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Nonperforming Loans and Macrofinancial Vulnerabilities in Advanced Economies

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Nonperforming Loans and Macrofinancial Vulnerabilities in Advanced Economies

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Abstract

We analyze the link between nonperforming loans (NPL) and macroeconomic performance using two complementary approaches. First, we investigate the macroeconomic determinants of NPL in panel regressions and confirm that adverse macroeconomic developments are associated with rising NPL. Second, we investigate the feedback between NPL and its macroeconomic determinants in a panel vector autoregressive (PVAR) model. The impulse response functions (IRFs) attribute to NPL a central role in the linkages between credit market frictions and macrofinancial vulnerability. They suggest that a sharp increase in NPL triggers long-lived tailwinds that cripple macroeconomic performance from several fronts.

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"Often, the banking problems do not arise from the liability side, but from a protracted deterioration in asset quality, be it from a collapse in real estate prices or increased bankruptcies in the nonfinancial sector". Kaminky and Reinhart, 1999.

I. Introduction

The deterioration in the quality of banks' loan portfolio has been at the center of episodes of costly banking system distress and economic crises in both developing and advanced economies. The 2008 global financial crisis is no exception. Its devastating effects, as well as its origination from a sharp increase in mortgage loan defaults in the United States, underscore the linkages between financial and macroeconomic shocks and have renewed interest in the relationship between credit market frictions and the risk of financial instability. The objective of this paper is to uncover macrofinancial vulnerabilities from the linkages between nonperforming loans (NPL) and macroeconomic performance in advanced economies.

The paper contributes to an abundant empirical literature on the interactions between macroeconomic performance and credit market frictions, in particular rising NPL. The existing literature on the relationships between NPL and real economic activity deals with diverse aspects on samples covering diverse geographic areas or different country groups (Keeton and Morris, 1985; Rinaldi and Sanchis-Arellano, 2006; Quagliariello, 2007; Jappelli, Pagano, and Marco, 2008; Espinosa and Prasad, 2010). To our knowledge, this paper is the first to look into the macrofinancial vulnerabilities associated with rising aggregate NPL from a sample covering most advanced economies and data related to the 2008 global financial crisis, which is foremost an advanced economies' crisis.

The paper addresses two empirical questions on NPL and macrofinancial vulnerabilities: the question of the determinants of NPL and that of the interactions between NPL and economic performance. It uses two complementary approaches on a sample of 26 advanced countries that spans the period from 1998 to 2009. To address the first question we use single-equation panel regressions. The literature suggests that the determinants of NPL can be macroeconomic, financial, or purely institutional. The literature also associates episodes of sharp increases in NPL with asset price declines and disruptions to the supply of credit. Against this backdrop, in addressing the second question, we investigate the extent to which falling asset prices and credit constraints facing borrowers may backfire and lead to an extra round of financial system stress and subdued economic activity. We use a panel vector autoregressive (PVAR) approach and rely on impulse response functions (IRFs) to examine the interrelations among variables.

The findings indicate that NPL play a central role in the linkages between credit markets frictions and macroeconomic vulnerabilities. The results confirm that a sharp increase in NPL weakens macroeconomic performance, activating a vicious spiral that exacerbates macrofinancial vulnerabilities. This finding is not unique to our analysis. We go beyond its simple narrative by attaching magnitudes to the adverse responses highlighted in the feedback loop. These magnitudes, which are meaningful in the advanced economies' context, can be used for macro stress testing or assessment of macrofinancial vulnerability more generally. The broad policy implication of our analysis is that, while NPL remain a permanent feature of banks' balance sheets, policies and reforms should be geared to avoiding sharp increases that set into motion the adverse feedback loop between macroeconomic and financial shocks.

The paper is organized as follows. Section II reviews the literature review. Section III presents the models to be estimated and reports and discusses the econometric results. Section IV concludes and discusses the policy implications of our findings.

II. Literature

The empirical literature on the determinants of NPL and the interactions between NPL and macroeconomic performance is grounded in theoretical models as well as empirical regularities. In general, theoretical business cycle models with an explicit role for financial intermediation offer a good background for modeling NPL as they highlight the countercyclicality of credit risk and business failures (Williamson, 1987). In the spirit of these models, the financial accelerator theory—discussed in Bernanke and Gertler (1989), Bernanke and Gilchrist (1999), and Kiyotaki and Moore (1997)—has become the most prominent theoretical framework for thinking about macrofinancial linkages. As such, it is influential in the modeling of both NPL and its interaction with macroeconomic performance.

Empirical regularities, which tend to substantiate the financial accelerator theory, shape the modeling of NPL. These regularities include the cyclical nature of bank credit, NPL, and loan loss provisions. In particular, in upturns, contemporaneous NPL ratios tend to be low and loan loss provisioning subdued. Also, competitive pressure and optimism about the macroeconomic outlook lead to a loosening of lending standards and strong credit growth, sowing the seeds of borrowers' and lenders' financial distress down the road. The loosening of lending standards in upturns depends on the existing regulatory and supervisory framework. In downturns, higher-than-expected NPL ratios, coupled with the decline in the value of collaterals, engenders greater caution among lenders and lead to a tightening of credit extension, with adverse impacts on domestic demand.

Against this background, the determinants of NPL are both institutional/structural and macroeconomic. The institutional or structural indicators pertain to financial regulation and supervision and the incentive structure therein. Intuitively, disparities in financial regulation and supervision affect banks' behavior and risk management practices and are important in explaining cross-country differences in NPL. The macroeconomic environment influences borrowers' balance sheets and their debt servicing capacity. The set of macroeconomic variables used varies across previous studies, but broad indicators of macroeconomic performance, such as GDP growth and unemployment are generally included in the three strands of the literature we consider on the determinants of NPL. The finding of a negative relationship between NPL and economic growth is a common thread among studies surveyed and will therefore not be mentioned.

The first strand of the literature has focused on explaining differences in NPL across banks within specific countries highlighting the role of macroeconomic performance and the management quality and policy choices. Dash and Kabra (2010) provide a more detailed review of this literature. In a study covering Greece's 9 largest banks during 2003–09 and analyzing NPL broken down by types of loans—business, consumer, and mortgages—Louzis, Vouldis and Metaxas (2010) find that management quality and macroeconomic fundamentals explain NPL, with NPL on mortgages being the least responsive to macroeconomic conditions.[2] They find a positive relationship between NPL and real lending rates. As for bank-specific characteristics, they find that management inefficiency, proxied by a higher ratio of operating expenses-to-operating income is positively associated with NPL.[3] This result is in line with Espinosa and Prasad (2010).

The second strand of the literature analyzes the link between NPL and macrofinancial conditions by highlighting the positive impact of NPL on the probability of crisis. Stressing the key role NPL plays in banking crises, Kaminsky and Reinhart (1999) suggest that a large increase nonperforming loans could be used to mark the onset of the crisis.[4] Although the literature on banking crises does not attempt to explain NPL directly, it highlights the adverse impact of high NPL on macrofinancial vulnerabilities as part of a wide range of variables that might, directly or indirectly, help predict crises (Caprio and Klingebiel, 1996; Drees and Pazarbasioglu, 1998; Kaminsky and Reinhart, 1999).

The third branch of the literature, to which our analysis pertains, focuses on explaining or predicting NPL at the macroeconomic level from aggregate NPL ratios. These aggregates can relate either to total outstanding loans in an economy or to specific types of loans. Brooks, Dicks, and Pradhan (1994) model mortgage arrears in the books of building societies in the United Kingdom and highlight the role of rising inflation in increasing mortgage defaults. Rinaldi and Sanchis-Arellano (2006) model NPL from households' debt for a panel of seven euro area countries while Jappelli, Pagano, and Marco (2008) model arrears on consumer credit and mortgage debt from a sample of 11 euro area countries. Both studies find,

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[2]This supports the conjecture that macroeconomic developments and business cycles may affect differently commercial loans as opposed to loans to households such as mortgages and consumer loans.

