

C BALANCE SHEET CONTAGION AND THE TRANSMISSION OF RISK IN THE EURO AREA FINANCIAL SYSTEM

The identification of vulnerabilities, trigger events and channels of transmission is a fundamental element of financial stability analysis. Using data for the euro area, this article combines measures of leverage and volatility with interlinked balance sheets to show how local financial shocks can spread through the financial system and affect balance sheets and risk exposures in other parts of the system. Analysis of this network of interlinked assets and liabilities leads to the conclusion that the cross-sector balance sheet exposures in the euro area financial system constitute important channels through which shocks can be transmitted across sectors. High financial leverage and elevated asset volatility are key factors in increasing a sector's vulnerability to shocks and contagion.

INTRODUCTION

Assessing financial stability involves identifying risks and vulnerabilities in the various parts of the financial system. It also calls for the recognition of potential trigger events which could, if they materialise, flip the state of the financial system from stability to instability. Financial stability analysis should also aim at identifying the channels through which shocks may spread more widely across the financial system, possibly affecting parts of the system that might not have been considered particularly vulnerable to the initial shock, but may nevertheless be adversely affected owing to their close interconnection with sectors that are directly confronted by the unforeseen events.

The financial crisis has highlighted the particular need for a framework that can capture the interlinkages between sectors.¹ In order to conceptualise such a framework, measures are needed that can capture the accumulation of imbalances and the transmission of local balance sheet dislocations. This article uses data on the euro area financial accounts to construct a network of balance sheet exposures that connect

the main sectors of the euro area financial system. The analysis focuses on measures of leverage, which is a key indicator of balance sheet vulnerability owing to its ability to increase the sensitivity of agents' net financial wealth positions to changes in cash flows and asset prices. The article goes on to show how shocks to some parts of the financial system can affect net financial wealth positions in other parts of the network. Finally, it illustrates how the network of leveraged exposures can be combined with data on asset returns and asset volatility to provide measures of risk exposures for individual sectors.

SECTOR-LEVEL BALANCE SHEETS IN THE EURO AREA FINANCIAL SYSTEM

In this special feature, the euro area financial system is considered as a closely intertwined group of seven distinct sectors: households, non-financial corporations (NFCs), banks and other monetary financial institutions (MFIs), insurance companies, other financial intermediaries (OFIs), government and the rest of the world (RoW). The data used to construct the sector-level balance sheets are from the ECB's euro area accounts. In these euro area accounts, the analytical grouping of economic agents into institutional sectors and transactions is based on the methodological framework established in the European System of Accounts 1995 (ESA 95).²

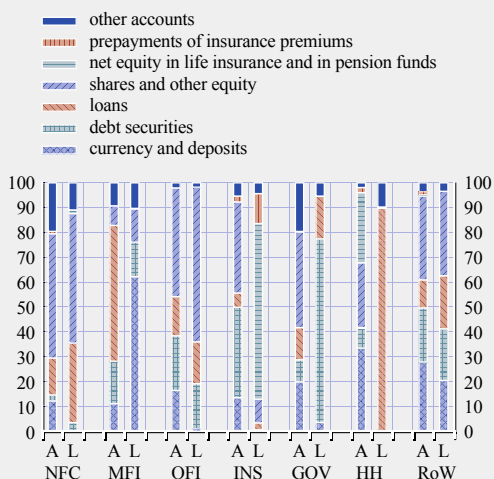
Chart C.1 illustrates the composition of the balance sheets (assets and liabilities) of the seven sectors as at the end of the third quarter of 2008. The categories of financial instruments included in the balance sheets are those used in the

¹ Indeed, recent policy advice issued by international committees, which includes recommendations for European financial supervision, have suggested that systemic risk indicators should be developed. See, for example, O. Issing et al., "New Financial Order" *Recommendations of the Issing Committee*, 2009; UK Financial Services Authority, *The Turner Review*, 2009; and J. De Larosiere et al., "Report", *The high-level group on financial supervision in the EU*, 2009.

² For more details, see <http://forum.europa.eu.int/irc/dsis/nfaccount/info/data/esa95/en/titelen.htm>. The ESA 95 is the European application of the System of National Accounts 1993 (SNA 93).

Chart C.1 The composition of sector-specific balance sheets in the euro area financial system

(Q3 2008; A = financial assets; L = financial liabilities)



Source: ECB.

