BANCA D'ITALIA
EUROSISTEMA

Questioni di Economia e Finanza

(Occasional Papers)

Macroeconomic determinants of bad loans: evidence from Italian banks

by Marcello Bofondi and Tiziano Ropele

March 2011

Number 89

BANCA D'ITALIA
EUROSISTEMA

Questioni di Economia e Finanza

(Occasional papers)

Macroeconomic determinants of bad loans: evidence from Italian banks

by Marcello Bofondi and Tiziano Ropele

Number 89 – March 2011

The series Occasional Papers *presents studies and documents on issues pertaining to the institutional tasks of the Bank of Italy and the Eurosystem. The* Occasional Papers *appear alongside the* Working Papers *series which are specifically aimed at providing original contributions to economic research.*

The Occasional Papers *include studies conducted within the Bank of Italy, sometimes in cooperation with the Eurosystem or other institutions. The views expressed in the studies are those of the authors and do not involve the responsibility of the institutions to which they belong.*

The series is available online at www.bancaditalia.it.

MACROECONOMIC DETERMINANTS OF BAD LOANS: EVIDENCE FROM ITALIAN BANKS

by Marcello Bofondi* and Tiziano Ropele**

Abstract

In this paper we use a single-equation time series approach to examine the macroeconomic determinants of banks' loan quality in Italy in the past twenty years, as measured by the ratio of new bad loans to the outstanding amount of loans in the previous period. We analyse the quality of loans to households and firms separately on the grounds that macroeconomic variables may affect these two classes of borrowers differently. According to our estimated models: i) the quality of lending to households and firms can be explained by a small number of macroeconomic variables mainly relating to the general state of the economy, the cost of borrowing and the burden of debt; ii) changes in macroeconomic conditions generally affect loan quality with a lag; and iii) the out-of-sample prediction accuracy of the models is quite satisfactory and proved to be robust to the recent financial crisis.

JEL Classification: G21, C22.

Keywords: bad loans, macroeconomic determinants, Italian banking system.

Contents

* Bank of Italy, Structural Economic Analysis Department.
** Bank of Italy, Economic Outlook and Monetary Policy Department.

1 Introduction[1]

Deterioration in banks' loan quality is one of the major causes of financial fragility. Past experience shows that a rapid build-up of bad loans plays a crucial role in banking crises (see, e.g., Demirgüç-Kunt and Detragiache, 1998, and González-Hermosillo, 1999). In recent years, the global financial crisis and the subsequent recession in many developed countries have increased households' and firms' defaults, causing significant losses for banks. Regular monitoring of loan quality, possibly with an early warning system capable of alerting regulatory authorities of potential bank stress, is thus essential to ensure a sound financial system and prevent systemic crises. In this regard, the analytical tools currently under scrutiny in the context of macro-prudential regulation do in fact assign great emphasis to indicators of asset quality.[2]

In this paper we study the main macroeconomic determinants of banks' loan quality in Italy over the period 1990q1–2010q2. As macroeconomic developments may have a different impact on loan quality depending on the type of borrower, we conduct separate analyses for households and firms.[3] In particular, we estimate single-equation time series regressions that map a set of macroeconomic indicators into a measure of the quality of banks' loans. More specifically, our dependent variable is the new bad loans ratio (henceforth, NBL ratio), defined as the ratio of the flow of bad loans ("*sofferenze*") to the stock of performing loans at the end of the previous period. We then assess the predictive power of these models by running recursive out-of-sample forecasts, so as to identify the best-performing specification.

The single-equation time series regression approach we propose in this paper has two main advantages. First, it is relatively easy to handle and to interpret. Second, the estimated specifications can be easily employed to predict the NBL ratios using the projections of the explanatory variables that are regularly produced with the Bank of Italy's quarterly macro-econometric model.

[1] We are especially grateful to Paolo Del Giovane for many valuable suggestions and comments. We also thank Ugo Albertazzi, Giorgio Gobbi, Giulio Nicoletti, Fabio Panetta and Mario Porqueddu. The views expressed in this paper are those of the authors and do not necessarily reflect the opinions of the Bank of Italy.

[2] Agresti et al. (2008) reports a comparison between the financial soundness indicators compiled by the IMF and the macro-prudential indicators compiled by the European Central Bank together with the Basel Committee on Banking Supervision. The IMF indicators are non-performing loans to capital and non-performing loans to total loans. The ECB-Basel indicators comprise provision to total assets, non-performing loans and doubtful loans to total loans, non-performing loans and doubtful loans to total own funds and total provision to total non-performing and doubtful assets.

[3] The household sector consists of consumer households while the firm sector includes non-financial corporations and producer households.

The main results of our analysis are as follows. First, in line with previous studies, the quality of loans, both to households and to firms, depends on only a few macroeconomic variables and improves as business cycle conditions become more buoyant. In particular, according to our best-performing specifications, the NBL ratio for households is inversely related with the annual growth rates of real gross domestic product and house prices, while it is positively associated with the unemployment rate and the short-term nominal interest rate. For firms, the NBL is positively correlated with the unemployment rate and the ratio of net interest expenses to gross operating profits; it is inversely related to the annual growth rate of durable goods consumption. Unlike households, for firms the NBL ratio also displays significant endogenous persistence.

Second, changes in macroeconomic determinants affect the quality of loans with different time lags. For example, for households the annual growth rate of real gross domestic product and the short-term nominal interest rate enter with a lag of 4 and 3 quarters, respectively; for firms, the ratio of net interest expenses to gross operating profits enters with a lag of 2 quarters. For both classes of borrowers, the unemployment rate affects the NBL ratio simultaneously.

Third, the out-of-sample prediction accuracy of our best-performing specifications is quite satisfactory. For households, the root mean squared forecast error is particularly small at all forecasting horizons (on average 0.1). For firms, prediction accuracy is poorer and worsens quite rapidly as the forecasting horizon increases: the root mean squared forecast error rises from 0.25 to 0.35 when moving from one- to eight-quarter-ahead forecasts.

Fourth, the prediction accuracy of our best-performing specifications has proved robust to the rapid changes in many macroeconomic variables from mid-2007 onwards, in connection with the outbreak of the financial crisis. Indeed, in the case of firms, the prediction accuracy has even improved slightly in the crisis period for all forecast horizons, possibly reflecting a stronger information content of macroeconomic regressors.

The rest of the paper is organized as follows. Section 2 briefly reviews the empirical literature on the macroeconomic determinants of the quality of banks' loans, focusing primarily on empirical studies that employ time-series methodologies. Section 3 describes our data set and presents the empirical strategy to model the NBL ratios for lending to households and firms; Section 4 presents the estimation results. Section 5 tests the forecasting accuracy of our estimated models through recursive out-of-sample forecasts, ultimately selecting the best-performing specification for households and for firms. This section also discusses the relative importance of the different forces driving the dynamics of the NBL ratios in the past twenty years and during the recent recession. Section 6 evaluates if and to what extent the recent economic crisis has affected the prediction accuracy of our preferred specifications, and Section 7 concludes.

2 Overview of the empirical literature

The macroeconomic determinants of the quality of banks' loans have attracted mounting interest over the last two decades.

One of the earliest studies on this topic is by Keeton and Morris (1987), who investigated the fundamental drivers of loan losses for a sample of nearly 2,500 US commercial banks for the period 1979–1985. Using simple linear regressions, they find that a large portion of loan losses variation reflected adverse local economic conditions and, in particular, unusually poor performances of specific industries such as agriculture and energy.

One strand of the literature has exploited the time- and cross-sectional dimensions of bank-specific data and macroeconomic variables to explain the quality of bank loans (see, e.g., Berger and DeYoung, 1997, for the US; Jimenez and Saurina, 2006, for Spain; Quagliariello, 2007, for Italy; Pain, 2003, for the UK; and Bikker and Hu, 2002, for 29 OECD countries). These studies document significant correlations between bank-specific features, such as size, profit margins, cost efficiency, risk profile and market power, and the evolution of problem loans; macroeconomic indicators are included mainly as control variables and are thus treated as exogenous.

A second strand of the literature has relaxed the strict assumption that the macroeconomic environment is exogenous with respect to the quality of banks' loan and employed the vector autoregressive (VAR) methodology to account for the simultaneity and the feedback effects that exist between the business cycle and banks' balance sheets.

Hoggarth et al. (2005) employ UK quarterly data for the period 1988–2004 to evaluate the dynamics between banks' write-off to loan ratio and several macroeconomic variables. In general, their results show a significant and negative relationship between changes in the output gap and the write-off ratio, with the maximum impact occurring after one year. Banks' write-off ratio also increases after increases in retail price inflation and nominal interest rates. At a sectoral level, the write-off ratio for firms increases following unexpected adverse output shocks or rises in the nominal interest rate, while that for households seems more sensitive to changes in the ratio of interest payments to disposable income than to changes in business cycle conditions. Similarly, Babouček and Jančar (2005) quantify the effects of macroeconomic shocks on the loan quality of the Czech banking sector for the period 1993–2006 and report evidence of a positive correlation of non-performing loans with the unemployment rate and consumer price inflation. Gambera (2000) assesses the impact of state and nation-wide macroeconomic variables on the quality of different types of loans (agricultural, commercial, industrial and residential) using US quarterly data for 1987–1999. The author reports that the unemployment rate, farm and non-farm incomes, bankruptcy fillings and car sales, among various explanatory variables, were significant predictors of bank asset quality.

Marcucci and Quagliariello (2008) and Filosa (2007) are studies focused on the Italian banking system. Marcucci and Quagliariello (2008) employ a reduced-form VAR to assess, among other things, the effects of business cycle conditions on bank customers' default rates over the period 1990–2004. Their results show that the default rates follow a cyclical pattern, falling during macroeconomic expansions and increasing during downturns. Moreover, this evidence is robust to different measures of the output gap and holds for households, firms and the non-financial sector as a whole. Finally the authors do not find strong evidence of feedback effects from the soundness of banks' balance sheets to economic activity. Filosa (2007), estimating three distinct VAR models over the period 1990–2005 with different indicators of banks' soundness, finds a somewhat weaker relation between macroeconomic developments and banks' soundness. In particular, his results show that the responses of the indicators of banks' soundness to output shocks, while of the expected signs and statistically significant, explain only a small fraction of the historical variability of the dynamics of bad loans. On the other hand, he finds that deterioration (improvement) in the quality of loans weakens (reinforces) real activity and inflation.

More closely related to our paper, at least from a methodological perspective, are three recent studies that use a single-equation time series approach. Kalirai and Scheicher (2002) employs a simple linear regression to examine the interdependence of credit risk for Austrian banks and the state of the economy, portrayed by real gross domestic product, industrial production, consumer price inflation, money growth, interest rates, stock market indices, and other macroeconomic indicators. According to their estimates, during the period 1990–2001 the loan quality was influenced in particular by the short-term nominal interest rate, industrial production, the stock market return and a business confidence index. Arpa et al. (2001) assess the effects of macroeconomic developments on risk provisions (calculated as the ratio of total provisions for loans to the sum of total loans and total provisions for loans) of Austrian banks for the period 1990–1999. They use a single-equation time series model in which the dependent variable, i.e. banks' risk provisions, is regressed on the growth rate real gross domestic product, real estate price developments and real interest rates. The estimated model delivers a good empirical fit and all explanatory variables are highly significant. In particular, risk provisions rise when real gross domestic product growth declines, real interest rates fall and real estate prices increase. However, the authors consider the last-mentioned result at odds with expectations, because one would expect the value of mortgages to increase that when real estate prices rise, thus reducing the likelihood of loan losses. Finally, Shu (2002) uses a similar single-equation time series model to examine the impact of macroeconomic developments on loans quality in Honk Hong for the period 1995–2002. The results show that the ratio of bad loans to performing loans falls with higher real gross domestic product growth, higher consumer price inflation rate and higher property prices growth, whereas it rises with increases in nominal interest rates. The unemployment rate and performance of equity prices growth are not significant.