[3]Hughes and others (1995) associate high operating cost with a low risk profile for risk-averse managers as the latter may be willing to incur higher screening and monitoring costs to reduce the riskiness of the loan portfolio thereby trading off subdued earning with better loan quality.

[4]Some studies find evidence of a negative relationship between NPL and the probability of a banking crisis arguing that strong credit in the run up to a crisis masks the deterioration in loan quality by containing the NPL ratio (Duttagupta and Cashin, 2008).

unsurprisingly, that a higher ratio of debt-to-income is associated with a higher level of NPL in subsequent periods.[5] Another noteworthy finding in Rinaldi and Sanchis-Arellano (2006) is that, in the short-run, house prices are negatively related to NPL, lending support to the idea that wealth can play the role of a buffer in case of unexpected shocks or that housing wealth can be used as collateral to ease access to credit.

The empirical literature on the linkages between NPL and macrofinancial performance relies on the VAR approach to highlight the feedback loop between the two. Marcucci and Quagliariello (2009) analyze the cyclical behavior of default rates in Italian banks and find that default rates decline in good macroeconomic times and increase during downturns. They also find that there is a feedback from the banking sector to the macroeconomy which operates via the bank capital channel. Espinosa and Prasad (2010) use a sample of 80 banks of the Gulf Cooperation Council (GCC) region and find that the NPL ratio worsens as economic growth weakens and interest rates increase. Their investigation of the effects of increasing NPL on growth suggests that there could be a strong, albeit short-lived adverse feedback effect from losses in banks' balance sheets on economic activity. The VAR approach is also used in papers on many central banks' financial stability analyses. In general, the papers show that there are significant interactions between credit quality and macroeconomic conditions that lend support to the financial accelerator theory.

III. Empirical Analysis

A. Specification

The analysis follows a two-pronged approach aimed at identifying factors that explain NPL and assessing the interactions among NPL and macroeconomic variables in a system. It starts with single-equation panel regressions of the determinants of NPL, followed by a panel vector autoregressive (VAR) estimation that helps identify how variables in the system respond to shock affecting other variables.[6] As discussed below, the two approaches are complementary.

Modeling NPL: single-equation panel regressions

The model to be estimated is given by

$$NPL_{it} = Y_{it}'\beta + \nu_i + \varepsilon_{it},$$

where

Y_{it} is a vector of endogenous and predetermined variables, including lag(s) of the dependent variable; i=1,..., N is the cross-section indicator; t=1, ..., T is the time dimension; β is vector

[5]In the analysis by Jappelli, Pagano, and Marco, arrears refer to the fraction of households that have arrears on their outstanding loans rather than the share of overdue loans in gross loans.

[6]The sources and description of variables used are in the Appendix.

of coefficients to be estimated, η_i is a time-invariant unobserved country-specific effect, and ε_{it} is a vector of disturbances. Lags of the dependent variable are included in the set of regressors to capture the effect of omitted explanatory variables and the persistence of NPL.

The explanatory variables' set includes a broad range of macroeconomic and financial variables. GDP growth and unemployment are used as indicators of general macroeconomic performance. Inflation, interest rates, and changes in the housing and stock price indices are included as additional indicators of the state of the macroeconomic and financial environment that affect loan quality. Another variable of importance is the private sector credit-to-GDP ratio, which, as a proxy of the aggregate debt burden of households and businesses, reflects, to some extent, banks' risk-taking behavior.

The relevance and expected signs of the relationships between NPL and the selected variables are as follows:

- A growing economy is likely to be associated with rising incomes and reduced financial distress. Accordingly real GDP growth and employment are negatively associated with NPL. Conversely, unemployment is positively related with NPL.
- Rising asset prices boost financial and housing wealth and can help borrowers face unexpected adverse shocks or ease their access to credit by boosting the value of the underlying assets used as collateral. In this regard, equity or house price changes are expected to be negatively related with NPL.
- A hike in interest rates weakens borrowers' debt servicing capacity, more so if loan rates are variable. Therefore, NPL is expected to be positively related with interest rates.
- High debt burdens make debtors more vulnerable to adverse shocks affecting their wealth or income, thereby raising the likelihood that they would run into debt servicing problems. In economic upturns, indebtedness, captured by credit to the private sector as a percent of GDP, is expected to be negatively correlated with contemporaneous NPL. Nonetheless, to the extent that high borrowers' indebtedness in economic upturns can also reflect inadequate risk management or a softening of lending standards, it would be positively related with subsequent periods' NPL.[7]
- Inflation affects borrowers' debt servicing capacity through different channels and its impact on NPL can be positive or negative. Higher inflation can make debt servicing easier either by reducing the real value of outstanding loans or simply because it is associated with low unemployment as the Phillips' curve suggest. However, it can

[7]The crisis literature has established that banking crises are often preceded by a considerable expansion of credit to the private sector (Demirgüç-Kunt and Detragiache, 1998; Drees and Pazarbasioglu, 1998; and Kaminsky and Reinhart, 1999). The annual increase in the credit-to-GDP ratios varies between 5 and 10 percentage points in the years preceding banking crises (Cottarelli, Dell'Ariccia, and Vladkova-Hollar (2005)).

also weaken some borrowers' ability to service debt by reducing real income when wages are sticky. Moreover, when loan rates are variable, inflation is likely to reduce borrowers' loan servicing capacity as lenders adjust rates to maintain their real returns or simply to pass on increases in policy rates resulting from monetary policy actions to combat inflation. Against this background, the relationship between NPL and inflation can be positive or negative.

- An appreciation of the exchange rate can have mixed implications. On the one hand, it can weaken the competitiveness of export-oriented firms and adversely affect their ability to service their debt (Fofack, 2005). On the other, it can improve the debt-servicing capacity of borrowers who borrow in foreign currency. As we include inflation in the regressions, nominal effective exchange rate (NEER) is the exchange rate measure. The sign of the relationship between NEER and NPL is indeterminate.

Assessing the interactions among NPL and macroeconomic variables: panel VAR

We estimate an unrestricted VAR and uncover impulse responses. The model is specified as follows:

$$y_{it} = B(L)y_{it} + \varepsilon_{it}, \qquad (2)$$

where y_{it} is a k x 1 vector including NPL and the macrofinancial variables of interest discussed above, B(L) is a matrix in the lag operator; i=1,...,N is the cross-section indicator; t=1, ..., T is the time dimension; and ε_{it} is a vector of disturbances assumed to have zero mean and covariance matrix Σ_ε.

The dynamic interactions between NPL and macroeconomic variables are uncovered from impulse response functions (IRFs). A more compact representation of the VAR model in (2) is $B(L)y_t = \varepsilon_{it}$. Assuming that the polynomial defined by the determinant of a B matrix represents a stationary process, equation (2) can be written as $y_t = B(L)^{-1}\varepsilon_t = \varepsilon_t + \sum_{j=1}^{\infty}\phi_j\varepsilon_{t-j}$.

The IRFs are the elements of the matrix ϕ_j . In our exercise, the impacts of the variable NPL on the other variables are obtained by shocking the error term for NPL and tracing its marginal effects through all equations in the system. As an impulse in one variable is likely to be accompanied by an impulse in another variable, orthogonalized impulses are considered. They are obtained from (2) by choosing some matrix A such that $AA = \sum_\varepsilon$ or such that $A^{-1}\sum_\varepsilon A^{'-1}$ is a diagonal matrix and defining $u_t = A^{-1}\varepsilon_t$. The u_t's have a diagonal unit covariance matrix and are hence contemporaneously uncorrelated, allowing for the u_t shocks to provide a more realistic representation of the reactions of the system (Lütkepohl, 2008). It is from this framework that we get for instance estimates of the reaction of economic growth (GRW) to u_t^{npl} or the reaction of NPL to u_t^{grw}.

