: Output dynamics

Panel A: Output path and high NPLs outcomes

Panel B: Output path and NPL resolution outcomes

Notes: Panel A (Panel B) plots the coefficients of the average real GDP (in logs, relative to the crisis year, multiplied by 100) in crises with high NPLs (timely resolution) relative to crises with low NPLs (untimely resolution). High NPLs are defined as NPLs above 7 percent of total loans. Timely resolution is defined as NPL ratio falling under 7 percent within 7 years after the crisis. The blue bars are the 90 percent confidence intervals.
Figure 9: Comparison of European Crisis Experience with Model Predictions

Panel A: Peak NPLs

Panel B: Time to peak

Panel C: Time to resolve

Panel D: NPL resolution probability
Figure 10: Economic and NPL Risks of COVID-19 across Groups of Countries

Panel A. Peak NPLs

Panel B. NPL time-to-peak

Panel C. NPLs time-to-resolve

Panel D. Probability of timely NPL resolution
Figure 11: Selected predictors of NPL Risks around GFC and around COVID-19 in European Crisis Countries

Panel A. Domestic credit
Panel B. Corporate debt
Panel C. Public debt
Panel D. Bank profitability
Table 1: Summary statistics

| Panel A | | | | | |
|---------|------------------|------------------|------------------|------------------|------------------|
|         | Total crisis episodes | Episodes with pre- & post-crisis data | Episodes with peak NPLs>=7% | | |
|         | No. | No. | col. B / col. A (%) | No. | col. D / col. B (%) | |
| All     | 92  | 73  | 79.3 | 61  | 83.6 | |
| Asian financial crisis, Asia | 8   | 8   | 100.0 | 8   | 100.0 | |
| Asian financial crisis, non-Asia | 5   | 4   | 80.0 | 4   | 100.0 | |
| Global financial crisis | 26  | 26  | 100.0 | 15  | 57.7 | |
| Low-income countries | 18  | 11  | 61.1 | 10  | 90.9 | |
| Transition, EU accession | 8   | 6   | 75.0 | 6   | 100.0 | |
| Transition, non-EU accession | 8   | 2   | 25.0 | 2   | 100.0 | |
| Nordic | 3   | 3   | 100.0 | 3   | 100.0 | |
| Other, non-Nordic | 16  | 13  | 81.25 | 13  | 100 | |

| Panel B | | | | | |
|---------|------------------|------------------|------------------|------------------|------------------|
|         | Peak NPLs (mean) relative to NPLs at T | Time to peak (mean, year from T) | Time to resolve (mean, year from T) | No. resolved in 7 years | |
|         | % of total loans | | | | NPLs<7% | NPLs<25% of peak | |
| All (with peak NPLs>=7%) | 21.6 | 2.9 | 2.3 | 5.4 | 41 | 31 | |
| Asian financial crisis, Asia | 24.6 | 3.9 | 2.1 | 6.8 | 4 | 3 | |
| Asian financial crisis, non-Asia | 33.2 | 1.0 | 0.5 | 4.3 | 4 | 3 | |
| Global financial crisis | 15.1 | 3.7 | 3.9 | 6.5 | 5 | 3 | |
| Low-income countries | 28.4 | 2.1 | 2.4 | 5.4 | 6 | 7 | |
| Transition, EU accession | 26.7 | 1.6 | 1.8 | 6.0 | 5 | 5 | |
| Transition, non-EU accession | 22.7 | 2.5 | 4.0 | 5.5 | 1 | 0 | |
| Nordic | 9.8 | 1.7 | 0.7 | 3.0 | 3 | 2 | |
| Other, non-Nordic | 23.8 | 2.7 | 1.5 | 4.0 | 13 | 8 | |
Table 1: Summary statistics (cont’)

| Panel C | Peak NPLs (mean) relative to NPLs at T | Time to peak (mean, year from T) | Time to resolve (mean, year from T) | No. resolved in 7 years |
|---------|---------------------------------------|----------------------------------|-------------------------------------|------------------------|
|         | % of total loans                       |                                  |                                     |                        |
|         | All (with peak NPLs>=7%)               | 13.6                             | 3.1                                 | 3.3                    | 5.7                    | 12                       | 9                       |
|         | Asian financial crisis, Asia           | 8.7                              | 1.5                                 | 3.5                    | 5.0                    | 2                        | 1                       |
|         | Asian financial crisis, non-Asia       | 33.6                             | 1.1                                 | 1.0                    | 1.0                    | 1                        | 1                       |
|         | Global financial crisis, EU accession  | 11.8                             | 3.8                                 | 4.8                    | 3.0                    | 3                        | 2                       |
|         | Other, Nordic                          | 25.5                             | 1.3                                 | 2.0                    | 3.0                    | 3                        | 3                       |
|         | Advanced                               | 9.8                              | 1.7                                 | 0.7                    | 3.0                    | 3                        | 2                       |
|         | Emerging and Developing                | 26.9                             | 2.7                                 | 2.0                    | 5.3                    | 26                       | 23                      |
|         | All (with peak NPLs>=7%)               | 29.9                             | 4.7                                 | 1.7                    | 7.3                    | 2                        | 2                       |
|         | Asian financial crisis, Asia           | 33.1                             | 1.0                                 | 0.3                    | 3.0                    | 3                        | 2                       |
|         | Asian financial crisis, non-Asia       | 25.9                             | 3.3                                 | 2.7                    | 2.0                    | 2                        | 2                       |
|         | Global financial crisis, EU accession  | 28.4                             | 2.1                                 | 2.4                    | 6.0                    | 6                        | 7                       |
|         | Low-income countries, EU accession     | 27.9                             | 1.9                                 | 1.7                    | 0.0                    | 0                        | 2                       |
|         | Transition, non-EU accession           | 22.7                             | 2.5                                 | 2.4                    | 1.0                    | 1                        | 0                       |
|         | Other, non-Nordic                      | 23.8                             | 2.7                                 | 2.4                    | 12.0                   | 12                       | 8                       |

Note: Panel A shows the number of crises episodes in our sample period (1990-2017), with pre- and post-crisis NPL data, and with peak NPLs greater or equal to 7 percent of total loans. Panel B and C show summary statistics for the sample of crises with peak NPLs greater or equal to 7 percent of total loans. T is the starting year of the crisis as identified by Laeven and Valencia (2013, 2018).
### Table 2: NPLs and output dynamics

|                | (1)  | (2)  | (3)  | (4)  | (5)  | (6)  |
|----------------|------|------|------|------|------|------|
| **Panel A: Elevated NPLs (actual)** |      |      |      |      |      |      |
| Year 1         | -1.344 | -3.533*** | -5.024*** | -5.252** | -5.146* | -5.236 |
| Year 2         | (0.918) | (1.142) | (1.462) | (1.989) | (2.565) | (3.216) |
| Year 3         | -3.607*** | -3.230** | -1.665 | -1.583 | -0.743 | 1.348 |
| Year 4         | (1.189) | (1.512) | (1.885) | (2.672) | (3.863) | (4.528) |
| Year 5         | Observations | 54  | 54  | 54  | 52  | 52  |
| Year 6         | R-squared | 0.588 | 0.607 | 0.634 | 0.624 | 0.587 | 0.582 |
| **Panel B: NPL resolution (actual)** |      |      |      |      |      |      |
| Timely NPL resolution | 1.795 | 3.292 | 5.946 | 8.517* | 9.817* | 9.718* |
| (1.814) | (2.781) | (3.539) | (4.356) | (4.833) | (5.507) |
| Constant      | -4.528** | -4.748 | -4.656 | -5.175 | -5.102 | -2.529 |
| (2.065) | (3.268) | (4.030) | (5.465) | (7.016) | (8.094) |
| Observations  | 39  | 39  | 39  | 39  | 39  | 39  |
| R-squared     | 0.423 | 0.394 | 0.402 | 0.391 | 0.386 | 0.377 |

Note: This table reports the result of a local projection model estimating the average cumulated response of real GDP relative to the crisis year (year zero) across crises from a set of regressions at each horizon after the crisis year. The dependent variable is the log of real GDP (relative to year zero, multiplied by 100). Controls (not shown) include exchange rate, debt to GDP ratio, credit to the private sector (all measured in first difference), real GDP growth, and NPL to total loans ratio. Contemporaneous and 1-year lagged values of controls (measured at year zero) are included. High NPLs is a dummy variable that equals 1 if peak NPLs are above 7 percent of total loans. Standard errors in parentheses. Timely NPL resolution is a dummy variable that equals 1 if NPLs are resolved (i.e. fall below 7 percent of total loans) within 7 years after the start of a crisis. Standard errors in parentheses. ***, ** and * respectively indicate 1, 5 and 10 percent significance levels.
### Table 3: Model selection results

#### Panel A: Probability of elevated NPLs

| Specification | Macro | Bank | Corporate |
|---------------|-------|------|-----------|
| Dependent variable: Elevated NPLs dummy (Peak NPLs>7%) | (1) | (2) | (3) |
| GDP per capita | -0.189*** (0.016) | | |
| No. of observations | 59 | 43 | 35 |
| Log likelihood | -13.35 | n.a. | n.a. |
| Adj. Pseudo R² | 0.418 | n.a. | n.a. |

#### Panel B: Peak NPLs

| Specification | Macro | Bank | Corporate |
|---------------|-------|------|-----------|
| Dependent variable: Peak NPLs (% of total loans) | (1) | (2) | (3) |
| Bank return on assets | | -5.050** (2.212) | |
| Corporate short-term debt (as % of total debt) | | | 4.019* (2.190) |
| No. of observations | 47 | 32 | 24 |
| R² | 0.194 | 0.142 | 0.209 |
| Adj. R² | 0.138 | 0.113 | 0.134 |
| Panel C: Time to peak | Specification | Panel D: Time to resolve | Specification |
|----------------------|--------------|-------------------------|--------------|
|                      | (1)          | (2)                     | (3)          |
| Macro                |              |                         |              |
| Bank                 |              |                         |              |
| Corporate            |              |                         |              |
| **Dependent variable:** | **Time to peak** | **Time to resolve** | **GDP per capita** | 1.215** (0.440) | **Government debt-to-GDP ratio (gross)** | 1.077*** (0.321) |
|                      |              |                         |              |
| **GDP growth**       | -0.999*** (0.251) |                         |              |
|                      |              |                         |              |
| **Change in unemployment rate** | -0.450** (0.206) |                         |              |
|                      |              |                         |              |
| **Exchange rate regime change** |                       | -1.170** (0.493) |              |
|                      |              |                         |              |
| **Exchange rate depreciation against USD** | -1.123*** (0.373) | -0.840*** (0.292) |              |
|                      |              |                         |              |
| **Government debt-to-GDP ratio (gross)** |                       | 0.949*** (0.249) |              |
|                      |              |                         |              |
| **Change in domestic credit to private sector** | 0.743** (0.366) |                         |              |
|                      |              |                         |              |
| **Corporate short-term debt (as % of total debt)** |                       | -0.551* (0.317) |              |
|                      |              |                         |              |
| **No. of observations** | 47 32 24     |                         | 43 29 23     |
| **Log likelihood**    | -93.22       | -52.78                  | -35.75       |
| **Adj. Pseudo R²**    | 0.032        | 0.138                   | 0.228        |
Table 3: Model selection results (cont’)

| Panel E: NPL resolution probability | Specification |
|------------------------------------|---------------|
| Dependent variable:               | (1)           |
| NPL resolution dummy              | (2)           |
| NPL resolution dummy              | (3)           |
| Macro                             | Bank          |
| Corporate                         |               |

| Variable                          | (1)          | (2)          | (3)          |
|-----------------------------------|--------------|--------------|--------------|
| GDP growth                        | 0.102***     |              |              |
|                                  | (0.046)      |              |              |
| Change in unemployment rate       | 0.123***     | 0.114**      |              |
|                                  | (0.044)      | (0.041)      |              |
| Exchange rate depreciation against USD | 0.338***    |              |              |
|                                  | (0.093)      |              |              |
| Government debt-to-GDP ratio (gross) | -0.154**    |              |              |
|                                  | (0.058)      |              |              |
| Change in government debt-to-GDP ratio (gross) | -0.195***   |              |              |
|                                  | (0.053)      |              |              |
| Change in domestic credit to private sector | -0.251***   |              |              |
|                                  | (0.072)      |              |              |
| Bank noninterest income to total income ratio | 0.211***   |              |              |
|                                  | (0.059)      |              |              |
| Corporate current asset to liability ratio |              | -0.140***   |              |
|                                  |              | (0.046)      |              |
| No. of observations              | 44           | 30           | 24           |
| Log likelihood                   | -17.49       | -9.71        | -7.96        |
| Adj. Pseudo R²                   | 0.200        | 0.284        | 0.157        |

Note: Robust standard errors are in parentheses. ***, ** and * respectively indicate 1, 5 and 10 percent significance levels. Panel A is based on observations from the whole sample of banking crises for which sufficient data on NPL dynamics and candidate predictors are available. Panels B-E are based on the subset of crises with elevated NPLs (i.e. peak NPL ratio over 7 percent). Predictors are selected using the post-r-lasso estimator (Belloni et al., 2012; Belloni and Chernozhukov, 2013). For the second step estimates, Panels A, E report results from logistic regressions and C, D report results from Tobit regressions. The coefficients reported in these panels correspond to marginal effects. Panel B reports OLS results. Change refers to cumulative change over the 5 years prior to the banking crisis. All other variables represent average values over the same period. Coefficients for intercepts and statistically insignificant predictors are not reported. Specifications (2) and (3) in Panel A are not reported as the selected predictors lead to a perfect fit which precludes the computation of standard errors. Adjusted Pseudo R² values are calculated according to McFadden (1974). See Appendix Tables B2, D2 and D3 for variable definitions, data sources and further details on specifications.
Table 4: Summary of predictors

**Panel A: Dependent variable is high NPL probability**

| Predictor category | Predictors for the baseline definition (NPL>7%) | Predictors for an alternative definition (NPL>5%) |
|--------------------|-----------------------------------------------|------------------------------------------------|
| Macroeconomic       | GDP per capita                                 | GDP per capita                                   |
|                     | Change in domestic credit to private sector    | Change in unemployment rate                      |
| Bank                |                                               | Bank operating expenses as a share of net interest |

**Panel B: Dependent variable is peak NPLs**

| Predictor category | Predictors for the baseline definition (% of total loans) | Predictors for an alternative definition (relative to NPL ratio at crisis date) |
|--------------------|----------------------------------------------------------|--------------------------------------------------------------------------------|
| Macroeconomic       |                                                          | Exchange rate depreciation against USD                                                |
| Bank                | Bank return on assets                                    |                                                                                   |
| Corporate           | Corporate short-term debt (as % of total debt)           |                                                                                   |

**Panel C: Dependent variable is time to peak**

| Predictor category | Predictors for the baseline definition (relative to crisis year) | Predictors for an alternative definition (relative to first year when NPL > 7%) |
|--------------------|------------------------------------------------------------------|--------------------------------------------------------------------------------|
| Macroeconomic       | GDP per capita                                                   | Exchange rate peg                                                               |
|                     | GDP growth                                                       |                                                                                |
|                     | Change in unemployment rate                                       |                                                                                |
|                     | **Exchange rate regime change**                                   |                                                                                |
|                     | **Exchange rate depreciation against USD**                       |                                                                                |
|                     | Government debt-to-GDP ratio (gross)                             |                                                                                |
|                     | Change in domestic credit to private sector                      |                                                                                |
| Corporate           | Corporate short-term debt (as % of total debt)                   |                                                                                |
Table 4: Summary of predictors (cont’)

**Panel D: Dependent variable is time to resolve**

| Predictor category | Predictors for the baseline definition (relative to crisis year) | Predictors for an alternative definition (relative to first year when NPL > 7%) |
|--------------------|----------------------------------------------------------------|------------------------------------------------------------------|
| Macroeconomic       | Government debt-to-GDP ratio (gross)                           | Exchange rate peg                                                  |
|                     | Change in domestic credit to private sector                   |                                                                  |
| Bank                | Bank operating expenses as a share of net-interest             |                                                                  |

**Panel E: Dependent variable is NPL resolution probability**

| Predictor category | Predictors for the baseline definition (NPLs<7% of total loans 7 years after a crisis) | Predictors for an alternative definition (NPLs < 25% of peak) |
|--------------------|----------------------------------------------------------------------------------------|-------------------------------------------------------------|
| Macroeconomic      | GDP growth                                                                             | Exchange rate peg                                           |
|                     | Change in unemployment rate                                                            | Change in government debt-to-GDP ratio (gross)               |
|                     | Exchange rate depreciation against USD                                                 | Change in domestic credit to private sector                 |
|                     | Government debt-to-GDP ratio (gross)                                                   |                                                             |
|                     | Change in government debt-to-GDP ratio (gross)                                          |                                                             |
|                     | Change in domestic credit to private sector                                           |                                                             |
| Bank                | Bank noninterest income to total income ratio                                         |                                                             |
| Corporate           | Corporate current asset to liability ratio                                             |                                                             |

Note: This table summarizes predictors under the baseline and alternative definitions of NPL dynamics. Identical or conceptually similar predictors under the baseline and alternative definitions are in bold.
Online Appendix for

The Dynamics of Non-Performing Loans during Banking Crises:
A New Database with Post-COVID-19 Implications

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1 Any views expressed are only those of the authors and do not represent the views of the IMF, its Executive Board, IMF management, the ECB or the Eurosystem.
A. Literature review

In this section, we present a comprehensive survey of the literature on the data and determinants of NPLs and discuss the contribution of our paper to the literature.

