



SPECIAL FEATURES

A FIRE-SALE EXTERNALITIES IN THE EURO AREA BANKING SECTOR¹

This special feature studies the effects of fire-sale externalities in the euro area banking sector. Using individual bank balance sheet data and a framework developed by Greenwood et al. (forthcoming), an indicator is constructed to quantify the effects of fire-sale spillovers in terms of losses in equity capital in the banking system. For some countries, loans to monetary financial institutions are the most systemic assets, while for others loans to households can pose systemic risks. Thanks to the fine granularity of the background data and monthly updates, the index can be used as an early warning indicator and a measure of systemic risk.

INTRODUCTION

The recent financial crisis has shown that a shock affecting a financial institution can propagate to other financial firms and jeopardise the stability of the whole financial system. One channel through which such contamination can spread is fire-sale spillovers.

The mechanics of such spillovers can be described as follows. As documented in a number of studies, financial firms often target leverage.² When a bank experiences an adverse shock to its equity capital which increases its leverage, one way for the bank to return to the target leverage is to shed assets and pay off debt. At times when market liquidity is scarce or an asset is illiquid, a financial institution which is forced to liquidate that asset may depress its price. As a consequence, other financial institutions holding the same asset (or assets of the same asset class) will suffer a loss, even if they do not have direct links with the firms initiating the (fire) sale. Affected financial institutions may, in turn, sell other assets to bolster their balance sheets. Therefore, common asset exposures can result in contagion, even between seemingly unrelated assets and banks.

Fire sales and the ensuing liquidation spirals have received extensive attention in the literature and are believed to have contributed significantly to systemic risk in the financial system.³ The paper of Greenwood, Landier and Thesmar (Greenwood et al. (forthcoming)) proposes a framework to quantify such fire-sale externalities.⁴

By using individual bank balance sheet data, this special feature provides an aggregate vulnerability (AV) indicator for euro area banks which is based on the framework developed by Greenwood et al. This vulnerability indicator measures how much equity capital in the banking system is wiped out after a shock and when liquidation spirals occur.

The results of the analysis show that losses arising from asset fire sales can be large. The average value of fire-sale externalities after a 1% shock to assets throughout the sample is 37% of total euro area banking system equity. The AV index reaches its peak in autumn 2008, coinciding with the intensification of the financial crisis after the failure of Lehman Brothers. The outbreak of the euro area sovereign debt crisis in 2010 is also captured. Importantly, it is found that for some countries the

The mechanics of fire sales

Losses arising from asset fire sales can be large

1 Prepared by Lorenzo Cappiello and Dominik Supera.

2 See, for instance, Adrian, T. and Shin, H., "Liquidity and Leverage", *Journal of Financial Intermediation*, Vol. 19, No 3, July 2010, pp. 418-437.

3 See, for example, Shleifer, A. and Vishny, R., "Liquidation Values and Debt Capacity: A Market Equilibrium Approach", *Journal of Finance*, Vol. 47, No 4, 1992, pp. 1343-1366; Shleifer, A. and Vishny, R., "Fire Sales in Finance and Macroeconomics", *Journal of Economic Perspectives*, Vol. 25, No 1, 2011, pp. 29-48; Brunnermeier, M. and Pedersen, L., "Market Liquidity and Funding Liquidity", *The Review of Financial Studies*, Vol. 22, Issue 6, June 2009, pp. 2201-2238; and Allen, F., Babus, A. and Carletti, E., "Asset commonality, debt maturity and systemic risk", *Journal of Financial Economics*, Vol. 104, Issue 3, 2012, pp. 519-534.

4 Greenwood, R., Landier, A. and Thesmar, D., "Vulnerable Banks", *Journal of Financial Economics*, forthcoming.

Policy implications

most systemic assets in the banking system are loans to monetary financial institutions (MFIs), while for others loans to households can pose systemic risks. However, asset “systemicness” differs across countries. The framework applied in this study can also be used to analyse the systemicness of specific assets. For example, when assuming a 25% write-off on a given set of countries’ government bonds, the AV index increases well before the outbreak of the sovereign debt crisis.

The findings have important policy implications. First, the analysis sheds light on the importance of monitoring leverage as a complement to capital requirements. Second, it shows that systemic risk can build up when certain assets in the banking system keep on growing, even if leverage remains approximately constant.⁵ This suggests that in some cases a mere (relatively rapid) expansion of assets can pose risks to financial stability. Third, the study shows that banks in different countries can be vulnerable to different asset classes. This indicates that policy measures aimed at guaranteeing financial stability should be calibrated to the specific characteristics of different jurisdictions, a lesson which is very relevant for the euro area. Finally, since fire-sale spillovers can propagate across countries, it is essential that policy measures are coordinated internationally.

