B GLOBAL MACRO-FINANCIAL DEVELOPMENTS AND EXPECTED CORPORATE SECTOR DEFAULT FREQUENCIES IN THE EURO AREA

Identifying the macro-financial factors that drive the default probability of banks' borrowers and thus the default risk in banks' loan books is important in order to obtain a better understanding of conjunctural sources of risk in the financial system. This Special Feature presents an original approach for modelling the links between a global macroeconomic model already used at the ECB for modelling international economic and financial linkages and corporate sector expected default frequencies (EDFs) in the euro area. The results show that euro area default probabilities are strongly affected by shocks to GDP, stock prices, exchange rates and oil prices. Furthermore, the model is capable of providing robust estimations under a wide range of shocks. It could thus be particularly useful for generating scenarios in order to stress test the resilience of individual banks along with the entire banking system.

INTRODUCTION

Modelling the link between global macro-financial factors and firms' default probabilities constitutes an elementary part of financial sector stress-testing frameworks. This is because default and credit risks show a cyclical pattern which can to a large extent be attributed to observable economic and financial variables. At the same time, with the financial system becoming increasingly globally integrated, the need to consider global rather than country-specific macro-financial factors has increased. Indeed, large banks, such as the euro area large and complex banking groups (LCBGs), are increasingly operating in the cross-border markets both in terms of their lending and their trading activities. This suggests that a global model is needed to analyse the impact of shocks on firm's default probabilities and banks' credit risk.

Nevertheless, previous studies in this field have often been restricted to a limited number of domestic variables. This Special Feature illustrates how to analyse the euro area corporate sector probability of default under a range of macroeconomic scenarios both at the domestic and global level. To this end, a Global Vector Autoregressive (GVAR) model is used, which takes into account a large set of international linkages across macroeconomic and financial variables. In addition, a "satellite" model is constructed to the GVAR, linking the EDFs of different euro area corporate sectors to a set of macroeconomic and financial variables. The results from the combined models (the Satellite GVAR model) show that, at the euro area aggregate level, the EDFs react most to shocks to GDP, equity prices, exchange rates and oil prices. In general, most sectoral EDFs react in a rather similar fashion, except for the EDF for the technology sector, which is relatively more sensitive in the sample period. Overall, the Satellite GVAR model appears to be a useful tool for analysing plausible macro-financial shock scenarios designed for stress-testing purposes.

Before presenting the model and the estimation results, this Special Feature first discusses some issues regarding the importance of the analysis of default rates from a financial stability perspective, together with a brief overview of previous work in this area.

THE IMPORTANCE OF MODELLING DEFAULT PROBABILITY FOR FINANCIAL STABILITY ANALYSIS

Financial institutions, especially banks, are at the heart of the financial system. Ensuring the financial soundness of banks is therefore paramount for safeguarding financial stability. Owing to the wide variety of their activities, banks are exposed to a number of risks. Among these, credit risk – the risk that a borrower may not pay a loan as called for in the original loan agreement, and could eventually default on the obligation – is the most important for banks as it is closely related to their lending activities. Looking at banks' credit risk exposures is therefore a natural starting point for a financial stability assessment, although a more complete model should also incorporate elements of other parts of the financial system, including financial markets, other financial institutions and financial infrastructures.

For banks, an assessment of the probability that some of their borrowers may default over a given future time frame is an important input to the estimation of the expected losses and economic capital related to their loan portfolio. Expected and unexpected losses in turn determine the amount of funds for impairment charges and capital buffers that banks need to set aside as a cushion for shocks. At the systemic level, central banks and supervisors have a strong interest in the banks' shock absorption capacity, as liquidity and solvency problems in individual banks or groups of banks can easily spread on a wider basis to the system via interbank linkages or common lending exposures.