B. Data

The sample covers annual data from 1998 to 2009 for a sample of 26 advanced economies.[8] NPL is modeled at the macroeconomic level from the consolidated balance sheet of each country's banking sector. The time span is constrained by the scarcity of long enough NPL time series for individual countries. In fact, owing to the unavailability of NPL data for the earlier years of the sample period for some countries, the sample is unbalanced. The use of panel data offers the benefit of increasing the sample size while gaining a cross-country perspective.

The NPL measure used does not reflect the same reality across countries. NPL is defined as the ratio of overdue loans to gross loans. The use of NPL in the remainder of the paper refers to this definition. Cross-country differences in regulation and supervisory practices and differences in accounting procedures pose serious constraints to comparability of NPL across countries. For instance, NPL levels may not reflect the extent of impaired loans as some banks may preemptively restructure or roll-over bad loans while others may write off their bad loans relatively quickly.Also, peak levels of impaired loans are generally much higher in developing countries compared with advanced ones.[9] Accordingly, the same NPL ratio can have different implications in different countries.

Differences in the structure of financial systems between advanced and developing countries could explain the observed stark differences in levels at which NPL peaks at the onset of systemic banking crises. The share of credit to the private sector emanating from banks is likely to be larger in developing countries than in developed ones where nonbank credit institutions play an important role. In developed countries, financial sector distress would be spread across balance sheets of banks as well as nonbank credit institutions so that the emergence of a moderate increase in NPL in banks' balance sheets may be associated with greater distress in credit institutions at large and sharply subdued economic activity.

The list and description of other variables used in the analysis are in the Appendix. The list includes GDP growth (GRW), unemployment (UNEMP), change in the house price index (DLHOUSEPR), change in the equity price index (DLEQUITYPR), inflation (INFL), the

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[8]Australia (AUS), Austria (AUT), Belgium (BEL), Canada (CAN), Czech Republic (CZE), Denmark (DEN), Finland (FIN), France (FRA), Germany (GER), Greece (GRE), Iceland (ICL), Israel (ISR), Italy (ITA), Japan (JPN), Korea (KOR), Luxembourg (LUX), the Netherlands (NET), New Zealand (NZL), Norway (NOR), Portugal (POR), Singapore (SGP), Spain (SPA), Sweden (SWE), Switzerland (SWI), the United Kingdom (UK), the United States (US).

[9]Laeven and Valencia (2008) indicate that the 1997 Asian financial crisis coincided with peak NPL levels of 20 percent, 30 percent, 32.5 percent, 33 percent, and 35 percent in Philippines, Malaysia, Indonesia, Thailand, and Korea, respectively. Except for a few exceptions, peak NPL at the onset of systemic banking crises are much lower in advanced economies: 13 percent in Finland and Sweden in 1991, 16.4 percent in Norway. At the onset of the 2007 crisis in the U.S. and the U.K. NPL ratios were under 5 percent.

nominal effective exchange rate (NEER), policy rate of interest (IPOL), and credit to the private sector (PSCGDP).

To inform model specification, we assess the level of integration of the variables of interest and find that most series are stationary in level and for some after first-differencing. We run the Fisher-ADF and Fisher-PP tests, which assume individual unit root processes across countries included in the panel.[10] The Fisher-ADF test suggests that, except for credit to the private sector, PSCGDP, all the remaining variables are stationary in level. The stationarity bar appears to be somewhat higher on the Fisher-PP test because for the logarithm of house prices (LNHOUSEPR), the null of a unit root could not be rejected even after first differencing.[11] We consider LNHOUSEPR as first-difference stationary based on the Fisher-ADF test. The different orders of integration of the variables point to the need to check for cointegration to ensure that the estimates resulting from models including the different variables can be relied upon for inference.

Table 1. Panel Unit Root Tests

		Assuming individual unit root processes	
Variables		Fisher-ADF	Fisher-PP
NPL	Level	80.955 ***	49.844
	1st difference	-2.398 ***	72.662 **
IPOL	Level	107.931 ***	91.916 ***
	1st difference	-8.194 ***	151.568 ***
LNEQUITYPR	Level	98.626 ***	55.185
	1st difference	-6.847 ***	132.034 ***
LNHOUSEPR	Level	89.091 ***	57.197
	1st difference	-2.016 **	49.167
NEER	Level	28.054	15.671
	1st difference	150.440 ***	78.829 ***
PSCGDP	Level	25.611	28.326
	1st difference	-6.170 ***	123.911 ***
GRW	Level	94.595 ***	88.071 ***
	1st difference	95.045 ***	117.606 ***
INFL	Level	152.803 ***	179.480 ***
	1st difference	-11.645 ***	251.853 ***
UNEMP	Level	39.134	51.613
	1st difference	157.570 ***	110.466 ***

*, **, and *** denote significance at 10 percent, 5 percent, and 1 percent, respectively.

[10]We avoid using panel unit root tests that require a balanced sample because we would have had to reduce further the already limited time span of our sample. These tests requiring a balanced sample are the Lin, Levin, and Chu (2002), which assume a common unit root process as well as the Im, Pesaran, and Shin (2003), which assumes individual unit root processes.

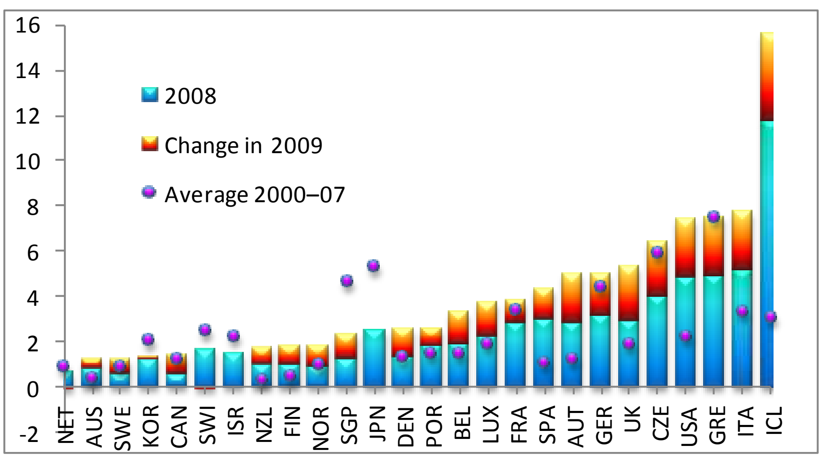
[11]The Fisher test combines the p-values from N independent unit root tests, as developed by Maddala and Wu (1999). Based on the p-values of individual unit root tests, Fisher's test assumes that all series are nonstationary under the null hypothesis against the alternative that at least one series in the panel is stationary.

C. Stylized Facts

The NPL dynamics in our sample are mixed, reflecting the fact that the sample period covers years of both weak and strong macroeconomic performance. The sample can be divided into three sub-periods. The pre-2003 period is characterized by relatively high or rising NPL, reflecting subdued macroeconomic performance associated with the aftermath of the East-Asia crisis first and then the bursting of the dot com bubble. The precrisis 2003–07 period is one of strong macroeconomic performance and low or declining NPL. During the last leg of the sample period, 2008–09, slower growth or outright recessions was associated with an increase in NPL across all countries, albeit the magnitudes of the increase varied.

The observed summary statistics and individual country figures clearly reflect the mixed record of NPL and other macroeconomic and financial variables (Table A2). GDP growth ranges from negative 8 percent in Finland in 2008 to 10.7 percent in Korea in 1999, whereas unemployment ranges from about one percent in Iceland in 2007 to 18 percent in Spain in 2009. The maximum NPL is observed in Iceland in 2009, while the minimum is observed in Belgium in 1999. In most countries, NPL is notably much higher during 2008–09 than in the precrisis years. Country-specific NPL averages during 2000–07 exceed 2008 and 2009 levels only in a few countries (Figure 1).