Table A1 summarizes 44 papers we surveyed. For each paper, the summary lists the research question, determinants of NPLs analyzed, data coverage, and data sources. Of the 44 papers, 37 use data for a single country or a small set of countries in the same region (e.g. Eastern Europe, Sub-Saharan Africa, or the Gulf). The remaining 7 papers have wider geographic coverage but suffer from data limitations. Two papers, Beck, Jakubik & Ploia (2013) and Boudriga, Taktak & Jellouli (2009), rely on NPL data from the IMF’s Financial Soundness Indicators (FSI) and the World Bank’s World Development Indicators (WDI). The coverage of FSI starts in 2005 for 16 percent of countries (30 out of 189) and increases gradually, exceeding 50 percent of countries only after 2010. The WDI’s original sources are FSI and the IMF’s Global Financial Stability Report. Compared to FSI, WDI covers only 6 more countries during the 2000-2004 period, none of which experienced a banking crisis at the time. Consequently, these papers contain little information on the Asian Financial Crisis, the Nordic banking crises, and on numerous crises in transition economies and low-income countries. By contrast, our dataset extends to 1990, with pre-2000 data covering 60 out of the 88 banking crises.

The other five papers, Balgova, Plekhanov, and Skrzypinska (2017), De Bock and Demyanets (2012), Godlewski (2004), Glen and Mondragón-Vélez (2011), and Nkusu (2011), use NPL data from Bankscope. Bankscope data has two key limitations. First, the coverage of individual banks in Bankscope deteriorates back in time. This makes data less informative of the financial system as a whole. Moreover, shifts in coverage may create artificial trends when country-level NPL data is constructed by aggregating bank-level data. For example, if the coverage expands to include a bank with particularly high NPLs in a given year, this creates the appearance of an increase in NPLs while none has actually occurred. Second, in emerging market economies Bankscope has better coverage for larger banks, while often excluding rural, regional and foreign-owned banks (Bhattacharya, 2003). This makes aggregate NPL inferences biased when NPLs vary across bank sizes, location, and ownership.

In comparison, our dataset includes a substantial amount of hand-collected data from IMF Staff Reports and national sources, covering 90 percent of our NPL data series, which we use to cross-check and extend FSI and WDI data. We only use Bankscope when other data sources (FSI, WDI, IMF Staff Reports, national sources) are unavailable. Furthermore, as discussed in Section II of the paper, we make substantial efforts to adjust the data for NPL definition differences across data sources, and for imperfect coverage in Bankscope. To ensure transparency in data construction and to facilitate future studies of NPLs, the combined NPL data and all underlying original data are available in the companion data of
this paper. Country-specific details on NPL data sources and definitions are available in Appendix Table A1.

Besides data construction, our paper also differs from the previous literature in its focus on NPLs during banking crises, which have different characteristics from NPLs in normal times. As we document in Section II, NPLs are substantially higher and more volatile during banking crises. We furthermore construct several quantifiable metrics of NPL dynamics: peak NPLs, time for NPLs to peak, time for NPL resolution, and the likelihood of timely NPL resolution. We use these intuitive metrics to provide key stylized facts about NPLs during banking crises (Section II), analyze the association of NPLs with post-crisis GDP growth (Section III), and examine the determinants of NPLs in a model selection exercise (Section IV).

Finally, our model selection exercise contributes to the literature by identifying NPL risk factors in a systematic way. Our survey of the literature indicates that there are over 20 potential determinants of NPL trajectories (see Table 1, Column 3). Since banking crises are relatively rare events, the small sample size precludes the inclusion of all these determinants in a single regression specification. Consequently, much of the literature uses ad hoc specification choices. We contribute to the literature with a machine learning approach to consistently determine the most informative combination of NPL predictors for each NPL metric. The machine learning approach we adopt, “post rigorous least absolute shrinkage and selection operator” (“post-r-lasso”; Belloni et al., 2012; Belloni and Chernozhukov, 2013), is suitable to this purpose thanks to its strong performance when there is a large number of independent variables relative to the sample size.
| Reference | Research question | NPL determinants included in specification | Data coverage | Data sources |
|-----------|------------------|------------------------------------------|---------------|-------------|
| Adebola, Wan Yusoff & Dahalan (2011) | Determinants of NPLs | Industrial production index, interest rates, production price index | Time: 2007-2009, monthly frequency Region: Malaysia Granularity: Country-level, covering Islamic banks | Bank Negara, IMF IFS |
| Babouček & Jančar (2005) | Transmission of shocks to macroeconomic variables including NPLs | Real effective exchange rate, exports, monetary aggregates, imports, loan growth, unemployment rate, inflation rate, interest rates. | Time: 1993-2005, monthly frequency Region: Czechia Granularity: Bank-level, 207 banks accounting for >90% bank assets | Czech Statistical Office, Czech National Bank |
| Beck, Jakubik & Piloiu (2013) | Determinants of NPLs | Real GDP, real credit, nominal effective exchange rate, lending interest rate, stock prices, international claims relative to GDP, stock market capitalization | Time: 2003-2013, annual frequency Region: 75 countries Granularity: Country-level | IMF FSI and IFS, WB WDI and FDSD, BIS |
| Balgova, Plekhanov & Skrzypinska (2017) | Impact of policy-assisted NPL reduction | Real GDP, GDP growth, inflation rate, public-debt-to-GDP ratio, private sector credit-to-GDP ratio, investment-to-GDP ratio, unemployment rate, policy intervention dummies, proxy for the strength of the insolvency resolution framework | Time: 1990-2016, annual frequency Region: 194 countries Granularity: Country-level | WB WDI, Bankscope |
| Berger & DeYoung (1997) | Relationship between cost efficiency and problem loans | Short-term cost efficiency of bank, equity-to-assets ratio, risk-weighted asset ratio | Time: 1985-1994, annual frequency Region: USA Granularity: Bank-level, most US commercial banks | Annual Reports of Condition and Income (Call reports) |
| Boudriga, Taktak & Jellouli (2009) | Determinants of NPLs | Real GDP growth, capital adequacy ratio, return-on-assets, loan loss reserves to total loans ratio, share of government-owned bank assets in total bank assets, share of foreign-owned bank assets in total bank assets, 5-bank asset concentration, dummies for supervisory powers and independence, dummy for democracies, capital stringency index, rule of law index | Time: 2002-2006, annual frequency Region: 59 countries Granularity: Country-level | IMF FSI, WB |
| Bofondi & | Macroeconomic | GDP, unemployment rate, inflation rate, money | Time: 1985-1994, quarterly frequency | Italian Central |
| Study                        | Determinants of NPLs | Determinants of NPLs | Determinants of NPLs | Determinants of NPLs | Region: Italy | Granularity: Country-level | Credit Register, Bank of Italy, ISTAT |
|------------------------------|----------------------|----------------------|----------------------|----------------------|---------------|---------------------------|----------------------------------------|
| Ropele (2011)                | growth, 3-month Euribor rate, household loan to disposable income ratio, firm net interest expense to gross operating profit ratio, firm leverage, stock prices, house prices, slope of the yield curve, durables consumption, gross fixed investment | Real GDP growth, interest rates on 10-year government bonds, return on assets, tier 1 capital ratio, loan growth, bank assets, market concentration, private credit by deposit money banks as a share of GDP, risk-weighted assets to total assets ratio, number of days required to enforce contracts | Real GDP Growth, credit growth, foreign portfolio and bank flows, net capital flows, foreign portfolio flows, foreign direct investment, exchange rate vis-à-vis USD, real effective exchange rate, terms of trade | Real GDP growth, inflation rate, return-on-equity, return-on-assets, nominal effective exchange rate, spread between loan rates and Treasury bill yield, loan-to-deposit ratio, equity-to-assets ratio, 5-bank asset concentration, loan loss reserves to gross loans ratio, operating costs to total assets ratio, credit growth, bank credit to private sector, lending rate, number of foreign owned banks, liquid assets as a share of total assets | Time: 2006-2016, annual frequency | Region: Euro area countries | Granularity: Bank-level, covering the largest 140 banking groups | Bankscope, Orbis, financial statements, WB, Datastream |
| Cerulli, D’Apice, Fiordelisi, & Masala (2017) | Determinants of NPLs | Determinants of NPLs | Determinants of NPLs | Determinants of NPLs | Time: 2006-2008, monthly frequency | Region: Italy | Granularity: Bank-level, covering 1927 banks that account for 85% of the banking system | ABI Banking Data, Bank of Italy, ISTAT |
| Cotugno, Stefanelli & Torluccio (2010) | Impact of bank business model on NPLs | Determinants of NPLs | Determinants of NPLs | Determinants of NPLs | Time: 1996-2010, annual frequency | Region: 25 emerging market economies | Granularity: Country-level | Bankscope, IMF WEO and IFS, Haver Analytics |
| De Bock & Demyanets (2012) | Determinants of NPLs | Determinants of NPLs | Determinants of NPLs | Determinants of NPLs | Time: 2000-2011, annual frequency | Region: 20 emerging European countries | Granularity: Country-level | IMF, WB, European Banking Authority |
| Erdinç & Abazi (2014) | Determinants of NPLs, impact of NPLs on economic growth. | Determinants of NPLs | Determinants of NPLs | Determinants of NPLs | Time: 1995-2008, annual frequency | Region: Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, UAE | Granularity: Country and bank level, covering 80 banks in the GCC region | IMF WEO, Bankscope |
| Espinoza & Prasad (2013) | Determinants of NPLs, impact of NPLs on economic growth. | Determinants of NPLs | Determinants of NPLs | Determinants of NPLs | Time: 1997Q2-2009Q4, quarterly | National | | |
| Authors                | Type                        | Predictors                                                                 | Time Period                      | Frequency               | Region/Granularity                  | Sources                                      |
|------------------------|-----------------------------|---------------------------------------------------------------------------|----------------------------------|-------------------------|-------------------------------------|----------------------------------------------|
| Novikov (2011)         | NPLs                        | growth, unemployment rate, regional NPLs growth, unemployment rate          |                                  |                         | Region: Country-level               | Estonia, Latvia, Lithuania                  |
| Fofack (2005)          | Determinants of NPLs        | Real GDP per capita, real GDP growth, inflation rate, interest rates, real effective exchange rate depreciation, interest rate spread, broad money supply, domestic credit provided by banks, domestic credit to private sector, equity-to-liquid assets ratio, equity-to-assets ratio, return-on-assets, return-on-equity, total deposits, net interest margin, net income, interbank loans | 1993-2002, annual frequency     | Region: Benin, Cameroon, Chad, Côte d'Ivoire, Mali, Senegal, Togo, Botswana, Cape Verde, Ethiopia, Kenya, Malawi, Rwanda, South Africa, Eswatini, Zimbabwe | Country-level                                 |
| Fuentes & Maquieira (2000) | Impact of institutional factors on NPLs | Real GDP growth, interest rates, information sharing reform dummy | 1960-1997, monthly frequency | Region: Chile | Country-level                       | National sources                           |
| Gambera (2000)         | Predictors of NPLs          | Per capita income, bankruptcy filings, state and national unemployment rate, high frequency indicators of economic activity, car sales, consumer sentiments, loan growth by sector | 1987Q1-1999Q4, quarterly frequency | Region: USA | Bank-level, covering banks from Seventh Federal Reserve District. | Chicago Fed, National Information Center, Haver Analytics |
| Ghosh (2015)           | Determinants of NPLs        | Credit growth, return on bank assets, equity capital-to-assets ratio, loan loss provisions to total loans ratio, share of non-interest income in total income, non-interest expenses to assets ratio, bank size, real GDP, real personal income, inflation rate, house prices, home ownership rates, housing starts, real interest rates, public deficit to GDP ratio, public debt to GDP ratio | 1984-2013, annual frequency    | Region: USA | Regional (50 US states and DC)     | FDIC, US BEA, BLS, US Census Bureau, US Federal Housing Finance Agency |
| Glen & Mondragón-Vélez (2011) | Effects of business cycles on commercial bank loan portfolio performance | Real GDP growth, lending interest rates, domestic credit to the private sector, domestic credit provided by banks, current account balance, loan loss reserves to total loans ratio, equity to total assets ratio, loans to total assets ratio | 1996-2008, annual frequency    | Region: 22 developing economies | Country-level                       | Bankscope, IMF, WB                           |
| Godlewski              | Impact of                  | Bank size, return-on-assets, equity-to-assets ratio,                       | 1996-2001, annual frequency     |                         |                                     | Bankscope                                   |
| Year       | Study                                | Dependent Variable                                      | Explanatory Variables                                                                 | Region                        | Granularity                      |
|------------|--------------------------------------|---------------------------------------------------------|---------------------------------------------------------------------------------------|-------------------------------|----------------------------------|
| 2004       | Capital requirements, and regulatory, institutional and legal factors on NPLs | dummy for capital shortfall relative to regulatory minimum capital requirements, bank net income, bank deposit insurance coverage ratio, number of denied foreign applications for a banking license, indices for government policy and legal transparency, rule of law, a set of dummies pertaining to deposit insurance coverage, credit registries, disclosure requirements of banks, powers and obligations of bank supervisors and auditors, and the ownership structure of banks | Region: 30 emerging market economies Granularity: Bank-level, same coverage as Bankscope |                               |                                  |
| 2010       | Greenidge & Grosvenor (2010)          | Determinants of NPLs, comparison of forecasting models  | Real GDP growth, Short-term interest rates, inflation rate, loan growth, bank size,   | Time: 1996-2008, quarterly frequency Region: Barbados Granularity: Bank-level, covering major banks | Central Bank of Barbados       |
| 2004       | Hu, Li & Chiu (2004)                 | Impact of bank ownership structure on NPLs               | Percentage of government shareholdings, bank size, bank diversification as measured by entropy index of revenues | Time: 1996-1999, annual frequency Region: Taiwan Province of China Granularity: Bank-level, covering 40 commercial banks | Financial statements, Taiwan Economic News Service reports |
| 2013       | Jakubik & Reininger (2013)           | Determinants of NPLs                                    | Real GDP, real exports, real domestic demand, VIX index, EMBIG index, stock prices, domestic bank credit to private sector, credit-to-GDP ratio, exchange rate against the euro and the US dollar, return on assets, | Time: 2004-2012, quarterly frequency Region: Selection of CESEE countries (Bulgaria, Croatia, Czechia, Hungary, Poland, Romania, Russia, Slovakia and Ukraine) Granularity: Country-level | National sources               |
| 2006       | Jiménez & Saurina (2006)             | Determinants of NPLs                                    | Real GDP growth, real interest rate, loan growth, market share, bank size           | Time: 1984-2002, annual frequency Region: Spain Granularity: Bank-level, accounting for >95% of banking assets | Bank of Spain                  |
| 2009       | Khemraj & Pasha (2009)               | Determinants of NPLs                                    | Real GDP growth, real interest rates, real effective exchange rate, nominal effective exchange rate, inflation rate, bank market share, loan growth | Time: 1994-2004, annual frequency Region: Guyana Granularity: Bank-level, covering six commercial banks | Bank of Guyana, Annual Reports of Commercial |
| Study                        | Determinants of NPLs | Variables                                                                 | Time and Region                          | Data Sources                          |
|------------------------------|----------------------|---------------------------------------------------------------------------|------------------------------------------|---------------------------------------|
| Klein (2013)                 | Determinants of NPLs | Equity-to-assets ratio, return on equity, loan-to-assets ratio, loan growth, inflation, exchange rate depreciation, change in unemployment, Euro area GDP growth, VIX index | Time: 1998-2011, annual frequency Region: Bosnia and Herzegovina, Bulgaria, Czechia, Estonia, Hungary, Latvia, Lithuania, N. Macedonia, Poland, Romania Russia, Serbia, Slovakia, Slovenia, Ukraine Granularity: Country and bank-level, covering >60% of bank assets in most countries | Banks, IMF IFS Haver Analytics, IMF WEO, Bankscope |
| Louzis, Vouldis & Metaxas (2012) | Determinants of NPLs | Real GDP growth, unemployment rate, lending interest rates, public debt to GDP ratio, return on equity, solvency ratio, operating expenses to operating income ratio, bank size, share of non-interest income in total income, leverage ratio, ownership concentration | Time: 2003Q1-2009Q3, quarterly frequency Region: Greece Granularity: Bank-level, covering the 9 largest Greek banks that account for 88% of the Greek banking system. | Bank of Greece |
| Macit (2012)                 | Determinants of NPLs | Real GDP growth, exchange rate vis-à-vis USD, net loans to total assets ratio, equity-to-assets ratio, net interest margin, bank size, bank ownership | Time: 2005Q1-2010Q4, quarterly frequency Region: Turkey Granularity: Bank-level, covering 15 largest commercial banks accounting for >90% total loans | Banks Association of Turkey |
| Makri, Tsagkanos and Bellas (2014) | Determinants of NPLs | Real GDP growth, public deficit to GDP ratio, public debt to GDP ratio, unemployment rate, inflation rate, loan to deposit ratio, return on assets, return on equity, capital adequacy ratio | Time: 2000-2008, annual frequency Region: 14 Euro area countries Granularity: Country-level | IMF, WB, Eurostat |
| Messai & Jouini (2013)       | Determinants of NPLs | Real GDP growth, unemployment rate, real interest rate, return-on-assets, loan growth, loan loss reserves to total loans ratio | Time: 2004-2008, annual frequency Region: Italy, Greece, Spain Granularity: Bank-level, covering 85 banks | Bankscope, WB WDI, Global Development Finance |
| Misra & Dhal (2010)          | Determinants and pro-cyclicality of NPLs | De-trended real GDP, real GDP growth, Interest income to loans ratio, interest cost on deposits, operating expenses to asset ratio, non-interest income to asset ratio, bank size, ratio of unsecured loans to total loans, ratio of term loans to total loans, capital | Time: 1996-2008, annual frequency Region: India Granularity: Bank-level, 27 public sector banks that cover a large portion of the banking system | Reserve Bank of India |
| Authors | Determinants of NPLs | Methodology | Time Period | Region | Granularity |
|---------|---------------------|-------------|-------------|--------|-------------|
| Mohaddes, Raissi & Weber (2017) | Non-monotonic impact of GDP growth on NPLs | Real GDP growth | Time: 1997-2014, annual frequency Region: Italy Granularity: 17 Italian regions | Bank of Italy, ISTAT |
| Nikolaidou & Vogiazas (2013) | Determinants of NPLs | Unemployment rate, money supply (M2), credit growth, loan loss provisions, Greek banks’ loan loss provisions | Time: 2001M12-2010M10, monthly frequency Region: Romania Granularity: Country-level | National Bank of Romania, ECB, Bank of Greece |
| Nikolaidou & Vogiazas (2014) | Determinants of NPLs | Unemployment rate, construction activity index, loan growth, loan loss provisions of Greek banks, spread between Greek and German long-term government bond yields | Time: 2001-2010, monthly frequency Region: Bulgaria Granularity: Country-level | Bulgarian National Bank, National Statistical Institute of Bulgaria, Bank of Greece, ECB, |
| Nkusu (2011) | Macroeconomic determinants of NPLs and feedback effects | Real GDP growth, nominal effective exchange rate, unemployment rate, inflation rate, interest rates, stock prices, house prices, credit-to-GDP ratio, | Time: 1998-2009, annual frequency Region: 26 advanced economies Granularity: Country-level | Haver Analytics, IMF IFS and WEO, BIS, Datastream, GDS, Bankscope, US Federal Reserve |
| Podpiera & Weill (2008) | Impact of cost efficiency on NPLs | Bank efficiency scores constructed using data on bank loans, investments assets, labor and physical capital costs and interest expenses on borrowed funds | Time: 1994-2005, quarterly frequency Region: Czechia Granularity: Bank-level, covering all Czech banks. | Czech National Bank |
| Quagliariello (2007) | Impact of business cycles on NPLs | Real GDP growth, interest rates on 10-year Italian Treasury bonds, stock prices, loan-deposit rate spread, credit growth, cost-to-income ratio, return-on-assets, | Time: 1985-2002, annual frequency Region: Italy Granularity: Bank-level, 207 banks accounting for >90% bank assets | Italian Credit Register, ISTAT, Bank of Italy, Datastream |
| Ranjan & Dhal | Determinants of NPLs | Real GDP growth, bank loan maturity, interest rate, | Time: 1990-2003, annual frequency | Reserve Bank |
| (2003) | NPLs | collateral value, bank size, credit-to-deposit ratio | Region: India Granularity: Bank-level | of India |
|-------|------|-------------------------------------------------|----------------------------------------|---------|
| Rossi, Schwaiger & Winkler (2005) | Relationship between cost efficiency, capitalization and problem loans | Operating cost efficiency, bank capitalization, loan-to-assets ratio | Time: 1995-2002, annual frequency Region: Czechia, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia Granularity: Bank-level, accounting for >80% of banking assets | Bankscope |
| Salas & Saurina (2002) | Determinants of NPLs | Real GDP growth, debt to equity ratio, loan growth, branch growth, share of loans without collateral, bank size, net interest margin, capital to asset ratio, market share, borrower leverage, ratio of operating expenses to operating margin, spread between loan interest rates and the interbank rate. | Time: 1985-1997, annual frequency Region: Spain Granularity: Bank-level, covering commercial and savings banks | Financial statements, Bank of Spain |
| Shu (2002) | Determinants of NPLs | Real GDP growth, inflation rate, unemployment rate, nominal effective exchange rate, house prices, stock prices, nominal interest rates, bankruptcy rates, banking claims to Mainland Chinese banks and non-bank customers as a fraction of total banking assets | Time: 1995Q1-2002Q2, quarterly frequency Region: Hong Kong SAR Granularity: Bank-level | Hong Kong Monetary Authority |
| Skarica (2014) | Determinants of NPLs | Real GDP growth, inflation rate, unemployment rate, credit growth, nominal effective exchange rate, interest rates, stock prices | Time: 2007Q3-2012Q3, quarterly frequency Region: Bulgaria, Croatia, Czechia, Hungary, Latvia, Romania, Slovakia Granularity: Country-level | National central banks, ECB, Eurostat, WB |
| Us (2017) | Determinants of NPLs and the impact of GFC on NPLs | Real GDP growth, inflation rate, policy interest rate, public debt to GDP ratio, equity-to-assets ratio, loan-to-assets ratio, other operating expenses to total assets ratio, bank size, bank ownership dispersion, | Time: 2002Q4-2013Q3, annual frequency Region: Turkey Granularity: Bank-level, covering 21 deposit banks Frequency: Quarterly | Banks Association of Turkey, Central Bank of the Republic of Turkey, Turkish Treasury |
| Vithessonthi (2016) | Impact of credit growth on NPLs in an economy with | Credit growth, bank size, ratio of common equity to total assets, ratio of non-interest income to net revenue, ratio of cash and cash equivalents to total deposits, deposits-to-assets ratio, return-on-assets, | Time: 1993-2013, annual frequency Region: Japan Granularity: Bank-level, covering 82 publicly listed commercial banks | Datastream, Worldscope |
| Study (Year)    | Relationship                                                                 | Key Ratios                             | Time: 1990-1998, annual frequency | Region: Denmark, France, Germany, Italy, Spain, the UK | Granularity: Bank-level | National regulators, financial statements |
|----------------|------------------------------------------------------------------------------|----------------------------------------|-----------------------------------|------------------------------------------------------|-------------------------|-------------------------------------------|
| Williams (2004)| Relationship between cost efficiency, capitalization and problem loans      | Operating cost efficiency, bank capitalization, loan-to-assets ratio |                                   |                                                      |                         |                                           |
B. Definition and Data Sources for Non-Performing Loans