The default probability of firms and households, and hence the credit risk that the banks face, varies according to the economic cycle. At the same time, putting aside capital for unexpected losses is costly for banks, as these funds could be used to generate additional interest income. In recognition of these facts, the Basel II Capital Accord, which will be implemented in the euro area in 2007, allows banks to use internal models to estimate their risk-weighted assets and capital buffers. This opportunity has spurred great interest among large banks in particular regarding models that allow them to estimate the extent of cyclical variation in their credit risk exposures.

From a financial stability perspective, it is crucial that the models applied by banks to calculate capital reserves are adequate and provide them with reliable estimates regarding the expected credit quality of their loan books. For these reasons, central banks and regulators also have a natural interest in enhancing their understanding of the interlinkages between the macro-financial environment and borrowers' credit quality.

PREVIOUS WORK ON CONNECTING MACROECONOMETRIC MODELS AND FIRMS' DEFAULT PROBABILITIES

At the systemic level, the interaction between macroeconomic variables and firms' default frequencies can be modelled in different ways. For central banks, a natural choice for a macroeconomic tool where default analysis can be incorporated would be the structural models often designed as forecasting tools for monetary policy purposes. These models permit an internally consistent representation of the entire economy under various scenarios. However, since they are typically designed to project the most likely future macroeconomic outcomes and often incorporate explicit policy rules, structural models are not always suitable for financial stability purposes where the focus is, by definition, on low probability but high-impact events. Moreover, in an increasingly integrated global financial system, empirical modelling of the complete international macro-financial environment using structural models has become an increasingly complex task.

To this end, vector autoregressive (VAR) models provide an alternative multivariate approach which allows for interdependency between selected variables. VAR modelling is one of the principal tools that have been used for forecasting and policy analysis, such as assessing consistency with impulse response functions and judging the empirical adequacy of various theories.

Mainly due to the scarcity of non-confidential and sufficiently homogeneous data on household sector credit exposures, much of the work in this field has concentrated on the analysis of macro-financial shocks on corporate sector credit quality. Previous studies combining macroeconomic VAR models and variables measuring firms' default frequency have incorporated Moody's KMV expected default frequency data into a co-integrated VAR model to analyse the interaction between EDFs and macroeconomic developments.[1] Other papers use realised default data to study the interactions between firms' balance sheets and the evolution of the macroeconomy.[2] These studies have found that the aggregate default frequency constitutes an important link between the financial and the real side of the economy, and that macroeconomic variables are relevant when it comes to explaining the time-varying default frequency.

As an extension to the traditional VAR analysis, global VAR (GVAR) models take into account a large number of linkages across macroeconomic and financial variables.[3] GVAR models consist of a set of individual VAR models for all countries included in the system. Each country is assigned its own set of "foreign" variables, depending on its own trade links. These country-specific foreign variables can be constructed using data on trade flows between the countries/regions. By providing a framework which is capable of accounting for both trade and financial transmission channels, the GVAR model is particularly suitable for analysing the transmission of real and financial shocks across countries and regions. Earlier financial stability applications of the GVAR models have used this modelling approach to generate conditional loss distributions of credit portfolios.[4]

METHODOLOGY AND DATA

To link the GVAR model with the financial sector, a framework is needed which quantifies the impact of domestic and global macroeconomic shocks on corporate sector probability of default. In what follows, an original framework is presented which links the EDFs of publicly listed companies in the euro area to a macro-econometric framework as modelled by the GVAR. The analysis considers the EDFs on both euro area aggregate and sectoral levels. The chosen approach provides new insights in three important respects. First, it quantifies the impact of domestic and global macroeconomic shocks on the EDFs for euro area firms. Second, by considering EDFs, a structural Merton-type model is combined with a macro-econometric model. Third, the analysis is restricted to consider purely the effect of economic and financial variables on the firms' default probability; it therefore explicitly ignores any feedback effects on the macroeconomy which are controversial to model and often challenging to interpret. For these purposes, a linking equation to the GVAR model is constructed which isolates the EDFs from the system. The GVAR model together with the linking equation to the EDFs is titled the "Satellite GVAR model".

