What does a financial shock do? First international evidence

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Abstract

In this paper we attempt to evaluate the quantitative impact of financial shocks on key indicators of real activity and financial conditions. We focus on this type of shocks as they have received wide attention in the recent literature and in the policy debate after the global financial crisis. We estimate a panel VAR for 21 advanced economies based on quarterly data between 1985 and 2011, where financial shocks are identified through sign restrictions. We find robust evidence that financial shocks can be separately identified from other shock types and that they exert a significant influence on key macroeconomic variables such as GDP and (particulary) investment, but it is unclear whether these shocks are demand or supply shocks from the standpoint of their macroeconomic impact. The financial development and structure of a given country is found not to matter much for the intensity of the propagation of financial shocks. Moreover, we generally find that these shocks play a role not only in crisis times, but also in normal conditions. Finally, we discuss the implications of our findings for monetary policy.

Keywords: Financial shocks, VAR, identification, stochastic pooling, leverage, credit.

JEL: E44, E52, E58, G20.

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1 Introduction

The global financial crisis 2007-09 has shaken the previous consensus, widespread amongst policy makers and academics, that 'leaning against the wind' policies were undesirable or impractical, both in the regulatory and macro-prudential sphere as well as a strategy of monetary policy for central banks (Bernanke and Gertler 2001). In the regulatory field, initiatives to strengthen the 'leaning against the wind' orientation of policy are well under way in a global context under the aegis of the G20, while in the monetary policy field we are still at a relatively early stage of the debate.

It is important to be clear, however, against what type of underlying phenomena and shocks the policies (including monetary policy) should lean. In the paper we focus in particular on credit creation and conditions in the financial sector and we aim to understand whether they are autonomous sources of shock against which policies need to take steps or just a side-show or a second order phenomenon which can be accounted for by more traditional and better understood macroeconomic shocks. Indeed, many of the shocks that have been considered in the academic literature as well as in the practice of policy for decades (such as demand, supply and cost push shocks) can and should as well lead to fluctuations in credit, asset prices and financial market conditions. Therefore, what are the features of the winds that one should lean against?

There is already a large literature analysing the role of the financial sector as an amplifier of other types of shock. Credit cycles may result from collateral constraints and financial frictions, as emphasised by Kiyotaki and Moore (1997). Monetary policy and technology shocks may be propagated differently in an environment in which agents have collateral constraints. However, this amplification mechanism is already quite well understood, and thus taking this possible amplification better into account could lead at most to a refinement, rather than to a radical change, in the policy conduct after the crisis. In addition, the literature has emphasised that the degree of amplification stemming from credit constraints is empirically very limited outside crisis periods (Kocherlakota 2000; Cordoba and Ripoll 2004).[1]

In this paper, therefore, we do not focus on the amplification role of a given shock that financial intermediation could exert on real activity. Rather, we are closer to another, now almost mainstream narrative of the 2007-09 global financial crisis, which interprets it as resulting from shocks originating endogenously within the financial sector. Some of these contributions emphasise how changes in asset prices may be driven by non-fundamental or 'inefficient' shocks. Gilchrist and Leahy (2002), for example, identify asset price bubbles as resulting from favourable news about future productivity that eventually fail to materialise. A small but growing literature examines the relevance of 'news' and 'confidence' shocks, as in Blanchard et al. (2009),

[1] See however recent attempt by Liu et al. (2009). An important, more recent twist to this literature, based on the role of banks' risk limits (such as Value at Risk) and their amplification role, has been proposed by Adrian and Shin (2008).

Barsky and Sims (2008), and Beaudry and Portier (2006). Farmer (2009) proposes a model in which confidence is an independent driver of economic activity. In this literature, confidence may be driven, in particular, by 'noise shocks', i.e. news items which are wrongly interpreted as anticipators of gains in productivity and which therefore lead to a later reversal in confidence and in real activity (see also Gilchrist and Leahy, 2002). Lorenzoni (2009) uses a very similar concept in order to build a theory of aggregate demand shocks. Geanakoplos (2009) relates variations in leverage to fluctuations in asset prices and concludes that the leverage cycle is potentially harmful and should be regulated. In his work, leverage cycles are primarily caused by lenders' perception of (default) risk, which is time-varying. A small but burgeoning literature (Jermann and Quadrini 2009; Gilchrist and et al. 2009; Nolan and Thoenissen 2009; Meh and Moran 2010; Hirakata et al. 2010) propose Dynamic Stochastic General Equilibrium (DSGE) models with 'financial shocks', which are either i) shocks affecting the degree to which collateral can be used in financial intermediation or ii) shocks to the financial friction in a Bernanke-Gertler-Gilchrist financial accelerator model. In this way, these shocks can directly affect the extent in which borrowers are constrained and as such they also directly influence leverage. For example, exogenous changes in the loan to value ratio of a mortgage contract due to a more optimistic view about future developments in credit risk could be characterised as a financial shock. Adrian et al. (2010) also posit that changes in the risk appetite of financial intermediaries, induced by the time variation in a Value-at-Risk type constraint on their portfolios, influence the growth of the balance sheets of these intermediaries and hence their leverage.

Against this background, this paper represents a first attempt at a systematic *quantification* of the real and financial effects associated to financial shocks based on a panel of 21 advanced economies. One of the greatest challenges for the identification of leverage cycles lies in the data availability, since consistent time series of leverage and credit spreads simply do not exist in most countries, let alone the problem of cross country comparability. For this reason we take a more indirect route, estimating VAR models at a country level for each of the 21 countries to then aggregate the cross sectional results via the 'stochastic pooling' approach of Canova and Pappa (2007). In this way, the weight of a single country in the aggregate is inversely proportional to the precision of the estimates of the country-specific VAR. Based on the impulse responses of the VAR models we seek to identify three different types of shocks: (non-financial) aggregate demand, monetary policy and financial. We identify the structural shocks through sign restrictions. In particular, we impose that the financial shock has an impact on the *relative share price of the financial sector vs. the non-financial sectors*, given that this sector (i) is at the heart of the financial intermediation process that is subject to the disturbance and (ii) is itself significantly more leveraged than the rest of the economy.[2] The intuition behind this choice is that a shock that is accompanied by rising leverage and less stringent credit constraints has a larger impact on the

[2] The way in which we identify higher or lower exposure to financial leverage is inspired by the classic paper of Rajan and Zingales (1998).

return on equity (and hence the share price) of those sectors that are more highly exposed to the external finance premium and therefore benefit more than the others from more favourable financing conditions. For example, a shift to a more optimistic assessment of credit risk should affect much more the equity of a firm that is heavily dependent on external finance, say a high tech firm, and much less a firm that is typically largely financed out of its own means, say a large energy company.

Overall, the key objective of this paper is to empirically identify financial shocks based on a wide database covering all main industrial countries, in order to evaluate their impact on standard macro variables, also relative to other types of shocks, and to assess their domestic and global relevance. We also address the question of whether the strength and propagation of financial shocks depends on the structural characteristics of the individual countries, such as the degree of financial development and openness. Is it the case, for instance, that a country with a particularly large financial sector, such as Iceland or Ireland, is more exposed to financial shocks? Finally, we touch upon the potential role of monetary policy in offsetting the effect of financial shocks which is relevant in the 'leaning against the wind' debate, similar to Assenmacher-Wesche and Gerlach (2010).

Being severely constrained in the set of variables that have sufficiently harmonised data at an international level, our approach should be considered as a first attempt to collect international evidence and is possibly not the ideal way to identify financial shocks from a methodological standpoint. In particular, the identification of financial shocks could be corroborated and improved when looking at a more restricted set of countries for which more data are available, such as data on credit spreads and on the balance sheet of financial intermediaries.