Summing up, the existing empirical evidence shows, quite convincingly, that favourable macroeconomic conditions, such as sustained economic growth, low unemployment and interest rates, tend to be associated with a better quality of bank loans; under favourable economic circumstances, borrowers receive sufficient streams of income and meet their debt obligations more easily. Furthermore, these results are robust to different empirical methodologies and hold across countries.

3 Data and empirical methodology

3.1 Indicator of the quality of loans to households and firms

To measure the quality of Italian banks' loans we use the quarterly ratio (annualized and seasonally adjusted) of the flow of new bad loans to the stock of performing loans at the end of previous quarter. We draw our data from the Italian Central Credit Register[4] and the supervisory reports to the Bank of Italy. Bad loans are defined on a customer basis and therefore include all the outstanding credit extended by a bank to a borrower considered insolvent. Under Italian regulations, banks are asked to classify as bad loans outstanding exposures to borrowers who are not expected to meet their obligations. This allows banks some discretion in judging the quality of a loan. To overcome this drawback, at least partially,

[4] This information system, administrated by the Bank of Italy, collects data on borrowers from their lending banks. Reporting banks file detailed information for each borrower with total loans and credit lines of more than €75,000. Banks are requested to report smaller exposures only in the case of default.

we use an "adjusted" definition of bad loans provided by the Central Credit Register. In the case of a single bank relationship this definition coincides with that of bad loans, covering all the loans extended to the insolvent borrowers. Loans to borrowers with multiple bank relationships are all classified as ("adjusted") bad loans when: (i) the borrower is reported as insolvent by a bank that accounts for 70 per cent or more of the borrower's exposure to the banking system; (ii) the borrower is reported as insolvent by two or more banks that account for at least 10 per cent of its total exposure to the banking system.

Figure 1 depicts the development of the NBL ratios for lending to households and firms over the period 1990q1–2010q2. Although it is limited by data availability, this sample period is long enough to include a number of technical recessions[5] (indicated by the shaded areas in Figure 1) and important structural changes in the Italian banking system.

Both NBL ratios share a common qualitative pattern. In the first half of the 1990s they increased considerably, to nearly 3 per cent for households and above 5 per cent for firms, reflecting the sharp 1992–93 recession. In the following years credit quality remained low, following the crisis that involved a significant part of the banking system in Italy's southern regions. In the late 1990s the NBL ratios trended downward. Then, from 2000 through 2007 they hovered in relatively narrow ranges, between 0.7 and 1.0 per cent for households and between 1.1 and 2.2 per cent for firms.[6] Thus, while the 2001 economic recession did not have a significant impact on loan quality, the recent financial crisis and the severe recession that followed in its wake significantly worsened the quality of credit.

The long downward trend of the NBL ratios between the late 1990s and 2007 can be ascribed, not only to relatively good general economic conditions but also to structural changes. Following the new 1993 banking law and the privatization of the banks previously under public control, the Italian banking system experienced a wave of mergers and acquisitions that eventually stoked competition (Angelini and Cetorelli, 2003) and efficiency (Focarelli and Panetta, 2003). Moreover, consolidation increased banks' size, enabling them to exploit scale economies deriving from the adoption of costly information technology. The rapid spread of credit scoring (Bofondi and Lotti, 2004) and, more generally, their enhanced data-processing, capacity allowed Italian banks to screen borrowers better (Panetta et al., 2009).

[5] A technical recession occurs when real GDP declines over two successive quarters. Our sample period contains three technical recessions: 1992q2 to 1993q2, 2001q2 to 2002q4, and 2008q2 to 2009q2.

[6] The series of NBL ratio for lending to firms has been adjusted for the massive increase of new bad loans recorded in the fourth quarter of 2003 due to the default of Parmalat.

Notwithstanding the similar dynamics exhibited by the NBL ratios for households and firms, we chose to model the NBL ratios with two different specifications, since, from a theoretical point of view, households' and firms' ability to repay their loans may be affected by different macroeconomic indicators, possibly also with different lags. Moreover, from a quantitative standpoint, the NBL ratios for households and firms show important differences in terms of sample means and variability. In fact, as reported in Table 1a, the NBL ratio for households has a mean of 1.4 per cent and a standard deviation of 0.5 while that for firms has a mean of 2.3 per cent and is more volatile, with a standard deviation of 1.

We also tested for the presence of unit roots in the NBL ratio for households and firms using the Augmented Dickey-Fuller (ADF) test as well as the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test. Table 1b reports the results. The ADF test cannot reject the null of a unit root for both NBL ratios. However, given the low power of the ADF test in small sample, we also applied the KPSS, which instead cannot reject the null hypothesis of stationarity at least at 1 per cent for all the series involved in our main empirical analysis. Given this mixed evidence, we decided to proceed by assuming stationarity of the NBL ratios. [7]

3.2 Macroeconomic determinants of the NBL ratio

In this section we present the set of macroeconomic determinants that we used to model the NBL ratio for lending to households and firms.[8] We consider five categories of macroeconomic variables relating to: (1) the general state of the economy; (2) the conditions of price stability; (3) the cost of servicing debt; (4) the debt burden ; (5) financial and real wealth; and (6) the outlook for economic growth.[9]

As indicators of the general state of the economy we use the annual growth rate of real gross domestic product (GDP) and the seasonally adjusted unemployment rate (UNEMPL). The dynamics of both variables are closely related to households' and firms' capacity to meet their debt obligations. An increase in GDP generally reflects larger flows of income for households and higher profitability for firms. Increases in the unemployment rate curtail the present and future purchasing power of households and are commonly associated with a decrease in the

[7] Consequently, we did not test for the presence of cointegration between the NBL ratios and the macroeconomic variables.

[8] Appendix A reports the statistical sources of the macroeconomic variables and also gives a list of other economic indicators that we tested but whose results we decided not to include in the tables.

[9] The connection between macroeconomic conditions and banks' loan quality can also be justified on theoretical grounds. For example, Lawrence (1995) and more recently Rinaldi and Sanchis-Arellano (2006) present models of life-cycle consumption in which households' default probability on loans depends on current income, the unemployment rate and the lending rate. In the same vein, the arbitrage pricing theory proposed by Ross (1976) shows that the market value of firms depends, among other things, on the underlying macroeconomic variables. Thus, changes in economic conditions may affect the overall profitability of firms and their capacity to repay debt.

production of goods and services. Thus, in periods of strong economic growth and favourable labour market conditions borrowers are better able to support debt, so one should expect a decline in the NBL ratio.

We use two indicators of price stability: annual consumer price inflation (INFL) and the annual growth rate of the M3 monetary aggregate M3 (M3). *A priori,* it is hard to tell what we should expect the relation of these variables to be with the NBL ratio. On the one hand, price stability is generally considered a prerequisite for sound economic growth. Also, high inflation passes through to nominal interest rates, making debt servicing more onerous. On the other hand, high inflation may help borrowers, whose debt is denominated in nominal terms, as it erodes the real value of debt. Rinaldi and Sanchis-Arellano (2006) find a positive relation between the inflation rate and non-performing loans, while Shu (2002) reports a negative relation. Concerning the growth rate of M3, accelerating money supply growth can act as an indicator of future growth potential (Boeschoten et al., 1994; Berk and Bikker, 1995).

As a measure of debt-servicing cost we use the 3-month Euribor rate (NINT). We elected to employ a short-term money market rate since a large proportion of Italian households' and firms' outstanding bank debt (about 70 and 90 per cent, respectively) consists of floating rate loans or loans with short maturity. As found in other studies, we expect that increases in NINT worsen the quality of loans as higher debt-servicing costs make it harder for borrowers to honour their debt.[10] Furthermore, higher interest rates may result in adverse selection of borrowers, with only the riskier ones left in the market.[11]

As indicators of the burden of debt we consider, for households, the ratio of loans to disposable income (DISP) and, for firms, the ratio of net interest expense to gross operating profit (GOP) and the ratio of financial debt to the sum of financial debt and equity (LEVERAGE). We expect a rise in the debt burden to result in a higher NBL ratio: if borrowers accumulate too much debt relative to their assets, then their capacity to meet their obligations declines under worsening economic conditions; furthermore, rising DISP or GOP may increase moral hazard by reducing borrowers' incentive to service debt ("strategic default").

As a measure of changes in financial and real wealth we use the growth rate of the Italian stock prices index (STOCKS) and that of house price index (HOUSING). Buoyant stock markets reflect a positive outlook on firms' profitability; moreover, an increase in financial wealth is expected to decrease households' probability of defaulting on loans since it gives them

[10] However, it is important to bear in mind that high or rising nominal interest rates are typically observed during booms or economic recovery, so the NBL ratio might well be inversely related to NINT.
[11] See, e.g., Stiglitz and Weiss (1981).

additional means for servicing their debt. Similarly, increases in house prices may improve the quality of loans. First, since loans for house purchases are usually mortgage loans, a rise in house prices increases the value of the collateral, facilitating debt renegotiation. Second, house prices are positively related with the housing market cycle; thus, when the housing market is buoyant, a household that has difficulty meeting its debt obligations may find it easier to sell its house and extinguish the loan, without defaulting.[12] Finally, the increase in the value of collateral may alleviate the adverse selection and moral hazard.

Finally, we also test macroeconomic variables relating to the outlook for economic growth, namely the slope of the yield curve (SLOPE), calculated as the difference between the 10-year Italian government bond and the 3-month Euribor rate; the annual growth rate of durables consumption (DURABLES) and that of gross fixed investment (INVEST). A steepening of the yield curve is a leading indicator of growth in real economic activity.[13] Therefore, borrowers' ability to repay debt might be enhanced and at the same time banks might have stronger incentives to renegotiate loan terms, ultimately leading to fewer defaults (see, e.g., Ötker-Robe and Podpiera, 2010). Furthermore, increases in consumption and investment stimulate aggregate expenditure, which subsequently fuel more rapid economic growth (see, e.g., De Long and Summers, 1991) and thus feed into an improvement in loan quality.

Table 1c reports the dynamic cross-correlations, up to four lags, between the NBL ratios and selected macroeconomic variables. With regard to lending to households, the NBL ratio shows positive and statistically significant correlations with the current unemployment rate (with a coefficient of 0.63) and current growth in durables consumption (0.18), and with the short-term nominal interest rate (0.82) and inflation (0.68) with a one-year lag; the current growth rate of house prices (-0.27) is instead negatively correlated with the NBL ratio. Similar results with respect to the unemployment rate (0.68), the short-term nominal interest rate (0.78) and inflation (0.61) also hold true for firms. In the case of firms, the NBL ratio is also negatively correlated with fixed gross investment growth (-0.19) and with the growth rate of M3 (-0.19). Surprisingly, neither of the two NBL ratios displays a significant correlation with real GDP growth.

[12] Empirical evidence for several countries including the US, UK, Canada, Australia and New Zealand has shown that households with high housing wealth are better able to fund consumption or to bear debt service in the face of adverse shocks (see, e.g., Beaumont, 2005, and Hiebert 2006).

[13] E.g., Fama (1984), Mankiw and Miron (1986), Estrella and Hardouvelis (1991) and Estrella and Mishkin (1998) find a strong predictive power of the term structure with respect to future real economic activity.

3.3 Empirical methodology

Drawing on the empirical literature, which finds that macroeconomic shocks take some time to affect borrowers' ability to meet debt obligations and possibly impair the quality of loans, we estimate a single-equation time series regression to model the development of the NBL ratio (see Kalirai and Scheicher (2002), Arpa et al., 2001, and Shu, 2002). Hence,

$$NBL_t = c + \sum_{j=1}^{q} \beta_j NBL_{t-j} + \sum_{j=0}^{p_i} \gamma_j X_{i,t-j} + \varepsilon_t \qquad (1)$$

where the dependent variable *NBL* is regressed on its own past values, on current and past values of macroeconomic variables, indicated by X_i, and a deterministic part (e.g., a constant term). The lag structure of equation (1), namely the q's and p_i's, is selected by checking the statistical significance of estimated coefficients and the Akaike and Schwartz information criteria. Equation (1) is estimated by ordinary least squares with Newey-West robust standard errors.