In somewhat more technical terms, the Satellite GVAR model can take different representations. Corporate sector default rates vary over time and, in order to capture this dynamics, the multivariate distribution of risk factor changes is combined with the GVAR model. The model translates macroeconomic risk factor changes into default probabilities for different industry sectors, and allows for an analysis of macroeconomic stress-scenarios which are related to default probabilities. Intuitively, the EDFs can be interpreted as estimators that measure how closely a firm's assets are expected to approach its liabilities given the macroeconomic scenario. In other words, the

1 See I. Alves (2005), "Sectoral Fragility: Factors and Dynamics", *BIS Papers*, 22, who analyses corporate sector EDFs in a cointegrated macroeconomic model for the euro area; O. Aspachs, C. A. E. Goodhart, D. P. Tsomocos and L. Zicchino (2006), "Towards a Measure of Financial Fragility", *Oxford University Working Papers*, who consider the links between banks' equity prices and default probabilities and output in the UK; and H. Shahnazarian and P. Åsberg-Sommer (2007), "Macroeconomic Impact on Expected Default Frequency", Sveriges Riksbank (mimeo), who find evidence of a long-term relationship between EDFs and macroeconomic variables in Sweden.

2 See T. Jacobson, J. Lindé and K. Roszbach (2005), "Exploring Interactions between Real Activity and the Financial Stance", *Journal of Financial Stability*, 1, 308-341.

3 For a thorough discussion of GVAR and its properties, see S. Dees, F. Di Mauro, M. H. Pesaran and L. V. Smith (2007), "Exploring the International Linkages of the Euro Area: A Global VAR Analysis", *Journal of Applied Econometrics*, 22, 1-38.

4 See M. H. Pesaran, T. Schuermann and S. M. Weiner (2004), "Modeling Regional Interdependencies Using a Global Error-correcting Macroeconometric Model", *Journal of Business and Economic Statistics*, 22, 129-162, who use a portfolio consisting of 119 firms in 10 regions of the world. They use the GVAR as a linking model and assume that equity return of firms with debt outstanding is a function of the regional and global macroeconomic environment.

EDFs measure the conditional expectation of the default intensities in the different industry sectors. In the present model, the conditioning variables are the macroeconomic risk factor changes that describe a particular macro scenario generated by the GVAR model.

In the present study, a version of the GVAR model is applied which is calibrated for euro area data and frequently used at the ECB to analyse international macroeconomic and financial market developments.[5] The dataset for the GVAR model consists of 33 countries from different regions in the world. The data include eight of the eleven euro area countries that joined the single currency in 1999. These eight countries are grouped together in order to represent one region. Bilateral trade is a crucial factor for international business cycle movements.[6] The framework presented in this article uses fixed trade weights based on average trade flows over three years (1999-2001). The sample period for the variables included in the GVAR extends from 1979 to 2005 on a quarterly basis.

The EDFs for the euro area corporations are obtained from the Moody's KMV database, which combines a large database of historical firm-level accounting data with the volatility of the firms' stock prices. This Special Feature considers the median EDFs on both aggregate and sectoral levels on a quarterly basis for the period 1992-2005.[7] The median EDF at each point in time represents the median EDF among a panel of available corporations in the euro area or in a sector. The following sectors are analysed: aggregate (Aggr), basic and constructions (BaC), energy and utilities (EnU), capital goods (Cap), consumer cyclical (CCy), technology (TMT), consumer non-cyclical (CNC) and financial (Fin) sector.[8]