It should also be noted that the financial shocks that we seek to identify in this paper are different from the credit demand and supply shocks that have been typically dealt with in the literature. Credit demand and supply shocks can have their roots in developments recorded both within and outside the financial sector, which in turn may be largely unrelated to the financial shocks examined in this paper. For example, a positive technology shock can increase both credit demand (by increasing borrowers' permanent income) and credit supply (by increasing borrower's net worth). By contrast, financial shocks (since they have a direct connection to leverage and credit creation) should be most correlated with those shocks that drive asset prices *and credit*, the shocks which - according to many observers - are most dangerous from a financial stability perspective (Blinder 2008; Schularick and Taylor 2009). This can be illustrated by looking at the data reported in *Figure 1*, which shows the share price of the financial sector in the United States relative to a composite stock market index of that country of all non-financial firms (henceforth named *relative share price*). The collapse of the dot-com bubble in the early 2000s has had little impact on the relative share price (while the financial distress of 1998-99 is clearly visible in the data), especially when compared to its large and abrupt fall observed during the 2007-09 global financial crisis. We now know the different macroeconomic implications of the two episodes.

Our study reaches four main conclusions. First, we find evidence that a financial shock - at least the kind of financial shock we identify - exerts a non-negligible influence on key macroeconomic variables such as output, investment and the price level. Second, we find that it is generally not clear whether the financial shock is mainly an aggregate demand shock or a supply shock, since the impact of this shock on the CPI (which would tell apart one interpretation from the other) is not estimated very precisely. Third, we find that our results are not driven in particular by crisis times, including the 2007-09 global financial crisis. This suggests that financial shocks affect the economy also in normal times and not only in turbulent periods, as could have been surmised. We also find that results are generally robust when taking out periods of credit booms and busts and of very low nominal and real interest rates. Finally, we find that the propagation of the financial shocks does not depend much on the financial and economic structures of the countries, nor do financial development and structure generally matter for the transmission of the other identified shocks (demand and monetary policy) within a given country.

The paper is structured as follows. Section 2 presents the econometric approach and the identification of the shocks. Section 3 describes the data and presents some preliminary analysis. Section 4 presents the results. Section 5 draws the implications of our results for monetary policy, and Section 6 concludes.

2 Specification and identification of the financial shock

For each country i (see *Table 1* for the country list) we estimate a VAR and apply sign restrictions as in Rubio-Ramirez, Waggoner and Zha (2010) to identify structural shocks. In each domestic VAR foreign variables are included in order to control for international interdependence and to better identify domestic, as opposed to global or foreign, structural shocks. The estimated VAR is therefore,

$$A_{i0}x_{it} = A_i(L)x_{i,t-1} + C(L)x^*_{it} + B_i\varepsilon_{it} \tag{1}$$

where x is a $k * 1$ vector,

$$x_{it} = [p_{it}, y_{it}, inv_{it}, R_{it}, \widetilde{q}_{it}, q_{it}^{NONFIN}, b_{it}] \tag{2}$$

$$\widetilde{q}_{it} = \frac{q_{it}^{FIN}}{q_{it}^{NONFIN}} \tag{3}$$

with R the short-term interest rate, p the log of the CPI, y log real GDP, inv log investment, q^{NONFIN} is the composite share price index of non-financial sectors ($\widetilde{q}$ is the relative share price of the financial sector compared with the rest of the stock market), b is credit to the private sector, and A_{i0} is a non-singular $k * k$ matrix. All variables in the VAR except the nominal rate R are in logs and standardised, in order to ensure comparability across countries. We apply 2 quarterly lags for all countries (1 lag for the variables in the x^* vector).

The x^* vector

$$x^*_{it} = [p^*_{it}, y^*_{it}, R^*_{it}, b^*_{it}] \quad (4)$$

contains country-specific "external" variables included as exogenous variables in the VAR for each country i. The "external" variables for each country are computed by aggregating variables over remaining countries using their relative real GDP weight at Purchasing Power Parity (PPP), hence excluding country i itself.[3] The data are quarterly and the sample starts in 1985 so that data come from a relatively homogeneous period in terms of macroeconomic volatility and monetary policy regime.

A crucial step in our analysis is the identification of the financial shock and of the other structural shocks. We rely as much as possible on existing DSGE models to figure out what the implications of these shocks on the variables of interest should be. In particular, we interpret the financial shock primarily as a *shock to the financial sector*, i.e. as a sectoral shock, in line with the interpretation of Hirakata et al. (2010): a positive financial shock is a transfer of net worth from the non-financial to the financial sector. Hirakata et al. (2010) show that the distribution of net worth between the financial and non-financial sector matters for investment. This concept is closely related to the definition of financial shock given by Hall (2010): a positive financial shock is akin to a selective fall in taxation of financial intermediation, which makes financial intermediation less costly and more efficient. As a consequence of this supply-like shock, the firms offering financial intermediation services – the financial intermediaries – become more profitable, and more credit is extended. Nolan and Thoenissen (2009) also have a similar definition where "financial frictions shocks" are shocks to the efficiency of contractual relationships between borrowers and lenders. After such a shock, it becomes more (or less) difficult and costly to write debt contracts. Gilchrist et al. (2009) define the financial shock as an additive shock to the external finance premium. Meh and Moran (2010) identify the financial shock as an exogenous change in bank net worth (such as a tax on bank capital). Since bank capital is a key tool of financial intermediaries' debt production capacity, the shock may have wider consequences for financing conditions and the real economy.

Against this background, this paper uses the stock price of the financial sector as the key variable for the identification of the financial shock. If the financial shock is akin to a *sectoral tax on financial intermediation*, then it should further compress profits in the financial intermediation sector relative to the broader economy and especially so relative to sectors that are more distant from financial intermediation and debt. Therefore, we postulate that a positive (negative) financial shock has a positive (negative) impact on the ratio between the share price of the financial sector and the composite stock market index, under the assumption that share prices

[3] Aggregates using trade weights are very similar, but are available for a shorter sample period.

correctly discount current and expected profits.[4] In addition, as the financial sector is also typically more leveraged than most other sectors, it is bound to be affected more strongly than less leveraged sectors by a disturbance to intermediaries' debt production capacity and a corresponding rise in the external finance premium. Indeed in several DSGE models with financial frictions, the impact of financing conditions on entrepreneurial net worth is larger, the more leveraged the entrepreneur (see e.g. Christensen and Dib 2008, eq. (15), p. 160; Gilchrist et al. 2009, eq. (25), page 18). For *both* these reasons, we expect a financial shock to influence the share price index of the financial sector more than the broad index. Note that in the remainder of this paper, unlike in the mentioned DSGE models, for illustration purposes a financial shock has a positive connotation, i.e. it is a situation where debt accumulation is made easier and financial intermediation is more profitable.

In addition to its effect on the financial stock price index, we expect a positive financial shock to lead to higher credit to the private sector and to higher private investment, on account of the fact that external finance is an important element in the production of capital goods, more so than for consumption goods (Hall 2010).[5] This also helps distinguish this shock from a *credit demand* shock, which should push the quantity of credit and its price in the same direction. A rise in the price of credit (for which international data of sufficiently harmonised nature are unfortunately not available) should arguably have a negative, not a positive effect on investment. Note that we are instead open as to whether the financial shock is mainly a demand or a supply shock in terms of economic activity, and therefore do not constrain the reaction of the price level to this shock. Theoretically, one could expect either effect to prevail depending on whether credit availability matters more for the expenditure or the production side of the economy (e.g. whether the credit shock is more concentrated in the household or the corporate sector). In some recent DSGE models like Meh and Moran (2010) and Gerali et al. (2010), the financial shock is mainly a supply shock because it influences firms' marginal costs. In other models, however, a credit supply shock has the effect of an aggregate demand shock (e.g. Curdia and Woordford 2010).[6]

Another important element for the identification of the financial shock is the need to ensure that it is not contaminated by other shocks and that shocks are identified in a mutually exclusive way so that they do not fully overlap. In this respect, a particular concern could be that the financial shock is actually capturing an expansionary monetary policy shock. A tightening of monetary policy conditions might indeed have effects (fall in investment and credit, stronger contraction of profits

[4] Indeed, in the DSGE model of Meh and Moran (2010) a negative financial shock (negative shock to bank capital in their terminology) leads to a fall in investment and in bank net worth, the latter bigger than the fall in entrepreneurial net worth. If the stock market is rational, this should translate into a fall in the *relative* share price of the financial intermediation (banking) sector.