The regulatory definition of non-performing loans (NPLs) varies across jurisdictions. For countries reporting Financial Soundness Indicators (FSI) to the IMF, the FSI guideline recommends that loans (and other assets) should be classified as NPL when (1) payments of principal and interest are past due by 90 days or more, or (2) interest payments equal to 90 days interest or more have been capitalized (reinvested into the principal amount), refinanced, or rolled over (payment delayed by agreement). or (3) evidence exists to reclassify them as nonperforming even in the absence of a 90-day past due payment, such as when the debtor files for bankruptcy (IMF 2019, pg. 59).

The 90-day past due criterion is most widely used by countries (Cortavarría and others, 2000) and in line with the Basel criteria for problem asset (Basel Committee on Banking Supervision, Core Principle 18) or establishing default (Basel II), and the European Banking Authority’s (EBA) criteria for non-performing exposures (ECB 2017). The Basel and EBA criteria also include loans that are less than 90 day overdue but are deemed unlikely to be repaid similar to the FSI guideline (criteria 2 and 3).

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2 Previous FSI guideline on NPLs are similar (IMF 2006) with one exception. The 2007 revision of FSI guideline redefined NPLs base on a narrow criterion of “principal or interest payments 90 days overdue”. In cases where countries follow different FSI guidelines, the FSI NPL series may not be consistent.
## Table B1. Data sources and definitions of NPLs

