9TH JACQUES POLAK ANNUAL RESEARCH CONFERENCE
NOVEMBER 13-14, 2008

From Subprime Loans to Subprime Growth? Evidence for the Euro Area

Martin Čihák and Petya Koeva Brooks
International Monetary Fund

Paper presented at the 9th Jacques Polak Annual Research Conference
Hosted by the International Monetary Fund
Washington, DC─November 13-14, 2008

WP/08/xx

IMF Working Paper

From Subprime Loans to Subprime Growth? Evidence for the Euro Area

Martin Čihák and Petya Koeva Brooks

DRAFT

INTERNATIONAL MONETARY FUND

 WP/08/xx

IMF Working Paper

European Department

From Subprime Loans to Subprime Growth? Evidence for the Euro Area

Prepared by Martin Čihák and Petya Koeva Brooks[1]

Authorized for distribution by [Luc Everaert]

November 2008

Abstract

The 2007–08 global financial crisis has highlighted the potential of financial conditions in influencing real economic activity. We examine the linkages between the financial and real sectors in the euro area, finding that (i) bank loan supply responds negatively to declines in bank soundness; (ii) a cutback in bank loan supply has a negative impact on economic activity; (iii) a positive shock to the corporate bond spread leads to a significant negative response of industrial output; and (iv) risk indicators for the banking, corporate, and public sectors show an improvement since 2002–03, followed by a deterioration in 2007–08 . These estimates imply that the currently estimated bank losses would subtract some 2 percentage points from the euro area output (but with considerable uncertainty around the estimates).

JEL Classification Numbers: E44, G12, G21

Keywords: Euro area, financial sector, real sector, linkages, contingent claims approach

Authors' E-Mail Addresses: mcihak@imf.org; pkoeva@imf.org

[1] We would like to thank, without implicating, Jörg Decressin for guidance, Chanpheng Dara for research assistance, and Marie Donnay, Heiko Hesse, Luc Laeven, Kevin Ross, and participants in seminars at the IMF, the European Central Bank, and the European Commission for useful comments on earlier versions of the paper. All remaining errors are our own.

Contents Page

I. INTRODUCTION

The ongoing financial crisis has underscored the importance of financial linkages among countries, and the impact of financial conditions on real economic activity (e.g., Strauss-Kahn, 2008). This paper studies empirically linkages between the financial and real sectors in the euro area. To assess the robustness of the main results, we use a battery of possible estimation approaches.

Since mid-2007, the sub-prime mortgage crisis in the United States has sparked a reassessment of risk across global markets. Risk premia in money and credit markets have spiked, raising the cost of interbank and corporate financing, including in the euro area. The situation worsened substantially in September–October 2008, when key money market indicators—the 3-month spreads over policy rates, use of central bank facilities, and measures market segmentation on the basis of credit risk—all rose to unprecedented levels.

The impact of the global financial crisis on the euro-area real sector is an important, and still open, question. It may be too early to observe in full how the deterioration in financing conditions will affect the euro-area economy. Nonetheless, it is useful to examine the linkages between the financial and real sectors in the euro area, using a combination of past and recent data.

The tight financial conditions associated with the crisis affect euro-area activity through four main channels, namely:

- First, the increase in bank funding costs (due to higher money market premia and rates) may be passed on to firms and consumers via higher lending rates. Indeed, of retail lending rates have gone up somewhat since mid-2007, even though this has been largely a continuation of a previous trend (Figure 1).

- Second, in response to their own deteriorated balance sheets and financial conditions, banks may limit the amount of credit available to borrowers for any given price. This could be in the form of stricter lending standards. Bank lending surveys indicate a considerable tightening in quantitative bank lending conditions since mid-2007, suggesting that the credit cycle has turned (Figure 2).

- Third, the costs of corporate bond and equity financing may also be higher, limiting the scope for substitution from bank financing. The corporate bond and credit default spreads of all maturities and ratings have increased sharply, and the stock market has fallen since the start of the crisis (Figure 3).

- Fourth, tighter financing conditions could create “financial accelerator effects” by depressing asset prices and reducing the value of collateral. Available data indeed confirm that asset prices have declined precipitously (Figure 3); this has an impact on collateral values.

The recent data show that monetary aggregates have decelerated, as has bank credit to the private sector. This is a combination of a continued slowdown of bank credit to households and a starting slowdown in the (still relatively rapid) growth of corporate credit. Equity and bond issuance by non-financial firms has also decelerated (Figure 4).

To preview our findings, we find that the financial tightening affects euro-area activity through several channels, including an increase in bank funding costs, bank credit rationing, increased costs of corporate bond and equity financing, and depressed collateral values. Based on a set of closely linked empirical approaches, we find that (i) bank loan supply responds negatively to declines in banks' soundness; (ii) a cutback in bank loan supply is likely to have a negative impact on economic activity; (iii) a positive shock to the corporate bond spread leads to a significant negative response of industrial output; and (iv) risk indicators for the banking sector, the non-bank corporate sectors, and the public sector show a steady improvement since 2002–03, followed by a deterioration in 2007–08. Combining the existing expert estimates of financial sector losses with our econometric estimates of the relationship between financial sector losses and aggregate output, we conclude that the currently estimated banking sector losses would translate into a negative 2 percentage point impact on real output in the euro area (with considerable uncertainty around this estimate).

The remainder of the paper is structured as follows. Section II analyzes the empirical evidence on the financial-real linkages, using a battery of approaches. Section III puts the individual approaches together and quantifies the implications of the results. Section IV concludes.

II. Empirical Evidence

We examine empirically the linkages between the financial and real sectors in several alternative but complementary ways. In the next four sub-sections, we focus on:

A. Linkages between bank characteristics and lending behavior. This analysis helps us understand how financing conditions for banks, which are a crucial part of the financial intermediation in Europe, translate into banks' lending behavior, and thereby into financial conditions of banks' clients.

B. Linkages between bank loan supply and aggregate output. This part of the analysis allows us to examine the relationship between the supply of bank credit and economic activity. Subsequently, we link the analysis in part B with the analysis in part A, to examine the linkages between bank characteristics, bank lending, and aggregate output performance (the so-called "bank lending channel").

C. Linkages between corporate sector financing conditions and economic activity, using data on corporate bond spreads and output. This part of the analysis allows us to gauge how a change in corporate sector financing conditions affects industrial output.

D. Risk transfers between banks, non-bank companies, and the public sector, using a combination of sectoral balance sheets and market-based data.

A. Linkages Between Bank Characteristics and Lending Behavior

Is bank loan supply in the euro area adversely affected by deteriorating financing conditions? If this is correct, it means that banks are not able to fully shield their loan portfolios from changes in financing costs.

Most of the literature on the bank lending channel deals with the U.S. economy (e.g., Bernanke and Blinder, 1988; Bernanke and Gertler, 1995). It generally finds strong evidence that banks decrease their loan supply in response to tighter financing conditions (in particular for small balance sheet-constrained banks), although there is little evidence that the cutback in bank loan supply leads to lower real activity (e.g., Ashcraft, 2003; Driscoll, 2003).

The fact that banks still finance the bulk of investment in Europe constitutes a good reason for investigating their impact on the monetary transmission process. However, the empirical evidence on the bank lending channel in Europe has been mixed. Several studies tested for the existence of a bank lending channel across euro-area countries (De Bondt, 1999; Favero, Giavazzi, and Flabbi, 1999; Altunbaş, Fazylov, and Molyneux, 2002; Angeloni and Ehrmann, 2003), and a number of studies examined the lending channel for individual countries (Angeloni and others (2003), for several countries; Kakes and Sturm (2002) for Germany, and Iacoviello and Minetti (2008) on four European housing markets).[2] The results from these studies are inconclusive, suggesting that the bank lending channel may be operating significantly in Germany, Italy and Greece, while it appears not to be important in some other euro area countries. Most of these studies focus on the first (necessary) condition for the existence of a bank lending channel (i.e., that bank loan supply is affected by higher financing costs), without examining whether the decline in credit supply has an adverse effect on the real economy.

Identifying the determinants of credit developments is complicated by the interplay of cyclical and long-term factors that influence both credit demand and credit supply. On the credit demand side, these include a combination of cyclical developments and structural shifts. On the credit supply side, the impact of the economic downturn on financial markets and the financial situation of the banks seems to have influenced their lending. Moreover, banks in the euro area have gone through important structural changes that included a move

[2] In addition, there are also other studies covering banking intermediation in the euro area, but focus on other issues than the bank lending channel. For instance, Bruggeman and Donnay (2003) estimate a monthly monetary model with banking intermediation for the euro area in 1981–2001, but instead of the bank lending channel focus on the relationship between short-term market interest rates, retail interest rates, and inflation.

from relationship-based banking to more market-based banking, and a growing role of securitization (e.g., Gambacorta and others, 2008).

A rough tool for distinguishing credit supply and demand factors are the bank lending surveys. These surveys, organized by the Eurosystem central banks since 2003, summarize responses of senior loan officers regarding loan demand and changes in their bank's lending policy in the previous quarter. The changes in demand conditions and credit standards in a preceding quarter are summarized by a difference between positive and negative responses, in percent of all responses ("net percentage").[3] When interpreting the results of the survey, one needs to take into account the qualitative, subjective nature of the survey data. In particular, experience from similar surveys suggests that bankers' responses may be biased towards tightening, and therefore a zero net percentage may in fact mean a slight easing. With that in mind, the latest survey data indicate that bank credit standards have tightened considerably since mid-2007, both for households and for enterprises (Figure 2). The three most important factors listed by banks when explaining changes in credit standards were those related to the perception of risk.

Empirically, there is some basic evidence that the bank lending surveys contain useful information about subsequent macroeconomic developments. For example, there is a positive correlation between the quarter-to-quarter growth of real GDP and lagged values of the net percentage balance of loan demand (interestingly, the correlation coefficient is the same, 0.41, for both household lending and enterprise lending); and there is a negative correlation between the quarter-to-quarter growth of real GDP and the lagged net percentage balance reflecting credit standards (the correlation coefficient being -0.40 for household lending and -0.43 for enterprise lending). This suggests that both the loan demand and the lending standards are procyclical. The time series of lending surveys are too short to allow for a more elaborate analysis or to test for breaks in the correlations.

To analyze the bank credit channel in the euro area, we use a supply-demand disequilibrium model. Equilibrium approaches, such as VEC/VAR models or single-equation estimates can provide only a limited answer to the causes of credit slowdown, because they do not address the question whether the demand or supply function determines the credit. Following the examples of Pazarbasioglu (1997), and Barajas and Steiner (2002), a credit demand- and a credit supply-function are estimated under the restriction that the minimum of the two determines the credit. This strategy avoids the identification problem of equilibrium models, and allows to make a statement on the existence of a credit crunch.

[3] A positive net balance on demand side means more demand, while on supply side it means less supply. See Berg and others (2005) for an overview of the methodology of the surveys.