[5] Indeed, as pointed out by Hall (2010), the Great Recession of 2008-09 is almost entirely concentrated in investment (including consumer durables).

[6] For an overview, see Table 2 in Hristov et al. (2011).

in the financial sector) that are similar to those generated by a positive financial shock. We therefore impose that, after a positive financial shock (i.e. when credit conditions improve), the reaction of the short term interest rate is *not negative*. We also include non-financial, non-monetary demand shocks in the identification, in order again not to confound them with the financial shock. Specifically, a demand shock is a shock leading to a rise in the price level, output as well as to a higher interest rate, conditions which keep it distinct from a monetary policy shock. The non-financial demand shock is also assumed to lead to a rise in the share price of non-financial firms, but not to a larger rise in the stock price of financial firms, in contrast with the financial shock; this latter condition ensures that all the shocks we identify are mutually exclusive. We identify the three structural shocks simultaneously, since this should produce more reliable results (see Paustian 2007), although this is computationally challenging in our multi-country analysis. Overall, these considerations lead to the following matrix of sign restrictions:

Table - Sign restrictions applied

	Non financial demand shock	Monetary policy shock	Financial shock
p_t	> 0 (a)	> 0 $(t+8)$	
y_t	> 0 (a)	> 0 (a)	
inv_t		> 0 (a)	> 0
R_t	≥ 0	< 0	≥ 0
$\frac{q_t^{FIN}}{q_t^{NONFIN}}$	≤ 0		> 0 (and $q_t^{FIN} > 0$)
q_t^{NONFIN}	> 0	> 0	
b_t			> 0

Note: Sign restrictions are imposed using the approach of Rubio-Ramirez, Waggoner and Zha (2010). They are imposed on impact unless otherwise stated.

(a) Restriction also imposed on the accumulated impulse response after one year.

We estimate the VAR models country-by-country and therefore need a metric to standardise the size of the structural shocks. To ensure comparability across countries, as noted, we standardise all variables with the exception of the short term interest rate, and assume that (i) the size of the demand shock is determined by its impact on real GDP, (ii) the size of the monetary policy shock by its impact on the short term rate, and (iii) the size of the financial shock by its impact on the relative share price of the financial sector. The size of the monetary policy shock, in particular, is equal to a rise of the short term rate by 100 basis points. Finally, we follow Fry and Pagan (2010) and select a single model among the many which are found to satisfy the sign restrictions. This is chosen as the model which generates impulse responses having the minimum distance from the median of all impulse responses across all models which satisfy the restrictions. Although it is more common to report the median impulse response across all models satisfying the restrictions, selecting a single model has the advantage that structural shocks are orthogonal, which allows the computation of the variance decomposition with the contribution of the different shocks.

Country-level impulse responses and the associated standard errors are aggregated with a stochastic pooling approach as proposed by Canova and Pappa (2007) and in particular as applied in Calza et al. (2011). In this (Bayesian) stochastic pooling approach, described formally in the Annex, each country receives a weight which is inversely proportional to the precision of the associated impulse responses. In other words, a country whose impulse response is characterised by very large standard errors will receive a smaller weight than a country with smaller standard errors. Since this may imply that some countries receive a tiny weight, we also look at simple averages of the impulse responses across countries (where standard errors are obtained assuming no cross sectional dependence) as a robustness check.

3 Data and preliminary analysis

As mentioned before, the empirical analysis is conducted on data from 21 advanced countries (see *Table 1*), sampled quarterly between 1985:1 and 2011:2 (or longest available sample). In addition to the variables included in the VAR (see above) we also use Moody's data on Expected Default Frequencies (henceforth EDF) computed across financial and non-financial firms separately, considering the median EDF across these firms as well as their 90th percentile, although these data do not enter the VAR in direct way. *Table 2* reports information on the sources and characteristics of the data that we use. *Table 3* reports the summary statistics for all variables. Note that the EDF data are available for a smaller sample (since 1992) and also for fewer countries than the 21 considered in the VAR estimation. For this reason we keep them out of the baseline analysis, for which over 2,000 quarterly observations are available as a whole.

We also collect annual data on selected structural characteristics of the countries (not reported in Table 3) which may be behind the origination and/or the propagation of financial shocks. In particular, we look at three measures of financial development compiled by the World Bank, namely stock market capitalisation over GDP, private credit over GDP, and liquid liabilities over GDP. We also look at four measures of openness, namely financial openness (sum of external financial assets and liabilities over GDP), the ratio of foreign loans and international debt to GDP, and trade openness (sum of imports and exports over GDP). These data are helpful to test the robustness of our results, i.e. their stability across different country groups.

(Tables 1–3 here)

Because the relative share price of the financial sector vs. the non-financial sectors plays a key role for the identification of the financial shocks, it is important to first devote some time to the analysis of its properties. As noted in the previous section, ideally we would like this measure to reflect both the relative health of the financial sector (compared to the rest of the economy) and the relative performance of the more leveraged sectors, i.e. the sectors that are more exposed to external finance. On the first question, we need to evaluate, in particular, whether the fluctuations in the relative share price of the financial sector just reflects the business cycle as such, or it really captures the degree of distress prevailing in the financial sector. In order to test for this conjecture, we estimate the following panel regression,

$$\widetilde{q}_{it} = \alpha_i + \gamma_t + \beta \widetilde{q}_{i,t-1} + \delta ygap_{it} + \zeta Bankcrisis_{it} + \theta EDF\_FIN_{it} + \phi EDF\_NONFIN_{it} + u_{it} \tag{5}$$

where $ygap$ is the output gap (obtained by detrending real GDP using the HP filter), $Bankcrisis$ is a dummy variable taking values 1 if the country is experiencing a banking crisis and zero otherwise, from Laeven and Valencia (2008), EDF_FIN and EDF_NONFIN are the Moody's measures of distance to default in the financial and non-financial sectors respectively. *Table 4* reports results from a pooled OLS regression where we first include only the output gap, then the banking crisis dummy, then the EDF measures, and finally all variables together (which however significantly reduces the sample size). The relative share price is not correlated with the business cycle and with real GDP growth, while the bank crisis dummy has a strong and statistically significant downward impact. When putting all variables together, the only significant variables are the bank crisis dummy and the EDF *of the financial sector only*, while the output gap and the EDF of the non-financial sector are insignificant.[7] Note that this regression does not intend to establish causal interpretations; we are simply suggesting that the relative share price of the financial sector is a good indicator of the 'state of health' of the sector and does not just reflect pro-cyclicality alone.

Another piece of evidence indirectly suggesting that the variable that we use is a good indicator of financial health or distress could be gathered by looking at its behaviour across countries. In *Figure 2* we report the indicator for two countries, Ireland and Finland, which are known to be polar cases as far as the effect of the 2007-09 global financial crisis is concerned. Indeed, the relative share price of the Irish financial sector plummets in 2008-09, while it stays afloat in Finland, where instead it fell sharply in the mid-1990s, owing to the Nordic financial crisis.