Greenwood et al. apply their framework to produce measures of the contribution of each bank to systemic risk, the interconnectedness between two banks and an AV indicator. In particular, using commercial bank exposures provided by the European Banking Authority’s July 2011 stress test, Greenwood et al. analyse the 2010-11 sovereign debt crisis and estimate the potential spillovers following the significant haircuts experienced by a set of European sovereigns. Furthermore, they evaluate the outcome of various policies aimed at reducing fire-sale spillovers during the crisis, i.e. forced mergers among the most exposed banks and equity injections.⁶

In a related work, Duarte and Eisenbach (2014) implement the Greenwood et al. framework⁷ to construct the time series of a systemic risk measure that quantifies vulnerability owing to fire-sale spillovers using the regulatory balance sheet data for US commercial banks. Not surprisingly, their measure reaches a peak in Q4 2007 and spikes again in Q3 2008 but, interestingly, it starts to increase already in 2004, showing its relevance as an early warning indicator.

5 In this case equity capital grows at the same pace as assets.

6 While forced mergers would not have substantially reduced systemic risk, equity injections can significantly decrease banking sector vulnerability.

7 For more details on the methodology, see Greenwood et al., op. cit.; Duarte, F. and Eisenbach, T., “Fire-Sale Spillovers and Systemic Risk”, *Federal Reserve Bank of New York Staff Reports*, No 645, 2014.

Box A.1

THEORETICAL FRAMEWORK

To evaluate spillover losses, this special feature adopts the framework proposed by Greenwood et al. and assumes that banks are hit by a hypothetical shock, which either erodes their returns on assets or their equity capital. This will give rise to the liquidation spirals discussed in the Introduction above. In line with Greenwood et al., the framework is based on three hypotheses. First, it is assumed that banks target a given leverage and that, after a shock, they will sell assets in order to return to that target leverage. This leverage-targeting hypothesis is in line with

empirical evidence from, for example, Adrian and Shin (2010),¹ who show that banks manage book leverage to offset shocks to asset values. Second, it is assumed that banks, after the initial shock, will sell assets proportionally to their existing holdings. The third assumption is that asset sales generate a price impact of 10 basis points per €10 billion worth of assets sold. This assumption is in line with Amihud (2002),² who shows that this figure is close to the liquidity of a broad spectrum of stocks. Since most of the assets considered are less liquid than stocks, the price impact generated by the model is likely to be at a lower bound.

To understand the intuition of the model, it is useful to consider the following steps in the sequence of events occurring in a fire sale. The framework adopted quantifies each of those steps. The algebra is worked out in Greenwood et al. and Duarte and Eisenbach (2014).³

1) Initial stage (bank j)

A population of N banks and K assets is considered. For simplicity, it is assumed that $N = 2$ (indexed by j and h) and $K = 3$ (indexed by X , Y and Z). At time $t = 0$, bank j has total assets $A_{j,0}$, total liabilities (excluding capital) $L_{j,0}$ and total capital $E_{j,0}$. It is also assumed that at time $t = 0$, bank j 's asset holding is given by $X_{j,0}$, $Y_{j,0}$, and $Z_{j,0}$. Part 1 of the table below shows the balance sheet of bank j at time $t = 0$. For illustrative purposes, throughout the time periods of the exercise, we assume that bank h holds only assets Y and Z .

2) Initial shock and direct losses (bank j)

At time $t = 1$, a shock occurs that wipes out 50% of asset X value. As a result, bank j incurs direct losses since the value of asset X decreases from $X_{j,0} = €50$ billion to $X_{j,1} = €25$ billion. At the same time, its capital is eroded by the same amount from $E_{j,0} = €50$ billion to $E_{j,1} = €25$ billion. Part 2 of the table presents the balance sheet of bank j at time $t = 1$, after the shock. As a result of the haircut, the leverage of bank j increases from $Lev_{j,0} = L_{j,0}/E_{j,0} = 3$ at time $t = 0$ to $Lev_{j,1} = 6$ at time $t = 1$. To keep leverage constant at the level prevailing before the shock, bank j sells $SO_{j,1} = Lev_{j,0} * (E_{j,0} - E_{j,1}) = €75$ billion. Since it is assumed that bank h does not hold asset X , it will not be subject to the direct losses stemming from the initial shock.