The disequilibrium model is estimated with bank-by-bank panel data for 50 largest euro-area banks from 1997 to 2007.[4] The specification of the demand side follows Bundesbank (2002). The specification of the supply side is close to Pazarbasioglu (1997), but with the distance to default (DD) among the supply-side variables. The distance to default was used to approximate banking sector vulnerability as a possible source of credit supply strain (see Appendix I for details). The DD for this estimate was calculated for each individual bank. The advantage of using individual bank data is that it allows for testing whether weaker banks are more likely to restrain their credit. Nonetheless, we have also calculated the aggregate DD for a "portfolio" of euro area banks (using a methodology explained in Appendix I and also in De Nicolò and others (2005) and Čihák (2007)). To provide an illustration of the overall developments in the DD, Figure 5 shows the development of the portfolio DD for daily data since early 1990s. The portfolio DD has generally been above 2, except for a brief period in 2003 (which can be linked to weakness in German banks), and except for the most recent period: in October 2008, the portfolio DD reached zero, its lowest recorded value.

The estimated model provides a plausible explanation of the factors contributing to credit developments in the major euro area banks (Table 1). All the key coefficients have the expected signs and are significant. The model explains year-on-year real growth rates of customer loans as a function of a bank's distance to default (with an expected positive sign, as higher distance to default is associated with greater soundness, making it easier for banks to expand lending), real GDP growth rate as a proxy for overall economic activity (positive sign), lending rate and net interest margin (expected negative signs, reflecting more expensive lending for borrowers), and bank size approximated by total value of loans (expected negative sign). The key variable of interest is the distance to default, which captures the effect of bank financial conditions on credit supply.

Based on the estimated coefficients, the effect of bank soundness on loan supply is significant, but relatively small. For example, the estimate implies that *a one-standard-deviation drop in the distance to default is associated with a year-on-year real growth of credit that is 1.5 percentage points lower than otherwise*.

Figure 6 illustrates the development of the excess demand for credit in the model. It is an aggregate number, calculated by aggregating the demand and supply estimates for all the individual banks. The figure suggests that in 2000 there was a period of excess supply of credit, while 2003 and 2004 were characterized by excess demand for credit. Since then, demand and supply have been relatively balanced.

[4] Data are from the BankScope database by Bureau van Dijk for 1997–2007. To explain the factors contributing to credit developments, the following variables are used: total bank assets, total loans, shareholders' equity, short-term liabilities, long-term liabilities, liquid holdings (cash, ECB and other financial institutions' securities, and government securities), equity price data ("last price," daily), and equity shares outstanding (daily).

As a robustness test, we ran the same model, replacing the distance to default by the probability of distress (PD) calculated in Poghosyan and Čihák (2008). The PD has the expected (negative) sign in the loan supply (higher PD, i.e. lower soundness, implies lower supply of loans), and the coefficients of the other variables are largely unaffected.

As another robustness check, we have performed this analysis also at the level of countries rather than the level of individual banks. Specifically, this means that instead of individual bank DDs, we have used the aggregated DDs for portfolios of banks in the individual Euro area countries (see Appendix I). This reduces the number of available observations, but it allows for an easier link to the subsequent analysis (of linkages to aggregate output), which is also carried out at the level of countries rather than banks.

In addition to the disequilibrium model presented in Table 1, a series of pairwise Granger causality tests were run to assess the relationships between real credit growth, real output growth, and banking sector vulnerability (approximated again by distance to default). The results of the exercise suggest that banking sector vulnerability, measured by distance to default, is influenced by real GDP and real credit in the horizon of 2–4 quarters. The distance to default influences real credit, but not GDP, with a lag of 6 quarters (detailed results available upon request).

B. Linkages Between Bank Loan Supply and Aggregate Output

Our next step is to examine the relationship between the supply of bank credit and economic activity. Declining loan supply may suppress economic activity if firms and households cannot replace completely the "missing" loans with other funding. For this to hold, a substantial group of borrowers (firms or households) must be unable to insulate their spending from the reduction in bank credit.

As the data illustrate, bank credit to the private sector and output do move together (Figure 7). But this does not necessarily mean that the *supply* of bank loans has a significant effect on output. An alternative (and equally plausible) possibility is that as economic activity slows, the *demand* for bank loans declines, leading to a positive relationship between the two series. Disentangling the demand and supply effects (i.e., solving the identification problem) is very hard, since these effects tend to occur at the same time but only the equilibrium outcome is observed.

The identification problem can be addressed by using an instrumental variables (IV) technique to isolate the loan supply effect on real output. We use shocks to country-specific money demand as an instrument for shocks to loan supply, as first proposed by Driscoll (2004) in addressing a similar question for the United States. The logic behind this approach is based on the premise that country-specific shocks to money demand should lead to country-specific changes in the supply of loans, and therefore changes in output. This would allow to isolate the effect of loan supply on real activity.

The identification scheme involves the following three steps, with all variables used in the regressions constructed as deviations from their cross-sectional mean values, as implied by the identification scheme (see Appendix II for details):

- The overall effect of bank credit on output is investigated by regressing output growth on the growth rate of bank loans (and its lagged value), as well as its own lagged values. The resulting coefficient will reflect both the supply and demand effects of bank credit on real activity.

- The shocks to money demand are recovered after estimating money demand functions for each euro-area country in the sample. Then the growth rate of bank loans is regressed on its lagged values and the estimated money demand shocks, in order to establish whether the latter are a good instrument for shocks to loan supply.

- The effect of bank credit on output (see first bullet) is re-estimated using the country-specific shocks to money demand as instruments. The resulting coefficient of bank loans is indicative of the supply effect, as the demand effect has been stripped out.[5]

The estimations are done using country-level data from 1999Q1 to 2008Q2. The sample includes 11 euro-area countries (Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, Spain).[6] The key variables used in the analysis are: real GDP, M3, deposit rates, and bank loans to non-financial corporations. For each country, the money supply (M3) and bank loan variables are deflated by the corresponding GDP deflator. Except for deposit rates, all other variables are in logarithmic form.

One issue when doing any analysis for euro area banks involving interest rate statistics is that harmonized data on interest rates are available from the ECB only from January 2003. For the earlier period, we have to rely on non-harmonized country-level data, available since January 1999. To address this issue, we carry out a robustness check by performing the same analysis only for the sub-period for which harmonized deposit rate data are available, i.e. for the period since 2003Q1.

The estimation results from the first step confirm the positive relationship between bank credit and economic activity. As shown in Table 2, real bank credit has a significant and positive effect on output. The size of the coefficient suggests that an increase in bank credit (in real terms) by 10 percentage points is associated with an increase in real GDP by about 1.5 percentage points.

[5] Assuming that shocks to loan demand and supply are positively correlated, we would expect the instrumented coefficient of bank loans to be smaller than the non-instrumented one.

[6] Cyprus, Malta, Luxembourg, and Slovenia are not included due to data limitations.

Turning to the second step, we find that positive money demand shocks are associated with higher growth in bank loans. The shocks to money demand are constructed using estimates of country-specific money demand functions (see Appendix II). Their impact on bank loans is illustrated by the positive and significant coefficient of the (country-specific) residuals from the estimated money demand functions on the growth of bank loans, even after controlling for lagged values of output (Table 3). Therefore, the money demand shocks can be used as an instrument for loan demand in the next step.

Once demand effects are taken into account, the loan supply effect on output is positive, and statistically significant, even though relatively small. As the results in Table 4 show, the coefficient of the bank loan variable is still positive but somewhat smaller than in the first step (0.10 instead of 0.15) when the instrumental variables estimation is implemented. Overall, the estimation results suggest that *an increase in the supply of bank loans by 10 percentage points is likely to lead to an increase in real GDP by about 1 percentage point*. Therefore, our analysis implies that a cutback in bank loan supply is likely to have a negative impact on economic activity.

As another robustness check, we have tried an alternative approach in which we have introduced the difference between unsecured and government-backed deposit rates as an additional instrument for credit risk. This is motivated by the approach of Greenlaw and others (2008), who used the Treasury-Eurodollar (TED) spread as an instrument for credit supply in the United States. A weakness of the TED spread is that it may be influenced by "flight to quality" flows that move Treasury bill yields, as well as the funding pressures that drive LIBOR rates. Nonetheless, as the difference between unsecured and government-backed deposit rates, the TED spread could potentially provide a measure of credit risk, which is likely to be correlated with credit supply. Using a similar line of argumentation, we have introduced in our regressions the spread between the 3-month euro LIBOR rate and the German government bund rate, to instrument for credit risk. This robustness check has not affected the quantitative predictions from the main regression.

C. Linkages Between Corporate Financing Conditions and Economic Activity

Turning to the question of how corporate sector financing conditions affect activity, we analyze the relationship between the corporate bond spread and the euro area output. The corporate bond spread is defined as the difference between the yield on a corporate bond (risky asset) of a given maturity and quality and the yield on a government bond (riskless asset) of the same maturity. The corporate bond risk premium has been shown to be a good predictor of real activity in the United States (Chan-Lau and Ivaschenko, 2002; Mody and Taylor, 2004) and there were some early results suggesting a similar relationship for the euro area (De Bondt, 2002).

There are a number of reasons why the corporate bond spread can be a good predictor of real activity. First, financial instruments, such as corporate bonds, ultimately represent claims on the real economy. Financial information is readily available at high frequencies and transmitted relatively rapidly compared with economic information such as that on output. Therefore, financial prices such as corporate bond spreads could provide useful leading information on economic activity. Second, corporate-sovereign bond spreads are a key measure of the credit terms. Their role in predicting output is consistent with the presence of a financial accelerator in the economy, i.e. with the presence of a mechanism linking the condition of borrower balance sheets to the terms of credit, and hence to the demand for capital. Third, the bond market has become a relevant source of corporate financing in the euro area. Since 1999, the euro-area market for corporate debt securities has grown tremendously (Figure 8). Fourth, as corporate bond spreads tend to move together with the tightness of bank lending standards (for evidence in the United States, see Duca, 1999; Gertler and Lown, 2000), they can also be treated as a proxy for corporate sector financing conditions.

At the euro-area level, aggregate data on corporate bond yields are available for securities of different maturities and quality. The spreads for AAA, AA, A, and BBB 7-year corporate bonds in the euro area (in relation to a 7-year government bond) are shown in Figure 3. Given the high frequency nature of these data, we use monthly industrial production (rather than real GDP) as an indicator for economic activity.

The analysis is conducted using vector autoregression (VAR) estimates run over the period from 1999M1 to 2008M1. The key variables in the regressions are the corporate bond spread, the annual growth in industrial production, and the annual change in the real effective exchange rate. Our baseline specification of the VAR includes three lags; as a robustness check, we also experiment with increasing the number of lags in the VAR. The corporate bond spread is defined as BBB yield minus government bond yield in the benchmark regressions; as a sensitivity analysis, we also conduct the same analysis for AA and A rated bonds.

The estimation results show that a positive shock to the corporate bond spread leads to a significant negative response of industrial output. The impulse responses of the baseline regressions are shown in Figure 9. The results illustrate that a one-standard-deviation shock to the corporate bond yield (about 60 basis points) has an adverse effect on the growth rate of industrial output, which peaks at about 0.25 percent in 8–20 months. This effect is statistically significant, as shown by the 95 percent confidence bands.