Note: NFC stands for the non-financial corporations sector, MFI for the monetary financial institutions sector, OFI for the other financial intermediaries sector, INS for the insurance sector, GOV for the government sector, HH for the households sector and RoW for the rest of the world.

ESA 95 statistics, which are classified according to liquidity factors and legal characteristics.

For most sectors, the asset sides of the financial account balance sheets consist of holdings, in different proportions, of cash and money market instruments, as well as debt and equity securities issued by financial and non-financial firms. Several sectors (notably MFIs, but also NFCs and OFIs) are also large issuers of loans to the other sectors. There are also smaller asset items, such as pre-payments of insurance premiums and net equity in life insurance and pension funds. Owing to the inclusion of the RoW sector, these asset holdings include instruments originated by both domestic and foreign counterparties.

In contrast to the asset holdings, the sector-specific liability positions show more distinct characteristics. The liabilities of the NFC sector consist of loans from banks and other firms, as well as equity and debt securities issued to other firms and other sectors in the financial system. For banks (MFIs), the liabilities are currency and deposits collected from other

banks and from the private sector, as well as stocks and bonds issued to investors in the other sectors. The bulk of the OFI sector's liabilities are mutual fund shares, while the largest share of the insurance sector's liabilities is made up of net equity of households in life insurance cover and pension funds. For government, government bonds account for the largest share of liabilities, most of which are denominated in the domestic currency in developed economies. Household sector liabilities are accounted for almost entirely by MFI loans to finance housing and consumption expenditure. Finally, for the rest of the world, both sides of the balance sheet are rather evenly split between cash, loans and investment securities.

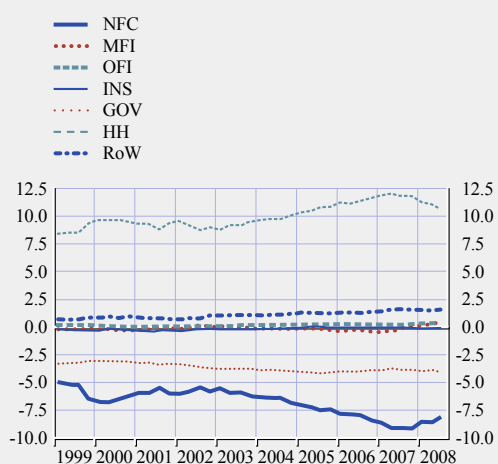
LEVERAGE AS A MEASURE OF FINANCIAL FRAGILITY

Although the assets must equal liabilities at the system level in an integrated financial system like the ECB's euro area accounts, this is not necessarily the case at the sector level. Indeed, some sectors in the financial system show systematic deficits in their financial accounts, while others report systematic surpluses. The NFC and government sectors typically (although not always) belong to the former category, while households form the largest part of the latter category. Insofar as the deficits run by the borrowing sectors exceed the surpluses recorded by the lending sectors, the gap must be financed by borrowing from abroad. There is therefore a need for an RoW sector, whose financial position mirrors the current account of the balance of payments of the domestic financial system.

The difference between a sector's financial assets and liabilities equals that sector's net financial wealth. Chart C.2 illustrates the evolution over time of the net financial wealth positions of the sectors of the euro area financial system. In the euro area, the positive net financial wealth of the surplus sectors (mainly households and the rest of the world) matches the negative net financial wealth of the deficit sectors (mainly the government sector and

Chart C.2 Evolution of sector-level net financial wealth in the euro area financial system

(Q1 1999 – Q3 2008; EUR trillions)



Source: ECB.
Notes: Net financial wealth is defined as total financial assets minus total liabilities. For the explanation of the abbreviations used, see the note in Chart C.1.

non-financial corporations). It is noteworthy that the net financial wealth of the financial sectors is small. This reflects the fact that, as financial intermediaries, the bulk of their assets and liabilities consist of financial instruments, and that their holdings of non-financial assets such as real estate and capital goods are relatively insignificant.