3) Asset sales (bank j)

At time $t = 2$, bank j sells its assets proportionally to its holding at time $t = 1$:

$$- \text{Asset } X: SO_{j,1} * X_{j,1} / A_{j,1} = €10.71 \text{ billion}$$

$$- \text{Asset } Y: SO_{j,1} * Y_{j,1} / A_{j,1} = €21.42 \text{ billion}$$

$$- \text{Asset } Z: SO_{j,1} * Z_{j,1} / A_{j,1} = €42.86 \text{ billion}$$

Part 3 of the table reports the balance sheet of bank j at time $t = 2$.

1 Adrian and Shin (2010), op. cit.

2 Amihud, Y., "Illiquidity and stock returns: cross-section and time-series effects", *Journal of Financial Markets*, Vol. 5, Issue 1, 2002, pp. 31-56.

3 Op. cit.

4) Price impact (bank *j*)

Bank *j*'s asset sell-off affects the prices of assets at time $t = 3$. Assuming that the price impact is 10 basis points per €10 billion worth of assets sold, the liquidation of assets by bank *j* has the following price impact:

- Asset *X*: 14.29 basis points = 0.1429%
- Asset *Y*: 28.58 basis points = 0.2858%
- Asset *Z*: 57.14 basis points = 0.5714%

Therefore, bank *j* incurs additional losses stemming from the adverse price impact. The value of assets in the balance sheet of bank *j* decreases accordingly (as in step 2):

- Asset *X*: $X_{j,3} = X_{j,2} * (1 - 0.5714\%) = €14.27$ billion
- Asset *Y*: $Y_{j,3} = Y_{j,2} * (1 - 0.2858\%) = €28.50$ billion
- Asset *Z*: $Z_{j,3} = Z_{j,2} * (1 - 0.5714\%) = €56.81$ billion

Part 4 of the table reports bank *j*'s balance sheet at the end of time $t = 3$. The decrease in the value of assets – which takes into account the effects stemming from the price impact – triggers a second-round sell-off of assets (as in step 3).

Balance sheet of banks *j* and *h* throughout the sample

1. Initial stage, $t = 0$, bank <i>j</i>		2. Initial shock and direct losses, $t = 1$, bank <i>j</i>	
Assets:	Liabilities:	Assets:	Liabilities:
$X_{j,0} = 50$	$L_{j,0} = 150$	$X_{j,1} = 25$	$L_{j,1} = 150$
$Y_{j,0} = 50$	Capital:	$Y_{j,1} = 50$	Capital:
$Z_{j,0} = 100$	$E_{j,0} = 50$	$Z_{j,1} = 100$	$E_{j,1} = 25$
3. Asset sales, $t = 2$, bank <i>j</i>		4. Price impact, $t = 3$, bank <i>j</i>	
Assets:	Liabilities:	Assets:	Liabilities:
$X_{j,2} = 14.29$	$L_{j,2} = 75$	$X_{j,3} = 14.27$	$L_{j,3} = 75$
$Y_{j,2} = 28.58$	Capital:	$Y_{j,3} = 28.5$	Capital:
$Z_{j,2} = 57.14$	$E_{j,2} = 25$	$Z_{j,3} = 56.81$	$E_{j,3} = 24.86$
5. Initial stage, $t = 2$, bank <i>h</i>		6. Spillover losses, $t = 3$, bank <i>h</i>	
Assets:	Liabilities:	Assets:	Liabilities:
$Y_{h,2} = 75$	$L_{h,2} = 100$	$Y_{h,3} = 74.79$	$L_{h,2} = 100$
$Z_{h,2} = 50$	Capital:	$Z_{h,3} = 49.71$	Capital:
	$E_{h,2} = 25$		$E_{h,2} = 24.5$

5) Initial stage (bank *h*)

Since it is assumed that bank *h* holds only assets *Y* and *Z*, it will not be affected by the initial shock to asset *X*. However, bank *j*'s asset sell-off determines a price impact which affects bank *h* because of the decline in the value of assets *Y* and *Z* observed in step 4. In this example, the target leverage of bank *h* is assumed to be equal to 4. Therefore, the price impact on assets *Y* and *Z* triggers a sale of assets by bank *h* as well. Part 5 of the table shows bank *h*'s balance sheet at time $t = 2$.