4 Empirical Results

In this section we discuss the estimation results and then compare the in-sample fit of the alternative models.

4.1 The NBL ratio for lending to households

We first tested the explanatory power of just three macroeconomic variables, namely GDP, UNEMPL and NINT. In particular, regression (a) includes UNEMPL and NINT, regression (b) replaces UNEMPL with GDP, and regression (c) considers all three variables together. Table 2 reports the results. In each model, the estimated coefficients of these variables are statistically significant and have the expected sign. An increase in GDP reduces the NBL ratio with a 4-quarter lag, while a rise in UNEMPL and NINT increases it (in the same quarter and with a 3-quarter lag, respectively). The contemporaneous relation between the NBL ratio and UNEMPL may reflect the fact that UNEMPL is itself a lagging indicator of the business cycle. In all specifications, the first-order autoregressive terms are statistically significant with values generally lower than 0.5. Interestingly, even though these models are extremely parsimonious, they exhibit fairly large values for the adjusted R^2. In particular, model (c) reaches the best goodness of fit (with an adjusted R^2 of nearly 0.8) and according to the Akaike and Schwarz criteria is the preferred one.

On the basis of the previous result, we expanded model (c) with other macroeconomic variables, namely HOUSING, M3, INFL, DURABLES, SLOPE, STOCKS and DISP. Models (d), (e), (f), (g), (h), (i) and (j) augment model (c), adding each of these variables one by one. The coefficients of HOUSING, M3, DURABLES and DISP are statistically significant and present the expected signs; moreover, introducing these variables generally increases the goodness of fit. In particular, a rise in HOUSING or DURABLES decreases the NBL ratio with a lag of 2 and 3 quarters, respectively, while a rise in M3 improves the quality of loans within the same quarter. In the latter case, UNEMPL becomes insignificant. In line with previous empirical studies these results support that the view that an acceleration in house prices, and thus in the value of mortgages, by making debt renegotiation easier to implement, enables borrowers not to default. The negative relation of the NBL ratio with M3 and DURABLES, instead, reflects the leading behaviour of these two variables with respect to households' future income and the outlook for economic growth. Furthermore, as expected, an increase in the degree of households' indebtedness raises the NBL ratio (with a 3-quarter lag). It is also worth noting that the NBL ratio for lending to households does not exhibit strong endogenous persistence. Following the inclusion of HOUSING, M3, DURABLES and DISP, the coefficient associated with the first-order autoregressive term becomes smaller and barely significant. Finally, the coefficients relative to STOCKS, INFL and SLOPE are statistically insignificant.

We also tested the joint inclusion of HOUSING and DURABLES. As reported in regression (k), both these macroeconomic variables continue to be statistically significant and maintain the expected sign. Compared with the previous models, the value of the adjusted R^2 further increases (slightly above 0.8) and the AIC and SBC information criteria also improve further.

Finally, in model (l) we included all the variables previously considered, finding that, with few exceptions, most of the estimated coefficients are statistically insignificant.[14]

4.2 The NBL ratio for lending to firms

Following the same strategy adopted for households, we started regressing the NBL ratio for firms on a restricted set of variables, namely UNEMPL, NINT, GOP and LEVERAGE. Table 3 reports the results. As reported in models (a), (b) and (c), the estimated coefficients are statistically significant and show the expected sign. An increase in UNEMPL raises the NBL ratio in the same quarter; increases in NINT are associated with a deterioration in loan quality with a 3-quarter lag, while GOP and LEVERAGE are inversely related with the NBL ratio, with

[14] We also tried augmenting model (k) with M3 and DISP, but it turned out that these variables were statistically insignificant, so we decided not to report this result.

a 2-quarter lag. Furthermore, in each of these models the first lag of the NBL ratio is statistically significant, with values of about 0.5 for model (a) and about 0.3 for models (b) and (c). The goodness of fit of these early specifications is satisfactory, with values of the adjusted R^2 above 0.7. In particular model (b), which includes UNEMPL and GOP, attains the highest in-sample fit (the adjusted R^2 is nearly 0.8) and the AIC and SBC information criteria also appear to support this specification.

As with households, we augment model (b) with other macroeconomic variables, namely GDP, DURABLES, INVEST, INFL, M3, SLOPE and STOCKS. Table 3 – Models (d)-(j) – reports the estimation results when each of these regressors is individually added to model (b). All the estimated coefficients are statistically significant at either the 5 or 10 per cent level, but none is strongly significant (at 1 per cent). Moreover, all estimated coefficients, perhaps with the exception of SLOPE, present the expected sign. An increase in GDP reduces the NBL ratio with a 3-quarter lag, thus somewhat faster than in the case of households. Increases in DURABLES, INVEST and STOCKS improve the quality of loans to firms (with a lag of 3, 2 and 3 quarters, respectively). As with households, an expansion in M3 is inversely related to the NBL ratio in the same quarter. The inverse relation between the NBL ratio and the growth rates of durable goods consumption and fixed private investment may reflect the fact that both variables are leading economic indicators of future business cycles. Households and firms embark on this type of consumption and investment when they believe that their financial situation is healthier and there is stronger confidence in the business outlook. Against this backdrop, banks may be more inclined to assist firms with financial restructuring plans. According to our results, there is an inverse relation between the NBL ratio and INFL with a 2-quarter lag. Somewhat unexpected is the finding that a rise in SLOPE, i.e., a steepening of the yield curve, is associated with a deterioration in loan quality, with a 1-quarter lag. As remarked in the previous section, leading indicators of an improvement in economic activity should be, in principle, associated with lower borrowers' default rates. However, an increase in SLOPE might be driven chiefly by a sharp fall in the short-term interest rates rather than an increase in long-term rates, and this might indicate a weakening of the economy.

Finally, in all these specifications the estimated coefficient of the 1-quarter lagged NBL ratio remains statistically significant at the 1 per cent level. Although the estimated autoregressive coefficient is not particularly large (approximately 0.3), the presence of endogenous persistence has important implications: a persistent process implies that, all else equal, a positive (negative) movement in the NBL ratio for firms is statistically more likely to be followed by another positive (negative) movement. This robust finding may be related to the fact that, unlike households, borrowers in production sectors are interdependent through many links (commercial links, supply chains, inter-firm lending, etc.). The direct consequence of this interdependence is that a default by one firm can, with a certain lag, generate a sort of domino-effect.[15]

As shown in model (k), when all the macroeconomic variables are simultaneously included in the regression only a few variables are statistically significant, namely those appearing in model (h). For model (k) there are some signs of autocorrelation in the residual as indicated by the LM test reported at the bottom of the table. Furthermore, although the value of the adjusted R^2 is slightly higher for model (k), the AIC and SBC information criteria support the more parsimonious specification (h).

4.3 In-sample fit of the models

Figures 2 and 3 graphically illustrate the in-sample fit, i.e. the comparison between actual and fitted values, of selected models presented in Tables 2 and 3. In particular, for households we show the fit of models (d), (e), (f), (g) and (h), for firms that of models (d), (e) and (f).[16]

Visual inspection of these figures shows that in-sample fit of these models, both for households and firms, is good overall. Although in the early years of the sample (specifically 1990 through 1995) the in-sample fit is rather poor due to high volatility of the NBL ratios, it becomes significantly more accurate thereafter. Indeed, all models very closely track the downward trend that characterized the NBL ratios from 1996 through 2001 and the abrupt deterioration in loan quality from the beginning of 2008. Furthermore, the slight decline in the NBL ratios from 2009q3 onwards is matched quite precisely.

The only noteworthy difference between the in-sample fit for households and firms is that for households there are periods in which (to a varying extent depending on the model) the NBL ratio is systematically over- or under-fitted. This is particularly evident in Figure 2 for models (f) and (g), which tend to over-fit the NBL ratio in 2000–2004 and under-fit it in 2006–2008.

[15] Fiori et al. (2009) examine the correlation across corporate default rates in Italy in order to assess whether these correlations are linked to common dependence on macroeconomic variables or instead reflect latent factors arising from micro-business inter-dependence. Their econometric analysis shows that common factors that summarize the general macroeconomic business conditions have a large effect on corporate default risk, but they also find a residual correlation, which is indicative of sectoral interdependence that might produce contagion across firms.

[16] We decided to show the fit of only these models because these are the ones with the highest values of the adjusted R^2 and that the information criteria (AIC and SBC) indicate as the most preferable. We also considered the results of the LM tests for the presence of autocorrelation in the estimated residuals.

5 Forecast-based model selection

In Section 4 we showed that various models describe the developments of the NBL ratios reasonably well. Here we analyse the prediction accuracy for these models by performing sequential out-of-sample forecasts (one through eight quarters ahead). The purpose is twofold: (1) to identify which models show the best forecasting performance in terms of root mean squared forecast errors (RMSFE); and (2) to compare the forecasting performance for households and firms. In particular, we concentrate on specifications (c), (d), (e), (f), (g) and (k) in Table 2 and (b), (d), (e), and (f) in Table 3.

Sequential out-of-sample forecasts are constructed in the following way. Initially we estimate each model from 1990q1 through 2004q3 and generate one- to eight-quarter-ahead forecasts of the NBL ratio.[17] We then extend the sample by one quarter, re-estimate the models from 1990q1 through 2004q4, and generate new one- to eight-quarter-ahead forecasts. We continue in this fashion until the estimation sample is 1990q1–2008q2 and the last eight-quarter-ahead forecast falls in 2010q2. For each forecast we compute the RMSFE and average the results according to the forecasting horizon.

The results of this exercise are illustrated in Figure 4, which reports two panels, respectively for lending to households and lending to firms. Each graph displays the RMSFE on the vertical axis and the forecasting horizon on the horizontal axis.

Concerning the NBL ratio for households, the results indicate quite clearly that model (d), which includes UNEMPL, GDP (with a 4-quarter lag), NINT (with a 3-quarter lag) and HOUSING (with a 2-quarter lag) as macroeconomic determinants, delivers the lowest RMSFE at all horizons. The results for the NBL ratio for firms are less clear-cut by visual inspection, as the RMSFE are closely clustered. However, depending on the forecasting horizon two specifications seem to perform better. In particular, model (b), which includes UNEMPL and GOP (with a 2-quarter lag) as macroeconomic determinants, delivers the most accurate predictions on shorter horizons (from 1 to 4 quarters ahead) and the worst ones on longer horizons. Model (e), which augments model (b) with DURABLES (with a 3-quarter lag), provides the best prediction performance for horizons of 5 to 8 quarters. Finally, it is worth noting that model (d), which includes GDP, while exhibiting a prediction performance similar to model (e) on short-tem horizons, has a significantly worse forecast accuracy for horizoins from 5 to 8 quarters ahead. This suggests that GDP, once other macroeconomic determinants

[17] We compute dynamic forecasts. This means that for forecasting horizons after the one-quarter-ahead we use the previously forecasted value of the lagged dependent variable rather than its actual value.

such UNEMPL, GOP and DURABLES are taken into account, does not significantly contribute to predicting the NBL ratio for firms.

Comparing the RMSFE for households with that for firms indicates that the former's forecasting performance is generally more accurate at all forecasting horizons. Furthermore, as the forecasting horizon lengthens the prediction accuracy worsens quite quickly for firms, whereas it remains basically unaffected for households. This might in part be due to the fact that the estimated coefficients for the lagged dependent variable are generally larger in the specifications for firms. Hence, the prediction error for the NBL ratio at a given point in time has a larger impact on the RMSFE in the following periods.