Net financial wealth and its role in attributing sectors to the borrowers or lenders in the financial system also provides a link between the financial and the real accounts. Therefore, it allows an analysis of the transmission of “vertical” contagion whereby shocks may spread from the real sector to the financial sector via the net lending positions of the different sectors.³

From the financial stability perspective, the concept of net financial wealth provides an insight into how indebtedness and leverage can increase the vulnerability of a sector to cash flow and asset price shocks. This can be illustrated using the following intertemporal identity, which equates a sector’s future financial assets position (A_{t+1}) with the difference between the current

market value of assets ($P^A A_t$) and liabilities (D_t) plus the flow return on the assets (RoA).

$$(1) \quad A_{t+1} = \frac{RoA + (P^A \cdot A_t) - D_t}{P^A}$$

Importantly, if the stock of debt outstanding is large relative to the flow return on assets, then the net wealth (the nominator in equation 1) is more sensitive to fluctuations in asset prices (P^A). In other words, sectors with high debt relative to cash flows tend to be more vulnerable to asset price and cash flow shocks. This captures the “leverage effect” of debt accumulation, which is an important concept in financial contagion literature.

Constructing a comparable measure of leverage for different sectors is complicated somewhat by the above-mentioned differences in the composition of the liability sides of the balance sheets. Chart C.3 provides a measure of debt-to-asset ratios for the individual sectors, where debt is defined as total liabilities minus shareholder equity and net financial wealth.

Leverage increased for euro area non-financial corporations in the run-up to the stock market crash in 2000-01 and then broadly declined, before starting to increase again from mid-2007. For the euro area household sector, financial leverage has increased steadily over the period under review, although the ratio remains low, equalling around one-third of the corporate sector leverage on this particular measure.⁴

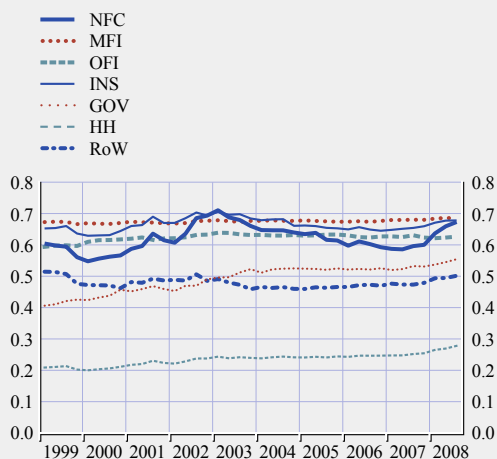
The leverage of the banking sector has remained rather stable, which is consistent with the notion that banks tend to target constant leverage ratios over time as they strive to minimise fluctuations

3 More specifically, net wealth (a measure of stocks) can be defined as accumulated lending or borrowing (flow measures), including changes in prices and other components. The net lending/borrowing of a sector can be decomposed into investment (gross capital formation) and saving. Therefore, shocks to savings and investment are conveyed to the financial accounts via their impact on the flows of net lending and, thus, on the net wealth position.

4 However, there are important differences across Member States in this respect.

Chart C.3 Sector-level measures of leverage in the euro area financial system

(Q1 1999 – Q3 2008)



Source: ECB.

Notes: Leverage is defined as debt over market value of financial assets. For the explanation of the abbreviations used, see the note in Chart C.1.

in their regulatory capital and credit ratings.⁵ Regarding insurance companies, leverage increased in the period 2001-03, as the decline in the euro area equity markets caused a sharp drop in the market value of their financial assets. This was followed by a period of balance sheet deleveraging and, subsequently, by a gradual increase in the leverage ratio since 2007.

A NETWORK OF BALANCE SHEET EXPOSURES FOR THE EURO AREA FINANCIAL SYSTEM

The financial accounts in the ECB's euro area accounts do not currently provide detailed information on the specific counterparties of the instruments issued by a given sector (the "who-to-whom" accounts).⁶ In the absence of this information, the balance sheet linkages between sectors can be estimated using statistical techniques. More specifically, when the aggregate asset (liability) holdings of each sector are known on an instrument-by-instrument basis, the allocation of these aggregate holdings across the liabilities (assets) of all other sectors can be approximated using the maximum entropy technique, which exploits the relative shares of the sectoral total assets and liabilities. In other