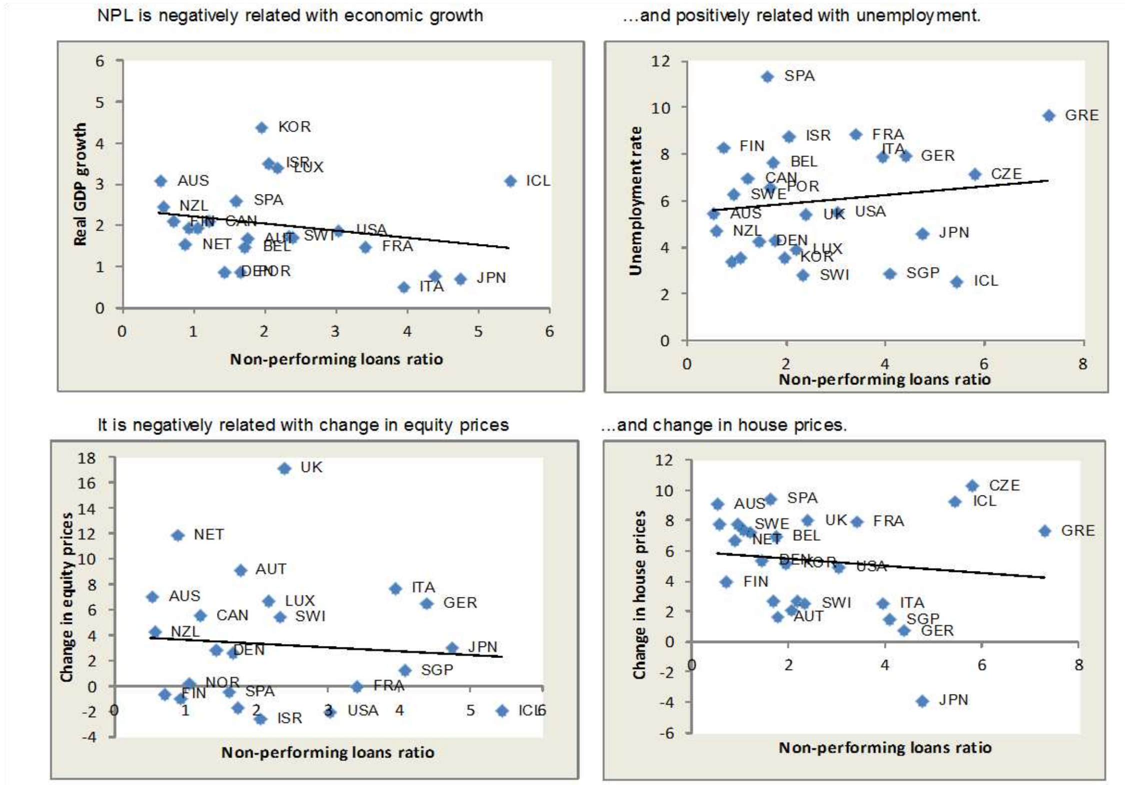
Figure 1. Advanced Economies' Nonperforming Loans Average 2000–07, Level in 2008, and Change in 2009 (in percent)



Sources: Bankscope, U.S. Federal Reserve Economic Database, IMF Global Financial Stability Report (GFSR).

Cross-correlations between variables broadly confirm the expected relationships (Table A3). Indicators of good macroeconomic performance and rising asset prices are negatively related with NPL. The relationships between NPL on the one hand and economic growth, unemployment, house prices, and equity prices on the other are depicted in Figure 2.

Figure 2. Nonperforming Loans and Key Macroeconomic Variables, Averages 2000–09 (in percent)



Sources: Bankscope, GFSR, US Federal Reserve, Haver, WEO, and author's calculations.
Note: Trendlines in the upper- and lower left charts exclude Greece (GRE) and the Czech Republic (CZE).

D. Estimation

Single panel regressions

We run models using several specifications presented in Table 2. First, we fit an OLS model with lags of the dependent variable as explanatory variables (column 1). Then we relax the assumption of independent and identically distributed disturbances and estimate panel-corrected standard error (PCSE) models with unobserved country-specific effects—models (2) and (3). Hsiao (1986) and Arellano and Bond (1991) indicate that with the lagged dependent variable included in the set of explanatory variables the least square estimator becomes biased for small values of T. We try alternative specifications excluding either lagged dependent variables (model 4) or fixed effects (model 5). We also use the one-step generalized method of moments (GMM) developed by Arellano and Bond (1991) in model 6.[12] In all models, the signs of the explanatory variables are intuitive.

[12] Of the available two GMM estimators, the one-step and the two-steps, we choose the one-step GMM estimator, which, in small samples, generally tends to be less biased than the two-step estimator (Arellano and Bond, 1991; Judson and Owen).

Table 2. Determinants of Non-Performing Loans

Dependent variable / Explanatory variables	NPL OLS (1)	DNPL PCSE (2)	DNPL PCSE (3)	DNPL PCSE (4)	DNPL PCSE (5)	NPL AB_GMM (6)
NPL first lag	0.875***	-0.351***	----	----	----	0.608***
	(0.136)	(0.071)				(0.104)
NPL 2nd lag	-0.239*	----	-0.355***	----	-0.168***	----
	(0.105)		(0.048)		(0.022)	
GRW (GDP growth)	-0.179***	----	----	----	----	-0.157***
	(0.034)					(0.042)
GRW_{t-1} (lagged GDP growth)	----	-0.168***	-0.087*	-0.040*	-0.042*	----
		(0.039)	(0.045)	(0.071)	(0.022)	
DUNEMP (unemployment change)	----	0.245***	0.204***	0.219***	0.207***	----
		(0.081)	(0.086)	(0.000)	(0.043)	
DLHOUSEPR (change house prices)	-0.026*	-0.047***	-0.027***	-0.026***	-0.021***	-0.065**
	(0.011)	(0.010)	(0.009)	(0.000)	(0.005)	(0.020)
DLEQUITYPR (change equity prices)	-0.009***	-0.011***	-0.014***	-0.006***	-0.007***	-0.013***
	(0.002)	(0.003)	(0.003)	(0.000)	(0.001)	(0.007)
IPOL (policy rate)	0.071	----	----	----	----	0.256**
	(0.080)					(0.121)
Constant	1.596***	1.896***	1.523***	0.335***	0.056***	----
	0.408	(0.329)	(0.281)	(0.000)	(0.022)	----
Number of observations	244	267	244	264	241	241
R-squared	0.863	0.493	0.543	0.357	0.403	----
AR(1), p-value	----	----	----	----	----	0.045**
AR(2), p-value	----	----	----	----	----	0.175

Note: DNPL is the first-difference of NPL. Standard errors are below coefficient estimates. *** , ** , and * denote significance at 1 percent, 5 percent, and 10 percent, respectively. Models (1) through (4) include fixed effects, whereas model (5) does not. Models (2) through (5) are based on panel-corrected standard errors (PCSE). Arellano-Bond one-step GMM estimator with robust standard errors is used in model (4). AR(1) and AR(2) are the Arellano-Bond tests for first- and secon-order autocorrelation in first-differenced errors.

The regressions in Table 2 meet relevant specification tests. Fixed effects are deemed appropriate in models (1) thru (4). For each model, the Fisher and chi-square test statistics strongly reject the hypothesis that the country-specific fixed effects are redundant. In the GMM estimation, two diagnostics tests for autocorrelation in first-differenced errors are conducted using the Arellano and Bond procedure. One should reject the null of zero first order serial correlation and not reject the absence of second order serial correlation.

The p-values associated with AR(1) and AR(2) clearly indicates that these requirements are met.[13]

Panel VAR

As indicated earlier, we estimate a VAR to analyze the interaction among variables and, to some extent, offer a robustness check of the panel regression results. The VAR model comprises the variables included in the panel regressions, as well as the ones that were used in the specification search but did not make it into the final regressions presented in Table 2 because they were not statistically significant. Of the nine variables of the VAR, four are in annual percentage change (DLHOUSEPR, DLEQUITYPR, INFL, and GRW) and five in level (IPOL, NEER, UNEMP, NPL, and PSCGDP). As discussed below, the VAR lends support to the panel regression results.