In light of the out-of-sample prediction accuracy results, and also taking into account the in-sample fit of the models and the indications of the information criteria, we select model (d) in Table 2 as best describing the NBL ratio for households and model (e) in Table 3 for firms.

5.1 Individual contribution of explanatory variables to the NBL ratios

In this section we use the results of our estimates to quantitatively assess how shifts in macroeconomic determinants affect the NBL ratios. We then propose an historical decomposition of the contributions from each of the explanatory variables in accounting for the evolution of loan quality, with a particular focus on the recent recession.

According to our preferred model for the quality of loans to households, an increase in UNEMPL of 100 basis points would *ceteris paribus* increase the NBL ratio by just 4 basis points, while an increase in GDP of 1 percentage point would lower the NBL ratio by 6 basis points after 4 quarters. An increase in NINT of 1 percentage point would increase the NBL ratio by about 12 basis points after 3 quarters, indicating that the cost of debt servicing is crucial for developments in bad loans. A positive shift of 1 percentage point in HOUSING would instead reduce the NBL ratio by 2.5 basis points after 2 quarters.

Turning to the NBL ratio for lending to firms, all else being equal, an increase in UNEMPL of 1 percentage point would raise the NBL ratio by 27 basis points, while an increase in GOP would raise it by 12 basis points after 2 quarters. An increase in DURABLES of 1 percentage point would instead lower the NBL ratio by just 2 basis points after 3 quarters. In the case of firms both general business cycle conditions and the debt burden are fundamental for the evolution of the NBL.

In order to get a sense of the economic significance of our results, we use our estimated preferred models to take a closer look at the driving forces behind developments in the NBL ratios for households and firms in last twenty years. Figure 5 illustrates the contribution from each of the explanatory variables to NBL ratios, calculated as the actual value of each regressor times the corresponding estimated coefficient. Thus, at each point in time the height of the piled histogram corresponds to the fitted value. We obtain several interesting results.

First, as regards lending to households, for the period 1990q1–2010q2 the two major variables that negatively affected loan quality were NINT and UNEMPL. While the contribution of UNEMPL was fairly stable over time, the effects of NINT were more variable; in particular, low interest rates during the first decade of the new century were associated with a lower NBL ratio. The contributions of HOUSING and GDP, which reduced the NBL ratio were quantitatively smaller and unstable. As to firms, the NBL ratio was driven primarily by UNEMPL and secondly by GOP. The evolution of DURABLES barely affected loan quality.

Second, Figure 5 allows us to compare the rise in the NBL ratios in the two periods 1993–1994 and 2008–2009 and to evaluate the underlying determinants. According to our results, in the period 1993–1994 the marked deterioration in loan quality was largely due to the high levels of NINT for households. For firms, UNEMPL was the main driver, with GOP only a secondary factor. In the period 2008–2009 lower debt servicing cost and sounder financial conditions prevented the NBL ratios from reaching the high level recorded in the early 1990s. The contribution of UNEMPL was similar in both periods. Considering that the recent recession was significantly deeper than that of the early 1990s, these results suggest that the deterioration in loan quality was moderated to a significant extent by low interest rates and low levels of indebtedness.

Focussing on the increase in the NBL ratios between 2008q3 (immediately before the surge in bad loans) and 2009q4, Table 4 shows how much the change in each macroeconomic indicator contributed to the change in the NBL ratios for households and firms in that period.[18] The NBL ratio for firms increased by almost 1 percentage point. The variable that contributed most to this change was UNEMPL, which rose by 1.8 percentage points, explaining 49 per cent of the increase in the ratio. The decrease (15.1 percentage points) in DURABLES contributed 26 per cent. GOP remained substantially stable. With regard to households, the main contribution to the 0.5 percentage point increase in the NBL ratio came from the abrupt drop in GDP (-5.0 percentage points), which accounted for 53 per cent of the total change. The rise in UNEMPL and the decrease in contributed, respectively 14 and 20 per

[18] See Appendix B for an explanation of the method used to decompose the change in the NBL ratio.

cent. On the other hand, the decrease of 2.7 percentage points in NINT significantly curbed the increase in ratio, contributing negatively (-59 per cent) to the total change.

6 Has the recent economic crisis affected the prediction accuracy?

In this section we test the robustness of model (d) for households and model (e) for firms to the abrupt changes in macroeconomic conditions in the period 2008q3–2010q2 by investigating if and to what extent the recent economic crisis has affected the prediction accuracy of our preferred models.

To do this, we run sequential out-of-sample forecasts, constructing and comparing the RMSFE in two samples: pre-crisis and crisis. For the pre-crisis sample, we sequentially estimate our preferred models starting with the sample 1990q1–2004q3 until reaching 1990q1–2007q1. For each estimation we compute one- to four-quarter-ahead out-of-sample forecasts and calculate what we call the "pre-crisis RMSFE". For the crisis sample, we sequentially estimate our models starting with the sample 1990q1–2008q2 until reaching 1990q1–2009q1. Again, in each round we compute one- to four-quarter-ahead out-of-sample forecasts and calculate the "crisis RMSFE". In the latter case, the forecasts cover the period 2008q3–2010q2, which includes the most acute phase of the economic crisis.

Figure 6 shows the results. For the NBL ratio for households there is no strong evidence of significant changes in the prediction accuracy. A mild deterioration is detectable for the two-quarter-ahead forecast; nevertheless, the values of the RMSFE remain low. As regards the NBL ratio of firms, instead, the forecast accuracy appears to have improved throughout the crisis, at all forecasting horizons. This may seem odd at a first sight; one explanation could be that the higher variability observed in business conditions throughout the crisis enhanced the information content of the macroeconomic variables.

All in all, these results indicate that our preferred specifications for modelling and forecasting the NBL ratio for households and firms proved robust and performed particularly well throughout the recent financial crisis.

7 Conclusions

This paper investigated the macroeconomic determinants of the quality of loans to households and firms in Italy in the period 1990q1–2010q2. To measure the quality of loans we used the ratio of new bad loans to the stock of performing loans at the end of previous period (NBL ratio).

The main results are the following. First, the NBL ratios are well explained by just a few macroeconomic variables bearing on general economic conditions, the cost of borrowing and the burden of debt. In particular, the NBL ratio for lending to households varies inversely with the growth rates of real gross domestic product and house prices while it varies directly with the unemployment rate and the short-term nominal interest rate. As for firms, the NBL ratio increases with the unemployment rate and the ratio of net interest expenses to gross operating profits, while it diminishes as the consumption of durables increases. In contrast to our findings regarding households, the NBL ratio for firms presents evidence of endogenous persistence. The above-mentioned macroeconomic determinants affect the evolution of the NBL ratios with different time lags.

Second, the out-of-sample predictive accuracy of our models is quite satisfactory and proved robust to the rapid changes observed in many macroeconomic variables during the recent financial and economic crisis.

Third, the increase in the NBL ratio for firms following the financial crisis was mainly due to the rise in unemployment and the slowdown in durables consumption. By contrast, the relatively good financial conditions of firms helped keep the NBL ratio low by comparison with the recession of the early 1990s. Concerning the NBL ratio for households, the main drivers of the recent increase were the fall in GDP and the rise in unemployment, while the decline in short-term interest rates significantly dampened the rise in the NBL ratio.

We believe that these findings encourage a macro-prudential approach to financial stability. The monitoring of changes in specific business cycle conditions, which we have shown anticipate future developments in loan quality, can be used as an early warning system to alert authorities to potential banking strains.

References

Agresti A.M., P. Baudino and P. Poloni (2008). "The ECB and IMF indicators for the macro-prudential analysis of the banking sector: a comparison of the two approaches." ECB Occasional Paper no. 99.

Amel D., C. Barnes, F. Panetta and C. Salleo (2004). "Consolidation and Efficiency in the Financial Sector: A Review of the International Evidence." *Journal of Banking and Finance*, vol. 28, pp. 2493–2519.

Angelini P. and N. Cetorelli (2003). "The effects of regulatory reform on competition in the banking industry." *Journal of Money, Credit, and Banking*, vol. 35, pp. 663–84.

Arpa M., I. Giulini, A. Ittner, and F. Pauer (2001). "The influence of macroeconomic developments on Austrian banks: implications for banking supervision." BIS Paper no. 1, pp. 91-116.

Beaumont C. (2005). "Household indebtedness and monetary policy." New Zealand: Selected Issues, IMF, No. 153.

Berk J.M. and J.A. Bikker (1995). "International interdependence of business cycles in manufacturing industry: the use of leading indicators for analyses and forecasting." *Journal of Forecasting*, vol. 14, pp. 1-23.

Babouček, I. and M. Jančar (2005). "Effects of Macroeconomic Shock to the Quality of the Aggregate Loan Portfolio." Czech National Bank, Working Paper Series, no. 1, pp. 1 – 62.

Berger A. N. and R. DeYoung (1997). "Problem loans and cost efficiency in commercial banks." *Journal of Banking and Finance*, vol. 21, pp. 849-870.

Bikker J. A. and H. Hu (2002). "Cyclical patterns in profits, provisioning and lending of banks and procyclicality of the new Basel capital requirements." *BNL Quarterly Review*, vol. 55, pp. 143-75.

Bikker J.A. and P.A.J. Metzemakers (2005). "Bank provisioning behaviour and procyclicality." *Journal of International Financial Markets, Institutions and Money*, vol. 15, pp. 141-157.

Boeschoten W.C., P.J.A. van Els, and J.A. Bikker (1994). "Monetary transmission in a small open economy: the case of the Netherlands." Nederlandsche Bank, Research Memorandum, no. 406.

Bofondi, M. and F. Lotti (2006). "Innovation in the Retail Banking Industry: The Diffusion of Credit Scoring." *Review of Industrial Organization*, vol. 28, pp 343-358,

Čihák, M. and J. Heřmánek (2005). “Stress Testing the Czech Banking System: Where Are We? Where Are We Going?” CNB Research Policy Note, no. 2.

De Long J. B. and L. H. Summers (1991). “Equipment investment and economic growth.” *Quarterly Journal of Economics*, vol. 106, pp. 445–502.

Demirgüç-Kunt A. and E. Detragiache (1998). “The Determinants of Banking Crises: Evidence from Developed and Developing Countries.” IMF Staff papers, Vol. 45, No. 1.

Estrella A. and G. Hardouvelis (1991). “The term structure as a predictor of real economic activity.” *Journal of Finance*, vol. 46, pp. 555-576.

Estrella A. and F. S. Mishkin (1998). “Predicting US recessions: Financial variables as leading indicators.” *Review of Economics and Statistics*, vol. 80, pp. 45-61.

Fama E. F. (1984). “The Information in the Term Structure.” *Journal of Financial Economics*, vol. 13, pp. 509-528.

Fiorentino E. , A. De Vincenzo, F. Heid, A. Karmann and M. Koetter (2009). “The effects of privatization and consolidation on bank productivity: comparative evidence from Italy and Germany.” Banca d’Italia, Temi di Discussione, no. 722.

Filosa R. (2007). “Stress Testing of the Stability of the Italian Banking System: a VAR Approach.” Heterogeneity and Monetary Policy, no. 703, pp. 1–46.

Fiori R., A. Foglia and S. Iannotti (2009). “Beyond Macroeconomic Risk: the Role of Contagion in the Italian Corporate Default Correlation.” CAREFIN Working Papers, n. 12.

Focarelli D. and F. Panetta (2003). “Are Mergers Beneficial to Consumers? Evidence from the Market for Bank Deposits.” *American Economic Review*, vol. 93, pp. 1152-1172.

Gambera M. (2000). “Simple Forecasts of Bank Loan Quality in the Business Cycle.” Emerging Issues Series, Federal Reserve Bank of Chicago.