A limitation of these estimates is that simultaneity might be an issue in the basic VAR estimation (we are not using a structural VAR). Nonetheless, these results are fairly robust across alternative specifications.

D. Risk Transfers Between Banks and Other Sectors: Contingent Claims Analysis

How are risks transmitted between the corporate sector, the financial sector, and the public sector in the euro area? One way of addressing this question is to employ a contingent claims analysis (CCA). The CCA is an improved version of the balance-sheet approach, which incorporates not only accounting data, but also information contained in market prices. It starts with information on the size and structure of assets and liabilities of key economic sectors, with the aim of assessing the extent of currency and maturity mismatches, or imbalances in the debt and equity structure. Given that economy-wide balance sheet data do not provide a full picture of all the risks (because of the contingent nature of many risks), and given that they are usually valued at book value, they do not capture changes in the likelihood of default related to recent market developments. To provide a more complete picture of the risks inherent in a balance sheet, the CCA values assets using marked-to-market prices and incorporates contingent liabilities.

To the best of our knowledge, this is the first time in the literature that CCA is used to identify vulnerabilities in the corporate, banking, and public sectors in the euro area (and to estimate the associated value of risk transfer across the balance sheets). Appendix III provides more details on the CCA methodology employed in this paper.

Default indicators for both the banking system and non-bank corporate sector show an improvement from the lows of 2002–03, followed a major deterioration in the second half of 2007 and 2008 (Figure 10). The distribution of default risk by assets confirms the general improvement in both banking system and non-bank corporate sector indicators, with the riskiest banks (those with the highest default probability) accounting for a smaller percentage of total assets over time. Expected losses for the banking system have declined steadily since 2002–03; the indicator has deteriorated in the second half 2007 and 2008. The generally positive trend of the last 5 years reflected rising equity valuations and declining volatilities, as balance-sheet structures have improved and non-performing assets have declined (the measure of expected losses for the largest banks moves closely with the overall NPL ratio and tends to lead changes in the NPL ratio by 1–2 quarters).

For the public sector balance sheets, Figure 11 shows an improvement in the soundness over the past five years. It shows the estimated default probability when 100 percent of expected losses of the banks are assumed to be guaranteed by the sovereign (solid line) and when expected losses are excluded (dashed line). The figure suggests a gradual decline in default probabilities since 2002–03. For the later period for which daily information is available, the sovereign spread and default probability move in line with the downward trend in spreads on government debt quoted by the market.

The estimated probability of default for the public sector is substantially lower than those reported in previous CCA studies. This reflects the fact that previous applications of CCA (surveyed in Appendix III) have covered emerging market economies (e.g., Brazil, Turkey, Thailand, Indonesia), while this analysis focuses on an advanced economy (or, more specifically, the set of advanced economies that form the euro area). For example, Gray and Jones (2006) examine the 1-year sovereign default probability in Indonesia in 1999–2006, and find that most of the period it was in the range of 2–6 percent (with a spike to 11 percent in 2001). The other studies surveyed in Appendix III find numbers in a similar range. The numbers reported for euro area in Figure 11 are lower by an order of magnitude, being generally below 0.2 percent. This is consistent with the high sovereign ratings of euro area countries.

The financial turbulence experienced since mid-2007 has led to increased volatility in a variety of risk indicators. Figure 10 shows the development in the estimated probabilities of default for the large banks and non-bank corporations in the euro area. The two move broadly in line, but banks have so far been affected much more by the recent financial turmoil. The global market turmoil experienced since mid-2007 caused a substantial worsening in risk indicators for the banking system. A combination of reduced market capitalization and increase in its volatility decreased implied assets and increased their volatility, leading to a decline in distance-to-default measures and increases in expected losses. These developments reflect the increased market volatility, in combination with declining capitalization and lower earnings.

Figure 11 shows the estimated public sector default probabilities, illustrating the impact of the financial sector instability on public sector soundness. The public sector probability of default is, but assuming that the public sector would be willing to guarantee the large banks (indicated by the line "with guarantees"), the impact on public sector stability would be considerable.

III. QUANTITATIVE IMPLICATIONS

What do the calculations imply quantitatively for euro-area developments? Based on the estimates presented in the preceding section, we can calculate the potential impact of banking sector losses on future economic growth in the euro area. Specifically, the current estimates of losses in the banking sector would imply a negative 2 percentage point impact on GDP in the euro area. Here is how this estimate is derived:

- A natural starting point are estimated losses in euro-area commercial banks. These losses have been somewhat of a moving target, as the crisis evolved from the sub-prime crisis in the United States into a global crisis. The estimated sub-prime related losses in euro-area banks as of March 2008 were "only" US$45, as reported in IMF's April 2008 *Global Financial Stability Report* (IMF, 2008a); the latest estimates of the total exceptional losses in euro-area global banks (which combines the sub-prime related losses with the exceptional part of losses generated on European assets) may be as large as 10 times that amount. The estimated losses for the whole of Europe were even larger, but substantial chunks of these losses were in global banks based in the United Kingdom and Switzerland.[7]

- These estimated losses correspond to about 14 percent of the euro-area banks' capital and reserves. If nothing else happened, the ratio of capital to total (unweighted) assets in euro area banks, currently at 5.6 percent (Figure 12), would decline to 4.8 percent, and the banks' leverage would increase correspondingly.

- One way to think about the potential impact of these losses on asset growth is to ask how much would assets have to shrink to prevent the leverage ratio from declining. Keeping leverage ratio at 5.6 percent would at the new (decreased) level of capital require that assets go down by 14 percent.

- The impact of bank losses on lending (and thereby on output), can be larger if banks (or their regulators) aim to de-leverage, i.e. decrease their leverage target, which is quite likely given the overall increase in risk aversion (see, e.g., IMF, 2008), and if they get hit by additional shocks, such as stock price declines.[8] To increase leverage ratio to 5.9 percent (the sample maximum in Figure 12), assets would have to go down by 19 percent. Just to illustrate the sensitivity of this result, increasing the leverage to 7 percent (which is beyond the recent historical experience, but not implausible) would in this situation imply a decline in assets by 31 percent.

- From the estimate in Section II.B, a decline in the supply of bank loans by 10 percentage points is likely to lead to a decline in real GDP by about 1 percentage point. Following up on the calculations from the previous bullet point, a loan decline by 14 percent therefore corresponds to 1.4 percentage points negative impact on real GDP; a loan decline by 19 percent corresponds to 1.9 percentage points negative impact on real GDP; and a loan decline by 31 percent corresponds to 3.1 percentage points negative impact on real GDP.

An alternative approach to analyzing the recent developments is to start from the recent changes in distance to default and their estimated impact on loan supply. As previously discussed, distance to default is a market-based indicator that incorporates market participants' view on banks' situation and outlook. It can therefore provide an alternative assessment of the likely impact of the shocks that hit the banks.

---

[7] The calculations underlying the October 2008 *Global Financial Stability Report* (IMF, 2008b) suggest total exceptional losses in large banks in continental Europe close to $500 billion.

[8] On the other hand, these effects can be mitigated to some extent if banks achieve the increases in their capital-to-asset ratios (decrease leverage) through capital injections rather than (or in addition to) asset manipulation.

To calculate the impact on banks' lending, we can use the results of the distance-to-default calculations in Section II.A. The average distance to default was 0.0 in October 2008 (Figure 5), compared to 8.0 in July 2007. Using the estimates in Section II.A, this translates into a decline in real credit by 19 percentage points. That in turn (using the estimates from Section II.B.) translates into a real GDP decline by some 1.9 percentage points. In other words, this method yields a broadly similar estimate of the likely GDP impact than the method based on projected capital losses.

The difference between the two approaches reflects a variety of factors. This includes the extent to which the banks will (or will not) be recapitalized. The extent of recapitalization is not trivial to estimate, making the market's guess a useful alternative input.

The above calculations illustrate that there are linkages between the financial sector soundness and real economic developments. They also illustrate the challenges of quantifying the exact relationship, and the uncertainties surrounding the estimates. We find that based on current information, the likely impact of the recent and projected banking losses on output around 2 percentage points (with substantial uncertainty relating to the impact of the recapitalization and more generally to the impact on market confidence).

IV. Conclusions

This paper examines the impact of financing conditions on real economic activity in the euro area, exploring some key linkages between the financial and real sectors. To explore the evidence, it applies a broad range of empirical approaches and estimation methods to bank-level, country-level and aggregate data.

The main findings are as follows:

- First, a deterioration in the financial health of banks could translate into lower bank loan supply; this effect is statistically significant, but quantitatively small.

- Second, a cutback in bank loan supply is likely to have a negative impact on economic activity in the euro area; again, this effect is statistically significant, but relatively small. These findings are not dissimilar to the literature on the bank lending channel in the United States, which generally finds strong evidence banks decrease their loan supply in response to tighter financing conditions, but little evidence that the cutback in bank loan supply leads to lower real activity.

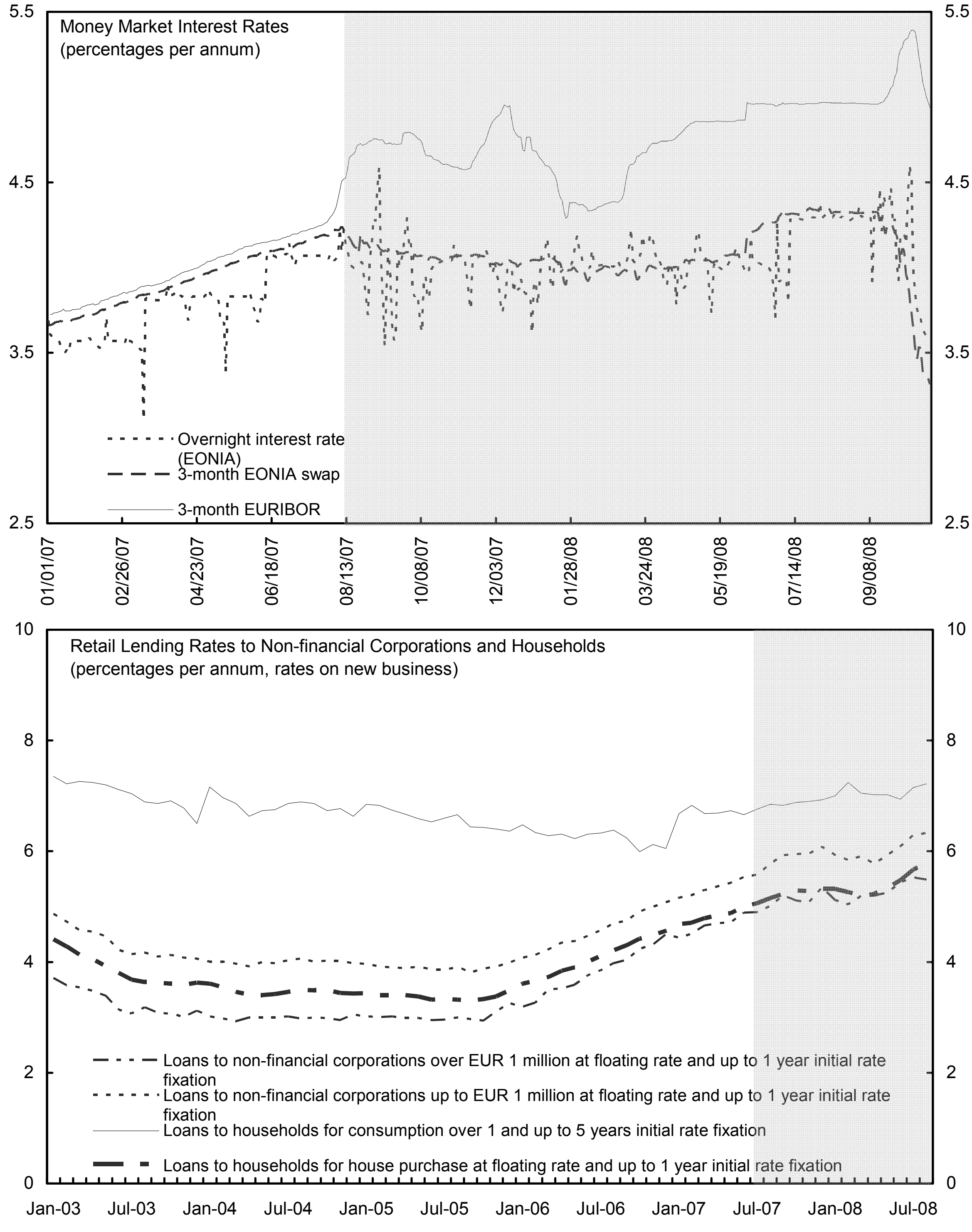
- Third, higher costs of corporate bond financing (which could also reflect broader financial conditions in the economy) tend to lead to a significant negative response of industrial production growth.