The VAR model includes one lag of each variable. The number of lags suggested by all the lag length selection tests is in the one to three range (Table A4). Mindful of the limited degrees of freedom associated with the relatively short time span of our data, we use one lag based on the Schwartz Bayesian information.

We conduct cointegration tests on the panel VAR to ensure that inference is based on non-spurious relationships.[14] The cointegration analysis is useful to the extent that the variables included in the VAR have different order of integration. The Johansen's trace and maximum eigenvalue tests unequivocally supports the existence of cointegrating relationships, with the number of cointegrating vectors ranging from 3 to 5 (Table 4). The finding of cointegration in the system suffices for us to proceed with the examination of interactions among variables.

[13]Although the GMM estimator is theoretically superior, it may not prove useful in predictions since the dependent variable is truncated (Salas and Saurina, 2002). Also, internal instruments used in GMM estimation, though attractive as a response to endogeneity, have serious limitations (Roodman, 2009). Judson and Owen (1999) suggest that the corrected least-square dummy variable methodology outperforms GMM estimators, but this methodology cannot be used in our case because of the sample's short time span and the requirement that the sample be balanced. Models (4) and (5) aim at overcoming the bias associated with the inclusion of both lagged dependent variables and fixed effects by avoiding including them simultaneously in an equation. In the end, noting that neither specification leads to bias-free estimates, we favor model (3), which has the highest predictive power amongst specifications with first-differenced NPL.

[14]Unit root tests on the residuals from panel regressions in models (3) through (5) suggest that the residuals are stationary, a confirmation that they emanate from cointegrated relationships.

Table 3. Panel VAR—Johansen Cointegration Test

	Assumptions on Cointegration Test Specification				
	No trend in data		Linear trend in data		Quadratic trend in data
Test type	No int., no trend in CE	Int., no trend in CE	Int., no trend in CE	Int. and trend in CE	Int. and trend in CE
Trace	5	5	4	3	3
Max-Eigenvalue	5	5	5	4	4

Note: 215 observations included. The series are: DLEQUITYPR, DLHOUSEPR, INFL, IPOL, NEER, GRW, UNEMP, NPL, and PSCGDP. CE and int stand for cointegration equation and intercept, respectively.The figures in each column indicate the selected number of cointegration relations at the 5 percent significance level.

Our examination of interactions among variables is based on generalized IRFs. In our analysis, we care more about the dynamic interactions between macrofinancial variables and NPL than about which shock comes first in the feedback loop. With generalized impulses, the ordering of variables does not matter. Accordingly, generalized impulses serve the purpose or our analysis.[15]

The IRFs we uncover are generally intuitive, in line with the literature, and very informative (Table A5). We want to single out the responses of NPL, economic growth, and credit-to-GDP ratio to their own shocks and shocks to other variables. These responses, which better highlight the feedback loop between adverse macroeconomic shocks and financial distress, are plotted in Figures 3, 4, and 5.[16]

[15]As such, the recourse to generalized impulses helps avoid uncertainties associated with the ordering of the variables when impulses orthogonalized by Choleski decomposition are used.

[16]The charts illustrate the impulse response functions and the ± 2 standard error confidence bands. The standard error bounds were generated from the simulated impulse responses across 1000 Monte Carlo repetitions.