### Panel A. Main data

| Source                  | Crisis       | Variable Name                                      | Notes                                                                                                                                                                                                                                                                                                                                 |
|-------------------------|--------------|----------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| IMF Financial Soundness | All          | Bank Non-Performing Loans to Gross Loans (%)       | Calculated by taking the value of NPLs as the numerator and the total value of the loan portfolio (including NPLs, and before the deduction of specific loan loss provisions) as the denominator. Loans are classified as NPL when (1) payments of principal and interest are past due by 90 days or more, or (2) interest payments equal to 90 days interest or more have been capitalized (reinvested into the principal amount), refinanced, or rolled over (payment delayed by agreement), or (3) evidence exists to reclassify them as nonperforming even in the absence of a 90-day past due payment, such as when the debtor files for bankruptcy. After a loan is classified as nonperforming, it (and/or any replacement loan(s)) should remain classified as such until written off or payments of interest and/or principal are received on this or subsequent loans that replace the original. Loans include those financial assets created through the direct lending of funds by a creditor to a debtor through an arrangement in which the lender either receives no security evidencing the transactions or receives a nonnegotiable document or instrument. Collateral, in the form of either a financial asset (such as a security) or nonfinancial asset (such as land or a building), may be provided under a loan transaction, though it is not an essential feature. Loans include commercial loans, installment loans, hire-purchase credit, loans to finance trade credit and advances, financial leases, repurchase agreements not classified as a deposit, and overdrafts. Trade credit and similar accounts receivable/payable are not loans. |
| World Bank              | All          | Bank Non-Performing Loans to Gross Loans (%)       | Data are submitted by national authorities to the IMF following the Financial Soundness Indicators (FSI) Compilation Guide.                                                                                                                                                                                                                                                                   |
| World Global            | All          | Total impaired loans to gross loans (%, Bankscope) | Total impaired loans to gross loans from Bankscope. Bank-level data are aggregated to country level using gross loans as weights. Bankscope does not report NPLs; instead it reports impaired loans. The source of these figures is mostly banks' annual reports and accounts, and these are all loans that have a specific impairment against them. There is no conformity to defining impaired loans, both across country and intracountry because all accounting standards are vague in their definition of when a loan is impaired and because management discretion can change from one year to the next within a particular bank. |
| IMF Staff Report        | All          | Bank Non-Performing Loans to Gross Loans           | Loans are classified as nonperforming if payments are overdue for three months or more. Reported on a gross basis over all banks, unless otherwise indicated below.                                                                                                                                                                                                                          |
| National source | Country, Year | NPL as % of total loans | Source |
|-----------------|---------------|------------------------|--------|
| Albania, 1994   | NPL as % of total loans | International Monetary Fund (IMF), 1996. “Table 24. Nonperforming Bank Loans.” Source in: World Economic Outlook, May 1996: Focus on Fiscal Policy.” World Economic Outlook, IMF, Washington, DC. |
| Argentina, 1995 | NPL as % of total loans, Total financial system | Central Bank of Argentina, International Monetary Fund (IMF), 1994. “Table 13. Argentina: Indicators on Provisioning and Quality of Loan Portfolio.” Source In: “Argentina - Background Papers.” IMF Country Report No. 94/177, IMF, Washington, DC. |
| Bolivia, 1994   | NPL as % of total loans | Sources: Central Bank of Bolivia; Ministry of Finance; and Fund staff estimates and projections. International Monetary Fund (IMF), 1999. “Table 5. Selected Economic Indicators, 1986–2004.” Source in: “Bolivia—Ex Post Assessment of Longer-Term Program Engagement.” IMF Country Report No. 05/99, IMF, Washington, DC. |
| Brazil, 1994    | NPL as % of total loans | Bank of International Settlements (BIS), 1996. “Table VI.5: Non-performing loans as a percentage of total loans.” Source in: “Bank of International Settlements 67th Annual Report.” BIS, Basle, Switzerland. |
| Bulgaria, 1996  | NPL as % of total loans | Total non-performing balance and off-balance sheet assets in total assets. World Bank, 2001. “Table 1.2: Non-Performing Loans in Central and Eastern European Countries (Percent of total loans).” Source in: “Czech Republic - Enhancing the prospects for growth with fiscal stability - a public expenditure review (English).” World Bank Report No. 22114-CZ, World Bank, Washington, DC. |
| Burkina Faso, 1990 | NPL as % of total loans | Overdue and doubtful credit (credits en souffrance) as a percentage of total credit. Source: Banque Centrale des Etats de l’Afrique de l’Ouest (BCEAO). |
| Cameroon, 1995  | NPL as % of total loans | Overdue and doubtful credit (créances en souffrance) as a percentage of total credit, measured at end-September. Source: Bulletin de la Commission Bancaire de l’Afrique Centrale, No, 5, December 2003. |
| Central African Republic, 1995 | NPL as % of total loans | Overdue and doubtful credit (créances en souffrance) as a percentage of total credit, measured at end-September. Source: Bulletin de la Commission Bancaire de l’Afrique Centrale, No, 5, December 2003. |
| China, 1998     | NPL as % of total loans, state-owned commercial banks | Sources: Zhao Yi, 2001; Liu Mingkang’s talk on May 29, 2003, China Banking Regulatory Commission; China Statistical Year Book. “Table 1. NPLs of State-owned Commercial Banks Between 1985 and 2005.” Source in: “Non-Performing Loan of China’s Banking System.” Tokyo Meiji Gakuin University Annual Report. Retrieved from: http://www.meijigakuin.ac.jp/econ/academics/publications/annual/PDF/23_asia%20east_4.pdf |
| National source | Country, Year | Measure | Details |
|-----------------|---------------|---------|---------|
| Colombia, 1998  | NPL as % of outstanding credit | Source: Banco de la Republica. Outstanding credit data does not include leasing transactions. French-Davis R., Villar L., 2006. “Table 4. Chile and Colombia: financial sector, 1990-2003.” Source in: “Real Macroeconomic Stability and the Capital Account in Chile and Colombia.” Working paper No. 294, Banco de la Republica, Colombia. Retrieved from: [http://www.banrep.gov.co/es/node/545](http://www.banrep.gov.co/es/node/545) |
| Croatia, 1998   | Nonperforming assets as % of total assets | Nonperforming assets include loans classified in percent of total assets, which here refers to total assets of deposit money banks. At end-2001, nonperforming loans amounted to 7.8 percent of classified assets. International Monetary Fund (IMF), 2002. “Table 3. Croatia: Selected Macro Prudential Indicators, 1995-2002.” Source in: “Republic of Croatia - Financial System Stability Assessment.” IMF Staff Report No. 02/244, IMF, Washington, DC. |
| Czech Rep., 1996 (1994 onwards) | NPL as % of total loans | Total non-performing balance and off-balance sheet assets in total assets. World Bank, 2001. “Table 1.2: Non-Performing Loans in Central and Eastern European Countries (Percent of total loans).” Source in: “Czech Republic - Enhancing the prospects for growth with fiscal stability - a public expenditure review (English).” World Bank Report No. 22114-CZ, World Bank, Washington, DC. |
| Czech Rep., 1996 (Pre-1994) | NPL as % of total credit | From 1994 loans previously classified as temporarily in arrears are now included under dubious and questionable claims. Includes claims both temporarily in arrears and those classified as dubious and questionable. International Monetary Fund (IMF), 1994. “Table 28. Czech Republic: Nonperforming Loans of the Banking System, 1992-94.” Source in: “Czech Republic - Recent Economic Developments.” IMF Country Report No. 94/194, IMF, Washington, DC. |
| Ecuador, 1998   | NPL as % of total credit | Foreign currency components are valued at end-period exchange rate. Excludes acceptances, equity holdings, and investment trusts. Nonperforming loans are defined broadly (including loans that no longer accrue interest). International Monetary Fund (IMF), 2000. “Table 36. Ecuador: Commercial Banks’ Outstanding Credit to the Private Sector and Nonperforming Loans.” Source in: “Ecuador-Selected Issues and Statistical Annex.” IMF Country Report No. 00/194, IMF, Washington, DC. |
| Estonia, 1992   | NPL as % of total loans | Source: EBRD Transition Report, 1998; International Monetary Fund; Central Banks. Tang, H., Zoli, E., Klytchnikova, I., 2000. “Table 3. Soundness of the Banking Sector: Non-performing Loans.” Source in: “Banking crises in transition economies: fiscal costs and related issues (English).” World Bank Policy Research Working Paper No. 2484, World Bank, Washington, DC. |
| Finland, 1991   | NPL as % of total loans | Bank of International Settlements (BIS), 1996. “Table VI.5: Non-performing loans as a percentage of total loans.” Source in: “Bank of International Settlements 67th Annual Report.” BIS, Basle, Switzerland. |
| Georgia, 1991   | NPL as % of total loans | Source: EBRD Transition Report, 1998; International Monetary Fund; Central Banks. Tang, H., Zoli, E., Klytchnikova, I., 2000. “Table 3. Soundness of the Banking Sector: Non-performing Loans.” Source in: “Banking crises in transition economies: fiscal costs and related issues (English).” World Bank Policy Research Working Paper No. 2484, World Bank,
Washington, DC.

| IMF Staff Report | Greece, 2008 | NPL as % of total loans | Until June 2017 loans were classified as nonperforming when (1) payments of principal and interest are past due by 90 days or more, or (2) interest payments equal to 90 days or more have been capitalized (reinvested in to the principal amount, refinanced, or rolled over), or (3) payments less than 90 days past due that are recognized as nonperforming under the national supervisory guidance. (IMF 2018 Article IV Staff Report). |
| National source | Guinea, 1993 | NPL as % of total loans | Caprio, Gerard and Daniela Klingebiel, 1996. “Bank insolvencies: cross-country experience.” Washington: World Bank. |
| National source | Hungary, 1991 | Problem loans as % of domestic credit | Source: Berglöf, E., Mizsei, K., 1996. “Banking Sector Development in Central and Eastern Europe.” Economic Policy Initiative CEPR and Institute for East West Studies. As sourced in: International Monetary Fund (IMF), 1997. “Table 32. Selected Countries in Transition: Problem Loans.” Source in: “World Economic Outlook, October 1997: EMU and the World Economy.” World Economic Outlook, IMF, Washington, DC. |
| National source | India, 1993 | NPL as % of total loans (public sector banks only) | Bank of International Settlements (BIS), 1996. “Table VI.5: Non-performing loans as a percentage of total loans.” Source in: “Bank of International Settlements 67th Annual Report.” BIS, Basle, Switzerland. |
| National source | Indonesia, 1997 | NPL/total property loans (%) | Pangestu, M., 2003. Table 2. Non-Performing Property Loans, 1992-April 1997. “Source in: “The Indonesian bank crisis and restructuring: lessons and implications for other developing countries.” G-24 Discussion Paper No. 23, Intergovernmental Group of Twenty-Four on International Monetary Affairs, United Nations, Geneva. Retrieved from: https://g24.org/wp-content/uploads/2014/03/23.pdf |
| National source | Kenya, 1992 | NPL as % of total loans | Waweru, N., Kalani, V. M., 2009. “Table 1: Non-Performing Loans 1995-2003.” Source in: “Commercial Banking Crises in Kenya: Causes and Remedies.” African Journal of Accounting, Economics, Finance and Banking Research 4(4). |
| National source | Kyrgyz Rep., 1995 | NPL as % of total loans | Source: EBRD Transition Report, 1998; International Monetary Fund; Central Banks. Tang, H., Zoli, E., Klytchnikova, I., 2000. “Table 3. Soundness of the Banking Sector: Non-performing Loans.” Source in: “Banking crises in transition economies: fiscal costs and related issues (English).” Policy Research Working Paper No. 2484, World Bank, Washington, DC. Total non-performing balance and off-balance sheet assets in total assets. World Bank, 2001. “Table 1.2: Non-Performing Loans in Central and Eastern European Countries (Percent of total loans).” Source in: “Czech Republic - Enhancing the prospects for growth with fiscal stability - a public expenditure review (English).” World Bank Report No. 22114-CZ, World Bank, Washington, DC. |
| National source | Latvia, 1995 | NPL as % of total loans | Total non-performing balance and off-balance sheet assets in total assets. World Bank, 2001. “Table 1.2: Non-Performing Loans in Central and Eastern European Countries (Percent of total loans).” Source in: “Czech Republic - Enhancing the prospects for growth with fiscal stability - a public expenditure review (English).” World Bank Report No. 22114-CZ, World Bank, Washington, DC. |
| National source | Lithuania, 1995 | NPL as % of total loans | Total non-performing balance and off-balance sheet assets in total assets. World Bank, 2001. “Table 1.2: Non-Performing Loans in Central and Eastern European Countries (Percent of total loans).” Source in: “Czech Republic - Enhancing the prospects for growth with fiscal stability - a public expenditure review (English).” World Bank Report No. 22114-CZ, World Bank, Washington, DC. |
| National source | Country, Year | NPL as % of total loans | Notes |
|-----------------|---------------|------------------------|-------|
| Malaysia, 1997  | NPLs including housing loans. International Monetary Fund (IMF), 2005. “Table 6. Malaysia: Indicators of Financial Institution Soundness, 2000–04.” Source in: “Malaysia—Staff Report for the 2004 Article IV Consultation.” IMF Country Report No. 05/15, IMF, Washington, DC. |
| Mexico, 1994    | NPLs including restructured and reprogrammed loans. International Monetary Fund (IMF), 2005. “Table 3. Reported and Estimated Risk Profile of the Bank Loan Portfolios, 1991-2003.” Source in: “These Are the Good Old Days: Foreign Entry and the Mexican Banking System.” NBER Working Paper No. 18713. |
| Nicaragua, 2000 | NPLs including restructured and reprogrammed loans. International Monetary Fund (IMF), 2006. “Table 9. Nicaragua: Financial Soundness Indicators: Core and Encouraged Sets, and Structure and Performance (in percent).” Source in: “Nicaragua: 2005 Article IV Consultation, Seventh, Eighth, and Ninth Reviews Under the Three Year Arrangement Under the Poverty Reduction and Growth Facility, Requests for Rephasing and Waiver of Performance Criteria, Financing Assurances Review, and Request for Extension of the Arrangement: Staff Report; Staff Statement; Public Information Notice and Press Release on the Executive Board Discussion; and Statement by the Executive Director for Nicaragua.” IMF Country Report No. 06/174, IMF, Washington, DC. |
| Nicaragua, 2000 | Source: Superintendency of Banks; and Central Bank of Nicaragua. In 2006, a regulatory change narrowed the definition of Tier 1 capital. NPLs including restructured and reprogrammed loans. International Monetary Fund (IMF), 2012. “Nicaragua: Financial Soundness Indicators, 2005–11.” Source in: “Nicaragua: Ex Post Assessment of Longer-Term Program Engagement.” IMF Country Report No. 12/258, IMF, Washington, DC. |
| Nigeria, 1991   | Source: Caprio, Gerard and Daniela Klingebiel, 1996: “Bank insolvencies: cross-country experience.” Washington: World Bank. |
| Norway, 1991    | Source: Norges Bank. International Monetary Fund (IMF), 2005. “Table 3. Norway: Bank Financial Soundness Indicators (FSIs).” Source in: “Norway: Financial System Stability Assessment, including Reports on the Observance of Standards and Codes on the following topics: Banking Supervision, Insurance Regulation, and Payment Systems.” IMF Country Report No. 05/200, IMF, Washington, DC. |
National source  | Paraguay, 1995  | NPL as % of total loans  | Source: Central Bank of Paraguay and Fund staff estimates. International Monetary Fund (IMF), 2001. “Table 1.1: Selected Macroeconomic Indicators 1992-98.” Source in: “Paraguay Country Assistance Evaluation.” World Bank Report No. 22874, World Bank Operations Evaluation Department, Washington, DC.

National source  | Poland, 1992  | NPL as % of total loans  | Source: EBRD Transition Report, 1998; International Monetary Fund; Central Banks. Tang, H., Zoli, E., Klytchnikova, I., 2000. “Table 3. Soundness of the Banking Sector: Non-performing Loans.” Source in: “Banking crises in transition economies: fiscal costs and related issues (English).” Policy Research Working Paper No. 2484, World Bank, Washington, DC.

National source  | Romania, 1998  | Ratio of NPL provisions made to gross portfolio  | Source: National Bank of Romania. Beginning with October 1, 2000, Regulation no. 2/2000 requires a monthly classification of loans and investments. The figures for December 2005 are calculated based on the prudential reports submitted by banks before the conclusion of banks’ balance sheet. International Monetary Fund (IMF), 2006. “Table 21. Romania: Commercial Banks’ Specific Provisions, 1995-2005.” Source in: “Romania: Selected Issues and Statistical Appendix.” IMF Country Report No. 06/169, IMF, Washington, DC.

National source  | Russia, 1998  | NPL as % of total loans  | Barisitz, S., 2004. “Table 2. Russia: Banking Sector-Related Indicators.” Source in: “Distorted Incentives Fading? The Evolution of the Russian Banking Sector since Perestroika, in Focus on European Economic Integration,” Österreichische Nationalbank Eurosystsem (ed.) Focus on European Economic Integration 1: 122-152.

National source  | Slovak Republic, 1998  | NPL as % of total loans  | Total non-performing balance and off-balance sheet assets in total assets. World Bank, 2001. “Table 1.2: Non-Performing Loans in Central and Eastern European Countries (Percent of total loans).” Source in: “Czech Republic - Enhancing the prospects for growth with fiscal stability - a public expenditure review (English).” World Bank Report No. 22114-CZ, World Bank, Washington, DC.

National source  | Slovenia, 1992  | NPL as % of total loans  | Total non-performing balance and off-balance sheet assets in total assets. World Bank, 2001. “Table 1.2: Non-Performing Loans in Central and Eastern European Countries (Percent of total loans).” Source in: “Czech Republic - Enhancing the prospects for growth with fiscal stability - a public expenditure review (English).” World Bank Report No. 22114-CZ, World Bank, Washington, DC.