6) Spillover losses (bank *h*)

The price impact determines the spillover losses to all banks holding assets of the same asset class as those sold. In this example, in order to keep leverage constant, bank *h* needs to sell a share of its assets (as in step 3). This action decreases the price of those assets which are sold off and triggers a liquidation spiral in the banking system. The result of the price impact through bank *j*'s sales is that the value of bank *h*'s assets will decrease as shown in the calculations for step 4:

$$- \text{Asset Y: } Y_{h,3} = Y_{h,2} * (1 - 0.2858\%) = \text{€74.79 billion}$$

$$- \text{Asset Z: } Z_{h,3} = Z_{h,2} * (1 - 0.5714\%) = \text{€49.71 billion}$$

Part 6 of the table shows bank *h*'s balance sheet after spillover losses. To keep leverage constant at the level prevailing before the shock (i.e. $Lev_{h,1} = 4$), bank *h* needs to sell €2 billion worth of assets as described in step 3.

APPLICATION OF THE MODEL TO EURO AREA BANKS

A framework based on that proposed by Greenwood et al. is implemented using granular balance sheet data for a large sample of euro area banks.⁸ Observations span from July 2007 until May 2014 at monthly frequency. The total AV index is computed at each point in time. Assuming an initial shock such that all assets decrease in value by 1%, the AV index is defined as the fraction of total banking system equity capital which would be wiped out owing to direct and second-round effects of fire-sale spillovers⁹ (see Chart A.1).

The index increases steadily from around 39% of banking system equity capital in July 2007 until it reaches its peak in September 2008 at 52.5%, at the time of the Lehman Brothers failure.

Chart A.1 Aggregate vulnerability index

(July 2007 – May 2014; fraction of total banking system equity)



Sources: ECB and ECB calculations.

The vulnerability index reaches its peak in September 2008 and decreases thereafter

⁸ For the purpose of this special feature, we use confidential balance sheet panel data for the 177 largest euro area credit institutions.

⁹ The purpose of the exercise is not to identify the shock but to show the effects of the decrease in the value of the assets on equity.

Systemic risk can build up when assets keep on growing, even if leverage remains constant...

... but it decreases when banking system leverage falls and assets grow at a slower pace

The AV index then follows a downward sloping trend, with a spike in May 2010 capturing the outbreak of the sovereign debt crisis in the euro area. From September 2011 until May 2012 this trend comes to a halt and the index stabilises at around 35%, most likely reflecting the spread of the sovereign debt crisis within the euro area. Thereafter the index decreases almost continuously.

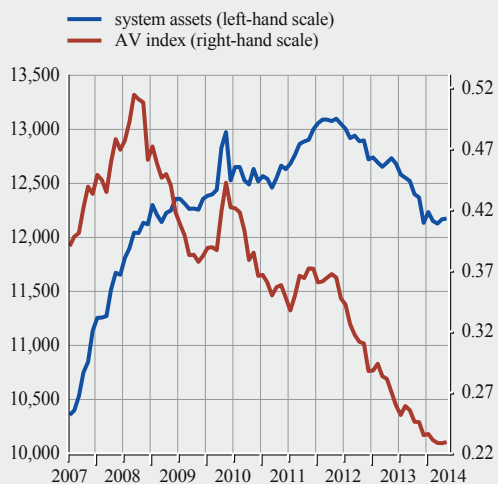
DECOMPOSITION OF THE AGGREGATE VULNERABILITY INDICATOR

To understand the factors determining the extent of the spillover losses and how they vary over time, the AV index is decomposed into three components: the system assets (i.e. the total size of the assets in the banking system), the system leverage (i.e. the average leverage weighted by total liabilities), and the illiquidity concentration. The first factor is a relevant determinant of the AV index since the larger the size of the assets in the system, the larger the overall price effects. The system leverage contributes more than proportionately to the AV indicator because, for a given shock, the more highly leveraged the system, the larger the fire sales and, for a given fire sale, the larger the spillover losses in terms of equity capital. The illiquidity concentration denotes a modified Herfindahl-Hirschman index for asset classes. This factor indicates that if a given asset is widely held in banks' balance sheets and has a large aggregate share, if it is illiquid and concentrated in banks which are large, relatively highly leveraged and exposed to the initial shock, then that asset will contribute significantly to the vulnerability of the system (see Duarte and Eisenbach (2014)). Charts A.2 to A.4 plot the evolution of total assets, system-wide leverage and illiquidity concentration against the AV index.