(Insert Table 4 and Figure 2 here)

Turning to the second question, namely whether the relative share price of the financial sector really mirrors the worsening conditions for the more levered firms at times of turbulence, we compute (for the US only, due to data availability) the returns of two stock indices: the former refers to firms which are highly levered, the second

[7] In interpreting the size of the coefficients, note that the relative share price of the financial sector used in Table 4 is standardised.

to firms which have low leverage. In this exercise, leverage is measured through the Total Assets/Common Equity Ratio as reported at year-end in the firms' balance sheet, which are collected and distributed by Worldscope. To assign firms to the two groups we first i) compute, as of each year-end (t) between 1984 and 2009, the 10% and 90% percentile of the distribution of the cross sectional Total Assets to Common Equity ratios and then ii) assign to the first group, for all quarters in year $t + 1$, the firms whose Total Assets to Common Equity ratio is below the 10% percentile and to the second group those firms whose ratio exceeds the 90% percentile. We also compute the return indices via the 25% and 75% percentiles of the Total Assets to Common Equity ratio, finding only minor differences on their results. Overall, as of December 2010 we look at around 1000 US firms, while back in 1985 the number of available firms drops to around 400. In principle, we could enlarge the number of firms by considering as well those firms that ceased activity before end-2010, but this would not necessarily lead to a better measure of the difference in returns between the two groups. When constructing the returns for the two groups, we consider all sectors, although some more pronounced differences between the two groups could emerge if we were to keep financial and non financial firms separated. Once identified the firms in the two groups, we construct the respective indices by aggregating firm-level returns through their market capitalization recorded in the preceding quarter.

In *Figure 3*, we report the relative share price of high-levered firms vs. low-levered firms constructed in this way. Indeed, there is a high positive correlation between this series and the relative share price of the financial sector relative to the composite index.

(Insert Figure 3 here)

In order to further validate our choice of this relative share price index as our key indicator for the identification of the financial shock, we regress the monthly returns on ten US sectoral equity indices (Oil and Gas, Basic Materials, Industrials, Consumer Goods, Healthcare, Consumer Services, Telecom, Utilities, Financials, Technology) on the lagged return of the aggregate equity index, the change in the US credit spread and lagged US output gap. The credit spread (a proxy for the external finance premium) is the differential between the yield on 10-year Baa-rated industrial bonds as computed by Moody's and the 10-year Government bonds. For this analysis, the output gap is computed applying the HP filter to the monthly US Industrial production index. The regressions for the ten sectors are run between January 1985 and September 2010 so to broadly match the sample for which the VAR is estimated and the regressors are lagged by between 1 and 4 quarters, so to allow a delayed response of stock returns to the emergence of tighter credit conditions or changes in economic activity.

Again, this analysis is carried out for the United States only, where better data and longer time series are available and results are briefly described here but not reported for brevity (but they are available from the authors upon request). The sensitivity of sectoral equity returns to credit conditions is computed summing the coefficients of the four lags of the Baa credit spread if they were individually significant. Overall, the Oil and Gas and the Industrial sector do not appear to be affected by developments in the Baa-yield, once one controls for the aggregate movement of the equity market as well as for the cyclical position of the US economy. At the other extreme, Consumer Services, Financials, Telecommunication and Utilities evidence a large negative exposure to the Baa-yields, i.e. the price indices of these sectors fall when credit spreads have been getting wider, possibly reflecting a higher dependence on external finance conditions.

4 Results

4.1 Baseline

Figure 4 reports the impulse responses of all the variables in the VAR to monetary policy, demand and financial shocks, after aggregating the impulse responses across countries using the stochastic pooling approach (see the Annex). Overall, the impulse responses agree with the conventional wisdom on the effect of monetary policy and demand shocks. For example, the effect of the expansionary monetary policy shock (third column from the left) reduces the interest rate on impact and leads to a temporary rise in real GDP, investment, the share price of non-financial sectors, and credit. Although the financial stock price also rises after a monetary policy shock, the relative share price actually falls, indicating that a monetary policy loosening does not favour the financial sector in a particularly strong way compared with other sectors. Different from the typical result of identification through Cholesky decomposition (but as rather common when applying sign restrictions), there is no price puzzle as the log CPI declines on impact.

Turning to the aggregate demand shock, we find that this shock is particularly "non-financial": it leads to a statistically significant *fall* in the relative share price of the financial sector (note that our sign restrictions only imply that this variable *does not rise* in a statistically significant way) and the impact on credit to the private sector is not significant. It is likely that the latter result is due to the offsetting effects of, on the one hand, the rise in economic activity following the demand shock (which should support credit growth) and, on the other, of the rise in the interest rate and hence in lending rates, which has the opposite influence (see also Hristov et al. 2011 and Helbling et al. 2010).

(Figure 4 here)

Coming to the key shock for our analysis, i.e. the financial shock, we find that its impact is positive and statistically significant for both real GDP and investment; the impact on investment is much larger than for GDP (about 10 times), not only in absolute terms but also in relation to what we see for the monetary policy shock.

Therefore, the relative reaction of investment as compared with GDP may be a good way to identify a financial shock from other shocks such as aggregate demand and monetary policy. Overall, we find that the financial shock has expansionary features, as also visible in the sizeable and statistically significant upward impact on the share price of non-financial corporations. However, the impact on the CPI is not measured very precisely: it tends to be negative, suggesting that the shock has on balance the features of a supply shock as for example in Gerali et al. (2010), but is not statistically significant. Moreover, this result is not very robust across specifications (see further below). We also find a statistically significant and relatively large movement of the interest rate in response to a financial shock, suggesting that central banks have typically tended to react to such shocks or at least, indirectly, to their influence on key macro variables.

The stochastic pooling aggregation procedure may produce rather uneven weights across countries, depending on how precisely the respective impulse responses are estimated. This raises the question of whether results may be driven by a small subset of countries which happen to have very precise estimates. To test the robustness of the baseline results, *Figure 5* reports impulse responses based on the stochastic pooling approach (as in the baseline exercise in Figure 4) as well as on simple averages across countries, assuming that structural shocks are uncorrelated across countries. The results are overall the same in terms of sign and statistical significance; indeed for all variables the difference with the baseline estimation is not statistically significant.

(Figure 5 here)

How much can the financial shock account of the observed fluctuations in key macro variables? This is an important step of the analysis since we are not only interested in the statistical significance of this shock, but also - and even more - in judging its economic significance. *Table 5* reports the variance decomposition for the variables included in the VAR at an horizons of 24 quarters. The importance of the financial shock is non-negligible at that horizon (results for alternative horizons, not reported for brevity, led to similar results). Indeed, this shock is found to explain some 12% of real GDP variability, 16% of credit variability, and 15% of the variability of the share price of non-financial firms. These are values which are in the same ballpark of other key shocks (such as demand and monetary policy). Hence, the financial shock does play a role, although not a dominant one, in explaining business cycle fluctuations, at least according to the model and the identification scheme proposed here.