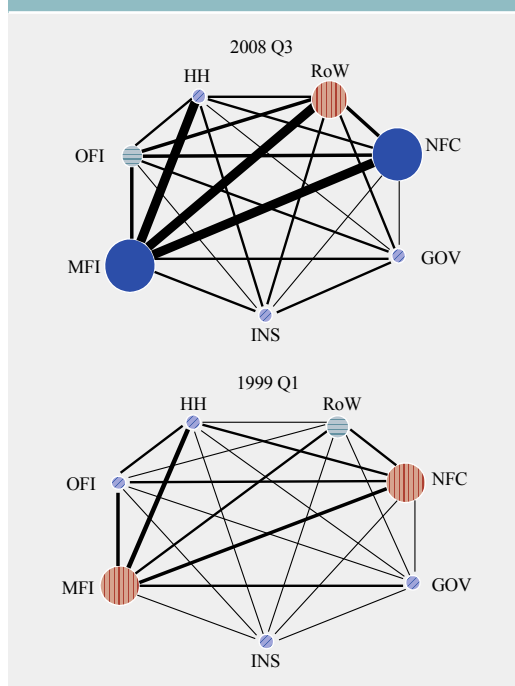
words, the who-to-whom detail is approximated to follow the distribution of assets and liabilities. The use of this assumption is standard in statistical exercises and in the literature on financial contagion.⁷

Once the bilateral exposures have been calculated, a network connecting all sectors in the financial system can be constructed. Chart C.4 illustrates this network of balance sheet exposures for the euro area financial system at two distinct points in time, namely in the first quarter of 1999 and in the third quarter of 2008. The lines in the charts show the gross exposures, i.e. the sums of exposures on the asset and the liability sides between two sectors. The thickness of the line connecting two sectors is commensurate with the magnitude of the gross exposure, while the sizes of the circles describe the exposures within sectors. The latter include, among other items, cross-shareholdings of firms, intercompany loans and interbank credit exposures.

Three main observations can be drawn from Chart C.4. The first is the overall increase in the size of balance sheet exposures in the first decade of Stage Three of Economic and Monetary Union. The second is the crucial role played by the banking (MFI) sector in

- 5 See T. Adrian and H. Shin "Liquidity and Leverage", *Federal Reserve Bank of New York Staff Report*, No 328, 2008. Consistent with their findings, when plotting the changes in leverage against changes in total assets for the different sectors on the basis of data from the ECB's euro area accounts, it can be noted that, in the euro area, all sectors except the MFI and OFI sectors show a negative relationship. This suggests that for the non-financial sectors and insurance companies, leverage ratios adjust passively, i.e. the ratios fall when the denominator (financial assets) increases. By contrast, the MFI and OFI sectors actively manage their leverage ratios by increasing (decreasing) debt when assets increase (decrease), mainly reflecting common risk management strategies that call for constant leverage across the cycle.
- 6 This situation is expected to improve with the implementation of "who-to-whom" statistics in the coming years.
- 7 See, for example, C. Upper and A. Worms "Estimating bilateral exposures in the German interbank market: is there a danger of contagion?" *European Economic Review*, 2004; I. van Lelyveld and F. Liedorp "Interbank contagion in the Dutch banking sector: a sensitivity analysis", *International Journal of Central Banking*, 2006, and S. Wells "Financial interlinkages in the UK interbank market and the risk of contagion," *Bank of England Working Paper*, No 230, 2004.

Chart C.4 Cross-sector balance sheet exposures of the euro area financial system



Sources: ECB and ECB calculations.
Notes: The thickness of the lines shows the size of the gross balance sheet exposures (assets plus liabilities) between two sectors. The size of the circle illustrates the amount of gross exposures within sectors. For the explanation of the abbreviations used, see the note in Chart C.1.

the euro area financial system. As a financial intermediary, it holds liabilities in the form of deposits from mainly the household, NFC and RoW sectors, while it holds assets in the form of loans extended predominantly to these same sectors. In addition, the MFI sector also plays an important role in securities markets, as it issues equity and debt securities mainly to the household, insurance, OFI and RoW sectors, and holds securities issued mainly by the NFC, OFI, government and RoW sectors. The third observation is the growing role played by the OFI sector over the past ten years. While the bulk of the sector in the euro area consists of money market funds, its growth also reflects the expansion of securitisation transactions and off-balance-sheet structures.

Overall, it is evident from the above that potential stresses in the MFI sector have substantial negative spill-over effects into virtually all

other sectors in the euro area financial system, while the MFI sector is vulnerable to contagion especially from the household, NFC, RoW and OFI sectors, as well from the interbank credit market within the MFI sector itself.