- Last but not least, risk indicators for the banking, corporate, and public sectors in the euro area (derived from the CCA) show a steady improvement in balance sheets since

2002–03, followed by a major deterioration in 2007 and especially 2008, reflecting a combination of the increased market volatility and lower capitalization. Conditions as of October 2008 were the worst in the whole sample period (since early 1990s).

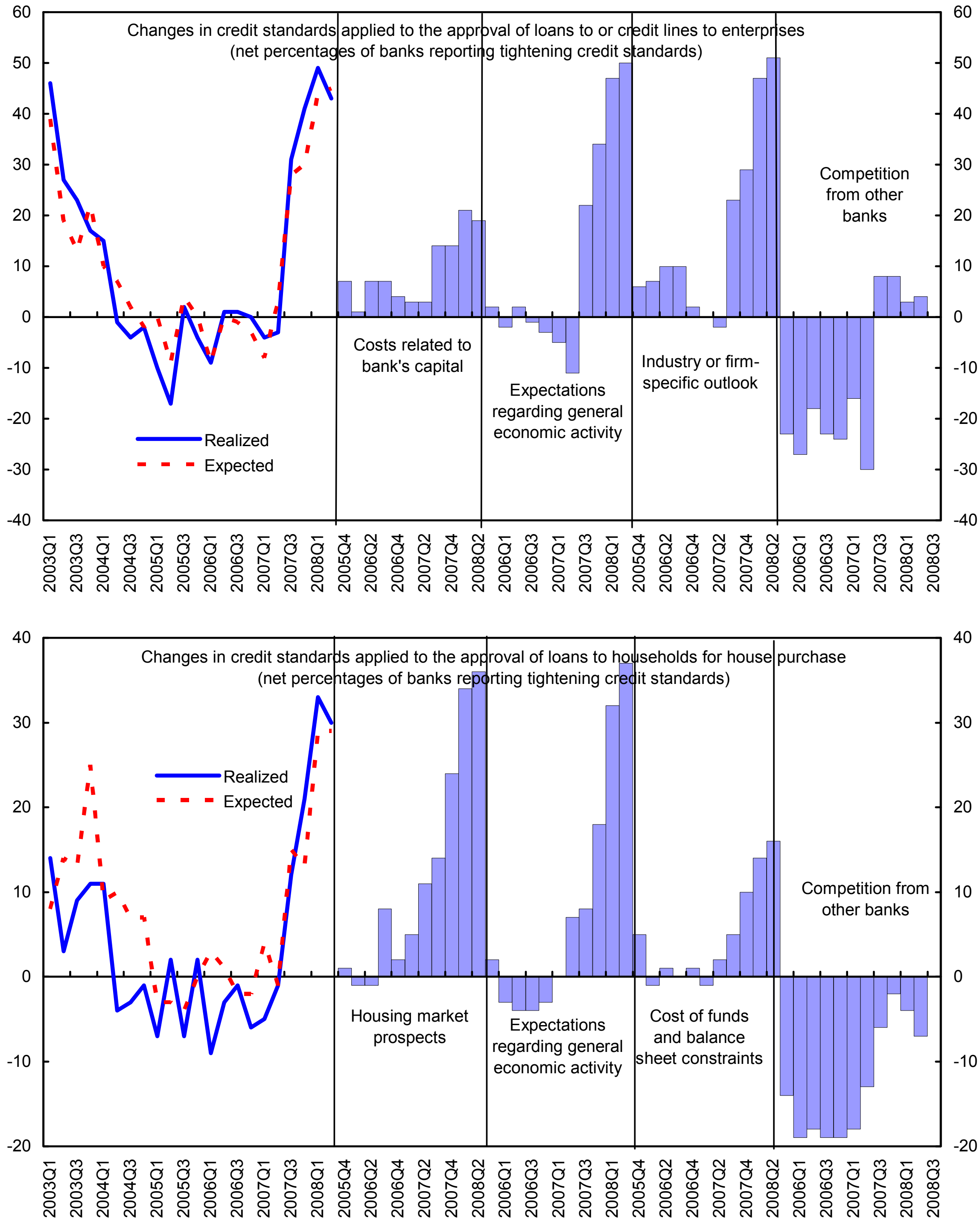
The estimates presented in this paper can be used to calculate the potential impact of the banking sector losses on future economic growth in the euro area. They suggest that current estimates of losses in the banking sector would mean a negative 2 percentage point impact on GDP in the euro area, but with substantial uncertainty around this estimate.

Figure 1. Euro Area: Money Market and Retail Lending Rates



Sources: Deutsche Bundesbank, Datastream.

Figure 2. Euro Area: Changes in Credit Standards to Enterprises and Households, 2005-08



Source: European Central Bank.

Figure 3. Euro Area: Corporate and Equity Market Prices, 2007–08

(Yields in percent, spreads in basis points)

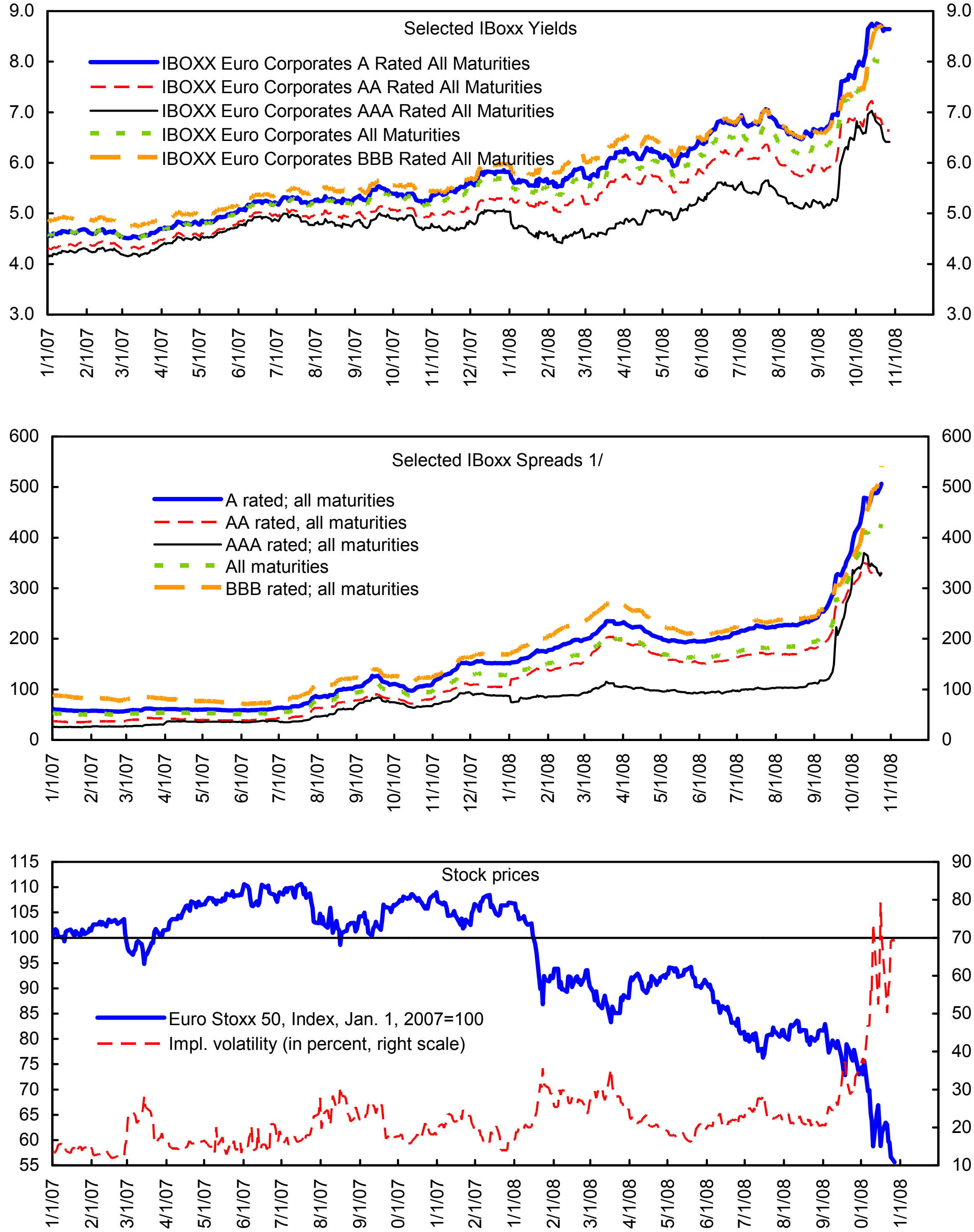
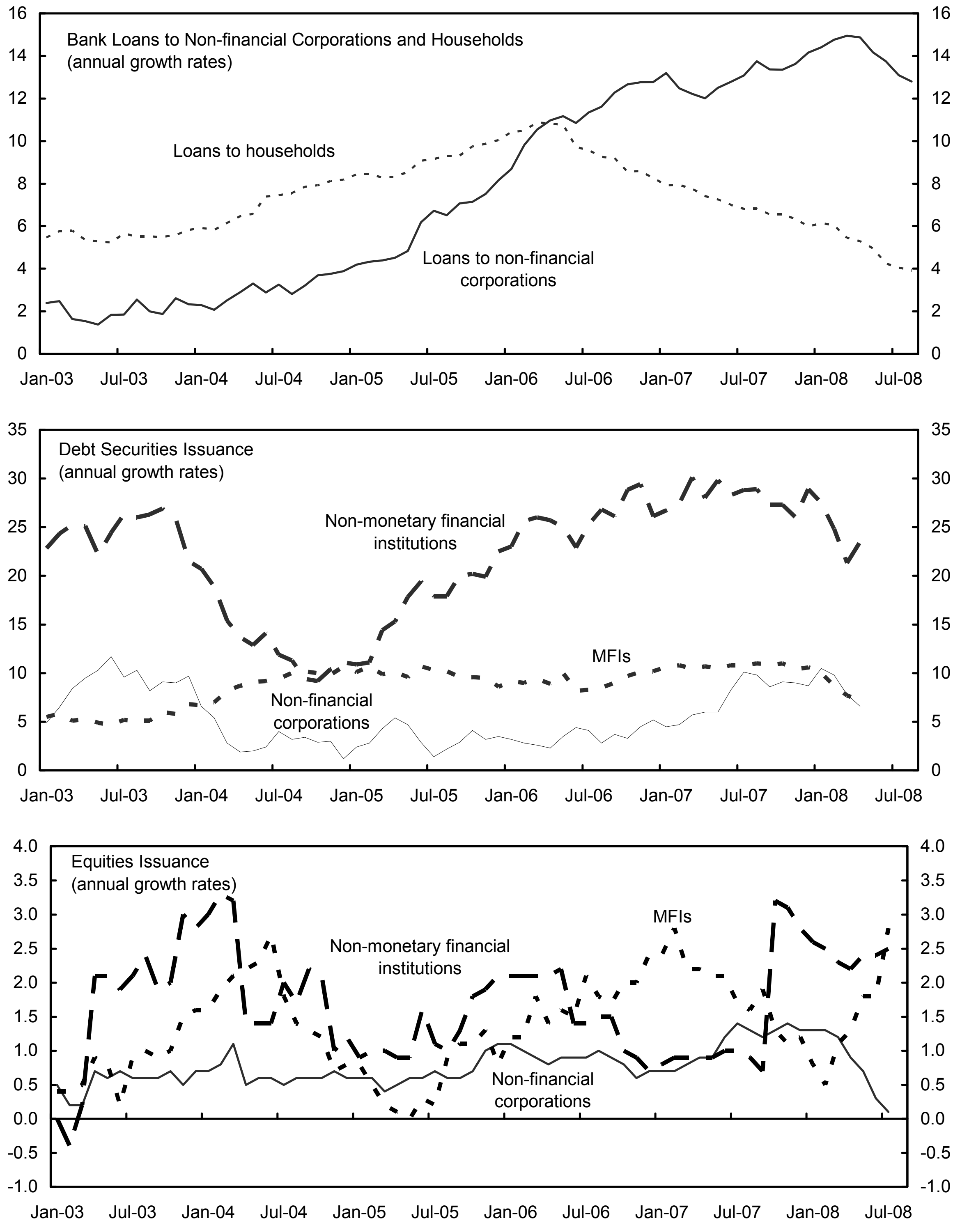


