Questioni di Economia e Finanza

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(Occasional papers)

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BANKS' BALANCE SHEETS AND THE MACROECONOMY IN THE BANK OF ITALY QUARTERLY MODEL

by Claudia Miani*, Giulio Nicoletti*, Alessandro Notarpietro* and Massimiliano Pisani*

Abstract

We investigate the relationship between macroeconomic conditions and banks' balance sheets by referring to a modified version of the Bank of Italy Quarterly Model (BIQM), regularly used for forecasting and policy analysis. In particular, we examine how regulatory bank capital and private sector default probabilities affect interest rates on loans and, ultimately, economic activity. To this end, we build an enriched version of the model to include a number of banking variables. The changes introduced in the model result in an amplification of the responses of macroeconomic variables to monetary policy and world demand shocks, although, in normal times, the effect is not large.

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1 Introduction[1]

The recent financial crisis and growing discussion about a new banking regulatory framework have highlighted the need for a quantitative assessment of the relationship between the financial and credit sector and the macroeconomy, calling for the inclusion of an adequately detailed banking sector in the macroeconometric models used for forecasting and policy analysis.

The role of banks is particularly important for the Italian economy, characterized by the predominance of small and medium firms that finance their investment mainly through banking loans. This paper proposes an aggregate and parsimonious but sufficiently detailed framework of the Italian banking sector in the context of a macroeconometric model routinely used for forecasting and policy analysis at the Bank of Italy. Our enriched model is then used to investigate the interaction between the banking sector and the real economy, considering two alternative transmission channels.

The first, labelled *bank capital* channel, is based on the relationship between bank capital and credit supply. This channel focuses on the assessment of the credit exposure and potential losses faced by financial institutions and their interaction with the business cycle. When bank equity is low and it is too costly to issue new shares, banks may be forced to tighten lending or face the risk of capital being inadequate in the future.

The second, labelled *private sector default probability* channel, focuses on a direct link between the default probability of borrowers and the interest rate on loans. The deterioration of firms' solvency conditions typically induces banks to charge higher premia, thus increasing firms' funding costs.

We explore the two channels by modifying the Bank of Italy Quarterly Model[2] (henceforth BIQM), including banking sector variables, alongside macroeconomic aggregates. In the basic version of the BIQM, loan supply is represented in a stylized way via an equation that links the interest rate on loans to the policy rate; in this version, no explicit role is played by banking variables in the supply of loans or in the setting of loan interest rates. This role is included in the BIQM in two ways, consistent with the two channels described above.

First, the *bank capital* channel relates the cost of borrowing for Italian non-

[2]The theoretical features and statistical properties of the Bank of Italy Quarterly Model are described in Busetti, Locarno, and Monteforte (2005). See Appendix A for a brief outline of the model.

financial corporate firms to banks' excess regulatory capital, which in turn is a function of macroeconomic variables. Specifically, we explicitly account for the dynamics of the capital that banks hold in excess of the minimum required by prudential regulation standards, by introducing a law of motion of banks' capital and risk-weighted assets. As banks' capital is given by accumulating non-distributed profits, it can be tracked by endogenizing banks' revenues and costs, which we allow to depend upon macroeconomic variables. Risk-weighted assets are modelled as a function of aggregate lending volumes to households and firms[3] and private sector default probabilities, themselves a function of other macroeconomic variables.

Second, the *private sector default probability* channel relates the interest rate on bank loans to the default probability of the corporate sector. Banking variables are modelled as in the *bank capital* channel, but they do not affect loans' interest rates and, hence, other variables. This channel captures the impact of borrowers' solvency conditions on banks' lending decisions. In turn, the default probability is modelled as a function of macroeconomic conditions.

We highlight the main properties of each channel by simulating the response of the two enriched versions of the BIQM to a world demand shock and a monetary policy shock. We then run stochastic simulations of the BIQM augmented with the *bank capital* channel in a hypothetical mild financial distress scenario where banks' funding costs rise and firms' solvency conditions deteriorate and show how the enriched model can be used to characterize the probability distribution of, amongst others, banking variables. According to our results, *in normal times* (i.e. in the absence of major financial distress and when no credit rationing is in place) the inclusion of banking variables modifies the transmission of shocks in the model only mildly, with limited amplification effects.

The remainder of the paper is organized as follows. Section 2 reviews some of the literature; Section 3.1 reports on how banks' accounts are modelled as a function of macroeconomic conditions. Section 3.2 describes how the probability of default of private sector firms depends on the business cycle. Section 3.3 details the relationship between banking sector accounts and bank capital. Sections 4.1 and 4.2 detail, respectively, the *bank capital* and *default probability* channels. Section 5 discusses the transmission mechanism associated with these two channels, by means of impulse response analysis to world demand and interest rate shocks, while Section 6 reports the simulation results and examines the risks associated with a mild stress scenario. Section 7 concludes.

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[3]These are already incorporated in the BIQM in the form of credit demand equations.

2   Review of the related literature

Several contributions in the literature have stressed the importance of the *bank capital* and the *private sector default probability* channels as linkages between the real and financial sectors of the economy.

The *bank capital* channel reflects two peculiar features of the banking activity and its financing. First, as Myers and Majluf (1984) highlight, the market for bank equity is imperfect because of agency costs that banks face when issuing new equities. Second, bank lending is subject to capital requirements imposed by regulation.[4] When bank equity is sufficiently low and it is too costly to issue new shares, banks reduce lending in order to lower the risk of violating the regulatory capital requirements. Alternatively, a deterioration in business cycle conditions can negatively affect banks' profits and hence banks' capital accumulation. Also in this case the costs of issuing new equities and the regulatory capital requirements can induce banks to reduce the amount of existing loans. This transmission mechanism does not call for capital requirements to be binding period by period; even when capital exceeds regulatory capital requirements, relatively low-capitalized banks may optimally forgo lending opportunities now in order to lower the risk of capital inadequacy in the future. One example is the contribution of Van den Heuvel (2002). With regard to Italy the empirical evidence reported by Gambacorta and Mistrulli (2004) and, on interest rates, by Gambacorta (2008) show that even if Italian banks are not constrained at any given point in time, a *bank capital* channel is at work.