Figure 3. Impulse Response of NPL

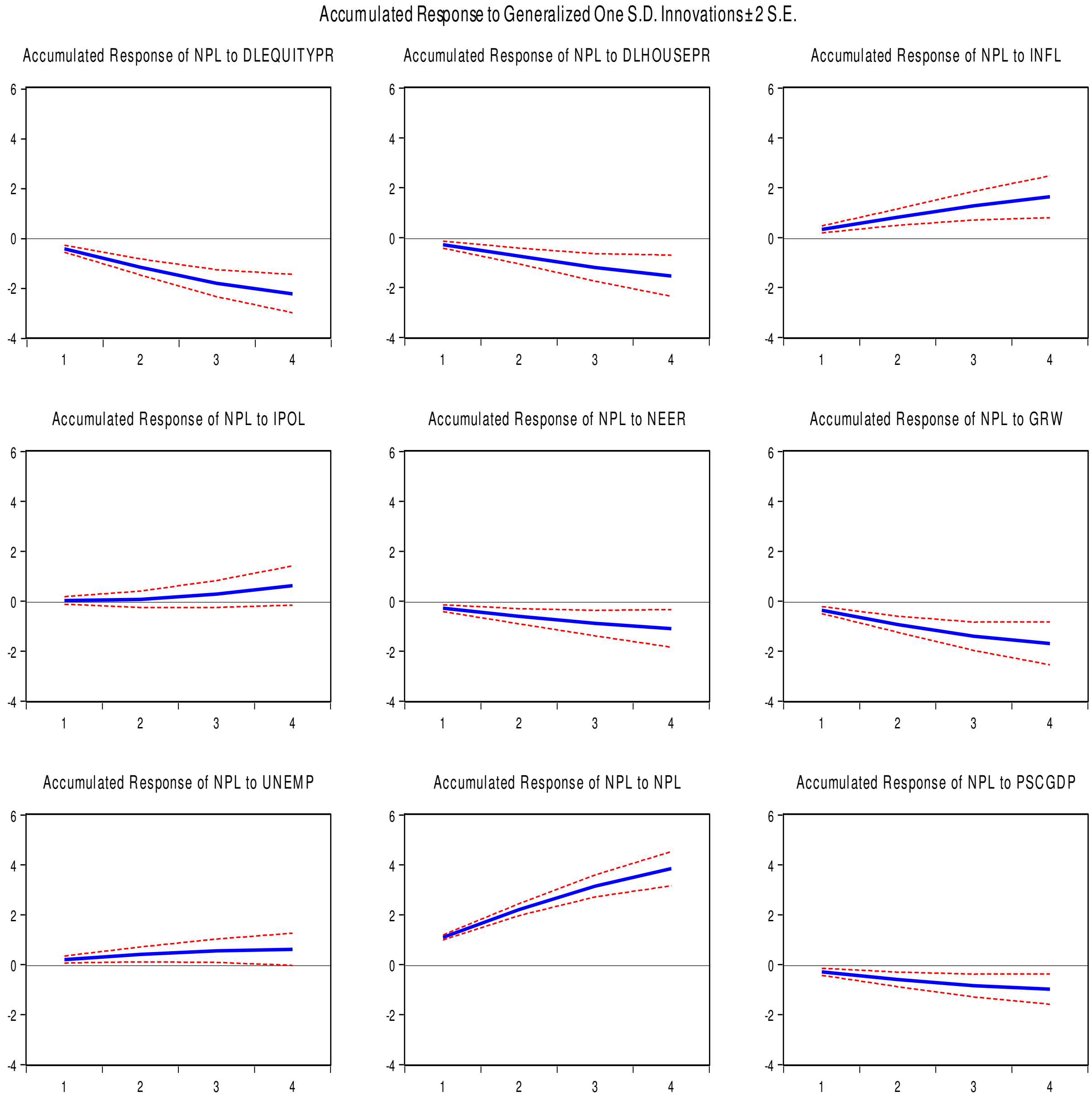


Figure 4. Impulse Response of Credit-to-GDP

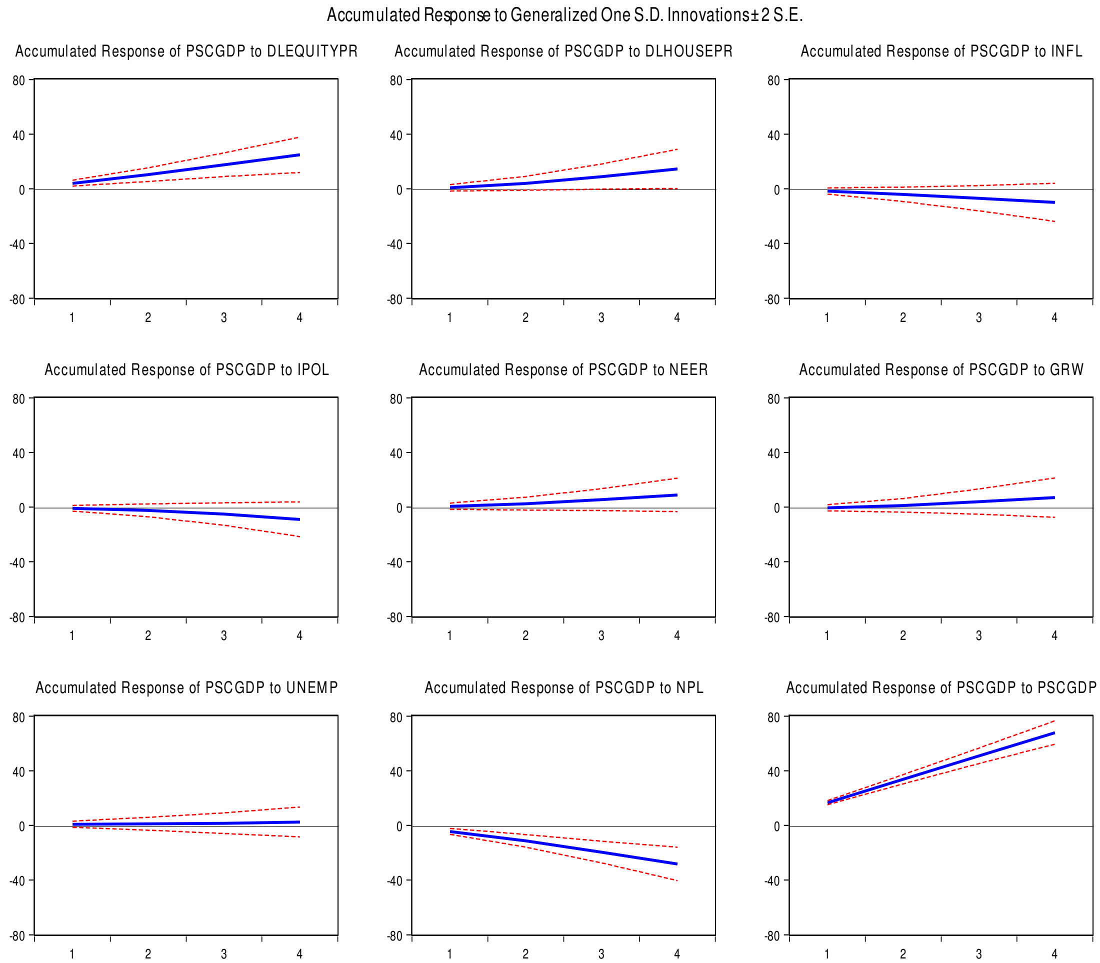
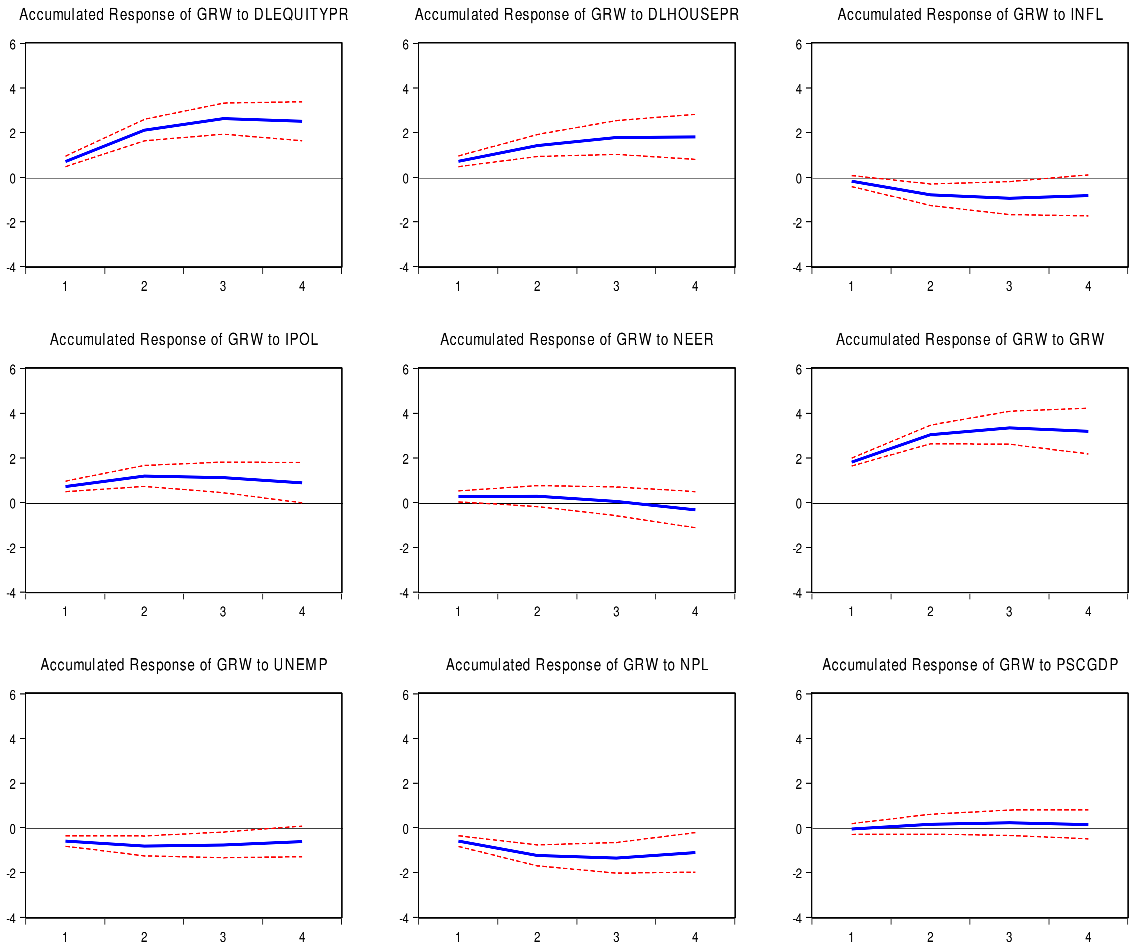


Figure 5. Impulse Response of GDP Growth

Accumulated Response to Generalized One S.D. Innovations±2 S.E.



Discussion of the results

The findings of the panel regressions are in line with stylized facts and expectations. They confirm that a deterioration in the macroeconomic environment—proxied by slower growth, higher unemployment or falling asset prices—is associated with debt service problems, reflected into rising NPL. Conversely, a favorable macroeconomic environment is associated with subdued NPL as was observed in the run up to the 2008 crisis. Asset quality tends to reinforce the business cycle and is therefore procyclical.

The IRFs reveal the important and central role of NPL in the macrofinancial linkages. Over a four-year forecast period, of all the variables included in the VAR, NPL is the only one that has both effects on- and responses to- every single variable that are statistically significant. Moreover, the effects and the responses are intuitive. The linkages between NPL, private credit-to-GDP, house prices, and growth are discussed below to highlight the macrofinancial linkages.

Adverse shocks to asset prices, macroeconomic performance, and credit to the private sector all cause loan quality to worsen. NPL's responses are persistent and for the most significant.

- When the change in house prices increases by one standard deviation increase, amounting to 6.1 percentage points, NPL increases by 0.3 percentage points the first year. By the fourth year, NPL is 1.5 percentage points higher than before the shock to house prices.
- An increase in inflation by 1.6 percentage points causes NPL to increase by 0.3 percentage points the first year and a cumulative 1.6 percentage points by the fourth year. The effects of shocks to private sector credit are surprisingly small, albeit statistically significant.
- A 2.7 percentage points adverse shock to GDP growth causes NPL to increase by 0.4 percentage point the first year, reaching 1.7 by the fourth year.
- A one standard deviation decrease in the credit-to-GDP ratio causes NPL to increase by 0.3 percentage points the first year and only 1 percentage point by the fourth year.