National source  | South Korea, 1997  | Non-performing credit of commercial banks as % of total loans  | Non-performing credit includes bad credit and substandard credit. Substandard credit is the credit due to customers classified under doubtful credit but covers the collateralized portion. Bad credit includes credit classified as “Doubtful” or “Estimated Loss”. Doubtful Credit is that in excess of the portion collateralized to customers in arrears for more than six months, or to issuers of dishonored bills and checks, or to companies under court receivership. The Estimated Loss category is equivalent to customers in Doubtful Credit, but the loss has been realized. Source: BOK, Financial Supervisory Service. As sourced in: Kataoka, H., 2001. “Table 1b. Non-performing loans of Korean Commercial Banks (trillion KRW).” Source in: “Korean Banking Reform: Following the Asian Financial Crisis.” J. Jay Choi (ed.) Asian Financial Crisis Financial, Structural, and International Dimensions (International Finance
| National source | Year  | NPL as % of total loans | Source and Details |
|-----------------|-------|-------------------------|--------------------|
| Sweden          | 1991  | NPL as % of total loans | Bank of International Settlements (BIS), 1996. “Table VI.5: Non-performing loans as a percentage of total loans.” Source in: “Bank of International Settlements 67th Annual Report.” BIS, Basle, Switzerland. |
| Thailand        | 1997  | NPL as % of total loans | Jansen, K., 2001, “Table 4: Non-performing loans as a percentage of total loans of financial system.” Central Bank of Argentina Thailand, Financial Crisis and Monetary Policy.” Journal of the Asia Pacific Economy 6(1): 124-152. https://doi.org/10.1080/135478660020024567 |
| Togo            | 1993  | NPL as % of total loans | Overdue and doubtful credit (crédits en souffrance) as a percentage of total credit. Source: Banque Centrale des Etats de l’Afrique de l'Ouest (BCEAO). |
| Uganda          | 1994  | NPL as % of total loans | Source: Various issues of Bank of Uganda Quarterly and Annual Reports. The figures for non-performing loans are average ratios per bank. Nannyonjo, J., 2002. “Table 4.4 Commercial Bank Activities, 1993-2000.” Source in: “Financial Sector Reforms in Uganda (1990-2000): Interest rate spreads, market structure, bank performance and monetary policy.” Economic Studies No. 110, Göteborg: Kompendiet. ISBN: 91-88514-70-6. Retrieved from: http://hdl.handle.net/2077/2947 |
| Ukraine         | 1998  | NPL as % of total loans | Source: EBRD Transition Report, 1998; International Monetary Fund; Central Banks. Tang, H., Zoli, E., Klytchnikova, I., 2000. “Table 3. Soundness of the Banking Sector: Non-performing Loans.” Source in: “Banking crises in transition economies: fiscal costs and related issues (English).” Policy Research Working Paper No. 2484, World Bank, Washington, DC. |
| Venezuela (1991-1993) | NPL as % of total loans | Source: Central Bank of Venezuela, Ministry of Finance, IMF staff estimates. International Monetary Fund (IMF), 1996. “Chart 2. Venezuela Commercial Banks, Non-Performing Loan Portfolio.” Source in: “Venezuela—Recent Economic Developments.” IMF Country Report No. 96/157, IMF, Washington, DC. |
| Venezuela (1994-1996) | NPL as % of total loans | Sources: Superintendency of Banks and Financial Institutions; Central Bank of Venezuela; and Fund staff estimates. International Monetary Fund (IMF), 1999. “Table 7. Venezuela: Commercial Banks Indicators.” Source in: “Venezuela-Staff Report for the 1999 Article IV Consultation.” IMF Country Report No. 99/184, IMF, Washington, DC. |
| Venezuela (1997-1999) | NPL as % of total loans | Bank of International Settlements (BIS), 1996. “Table VI.5: Non-performing loans as a percentage of total loans.” Source in: “Bank of International Settlements 67th Annual Report.” BIS, Basle, Switzerland. |
| Vietnam (1997)  | NPL of 4 SOCBs as % of total loans | Kubo, K., 2006. “Table 10.3. Overdue loans of deposit money banks, 1989-2002.” Source in: “Repression of the Banking Sector in the Transition to a Market-based Economy: The Case of Vietnam.” Watanabe M. (eds) Recovering Financial Systems. IDE-JETRO. Palgrave Macmillan, London. |
National source Yemen Arab Republic, 1996 (Pre-2000) Problem loans as % of total loans Defined as nonperforming loan over 90 days in arrears. The large increase in 1996 reflects the introduction of the CBY’s own rigorous classification system rather than reliance on commercial banks reporting. International Monetary Fund (IMF), 1999. “Box 5. Features of the Banking Sector.” Source in: “Republic of Yemen-Staff Report for the 1998 Article IV Consultation, Review Under the Extended Arrangement, and Request for the Second Annual Arrangement Under the Enhanced Structural Adjustment Facility.” IMF Country Report No. 99/25, IMF, Washington, DC.

National source Yemen Arab Republic, 1996 (2000 onwards) NPL as % of total loans Source: Central Bank of Yemen. Data refers to all banks except the Housing Bank and CAC bank. International Monetary Fund (IMF), 2009. “Table 6. Republic of Yemen: Indicators of Banking System Financial Soundness, 2001–09” Source in: “Republic of Yemen—Staff Report for the 2009 Article IV Consultation.” IMF Country Report No. 09/296, IMF, Washington, DC.

Panel B. Data for pre-1990 crises

| Source | Crisis | Variable Name | Notes |
|--------|--------|---------------|-------|
| National source | Argentina, 1990, 1989 | NPL as % of total loans | Sources: Caprio and Klingebiel, 1996, “Table 7: Evaluating the Outcome of the Restructuring Exercises.” Source in: “Bank insolvencies: cross-country experience.” Washington: World Bank. Lindgren, Carl-Johan, Gillian García and Mathew I. Saal, 1996. “Table 2. Survey of Banking Problems: 1980-Spring 1996.” Source in: “Bank Soundness and Macroeconomic Policy.” Sheng, Andrew, 1996, “Table 1.5: Ratio of nonperforming loans to total loans, selected countries, 198090”. Source in: “Bank Restructuring: Lessons from the 1980s.” World Bank, Washington DC. |
| National source | Bangladesh, 1987 | NPL as % of total loans | NPLs of four banks accounting for 70 percent of total credit. Source: Sheng, Andrew, 1996. “Annex 1.1: Bank problems in the 1980s”. |
| National source | Benin, 1988 | NPL as % of total loans | Overdue and doubtful credit (credits en souffrance) as a percentage of total credit. Source: Banque Centrale des Etats de l'Afrique de l'Ouest (BCEAO). |
| National source | Cameroon, 1987 | NPL as % of total loans | Source: Lindgren, Carl-Johan, Gillian García and Mathew I. Saal, 1996. “Table 2: Survey of Banking Problems: 1980-Spring 1996.” Source in: “Bank Soundness and Macroeconomic Policy.” |
| National source | Colombia, 1981 | NPL as % of total loans | Source: Sheng, Andrew, 1996, “Table 1.5: Ratio of nonperforming loans to total loans, selected countries, 198090”. Source in: “Bank Restructuring: Lessons from the 1980s.” World Bank, Washington DC. |
| National source | Côte d’Ivoire, 1988 | NPL as % of total loans | Overdue and doubtful credit (credits en souffrance) as a percentage of total credit. Source: Banque Centrale des Etats de l'Afrique de l'Ouest (BCEAO). |
| National source | Ecuador, 1982 | NPL as % of total loans | Source: Sheng, Andrew, 1996. “Table 1.5: Ratio of nonperforming loans to total loans, selected countries, 198090.” Source in: “Bank Restructuring: Lessons from the 1980s.” World Bank, Washington DC. |
| National source | Country     | Year | NPL as % of total loans | Source |
|-----------------|-------------|------|-------------------------|--------|
| El Salvador,    | 1989        | NPL as % of total loans | Source: Lindgren, Carl-Johan, Gillian García and Mathew I. Saal, 1996. “Table 2: Survey of Banking Problems: 1980-Spring 1996.” Source in: “Bank Soundness and Macroeconomic Policy.” |
| Ghana, 1982     | NPL as % of total loans | NPLs of nongovernment borrower. Source: Lindgren, Carl-Johan, Gillian García and Mathew I. Saal, 1996. “Table 2: Survey of Banking Problems: 1980-Spring 1996.” Source in: “Bank Soundness and Macroeconomic Policy.” |
| Mali, 1987      | NPL as % of total loans | Overdue and doubtful credit (credits en souffrance) as a percentage of total credit. Source: Banque Centrale des Etats de l'Afrique de l'Ouest (BCEAO). |
| Mexico, 1981    | NPL as % of total loans | Source: Bank of International Settlements (BIS), 1995. [https://www.bis.org/publ/arpdf/archive/ar1995_en.pdf](https://www.bis.org/publ/arpdf/archive/ar1995_en.pdf). “Table VII.7: Non-performing loans as a percentage of total loans.” Source in “Bank for International Settlements 66th Annual Report.” BIS, Basle, Switzerland. |
| Niger, 1983     | NPL as % of total loans | Overdue and doubtful credit (credits en souffrance) as a percentage of total credit. Source: Banque Centrale des Etats de l'Afrique de l'Ouest (BCEAO). |
| Philippines, 1983 | NPL as % of total loans | Source: Sheng, Andrew, 1996. “Table 1.5: Ratio of nonperforming loans to total loans, selected countries, 1980-90.” Source in: “Bank Restructuring: Lessons from the 1980s.” World Bank, Washington DC. |
| Senegal, 1988   | NPL as % of total loans | Overdue and doubtful credit (credits en souffrance) as a percentage of total credit. Source: Banque Centrale des Etats de l'Afrique de l'Ouest (BCEAO). |
| Sri Lanka, 1989 | NPL as % of total loans | International Monetary Fund (IMF), 1999. “Sri Lanka: Recent Economic and Policy Developments.” IMF Staff Country Report No. 99/136. “Table 1: Sri Lanka: Indicators of Banking System Soundness, 1996-99”. |
| Thailand, 1983  | NPL as % of total loans | Bank of International Settlements (BIS), 1995. [https://www.bis.org/publ/arpdf/archive/ar1995_en.pdf](https://www.bis.org/publ/arpdf/archive/ar1995_en.pdf). “Table VII.7: Non-performing loans as a percentage of total loans.” Source in: “Bank of International Settlements Annual Report.” BIS, Basle, Switzerland |
| Turkey, 1982    | NPL as % of total loans | Sources: Caprio and Klingebiel, 1996, “Table 7: Evaluating the Outcome of the Restructuring Exercises”. “Bank insolvencies: cross-country experience.” Washington: World Bank. |
| United States, 1988 | NPL as % of total loans | Nonperforming loans (past due 90+ days plus nonaccrual) to total loans for all U.S. banks. Source: https://fred.stlouisfed.org/series/USNPTL. |
| Uruguay, 1981   | NPL as % of total loans | Source: Sheng, Andrew, 1996. “Table 1.5: Ratio of nonperforming loans to total loans, selected countries, 1980-90.” Source in: “Bank Restructuring: Lessons from the 1980s.” World Bank, Washington DC. |
| Dependent variable | Definition |
|--------------------|------------|
| Elevated NPLs      | Dummy variable that equals 1 if the peak NPL ratio is above 7 percent and zero otherwise. |
| Peak NPLs          | The absolute magnitude of the NPL ratio at its global maximum over the sample period. |
| Time to peak       | Defined as $t^{\text{peak}} - T$, where $T$ is the starting year of banking crisis in Laeven and Valencia (2018) and $t^{\text{peak}}$ is the year at which the NPL ratio reaches its global maximum. |
| Time to resolve    | Defined as $t^{\text{resolve}} - T$ where $t^{\text{resolve}} \geq t^{\text{peak}}$ is the first year after $t^{\text{peak}}$ where the NPL ratio is reduced below 7 percent. If there is no such year, then $t^{\text{resolve}} - T = 8$. |
| NPL resolution     | Dummy variable that equals 1 if the NPL ratio is reduced below 7 percent within 7 years after the banking crisis date and to zero otherwise. |
Figure B1. Contribution of NPLs to the NPL ratio

Panel A: Accumulation period

Panel B: Reduction period

Note: Panel A plots the contribution of the numerator of the NPL ratio (i.e. NPLs to total loans) to the NPL ratio during the accumulation period (from the start of the crisis to when the NPL ratio peaks). Panel B plots the contribution of the numerator of the NPL ratio (i.e. NPLs to total loans) to changes in the NPL ratio during the reduction period (from the NPL ratio peaks to when the ratio falls below 7 percent).
C. Local projections

Figure C1: NPL vulnerability and output dynamics

Panel A: Output path and predicted high NPLs vulnerability

Panel B: Output path and predicted NPL resolution vulnerability

Notes: Panel A (Panel B) plots the coefficients of the average real GDP (in logs, relative to the crisis year, multiplied by 100) in crises with predicted high NPLs (high NPL resolution likelihood) relative to crises with predicted low NPLs (low NPL resolution likelihood). The predictions are based on the model selection estimates of Section IV. The blue bars are the 90 percent confidence interval.
Figure C2: NPLs and output dynamics: robustness

Panel A: Output path and high NPLs outcome (5%)
Panel B: Output path and high NPLs outcome (10%)
Panel C: Output path and NPL resolution outcome (5%)
Panel D: Output path and NPL resolution outcome (10%)

Notes: Panel A and B plot the coefficients of the average real GDP (in logs, relative to the crisis year, multiplied by 100) in crises with high NPLs relative to crises with predicted low NPLs. High NPLs are defined as NPLs above 5 (10) percent of total loans in Panel A (Panel B). Panel C and D plot the coefficients of the average real GDP (in logs, relative to the crisis year, multiplied by 100) in crises with timely resolution relative to crises with untimely NPL resolution. Timely resolution is defined as NPL ratio falling under 5 (10) percent within 7 years after the crisis in Panel C (Panel D). The blue bars are the 90 percent confidence interval.
### D. Model selection

**Table D1: Crisis waves**

| Group                                             | Crises                                                                 |
|---------------------------------------------------|------------------------------------------------------------------------|
| Asian financial crisis (Asia)                     | China, 1998; Indonesia, 1997; Japan, 1997; Korea, 1997; Malaysia, 1997; Philippines, 1997; Thailand, 1997; Vietnam, 1997 |
| Asian financial crisis (non-Asia)                  | Croatia, 1998; Romania, 1998; Russia, 1998; Slovak Republic, 1998; Ukraine, 1998 |
| Global financial crisis (GFC)                      | Austria, 2008; Belgium, 2008; Cyprus, 2012; Denmark, 2008; France, 2008; Germany, 2008; Greece, 2008; Hungary, 2008; Iceland, 2008; Ireland, 2008; Italy, 2008; Kazakhstan, 2008; Latvia, 2008; Luxembourg, 2008; Mongolia, 2008; Netherlands, 2008; Nigeria, 2009; Portugal, 2008; Russia, 2008; Slovenia, 2008; Spain, 2008; Sweden, 2008; Switzerland, 2008; Ukraine, 2008; Ukraine 2014; United Kingdom, 2007; United States, 2007 |
| Low-income countries                              | Bolivia, 1994; Cape Verde, 1993; Haiti, 1994; Kenya, 1992; Moldova, 2014; Nicaragua, 1990; Nicaragua, 2000; Nigeria, 1991; Togo, 1993; Uganda, 1994; Yemen, 1996; Zambia, 1995; Zimbabwe, 1995 |
| Transition countries, EU accession                | Bulgaria, 1996; Czech Republic, 1996; Estonia, 1992; Hungary, 1991; Latvia, 1995; Lithuania, 1995; Poland, 1992; Slovenia, 1992 |
| Transition countries, non-accession               | Albania, 1994; Armenia, 1994; Azerbaijan, 1995; Belarus, 1995; Bosnia and Herzegovina, 1992; Georgia, 1991; Kyrgyz Republic, 1995; Macedonia, 1993 |
| Nordic                                            | Finland, 1991; Norway, 1991; Sweden, 1991 |
| Other                                             | Argentina, 1995; Argentina, 2001; Brazil, 1990; Colombia, 1998; Costa Rica, 1994; Dominican Republic, 2003; Ecuador, 1998; Eswatini, 1995; India, 1993; Jamaica, 1996; Lebanon, 1990; Mexico, 1994; Paraguay, 1995; Turkey, 2000; Uruguay, 2002; Venezuela, 1994 |