In the *private sector default probability* channel, the private sector's borrowing costs are directly affected by its default risk. While there is a substantial literature using macroeconomic variables to predict private sector probabilities of default (see Fiori, Foglia, and Iannotti (2009) for Italy; Jakubik (2006) for Finland; and Hamerle, Liebig, and Scheule (2004) for Germany), less work has been undertaken to assess the existence and strength of a feedback effect from default probabilities through the borrowing costs to the macroeconomy. In his study of the Great Depression, Bernanke (1983) concludes that the increase in defaults and bankruptcies and the progressive erosion of borrowers' collateral relative to their debt burdens during this period increased the cost of credit intermediation. In a theoretical framework Curdia and Woodford (2010) relate probabilities of default of private sector firms directly to lending rates via a no-arbitrage condition. Closely related to our work, Marcucci and Quagliariello (2008) estimate a VAR relating macroeconomic variables to firms' and households' probabilities of default. They find that default rates follow a cyclical pattern, falling in good macroeco-

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[4]See, among others, Bolton and Freixas (2006), Cornett and Tehranian (1994), Calomiris and Hubbard (1995) and Stein (1998).

nomic times and rising during downturns. They also find some support for the idea that a feedback effect operates via a *private sector default probability* channel. Jacobson, Lindé, and Roszbach (2005) investigate this channel using Swedish data.

In our equation for the *private sector default probability* channel we control for aggregate firm leverage. One microeconometric study on loan rates and default probabilities, which uses leverage as a control variable for perspective default risk as we do here, is that by de Bandt, Bruneaub, and El Amrib (2008). The main idea is that the ratio of non-performing loans to the total stock of outstanding loans provides a good proxy of the realized default risk, while leverage provides additional information on the prospects of a default. The mechanism at work is reminiscent of the so-called borrower balance sheet channel: the higher the firm leverage, the greater the likelihood of default and, hence, the higher the interest rate charged by banks.

Finally, to specify the equations for banks' balance sheets in the Italian economy, we draw on previous work by Casolaro and Gambacorta (2004) and Albertazzi and Gambacorta (2009). We also refer to Locarno (2011), who evaluates the macroeconomic implications of changes in the banking regulatory framework for the Italian economy. However, while his paper uses satellite models to map changes in capital requirements into changes in the setting of loan rates, which are then fed into the BIQM, we include banking variables in the BIQM directly, which allows us to perform stochastic simulations.

3   Bank accounts and macroeconomic conditions

This section first connects the determinants of banks' profits (gross revenues, costs and provisions) and the private sector's default probability (DP) to macroeconomic conditions. Then, it relates the *excess regulatory* capital to banks' profits, bank capital and risk-weighted assets (RWA). In particular, we provide a stylized description of the law of motion of the RWA as a function of the evolution of the total stock of loans (already included in the BIQM) and the DP. A comprehensive summary of the variables and the related data sources can be found in Appendix B; detailed estimation results are in Appendix C.

3.1   Factors determining the banking sector gross profits

The estimated banking sector's revenues and costs (Net Interest Margin NET, Other Revenues OR, Operating Costs OC and Provisions PR) are related to profits π by the following identity:

$$\pi_t \equiv NET_t + OR_t - OC_t - PR_t. \tag{1}$$

We regress each term on the right hand side of (1) on a set of macroeconomic variables. For the set of explanatory variables, we build on previous work by Casolaro and Gambacorta (2004) and Albertazzi and Gambacorta (2009) with the main difference being that we impose cointegration restrictions when appropriate.

3.1.1 Net Interest Margin

This variable measures the difference between interest income and the amount of interest paid to lenders and depositors, both on retail and interbank markets. We regress the (log) net interest margin (NET) on the (log) nominal gross domestic product ($NGDP$), the spread between short-term loan interest rates (R^{LS}) and deposit interest rates (R^D), the lagged growth rate of total credit to the private sector (CR) and changes in the yield of long-term government bonds (R^{GL}):[5]

$$NET_t = 0.86NET_{t-1} + 0.14NGDP_{t-1} + 0.04(R^{LS}_{t-1} - R^D_{t-1}) + \beta(L)_{NET}\Delta CR_t + 0.03\Delta R^{GL}_t; \tag{2}$$

Nominal GDP is a proxy for the size of economic activity; spread and total credit control for, respectively, the impact of loans' prices and quantities; changes in the long-term rate on government bonds (R^{GL}) proxy for bank revenues from the maturity transformation activity. A positive cointegration restriction between NET and $NGDP$ is imposed after successfully testing for it. The growth rate of lending volumes, in the form of an Almon lag polynomial (with $\beta_{NET}(1) = 1.62$), provides a positive contribution to the net margin.

The coefficient on nominal GDP is positive, as economic activity positively affects bank margins. The coefficient on the spread is also positive, as the net interest margin benefits, all other things being equal, from higher interest rates on loans and lower interest rates on deposits.

3.1.2 Other Revenues

This variable includes all revenues that do not belong to the net interest margin. These typically comprise fees and commissions from the financial intermediation activity provided to depositors and, more generally, net profits on financial operations. The main explanatory variables of the (log) other revenues are the (log) nominal gross domestic product ($NGDP$), the change in the three months Euribor rate volatility ($VOLA$) and a level shift dummy in 1995:Q1, which is meant to capture a shift in Italian banks' core business from traditional lending activities to financial services provided to the private sector, consistent with the narrative in De Vincenzo and Quagliariello (2005). Other regressors include an Almon polyno-

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[5]Estimation details for this and all the other equations are given in Appendix C.

mial of the lagged growth rate of the dependent variable (with $\beta(1)_{OR} = -0.9$).

$$OR_t = 0.93OR_{t-1} + 0.07NGDP_{t-1} + 0.59\Delta VOLA_{t-1} + 0.07(1 - DUM951) + \beta(L)_{OR}\Delta OR_{t-1}. \tag{3}$$

After testing, a positive cointegration restriction between other revenues and the nominal GDP, acting as a scale variable, is imposed. The change in the Euribor volatility is computed as the standard deviation of the two-period moving average divided by the moving average. The Euribor volatility positively affects other revenues, as the latter benefit from the higher number of transactions that characterize periods of increased market volatility.

3.1.3 Operating Costs

This variable tracks the labour and overhead costs of the banking sector. We regress (log) operating costs on the (log) total amount of wages ($wage$) paid in the banking sector and a level dummy in 1999:1:[6]

$$OC_t = 0.65OC_{t-1} + 0.35wage_{t-1} + 0.04(1 - DUM991) + \beta_{OC}(L)\Delta OC_{t-1}. \tag{4}$$

The dummy captures a restructuring of the bank industry, which took place in the late 1990s, as reported in De Vincenzo and Quagliariello (2005). As expected, the corresponding coefficient is positive. Operating costs and the banking sector wage bill are cointegrated.

3.1.4 Provisions

Provisions are resources set aside by banks to face future expected defaults in the private sector. Our endogenous variable is defined as provisions (PR) over total credit to the non-financial private sector (CR). The estimated equation is the following:

$$\frac{PR_t}{CR_t} = 0.62\frac{PR_{t-1}}{CR_{t-1}} - 0.06\Delta RGDP_{t-1} + 0.03DP_{t-1}, \tag{5}$$

The regressors include the lag of the dependent variable, the growth rate of real GDP ($RGDP$) and our (lagged) default probability measure for the non-financial private sector (DP, see next subsection). According to our estimates, the coefficient on the growth rate of GDP is negative, as a higher growth rate implies lower credit devaluations. The coefficient on the probability of default is positive, as the latter variable is associated with default risk.