This set of charts suggests that it is mainly the increase in asset size and, to a lesser extent, the rise in system leverage that drive the increase of the AV index from July 2007 to September 2008. In particular, a hypothetical shock would have its largest effect on the AV index when assets grow very rapidly (at around 1.1% on average per month) between July 2007 and September 2008. The

Chart A.2 System assets and aggregate vulnerability index

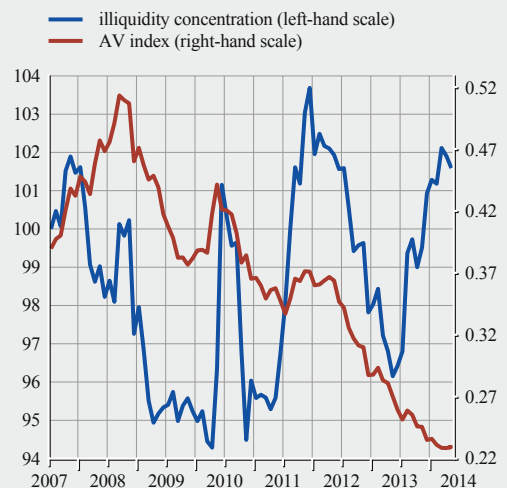
(July 2007 – May 2014; EUR billions (left-hand scale); fraction of total banking system equity (right-hand scale))



Sources: ECB and ECB calculations.

Chart A.3 Illiquidity concentration and aggregate vulnerability index

(July 2007 – May 2014; index: July 2007 = 100 (left-hand scale); fraction of total banking system equity (right-hand scale))



Sources: ECB and ECB calculations.

effect is smaller when assets grow at a slower pace (on average 0.27% per month) between October 2008 and March 2012. On the other hand, the substantial decrease in system leverage (from 16.5 in September 2008 to around 11.0 in May 2014) is largely responsible for the downward sloping trend of the AV index observed from September 2008. The illiquidity concentration is likely to contribute to the spike in the index observed in May 2010 and the interruption of the downward trend between September 2011 and May 2012, when the AV index tends to stabilise.

ASSET “SYSTEMICNESS”

The AV index is also decomposed according to the “systemicness” of each asset type – computing the contribution of an asset category to the aggregate vulnerability. Specifically, we consider the following question: how much equity capital would be lost owing to fire sales

if a particular asset class were the only one that suffered a shock? Chart A.5 shows that the most systemic asset classes (with the average share in the index in parentheses) throughout our sample are loans to MFIs (31.3%), loans to households (18.5%) and loans to non-financial corporations with a maturity of over one year (13.3%). It should be pointed out that the contribution of each of these three asset classes to the index is different from their respective share in banks’ portfolios, namely 25.3%, 20.4% and 14.9%. This indicates that, besides the size of an asset class, it is its systemicness that plays an important role (i.e. the fact that the asset is held by systemic banks which are defined as those banks that are large and leveraged and, in turn, hold large proportions of other illiquid assets). It should be noted that the framework of fire-sale spillovers applies well to tradable assets, while less to loans. However, after an adverse shock to a given class of loan extended to a given sector, banks might reduce their lending to that sector. This increases the risk associated with that class of loan, which may trigger a further reduction in lending (or a tightening of lending standards, including an increase in loan interest rates). This can have a negative impact on the sector and backfire on the banks themselves in a self-reinforcing spiral. As a result, banks could further reduce lending and fire-sale (tradable) assets in their portfolio. Following this reasoning, even though loans are relatively illiquid assets, the framework of Greenwood et al. could still be applied to a bank’s entire balance sheet.¹⁰

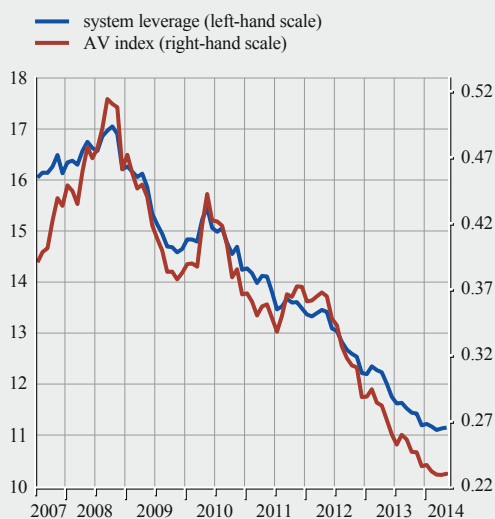
Furthermore, the AV index is decomposed according to the “systemicness” of the banking sector of each euro area Member State. This enables the estimation of the contribution of each country’s banking sector to euro area banking sector fragility. As shown in Chart A.6, banks in group 1 countries – Austria, Belgium, Finland, France, Germany, Luxembourg, the Netherlands and Slovenia – contribute the most to the AV index (70.7%), while the contribution to the index of banks in group 2 countries – Greece, Ireland, Italy, Portugal and Spain – is on average smaller (20.3%).¹¹

¹⁰ Indeed Greenwood et al. and Duarte and Eisenbach (2014) also apply the framework to loans. See also Ramcharan, R. and Rajan, R. “Financial Fire Sales: Evidence from Bank Failures”, *Finance and Economics Discussion Series*, Federal Reserve Board, June 2014.