Asset prices, credit to the private sector, economic growth, and NPL itself all worsen significantly in response to an NPL shock. A one-standard deviation shock to NPL amounts to a 2.4 percentage points increase, which is at least as large as increases observed in countries such as the Czech Republic, Italy, the United Kingdom, and the United States in any one of the two crisis year, 2008 or 2009. Such a shock leads to the following responses.

- The change in house prices subsides by 1.2 percentage points in the first year and continue to decline, reaching 3.2 percentage points by the fourth year.
- Private sector credit-to-GDP declines by 4.5 percentage points the first year, and the decline reaches 28 percentage points by the fourth year.
- GDP growth declines in the first year by 0.6 percentage points. The decline reaches a trough of 1.4 percentage points in the third year and subsides to 1.1 percentage point in the fourth year. The magnitude of the first-year decline is close to the one reported in Espinoza and Prasad (2010).
- NPL itself increases by a one percentage point the first year and the increase almost quadruples by the fourth year, reaching 3.8 percentage points.

The magnitudes of the uncovered NPL and GDP growth IRFs are very meaningful in the context of advanced economies. For developing countries, an NPL increase of 0.6 to 1.7 percentage points may not mean much as the onset of systemic crises generally coincides with very high NPL. For developed countries in contrast, NPL increases of these magnitudes can trigger very adverse macroeconomic and financial developments as the peak in NPL associated with the onset of systemic banking crises has been relatively low. For instance, in the U.K. and the U.S. where recent systemic banking crises are dated 2007 (Laeven and

Valencia, 2008), reported NPL increased to relatively moderate levels. In the U.K., NPL increased from 1.5 percent in 2006 to 1.7 in 2007 and 2.9 in 2008, whereas in the U.S., it increased from 1.8 percent in 2006 to 2.6 in 2007 and 4.9 in 2008. With regard to GDP growth, adverse responses of 0.6 to 1.4 percentage points are significant in advanced economies whose median growth is only 2.5 percent.

IV. Conclusion and Policy Implication

The 2008 global financial crisis is a relatively fresh reminder of the challenges posed by rising NPL in advanced economies, making a close examination of the relationship between NPL and macroeconomic performance worthwhile. While the existing literature has looked into the issue from different angles and on diverse samples, our analysis is the first to examine aggregate NPL from a sample that simultaneously covers most advanced economies and data related to the recent crisis, which is foremost an advanced economies' crisis.

Our investigation of the linkages between NPL and macroeconomic performance from a sample of 26 advanced countries attributes to NPL a central role. A sharp increase in NPL triggers long-lived tailwinds that cripple macroeconomic performance from several fronts. The IRFs indicate that, of all the variables included in the model, NPL is the only one that has both a statistically significant response to- and predictive power on- every single variable over a 4-year forecast period. The signs of the IRFs are broadly as expected and the magnitudes of the responses of NPL and indicators of macroeconomic performance to shocks affecting each other are very meaningful in the advanced economies' context. Regardless of the factors behind the deterioration in loan quality, the evidence suggests that a sharp increase in aggregate NPL feeds on itself leading to an almost linear incremental response that continues into the fourth year after the initial shock. The confluence of adverse responses in key indicators of macroeconomic performance—GDP growth and unemployment—leads to a downward spiral in which banking system distress and the deterioration in economic activity reinforce each other.

The main findings of our analysis have both practical applicability and policy implications. The econometric relations uncovered in this paper can be used for forecasting and stress testing purposes by supervisory authorities and, to some extent, banks. The regressions' coefficients and the impulse responses along with assumptions on the evolution of macroeconomic variables and asset prices can be used in a macro-stress testing exercise to assess the likely change in NPL and whether such a change could pose risk of financial instability based on some indicative threshold. The broad policy implication of our analysis, which highlights the central role of NPL in the credit frictions-adverse macroeconomic performance nexus, is that, while NPL remain a permanent feature of banks' balance sheets, policies and reforms should be geared to avoiding sharp increases that set into motion the adverse feedback loop between macroeconomic and financial shocks. In this regard, preventing excessive risk-taking during upturns through adequate macroprudential regulations is the first best.

Our analysis is subject to a number of caveats. First, the outstanding level of NPL is a rough measure of credit quality as a decrease can simply reflect the removal of unrecoverable loans from banks' balance sheets. In this regard, the flow of debt classified as nonperforming for the first time would be more informative. Second, with the cross-border expansion of banks, NPL also have cross-border implications as banks facing losses in a country can tighten credit in another to limit losses to their consolidated balance sheets. Third, just as the importance of banks in the overall credit allocated to the private sector differs across countries because of the involvement of nonbank financial institutions, so do the macrofinancial vulnerabilities associated with NPL from the only balance sheets of banks.

There are interesting avenues for future research. The relationships derived from aggregate NPL, while useful, can mask important differences in feedback between the macroeconomy and NPL on different types of loans. Such relationships can be uncovered on single countries for which there are disaggregated long enough NPL time series. Second, the output effects of credit market frictions could be nonlinear. Therefore, it may be worth exploring threshold effects. Third, provisioning for bad loans can make a difference on banks' ability to withstand adverse shocks to the quality of their loan portfolio and their ability to continue lending after such shocks. In this regard, data permitting, an analysis of the linkages between macroeconomic indicators and NPL net of provisioning for bad loans could enrich the understanding of associated macrofinancial vulnerabilities.

Appendix

Table A1. Variables' Description and Data Sources

Description	Main Source
Logarithm of the stock price index (LNHOUSEPR)	Stock price indices from IMF, International Financial Statistics
Logarithm of the house price index (LNEQUITYPR)	House price indices from Haver and Bank for International Settlements
First-difference of LNEQUITYPR in percent (DLEQUITYPR)	Calculated as noted in the description
First-difference of LNHOUSEPR in percent (DELHOUSEPR)	Calculated as noted in the description
Annual change in real GDP, in percent (GRW)	IMF, World Economic Outlook database
Annual change in the consumer price index, in percent (INFL)	IMF, World Economic Outlook database
Policy rate of interest, in percent (IPOL)	Datastream
Nominal effective exchange rate index, 2000=100 (NEER) An increase denotes an appreciation.	Global Financial database (GDS)
Ratio of non-performing loans to gross loans, in percent (NPL)	Bankscope, US Federal Reserve Database (for the United States), IMF, Global Financial Stability report.
Credit to the private sector in percent of GDP (PSCGDP)	IMF, International Financial Statistics.
Rate of unemployment in percent (UNEMP)	IMF, World Economic Outlook database

Table A2. Summary Statistics

	Mean		Median		Standard deviation		Maximum		Minimum	
	A	B	A	B	A	B	A	B	A	B
DLEQUITYPR	1.21	1.49	9.52	9.55	31.58	31.48	67.39	67.39	-230.01	-230.01
DLHOUSEPR	5.15	5.34	4.77	5.21	6.07	6.15	25.08	25.08	-15.23	-15.23
INFL	2.23	2.25	2.17	2.16	1.60	1.60	12.41	12.41	-1.38	-0.90
IPOL	3.36	3.33	3.00	3.00	2.35	2.32	18.00	18.00	0.001	0.001
NEER	106.85	106.89	106.42	106.38	12.31	12.56	157.09	157.09	47.95	47.95
GRW	2.34	2.33	2.46	2.46	2.72	2.54	10.73	10.73	-8.02	-8.02
UNEMP	6.25	6.37	6.13	6.16	2.73	2.67	18.01	18.01	1.01	1.81
NPL	2.54	2.44	1.73	1.70	2.39	2.20	15.56	13.40	0.11	0.11
PSCGDP	125.73	123.01	106.63	105.82	80.21	77.87	527.25	527.25	31.69	31.69

Note: Columns A relate to the full sample while columns B are for a restricted sample that excludes Iceland, whose NPL increased notably during the global financial crisis.