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[6]Other regressors include a lag and an Almon polynomial of the lagged growth rate of the dependent variable (with $\beta(1)_{OC} = -0.50$), as well as outlier dummies.

3.2 Default probabilities and macroeconomic conditions

To complete the description of the impact of macroeconomic conditions on the banking sector's accounts, in this section we model the default probability of the private sector (DP) as a function of macroeconomic variables. Specifically, as in Marcucci and Quagliariello (2008) and consistent with the definition used in the Bank of Italy's Financial Stability Review and the Annual Report, we choose to proxy private sector default probability with the flow of non-performing loans over the total stock of loans, as reported by Italian banks for regulatory purposes:[7]

$$DP_t = 0.86 DP_{t-1} + 0.11 \Delta R_{t-4}^{LS} - 5.37 \Delta RGDP_{t-3} \qquad (6)$$

Default probabilities depend on the lagged variations of the interest rate on loans ($\Delta(R_{t-4}^{LS})$) and the growth rate of real GDP. The inclusion of both GDP and interest rates is consistent with previous literature (see Jacobson, Lindé, and Roszbach (2005) and Carling, Jacobson, Lindé, and Roszbach (2002)). Macroeconomic variables exert a significant effect on the probability of default. In particular, the (lagged) growth rate of the interest rate on loans raises DP, as a higher cost of borrowing reduces firms' ability to repay loans. By contrast, the lagged growth rate of GDP has a strong negative effect on DP, as more sustained growth implies increasing firms' profits.

3.3 The relationship between the banking sector's accounts and banking capital

Excess capital with respect to the regulatory requirement is defined as follows:

$$REXC_t \equiv \frac{K_t}{RWA_t} - k^*, \qquad (7)$$

where K is (total) regulatory bank capital, RWA are risk-weighted assets and k^* represents the minimum amount of capital over risk-weighted assets that banks must hold as a regulatory requirement.

We model bank capital K as resulting from the accumulation process of retained bank profits:

$$K_t = K_{t-1} + \pi_t - \omega_t + \epsilon_t^k, \qquad (8)$$

where π are bank profits and ω is the sum of distributed dividends and taxes.[8] The error term ϵ^k captures factors that we do not model and that affect capital: among others, the issuance of new capital and a possible mismatch between definitions

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[7]See Appendix B for a description of this variable.

[8]We describe the data sources in Appendix B.

of regulatory capital accumulation and profits as they appear in banks' balance sheets. Our definition of K corresponds to the *total* regulatory capital and does not distinguish between the Tier 1 and Tier 2 components defined by regulatory standards.[9]

Risk-weighted assets are modelled in accordance with the method adopted in the banking supervision regulatory guidelines. These assets are essentially composed of loans and other securities, weighted by a measure of their respective risk:

$$RWA_t = \sum_i w_t^i Loans_t^i + \sum_j w_t^j Securities_t^j,$$

where w_t^i, w_t^j are the corresponding (time varying) risk weights and *Loans* denote (performing) loans.[10] A major issue related to the introduction of RWA into an aggregate model is risk heterogeneity across assets (performing loans and securities). In principle, we would need to track the dynamics of a large amount of heterogeneous loans and securities, also taking into account how their risk profiles evolve over time, which is unfeasible in our stylized aggregate framework. We keep the model parsimonious by approximating the accumulation of RWA using only information on the dynamics of total loans – including non performing loans – (L_t; this variable is already determined in the BIQM by a set of credit demand equations) and the probability of default of the private sector. We proceed as follows:

1. we track only loans to the private sector and disregard securities (which amounts to assuming that $RWA_t \propto \sum_i w^i Loans_t^i$). A large amount of securities in Italian banks' portfolios are in fact government bonds, which receive zero risk weight. We also disregard interbank market loans, most of which are assigned a small risk weight (20%);

2. loans comprise loans to firms (F) and households (H) with weights w^H and w^F, respectively. It is further assumed that the ratio between loans to firms and loans to households is constant. Therefore:

$$RWA_t \propto wLoans_t,$$

   where $w \equiv \left(w^H Loans_t^H + w^F Loans_t^F \right) / Loans_t$ and $Loans_t \equiv Loans_t^H + Loans_t^F$;

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[9]In Section 4.1 we briefly discuss how to tentatively disentangle their separate contribution to the setting of loan interest rates.

[10]For the purpose of the simulation, we assume that banks can exclude non-performing loans from the RWA by setting aside provisions. Therefore, for this purpose "loans" includes "performing loans".

3. the definition of the stock of loans (L_t) commonly used includes the non-performing ones, which should be excluded from the RWA, as discussed. We use private sector probabilities of default (DP as defined above) to take that into account. We then have:

$$Loans_t = (1 - DP_t)L_t.$$

Hence, risk-weighted assets are given by:

$$RWA_t \propto wL_t(1 - DP_t), \tag{9}$$

where DP_t is the default probability described in Section 4.2. The stock of total loans grows at the rate g_t (which already takes write-offs into account):

$$L_t = (1 + g_t)L_{t-1} \tag{10}$$

Using the equation above, one can solve (9) for L_t as a function of RWA_t and DP_t:

$$RWA_t = RWA_{t-1}(1 + g_t)\frac{1 - DP_t}{1 - DP_{t-1}} + \epsilon_t^{RWA}, \tag{11}$$

where g accounts for the effects of lending volumes on RWA and the growth rate of DP provides a measure of the effect of risks on RWA. The term ϵ_t^{RWA} is a (small) error term which accounts for the approximation we use in the law of motion of RWA.

Aggregate RWA modelled as in equation (11) is, overall, a satisfactory approximation of actual RWA as shown in Figure 1, with deviations between the two occurring only occasionally, in concomitance with tightening episodes.[11]

4 The two channels of transmission

4.1 The bank capital channel

The equations reported in the previous section document the impact of aggregate shocks on banks' accounts, in particular on profits and capital. In this section we estimate the impact of excess capital on the setting of interest rates on loans to private sector firms. We give separate consideration to loans with short–to–medium maturity, (up to one year; the corresponding interest rate is labelled R^{LS}) and long maturity (R^{LL}). Banking loans are the main source of financing for the private sector and hence loan interest rates are one of the main drivers