(Table 5 here)

One caveat which applies to the results just presented is that we estimate a VAR for each country separately. In reality, there is a large degree of co-movement among macroeconomic and financial variables across countries and the inclusion of the foreign variables (the x^* vector) might be an insufficient or inefficient way to capture international interdependency. Nonetheless, it is reassuring that in our empirical framework the structural shocks are not very correlated across countries, which suggests that a country-by-country estimation makes good sense from an econometric point of view. In *Table 6*, we report the average correlations and the average of the absolute values of the correlations across countries. The numbers reported in the table are relatively low and suggest that cross sectional dependence is unlikely to be a major factor undermining our results, although it may certainly affect results for individual countries.[8]

(Table 6 here)

4.2 Do financial shocks matter also in normal times?

Another potential concern with the results of the VAR exercise is that they are based on a linear structure. It may be argued that financial shocks do matter in crisis times or when they are particularly large, but not otherwise (in normal times). We cannot address this question in full in the context of our linear framework, but it is still interesting to see how our results depend on crisis times as opposed to normal times. We therefore carry out two alternative exercises in this section. First, we re-estimate the VAR models excluding the periods which have been classified as "banking crisis" by Laeven and Valencia (2008). Second, we estimate the VARs until 2007:2, leaving out the period of the global financial crisis which could arguably disproportionately influence our results.[9] The first exercise (not reported for brevity) leads to impulse responses that are very similar to the baseline ones. The outcome for the second exercise is reported in *Figure 6*. Again, results are mostly the same (quantitatively and qualitatively) as in the baseline exercise, suggesting that the latter do not depend on the observations from the global financial crisis only.

(Figure 6 here)

Another question which may arise is whether results are disproportionately driven by possibly a few episodes of booms and busts in credit growth. To address this question, we identify credit boom and bust periods by looking at deviations of real credit to the private sector (for at least two consecutive quarters) from a recursively estimated linear trend and taking a threshold which takes out 10 per cent of all observations. Moreover, in another variant of the baseline model we take out periods of very low interest rates (nominal short term rate below 2% or negative real interest rate) in order to check whether financial shocks arise in particular in periods of

[8] Correlations are indeed higher for specific country pairs. They are however almost never above 0.5.

[9] As a caveat, note that we do not change the identification of the shocks when removing observations from the sample to ensure comparability. This is based on the assumption that, when removing only a few observations, the structural shocks continue to be (at least approximately) orthogonal.

very low interest rates, as has been suggested by several observers. The results (not reported for brevity) are, overall, in line with the baseline results, again suggesting that non-linearities are probably not very important qualitatively.

4.3 Dealing with euro area monetary policy

One important caveat to our results (and indeed to all similar empirical exercises including euro area countries after 1999) is the possible mis-specification arising from the fact that country-level monetary policy shocks do not make much sense after 1999 for euro area countries. Indeed, the behaviour of the short-term interest rate is largely exogenous for the small countries in the euro area, and only partially endogenous for the larger countries. In principle, monetary policy shocks should become perfectly correlated across euro area countries after 1999, and any model where this is not the case is likely to be misspecified (although the same consideration might be valid, at least to some extent, for countries pegging their exchange rate to a foreign currency). To understand whether this potential source of mis-specification matters a lot for our results, we re-estimated the VAR models excluding the observations for countries joining the euro area from the moment they give up their own currency. The exercise is reported in *Figure 7*: results are qualitatively the same as in the baseline exercise, although they are less precise for some variables on account of the smaller sample size. Moreover, it is interesting to note that the CPI falls after the financial shock in a statistically significant way, suggesting a supply shock interpretation of this shock in this alternative exercise.

(Figure 7 here)

4.4 Financial structure and the propagation of financial shocks

A further step in the analysis aims to test whether financial shocks are more important (in terms of their size and propagation) depending on the financial structure of the selected countries. Is it true, for example, that financial shocks are more important in countries that are more financially developed and have a bigger financial sector (say, Iceland or Ireland), as the experience of the global financial crisis of 2007-09 appears to suggest?

There are two equally plausible conjectures that one can make as to the role of financial structure in influencing the size and the transmission of financial shocks. On the one hand, a more developed financial system may lead to a better resilience in the face of unfavourable shocks, by providing a better diversification of the sources of funds. For example, if the market for a particular source of financing seizes up, firms and households can more easily tap alternative sources of funds. Regulation may also be better in more financially developed countries. Finally, in countries with lower financial development a larger share of households and firms may be financially constrained, suggesting that they are more exposed to shocks in the external finance conditions. In fact, before the 2007-09 financial crisis it was common wisdom that banking and financial crises and financial headwinds were more likely in emerging countries, characterised by a significantly lower degree of financial development (see Dorrucci et al. 2009). On the other hand, it can also be argued that financial shocks may have a bigger impact in countries with a higher degree of financial development, since this implies that more economic actors take, and depend, on debt. In these countries economic agents may be better insulated from local shocks due to the possibility of diversification, but they may be actually more vulnerable to global financial shocks. This may be particularly true for households and small firms, which do not have access to international capital markets.

In order to tackle this question, we classify our 21 countries as having 'low' or 'high' financial development and openness according to the chosen indicators (see *Table 7*). Among these variables, three pertain to financial developments (stock market capitalisation to GDP, private credit to GDP, and liquid liabilities to GDP) and four to openness (financial openness, foreign loans and international debt to GDP, and trade openness). Countries are classified as low or high if the corresponding values of these variables are above or below the cross country average. If financial development matters for the transmission of financial shocks, then we should observe that these shocks have a larger impact in countries with comparatively higher readings for the proxies for development and openness. Within the subgroups of 'high' and 'low' openness/development countries, we apply the same procedure described for the baseline exercise, aggregating country-level impulse responses through the stochastic pooling approach of Canova and Pappa (2007).

(Table 7 here)

Overall, we find that the short answer to the question posed above is that the degree of financial development does not matter much, at least amongst the advanced countries considered in our sample, in influencing the propagation of financial shocks. As an illustration, in *Figure 8* we classify countries according to their credit to GDP ratio, in *Figure 9* according to their financial openness and in *Figure 10* according to their stock market capitalisation to GDP ratio. The thin blue lines represent the countries with lower financial development or openness, and the red thicker lines the countries with higher development or openness. The analysis of these results (as well as the others for the alternative indicators of Table 7, not reported for brevity) reveals that the fundamental characteristics and quantitative impact of the financial shock do not change much, or at least not in a statistically significant way, depending on countries' financial and economic structure.[10] On the positive side, this also suggests that the baseline results (Figure 4) are remarkably robust, as they tend to prevail

[10] Although we do not have the space to discuss this in detail here, we also find this to be the case for other key shocks, such as demand shocks and monetary policy shocks. This is also surprising since it may have been expected that financial structure would matter for these shocks too, even though the precise direction in which it would matter is not clear ex ante.

in all of the country groups that we look at. Again, an exception to this general robustness finding is the reaction of the price level to the financial shock, which is statistically significant in some country groups but not in others.

Finally, it could be that financial and economic structure matters not for the propagation of shocks, but for their size, for which we need to look at a variance decomposition analysis. We therefore analyse the variance decomposition, and in particular the share of the variance explained by the financial shock, in the country groups depending on whether they are 'high' or 'low' countries. This analysis - not reported for brevity - again does not reveal economically significant differences between the two groups, according to most of the considered variables.

A caveat surrounding this analysis is that we are looking at a sample of advanced countries, whose financial and economic structure may be relatively similar (and also be endogenous). It would be interesting to repeat the analysis for emerging countries, which would represent a better test for whether the financial structure is an important factor in the transmission of financial (and non-financial) shocks.

(Figures 8-10 here)

5 Implications for monetary policy

What do our results suggest for the optimal reaction of monetary policy to financial shocks, which - as argued in the Introduction - should be a material element of the discussion on the 'leaning against the wind' approach of monetary policy? To some extent, monetary policy shocks are the mirror image of financial shocks: based on our results a contractionary monetary policy leads to a fall in investment, GDP and credit, thus potentially un-doing the effect of a financial shock. In this section, we deal with two questions, namely (i) if it is desirable for monetary policy to lean against financial shocks and (ii) if leaning against the wind is a feasible strategy when such shocks are large, on account of the zero bound for the nominal interest rate. It should be clarified that the question we ask here departs from the standpoint taken in Assenmacher-Wesche and Gerlach (2010). There, the question is whether monetary policy is well placed to stabilise asset prices and economic activity (GDP growth and consumer price inflation) at the same time (their answer being essentially no). Our analysis is *conditional on the occurrence of financial shocks*: given that a financial shock takes place, how should monetary policy react and in particular can monetary policy withstand the impact of the shock on the variables it traditionally cares about, such as economic activity and inflation?