Figure 4. Euro Area: Growth in Bank Loans and Securities Issuance, 2003–08
(Percent)



Source: ECB.

Figure 5. Euro Area: Distance to Default for Banks, 1991–2008
(daily data; higher values mean higher soundness)

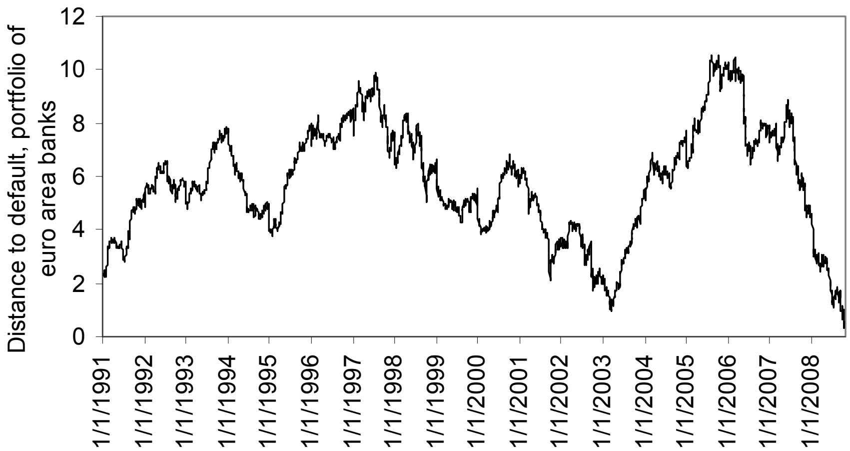


Figure 6. Euro Area: Excess Demand for Loans, 1997–2008

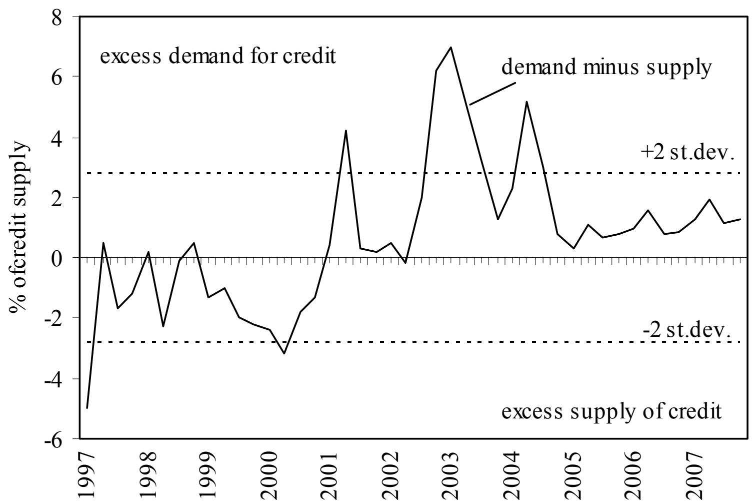


Figure 7. Euro Area: Growth in Real Output and Bank Loans, 2000–08

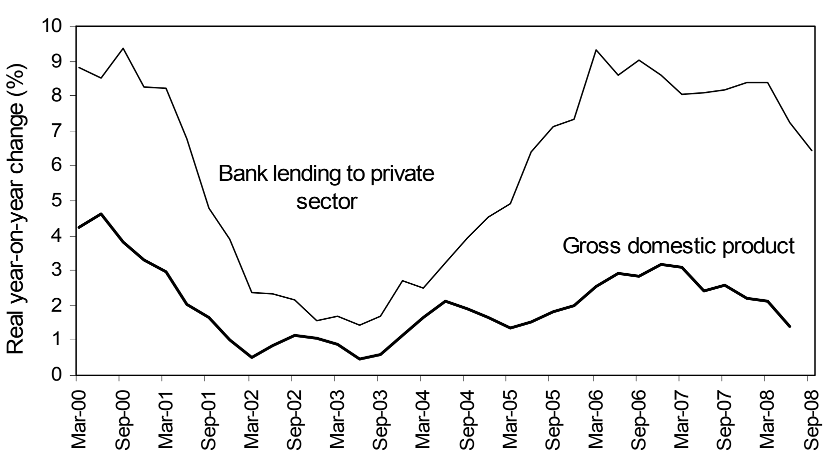


Figure 8. Euro Area: Corporate Debt Issuance, 1990–2008

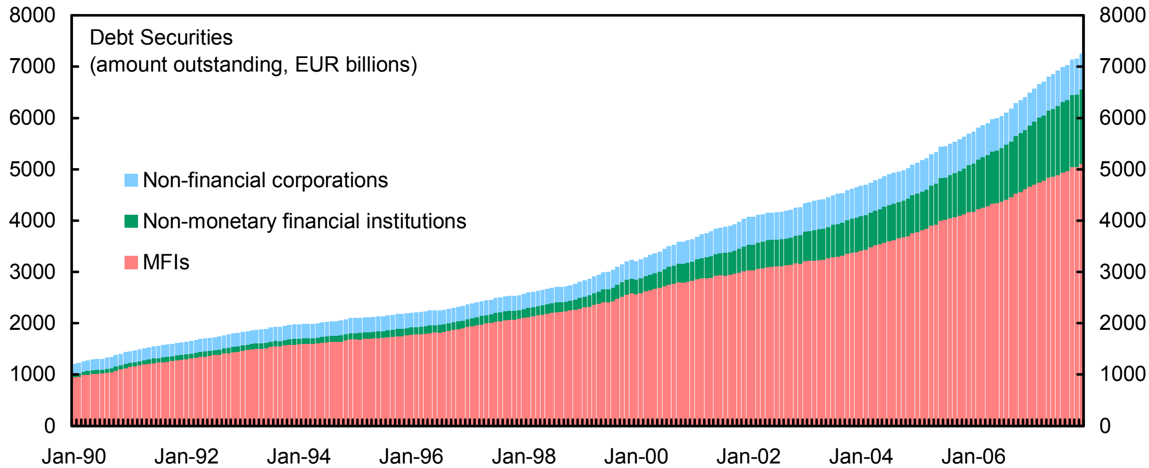


Figure 9. Euro Area: Response of Annual Growth in Industrial Production to One Standard Deviation Innovation in Corporate Bond Spread

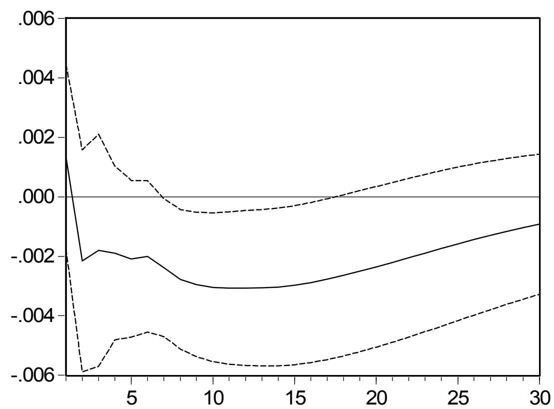


Figure 10. Euro Area: Estimated Default Probability (Banks and Non-Banks),1991–2008