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[11] The occurrence of a credit tightening episode is documented by the answers to the Eurosystem Bank Lending Survey for Italy.
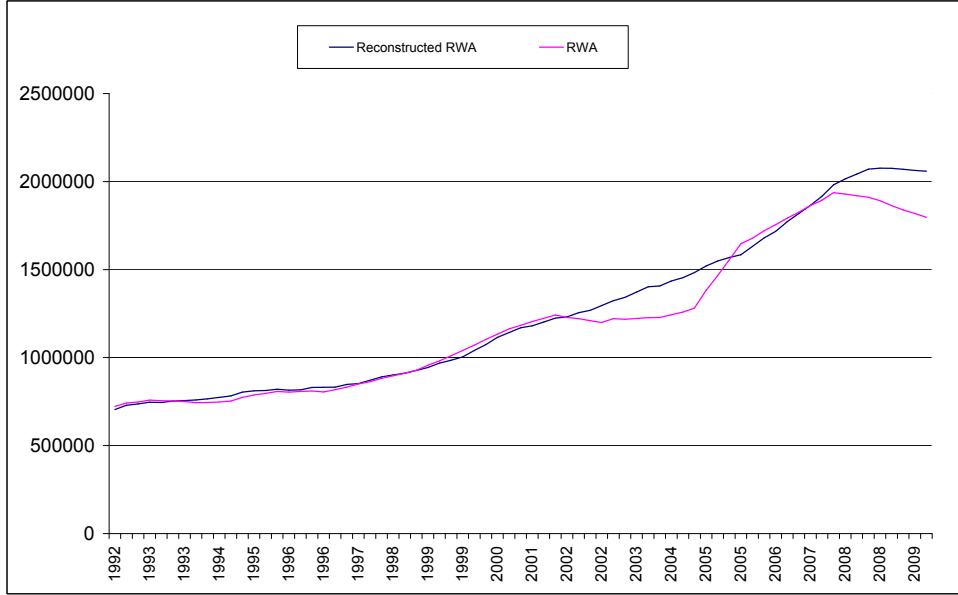
Figure 1: Risk-weighted assets: actual and reconstructed (millions of euros)

of equipment investment in the BIQM. We estimate the following regression for short–to–medium term loan rates:

$$R_t^{LS} = 0.66R_{t-1}^{LS} + 0.34R_{t-1}^{GS} + 0.17(R_{t-2}^{GL} - R_{t-2}^{GS}) - 18.50\Delta REXC_{t-3}, \qquad (12)$$

where a long-run restriction is tested and imposed between the interest rate on loans and the average rate on short-term government bonds (R^{GS}). Equation (12) specifies the level of the interest rate on loans as a function of the average rate on short-term government bonds (up to one year, R^{GS}), the term spread ($R_{t-2}^{GL} - R_{t-2}^{GS}$, where R^{GL} denotes the average rate on long-term government bonds) and changes in the excess capital of the banking sector ($\Delta REXC_{t-3}$): it implies that a 1 percentage point increase in excess capital temporarily lowers short-to-medium term loans rates by roughly 19 basis points.[12] The term spread ($R_t^{GL} - R_t^{GS}$) has a positive effect on R_t^{LS}. This captures movements in the term structure that reflect

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[12]A different specification using the level of excess capital rather than the first difference has similar dynamic properties but a slightly worse out-of-sample predictive ability.

broad macroeconomic conditions and are likely to influence banks' intermediation by affecting the activity of maturity transformation. As banks' assets typically have longer maturity than liabilities, factors that impact positively on the yield of long-term bonds tend to raise the opportunity cost of supplying long-term loans at a given interest rate. As a result, banks have an incentive to increase the interest rate on loans, as reflected in the positive estimate of the coefficient.

For long-term loan rates, the equation models the spread between the interest rate on long term loans (R^{LL}) and the long-term government bond yields (R^{GL}):

$$R_t^{LL} - R_t^{GL} = 0.67(R_{t-1}^{LL} - R_{t-1}^{GL}) - 0.71\Delta(R_t^{GL}) - 65.97\Delta(REXC_{t-3}) + 27.50\Delta(LEV_{t-1}), \quad (13)$$

where LEV is a control variable relating to private firms' leverage. Equation (13) relates changes in spreads to excess capital: it implies that a 1 percentage point increase in excess capital decreases the spread by roughly 66 basis points.[13]

According to our results, the excess capital has a significant negative sign in both equations (see Appendix C for estimation details). Other things being equal, a more capitalized banking sector offers loans at lower interest rates. This result provides evidence in favour of the existence of a *bank capital* transmission channel in the Italian economy, also documented in previous studies (see, for example, Gambacorta and Mistrulli (2004)).[14] The strength and economic significance of this channel are appraised in Section 5 by means of simulations of the BIQM.[15]

4.2   The private sector default probability channel

An alternative way to model the interaction between bank loans and the macroeconomy relies on using firms' default probability as a direct driver of credit supply decisions.

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[13]The instantaneous impact of R^{GL} on R^{LL} is equal to 0.29.

[14]Interaction terms, allowing for a faster adjustment of loan rates to changes in the policy rate conditional on different degrees of bank capitalization, were found not to be statistically significant. This finding is consistent with Gambacorta and Mistrulli (2004).

[15]Equation (12) was also estimated by relaxing the assumption of homogeneous capital K_t, and inserting the two Tiers separately in the regression. Our preferred specification replaces the term $\Delta REXC$ with two regressors related, respectively, to Tier 1 and to the remaining part of regulatory capital:

$$\Delta T1RWA = \left(\frac{Tier1_t}{RWA_t}\right) - \left(\frac{Tier1_{t-1}}{RWA_{t-1}}\right) \quad (14)$$

$$\Delta TRRWA = \left(\frac{Total_t - Tier1_t}{RWA_t}\right) - \left(\frac{Total_{t-1} - Tier1_{t-1}}{RWA_{t-1}}\right). \quad (15)$$

For the Tier 1 component, our (preliminary) results suggest a significant coefficient, equal to -0.16; for the remaining part, the effect is roughly double (-0.33).

We posit that the spread between the interest rates on short-term loans and short-term government bonds yields ($R^{LS} - R^{12m}$) depends on firms' default probability (DP) and firms' financial leverage (LEV). The spread is measured by the difference between the interest rate on short-term loans and the yield rate on 12-month Italian treasury bonds.[16] The estimated equation is:

$$R_t^{LS} - R_t^{12m} = 0.86(R_{t-1}^{LS} - R_{t-1}^{12m}) + 0.14 DP_{t-1} + 21.64\Delta LEV_{t-1}, \qquad (16)$$

An increase in the default probability raises the spread (a 1 percentage point increase in the probability of default implies, on impact, a rise of the spread of about 15 basis points) and hence the cost of loans. Similarly, an increase in firms' leverage increases the riskiness of firms – all other things being equal – leading the banks to charge a higher interest rate on loans. Overall, we find a significant effect of firms' economic and financial conditions in the setting of interest rates on loans by banks.