TRANSMISSION OF SHOCKS IN THE NETWORK VIA BALANCE SHEET EXPOSURES

From the financial stability perspective, the network of financial exposures outlined in Chart C.4 can be used to analyse how shocks to some sectors may cause a “horizontal” chain reaction in the network, whereby the other sectors may also see their financial positions adversely affected. The analysis below is inspired by the literature on credit chains and balance sheet contagion, which provides the theoretical underpinnings of shock transmission in the financial system.⁸

Shocks to the cash flows of the non-financial corporate sector are analysed below using the ECB’s euro area accounts data for the third quarter of 2008. More specifically, it is assumed that the NFC sector faces a negative earnings shock that is large enough to cause a 20% drop in the value of shareholder equity.⁹ For the sake of simplicity, it is also assumed that there are no further changes in cash flows in any other sectors in any future period and that all sectors must mark their investment losses to market. These rather restrictive assumptions nevertheless help to reveal the precise transmission of the shock over time and across sectors.¹⁰

Table C.1 shows the result of this simple exercise. It suggests that, overall, in terms of the negative impact on financial assets owing to the loss of value in investment in other sectors’ equity, the

8 See F. Allen and D. Gale “Financial contagion”, *Journal of Political Economy*, 2000, N. Kiyotaki and J. Moore “Credit Cycles”, *Journal of Political Economy*, 1997, and N. Kiyotaki and J. Moore “Balance Sheet Contagion”, *American Economic Review*, 2002.

9 Alternatively, the shock can be assigned to the asset prices, as shown in equation 1 above.

10 Note that since the euro area accounts are a closed system, the shock persists indefinitely unless it is assumed that future positive cash flows in some sector can offset the losses.

Table C.1 Simulated transmission of a shock to non-financial corporations' cash flows

(Q3 2008; percentage changes in financial assets)

	Round			Average
	1	2	3	
NFC	5.41	5.99	6.15	5.85
HH	1.88	2.03	2.00	1.97
MFI	0.85	0.86	0.84	0.85
INS	1.99	0.31	0.31	0.87
OFI	4.14	4.54	4.55	4.41
GOVT	3.98	4.38	4.35	4.24
ROW	1.80	1.93	1.86	1.86

Sources: ECB and ECB calculations.

Note: For the explanation of the abbreviations used, see the note in Chart C.1.

percentage impact on individual sectors is highest within the non-financial sector itself, as well as in the OFI and government sectors. This mainly reflects the large holdings by these sectors of non-financial corporate sector shares. However, the scale of the further impact of the shock also differs across sectors over time. In particular, the fact that in the later rounds a sector may be affected by valuation losses from other sectors to which it has large exposures means that the intensity of the shock may change over time. Indeed, Table C.1 shows that the second round of the impact has a stronger impact than the first round for almost all sectors except the insurance sector. The latter sector is relatively less affected by losses in the valuation of equity issued by sectors other than the NFC sector.¹¹

Finally, the fact that the financial asset positions of all the other sectors deteriorate as a result of the shock to an individual sector means that, overall, measures of leverage will increase. This may introduce further dynamics into the process if the affected sectors try to keep their leverage ratios constant and reduce their liabilities to accommodate the losses on their asset holdings.

RISK EXPOSURES AND THE TRANSMISSION OF RISK IN THE FINANCIAL SYSTEM

The identification of imbalances using sector-specific balance sheets and the illustration of the propagation of shocks via the network of exposures are useful tools for financial stability

analysis. However, since the presentation above is based on a purely deterministic framework, it is not possible to say anything about the accumulation and transmission of *risk exposures*. To incorporate such characteristics, the analysis has to be extended by using tools that also capture the volatility of the key balance sheet items, such as shareholder equity and assets. In this way, it is possible to quantify the uncertainty, or risk, involved in the leveraged positions.

Recent contributions to contingent claims analysis extend tools originally developed for assessing firm-level default risk at the macro-financial level and can provide insight into the measurement of sector-level risk exposures.¹² Contingent claims analysis is based on structural finance models, which use options pricing theory and include as inputs data on leverage, interest rates, the market value of assets, asset returns and asset volatility.¹³ The output consists of the optimal debt-equity structure of the firm plus a number of risk indicators, such as the distance to distress, the expected loss, the probability of distress, the expected recovery rate and the credit spread over the risk-free interest rate. While some of these indicators are available for selected financial and non-financial firms from various private data sources, their availability for other sectors such as households, government and OFIs is far more limited.