¹¹ Data for banks in Cyprus, Estonia, Malta and Slovakia were not available for the whole sample. Those banks are therefore excluded from the analysis.

Chart A.4 System leverage and aggregate vulnerability index

(July 2007 – May 2014; fraction of total banking system equity)



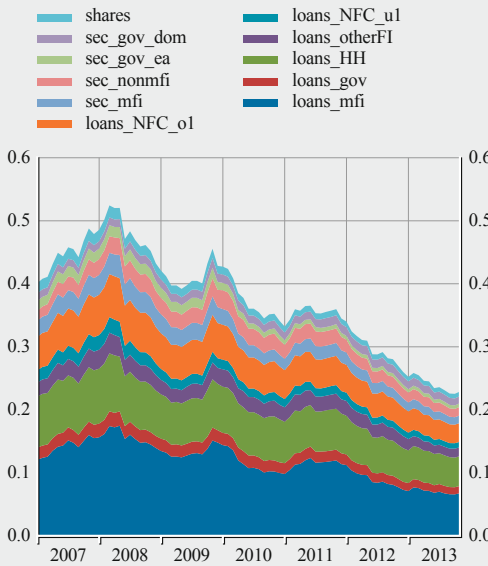
Sources: ECB and ECB calculations.

Certain asset classes are more systemic than others

Group 1 countries make the largest contribution to the AV index

Chart A.5 Contribution of each asset to the aggregate vulnerability index

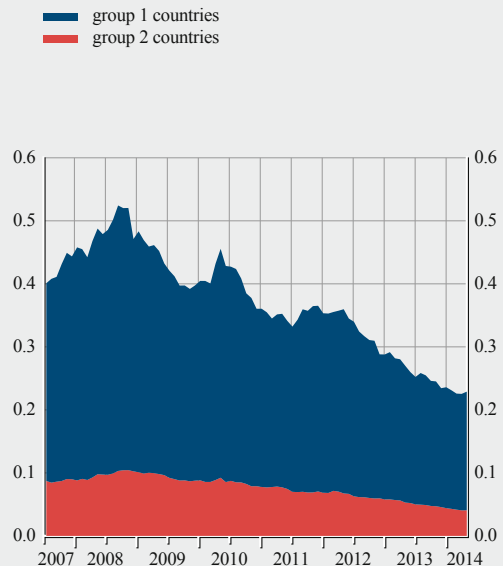
(July 2007 – May 2014; fraction of total banking system equity)



Sources: ECB and ECB calculations.
Notes: loans_mfi: loans to MFIs; loans_HH: loans to households; loans_NFC_o1: loans to non-financial corporations with maturity over one year; loans_gov: loans to general government; loans_otherFI: loans to other financial institutions, pension funds and insurance corporations; loans_NFC_u1: loans to non-financial corporations with maturity up to one year; sec_mfi: securities of MFIs; sec_nonmfi: securities of non-MFIs (excluding general government); sec_gov_ea: securities of euro area governments (excluding the reference area); sec_gov_dom: securities of domestic government; shares: shares and other equities.

Chart A.6 Aggregate vulnerability index – country breakdown

(July 2007 – May 2014; fraction of total banking system equity)



Sources: ECB and ECB calculations.
Notes: Group 1 countries refers to Austria, Belgium, Finland, France, Germany, Luxembourg, the Netherlands and Slovenia. Group 2 countries refers to Greece, Ireland, Italy, Portugal and Spain. Data for banks in Cyprus, Estonia, Malta and Slovakia were not available for the whole sample. Those banks are therefore excluded from the analysis.