Notes: “Low-income countries” is defined according to the IMF’s list of Poverty Reduction and Growth Trust (PRGT) eligible countries (IMF, 2016).
### Table D2: Predictors used in model selection

| Variable name | Definition                                                                                                                                                                                                 | Source                        |
|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|
| Corporate current asset to liability ratio | Ratio of current assets to current liabilities.                                                                                                                                                           | IMF CVU                       |
| Corporate debt to asset ratio | Total debt to total asset ratio, where total debt is the sum of short-term debt, current portion of long-term debt, and long-term debt.                                                                  | IMF CVU                       |
| Corporate interest coverage ratio | Ratio of earnings before interest and taxes (EBIT) to interest expenses on debt.                                                                                                                                                     | IMF CVU                       |
| Corporate foreign assets as percent of total assets | Foreign assets as a share of total assets, where foreign assets represent the consolidated firm’s total or identifiable assets of foreign operations.                                                                 | IMF CVU                       |
| Corporate short-term debt as percent of total debt | Short term debt as a share of total debt, where total debt is the sum of short-term debt, current portion of long-term debt, and long-term debt.                                                                 | IMF CVU                       |
| Bank net interest margin | Accounting value of bank's net interest revenue as a share of its average interest-bearing (total earning) assets.                                                                                                                        | World Bank GFDD              |
| Bank noninterest income to total income | Bank’s income that has been generated by noninterest related activities as a percentage of total income (net-interest income plus noninterest income).                                                                                       | World Bank GFDD              |
| Bank return on assets | Commercial banks’ after-tax net income to yearly averaged total assets.                                                                                                                                                  | World Bank GFDD              |
| Bank return on equity | Commercial banks’ after-tax net income to yearly averaged equity.                                                                                                                                                   | World Bank GFDD              |
| Bank operating expenses as a share of net-interest | Operating expenses of a bank as a share of sum of net-interest revenue and other operating income.                                                                                                                                 | World Bank GFDD              |
| Bank concentration | Assets of three largest commercial banks as a share of total commercial banking assets. Total assets include total earning assets, cash and due from banks, foreclosed real estate, fixed assets, goodwill, other intangibles, current tax assets, deferred tax assets, discontinued operations and other assets. | World Bank GFDD              |
| Domestic credit to private sector | As a percentage of GDP. Domestic credit to private sector refers to financial resources provided to the private sector by financial corporations, such as through loans, purchases of nonequity securities, and trade credits and other accounts receivable, that establish a claim for repayment. For some countries these claims include credit to public enterprises. The financial corporations include monetary authorities and deposit money banks, as well as other financial corporations where data are available (including corporations that do not accept transferable deposits but do incur such liabilities as time and savings deposits). Examples of other financial corporations are finance and leasing companies, money lenders, insurance corporations, pension funds, and foreign exchange companies. | World Bank GFDD              |
| Gross government debt-to-GDP ratio | Debt is the entire stock of direct government fixed-term contractual obligations to others outstanding on a particular date. It includes domestic and foreign liabilities such as currency and money deposits, securities other than shares, and loans. It is the gross amount of government liabilities reduced by the amount of equity and financial derivatives held by the government. | IMF Historical Public Debt    |
| Indicator                                           | Description                                                                                                                                                                                                                                                                                                                                 | Source                                      |
|----------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|
| Unemployment rate                                  | Unemployment, total (percent of total labor force). Unemployment refers to the share of the labor force that is without work but available for and seeking employment.                                                                                                                                         | World Bank WDI                              |
| GDP per capita                                     | Constant 2010 USD, included only in pre-crisis and crisis duration.                                                                                                                                                                                                                                                                           | World Bank WDI                              |
| GDP growth                                         | Real GDP growth rate (annual percent) at market prices based on constant local currency. Aggregates are based on constant 2010 U.S. dollars.                                                                                                                                                                                                   | World Bank WDI, IMF IFS                    |
| Inflation rates                                    | Inflation as measured by the consumer price index reflects the annual percentage change in the cost to the average consumer of acquiring a basket of goods and services that may be fixed or changed at specified intervals, such as yearly. If World Bank data is missing, we use consumer inflation data from the World Economic Outlook (April 2018) | World Bank WDI                              |
| Exchange rate depreciation against USD             | Annual growth rate of the bilateral nominal exchange rate (percent) to USD. Positive values indicate a depreciation of the local currency.                                                                                                                                                                                                     | BIS                                         |
| Exchange rate peg                                  | Dummy variable that equals 1 if the country's exchange rate regime was either fixed peg or crawling peg at time t, equals 0 otherwise. Exchange rate regimes are based on the Ilzetzki, Reinhart, and Rogoff classification.                                                                                                                             | Ilzettski, Reinhart & Rogoff (2017)         |
| Exchange rate regime change                        | Dummy variable that equals one if the exchange rate peg variable changed in the five years before the Laeven-Valencia crisis date.                                                                                                                                                                                                         | Ilzettski, Reinhart & Rogoff (2017)         |
| Nominal effective exchange rate depreciation*      | Annual growth rate of the nominal effective exchange rate, which measures the value of the local currency against a trade-weighted average of foreign currencies. Positive values indicate a depreciation of the local currency.                                                                                                           | IMF IFS                                     |
| Real effective exchange rate depreciation*         | Annual growth rate of the real effective exchange rate, which corresponds to the nominal effective exchange rate divided by a price deflator. Positive values indicate a depreciation of the local currency.                                                                                                                    | IMF IFS                                     |
| Foreign bank share*                                | Number of foreign owned banks divided by total number of banks.                                                                -------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------| Claessens & Van Horen (2015)                |
| Regulatory quality*                                | Perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development.                                                                                                                                                                      | World Bank WGI                              |
| Government effectiveness*                          | Perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.                                                                 100%                                        |
| Rule of law*                                       | Perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence.                                                                                                          | World Bank WGI                              |
| Countercyclical capital buffer*                    | A requirement for banks to maintain a countercyclical capital buffer. Equals one if tightened, minus one if loosened, and zero if no change in policy.                                                                                                                                                                                                 | IMF iMaPP                                   |

1 We are unable to use asset-weighted shares due to lack of available data for banking crises prior to 2005.
| **Capital conservation buffer*** | Requirements for banks to maintain a capital conservation buffer, including the one established under Basel III. Equals one if tightened, minus one if loosened, and zero if no change in policy. | IMF iMaPP |
|-------------------------------|-------------------------------------------------------------------------------|-----------|
| **Capital requirements***     | Capital requirements for banks, which include risk weights, systemic risk buffers, and minimum capital requirements, but exclude countercyclical capital buffers and capital conservation. Equals one if tightened, minus one if loosened, and zero if no change in policy. | IMF iMaPP |
| **Capital requirements:**     | Subcategory of capital requirements targeting the household sector. Equals one if tightened, minus one if loosened, and zero if no change in policy. | IMF iMaPP |
| **Households targeted***     | Subcategory of capital requirements targeting the corporate sector. Equals one if tightened, minus one if loosened, and zero if no change in policy. | IMF iMaPP |
| **Capital requirements:**     | Subcategory of capital requirements that are broad-based. Equals one if tightened, minus one if loosened, and zero if no change in policy. | IMF iMaPP |
| **Corporate sector targeted*** | Subcategory of capital requirements targeting the FX loans. Equals one if tightened, minus one if loosened, and zero if no change in policy. | IMF iMaPP |
| **Leverage limits***         | A limit on leverage of banks, calculated by dividing a measure of capital by the bank’s non-risk-weighted exposures (e.g., Basel III leverage ratio). Equals one if tightened, minus one if loosened, and zero if no change in policy. | IMF iMaPP |
| **Loan loss provision requirements*** | Loan loss provision requirements for macroprudential purposes, which include dynamic provisioning and sectoral provisions (e.g. housing loans). Equals one if tightened, minus one if loosened, and zero if no change in policy. | IMF iMaPP |
| **Limits on credit growth*** | Limits on growth or the volume of aggregate credit, the household-sector credit, or the corporate-sector credit by banks, and penalties for high credit growth. Equals one if tightened, minus one if loosened, and zero if no change in policy. | IMF iMaPP |
| **Limits on credit growth:**  | Subcategory of limits on credit growth that are broad based. Equals one if tightened, minus one if loosened, and zero if no change in policy. | IMF iMaPP |
| **General***                 | Subcategory of limits on credit growth targeting household sector credit. Equals one if tightened, minus one if loosened, and zero if no change in policy. | IMF iMaPP |
| **Limits on credit growth:**  | Subcategory of limits on credit growth targeting corporate sector credit. Equals one if tightened, minus one if loosened, and zero if no change in policy. | IMF iMaPP |
| **Corporate sector targeted*** | Subcategory of loan restrictions targeting loans to households. Equals one if tightened, minus one if loosened, and zero if no change in policy. | IMF iMaPP |
| **Loan restrictions***       | Loan restrictions, that are more tailored than those captured in limits on credit growth. They include loan limits and prohibitions, which may be conditioned on loan characteristics (e.g., the maturity, the size, the LTV ratio and the type of interest rate of loans), bank characteristics (e.g., mortgage banks), and other factors. Equals one if tightened, minus one if loosened, and zero if no change in policy. | IMF iMaPP |
| **Loan restrictions:**       | Subcategory of loan restrictions targeting loans to the corporate sector. Equals one if tightened, minus one if loosened, and zero if no change in policy. | IMF iMaPP |
| Limits on foreign currency lending* | Limits on foreign currency lending, and rules or recommendations on foreign currency loans. Equals one if tightened, minus one if loosened, and zero if no change in policy. | IMF iMaPP |
|-----------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| Loan-to-value ratio*              | Limits to the loan-to-value ratios, including those mostly targeted at housing loans, but also includes those targeted at automobile loans, and commercial real estate loans. Equals one if tightened, minus one if loosened, and zero if no change in policy. | IMF iMaPP |
| Loan-to-income ratio*             | Limits to the debt-service-to-income ratio and the loan-to-income ratio, which restrict the size of debt services or debt relative to income. They include those targeted at housing loans, consumer loans, and commercial real estate loans. Equals one if tightened, minus one if loosened, and zero if no change in policy. | IMF iMaPP |
| Tax measures*                    | Taxes and levies applied to specified transactions, assets, or liabilities, which include stamp duties, and capital gain taxes. Equals one if tightened, minus one if loosened, and zero if no change in policy. | IMF iMaPP |
| Liquidity requirements*          | Measures taken to mitigate systemic liquidity and funding risks, including minimum requirements for liquidity coverage ratios, liquid asset ratios, net stable funding ratios, core funding ratios and external debt restrictions that do not distinguish currencies. Equals one if tightened, minus one if loosened, and zero if no change in policy. | IMF iMaPP |
| Loan-to-deposit ratio*           | Limits to the loan-to-deposit (LTD) ratio and penalties for high LTD ratios. Equals one if tightened, minus one if loosened, and zero if no change in policy. | IMF iMaPP |
| Limits on FX positions*          | Limits on net or gross open foreign exchange (FX) positions, limits on FX exposures and FX funding, and currency mismatch regulations. Equals one if tightened, minus one if loosened, and zero if no change in policy. | IMF iMaPP |
| Reserve requirements*            | Reserve requirements (domestic or foreign currency) for macroprudential purposes. Equals one if tightened, minus one if loosened, and zero if no change in policy. | IMF iMaPP |
| Reserve requirements: foreign currency differentiated* | Subcategory of reserve requirements differentiated by currency. Equals one if tightened, minus one if loosened, and zero if no change in policy. | IMF iMaPP |
| Measures targeting systemic banks* | Measures taken to mitigate risks from global and domestic systemically important financial institutions (SIFIs), which includes capital and liquidity surcharges. Equals one if tightened, minus one if loosened, and zero if no change in policy. | IMF iMaPP |
| Other macroprudential measures*  | Macroprudential measures not captured in the above categories—e.g., stress testing, restrictions on profit distribution, and structural measures (e.g., limits on exposures between financial institutions). Equals one if tightened, minus one if loosened, and zero if no change in policy. | IMF iMaPP |
| Macroprudential tightening*      | Overall macroprudential stance as captured by the sum of the above variables from IMF iMaPP, excluding subcategories. Positive values pertain to macroprudential tightening. | IMF iMaPP |

Note: CVU is IMF’s Corporate Vulnerability Utilities data. IFS is IMF’s International Financial Statistics data. iMaPP is IMF’s integrated Macroprudential Policy database, originally constructed by Alam et al. (2019). GFDD is World Bank’s Global Financial Development Database. WGI is World Bank’s World Governance Indicators. * denotes predictors only used in the extended specifications in Appendix Table D6.
| Specification          | List of candidate predictors                                                                                                                                                                                                 | Number of observations |
|------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
| Macroeconomic conditions | Exchange rate regime change, exchange rate peg, GDP per capita, GDP growth, inflation rate, exchange rate depreciation against USD, gross government debt-to-GDP ratio, change in gross government debt-to-GDP ratio, domestic credit to private sector, change in domestic credit to private sector, unemployment rate, change in unemployment rate. | 43-59                  |
| Banking sector conditions | Everything in the baseline specification, bank concentration, change in bank concentration, bank return on assets, bank return on equity, bank operating expenses as a share of net-interest, bank noninterest income to total income, bank net interest margin | 29-43                  |
| Corporate conditions   | Everything in the baseline specification, corporate current asset to liability ratio, corporate debt to asset ratio, corporate EBIT to total interest expense ratio, corporate foreign assets as percent of total assets, corporate short-term debt as percent of total debt | 23-35                  |

Note: Number of observations vary due to changes in the dependent variable (see Table A1) and missing values for independent variables. “Change” in a variable refers to cumulative change between $T - 5$ and $T - 1$ where $T$ is the banking crisis date.
### Table D4: Model selection with crisis wave fixed effects

#### Panel A: High NPL probability

| Specification | (1) | (2) | (3) |
|---------------|-----|-----|-----|
| Dependent variable: Elevated NPLs dummy (Peak NPL > 7%) | Macro | Bank | Corporate |
| GDP per capita | -6.697** | -9.588* | GDP growth |
| Exchange rate depreciation against USD | 4.246** | Government debt-to-GDP ratio (gross) |
| Bank return on assets | -4.449** | Corporate short-term debt (as % of total debt) |
| No. of observations | 59 | 43 | 35 |
| Log likelihood | -5.85 | n.a. | n.a. |
| Adj. Pseudo R² | 0.602 | n.a. | n.a. |

#### Panel B: Peak NPLs

| Specification | (1) | (2) | (3) |
|---------------|-----|-----|-----|
| Dependent variable: Peak NPL ratio (% of total loans) | Macro | Bank | Corporate |
| GDP per capita | -6.697** | -9.588* | GDP growth |
| Exchange rate depreciation against USD | 4.246** | Government debt-to-GDP ratio (gross) |
| Bank return on assets | -4.449** | Corporate short-term debt (as % of total debt) |
| No. of observations | 47 | 32 | 24 |
| R² | 0.393 | 0.430 | 0.316 |
| Adj. R² | 0.245 | 0.293 | 0.127 |

#### Panel C: Time to peak

| Specification | (1) | (2) | (3) |
|---------------|-----|-----|-----|
| Dependent variable: Time to peak | Macro | Bank | Corporate |
| GDP growth | -0.856*** | | |
| Government debt-to-GDP ratio (gross) | 0.786*** |
| Corporate short-term debt (as % of total debt) | 3.704* |
| No. of observations | 47 | 32 | 24 |
| Log likelihood | -87.85 | -46.96 | -34.67 |
| Adj. Pseudo R² | 0.036 | 0.165 | 0.190 |
Table D4: Model selection with crisis wave fixed effects (cont’)

### Panel D: Time to resolve

| Dependent variable: | Specification (1) | Specification (2) | Specification (3) |
|---------------------|-------------------|-------------------|-------------------|
| Time to resolve     | Macro | Bank | Corporate | Macro | Bank | Corporate |
| Inflation rate      | 0.319* (0.177)    |                   |                   |
| Government debt-to-GDP ratio (gross) | 1.115*** (0.367) |                   |                   |
| Change in domestic credit to private sector | 0.975** (0.416) | 1.507*** (0.443) |                   |

| No. of observations | 43 | 29 | 23 |
| Log likelihood      | -75.28 | -42.08 | -32.53 |
| Adj. Pseudo R²      | 0.034 | 0.002 | 0.102 |

### Panel E: NPL resolution probability

| Dependent variable: | Specification (1) | Specification (2) | Specification (3) |
|---------------------|-------------------|-------------------|-------------------|
| NPL resolution dummy | Macro | Bank | Corporate | Macro | Bank | Corporate |
| GDP growth          | 0.249*** (0.068)  |                   |                   |
| Change in unemployment rate | 0.185** (0.077) | 0.161*** (0.045) |                   |
| Exchange rate depreciation against USD | 0.460*** (0.157) |                   |                   |
| Government debt-to-GDP ratio (gross) | -0.250** (0.121) |                   |                   |
| Change in government debt-to-GDP ratio (gross) | -0.234*** (0.082) |                   |                   |
| Change in domestic credit to private sector | -0.252*** (0.089) | -0.278* (0.159) |                   |
| Bank noninterest income to total income ratio | 0.274*** (0.071) |                   |                   |
| Corporate current asset to liability ratio | -0.155*** (0.060) |                   |                   |

| No. of observations | 44 | 30 | 24 |
| Log likelihood      | -15.23 | -8.08 | -6.14 |
| Adj. Pseudo R²      | 0.106 | 0.217 | 0.086 |