González-Hermosillo, B. (1999). “Determinants of ex-ante banking system distress: A macro-micro empirical exploration of some recent episodes.” IMF Working Paper, 33.

Hiebert P. (2006). “Household saving and asset valuations in selected industrialized countries.” Reserve bank of Australia Research Discussion paper, no. 7.

Hoggarth G., S. Sorensen and L. Zicchino (2005). “Stress Tests of UK Banks Using a VAR Approach.” Bank of England Working Paper, no. 282.

Jimenez G. and J. Saurina (2006). “Credit Cycles, Credit Risk, and Financial Regulation.” *International Journal of Central Banking*, vol. 2, pp 65-98.

Kalirai H. and M. Scheicher (2002). “Macroeconomic Stress Testing: Preliminary Evidence for Austria.” *Austrian National Bank Financial Stability Report*, May, no. 3.

Keeton W. and C. S. Morris (1987). “Why Do Banks’ Loan Losses Differ?” Federal Reserve Bank of Kansas City, *Economic Review*, May, pp. 3-21.

Lawrance E. (1995). “Consumer default and the life cycle model.” *Journal of Money, Credit and Banking*, vol. 27, no. 4, pp. 939-954.

Louzis D. P., A. T. Vouldis and V. L. Metaxas (2010). “Macroeconomic and bank-specific determinants of non-performing loans in Greece: a comparative study of mortgage, business and consumer loan portfolios.” Bank of Greece, Working paper no. 118.

Mankiw N. G. and A. J. Miron (1986). “The changing behavior of the term structure of interest rates.” *Quarterly Journal of Economics*, vol. 101, pp. 211-228.

Marcucci J. and M. Quagliariello (2008). “Is Bank Portaolio Risk Procyclical? Evidence from Italy Using a Vector Autoregression.” *Journal of International Financial Markets, Institutions and Money*, vol. 18, pp. 46-63.

Messori M. (2009). “Consolidation, Ownership Structure and Efficiency in the Italian Banking System.” In *The Banks and the Italian Economy,* edited by Di Damiano Bruno Silipo.

Ötker-Robe İ. and J. Podpiera (2010). “The Fundamental Determinants of Credit Default Risk for European Large Complex Financial Institutions.” International Monetary Fund, Working Paper, no. 53.

Pain D. (2003). “The Provisioning Experience of the Major UK banks: A Small Panel Investigation.” Bank of England Working Paper, no. 177.

Panetta F., F. Schivardi and M. Shum (2009). “Do Mergers Improve Information? Evidence from the Loan Market.” *Journal of Money, Credit and Banking*, vol. 41, pp. 673-709.

Quagliariello M. (2007). “Banks' Riskiness over the Business Cycle: A Panel Analysis on Italian Intermediaries.” *Applied Financial Economics*, vol. 17, pp. 119-38.

Rinaldi L. and A. Sanchis-Arellano (2006). "Household debt sustainability: What explains household non-performing loans? An empirical analysis." ECB Working Paper, no. 570.

Ross S. A. (1976). "The Arbitrage Theory of Capital Asset Pricing." *Journal of Economic Theory*, vol. 13, pp. 341–360.

Shu C. (2002). "The Impact of Macroeconomic Environment on the Asset Quality of Hong Kong's Banking Sector." Hong Kong Monetary Authority Research Memorandums.

Sorge M. (2004). "Stress-Testing Financial Systems: An Overview of Current Methodologies." Bank for International Settlements, Working paper, no. 165.

Stiglitz J.E. and A. Weiss (1981). "Credit rationing in markets with imperfect information." *American Economic Review*, vol. 71, pp. 393–410.

Appendix A. Sources of macroeconomic variables

Macroeconomic Variables	Acronym	Sources
Flow of new bad loans (t) / performing loans (t-1)	NBL ratio	Bank of Italy
Annual growth rate of real gross domestic product	GDP	ISTAT
Unemployment rate	UNEMPL	ISTAT
3-month Euribor rate	NINT	Bank of Italy
Net interest expenses / gross operating profits	GOP	Bank of Italy and ISTAT
Financial debt/ (financial debt + equity)	LEVERAGE	Bank of Italy and ISTAT
Annual growth rate of durables consumption	DURABLES	ISTAT
Annual growth rate of gross fixed investment	INVEST	ISTAT
Annual consumer price inflation	INFL	ISTAT
Annual growth of M3	M3	ECB
Total loans / households' disposable income	DISP	Bank of Italy and ISTAT
Annual growth rate of house price index	HOUSING	Bank of Italy
Annual growth rate of Italian stock prices index	STOCKS	Bank of Italy
Slope of the yield curve (10-year bond – 3-month)	SLOPE	Bank of Italy

Other macroeconomic variables

We also tested the following macroeconomic variables. However, we decided not to report the results either because they were not statistically significant or because their inclusion in the regression did not improve the fit. In particular, we tested:

- Growth rate of industrial production
- 10-year Italian government bond rate
- Average interest rate on mortgage loans
- Average interest rate on lending to firms
- Ratio of gross operating profits to value added
- HICP inflation
- CPI inflation
- PPI inflation
- GDP deflator
- Growth rate of the M1 and M2 monetary aggregates
- Effective nominal exchange rate
- Real index of competitiveness
- Qualitative indicators drawn from the ISAE consumer and business surveys

Appendix B. How to decompose the change in the NBL ratio from t-k to t

In this Appendix we illustrate how to compute the contributions from each of the explanatory variable to the change in the NBL ratio from *t-k* to *t*.

Without loss of generality, let us assume that the NBL ratio is explained by just two variables, namely GDP and NINT, according to the following specification:

$$NBL_t = \beta_0 + \beta_1 NBL_{t-1} + \beta_2 NINT_t + \beta_3 GDP_t + \varepsilon_t \tag{B.1}$$

where β_i, with $i = 0, 1, 2, 3$, are the coefficients and ε is the error term.

Furthermore, assuming that $|\beta_1| < 1$, we can use the lag operator L to re-write equation (B.1) as

$$NBL_t = \left(\frac{\beta_0}{1-\beta}\right) + \left(\frac{\beta_2}{1-\beta_1 L}\right) NINT_t + \left(\frac{\beta_3}{1-\beta_1 L}\right) GDP_t + \left(\frac{1}{1-\beta_1 L}\right)\varepsilon_t \tag{B.2}$$

or equivalently as

$$NBL_t = \tilde{\beta}_0 + \underbrace{\beta_2 \sum_{i=0}^{\infty} \beta_1^i NINT_{t-i}}_{TOT\_NINT} + \underbrace{\beta_3 \sum_{i=0}^{\infty} \beta_1^i GDP_{t-i}}_{TOT\_GDP} + \underbrace{\sum_{i=0}^{\infty} \beta_1^i \varepsilon_{t-i}}_{TOT\_ERROR} \tag{B.3}$$

where $\tilde{\beta}_0 = \beta_0 / (1-\beta_1)$. So, according to (B.3) the NBL at time t is decomposed in a constant term, the total contribution from NINT, given by TOT_NINT, the total contribution of GDP, given by TOT_GDP, and the total contribution from the error terms, given by TOT_ERROR. Note that since in our cases $0 < \beta_1 < 1$, the contributions from $NINT_{t-i}$, GDP_{t-i} and ε_{t-i} decay geometrically as i increases.

Finally, the contributions of the explanatory variables NINT and GDP to the change of NBL from *t-k* to *t* are computed as:

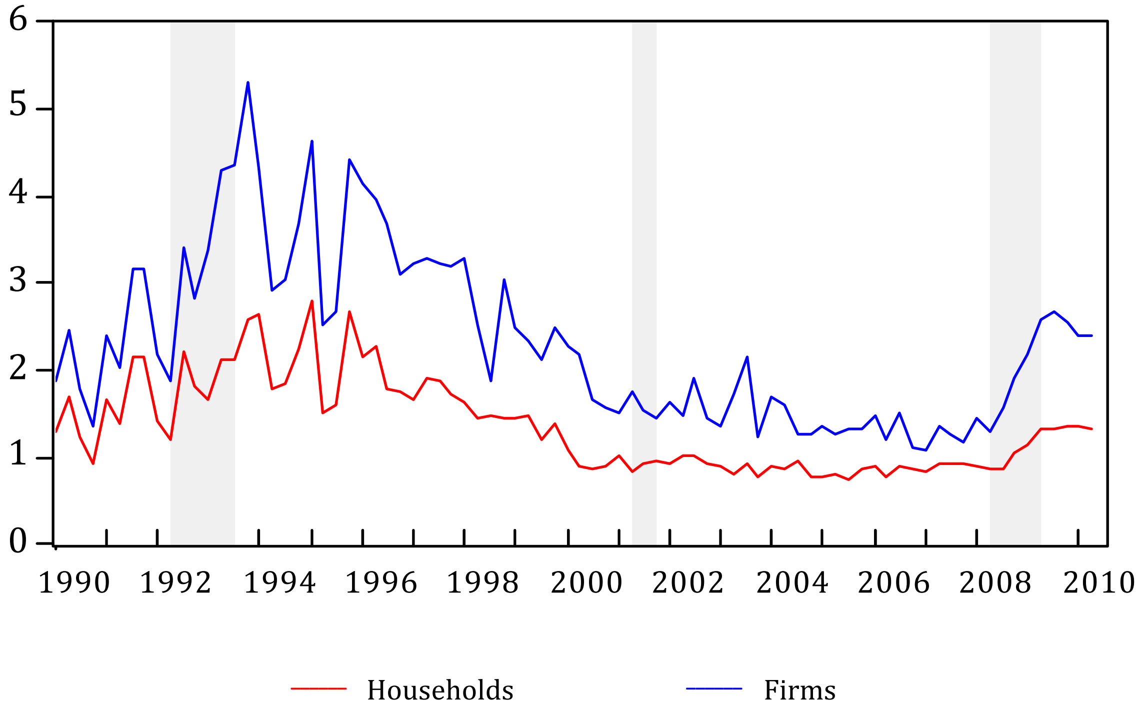
$$TOT\_GDP_{t-k,t} = \beta_3 \left(\sum_{i=0}^{\infty} \beta_1^i GDP_{t-i} - \sum_{i=0}^{\infty} \beta_1^i GDP_{t-k-i} \right)$$

and

$$TOT\_NINT_{t-k,t} = \beta_2 \left(\sum_{i=0}^{\infty} \beta_1^i NINT_{t-1} - \sum_{i=0}^{\infty} \beta_1^i NINT_{t-k-1} \right).$$