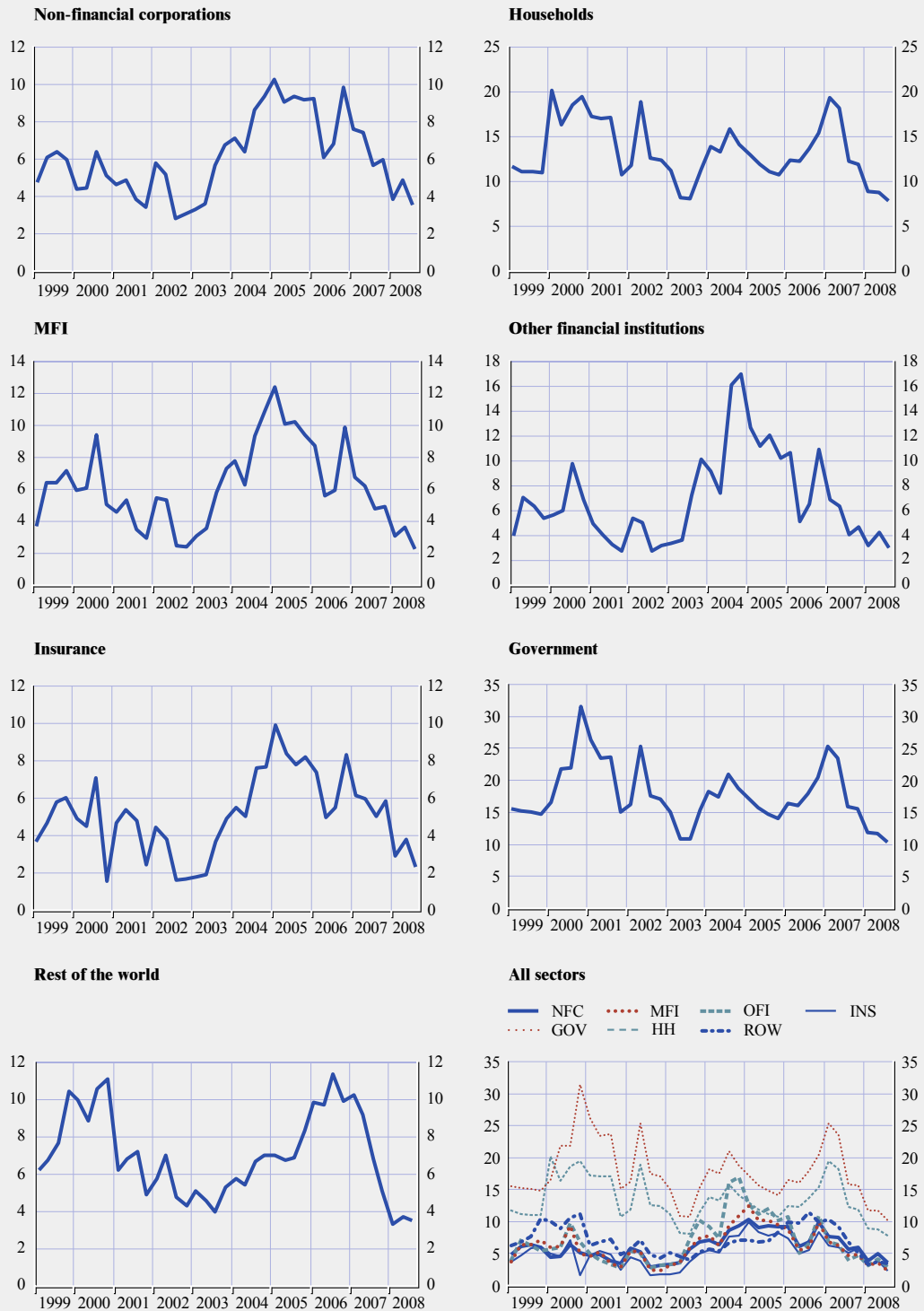
The fact that the euro area accounts provide a consistent source of leverage measures across different sectors makes it possible to construct time series for risk indicators at the sector level. It should be stressed from the outset, however, that

11 Note that the contagion impact to other sectors is in this case dependent on the size of the cross-exposure in equity holdings, which may not be in proportion to the aggregate cross-exposure between sectors as shown in Chart C.4.

12 See D. Gray, R. Merton and Z. Bodie, "A New Framework for Analysing and Managing Macrofinancial Risks of an Economy", *NBER Working Paper*, No 12637, 2006, and D. Gray and S. Malone, "Macrofinancial Risk Analysis" *Wiley Finance, UK*, 2008.