On the first question (the *should*) the fundamental matter is whether the financial shock acts, in terms of its effects, like a demand shock (the reaction to which is straightforward) or a supply shock like an oil shock, the reaction to which depends on central bank preferences for output and inflation stabilisation, or finally it produces effects which are in between those generated by the two shocks. As mentioned, the question is unresolved in the existing DSGE literature. For example, in models like Gilchrist et al. (2009) the financial shock is mainly a supply shock similar to an oil shock: like oil, financial intermediation is a necessary intermediate input in the production process.[11] In Curdia and Woodford (2010), credit is an important determinant of aggregate demand, and shocks to credit spreads affect the IS curve and are thus akin to demand shocks. Our international evidence is also inconclusive in this regard.

If a financial shock is ultimately a linear combination of demand and supply shocks in terms of its effects on the macro-economy, it is evident that some reaction from the monetary authority may be warranted, though not as forceful as it would be if this shock were an aggregate demand shock. Another element that our analysis brings to the policy debate is that the impact of financial shocks appears to be pretty much linear, i.e. not very dependent on whether turbulent periods are included or not. This is a further element suggesting that monetary policy may be an adequate tool to withstand these shocks, at least partially. Clearly, the question of whether monetary policy should react to a financial shock is best addressed with a full-fledged DSGE model, but the empirical analysis is useful in order to give a direction and some stylised facts that a good DSGE model should be able to reproduce. We conclude that more research is needed on this important question.

Turning now to the second question (*can* central banks withstand financial shocks), how much leeway does monetary policy have in order to go against 'large' financial shocks? Based on the results of the baseline exercise reported in Figure 4, a 100 basis points increase in the short term rate leads to a peak contraction of about 5 percent in the CPI, 14 percent of real GDP and 45 percent in investment (note that these numbers should not be taken at face value since variables are standardised, in order to ensure comparability across countries). How much of an effect would a large financial shock have? Although it is not easy to answer this question, as we don't have a clear idea of what a sensible order of magnitude for a financial shock should be, let us consider one example here. We assume a shock driving the relative share price of the financial sector down one standard deviation; as is evident from Figure 1, this is more or less the order of magnitude that we see in the US data at the time of the Lehman crisis (note that data in Figure 1 are standardised). Assuming that monetary policy would want to fully compensate for this shock, how large would the interest rate intervention have to be?

Rescaling the size of the impulse responses in Figure 4, we obtain that the large negative financial shock would decrease real GDP by about 3 per cent, and investment by about 35 per cent. Hence, the same effect could be compensated (taking real GDP as the key variable) by a decline in the nominal interest rate by little more than 20 basis points; the decline in the interest rate would however have to be much larger to offset the impact on investment. This evidence indicates that, unless the interest

[11] The question is not discussed explicitly but is evident from Meh and Moran (2010), Fig. 5 on page 571; and from Gilchrist et al. (2009), Fig. 4-5 on pages 40-41.

rate is already very low, even a Lehman-type shock does not necessarily push the central bank dangerously close to the zero bound. Nevertheless, this conclusion is surrounded by a number of caveats. The first is the mechanical nature of the exercise in a backward looking model like a VAR, which should really be tested in general equilibrium and under rational expectations. Second, even though hitting the zero bound is not a major concern for even very large financial shocks *in a given quarter*, the risk is still present when negative financial shocks hit *in sequence*, as was arguably the case in the 2007-09 global financial crisis. Finally, the construction of the VAR and the identification of the structural shocks requires the shocks to be orthogonal. In reality, however, a banking and financial crisis is often accompanied by sharp declines in confidence which suggest that the central bank will have to deal with the additional impact of a negative aggregate demand shock. This could further complicate the task for monetary policy and bring the interest rate closer to the zero bound.

6 Conclusions and policy implications

In this paper, we have used data from 21 advanced countries to shed some light on the existence, impact and importance of financial shocks, which we identify using a sign restrictions approach guided by some recent contributions in the DSGE literature (Gilchrist et al. 2009, Hirakata et al. 2010, Nolan and Thoenissen 2009, Meh and Moran 2010). One key variable for the identification of the financial shock in this paper is the relative share price of the financial sector; we show evidence suggesting that this indicator is highly correlated with the health of the financial sector and more generally of the financial intermediation process.

We estimate a VAR model over 21 countries on a sample period of quarterly data going from 1985 to 2011 and aggregate impulse responses across countries using the stochastic pooling approach proposed by Canova and Pappa (2007). We find that financial shocks have a noticeable influence on key macroeconomic variables such as output, investment and the consumer price index. We also find that the financial shock is neither an aggregate demand shock or a supply shock, and our analysis does not dispel the uncertainty about the nature of this shock which exists across different DSGE models. An important finding of our analysis is that investment reacts much more than overall GDP to the financial shock, significantly more so than for demand and monetary policy shocks. This feature may help to identify financial shocks in real time.

In addition, we find that our key results are not driven by crisis periods only, nor by the data for the 2007-09 global financial crisis, as could have been suspected, nor by periods of credit booms and busts or of very low nominal and real interest rates. This in turn suggests that the effects of the financial shock prevail also in normal times and it is therefore a force to be reckoned with also in normal circumstances. Finally, we find that our results (with the exception of the effect on the price level and hence the connotation of the shock as a demand or supply shock) are broadly maintained irrespective of the financial and economic structure of the countries. In short, financial shocks matter.

One important policy implication of this study is that monetary policy is rather well placed to fight financial shocks, as its effects are found to be to a large extent the mirror image of these shocks. Indeed, we find that a contractionary monetary policy shock reduces GDP, investment and credit; it is therefore largely (though not completely) a 'financial shock in the reverse'. A crucial question mark that our work still leaves open, however, is whether financial shocks are ultimately mainly demand shocks (in which case the role for monetary policy is well established) or rather supply shocks (in which case the optimal response of the monetary authority is far less straightforward). Be it what it may, if central banks want to be able to control financial shocks more effectively, either by using monetary policy or - in collaboration with other authorities - macro-prudential tools, they will need to invest more in collecting direct and reliable data on leverage and credit risk, a point also emphasised by Geanakoplos (2009).

This conclusion, and indeed the whole of our analysis, is subject to two important caveats. Our empirical approach is linear, and implies that the effect of financial shocks can be studies using linear models. If there are important non-linearities (say, a financial shock is either too small to matter in normal times or devastating when large, in crisis times; or its effects accumulate slowly over time and subsequently crash abruptly) then the role of monetary policy to withstand these shocks is much less straightforward. Although we have tried to address this question by analysis results with and without crisis times, this is only a first step. Second, our analysis has been heavily constrained by data availability at an international level and there is ample scope to improve our identification when studying an individual country (such as the US) or a very restricted set of countries where more pertinent data may be available. There is still a lot to be done in understanding the nature of financial shocks, and the optimal policy response to them.

References

[1] Adrian, T. and H. S. Shin (2008): "Financial intermediaries, financial stability and monetary policy", paper presented at the Federal Reserve Bank of Kansas City Symposium at Jackson Hole, August 2008.

[2] Adrian, T., Moench, E. and H. S. Shin (2010): "Macro risk premium and intermediary balance sheet quantities", Federal Reserve Bank of New York Staff Reports, N. 428.

[3] Assenmacher-Wesche, K. and S. Gerlach (2010): "Monetary policy, credit and asset prices: facts and fiction", Economic Policy, 25, 63, pp. 437-482.