Table A3. Cross-correlations Between Variables

	DLEQUITYPR	DLHOUSEPR	INFL	IPOL	NEER	GRW	UNEMP	NPL	PSCGDP
DLEQUITYPR	1.000								
DLHOUSEPR	0.158 ***	1.000							
INFL	-0.402 ***	0.180 ***	1.000						
IPOL	-0.105 *	0.358 ***	0.564 ***	1.000					
NEER	0.084	0.127 **	-0.221 ***	-0.204 ***	1.000				
GRW	0.288 ***	0.460 ***	0.033	0.319 ***	-0.069	1.000			
UNEMP	0.119 **	0.035	-0.083	-0.160 ***	0.090	-0.153 ***	1.000		
NPL	-0.148 **	-0.289 ***	0.105 *	-0.041	-0.246 ***	-0.159 ***	0.171 ***	1.000	
PSCGDP	-0.072	-0.113 *	0.019	0.021	0.037	-0.080	-0.228 ***	-0.083	1.000

Note: 267 observations included. *, **, and *** denote significance at 10 percent, 5 percent, and 1 percent.

Table A4. Vector Autoregression, Lag Length Selection

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-5054.1	NA	8.7e+12	55.3	55.5	55.4
1	-3795.5	2379.7	22397331	42.5	44.043*	43.1
2	-3660.1	242.7	12429039*	41.9	44.9	43.09*
3	-3578.3	138.47*	12515203	41.862*	46.3	43.7

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Table A5. Impulse Responses—Accumulated responses to Generalized One Standard Deviation Shocks

Response of DLEQUITYPR:

Period	DLEQUITYPR	DLHOUSEPR	INFL	IPOL	NEER	GRW	UNEMP	NPL	PSCGDP
1	**29.95**	**4.89**	**-11.77**	**5.37**	1.12	**11.65**	0.20	**-12.39**	**7.17**
2	**29.52**	**6.58**	**-9.20**	-0.54	0.84	**9.00**	1.71	**-12.15**	**7.43**
3	**24.85**	**6.36**	**-6.31**	**-4.97**	0.75	6.35	2.60	**-9.89**	**6.00**
4	**21.97**	5.33	-5.15	**-7.09**	0.73	4.93	3.21	**-8.00**	**4.67**

Response of DLHOUSEPR:

Period	DLEQUITYPR	DLHOUSEPR	INFL	IPOL	NEER	GRW	UNEMP	NPL	PSCGDP
1	**0.76**	**4.68**	-0.26	**1.03**	**1.03**	**1.84**	**-0.94**	**-1.23**	0.19
2	**2.47**	**7.89**	-0.84	**1.94**	**1.51**	**3.60**	**-1.42**	**-2.46**	0.50
3	**3.55**	**9.94**	-1.03	**2.30**	**1.52**	**4.59**	**-1.52**	**-3.11**	0.63
4	**3.93**	**11.09**	-0.91	**2.38**	1.20	**4.97**	-1.36	**-3.24**	0.54

Response of INFL:

Period	DLEQUITYPR	DLHOUSEPR	INFL	IPOL	NEER	GRW	UNEMP	NPL	PSCGDP
1	**-0.44**	-0.06	**1.12**	**0.13**	**-0.26**	-0.11	-0.01	**0.33**	-0.12
2	**-0.28**	**0.26**	**1.53**	**0.65**	**-0.34**	**0.40**	**-0.22**	**0.28**	-0.15
3	0.28	**0.74**	**1.56**	**1.20**	**-0.40**	**1.05**	**-0.42**	0.03	-0.09
4	**0.79**	**1.21**	**1.54**	**1.59**	**-0.52**	**1.54**	**-0.54**	-0.17	-0.02

Response of IPOL:

Period	DLEQUITYPR	DLHOUSEPR	INFL	IPOL	NEER	GRW	UNEMP	NPL	PSCGDP
1	**0.22**	**0.27**	**0.14**	**1.21**	-0.08	**0.48**	**-0.29**	0.03	-0.07
2	**1.01**	**0.82**	0.04	**2.28**	-0.13	**1.21**	**-0.59**	**-0.30**	0.05
3	**1.77**	**1.47**	-0.03	**3.05**	-0.22	**1.87**	**-0.83**	**-0.69**	0.19
4	**2.39**	**2.10**	-0.07	**3.57**	-0.35	**2.42**	**-1.02**	**-1.03**	0.31

Response of NEER:

Period	DLEQUITYPR	DLHOUSEPR	INFL	IPOL	NEER	GRW	UNEMP	NPL	PSCGDP
1	0.20	**1.17**	**-1.24**	-0.36	**5.29**	**0.80**	**-0.74**	**-1.37**	0.18
2	0.58	**2.67**	**-2.38**	-1.25	**10.71**	**1.71**	**-1.42**	**-2.91**	0.41
3	0.71	**4.26**	**-3.36**	**-2.63**	**16.21**	**2.51**	**-2.02**	**-4.36**	0.53
4	0.54	**5.77**	**-4.25**	**-4.36**	**21.77**	3.15	-2.50	**-5.62**	0.51

Response of GRW:

Period	DLEQUITYPR	DLHOUSEPR	INFL	IPOL	NEER	GRW	UNEMP	NPL	PSCGDP
1	**0.70**	**0.71**	**-0.18**	**0.72**	**0.28**	**1.81**	**-0.59**	**-0.60**	-0.06
2	**2.11**	**1.42**	-0.79	**1.19**	0.29	**3.04**	**-0.82**	**-1.24**	0.16
3	**2.62**	**1.78**	-0.95	**1.12**	0.05	**3.35**	**-0.77**	**-1.35**	0.22
4	**2.51**	**1.80**	-0.82	**0.89**	-0.32	**3.20**	**-0.62**	**-1.10**	0.15

Response of UNEMP:

Period	DLEQUITYPR	DLHOUSEPR	INFL	IPOL	NEER	GRW	UNEMP	NPL	PSCGDP
1	0.00	**-0.15**	-0.01	**-0.18**	**-0.10**	**-0.24**	**0.74**	**0.13**	0.03
2	**-0.53**	**-0.56**	**0.34**	**-0.50**	**-0.29**	**-0.89**	**1.51**	**0.57**	-0.03
3	**-1.21**	**-1.07**	**0.78**	**-0.72**	**-0.46**	**-1.57**	**2.22**	**1.08**	-0.11
4	**-1.78**	**-1.55**	**1.19**	**-0.79**	**-0.57**	**-2.13**	**2.84**	**1.52**	-0.16

Response of NPL:

Period	DLEQUITYPR	DLHOUSEPR	INFL	IPOL	NEER	GRW	UNEMP	NPL	PSCGDP
1	**-0.45**	**-0.29**	**0.32**	0.03	**-0.28**	**-0.36**	**0.20**	**1.09**	**-0.29**
2	**-1.19**	**-0.75**	**0.81**	0.08	**-0.60**	**-0.93**	**0.41**	**2.21**	**-0.59**
3	**-1.84**	**-1.20**	**1.28**	0.28	**-0.88**	**-1.41**	**0.55**	**3.15**	**-0.84**
4	**-2.25**	**-1.54**	**1.64**	**0.62**	**-1.10**	**-1.69**	**0.61**	**3.84**	**-0.98**

Response of PSCGDP:

Period	DLEQUITYPR	DLHOUSEPR	INFL	IPOL	NEER	GRW	UNEMP	NPL	PSCGDP
1	**3.97**	0.68	-1.71	-0.95	0.58	-0.54	0.71	**-4.47**	**16.59**
2	**10.28**	3.94	-4.14	-2.48	2.51	1.19	1.10	**-11.37**	**33.71**
3	**17.57**	**8.87**	-7.01	-5.11	5.38	3.98	1.57	**-19.62**	**50.92**
4	**24.86**	**14.53**	-10.03	-9.01	8.84	6.89	2.43	**-28.30**	**67.92**

Bold figures suggest significantly different from zero at the standard significance levels: 1 percent, 5 percent, and 10 percent.

Generalized Impulse
Standard Errors: Monte Carlo (1000 repetitions)

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