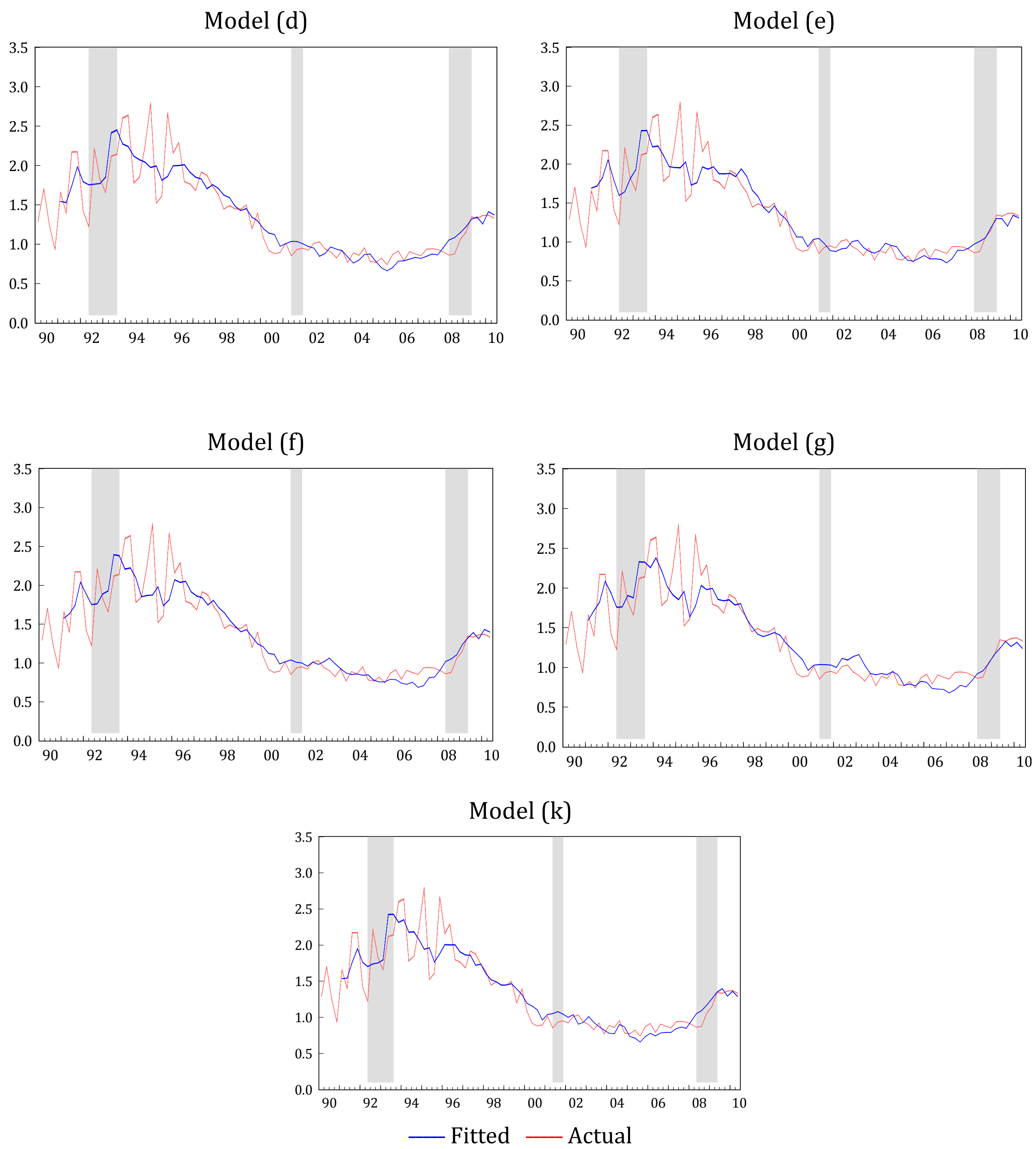
Figure 1. New bad loan ratios in Italy

(quarterly data)



Note. The NBL ratio is defined as the ratio of the flow of bad loans to the stock of performing loans in previous quarter. Shaded areas represent technical recessions (a technical recession occurs when real gross domestic product declines over two successive quarters).

Figure 2. New bad loan ratio for households: fit of models

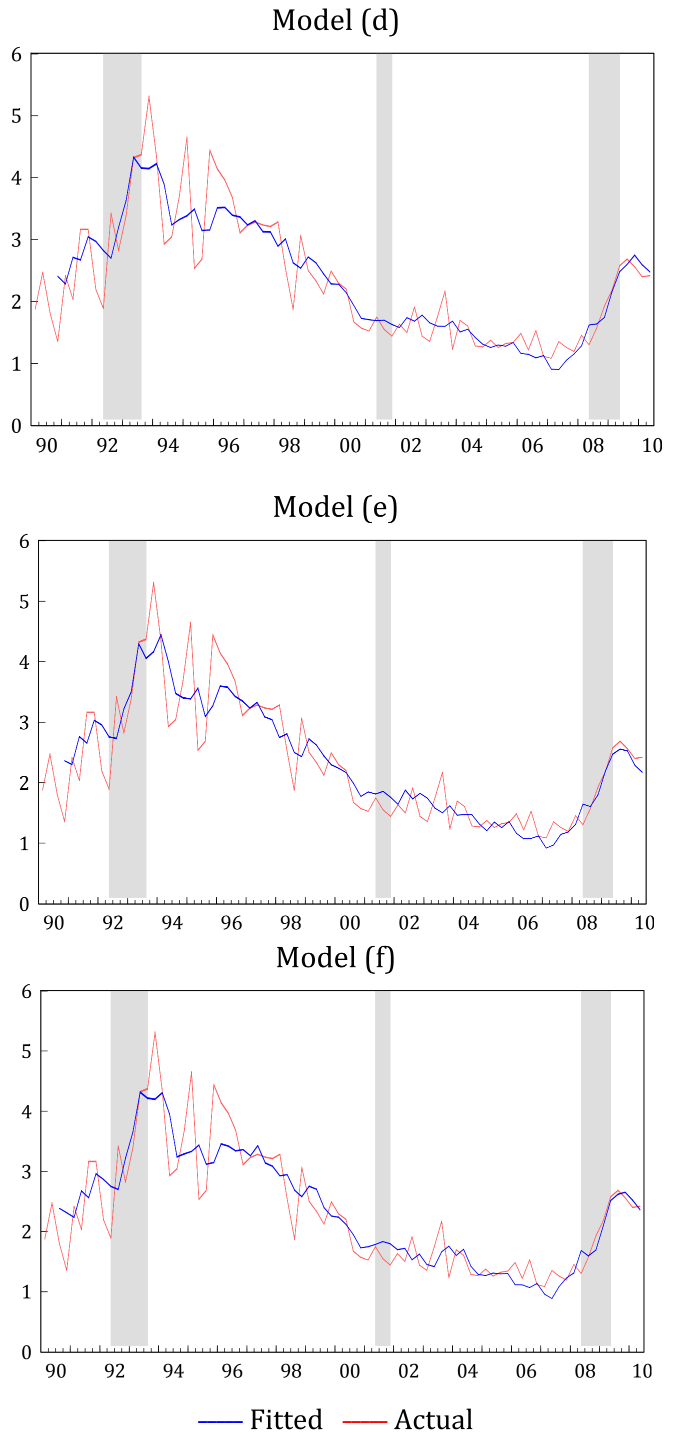


*Note***.** Shaded areas represent periods of technical recessions (a technical recession occurs when real gross domestic product declines over two successive quarters).

Memo. **Model (d)** includes: NBL ratio(-1), UNEMPL, GDP(-4), NINT(-3), HOUSING(-2). **Model (e)** includes: NBL ratio(-1), UNEMPL, GDP(-4), NINT(-3), M3. **Model (f)** includes: NBL ratio(-1), UNEMPL, GDP(-4), NINT(-3), DISP(-3). **Model (g)** includes: NBL ratio(-1), UNEMPL, GDP (-4), NINT(-3), DURABLES(-3); **Model (k)** includes: NBL ratio(-1), UNEMPL, GDP (-4), NINT(-3), HOUSING(-2), DURABLES(-3). Each model also includes the constant. Numbers in brackets indicate the lags with which explanatory variables enter the regression.

Acronyms: GDP = annual growth rate of real gross domestic product; UNEMPL = unemployment rate; NINT = short-term nominal interest rate; HOUSING = annual growth rate of house price index; DURABLES = annual growth rate of durables consumption; DISP = loans to households over disposable income.

Figure 3. New bad loans ratio for lending to firms: fit of models



*Note***.** Shaded areas represent periods of technical recessions (a technical recession occurs when real gross domestic product declines over two successive quarters).

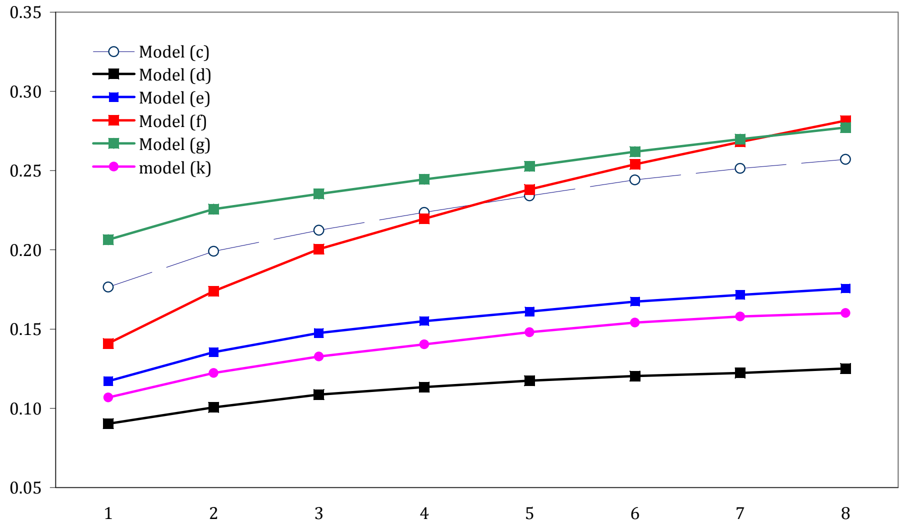
Memo. **Model (d)** includes: NBL ratio(-1), UNEMPL, GOP(-2), GDP(-4); **Model (e)** includes: NBL ratio(-1), UNEMPL, GOP(-2), DURABLES(-3); **Model (f)** includes: NBL ratio(-1), UNEMPL, GOP(-2), INVEST(-2). Each model also includes the constant. Numbers in brackets indicate the lags with which explanatory variables enter the regression.

Acronyms: UNEMPL = unemployment rate; GOP = ratio of net interest expenses to gross operating profits; LEVERAGE = ratio of financial debt to the sum of financial debt and equity; GDP = annual growth rate of real gross domestic product; DURABLES = annual growth rate of durables consumption; INVEST = annual growth rate of gross fixed investment.

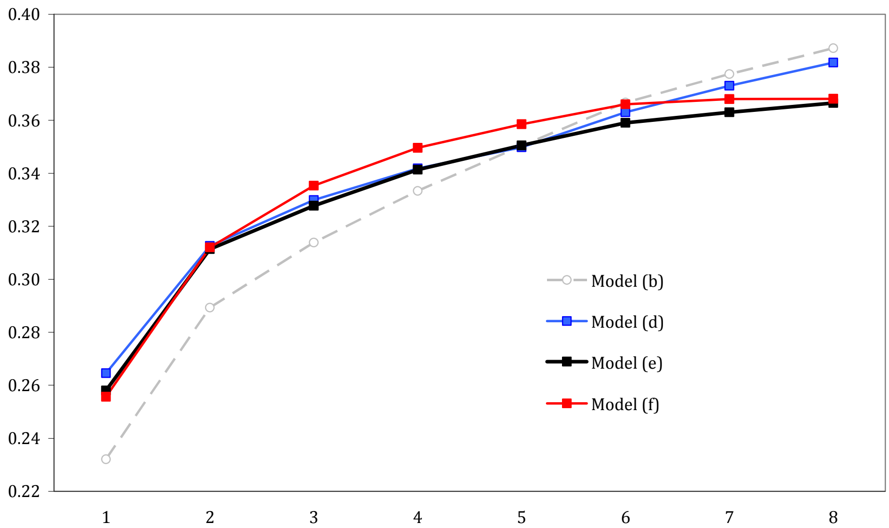
Figure 4. Out-of-sample root mean squared forecast errors

(forecast horizons are reported on the horizontal axis)

(a) NBL ratio for lending to households



(b) NBL ratio for lending to firms



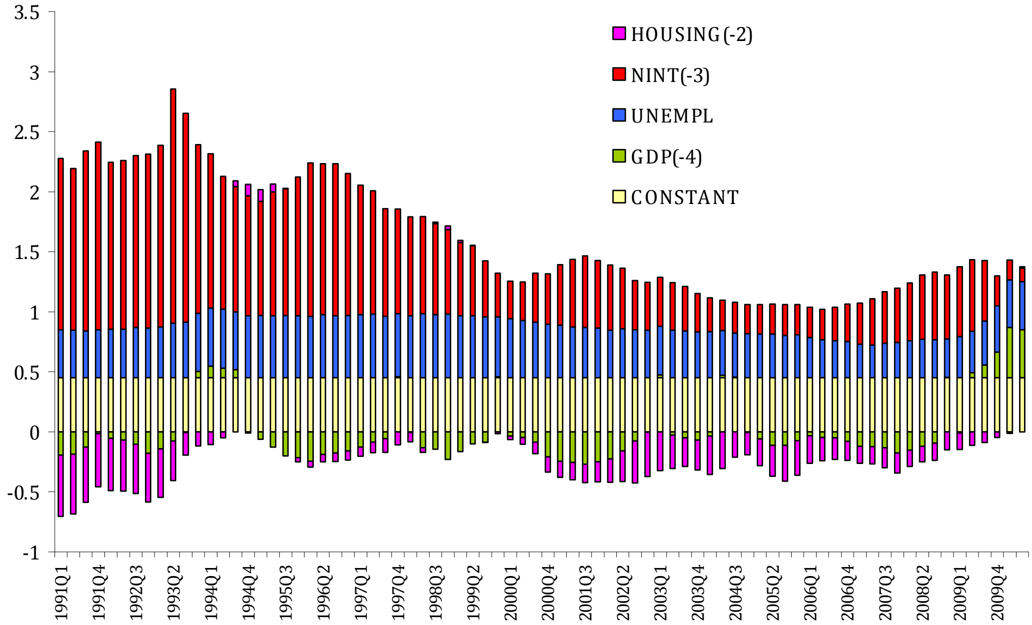
Note. Results based on sequential out-of-sample forecasts. Initial estimation sample from 1990q1 to 2004q3.