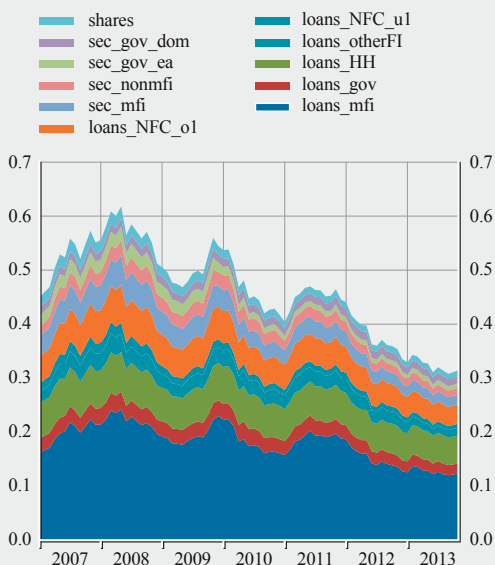
It is worth mentioning that the contribution of the banking sector of each country group is different from the share of that group's banking sector, as the share is computed as a fraction of the total euro area banking sector assets. The share of the group 1 countries is 59.6%, while that of the group 2 countries is 31.2%. Thus, the group 1 countries' banks are more systemic than banks in group 2 countries, not only because they have the largest share of assets but also because they hold a large proportion of illiquid assets.

The countries mostly exposed to loans to MFIs are mainly group 1 countries, while the countries mostly exposed to loans to households are mainly group 2 countries

The framework also enables vulnerability indices to be constructed grouping those countries' banking sectors that share similar sources of fragility. As shown from the breakdown into asset classes of the AV index, the most systemic assets are loans to MFIs and households. The analysis shows that the countries mostly exposed to loans to MFIs are mainly group 1 countries, while the countries mostly exposed to loans to households are mainly group 2 countries. The share of loans to MFIs in the AV index for the first group of countries is on average equal to 39.3%, while the share of loans to households in the AV index for the second group is on average equal to 30%. The indices for both groups of countries are reported in Charts A.7 and A.8 and are characterised by a similar pattern.

Chart A.7 Aggregate vulnerability index specific to countries with loans to MFIs being the most systemic asset

(July 2007 – May 2014; fraction of total banking system equity)

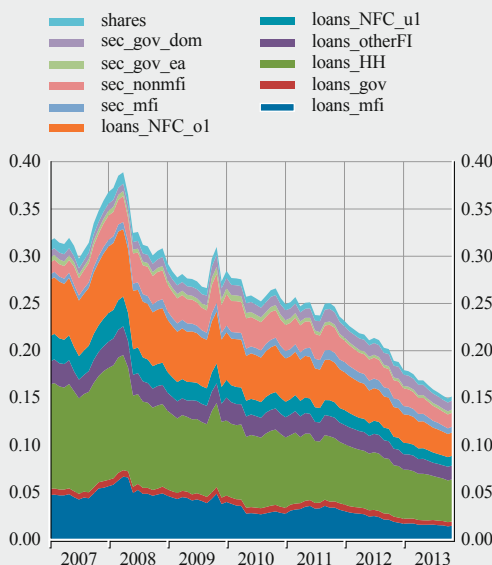


Sources: ECB and ECB calculations.

Notes: loans_mfi: loans to MFIs; loans_HH: loans to households; loans_NFC_o1: loans to non-financial corporations with maturity over one year; loans_gov: loans to general government; loans_otherFI: loans to other financial institutions, pension funds and insurance corporations; loans_NFC_u1: loans to non-financial corporations with maturity up to one year; sec_mfi: securities of MFIs; sec_nonmfi: securities of non-MFIs (excluding general government); sec_gov_ea: securities of euro area governments (excluding the reference area); sec_gov_dom: securities of domestic government; shares: shares and other equities.

Chart A.8 Aggregate vulnerability index specific to countries with loans to households being the most systemic asset

(July 2007 – May 2014; fraction of total banking system equity)



Sources: ECB and ECB calculations.

Notes: loans_mfi: loans to MFIs; loans_HH: loans to households; loans_NFC_o1: loans to non-financial corporations with maturity over one year; loans_gov: loans to general government; loans_otherFI: loans to other financial institutions, pension funds and insurance corporations; loans_NFC_u1: loans to non-financial corporations with maturity up to one year; sec_mfi: securities of MFIs; sec_nonmfi: securities of non-MFIs (excluding general government); sec_gov_ea: securities of euro area governments (excluding the reference area); sec_gov_dom: securities of domestic government; shares: shares and other equities.

The AV indices plotted in Charts A.7 and A.8 both reach a peak in autumn 2008 and then show a downward sloping trend. The difference between the indices for the two country groups mainly stems from the size of the fire-sale externalities. In the case of the first group (consisting mostly of group 1 countries), a 1% reduction in the value of all assets in the banking system would have wiped out around 62% of total equity capital at its peak in autumn 2008 and 46% on average throughout the sample. In the case of the second group (consisting mostly of group 2 countries), the direct effects and fire-sale externalities are of a lower magnitude – 39% at the peak and 26% on average.