RESULTS FROM THE ESTIMATED SATELLITE GVAR MODEL

In the estimation, the GVAR framework is treated as an exogenous "state of the world" system within which the co-integration relationships are well established. The explanatory variables for the EDFs in the satellite model come from the GVAR model and are treated in first differences. In the satellite model, the left-hand side denotes the EDF, α and β denote the parameters, and GDP_t, CPI_t, EQ_t, EP_t and IR_t stand for euro area real GDP, consumer price inflation (CPI), equity prices, the real euro/US dollar exchange rate and short-term interest rate, respectively. All variables are extracted from the euro area model of the GVAR:[9]

$$EDF = \alpha + \beta_1 \Delta GDP_t + \beta_2 \Delta CPI_t$$
$$+ \beta_3 \Delta EQ_t + \beta_4 \Delta EP_t + \beta_5 \Delta IR_t$$

Table B.1 presents the estimated satellite model for sector-specific EDFs. The results show that most of the estimated parameters are significant, except for some for the sectoral EDF estimates.

5 For model presentation and full description of the data, see S. Dees, F. Di Mauro, M. H. Pesaran and L. V. Smith (2007), op. cit.

6 See M. Baxter and M. A. Kouparitsas (2004), "Determinants of Business Cycle Co-movement: A Robust Analysis", *NBER Working Paper*, No W10725; J. Imbs (2004), "Trade, Finance, Specialization and Synchronization", *Review of Economics and Statistics*, 86, 723-734; and K. J. Forbes and M. J. Chinn (2004), "A Decomposition of Global Linkages in Financial Markets over Time", *Review of Economics and Statistics*, 86, 705-722.

7 One of the advantages of the Satellite GVAR framework is that is allows the user to work on different sample periods for the GVAR and the satellite model.

8 See I. Alves (2005), op. cit., for a detailed discussion on the definitions of sectors used in this article. Recently, several authors have stressed the role of heterogeneity among firms which could be captured by using the information about the entire distribution of EDFs. See e.g. S. Hanson, M. H. Pesaran and T. Schuermann (2006), "Firm Heterogeneity and Credit Risk Diversification", Federal Reserve Bank of New York (mimeo).

9 While the euro area block of the GVAR model is represented by six macroeconomic and financial time series (together with oil prices as a common variable to all economies), it was found preferable to restrict the number of variables to five to avoid estimating too many parameters. It is important to note, however, that although a factor is excluded from the satellite model, the effect of that particular factor is still represented through the impulse responses. For example, the effect of an oil price shock is transmitted to interest rates, GDP and consumer prices even if the oil price series is not explicitly included in the satellite equation.

Table B.1 Estimated coefficients of the satellite model

(% change)

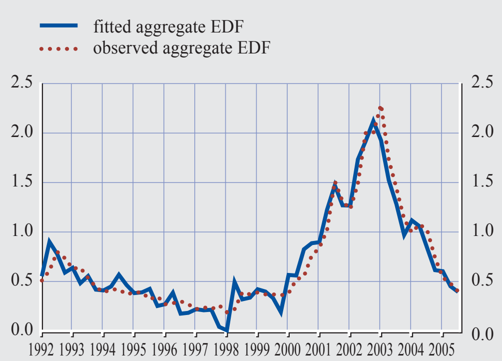
		Constant	GDP	CPI	Equity prices	USD/EUR exchange rate	Short-term interest rate
Aggr	beta	0.853	-0.350	-0.054	-0.018	-0.028	-0.010
	Pval	0.000	0.040	0.823	0.020	0.077	0.228
BaC	beta	0.663	-0.285	0.161	-0.014	-0.012	-0.007
	Pval	0.000	0.006	0.268	0.003	0.198	0.146
Cap	beta	1.167	-0.465	-0.097	-0.022	-0.034	-0.011
	Pval	0.000	0.030	0.749	0.025	0.089	0.268
CCy	beta	0.679	-0.266	0.018	-0.015	-0.017	-0.006
	Pval	0.000	0.022	0.915	0.005	0.120	0.270
CNC	beta	0.520	-0.117	-0.100	-0.010	-0.012	-0.003
	Pval	0.000	0.235	0.485	0.026	0.206	0.558
EnU	beta	0.160	-0.047	0.031	-0.005	-0.002	0.000
	Pval	0.000	0.080	0.421	0.000	0.332	0.737
Fin	beta	0.168	-0.030	0.081	-0.003	-0.002	-0.001
	Pval	0.000	0.118	0.005	0.001	0.196	0.404
TMT	beta	2.385	-1.179	-0.831	-0.062	-0.135	-0.038
	Pval	0.006	0.108	0.433	0.066	0.052	0.272

Source: ECB calculations.