Notes: Robust standard errors are in parentheses. ***, ** and * respectively indicate 1, 5 and 10 percent significance levels. Panel A is based on observations from the whole sample of banking crises for which sufficient data on NPL dynamics and candidate predictors are available. Panels B-E are based on the subset of crises with elevated NPLs (i.e. peak NPL ratio in excess of 7%). Predictors are selected using the post-r-lasso estimator (Belloni et al., 2012; Belloni & Chernozhukov, 2013). For the second step estimates, Panels A, E report results from logistic regressions and C, D report results from Tobit regressions. The coefficients reported in these panels correspond to marginal effects. Panel B reports OLS results. Change refers to cumulative change over the 5 years prior to the banking crisis. All other variables represent average values over the same period. Crisis wave fixed effects are specified in Appendix Table D1. Coefficients for intercepts, country group dummies and statistically insignificant predictors are not reported. Specifications (2) and (3) in Panel A are not reported as the selected predictors lead to a perfect fit which precludes the computation of standard errors. Adjusted Pseudo R² values are calculated according to McFadden (1974). See Appendix Tables B2, D2, and D3 for variable definitions, data sources and further details on specifications.
### Table D5: Model selection with alternative definitions

| Panel A: High NPL probability | Panel B: Peak NPLs | Panel C: Time to peak |
|--------------------------------|-------------------|-----------------------|
| **Dependent variable:** Elevated NPLs dummy (Peak NPL > 5%) | **Dependent variable:** Peak NPL ratio (relative to NPL ratio at crisis date) | **Dependent variable:** Time to peak (relative to first year with NPL > 7%) |
| Specification | Specification | Specification |
| (1) Macro | (1) Macro | (1) Macro |
| (2) Bank | (2) Bank | (2) Bank |
| (3) Corporate | (3) Corporate | (3) Corporate |

| GDP per capita | Exchange rate depreciation against USD | Exchange rate peg |
|----------------|----------------------------------------|-------------------|
| -0.154*** (0.019) | -0.895* (0.502) | 1.475** (0.660) |
| -0.134*** (0.033) | | 1.970** (0.906) |

| Change in domestic credit to private sector | | |
|--------------------------------------------|------------------|------------------|
| 0.060** (0.025) | | |
| 0.055* (0.030) | | |

| Change in unemployment rate | | |
|-----------------------------|------------------|------------------|
| 0.072* (0.042) | | |

| Bank operating expenses as a share of net interest | | |
|----------------------------------------------------|------------------|------------------|
| -0.077*** (0.025) | | |

| No. of observations | 59 | 43 | 35 |
|---------------------|----|----|----|
| Log likelihood      | -9.63 | -4.60 | n.a. |
| Adj. Pseudo R²      | 0.459 | 0.520 | n.a. |

| No. of observations | 47 | 32 | 24 |
|---------------------|----|----|----|
| R²                  | 0.030 | 0.167 | 0.183 |
| Adj. R²             | 0.009 | 0.078 | 0.106 |

| No. of observations | 47 | 32 | 24 |
|---------------------|----|----|----|
| Log likelihood      | -99.77 | -66.27 | -51.70 |
| Adj. Pseudo R²      | 0.016 | -0.003 | 0.019 |
### Table D5: Model selection with alternative definitions (cont’)

#### Panel D: Time to resolve

| Specification | Macro | Bank | Corporate |
|---------------|-------|------|-----------|
| (1)           |       |      |           |
| (2)           |       |      |           |
| (3)           |       |      |           |

| Dependent variable: | Time to resolve (relative to first year with NPL > 7%) |
|---------------------|-------------------------------------------------------|
| Exchange rate peg   | 1.984* (1.050)                                        |
| Bank operating expenses as a share of net-interest | -0.686** (0.358)                                        |

| No. of observations | 46 | 32 | 24 |
|---------------------|----|----|----|
| Log likelihood      | -104.30 | -69.25 | -52.29 |
| Adj. Pseudo R²      | 0.000 | 0.006 | 0.008 |

#### Panel E: NPL resolution probability

| Specification | Macro | Bank | Corporate |
|---------------|-------|------|-----------|
| (1)           |       |      |           |
| (2)           |       |      |           |
| (3)           |       |      |           |

| Dependent variable: | NPL resolution dummy (=1 if NPL 7 years after crisis date below 25% of peak NPL) |
|---------------------|--------------------------------------------------------------------------------|
| Exchange rate peg   | -0.214* (0.124)                                                                 |
| Change in government debt-to-GDP ratio (gross) | -0.132*** (0.047)                                                        |
| Change in domestic credit to private sector | -0.260*** (0.066) |

| No. of observations | 44 | 30 | 24 |
|---------------------|----|----|----|
| Log likelihood      | -15.96 | n.a. | n.a. |
| Adj. Pseudo R²      | 0.252 | n.a. | n.a. |

Notes: Robust standard errors are in parentheses. ***, ** and * respectively indicate 1, 5 and 10 percent significance levels. Panel A is based on observations from the whole sample of banking crises for which sufficient data on NPL dynamics and candidate predictors are available. Panels B-E are based on the subset of crises with elevated NPLs (i.e. peak NPL ratio in excess of 7%). Predictors are selected using the post-r-lasso estimator (Belloni et al., 2012; Belloni & Chernozhukov, 2013). For the second step estimates, Panels A, E report results from logistic regressions and C, D report results from Tobit regressions. The coefficients reported in these panels correspond to marginal effects. Panel B reports OLS results. Change refers to cumulative change over the 5 years prior to the banking crisis. All other variables represent average values over the same period. Coefficients for intercepts and statistically insignificant predictors are not reported. Specification (3) in Panel A and specifications (2) and (3) in Panel E are not reported as the selected predictors lead to a perfect fit which precludes the computation of standard errors Adjusted Pseudo R² values are calculated according to McFadden (1974). See Appendix Tables B2, D2 and D3 for variable definitions, data sources and further details on specifications.
Table D6: Model selection results with additional candidate predictors

Panel A: Macro specification with nominal and real effective exchange rates

| Dependent variable | (1) | (2) | (3) | (4) | (5) |
|--------------------|-----|-----|-----|-----|-----|
| Elevated NPLs dummy (Peak NPLs>7%) | GDP per capita | -0.295*** (0.0335) | | | |
| Peak NPLs (% of total loans) | Change in unemployment rate | 0.127*** (0.043) | | | |
| Time to peak | Nominal effective exchange rate depreciation | -1.814*** (0.642) | -3.246** (1.448) | 0.737*** (0.273) | |
| Time to resolve | Domestic credit to private sector | 0.564* (0.284) | | | |
| NPL resolution dummy | Change in domestic credit to private sector | 0.761* (0.383) | 0.790** (0.290) | -0.141* (0.077) | |
| Change in government debt-to-GDP ratio (gross) | | 2.969* (1.555) | | | |
| Government debt-to-GDP ratio (gross) | | | 1.373** (0.545) | 0.801** (0.347) | |
| No. of observations | 41 | 30 | 30 | 26 | 27 |
| Log likelihood | | -8.24 | -51.65 | -34.64 | -11.13 |
| Adj. Pseudo R² | | 0.529 | 0.114 | 0.167 | 0.238 |
| R² | | 0.045 | | | |
| Adj. R² | | 0.011 | | | |

**Note:** Table includes coefficients with standard errors in parentheses. Levels of significance are indicated as follows: **p < 0.01, *p < 0.05, ***p < 0.001.
### Table D6: Model selection results with additional candidate predictors (cont’)

#### Panel B: Bank specification with foreign bank share

| Dependent variable: | (1) Elevated NPLs dummy (Peak NPLs>7%) | (2) Peak NPLs (% of total loans) | (3) Time to peak | (4) Time to resolve | (5) NPL resolution dummy |
|---------------------|----------------------------------------|---------------------------------|-----------------|-------------------|------------------------|
| GDP per capita       | 1.518***                               |                                 |                 |                   |                        |
|                      | (0.546)                                |                                 |                 |                   |                        |
| Change in unemployment rate | 0.123**                                |                                 |                 |                   |                        |
|                      | (0.0601)                               |                                 |                 |                   |                        |
| Change in domestic credit to private sector | 0.557*                                 | 1.003***                        |                 |                   |                        |
|                      | (0.313)                                | (0.299)                         |                 |                   |                        |
| Government debt-to-GDP ratio (gross) | 0.620**                                |                                 |                 |                   |                        |
|                      | (0.269)                                |                                 |                 |                   |                        |
| Bank return on assets | -4.928*                                |                                 |                 |                   |                        |
|                      | (2.285)                                |                                 |                 |                   |                        |
| Bank noninterest income to total income ratio |                                     |                                 |                 |                   | 0.156***               |
|                      |                                         |                                 |                 |                   | (0.0479)               |
| Foreign bank share   |                                         |                                 |                 |                   | -0.185***              |
|                      |                                         |                                 |                 |                   | (0.054)                |
| No. of observations | 43                                      | 32                              | 32              | 29                | 30                     |
| Log likelihood       | n.a                                     | -56.74                          | -45.10          | -8.93             |                        |
| Adj. Pseudo R²       | n.a                                     | 0.094                           | 0.060           | 0.273             |                        |
| R²                   | n.a                                     | 0.180                           |                 |                   |                        |
| Adj. R²              | 0.123                                   |                                 |                 |                   |                        |
Table D6: Model selection results with additional candidate predictors (cont’)

Panel C: Macro specification with institutional indicators

| Dependent variable: | (1) | (2) | (3) | (4) | (5) |
|---------------------|-----|-----|-----|-----|-----|
| Elevated NPLs dummy (Peak NPLs>7%) | | | | | |
| Peak NPLs (% of total loans) | | | | | |
| Time to peak | | | | | |
| Time to resolve | | | | | |
| NPL resolution dummy | | | | | |
| Government effectiveness | -0.176*** | | | | |
| (0.030) | | | | | |
| Change in unemployment rate | | | 0.127** | | |
| (0.053) | | | | | |
| Change in domestic credit to private sector | 0.0470*** | | 1.090*** | -0.188*** | |
| (0.015) | | | (0.294) | (0.072) | |
| Government debt-to-GDP ratio (gross) | | 0.492* | | | |
| (0.280) | | | | | |
| No. of observations | 43 | 32 | 32 | 29 | 30 |
| Log likelihood | -4.65 | | -55.95 | -45.87 | -12.60 |
| Adj. Pseudo R² | 0.646 | | 0.076 | 0.045 | 0.191 |
| R² | | | | | |
| Adj. R² | n.a. | | n.a. | | |
| Adj. R² | n.a. | | n.a. | | |
Table D6: Model selection results with additional candidate predictors (cont’)

**Panel D: Macro specification with macroprudential policy measures**

| Dependent variable: | (1) Elevated NPLs dummy (Peak NPLs>7%) | (2) Peak NPLs (% of total loans) | (3) Time to peak | (4) Time to resolve | (5) NPL resolution dummy |
|---------------------|--------------------------------------|---------------------------------|-----------------|-------------------|------------------------|
| GDP per capita       | -3.024*** (0.668)                    |                                 |                 |                   |                        |
| Exchange rate peg    | 1.660** (0.722)                      | -0.703** (0.264)                | 1.039* (0.553)  |                   |                        |
| Change in unemployment rate |                     | -0.703** (0.264)                | 1.039* (0.553)  |                   |                        |
| Change in domestic credit to private sector | -1.308** (0.620) | 0.939** (0.348)                |                 |                   |                        |
| Government debt-to-GDP ratio (gross) |                     |                                 |                 |                   |                        |
| Change in government debt-to-GDP ratio (gross) | -1.764*** (0.631) |                                 |                 |                   |                        |

| No. of observations | 52 | 42 | 42 | 38 | 30 |
|---------------------|----|----|----|----|----|
| Log likelihood      | -9.93 | -85.74 | -64.18 | -13.49 |
| Adj. Pseudo R²      | 0.478 | 0.009 | 0.096 | 0.148 |
| R²                  | 0.220 | 0.096 | 0.096 | 0.148 |

Notes: Robust standard errors are in parentheses. ***, ** and * respectively indicate 1, 5 and 10 percent significance levels. Specification (1) is based on observations from the whole sample of banking crises for which sufficient data on NPL dynamics and candidate predictors are available. Panels (2)-(5) are based on the subset of crises with elevated NPLs (i.e. peak NPL ratio over 7 percent). Predictors are selected using the post-r-lasso estimator (Belloni et al., 2012; Belloni and Chernozhukov, 2013). For the second step estimates, specifications (1) and (5) report results from logistic regressions and (2) and (3) report results from Tobit regressions. The coefficients reported in these specifications correspond to marginal effects. Specification (2) B reports OLS results. Change refers to cumulative change over the 5 years prior to the banking crisis. All other variables represent average values over the same period. The institutional indicators included in Panel D are regulatory quality, government effectiveness and rule of law. Panel E includes a broad range of macroprudential policy measures from the IMF iMaPP database (see Appendix Table D2). Coefficients for intercepts and statistically insignificant predictors are not reported. Specification (1) in Panel C and specification (2) in Panel D are not reported as the selected predictors lead to a perfect fit which precludes the computation of standard errors. Adjusted Pseudo R² values are calculated according to McFadden (1974). See Appendix Tables B2, D2, and D3 for variable definitions, data sources and further details on specifications.
### Table D7: Model selection results with interaction effects

#### Panel A: Probability of elevated NPLs

| Dependent variable: Elevated NPLs dummy (Peak NPLs > 7%) | Specification |
|--------------------------------------------------------|---------------|
| | (1) | (2) | (3) |
| | Macro | Bank | Corporate |
| GDP per capita * | -0.139*** | | |
| AE dummy | (0.032) | | |
| Change in unemployment rate | 0.0406* | | |
| * AE dummy | (0.021) | | |
| No. of observations | 59 | 43 | 35 |
| Log likelihood | -13.52 | n.a. | n.a. |
| Adj. Pseudo R² | 0.412 | n.a. | n.a. |

#### Panel B: Peak NPLs

| Dependent variable: Peak NPLs (% of total loans) | Specification |
|-------------------------------------------------|---------------|
| | (1) | (2) | (3) |
| | Macro | Bank | Corporate |
| Bank return on assets | -5.050** | | |
| | (2.212) | | |
| Corporate short-term debt | 4.019* | | |
| (as % of total debt) | | | |
| | (2.190) | | |
| No. of observations | 47 | 32 | 24 |
| R² | 0.194 | 0.142 | 0.209 |
| Adj. R² | 0.138 | 0.113 | 0.134 |
Table D7: Model selection results with interaction effects (cont’)

| Panel C: Time to peak | Specification | Panel D: Time to resolve | Specification |
|-----------------------|---------------|--------------------------|---------------|
| Dependent variable:   |               |                          |               |
| Time to peak          |               |                          |               |
|                       | (1)           | (2)                      | (3)           |
|                       | Macro         | Bank                     | Corporate     |
| Unemployment rate     | 1.058**       | 0.856***                 |               |
| * AE dummy            | (0.412)       | (0.273)                  |               |
| Exchange rate peg     | 1.329*        |                          |               |
|                       | (0.744)       |                          |               |
| Exchange rate depreciation against USD | -0.653**     |                          |               |
|                       | (0.310)       |                          |               |
| Government debt-to-GDP ratio (gross) | 0.718***    |                          |               |
|                       | (0.220)       |                          |               |
| Government debt-to-GDP ratio (gross) * AE dummy | 1.064***     | 0.668**                  |               |
|                       | (0.287)       | (0.270)                  |               |
| Change in domestic credit to private sector * AE dummy | 0.432**     |                          |               |
|                       | (0.195)       |                          |               |
| Corporate short-term debt (as % of total debt) | -0.532*       |                          |               |
|                       | (0.285)       |                          |               |
| No. of observations   | 47            | 32                       | 24            |
| Log likelihood        | -92.84        | -50.50                   | -35.59        |
| Adj. Pseudo R²        | 0.046         | 0.202                    | 0.231         |