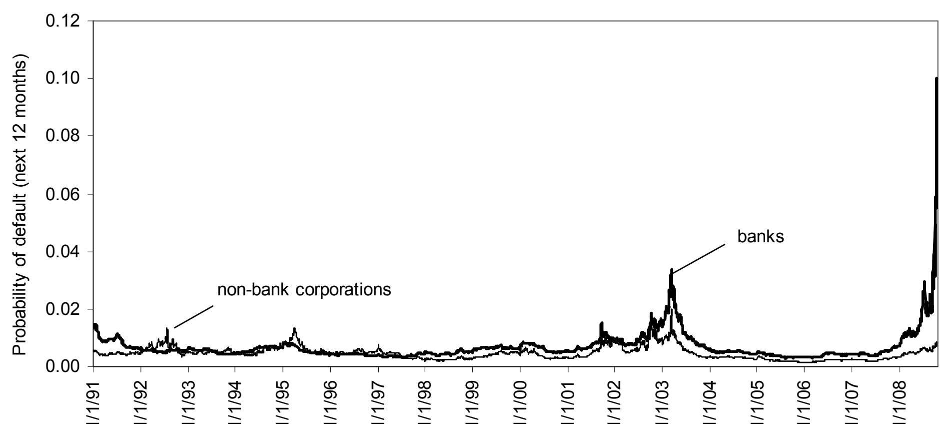


Figure 11. Euro Area: Estimated Default Probability (Public Sector), 1997–2008

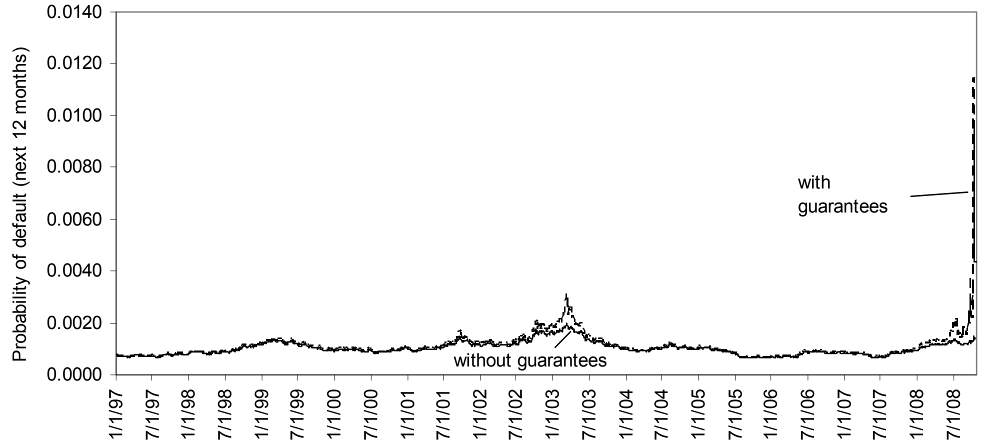


Figure 12. Capitalization in Euro Area Banks, 1997–2008
(Capital and Reserves as percentage of Total Assets)

Table 1. Demand and Supply in the Disequilibrium Model, 1997–2007 1/
(Dependent variable: year-on-year real growth rate of a bank's total credit)

Explanatory variables	Demand		Supply	
	Parameter	Std. Error	Parameter	Std. Error
Constant	- 10.24	0.48	-8.32	2.31
Real GDP growth	1.18	0.09		
Lending rate	-0.03	0.01		
Net interest margin	-0.09	0.05		
Distance to default			0.03	0.01
Log (total loans)			-0.02	0.01

Source: Authors' calculations based on data from BankScope and DataStream.
1/ Maximum likelihood estimation. Log likelihood = 125.31.

Table 2. OLS Regression of Output on Loans
Dependent Variable: $\Delta\tilde{y}_{it}$

Regressors	Coefficient	St. Error
$\Delta\tilde{y}_{it-1}$	-0.2135	(0.1805)
$\Delta\tilde{y}_{it-2}$	-0.0899	(0.1756)
$\Delta\tilde{l}_{it}$	0.1486	(0.0324)***
$\Delta\tilde{l}_{it-1}$	0.0115	(0.0342)
Obs.	232	
R-squared	0.09	

Notes: 1. All variables are demeaned by their cross-sectional averages
2. Critical values for 1 percent, 5 percent and 10 percent are denoted by
(***), (**) and (*), respectively.

Table 3. First Stage IV Regression: Loans on Money Demand Shocks
Dependent Variable: $\Delta\tilde{l}_{it}$

Regressors	Coefficient	St. Error
$\Delta\tilde{y}_{it-1}$	-0.2478	(0.3474)
$\Delta\tilde{y}_{it-2}$	-0.0119	(0.3287)
$\Delta\tilde{\varepsilon}_{it}$	0.0679	(0.0466)
$\Delta\tilde{\varepsilon}_{it=1}$	0.2205	(0.0492)***
Obs.	232	
R-squared	0.08	

Notes: 1. All variables are demeaned by their cross-sectional averages
2. Critical values for 1 percent, 5 percent and 10 percent are denoted by
(***), (**) and (*), respectively. 3. Money demand shocks are denoted by ε_{it}

Table 4. Second Stage IV Regression of Output on Loans
Dependent Variable: $\Delta\tilde{y}_{it}$

Regressors	Coefficient	St. Error
$\Delta\tilde{y}_{it-1}$	-0.1514	(0.0582)**
$\Delta\tilde{y}_{it-2}$	-0.0178	(0.0447)
$\Delta\tilde{l}_{it}$	0.0955	(0.0496)**
$\Delta\tilde{l}_{it-1}$	0.0178	(0.0447)
Obs.	232	

Notes: 1. All variables are demeaned by their cross-sectional averages
2. Critical values for 1 percent, 5 percent and 10 percent are denoted by
(***), (**) and (*), respectively. 3. Country-level money demand shocks are used
used as instruments.

APPENDIX I
CALCULATING THE DISTANCE TO DEFAULT

The distance-to-default (*DD*) measure is based on the structural valuation model of Black and Scholes (1973) and Merton (1974). The authors first drew attention to the concept that corporate securities are contingent claims on the asset value of the issuing firm.[9] This insight is clearly illustrated in the simple case of a firm issuing one unit of equity and one unit of a zero-coupon bond with face value D and maturity T. At expiration, the value of debt, B_T, and equity, E_T, are given by:

$$B_T = \min(V_T, D) = D - \max(D - V_T, 0), \qquad \text{(A.1)}$$

$$E_T = \max(V_T - D, 0), \qquad \text{(A.2)}$$

where V_T is the asset value of the firm at expiration. The interpretation of equations (A.1) and (A.2) is straightforward. Bondholders only get paid fully if the firm's assets exceed the face value of debt, otherwise the firm is liquidated and assets are used to partially compensate bondholders. Equity holders, thus, are residual claimants in the firm since they only get paid after bondholders.

Note that equations (A.1) and (A.2) correspond to the payoff of standard European options. The first equation states that the bond value is equivalent to a long position on a risk-free bond and a short position on a put option with strike price equal to the face value of debt. The second equation states that equity value is equivalent to a long position on a call option with strike price equal to the face value of debt. Given the standard assumptions underlying the derivation of the Black-Scholes option pricing formula, the default probability in period t for a horizon of T years is given by the following formula:

$$p_t = N\left[-\frac{\ln\frac{V_t}{D} + \left(r - \frac{\sigma_A^2}{2}\right)T}{\sigma_A\sqrt{T}}\right], \qquad \text{(A.3)}$$

[9] Models built on Black and Scholes (1973) and Merton (1974) are usually called structural models.

where N is the cumulative normal distribution, V_t is the value of assets in period t, r is the risk-free rate, and σ_A is the asset volatility.

The numerator in equation (A.3) is referred to as *distance-to-default*. An examination of equation (A.3) indicates that estimating default probabilities requires knowing both the asset value and asset volatility of the firm. The required values, however, correspond to the *economic* values rather than the accounting figures. It is thus not appropriate to use balance-sheet data for estimating these two parameters. Instead, the asset value and volatility can be estimated. It is possible to solve the following equations (A.4) and (A.5) for the asset value and volatility:

$$E_t = V_t N(d_1) - e^{=rT} DN(d_2)\text{, and} \tag{A.4}$$

$$\sigma_E = \frac{V_t}{E_t} N(d_1), \tag{A.5}$$

if E_t, the value of equity; σ_E, the equity price return volatility; and D, the face value of liabilities, are known; and d_1 and d_2 are given by:

$$d_1 = \frac{\ln \frac{V_t}{D} + \left(r - \frac{\sigma_A^2}{2} \right) T}{\sigma_A \sqrt{T}}\text{, and} \tag{A.6}$$

$$d_2 = d_1 - \sigma_A \sqrt{T}\ . \tag{A.7}$$

The parameters can be calibrated from market data:

- The time horizon T is usually fixed at one year.
- The value of equity, E_t, corresponds to the market value of the firm. The data are obtained from Bloomberg by multiplying the number of shares outstanding for a firm by the closing share price on a particular day.
- The equity volatility, σ_E, corresponds either to historical equity volatility or implied volatility from equity options. This is derived by calculating the standard deviation of daily share price returns over a one year period (around 260 days).

- The face value of liabilities, *D*, is usually assumed equal to the face value of short-term liabilities plus half of the face value of long-term liabilities.[10] This number represents the "default barrier". The liability data are obtained from Bankscope. The item "Deposits and Short-Term Funding" is used to represent short-term liabilities, while the long-term liabilities are derived by deducting the short-term liabilities from the "Total Liabilities" item. To obtain daily liability data from annual balance sheets, the data is intrapolated between two year-end balances.

- The risk-free rate, *r*, is the one-year government bond yield, in the same currency as those of the market and balance sheet data.

Once the asset value and volatility are estimated, the default probability of the firm could be derived from equation (A.3).

In addition to the individual bank DDs, we also calculate the so-called "portfolio DD." Following e.g., DeNicoló and others (2005), the portfolio DD is defined as

$$DD_t = \frac{\ln(A_t^P / L_t^P) + (\mu_p - 0.5\sigma_P^2)}{\sigma_P},$$

where $A^P = \sum_i A_t^i$ and $L^P = \sum_i L_t^i$ are the total values of assets and liabilities, respectively, for all financial institutions in the portfolio. The mean and variance of the portfolio are given respectively by $\mu_P = \sum_i w_t^i \mu^i$ and $\sigma_P^2 = \sum_i \sum_j w_t^i w_t^j \sigma_{ij}$, where $w_t^i = A_t^i / \sum_i A_t^i$ and σ_{ij} is the asset return covariance of financial institutions *i* and *j*. Thus, the "portfolio" DD to some extent embeds the structure of risk interdependencies among the financial institutions. "Default" at date t+1 occurs if $A_t^P <: L_t^P$. Thus, the DD indicates how many standard deviations $\ln(A_t^P / L_b^P)$ has to deviate from its mean for default to occur. Since $A_t^P = L_b^P + E_b^P$, declines in A_t^P / L_b^P are equivalent to declines in capitalization E_t^P / L_b^P. The "portfolio DD" could be viewed as a risk profile measure tracking the evolution of the joint risks of failure of the firms composing a portfolio. Lower (higher) levels of the DD imply a higher (lower) probability of firms' joint failure. Since variations in the individual firms' DD are allowed to offset each other, the DD of a portfolio is always higher than the (weighted) sum of the DDs of the individual firms. As a result, the probability of "failure" associated with the portfolio DD is always lower than that associated with the actual probability of joint failures of sets of firms in the portfolio. Thus, the "portfolio" DD tracks the lower bound to the joint probabilities of failure (for in-depth discussion of the pros and cons of the portfolio DD, see e.g. Čihák, 2007).

[10] This is based on work done by Moody's KMV (see Crosbie and Bohn, 2003).

APPENDIX II
IDENTIFYING THE LINKAGE BETWEEN BANK LOAN SUPPLY AND AGGREGATE OUTPUT

The theoretical framework used to derive the empirical specification of the model is an IS/LM model, which adds a credit channel of monetary transmission to the traditional interest rate channel (Bernanke and Blinder, 1988). A possible solution to the problem of identifying loan supply effects within this framework is offered by Driscoll (2004) in investigating the analogous question for the U.S. economy. As noted by Driscoll, "the approach could also be applied to regions in other countries, or other collections of small open economies under fixed exchange rates, such as the European Union."