5 Assessing the interaction between the banking sector and the real economy

We assess the effect of introducing banks' balance sheet variables in the BIQM by analyzing the response of GDP to two shocks: a monetary policy tightening (a permanent increase in the monetary policy rate by 100 basis points) and a permanent increase in world demand (by 10 percent). For each shock, we simulate the standard version of the BIQM and the BIQM augmented, respectively, by the *bank capital* channel and the *default probability* channel.

In what follows, we do not consider the possibility that quantitative limits on credit availability may constrain banks' credit supply and modify the transmission of external shocks to the real economy. While such an assumption reflects conditions that typically prevail in "normal" times, the effects of credit rationing may at times become substantial, if difficult to quantify. The analysis in Caivano, Rodano, and Siviero (2010) attempts to evaluate the effects of credit rationing on the Italian economy using the BIQM.

5.1 World demand shock

Figure 2 reports the effects on GDP of a permanent 10 percent increase in world demand.

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[16]R^{LS} refers to a bundle of loans with maturity up to 1 year, but 1-year loans amount to 85% of the total.

The impact of the shock is larger and more persistent in the BIQM augmented by the *default probability* channel, where the peak effect on real GDP is 0.2 percentage points higher than in the standard BIQM. In the BIQM augmented by the *bank capital* channel, by contrast, the effect of the shock is roughly the same as in the standard BIQM. In all cases the increase in GDP after 10 years is of around 1 percent.

GDP response to a 10% shock to world demand
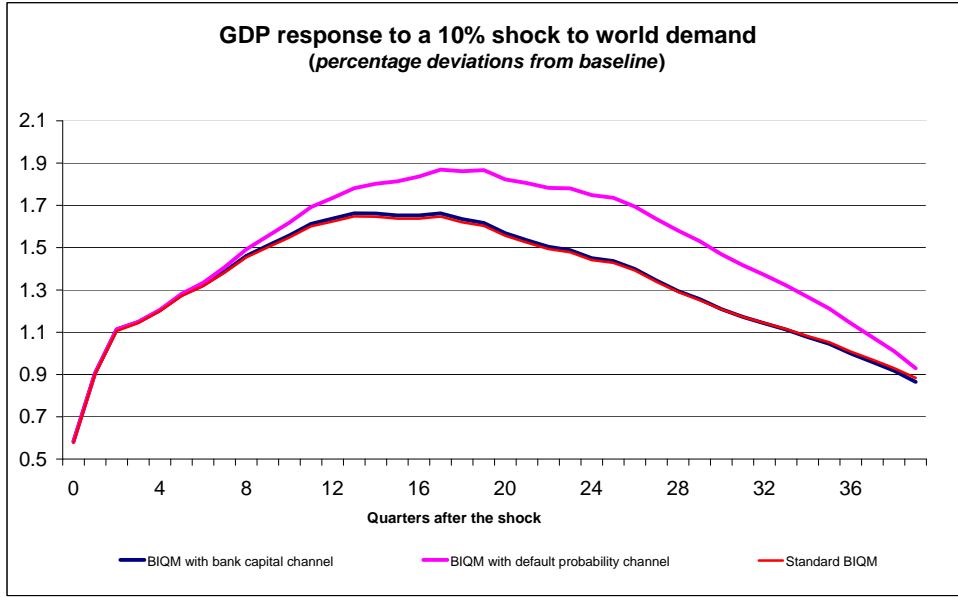*(percentage deviations from baseline)*

Figure 2: GDP response to a 10 percent positive world demand shock

The improvement in macroeconomic conditions driven by the increase in foreign demand reduces the private sector probability of default. The latter, when the *default probability* channel is at work, quickly translates into a reduction of interest rates on non-financial firms' loans (see equation (16)). This stimulus results in higher investment dynamics and then higher GDP. Banks' profits, in turn, benefit from a reduction of provisions and higher net interest margins.

The response of the main macroeconomic variables in the BIQM augmented by the *bank capital* channel are similar to those delivered by the standard version of the model. The intuition for the lack of amplification effects is as follows: first, the increase in banks' profits brought about by the improving macroeconomic

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conditions fosters bank capital accumulation only gradually; second, the effect of capital accumulation on excess capital is roughly counterbalanced by the increase in RWA that follows from the expansion in the private sector's demand for credit. Overall, the response of excess capital is negligible.

5.2   Monetary policy shock

Figure 3 reports the effects of a 100 basis point permanent increase in the policy rate. The shock generates a drop in GDP, with a maximum effect after approximately 5 years with all versions of the BIQM. As in the case of a world demand shock, the *default probability* channel generates larger and more persistent real effects than the *bank capital* channel.
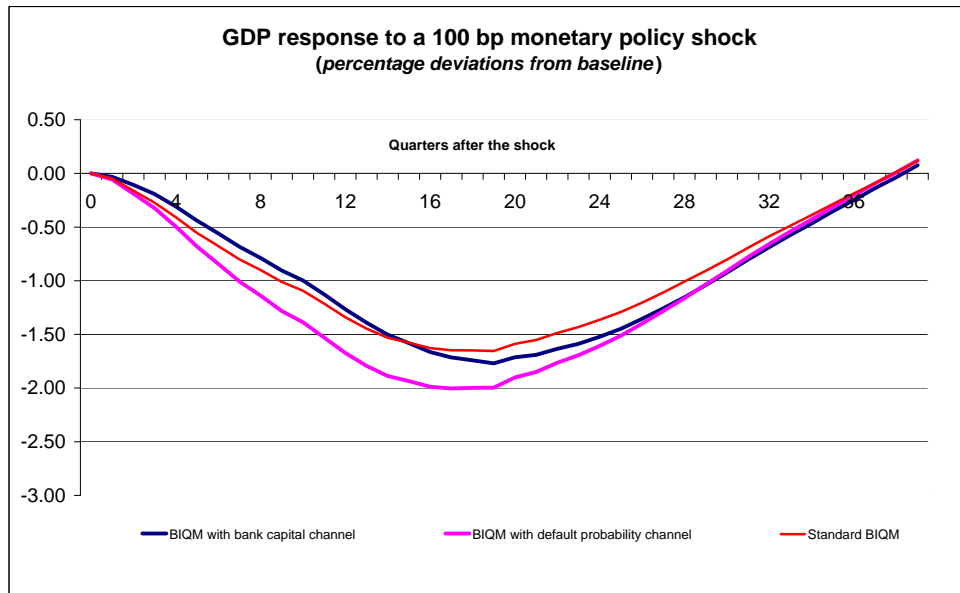

Figure 3: GDP response to a 100 basis points increase in policy rates

6   A risk scenario

This section reports an example of how the model can be used to derive the distribution of risks underlying the projections, based on the BIQM enriched with the *bank capital* channel.[17] Among other things, we show how the BIQM may be used to assess the risk that bank capital falls below the prudential regulatory threshold. The purpose of this section is purely illustrative; the assessment of risks presented below does not, by construction, give a realistic picture of the risk outlook as it appeared or might have appeared at any point in time. The focus is more on methodological issues (i.e. how the machinery presented here may be used and useful for appraising the risks for banks' profitability and capital) than on the results *per se*.