Change in unemployment rate * AE dummy: -0.508* (0.255)

Government debt-to-GDP ratio (gross): 1.158*** (0.398)

Government debt-to-GDP ratio (gross) * AE dummy: 0.554** (0.264)

Change in domestic credit to private sector: 1.152*** (0.356), 0.819** (0.377), 1.573*** (0.416)

No. of observations: 43, 29, 23

Log likelihood: -77.45, -44.16, -34.26

Adj. Pseudo R²: 0.044, 0.020, 0.085
### Table D7: Model selection results with interaction effects (cont’)

#### Panel E: NPL resolution probability

| Dependent variable: NPL resolution dummy | Specification | (1) | (2) | (3) |
|----------------------------------------|---------------|-----|-----|-----|
|                                        |               | Macro | Bank | Corporate |
| GDP growth                             | 0.110***      |       | (0.040) |       |
|                                        |               |       |       |       |
| Change in unemployment rate            | 0.116**       |       | 0.114*** |       |
|                                        |               |       | (0.050) | (0.041) |
| Exchange rate                          |               |       | 0.338*** |       |
| depreciation against USD               |               |       | (0.093) |       |
| Government debt-to-GDP ratio (gross)   |               |       | -0.154*** | (0.058) |
|                                        |               |       |       |       |
| Change in government debt-to-GDP ratio (gross) | -0.176*** |       | (0.047) |       |
|                                        |               |       |       |       |
| Change in domestic credit to private sector | -0.264*** |       | (0.044) |       |
|                                        |               |       |       |       |
| Bank noninterest income to total income ratio | 0.211*** |       | (0.059) |       |
|                                        |               |       |       |       |
| Corporate current asset to liability ratio | -0.140*** |       | (0.046) |       |
|                                        |               |       |       |       |
| No. of observations                    | 44            | 30   | 24   |       |
| Log likelihood                         | -9.71         | -12.54 | -7.96 |       |
| Adj. Pseudo R²                         | 0.284         | 0.145 | 0.157 |       |

Notes: Robust standard errors are in parentheses. ***, ** and * respectively indicate 1, 5 and 10 percent significance levels. Panel A is based on observations from the whole sample of banking crises for which sufficient data on NPL dynamics and candidate predictors are available. Panels B-E are based on the subset of crises with elevated NPLs (i.e. peak NPL ratio in excess of 7%). Predictors are selected using the post-r-lasso estimator (Belloni et al., 2012; Belloni & Chernozhukov, 2013). For the second step estimates, Panels A, E report results from logistic regressions and C, D report results from Tobit regressions. The coefficients reported in these panels correspond to marginal effects. Panel B reports OLS results. Change refers to cumulative change over the 5 years prior to the banking crisis. All other variables represent average values over the same period. Advanced economies (AE) are defined according to IMF WEO classifications. Coefficients for intercepts and statistically insignificant predictors are not reported. Specifications (2) and (3) in Panel A not reported as the selected predictors lead to a perfect fit which precludes the computation of standard errors Adjusted Pseudo R² values are calculated according to McFadden (1974). See Appendix Tables B2, D2 and D3 for variable definitions, data sources and further details on specifications.
E. NPL vulnerabilities after COVID-19

Figure E1. Economic and NPL Risks of COVID-19 across Groups of Countries –

Panel A. Peak NPLs

Panel B. NPL time-to-peak

Panel C. NPLs time-to-resolve

Panel D. Probability of timely NPL resolution
Figure E2. Economic and NPL Risks of COVID-19 across Groups of Countries – Corporate Specification

Panel A. Peak NPLs

Panel B. NPL time-to-peak

Panel C. NPLs time-to-resolve

Panel D. Probability of timely NPL resolution
Appendix References

Adebola, S. S., Wan Yusoff, W. S. B., and J. Dahalan, 2011, An ARDL approach to the determinants of nonperforming loans in Islamic banking system in Malaysia. Kuwait Chapter of Arabian Journal of Business and Management Review, 33(830), 1-11.

Alam, Zohair, Adrian Alter, Jesse Eiseman, Gaston Gelos, Heedon Kang, Machiko Narita, Erlend Nier, and Naixi Wang, 2019. "Digging Deeper – Evidence on the Effects of Macroprudential Policies from a New Database", IMF Working Paper No. 19/66.

Baboucek, Ivan and Martin Jancar, 2005. “Effects of Macroeconomic Shocks to the Quality of the Aggregate Loan Portfolio,” Working Papers 2005/01, Czech National Bank.

Balgova, Marta, Alexander Plekhanov, and Marta Skrzypinska, 2017, “Reducing non-performing loans: Stylized facts and economic impact,” mimeo.

Beck, R., Jakubik, P., and Piloiu, A., 2013, “Non-performing loans: what matters in addition to the economic cycle?” European Central Bank Working Paper Series 1515.

Belloni, Alexandre, Daniel Chen, Victor Chernozhukov, and Christian Hansen, 2012, “Sparse Models and Methods for Optimal Instruments with An Application to Eminent Domain”, Econometrica, 80(6): 2369-2429.

Belloni, Alexandre, and Victor Chernozhukov, 2013, “Least Squares After Model Selection in High-Dimensional Sparse Models”, Bernoulli, 19(2): 521–547.

Berger, Allen N., and Robert DeYoung, 1997, “Problem loans and cost efficiency in commercial banks,” Journal of Banking and Finance, 21(6): 849-870.

Bhattacharya, Kaushik, 2003, “How good is the BankScope database? A cross-validation exercise with correction factors for market concentration measures.” BIS Working Paper 133.

Bofondi, Marcello and Tiziano Ropele, 2011, "Macroeconomic determinants of bad loans: evidence from Italian banks," Questioni di Economia e Finanza (Occasional Papers) 89, Bank of Italy, Economic Research and International Relations Area.

Boudriga, A., Taktak, N. B., and S. Jellouli, 2009, “Banking Supervision and Nonperforming Loans: A Cross-Country Analysis.” Journal of Financial Economic Policy, 1 (4), pp. 286-318.

Cerra, Valerie, and Sweta Chaman Saxena, 2008, “Growth dynamics: the myth of economic recovery.” American Economic Review 98.1 (2008): 439-57.
Cerulli, G., D’Apice, V., Fiordelisi, F., and F. Masala, 2017, “Non-Performing Loans in Europe: the Role of Systematic and Idiosyncratic Factors.” Mimeo.

Claessens, Stijn and Neeltje van Horen, 2015, "The Impact of the Global Financial Crisis on Banking Glocalization" IMF Economic Review, vol. 63(4) pp. 868-918

Cortavarria, Luis, Claudia Dziobek, Akihiro Kanaya, and Inwon Song, 2000, “Loan Review, Provisioning, and Macroeconomic Linkages,” IMF Working Paper 00/195.

Cotugno, M., Stefanelli, V., and G. Torluzzo, 2010, “Bank intermediation models and portfolio default rates: what’s the relation?” In 23rd Australasian Finance and Banking Conference.

De Bock, R., and M. A. Demyanets, 2012, “Bank Asset Quality in Emerging Markets: Determinants and Spillovers,” IMF Working Paper 12/71.

De la Fuente, Moreno, 2014, “A Mixed Splicing Procedure for Economic Time Series”, Estadística Española, Vol. 56, pp. 107–121.

Dell’Ariccia, G., Peria, M. S. M., Igan, D., Awadzi, E. A., Dobler, M., and Sandri, D., 2018, “Trade-offs in Bank Resolution”, IMF Staff Discussion Note 18/02.

Espinoza, R. A., and Prasad, A., 2010, “Nonperforming loans in the GCC banking system and their macroeconomic effects”, IMF Working Paper, WP/10/224.

European Central Bank (ECB), 2017, Guidance to Banks on Non-Performing Loans.

Fainstein, Grigori and Igor Novikov, 2011, “The Comparative Analysis of Credit Risk Determinants in the Banking Sector of the Baltic States,” Review of Economics & Finance, vol. 1, pages 20-45.

Fofack, Hippolyte L., 2005. “Nonperforming loans in Sub-Saharan Africa: causal analysis and macroeconomic implications,” Policy Research Working Paper Series 3769, The World Bank.

Fuentes, R., and C. Maquieira, 2003, “Institutional arrangements, credit market development and loan repayment in Chile,” School of Business and Economics, Universidad de Chile.

Gambera, M., 2000, “Simple Forecasts of Bank Loan Quality in the Business Cycle. Emerging Issues Series,” Supervision and Regulation Department, Federal Reserve Bank of Chicago., pp. 1–27.

Ghosh, A., 2015, “Banking-industry specific and regional economic determinants of non-performing loans: Evidence from US states.” Journal of Financial Stability, 20, 93-104.
Glen, J., and Mondragón-Vélez, C., 2011, “Business Cycle Effects on Commercial Bank Loan Portfolio Performance in Developing Economies.” *Review of Development Finance*, 1(2), 150-165.

Godlewski, C. J., 2004, “Capital Regulation and Credit Risk Taking: Empirical Evidence from Banks In Emerging Market Economies,” Available at SSRN 588163.

Greenidge, K., and T. Grosvenor, 2010, “Forecasting Non-Performing Loans in Barbados,” *Journal of Business, Finance & Economics in Emerging Economies*, 5(1).

Hu, J. L., Y. Li, and Y. H. Chiu, Y. H., 2004, “Ownership and nonperforming loans: Evidence from Taiwan's banks,” *The Developing Economies*, 42(3), 405-420.

International Monetary Fund (IMF), 2006, *Financial Soundness Indicators Compilation Guide*.

International Monetary Fund (IMF), 2016, *Handbook of IMF Facilities for Low-Income Countries*.

International Monetary Fund (IMF), 2019, *Financial Soundness Indicators Compilation Guide*, Prepublication Draft, https://www.imf.org › Files › Data › fsicg2019-prepublication-final-042519.

Jakubík, P. and Reininger, T., 2013, "Determinants of Nonperforming Loans in Central, Eastern and Southeastern Europe," Focus on European Economic Integration, Oesterreichische Nationalbank (Austrian Central Bank), issue 3: 48-66.

Jiménez, G. and J. Saurina, 2006, “Credit cycles, credit risk, and prudential regulation Int. J. Central Banking,” 2 (2): 65-98

Jordà, Òscar, Moritz Schularick, and Alan M. Taylor, 2011, “Financial crises, credit booms, and external imbalances: 140 years of lessons.” *IMF Economic Review* 59.2 (2011): 340-378.

Khemraj, T. and S. Pasha, 2009, "The determinants of non-performing loans: an econometric case study of Guyana," MPRA Paper 53128, University Library of Munich, Germany.

Klein, N., 2013, “Non-Performing Loans in CESEE: Determinants and Macroeconomic Performance”, IMF Working Paper, WP/13/72.

Laeven, Luc, and Fabian Valencia 2013, “Systemic Banking Crises Database”, *IMF Economic Review*, 61(2): 225-270.

Laeven, Luc, and Fabian Valencia, 2018, “Systemic Banking Crises Revisited,” IMF Working Paper, 18/206.
Louzis, D. P., Vouldis, A. T., and V. L. Metaxas, 2012, “Macroeconomic and bank-specific determinants of non-performing loans in Greece: A comparative study of mortgage, business and consumer loan portfolios.” *Journal of Banking & Finance*, 36(4), 1012-1027.

Macit, Fatih, 2012, "What Determines the Non-Performing Loans Ratio: Evidence From Turkish Commercial Banks," *Journal Articles, Center For Economic Analyses*, pages 33-39, June.

Makri, V., Tsagkanos, A., and A. Bellas, 2014, “Determinants of non-performing loans: The case of Eurozone.” *Panoeconomicus*, 61(2), 193-206.

Messai, Ahlem Selma, and Fathi Jouini. "Micro and macro determinants of non-performing loans." *International Journal of Economics and Financial Issues* 3.4 (2013): 852.

McFadden, Daniel L, 1974, “Conditional logit analysis of qualitative choice behavior,” pp. 105-142 in P. Zarembka (ed.), *Frontiers in Econometrics*. Academic Press.

Misra, B. M., and S. Dhal, 2010, Pro-cyclical management of banks’ non-performing loans by the Indian public sector banks. *BIS Asian Research Papers*, 16, 1-23.

Mohaddes, K., Raissi, M., and Weber, A., 2017, “Can Italy grow out of its NPL overhang? A panel threshold analysis,” *Economics letters*, 159, 185-189.

Nikolaidou, E., and S. D. Vogiazas, 2013, “Credit Risk in the Romanian Banking System: Evidence from an ARDL Model,” In *Balkan and Eastern European Countries in the Midst of the Global Economic Crisis* (pp. 87-101). Physica, Heidelberg.

Nikolaidou, E., and S. D. Vogiazas, 2014, “Credit risk determinants for the Bulgarian banking system.” *International Advances in Economic Research*, 20(1), 87-102.

Nkusu, Mwanza, 2011, “Nonperforming Loans and Macrofinancial Vulnerabilities in Advanced Economies”, IMF Working Paper, 11/161.

Podpiera, Jiri., and Larent Weill, 2008, “Bad Luck or Bad Management? Emerging Banking Market Experience.” *Journal of Financial Stability*, 4(2), 135-148.

Quagliariello, M., 2007, “Banks’ Riskiness Over the Business Cycle: A Panel Analysis on Italian Intermediaries,” *Applied Financial Economics*, 17(2), 119-138.

Ranjan, R. and S.C. Dhal, 2003, “Non-performing loans and terms of credit of public sector banks in india: an empirical assessment.” Reserve Bank of India Occasional Paper, 24(3): 81-121
Rossi, Stefania P.S., Markus Schwaiger and Gerhard Winkler, 2005, "Managerial Behavior and Cost/Profit Efficiency in the Banking Sectors of Central and Eastern European Countries," Working Papers 96, Oesterreichische Nationalbank (Austrian Central Bank).

Salas, V., & J. Saurina, 2002, “Credit risk in two institutional regimes: Spanish commercial and savings banks,” *Journal of Financial Services Research*, 22(3), 203-224.

Shu, C., 2002, “The Impact of macroeconomic environment on the asset quality of Hong Kong’s banking sector,” Hong Kong Monetary Authority Research Memorandums.

Skarica, Bruna, 2014, “Determinants of non-performing loans in Central and Eastern European countries,” *Financial Theory and Practice*, Institute of Public Finance, 38(1): 37-59.

Us, V., 2017, “Dynamics of Non-Performing Loans in The Turkish Banking Sector By An Ownership Breakdown: The Impact Of The Global Crisis,” *Finance Research Letters*, 20: 109-117

Vithessonthi, C., 2016, “Deflation, bank credit growth, and non-performing loans: Evidence from Japan.” *International Review of Financial Analysis*, 45: 295-305.

Williams, J., 2004, “Determining Management Behaviour in European banking,” *Journal of Banking & Finance*, 28(10): 2427-2460