Memo. For households: **Model (c)** includes: NBL ratio(-1), UNEMPL, GDP(-4), NINT(-3); **Model (d)** includes: NBL ratio(-1), UNEMPL, GDP(-4), NINT(-3), HOUSING(-2). **Model (e)** includes: NBL ratio(-1), UNEMPL, GDP(-4), NINT(-3), M3. **Model (f)** includes: NBL ratio(-1), UNEMPL, GDP(-4), NINT(-3), DISP(-3). **Model (g)** includes: NBL ratio(-1), UNEMPL, GDP(-4), NINT(-3), DURABLES(-3). For firms: **Model (b)** includes: NBL ratio(-1), UNEMPL, GOP (-2); **Model (d)** includes: NBL ratio(-1), UNEMPL, GOP(-2), GDP(-4); **Model (e)** includes: NBL ratio(-1), UNEMPL, GOP(-2), DURABLES(-3); **Model (f)** includes: NBL ratio(-1), UNEMPL, GOP (-2), INVEST(-2). Each model also includes the constant. Numbers in brackets indicate the lags with which explanatory variables enter the regression.

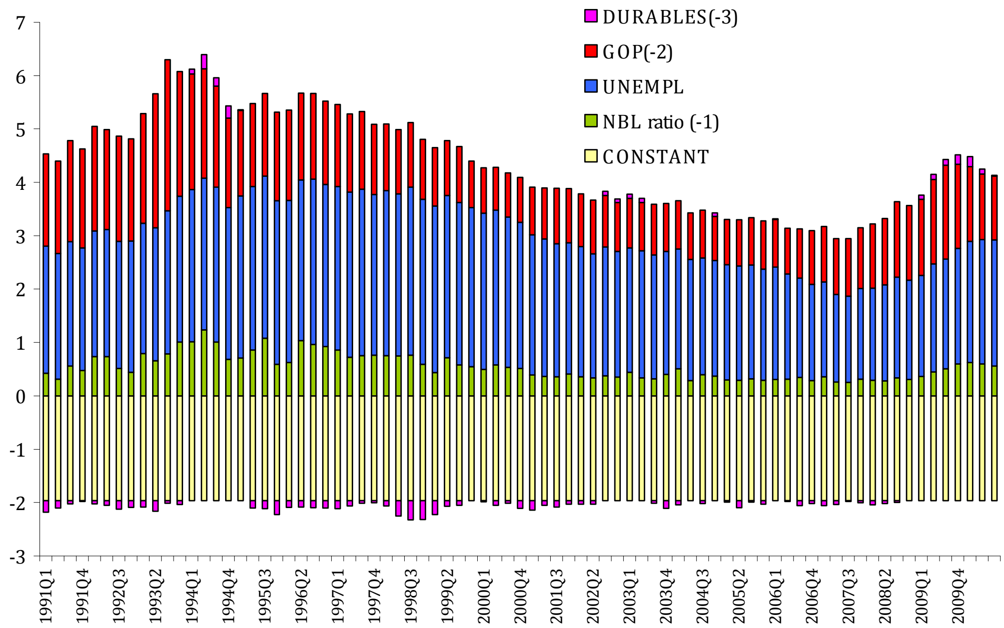
Acronyms: UNEMPL = unemployment rate; GDP = annual growth rate of real gross domestic product; NINT = short-term nominal interest rate; HOUSING = annual growth rate of house price index; M3 = annual growth rate of M3; DURABLES = annual growth rate of durables consumption; INVEST = annual growth rate of gross fixed investment; DISP = loans to households over disposable income; GOP = ratio of net interest expenses to gross operating profits; LEVERAGE = ratio of financial debt to the sum of financial debt and equity.

Figure 5. Contributions of explanatory variables

(a) NBL ratio for lending to households



(b) NBL ratio for lending to firms



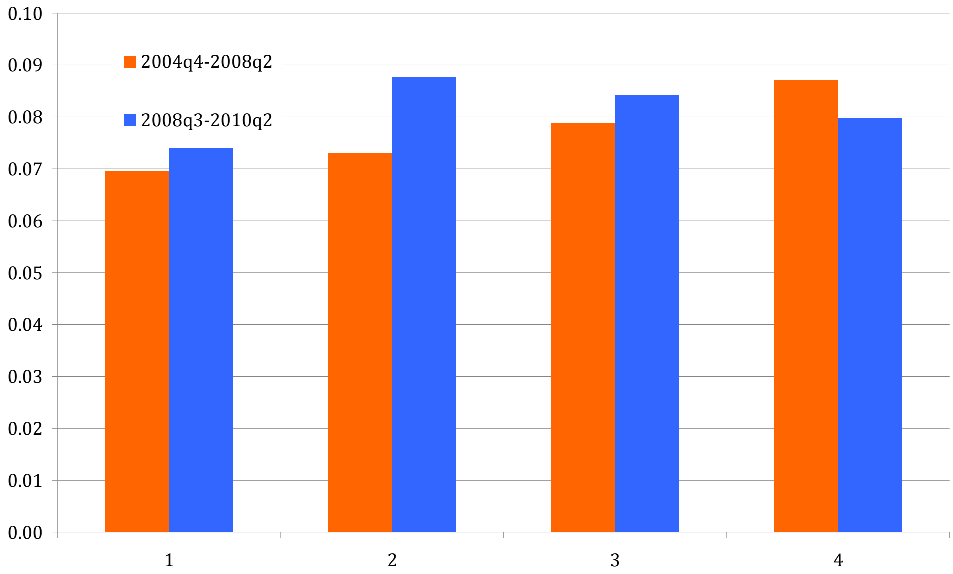
Note. Each bar represents the contribution of the explanatory variable (indicated in the legend). The contribution is computed by multiplying the estimated coefficient by the actual value of the variable at each quarter. Numbers in brackets indicate the lags with which explanatory variables enter the regression.

Acronyms: UNEMPL = unemployment rate; GDP = annual growth rate of real gross domestic product; NINT = short-term nominal interest rate; HOUSING = annual growth rate of house price index; DURABLES = annual growth rate of durables consumption; GOP = ratio of net interest expenses to gross operating profits; CONSTANT is the constant term.

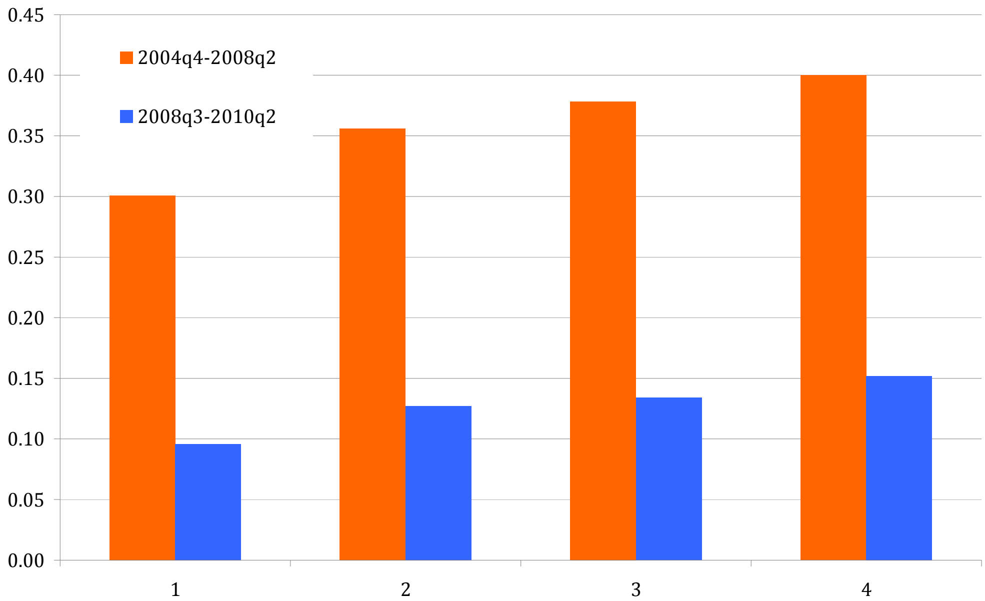
Figure 6. Out-of-sample root mean squared errors: the effects of the crisis

(out-of-sample forecast horizons, in quarters, on the horizontal axis)

(a) NBL ratio for lending to households



(b) NBL ratio for lending to firms



Note. Results based on sequential out-of-sample forecasts. For the pre-crisis period: initial estimation sample from 1990q1 to 2004q3; for the post-crisis period: initial estimation sample from 1990q1 to 2008q2 .

Memo. For households forecasts are based on **Model (d),** including: NBL ratio(-1), UNEMPL, GDP(-4), NINT(-3), HOUSING(-2). For firms forecasts are based **Model (e),** including: NBL ratio(-1), UNEMPL, GOP(-2), DURABLES(-3). Each model also includes the constant. Numbers in brackets indicate the lags with which explanatory variables enter the regression.

Acronyms: UNEMPL = unemployment rate; GDP = annual growth rate of real gross domestic product; NINT = short-term nominal interest rate; HOUSING = annual growth rate of house price index; M3 = annual growth rate of M3; GOP = ratio of net interest expenses to gross operating profits; DURABLES = annual growth rate of durables consumption.

Table 1a

Summary statistics

This table provides the summary statistics for the NBL ratios for lending to households and firms and for selected macroeconomic variables. All data are quarterly from 1990q1 to 2010q2. The NBL ratio is computed as the flow of new bad debts in each quarter over the stock of performing loans in the previous quarter. Growth rates are annual. Percentiles are calculated using the Rankit-Cleveland quantile estimation method.