[4] Barsky, R. B. and E. R. Sims (2008): "Information, animal spirits, and the meaning of innovations in consumer confidence", NBER Working Paper No. 15049.

[5] Beaudry, P. and F. Portier (2006): "Stock prices, news, and economic fluctuations", American Economic Review, pp. 1293-1307.

[6] Bernanke, B. and M. Gertler (2001): "Should central banks respond to movements in asset prices?", American Economic Review, 91, 2, pp. 253-257.

[7] Blanchard, O. J., L'Huillier, J.-P. and G. Lorenzoni 2009): "News, noise, and fluctuations: an empirical exploration", NBER Working Paper No. 15015.

[8] Blinder, A. (2008): "Two bubbles, two paths", The New York Times, 15 June.

[9] Calza, A., Monacelli, T. and L. Stracca (2011): "Housing finance and monetary policy", Journal of the European Economic Association, forthcoming.

[10] Canova, F. and E. Pappa (2007): "Price Differentials in Monetary Unions: The Role of Fiscal Shocks", Economic Journal, 117, 520, pp. 713-737.

[11] Canova, F. and M. Paustian (2010): "Measurement with Some Theory: A New Approach to Evaluate Business Cycle Models", CEPR Discussion Paper, No. DP8364.

[12] Christensen, I. and A. Dib (2008): "The financial accelerator in an estimated New Keynesian model", Review of Economic Dynamics, 11, pp. 155-178.

[13] Cordoba, J. C. and M. Ripoll (2004): "Credit cycles redux", International Economic Review, 45, 4, pp. 1011-1046.

[14] Curdia, V. and M. Woodford (2010): "Credit spreads and monetary policy", Journal of Money, Credit and Banking, 42, 6, pp. 3-35.

[15] Dorrucci, E., Meyer-Cirkel, A. and D. Santabarbara (2009): "Domestic financial development in emerging economies: evidence and implications", ECB Occasional Paper No. 123.

[16] Farmer, R. E. A. (2009): "Confidence, crashes and animal spirits", NBER Working Paper No. 14846.

[17] Fry, R. and A. Pagan (2010), "Sign Restrictions in Structural Vector Autoregressions: A Critical Review", NCER Working Paper Series 57, National Centre for Econometric Research.

[18] Geanakoplos, J. (2009): "The leverage cycle", Cowles Foundation Discussion Paper No. 1715.

[19] Gerali, A., Neri, S., Sessa, L. and F. M. Signoretti (2010): "Credit and banking in a DSGE model of the euro area", Journal of Money, Credit and Banking, 42, 6, pp. 108-141.

[20] Gilchrist, S., Ortiz, A. and E. Zakrajsek (2009): "Credit risk and the macroeconomy: evidence from an estimated DSGE model", mimeo.

[21] Hall, R. E. (2010): "Why does the economy fall to pieces after a financial crisis?", Journal of Economic Perspectives, 24, 4, pp. 3-20.

[22] Helbling, T., Huidrom, R., Kose, M. A. and C. Otrok (2010): "Do credit shocks matter? A global perspective", IMF Working Paper No. 10/261.

[23] Hirakata, N., Sudo, N. and K. Ueda (2009): "Chained credit contracts and financial accelerators", IMES Discussion Paper Series No 2009-E-30.

[24] Hristov, N., Hulsewig, O. and T. Wollmershauser (2011): "Loan supply shocks dueing the financial crisis: evidence from the euro area from a panel VAR with sign restrictions", mimeo.

[25] Jermann, U. and V. Quadrini (2009): "Macroeconomic effects of financial shocks", NBER Working Paper No. 15338.

[26] Kiyotaki, N. and J. Moore (1997): "Credit cycles", Journal of Political Economy, 105, 2, pp. 211-248.

[27] Kocherlakota, N. (2000): "Creating business cycles through credit constraints", Federal Reserve Bank of Minneapolis Quarterly Review, 24, 3, pp. 2-10.

[28] Laeven, L. A. and F. V. Valencia (2008): "Systemic Banking Crises: A New Database", IMF Working Papers 224/08.

[29] Liu, Z., Wang, P. and T. Zha (2010): "Do credit constraints amplify macroeconomic fluctuations?", Federal Reserve Bank of Atlanta Nr. 2010-01.

[30] Lorenzoni, G. (2009): "A theory of demand shocks", American Economic Review, 99, 5, pp. 2050-2084.

[31] Meh, C. and K. Moran (2010): "The role of bank capital in the propagation of shocks", Journal of Economic Dynamics and Control, 34.

[32] Nolan, C. and C. Thoenissen (2009): "Financial shocks and the US business cycle," Journal of Monetary Economics, vol. 56, 4, pages 596-604.

[33] Paustian, M. (2007): "Assessing sign restrictions", The B. E. Journal of Macroeconomics, Topics, Vol. 7, Issue 1, Article 23.

[34] Rajan, R. and L. Zingales (1998): "Financial Dependence and Growth", American Economic Review, vol. 88(3), pages 559-86.

[35] Rubio-Ramirez, J. F., Waggoner, D. F. and T. Zha (2010): "Structural vector autoregressions: theory or identification and algorithms for inference", Review of Economic Studies, 2010, 77, 2, pp. 665-696.

[36] Schularick, M. and A. M. Taylor (2009): "Credit booms gone bust: monetary policy, leverage cycles and financial crises, 1870-2008", NBER Working Paper No. 15512.

Annex - Description of the stochastic pooling approach

We aggregate the cross-sectional information based on the "stochastic pooling" Bayesian approach proposed by Canova and Pappa (2007). Let $dX^i(k)$ be the estimated impulse response (say to a unit size financial shock) of variable X at horizon k for country i. Similar to Canova and Pappa (2007)[12], we assume that the prior distribution is

$$dX^i(k) = \mu_k + v_k^i, \tag{6}$$

where μ_k is the cross-country average and

$$v_k^i = N\left(0, \frac{\tau_x^2}{k^{\gamma_x}}\right), \tag{7}$$

where $\tau_x > 0$ represents the assumed degree of dispersion across countries of the response of each variable X. We choose τ_x so as to allow for a significant degree of dispersion across units. The dispersion across countries decays over time at a rate dictated by the parameter γ_x.[13] We choose a very diffuse prior for μ_k, so that the average impulse responses are practically entirely driven by the data. As shown by Canova and Pappa (2007), the posterior mean for μ_k (the variable of interest in our analysis) is a weighted average of the OLS estimates across countries, with weights given by the precision of the estimates, i.e., the inverse of their variances; the posterior precision is also a linear combination of the τ_x parameters as well as the weighted precision of the OLS estimates.

[12] We refer in particular to their procedure for US states. Note that we specify our prior on the impulse response functions directly, rather than on the coefficients of the structural MA representation as in Canova and Pappa (2007). Since shocks are of unitary size there is a direct linear mapping between the two concepts, and the two approaches are therefore equivalent.

[13] In Canova and Pappa $\gamma_x = 1$ while we set $\gamma_x = 0.25$ in order to allow for a slower decay in the cross-country differentiation with respect to the horizon, which appears to be more realistic. We calibrate τ_x (i.e., the degree of heterogeneity after 1 period) to be of the same order of magnitude as the average impulse response for each variable *on impact*, thereby allowing for a significant degree of cross-country heterogeneity.