In the last decade or so, many central banks have taken to disseminating their views concerning the balance of risks around their published macroeconomic projections by means of *fan charts*. A by-product of embedding banks' accounts into a macroeconometric model such as the BIQM is the possibility of computing the probability distribution of banks' accounts and regulatory capital associated with the macroeconomic simulations.[18] Fan charts for endogenous variables (e.g. GDP or bank profits) published bi-annually in the Bank of Italy Economic Bulletin are symmetrical around a central projection; the width of the fan chart signals the degree of uncertainty around the baseline path of a given endogenous variable.[19] However, symmetrical fan charts often do not reflect the balance of risk-assessment of policy makers (e.g. risks to world demand may be judged to be prevalently on the upside or on the downside, depending on the circumstances). In the following, we produce non-symmetrical fan charts for banks' accounts and excess regulatory capital, reflecting a hypothetical scenario with *upside* risks on banks' funding costs and on firms' probability of default. The degree of asymmetry is measured by the distance between the median and the mode of the distribution of a particular variable. We conceive a baseline projection and we design a mild macro-financial distress scenario for the Italian economy.[20] More precisely, we make the following assumptions:[21]

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[17]Given the typical horizon of simulation exercises, using the BIQM inclusive of the *default probability* channel would deliver very similar results to those discussed in the text.

[18]Arguably, computing fan charts is even more relevant for banking variables than it is for macroeconomic variables. Specifically, fan charts may be used to compute, in the context of a stress exercise, the quantiles of excess capital, profits, risk-weighted assets and other relevant variables.

[19]See Miani and Siviero (2010) for details on the construction and use of fan charts at the Bank of Italy.

[20]For illustrative purposes, the baseline projection is constructed to coincide with the historical evolution up to 2011 Q2.

[21]It is worth emphasizing that the risk assessment exercise has a purely illustrative purpose.

1. risks of higher funding costs for banks prevail, with the distribution of interest rates in both the interbank and retail markets being skewed to the right. In particular, median interbank and deposit rates (the BIQM does not include bank bond issuance) are higher than in the baseline by 20 basis points for the whole simulation horizon;

2. there exist risks of a deterioration in the solvency conditions of private sector firms, with a 0.20 percentage points increase in the median default probability over the whole simulation horizon, compared to the baseline simulation;

3. risks around the main international exogenous variables are roughly balanced. The median of the distributions of exchange rates and commodity prices coincide with the baseline; the median of world demand is assumed to be marginally lower than in the baseline, by 0.2 percentage points, possibly reflecting international financial tensions;

4. further risks to the projection stem from the volatility of the unexplained components of each regression equation for banking variables. These risks are deemed to be symmetrical.

Given the set of assumptions above, the BIQM is used to derive the implicit distribution for the variables of interest, using the methodology presented in Miani and Siviero (2010).

In Figures 4–5 we report the baseline projection and the surrounding risk scenario for gross profits and excess regulatory capital; detailed fan charts for banks' accounts may be found in Appendix D. The assumptions would yield a moderate downside risk to gross banks' profits, as shown in Figure 4. Following assumptions 1-4 above, the resulting distribution for the net interest margin implies a median lying below the baseline projection (Figure 6), due to higher median funding costs. The assumptions would also entail the risk that other revenues decrease moderately in the period, while a downward risk to a fall in operating costs prevails. The risks to provisions are balanced. As a result, the distribution of gross profits is slightly skewed below the baseline outcome, reflecting the perception of downward risks to bank profitability under the assumptions formulated above (see Figure 4).

In this example, risks for excess capital are balanced, as an effect of two opposite forces: on the one hand a reduction in profits would deliver a lower bank capital (the numerator in equation (7)); on the other hand a lower demand for loans from households and firms would reduce banks risk-weighted assets (the denominator in equation (7)). These two forces roughly compensate each other and, as a result,

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The risk factors included in the scenario must therefore be understood to be neither exclusive nor comprehensive, even through the lens of 2010 Q2.
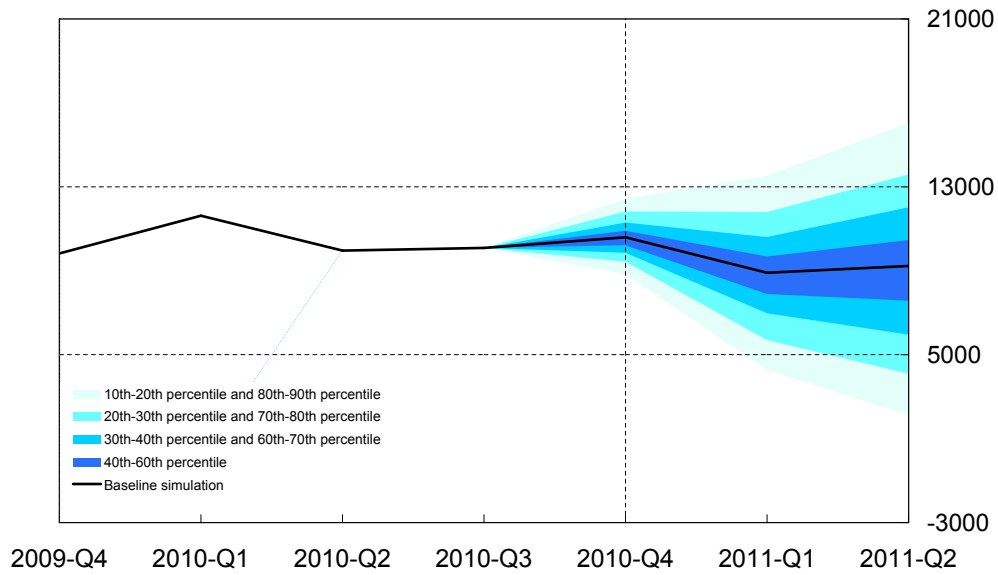
Figure 4: Illustrative profits probability distributions: millions of euros

the median excess regulatory capital is not far from the baseline projection, its distribution being basically symmetrical around the latter, as shown in Figure 5.