13 These analyses mostly derive from the classic paper by R. Merton, "On the Pricing of Corporate Debt: the Risk Structure of Interest Rates", *Journal of Finance*, 1974.

Chart C.5 Sector-level distances to distress for the euro area financial system



Source: ECB.

Note: The scales on the y-axes measure the distance, in standard deviations, between the market value of assets and the default point.

the interpretation of these indicators is not straightforward for two reasons. First, the liability structure of many of the sectors differs from the liability structure of the firm sector for which the relevant models were originally developed. Second, the risk measures should not be understood as reflecting, for example, the probability of distress or expected loss given financial distress of an entire sector (which is likely to be very close to zero anyway), but rather the risks faced by a representative agent in that sector.¹⁴ Bearing in mind these caveats, the dynamics of the indicators can nonetheless provide useful and timely signals on changes in individual sectors' risk exposures and how they can spread to other sectors in the financial system.

Using the sector-level balance sheet data on leveraged exposures from the euro area accounts and market data on volatilities, interest rates and the market price of risk as inputs, contingent claims analysis can be applied to calculate the risk indicators. By way of example, Chart C.5 depicts the evolution of the distance to distress for the different sectors in the euro area financial system from the first quarter of 1999 to the third quarter of 2008. The distance to distress measures the distance of a sector's market value of assets from the level of liabilities (the distress point). The impact of the financial sector turmoil that started in the second half of 2007 and intensified in the second half of 2008 resulted in a marked decrease in the distances to distress in all sectors, most notably in the banking (MFI) sector and the other financial sectors. This decrease started from the high level of distances to distress (i.e. low perception of distress risk) that had prevailed throughout the years before the turmoil, mainly driven by the very moderate levels of asset volatility observed in all sectors.

Despite of the rather sharp decline in distances to distress since the third quarter of 2007, the distances to distress for many sectors still remain above the troughs reached during the previous episode of financial turmoil after the bursting of the "new economy" stock market bubble. This holds particularly true for the NFC sector and reflects, on the one hand, the fact that the

Table C.2 Simulated transmission of shocks on distances to distress

(Q3 2008; in percentage)

	Decrease in distance-to-distress
NFC	3.70
HH	0.20
MFI	0.30
INS	7.00
OFI	2.52
GOV	0.10
ROW	0.20

Source: ECB calculations.

Notes: The shock scenario is the same as that applied in Table C.1. For the explanation of the abbreviations used, see the note in Chart C.1.

epicentre of the turmoil remained in the financial sector until late 2008 and, on the other, the fact that leverage among euro area non-financial firms was relatively low prior to the eruption of the financial stresses in August 2007.

Table C.2 shows the simulated impact on the sector-level distances to distress of the first-round shock applied in the balance sheet contagion analysis above. The shock that was assumed to materialise in the third quarter of 2008 would have caused the distances to distress to increase by between 2.5% and 7% in the OFI, insurance and NFC sectors. The impact on the risk indicators in the other sectors would have remained more muted, reflecting either low leverage (in the household sector) or an already increased level of risk (in the RoW sector).¹⁵

CONCLUDING REMARKS

This article used the data from the euro area accounts to construct a type of "systemic risk map" that illustrates how financial shocks are transmitted across sectors within the

¹⁴ It should also be noted that, in general, the level of default risk among households, for example, is a tiny fraction of that among non-financial corporations, owing to the much higher leverage and asset volatility in the latter sector.

¹⁵ An important mitigating factor with respect to the observed increase in risk is that, for the sake of simplicity, asset volatility of the affected sectors is assumed to remain unchanged. In practice, asset volatility typically increases quite sharply during periods of stress, which would push the distances to distress further down, possibly substantially so.

euro area financial system. The network of leveraged exposures was then combined with a contingent claims analysis, which introduces an additional channel of transmission that traces the propagation of risk in the financial system. What is important is that this final step makes it possible to produce indicators for risk exposure and risk contagion at the sector level. Analysis of balance sheet and risk networks is especially useful for macroprudential purposes, where attention should be paid to the vulnerabilities that arise from the interlinkages among agents in the financial system. In particular, these types of tools allow the early identification of risks that may not be easily recognisable when the focus of the analysis is only on measures of leverage and volatility within individual sectors.