The basic model consists of four equations for each country *i* in the euro area. There are three markets: a loan market, a money market, and a goods market.

On the loan market banks face the following loan demand l_{it}^d from households and firms:

$$l_{it}^d = \tau r_t - \chi \rho_{it} + \varpi y_{it} + \nu_{it} \qquad \text{(B.1)}$$

where y_{it} denotes output, ρ_{it} is the interest rate on loans, r_t is the interest rate on bonds (i.e., the price of financing expenditures from an alternative source), and ν_{it} is a demand shock. The loan rate is allowed to vary across euro area countries, while the bond rate is assumed to be the same for all countries. This is consistent with the evidence on a well-integrated bond market and segmented loan markets.

The loan supply function is specified by the following equation:

$$l_{it}^s = -\lambda r_t + \mu \rho_{it} + \beta(m_{it} - p_{it}) + w_{it} \qquad \text{(B.2)}$$

where $(m_{it} - p_{it})$ denotes money supply, and w_{it} is the shock to loan supply. Note that the supply of loans depends on deposits as a way to generate loans and the interest rates on loans (ρ_{it}) and bonds (r_t). The underlying assumption is that loans and bonds are imperfect substitutes.

The money market equilibrium for each country is given by:

$$m_{it} - p_{it} = \gamma y_{it} - \delta(r_t - r_{it}^d) + \varepsilon_{it}, \qquad \text{(B.3)}$$

where r_{it}^d is the country-specific rate on deposits, and ε_{it} is a country-specific money demand shock. Note that the money supply m_{it} is determined by the European Central Bank. (This is a reasonable simplification even though in practice the ECB controls money supply indirectly through setting money market rate.)

Finally, aggregate output is specified as function of the interest rate on bond (r_t), the interest rate on loans (ρ_{it}), and a country-specific shock (z_{it}):

$$y_{it} = -\theta r_t - \alpha \rho_{it} + z_{it} \tag{B.4}$$

Then the model is solved for output and loans, producing the following relationships:

$$y_{it} = \frac{\theta}{\chi + \varpi\alpha} r_t + \frac{\alpha}{\chi + \varpi\alpha} l_{it} - \frac{\alpha}{\chi + \varpi\alpha} v_{it} + \frac{\chi}{\chi + \varpi\alpha} z_{it} \tag{B.5}$$

$$l_{it} = \frac{\theta}{\chi + \varpi\alpha} r_t + \frac{\chi\beta}{\chi + \mu} \varepsilon_{it} + \frac{\chi\beta\gamma + \varpi\mu}{\chi + \mu} y_{it} - \frac{\mu}{\chi + \mu} v_{it} + \frac{\chi}{\chi + \mu} w_{it} + \frac{\chi\delta\beta}{\chi + \mu} r_{it} \tag{B.6}$$

These two equations illustrate the problem of identifying demand and supply effects in bank lending (i.e., separating the bank lending and interest rate channels), as bank loans and output are endogenous (jointly determined) as describe above.

To solve the identification problem, Driscoll (2004) proposes to demean each variable with its cross-sectional mean. This effectively “shuts down” the interest rate channel, as illustrated below.

After transforming each variable x_{it} into a deviation from its cross-sectional mean, $\widetilde{x}_{it} = \frac{1}{N}\sum_{i=1}^{N} x_{it}$, the model can be re-written as follows:

$$\widetilde{l}_{it}^{\,d} = -\chi \widetilde{\rho}_{it} + \varpi \widetilde{y}_{it} + v_{it} \tag{B.1'}$$

$$\widetilde{l}_{it}^{\,s} = \mu \widetilde{\rho}_{it} + \beta(\widetilde{m}_{it} - \widetilde{p}_{it}) + w_{it} \tag{B.2'}$$

$$\widetilde{m}_{it} - \widetilde{p}_{it} = \gamma \widetilde{y}_{it} + \delta \widetilde{r}_{it}^{\,d} + \varepsilon_{it} \tag{B.3'}$$

$$\widetilde{y}_{it} = -\alpha \widetilde{\rho}_{it} + z_{it} \tag{B.4'}$$

The corresponding expressions for the (demeaned) country-specific output and loan variables are:

$$\widetilde{y}_{it} = \frac{\alpha}{\chi + \varpi\alpha} \widetilde{l}_{it} - \frac{\alpha}{\chi + \varpi\alpha} v_{it} + \frac{\chi}{\chi + \varpi\alpha} z_{it} \tag{B.5'}$$

$$\tilde{l}_{it} = \frac{\chi\beta}{\chi+\mu}\varepsilon_{it} + \frac{\chi\beta\gamma+\varpi\mu}{\chi+\mu}\tilde{y}_{it} - \frac{\mu}{\chi+\mu}v_{it} + \frac{\chi}{\chi+\mu}w_{it} + \frac{\chi\delta\beta}{\chi+\mu}\tilde{r}_{it} \tag{B.6'}$$

The last two relationships indicate that the money demand shock ε_{it} is correlated with $\tilde{l}_{it}$ but not with $\tilde{l}_{it}$ but does not affect $\tilde{y}_{it}$ independently of its effect on $\tilde{l}_{it}$, i.e. it is uncorrelated with the disturbance terms in equation (B.5'). This makes money demand shocks a good candidate for an instrumental variable.

The shocks ε_{it} are obtained by estimating a money demand function for each euro area country. In the first stage an instrumental-variable estimation, we estimate if money demand shocks have a significant effect on aggregate lending in a pooled panel ordinary least squares (OLS) regression using the demeaned values of all variables. In the second stage, the money demand shocks are used as an instrument in a regression of loans on output, which helps isolate the supply effect of bank lending on real activity.

APPENDIX III
CONTINGENT CLAIMS ANALYSIS: A PRIMER

In the main text, risk transfers between banks, non-bank corporate sector, and the public sector in the euro area are examined using the contingent claims analysis (CCA). This appendix provides more details on the method.

The CCA is a type of the balance-sheet approach (Allen and others, 2002). It starts by collecting information on the size and structure of assets and liabilities of key sectors of an economy, in order to assess the extent of currency and maturity mismatches, or imbalances in the debt and equity structure. However, balance sheet data do not provide a full picture of all the risks facing a country, because of the contingent nature of many risks. Balance sheets at the economy-wide level are typically valued at book value, without adjusting for fluctuations in market prices or changes in the likelihood of default. The CCA attempts to provide a more complete picture of the risks in a balance sheet by using marked-to-market prices and incorporating contingent claims.

Approaches similar to the CCA have been used for some time by risk managers and investors for analyzing individual institutions;[11] these approaches have recently been extended to the systemic level (Gray, Merton, and Bodie, 2007). CCA has been performed on emerging markets, such as Brazil and Thailand (Gapen and others, 2004), Indonesia (Gray and Jones, 2006), and Turkey (Keller, Kunzel, and Souto, 2007). This is the first time, as far as we know, that CCA-style analysis is attempted for advanced Europe. It should be stressed that the CCA has been applied at the sovereign or industry level for illustrative purposes only, since there are numerous challenges in calibrating the methodology without extensive cross-sectional or historical databases, such as those available for models of the corporate sector.

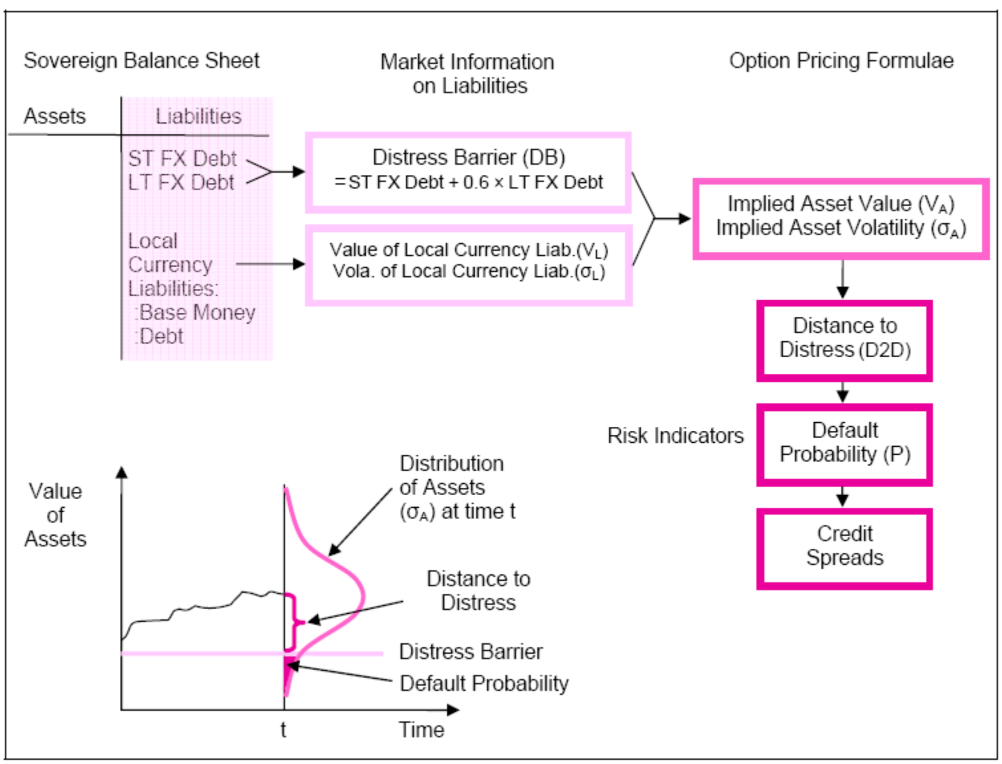
The basic idea of the CCA is that changes in observed variables (e.g., the value of securities in the capital structure) can be used to infer changes in unobserved variables (e.g., the value of the firm). The basic tool of the CCA is the risk-adjusted balance sheet, which shows the sensitivity of the enterprise's assets and liabilities to external shocks. At the national level, the sectors of an economy are viewed as interconnected portfolios of assets, liabilities, and guarantees. Traditional approaches have difficulty analyzing how risks can accumulate gradually and then suddenly erupt in a full-blown crisis. The CCA is well-suited to capturing such "non-linearities" and to quantifying the effects of asset-liability mismatches within and across institutions. Risk-adjusted CCA balance sheets facilitate simulations and stress testing to evaluate the potential impact of policies to manage systemic risk.

[11] An important example of private sector application of CCA has come from Moody's KMV (see e.g. Crosbie and Bohn, 2003). Using 30 years of extensive data on corporate defaults, Moody's KMV uses firm asset value, asset volatility, and the default barrier to derive firm-specific probabilities of default.

The CCA can be used to derive a set of risk indicators that can serve as barometers of risk and financial sector vulnerability. Specifically, two useful credit risk indicators that arise from the implementation of CCA are the distance to default and probability of default.