From a methodological standpoint, the fan charts can be used to fully characterize the distribution of excess regulatory capital. In particular, they indicate that, under the assumptions above, the probability of regulatory excess capital falling below 4.5% would have been around 30 percent at the end of the projection horizon.
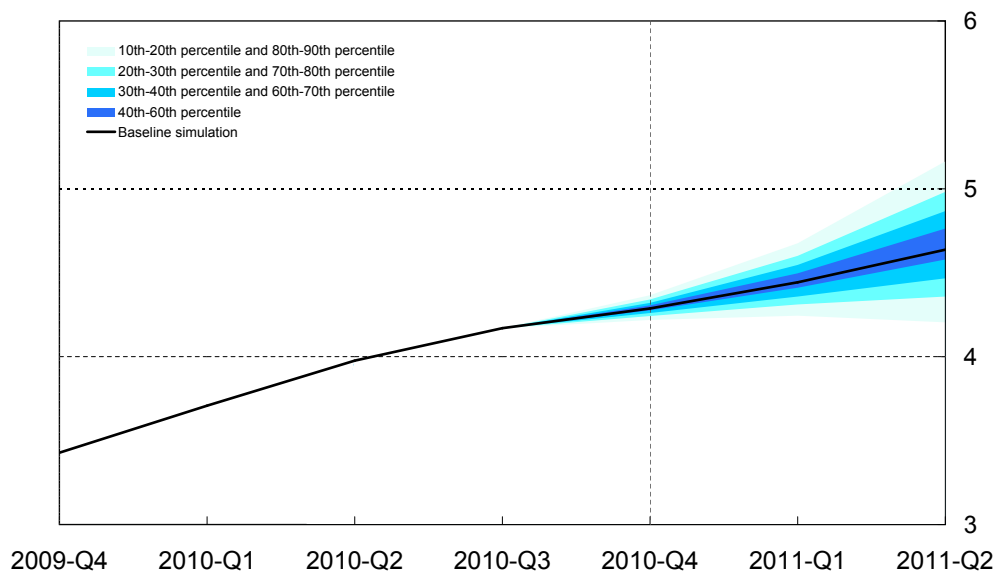
Figure 5: Illustrative excess capital probability distribution: percentage points

7 Conclusions

This paper showed how the Bank of Italy Quarterly Model was modified to include mechanisms reflecting the interaction between macroeconomic conditions and banking variables. Specifically, two possible transmission channels were identified (the *default probability* channel and the *bank capital* channel) through which banking variables can affect loan interest rates and, ultimately, the macroeconomy.

Simulation results show that, while in both cases the propagation of shocks change with respect to the standard BIQM, the amplification effects are rather small; the *default probability* channel results in a larger amplification effect than the *bank capital* channel.

Finally, the paper showed how the modified model may be used to characterize the probability distribution of relevant banking variables (among which banks profits and capital). The paper did not deal with the possibility that banks' credit supply also works through quantitative limits to credit availability and not only

through variations in the cost of credit. This issue, touched upon in Caivano, Rodano, and Siviero (2010), is left to future research.

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Appendix A. A brief description of the Bank of Italy Quarterly Model (BIQM)

The new version of the BIQM shares many of the characteristics of the previous one, released in 1986 (see Banca d'Italia, 1986). Its long-term properties are consistent with a neoclassical model postulating exogenous growth, in which full employment of factors is accompanied by a constant rate of inflation, hence constant relative prices. The levels of output and of the employment of capital and labour are consistent with the parameters of the aggregate production function and with relative factor costs. The steady-state growth path of the model, stemming from technical progress and the accumulation of real and financial wealth, interacts with the dynamics of the adjustment process to determine short-term characteristics. The adjustment processes essentially reflect three factors: the stickiness of prices and wages, which prevents their instantaneous adaptation to the situation of full resource utilisation; the non-malleability of installed physical capital, which limits the short-term modifiability of the relative composition of productive factors; and the possibility that expectations and outcomes may not coincide. In the short run, therefore, given these rigidities, the characteristics of the model fit the Keynesian framework in which the level of output is determined by the trend in aggregate demand, in a situation of oversupply in both the goods and the labour market.[22]

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[22]For a more detailed description of the main properties of the model, see Busetti, Locarno, and Monteforte (2005).

Appendix B. Data sources

The GDP, demand components and deflators are from national accounts (Istat data) as per the May 2010 release. Information on total compensations to the credit sector are also from Istat Annual Accounts. Quarterly time series for Economic bank accounts were reconstructed from 1989 (provisions from 1990). As in national accounts data are flow concepts (the annual value is obtained as the sum over the four quarters). Series are defined as in Regulatory Reports, Section 3 (subsection 4 to 6, Economic Accounts). Quarterly data on Regulatory Bank Capital and Risk-Weighted Assets are computed as an interpolation of semiannual consolidated data from regulatory reports. Taxes and distributed dividends are from the OECD, interpolated at a quarterly frequency. Default probabilities are computed as the ratio of (seasonally adjusted) new non-performing loans and the (seasonally adjusted) stock of existing loans. Data sources are as reported in the description of Figure 17.4 (the ratio of non-performing loans to performing ones, $RNPL$) of the 2010 Bank of Italy Annual Report (see the methodological notes): we use a simple transformation to map the $RNPL$ into our variable as follows $DP = RNPL/(1 - RNPL)$. In a small part of the sample (1990-1994), where only annual data are available we temporally disaggregate it at a quarterly frequency.

Leverage (LEV) is defined as the ratio of bank debt to total liabilities for non-financial firms; the source is annual data from Company Accounts.

Data on loan interest rates, both short–medium (R_t^{LS}) and long term (R_t^{LL}), are computed as a weighted average of rates on loans with maturities of, respectively, less and more than one year. Deposit interest rates (R_t^D) is a weighted average of rates for existing deposits. The long term rate (R_t^{LL}) of government bonds is given by a weighted average of bonds with maturity of more than one year; R_t^{GS} is the weighted rate for government bonds with maturity of less than one year.

Acronym	Variable name	Source
NET	Net Interest Margin	Bank of Italy
OR	Other Revenues	Bank of Italy
OC	Operating Costs	Bank of Italy
PR	Provisions	Bank of Italy
π	Bank profits	Bank of Italy
ω	Taxes and distributed dividends	OECD
DP	Flow of new non-performing loans over total stock	Bank of Italy
K	(Tier1 + Tier2 - Deductions)	Bank of Italy
RWA	Risk-Weighted Assets	Bank of Italy
REXC	Excess Regulatory Capital	Bank of Italy
R^{LL}	Interest rate on long term loans (maturity > 1 year)	Bank of Italy
R^{LS}	interest rate on short term loans (maturity < 1 year)	Bank of Italy
LEV	Non-financial firms leverage	Bank of Italy
R^{GS}	Yield on short-term gov. bonds (maturity < 1year)	Bank of Italy
R^{GL}	Yield on long-term gov. bonds (maturity > 1 year)	Bank of Italy
NGDP	Nominal GDP	Istat
RGDP	Real GDP	Istat
VOLA	Euribor 4 periods standard deviation	Euribor official
CR	Stock of total credit to private sector	Bank of Italy
R^{D}	Interest rate on retail deposits	Bank of Italy
R^{12m}	Yield on one year gov bonds	Bank of Italy
$wage$	Total compensation in the financial sector	Istat