The parameters can also be interpreted as elasticities. Most of the estimated signs are rather similar across the sectoral EDFs. Specifically, the estimation shows that a decrease in GDP causes an increase in euro area corporate sector default probabilities, which is an intuitive and well-established result in the literature. A decline in equity prices also contributes to an increase in euro area corporate default probabilities, as does an appreciation of the euro exchange rate. These latter results in particular reflect the importance for international financial developments and competitiveness for corporate default frequencies in the euro area. The impact of inflation is more mixed and varies across sectors, suggesting that the power of this variable in explaining developments in credit quality might be questionable in the present sample. The coefficients of short-term interest rates are mostly insignificant in the sample period.

Chart B.1 Goodness of fit of the Satellite GVAR model

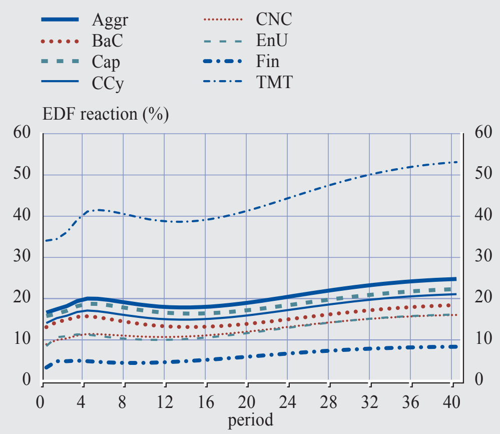
(% probability)



Source: ECB calculations.

Chart B.2 EDF reactions to a negative shock in euro area GDP

(% change)



Source: ECB calculations.

Once estimated, the satellite model is integrated into the GVAR model to form the Satellite GVAR model. Chart B.1 plots the fitted values of the Satellite GVAR model against the true aggregate euro area EDF time series. It is important to note that the present data set for euro area corporate EDFs is strongly dominated by the "new economy" cycle in the late 1990s and early 2000s. Nevertheless, the chart clearly shows that that the model fits rather well across the sample period.

REACTIONS OF EXPECTED DEFAULT RATES TO SHOCKS

One of the benefits of the VAR approach is that it makes it easy to evaluate the impact of shocks to a variable on other variables, by picking up the dynamics of the model. This section illustrates the simulated reactions of sectoral euro area EDFs over a ten-year horizon, as a deviation from the baseline after a one-standard deviation shock to selected macroeconomic and financial variables. All reactions are plotted in Charts B.2-B.4. A general observation is that owing to the importance of the 1990s technology sector boom and bust episode in the sample period, the technology sector EDFs react particularly strongly to various shocks in the present model.

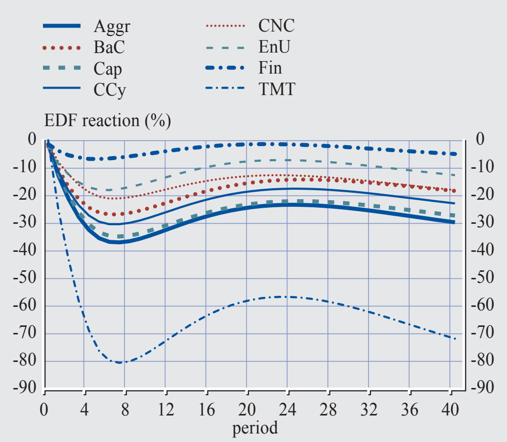
Chart B.2 illustrates that a negative shock on euro area GDP has a permanent positive impact on the EDFs of all sectors, with their intensity varying mostly between 10 and 20%.