EFFECTS OF AN ADVERSE SHOCK TO SOVEREIGN BONDS

Finally, the last experiment studies a bank's susceptibility to the deleveraging cycle caused by a potential write-down of sovereign bonds. Echoing a similar exercise carried out by Greenwood et al., a 25% write-off in the value of Greek, Irish, Italian, Portuguese and Spanish government debt is considered.¹² The data used provide information on banks' exposure to the sovereign debt

Assuming a substantial write-off of group 2 countries' government bonds, the AV index increases well before the outbreak of the sovereign debt crisis

12 The size of the assumed write-off is in line with the maximum drop in price observed for Spanish and Italian government bonds between August 2010 and November 2011, which was 21.8% and 29.5% respectively. By way of comparison, the price of Greek and Portuguese government bonds fell by 97.6% and 61.1% respectively between November 2009 and February 2012. The value of Irish government bonds decreased by 48.7% between November 2009 and June 2011.

of their own country of residence. However, the dataset only shows the banks' holdings of aggregate foreign sovereign debt. For example, one cannot observe how much German or French sovereign debt is held by an Italian bank; only the total foreign euro area debt held by the Italian bank can be observed. To circumvent this data limitation, it is assumed that banks in the group 1 countries hold a share of group 2 countries' government bonds equal to the share of outstanding public debt of group 2 countries in the total public debt of all of the euro area countries considered in this study.¹³ Chart A.9 plots the vulnerability indices after a 25% drop in the value of group 2 countries' government bonds for i) the group 1 countries' banks and ii) the group 2 countries' banks only.¹⁴

The AV index for the banking system for group 1 countries remains stable at around 20-25% until May 2010. The index thereafter exhibits a downward sloping trend, which stabilises at about 10%. On the other hand, the AV index for the banks in group 2 countries increases well before the outbreak of the sovereign debt crisis – from 13% in July 2007 and reaching a peak of 31% in May 2010. It then decreases before rising again in April 2012 with the second wave of the sovereign debt crisis. The index has decreased since April 2013 as confidence in the group 2 countries improves.

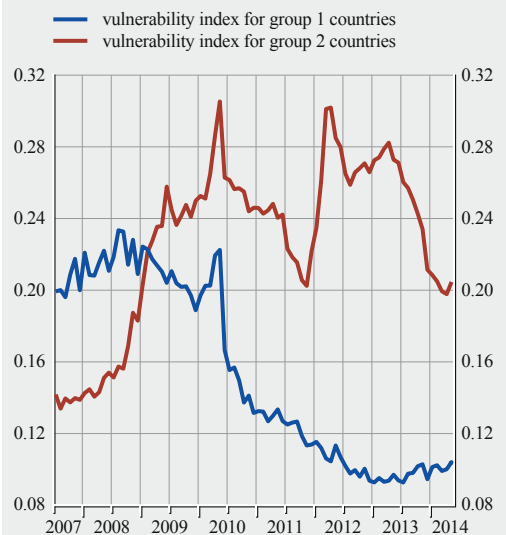
CONCLUDING REMARKS

Using a simple framework and detailed balance sheet data for euro area banks, this special feature finds that spillover losses from fire sales can be large. The average value of fire-sale externalities throughout the sample from July 2007 until June 2014 is 37% of the total euro area banking system equity capital. Loans to MFIs, loans to households, and loans to firms with a maturity of over one year are the most systemic assets.

The AV index proposed can be used as a systemic risk measure and an early warning indicator. Its main advantage is that it is based on individual banks' balance sheet data. The fine granularity offered by balance sheet data provides a detailed overview of the evolution, composition and determinants of fire-sale vulnerability in the euro area banking sector. Furthermore, since the dataset underlying the analysis can be updated at a monthly frequency, the AV index is well suited for timely monitoring.

Chart A.9 Vulnerability indices after a 25% drop in the value of group 2 countries' government bonds

(July 2007 – May 2014; fraction of total banking system equity)



Sources: ECB and ECB calculations.

Notes: Group 1 countries refers to Austria, Belgium, Finland, France, Germany, Luxembourg, the Netherlands and Slovenia. Group 2 countries refers to Greece, Ireland, Italy, Portugal and Spain. Data for banks in Cyprus, Estonia, Malta and Slovakia were not available for the whole sample. Those banks are therefore excluded from the analysis.

¹³ It should be noted that this assumption can affect the results of the exercise. The conclusions should therefore be interpreted with caution.

¹⁴ The two AV indices are computed as the fraction of group 1 and group 2 countries' banking system equity capital respectively.