Table 1: Legend and sources of mentioned variables

Appendix C. Equations

We report estimation results for banking variables and DP:[23]

	NET	OR	OC	PR/CR	DP
Dependent var_{-1}	0.86***	0.93***	0.65***	0.62***	
$(NGDP_{-1})$	0.14***	0.07***			
$\Delta(VOLA_{-1})$		0.59***			
$\log(wage_{-1})$			0.35***		
DP_{-1}				0.031**	0.86***
$\Delta(RGDP_{-1})$				-0.06***	
$\Delta(RGDP_{-3})$					-5.37**
$(R^{LS} - R^{D})_{-1}$	0.04***				
$\Delta(R^{GL})$	0.03***				
$\Delta(R^{LS}_{-4})$					0.11***
$\Delta\log(CR_{-1})$	1.24***				
$\Delta\log(CR_{-2})$	0.38***				
$\Delta(OR_{-1})$		-0.20***			
$\Delta(OR_{-2})$		-0.18***			
$\Delta(OR_{-3})$		-0.16***			
$\Delta(OR_{-4})$		-0.14***			
$\Delta(OR_{-5})$		-0.12**			
$\Delta(OR_{-6})$		-0.10**			
$\Delta(OC_{-1})$			-0.25***		
$\Delta(OC_{-2})$			-0.25**		
Adj. R-sq	0.88	0.99	0.98	0.72	0.92

*** regressor significant at 99%;** at 95%

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[23]NET, OR, OC, RGDP and NGDP are log levels. Regressions include a constant term and some outliers dummy variables. We do not report them here to save space. We use TRAMO–SEATS to seasonally adjust banks' account data.

Estimation results for the *bank capital* channel:

	$R^{LL} - R^{GL}$	R^{LS}
Dependent var_{-1}	0.67***	
(R^{LS}_{-1})		0.66***
(R^{GS}_{-1})		0.34***
$\Delta(R^{GL})$	-0.71***	
$\Delta(REXC_{-3})$	-65.97***	-18.50***
$\Delta(LEV_{-1})$	27.50***	
$(R^{GL} - R^{GS})_{-2}$		0.17***
Adj. R-sq	0.93	0.99

*** regressor significant at 99%;** at 95%

Estimation results for the *default probability* channel:

	$R^{LS} - R^{12m}$
Dependent var_{-1}	0.86***
DP_{-1}	0.14***
$\Delta(LEV_{-1})$	21.64***
Adj. R-sq	0.89

*** regressor significant at 99%;** at 95%

Appendix D

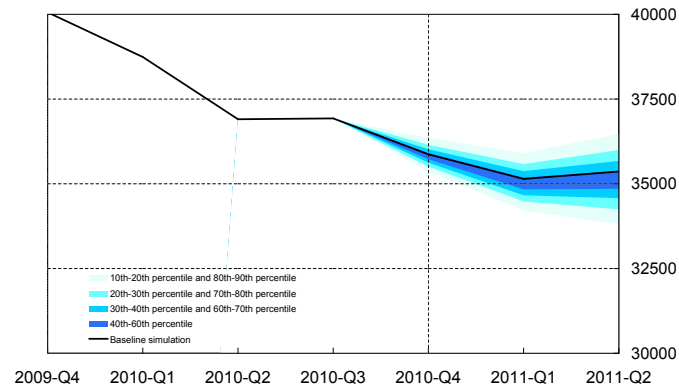We report fan charts for the whole set of bank accounts:

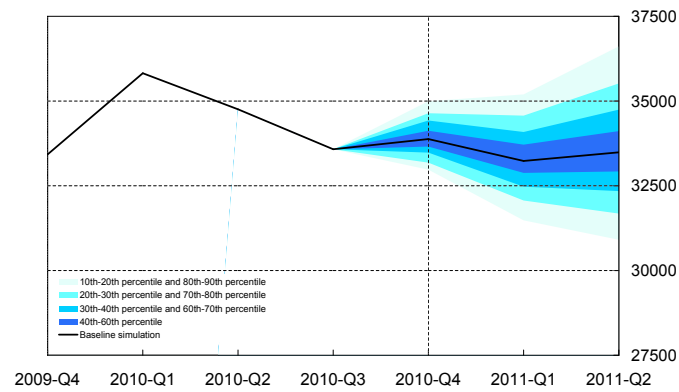Figure 6: Illustrative net interest margin probability distributions: billions of euros

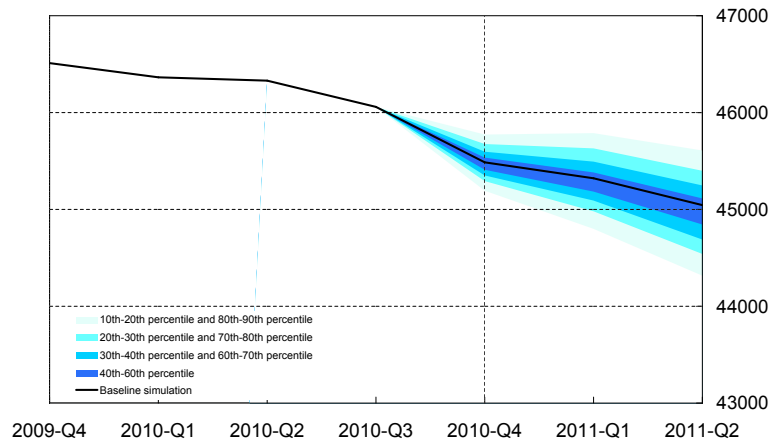Figure 7: Illustrative other revenues probability distributions: billions of euros

Figure 8: Illustrative operating costs probability distributions: billions of euros
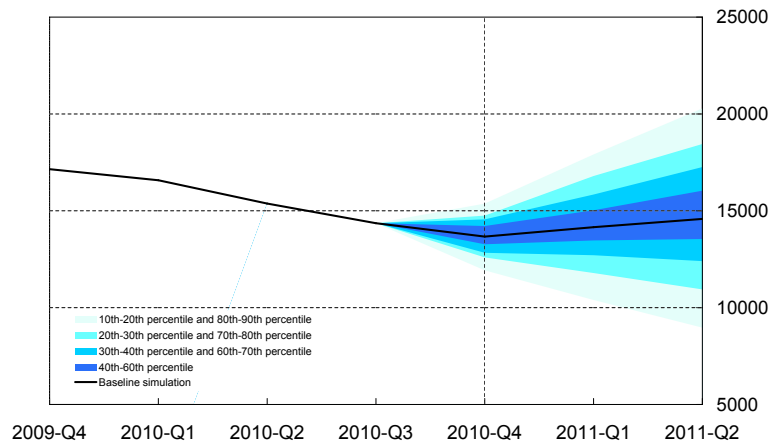

Figure 9: Illustrative provisions probability distributions: billions of euros

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