As a reaction to a negative shock to euro area short-term interest rates, expected default decline (see Chart B.3). However, the size of this reaction varies quite substantially across sectors. Somewhat surprisingly, the financial sector seems to be less sensitive than most other sectors to variation in interest rates, whereas cyclical sectors react more strongly. This could be an indication that banks in the euro area manage these risks rather well through, for instance, hedging.

Finally, Chart B.4 shows that a positive oil price shock has a positive and permanent impact on euro area corporate sector EDFs which is quite uniform across all sectors, indicating that commodity price shocks could have a deteriorating impact on the credit quality of banks' loan books.

Chart B.3 EDF reactions to a negative shock in euro area short-term interest rates

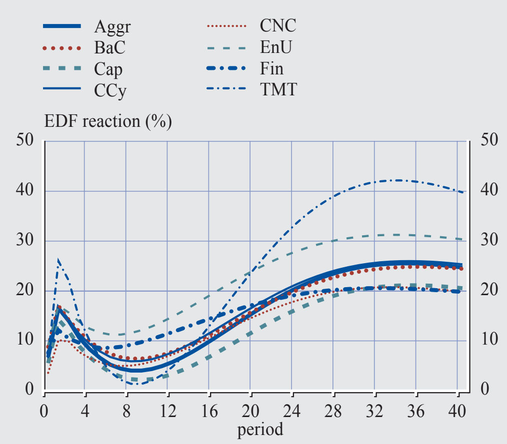
(% change)



Source: ECB calculations.

Chart B.4 EDF reactions to a positive shock in oil prices

(% change)



Source: ECB calculations.

CONCLUDING REMARKS

This Special Feature has illustrated one possibility of creating a link between macroeconomic variables and firms' expected default probabilities. Previous literature on the relationships between the probability of default and economic activity has generally been restricted to a limited number of domestic variables. The framework presented here uses the GVAR model, which takes into account a wider perspective of interdependency between a large set of countries. In addition, a "satellite" equation to the GVAR model was constructed which provides a convenient way of linking a structural credit risk model for euro area corporate sector EDFs to a time series econometric model. For large euro area banks whose credit risk exposures are of an increasingly global nature, such an approach to modelling the cyclical variation in the default frequency of their borrowers would be particularly relevant.

The estimation results confirm that the Satellite GVAR model offers a promising framework for analysing the impact of a wide range of shocks to euro area corporate credit quality. Several extensions to this work are possible. For example, formulating a non-linear satellite model could capture some of the characteristics of financial crises where the impacts of shocks are typically amplified by financial accelerators. Exploiting the heterogeneity in the sectoral EDF distributions would also add important information about default risks in various sectors. Finally, the existing model could be conveniently linked to a credit portfolio model, such as the one presented in the next Special Feature in this Review ("Assessing portfolio credit risk in a sample of EU large and complex banking groups"). [10]

10 A credit portfolio model is also used by the Sveriges Riksbank to assess credit risks through the use of EDFs and their impact on economic capital. See Sveriges Riksbank (2006), "Using External Information to Measure Credit Risk", Financial Stability Report, 2006/1. In addition, the Bank of England and the IMF both use different variants of a framework which connects macroeconomic shocks, sectoral default rates and banks' portfolio losses and economic capital. See A. Haldane, S. Hall and S. Pezzini (2007), "A New Approach for Assessing Risks to Financial Stability", Bank of England Financial Stability Paper, No 2; and R. Avesani, L. Liu, A. Mirestean and J. Salvati (2006), "Review and Implementation of Credit Risk Models of the Financial Sector Assessment Program", IMF Working Paper, No 134.