	Min	25% Percentile	Median	75% Percentile	Max	Mean	Std. Dev.	Skewness	Kurtosis
Quality of loans									
NBL ratio for lending to households	0.738	0.912	1.264	1.699	2.783	1.362	0.531	0.866	2.837
NBL ratio for lending to firms	1.081	1.496	2.171	3.059	5.294	2.333	0.992	0.856	2.996
Macroeconomic variables									
GDP	-6.390	0.100	1.165	2.190	4.120	0.973	1.986	-1.443	6.270
UNEMPL	5.900	7.900	8.800	10.700	11.500	9.085	1.602	-0.078	1.945
NINT	0.672	2.697	4.664	9.100	16.432	6.030	3.971	0.672	2.274
INFL	0.121	2.023	2.580	4.373	6.723	3.166	1.633	0.687	2.402
HOUSING	-3.513	1.891	5.258	9.571	18.920	6.193	5.720	0.556	2.507
DURABLES	-15.616	0.128	3.936	7.256	20.912	3.307	6.724	-0.186	3.887
INVEST	-16.300	0.830	5.385	8.110	14.640	3.902	6.964	-0.898	3.567
M3	-0.265	4.234	6.419	8.527	17.345	6.345	3.514	0.394	3.495
GOP	9.423	10.969	14.157	18.920	33.295	15.576	5.267	0.962	3.477
LEVERAGE	31.496	38.576	42.453	47.975	52.373	42.876	5.593	-0.092	1.866

Acronyms: GDP = annual growth rate of real gross domestic product; UNEMPL = unemployment rate; NINT = short-term nominal interest rate; INFL = annual CPI inflation rate; HOUSING = annual growth rate of house price index; DURABLES = annual growth rate of durables consumption; INVEST = annual growth rate of gross fixed investment; M3 = annual growth rate of M3; GOP = ratio of net interest expenses to gross operating profits; LEVERAGE = ratio of financial debt to the sum of financial debt and equity.

Table 1b
Unit roots tests

This table reports the test statistics of the Augmented Dickey-Fuller (ADF) test and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test for detecting unit roots in the time series of the NBL ratios for lending to households and to firms (NBL ratios are computed as the flow of new bad debts in each quarter over the stock of performing loans in the previous quarter). The ADF test assumes the presence of a unit root in the series under the null hypothesis; the KPSS test assumes instead stationarity of the series under the null hypothesis. Critical values for the tests are reported at the bottom. Sample used: 1990q1 – 2010q2.

	ADF		**KPSS**	
	without trend	with trend	without trend	with trend
NBL ratio for lending to households	-1.363	-2.106	0.433	0.128
NBL ratio for lending to firms	-2.785	-3.589	0.361	0.107
Crtical values:				
1% level	-3.513	-4.075	0.739	0.216
5% level	-2.898	-3.466	0.463	0.146

Table 1c

Dynamic cross-correlation

This table provides the dynamic cross-correlations (up to 4 lags) between the NBL ratios for lending to households and firms and selected macroeconomic variables. All data are quarterly from 1990q1 to 2010q2. The NBL ratio is computed as the flow of new bad debts in each quarter over the stock of performing loans in the previous quarter.

	NBL ratio for lending to households					NBL ratio for lending to firms				
	t	t+1	t+2	t+3	t+4	t	t+1	t+2	t+3	t+4
GDP	0.142	-0.008	-0.059	-0.064	-0.057	0.086	-0.097	-0.141	-0.138	-0.102
UNEMPL	0.629***	0.571***	0.513***	0.465***	0.407***	0.675***	0.614***	0.551***	0.496***	0.439***
NINT	0.638***	0.669***	0.702***	0.757***	0.815***	0.514***	0.571***	0.635***	0.707***	0.775***
INFL	0.466***	0.525***	0.556***	0.599***	0.682***	0.345***	0.415***	0.461***	0.519***	0.607***
HOUSING	-0.270**	-0.230**	-0.201*	-0.138	-0.049					
DURABLES	0.184*	0.141	0.049	0.003	0.074	0.084	0.07	-0.002	0.003	0.061
INVEST	0.005	-0.039	-0.102	-0.111	-0.064	-0.127	-0.16	-0.187*	-0.154	-0.082
M3	-0.115	-0.035	0.007	0.079	0.164	-0.188*	-0.104	-0.036	0.054	0.144
GOP						0.522***	0.607***	0.689***	0.759***	0.809***
LEVERAGE						0.609***	0.682***	0.737***	0.776***	0.811***

Acronyms: GDP = annual growth rate of real gross domestic product; UNEMPL = unemployment rate; NINT = short-term nominal interest rate; INFL = annual CPI inflation rate; HOUSING = annual growth rate of house price index; DURABLES = annual growth rate of durables consumption; INVEST = annual growth rate of gross fixed investment; M3 = annual growth rate of M3; GOP = ratio of net interest expenses to gross operating profits; LEVERAGE = ratio of financial debt to the sum of financial debt and equity.

Table 2

New bad loan ratio for households: estimation results

	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)
Regressor												
CONST	-0.080	0.369 ***	-0.128	0.403 **	0.418	-0.970	-0.201	-0.097	-0.061	-0.168	0.326 *	0.168
NBL ratio (-1)	0.420 ***	0.444 ***	0.239 **	0.089	0.186 *	0.180 *	0.190 *	0.241 **	0.201 **	0.223 **	0.079	0.013
UNEMPL	0.060 **		0.083 ***	0.043 **	0.037	0.131 ***	0.095 ***	0.080 **	0.077 **	0.080 ***	0.054 **	0.043
GDP (-4)		-0.032 ***	-0.048 ***	-0.052 ***	-0.055 ***	-0.046 ***	-0.043 ***	-0.048 ***	-0.061 ***	-0.043 ***	-0.035 **	-0.037
NINT (-3)	0.052 ***	0.069 ***	0.075 ***	0.107 ***	0.097 ***	0.097 ***	0.081 ***	0.080 ***	0.083 ***	0.081 ***	0.107 ***	0.124 ***
HOUSING (-2)				-0.026 ***							-0.025 ***	-0.020 *
M3					-0.030 **							-0.016
INFL (-3)								-0.012				0.028
DURABLES (-3)							-0.008 *				-0.008 *	-0.008
SLOPE (-2)										0.040		0.073 **
STOCKS (-2)									0.001			0.002
DISP (-3)						0.377 **						0.419
Adj. R^2	0.731	0.750	0.779	0.807	0.792	0.793	0.790	0.776	0.784	0.781	0.809	0.814
AIC	0.338	0.272	0.158	0.037	0.111	0.105	0.119	0.183	0.148	0.161	0.035	0.063
SBC	0.458	0.393	0.309	0.219	0.293	0.287	0.300	0.364	0.329	0.342	0.247	0.426
LM test(1)	0.012	0.029	0.028	0.030	0.022	0.041	0.015	0.028	0.033	0.004	0.027	0.004
N. obs	79	78	78	78	78	78	78	78	78	78	78	78

Regressors: CONST = constant; UNEMPL = unemployment rate; GDP = annual growth rate of real gross domestic product; NINT = short-term nominal interest rate; HOUSING = annual growth rate of house price index; M3 = annual growth rate of M3; INFL = annual CPI inflation rate; DURABLES = annual growth rate of durables consumption; SLOPE = 10-year bond yield minus the 3-month Euribor rate; STOCKS = annual growth rate of Italian Stock Exchange index; DISP = loans to households over disposable income. The number in brackets indicates the lags with which the explanatory variable enters the regression.
***, **, * denote statistical significant at 1, 5 and 10 per cent respectively. Estimation: OLS with Newey-West HAC Standard Errors & Covariance. AIC is the Akaike information criterion; SBC is the Schwarz Bayesian criterion. (1) For the LM test (whose null hypothesis of is no serial correlation in the residuals) we report the p-value of the test with 12 lags.

Table 3

New bad loans ratio for lending to firms: estimation results

	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)
Regressors											
CONST	-0.317	-1.659 ***	-3.650 ***	-1.834 ***	-1.964 ***	-1.811 ***	-1.807 ***	-1.223 ***	-1.835 ***	-1.791 ***	-1.361 **
NBL ratio(-1)	0.505 ***	0.309 ***	0.273 **	0.249 **	0.233 **	0.235 **	0.276 ***	0.280 **	0.291 **	0.287 ***	0.182 *
UNEMPL	0.110 *	0.223 ***	0.213 ***	0.268 ***	0.274 ***	0.264 ***	0.240 ***	0.183 ***	0.229 ***	0.252 ***	0.237 ***
NINT(-3)	0.078 ***										
GOP(-2)		0.077 ***		0.080 ***	0.085 ***	0.081 ***	0.102 ***	0.093 ***	0.085 ***	0.076 ***	0.093 ***
LEVERAGE(-2)			7.959 ***								
GDP (-3)				-0.058 **							0.027
DURABLES(-3)					-0.017 *						-0.010
INVEST(-2)						-0.018 *					-0.010
INFL(-2)							-0.087 *				0.024
M3								-0.036 **			-0.055 **
SLOPE(-1)									0.073 *		0.009
STOCKS(-3)										-0.004 **	-0.005
Adj. R^2	0.742	0.781	0.778	0.799	0.797	0.793	0.787	0.787	0.785	0.793	0.799
AIC	1.547	1.372	1.386	1.310	1.322	1.327	1.356	1.360	1.369	1.340	1.378
SBC	1.667	1.491	1.505	1.460	1.472	1.476	1.505	1.509	1.518	1.490	1.708
LM test (1)	0.335	0.190	0.527	0.085	0.123	0.337	0.151	0.184	0.214	0.011	0.013
N. obs	79	80	80	79	79	80	80	80	80	79	79

Regressors: CONST = constant; UNEMPL = unemployment rate; NINT = short-term nominal interest rate; GOP = ratio of net interest expenses to gross operating profits; LEVERAGE = ratio of financial debt to the sum of financial debt and equity; GDP = annual growth rate of real gross domestic product; DURABLES = annual growth rate of durables consumption; INVEST = annual growth rate of gross fixed investment M3 = annual growth rate of M3; INFL = annual CPI inflation rate; SLOPE = 10-year bond yield minus the 3-month Euribor rate; STOCKS = annual growth rate of Italian Stock Exchange index. The number in brackets indicates the lags with which the explanatory variable enters the regression.
***, **, * denote statistical significant at 1, 5 and 10 per cent respectively. Estimation: OLS with Newey-West HAC Standard Errors & Covariance. AIC is the Akaike information criterion; SBC is the Schwarz Bayesian criterion (1) For the LM test (whose null hypothesis of is no serial correlation in the residuals) we report the p-value of the test with 12 lags.

Table 4

Contributions of macroeconomic variables to the increase in the NBL ratios between 2008q3 and 2009q4

This table provides the contribution from different macroeconomic variables to the increase in the NBL ratios registered from 2008q3 (just before the the recession) to 2009q4. The absolute values of the contributions are computed as the product between the estimated coefficients (model (d), Figure 2 for households and model (e) Figure 3 for firms) and the difference between the values of the relative variables between 2008q3 and 2009q4. Further details on the methodology used to compute the contributions are given in Appendix B.

	Housholds				Firms			
	Estimated coefficient	Change between 2008q3 and 2009q4	Absolute value of the contribution to NBL ratio change	Percentage contribution to NBL ratio change	Estimated coefficient	Change between 2008q3 and 2009q4	Absolute value of the contribution to NBL ratio change	Percentage contribution to NBL ratio change
NBL ratio		0.49				0.99		
UNEMPL	0.043	1.60	0.07	14.1	0.274	1.80	0.49	50.0
GDP (-4)	-0.052	-4.99	0.26	53.4				
NINT (-3)	0.107	-2.69	-0.29	-59.2				
HOUSING (-2)	-0.026	-3.81	0.10	20.4				
GOP (-2)					0.085	0.83	0.07	7.1
DURABLES (-3)					-0.017	-15.13	0.26	26.1

Acronyms: UNEMPL = unemployment rate; GDP = annual growth rate of real GDP; NINT = short-term nominal interest rate; HOUSING = annual growth rate of house price index; GOP = ratio of net interest expenses to gross operating profits; DURABLES = annual growth rate of durables consumption. Numbers in brackets indicate the lags with which explanatory variables enter the regression.