To understand changes in the overall level of risk facing a balance sheet, an estimate of the value of total assets and their volatility is needed, since they are typically not observable directly. Because many of the assets on the balance sheet are not traded, and are observed only at infrequent intervals, it is difficult to derive marked-to-market balance sheets. In contrast, many liabilities are traded, and thus can be valued more readily using methods from finance theory to impute the value and volatility of assets using the liability side of the balance sheet. Merton's (1974) key insight in option pricing theory was that liabilities are contingent claims on total assets, with each liability having a different priority and maturity structure. The most junior liability on the balance sheet can be valued as an implicit call option on total assets. When the value of assets declines relative to the face value of debt, the value of the junior claims declines. Since the liability structure is observed, and many of the liabilities are traded, market prices of different liabilities can be used to derive information on the evolution of total assets. The framework can be applied to individual firms, or at a more aggregated level for an industry or for the sovereign.

The following chart provides an illustration of CCA for the sovereign:



Source: Gray and Jones (2006).

To estimate the risks to the euro-area public sector balance sheets, we follow the approach of Gray, Merton, and Bodie (2002), and Gapen and others (2005), with the added complications of working in a multi-country context rather than a single sovereign. The main elements on the asset side of the public sector balance sheet include international reserves, the net present value of primary surpluses, and the public sector's monopoly on the issuance of money. These assets are net of any guarantees the public sector may implicitly or explicitly provide to the private sector. The main elements on the liability side of the public sector balance sheet are domestic currency liabilities (domestic currency debt and base money), and foreign currency debt.

Estimating the observed value and volatility of sovereign assets directly is difficult, since only international reserves are observable on the asset side of the public sector balance sheet. In contrast, each entry on the liability side of the balance sheet is directly observable on a high-frequency basis. The CCA uses observed liabilities together with well-known option pricing techniques to derive implied estimates for sovereign asset value and asset volatility.

Domestic currency liabilities of the sovereign can be modeled as junior claims, whereby holders of these liabilities have a residual claim on sovereign assets above what is necessary to service foreign currency debt. If sovereign assets fall to a level where foreign currency debt payments cannot be made, then default is the result. This level is referred to as the distress barrier, and is equivalent to the default-free value of debt. Therefore, the value of domestic currency liabilities can be viewed as a call option on sovereign assets with a strike price equal to the level of the distress barrier. Holders of such liabilities receive the maximum of either sovereign assets minus the distress barrier, or nothing in default. The Black-Scholes option pricing formulae can be used to estimate sovereign asset value and volatility with only a few select variables: the value and volatility of domestic currency liabilities, the distress barrier, the risk-free interest rate, and time. Once the implied asset values and volatilities are calculated, a range of risk indicators can be derived, including the distance to distress (the number of standard deviations away from the distress barrier), the probability of default, and the credit spread on sovereign assets.

The process of estimating total assets and their volatility for the banking system is similar to that for the sovereign, but instead of focusing on the value of domestic currency liabilities, the market value of equity and its volatility, together with the distress barrier, are used to calculate implied assets and their volatility. We include data from Moody's KMV for the 50 largest euro area banks. The daily market capitalization based on traded stock prices is used to calculate the volatility of bank equity for all banks. The book value of short- and long-term obligations are used to calculate the distress barrier for the bank. The distress barrier, market capitalization, and volatility of market capitalization can be used to calculate the implied asset value and implied asset volatility. This is then used to calculate the distance-to-distress, the probability of default, as well as the expected losses of the individual banks. Aggregated figures for all banks are then derived by summing the respective balance sheets and calculating the risk indicators for the banks.

References

Allen, Mark Christoph Rosenberg, Christian Keller, Brad Setser, and Nouriel Roubini, 2002, "A Balance Sheet Approach to Financial Crisis," IMF Working Paper No. 02/210 (Washington: International Monetary Fund).

Altunbaş, Yener, Otabek Fazylov, and Philip Molyneux, 2002, "Evidence on the bank lending channel in Europe," *Journal of Banking & Finance*, Vol. 26, No. 11, November, pp. 2093–2110.

Angeloni, Ignazio, and Michael Ehrmann, 2003, "Monetary transmission in the euro area: early evidence," *Economic Policy* Vol. 18, No. 37, pp. 469–501.

Angeloni, Ignazio, Kashyap, Anil, Mojon, Benoit, 2003. *Monetary Policy Transmission in the Euro Area*. (Cambridge: Cambridge University Press).

Berg, Jesper, Adrian van Rixtel, Annalisa Ferrando, Gabe De Bondt, and Silvia Scopel, 2005, "The Bank Lending Survey for the Euro Area," ECB Occasional Paper No. 23, February, European Central Bank: Frankfurt.

Bernanke, Ben, and Alan Blinder, 1988, "Money, Credit and Aggregate Demand," *American Economic Review*, Vol. 78, pp. 901–21.

Bernanke, Ben, and Mark Gertler, 1995, "Inside the Black Box: The Credit Channel of Monetary Policy Transmission," *The Journal of Economic Perspectives*, Vol. 9, pp. 27–48.

Black, Fisher, and Myron Scholes, 1973, "The Pricing of Options and Corporate Liabilities," *Journal of Political Economy*, Vol. 81, No. 3, pp. 637−54.

Brissimis, Sophocles, and Manthos Delis, 2008, "Identification of a loan supply function: A cross-country test for the existence of a bank lending channel," *J Int Financial Markets Inst Money*, doi:10.1016/j.intfin.2008.01.004

Bruggeman, Annick, and Marie Donnay, 2003, "A Monthly Monetary Model with Banking Intermediation for the Euro Area," ECB Working Paper No. 264 (Frankfurt: European Central Bank).

Bundesbank, 2002, "The Development of Bank Lending to the Private Sector." Deutsche Bundesbank Monthly Report, Vol. 54, October.

Chan-Lau, Jorge, and Iryna Ivaschenko, 2002, "The Corporate Spread Curve and Industrial Production in the United States," IMF Working Paper No. 02/08 (Washington: International Monetary Fund).

Čihák, Martin, 2007. "Systemic Loss: A Measure of Financial Stability," *Czech Journal of Economics and Finance (Finance a uver)*, Vol. 57, No. 1–2, pp. 5-26.

Crosbie, Peter, and Jeffrey Bohn, 2003, "Modeling Default Risk," Moody's KMV.

De Bondt, Gabe, 1999, "Credit Channels and Consumption in Europe: Empirical Evidence," BIS Working Paper No. 69 (Basel: Bank for International Settlements).

———, 2002, "Euro Area Corporate Debt Securities Market: First Empirical Evidence," ECB Working Paper No.164 (Frankfurt: European Central Bank).

De Nicoló, Gianni, Robert Corker, Alexander Tieman, and Jan-Willem van der Vossen, 2005, "European Financial Integration, Stability and Supervision", in IMF Country Report No. 05/266, August, pp. 113–46.

Duca, John, 1999, "What credit market indicators tell us," *Economic and Financial Policy Review*, Federal Reserve Bank of Dallas, issue Q III, pages 2-13.

Driscoll, John, 2004, "Does Bank Lending Affect Output? Evidence From the U.S. States," *Journal of Monetary Economics,* Vol. 51, No. 3, April, pp. 451–47.

Favero, Carlo, Francesco Giavazzi, and Luca Flabbi, 1999, "The Transmission Mechanism of Monetary Policy in Europe: Evidence from Banks' Balance Sheets," NBER Working Paper 7231.

Gambacorta, Leonardo, Yener Altunbas, and David Marqués Ibañez, 2008, "Securitisation and the Bank Lending Channel," ECB Working Paper No. 838 (Frankfurt: European Central Bank).

Gapen, Michael, Dale Gray, Cheng Hoon Lim, and Yingbin Xiao, 2004, "The Contingent Claims Approach to Corporate Vulnerability Analysis: Estimating Default Risk and Economy-Wide Risk Transfer," IMF Working Paper No. 04/121 (Washington: International Monetary Fund).

———, 2005, "Measuring and Analyzing Sovereign Risk with Contingent Claims," IMF Working Paper No. 05/155 (Washington: International Monetary Fund).

Gertler, Mark, and Cara Lown, 2000, "The Information in the High Yield Bond Spread for the Business Cycle: Evidence and Some Implications" NBER Working Paper No. W7549.

Gray, Dale, and Matthew Jones, 2006, "The Contingent Claims Approach to Measuring Sovereign Risk in Indonesia," Selected Issues Paper (Washington: International Monetary Fund).

Gray, Dale, Robert Merton, and Zvi Bodie, 2007, "New Framework for Measuring and Managing Macrofinancial Risk and Financial Stability," NBER Working Paper w13607, November 2007.

Gray, Dale, Chen Hoon Lim, Elena Loukoianova, and Samuel Malone, 2008, "A Risk-Based Debt Sustainability Framework: Incorporating Balance Sheets and Uncertainty," IMF Working Paper No. 08/40 (Washington: International Monetary Fund).

Greenlaw, David, Jan Hatzius, Anil Kashyap, and Hyun Song Shin, 2008, "Leveraged Losses: Lessons from the Mortgage Market Meltdown," *U.S. Monetary Policy Forum Report No. 2* (Chicago: University of Chicago Graduate School of Business).

Iacoviello, Matteo, and Raoul Minetti, 2008, "The Credit Channel of Monetary Policy: Evidence from the Housing Market," *Journal of Macroeconomics*, Vol. 30, pp. 69–96.

International Monetary Fund, 2008a, *Global Financial Stability Report: April 2008* (Washington: International Monetary Fund).

International Monetary Fund, 2008b, *Global Financial Stability Report: October 2008* (Washington: International Monetary Fund).

Kakes, Jan, and Jan-Egbert Sturm, 2002, "Monetary policy and bank lending. Evidence from German banking groups," *Journal of Banking and Finance*, pp. 2077-2092

Keller, Christian, Peter Kunzel, and Marcos Souto, 2007, "Measuring Sovereign Risk in Turkey: An Application of the Contingent Claims Approach" IMF Working Paper No. 07/233 (Washington: International Monetary Fund).

Landesberger, Julian von, 2007, "Sectoral Money Demand Models for the Euro Area Based on a Common Set of Determinants," ECB Working Paper No. 741 (Frankfurt: European Central Bank).

Merton, Robert, 1974, "On the Pricing of Corporate Debt: The Risk Structure of Interest Rates," *Journal of Finance*, Vol. 29, No. 2, pp. 449−70.

Mody, Ashoka, and Mark Taylor, 2004, "Financial predictors of real activity and the financial accelerator," *Economics Letters*, Vol. 82(2), pages 167–172.

Pazarbasioglu, Ceyla, 1997, "A Credit Crunch? Finland in the Aftermath of the Banking Crisis," *IMF Staff Papers* 44, pp. 315–327.

Poghosyan, Tigran, and Martin Čihák, 2008, "Distress in European Banks: An Analysis Based on a New Dataset," Forthcoming IMF Working Paper (Washington: International Monetary Fund).

Strauss-Kahn, Dominique, 2008, "Lessons from the Financial Market Crisis: Priorities for the World and for the IMF" Speech to the Indian Council for Research on International Economic Research, New Delhi, India.