TABLE 1. List of countries

United States	Sweden
United Kingdom	Switzerland
Austria	Canada
Belgium	Japan
Denmark	Finland
France	Ireland
Germany	Portugal
Italy	Spain
Luxembourg	Australia
Netherlands	New Zealand
Norway	

TABLE 2. Sources of the data

Variable	Source	Notes
Real GDP, GDP deflator, CPI, non-residential investment, trade openness, 3-month interest rate	OECD Economic Outlook database	Trade openness is the sum of imports and exports over GDP
Credit to the private sector	ECB for EU countries, IMF (International Financial Statistics), Flow of Funds statistics for the United States	The IMF IFS data are subject to infrequent jumps apparently caused by structural breaks in the data. The data have therefore been corrected for these breaks.
Expected Default Frequency (EDF) at 1-year horizon: financial and non-financial sector, median and 90th percentile	Moody's	The data are provided by KMV and refer to an horizon of one year. They are initially computed at the firm level, based on balance sheet data, and then aggregated across sector or countries as a whole. They are computed according to the KMV model which is in turn based on Merton's (1974) model.
Relative share price of financial sector; share price of non-financial sectors	Datastream.	
Real effective exchange rate (CPI based)	Bank for International Settlements database	Data are based on a narrow index of 27 trading partners.
Banking crisis dummy	Laeven and Valencia (2008)	Original data are annual and are interpolated to a quarterly frequency by linear smoothing
Stock market capitalisation over GDP, private credit to GDP, credit to deposits ratio, liquid liabilities to GDP, foreign loans to GDP, international debt to GDP	World Bank Database of Financial Development and Structure	Annual frequency
Financial openness	IMF International Financial Statistics	Sum of external financial assets and liabilities over GDP; annual frequency

Note: Data, unless otherwise specified, are available at a quarterly frequency from 1985:1 to 2011:2; they refer to the countries listed in Table 1.

TABLE 3. Summary statistics

Variable	*Obs*	*Mean*	*Std. Dev.*	*Min*	*Max*
Log CPI	2174	0.00	1.00	-2.89	1.66
Log real GDP	2248	0.00	1.00	-2.67	1.85
Log investment	2248	0.00	1.00	-2.85	1.94
Short term rate	2244	5.72	4.09	0.03	25.78
Log relative share price of fin. sector	2162	0.00	0.66	-3.63	5.01
Credit growth	2172	0.03	0.04	-0.34	0.34
Log real effective exch. rate	2246	4.59	0.10	4.24	5.05
EDF fin. Sector	1349	0.37	0.69	0.01	8.48
EDF non-fin. Sector	1274	0.55	0.50	0.02	3.23
EDF fin. Sector, 90th percentile	1349	3.98	5.17	0.06	35.00
EDF non.fin sector, 90th percentile	1274	7.56	7.24	0.15	35.00
Output gap	2248	0.00	0.08	-0.49	0.34
Real GDP growth	2227	0.03	0.05	-0.40	0.33
Banking crisis dummy	2268	0.17	0.37	0.00	1.00

Note: The sample period is 1980:1 to 2011:2 (or longest available period), quarterly data. See Table 2 for the sources of the data. Note that data for the CPI have been seasonally adjusted using the X12 ARIMA approach. For the country list and the sources of the data see Tables 1-2.

TABLE 4. Panel regression, log relative share price of financial sector vs. non-financial sector

	(1)	(2)	(3)	(4)	(5)	(6)
Log relative share price of fin. sector, t-1	0.9135***	0.9137***	0.9134***	0.9311***	0.9400***	0.9355***
	(0.0188)	(0.0190)	(0.0189)	(0.0190)	(0.0162)	(0.0194)
Output gap	0.0282		0.0213	-0.0458	-0.0320	-0.0745
	(0.0825)		(0.0790)	(0.0762)	(0.0988)	(0.0963)
Real GDP growth		0.0267				
		(0.2422)				
Banking crisis dummy			-0.0781**			-0.1185**
			(0.0314)			(0.0436)
EDF of financial sector				-0.0195		-0.0291**
				(0.0198)		(0.0120)
EDF of non-financial sector					-0.0292	-0.0040
					(0.0182)	(0.0173)
Observations	2,122	2,121	2,122	1,347	1,272	1,272
Number of countries	21	21	21	18	17	17
R2 Within	0.869	0.869	0.869	0.903	0.915	0.916
R2 Between	0.658	0.667	0.632	0.974	0.971	0.972
R2 Overall	0.868	0.868	0.869	0.904	0.916	0.917
Adj. R2	0.862	0.862	0.862	0.897	0.909	0.910

Note: Pooled OLS. The sample period is 1985:1 to 2011:2. The model includes country fixed effects and time dummies. Robust standard errors in parentheses, */**/*** denotes significance at the 10%/5%/1% level. The output gap is obtained by applying the HP1600 filter to the log of real GDP. See Table 2 on the sources and definitions of the variables.

TABLE 5. Variance decomposition of selected shocks

	Non-financial demand shock	*Monetary policy shock*	*Financial shock*	*Other shocks*
CPI	18.8	14.8	9.5	56.8
Real GDP	14.7	19.1	11.8	54.3
Investment	10.8	15.7	10.9	62.6
Short term rate	16.3	18.9	14.0	50.7
Relative share price of fin. sector	11.7	10.4	16.5	61.4
Credit to the private sector	14.7	16.7	16.4	52.2
Share price of non-fin. sector	13.0	11.7	14.8	60.6

Note: the table shows the variance decomposition at 24 quarters horizon. This is based on VAR models estimated on each country separately, and aggregated using the stochastic pooling approach (see Annex in the text). The variance decomposition is based on a single model per country, which ensures that the structural shocks are orthogonal among each other. The sample period is 1985:1 to 2011:2.

TABLE 6. Average cross-sectional correlation among estimated structural shocks

	Average corr.	*Average absolute corr.*
Non-fin. demand shock	0.04	0.12
Mon. pol. shock	0.06	0.14
Financial shock	0.07	0.15

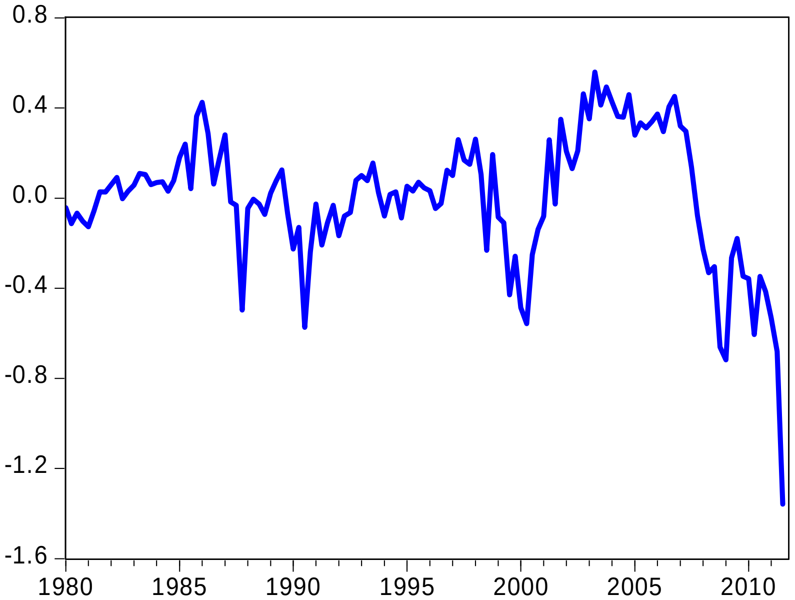
Note: The table reports the average correlation among the estimated structural shocks, identified using the sign restrictions approach. See the notes to Figure 5 for additional information. The sample period is 1985:1 to 2011:2.

TABLE 7. Structural indicators

	Low	*countries*	*High*	*countries*
Private credit / GDP	0.73	11	1.15	10
Financial openness	1.39	11	5.45	10
Foreign loans / GDP	0.19	11	0.72	10
International debt / GDP	0.20	11	0.41	10
Liquid liabilities / GDP	0.56	11	0.95	10
Trade openness	0.48	11	0.95	10
Stock mkt. cap. / GDP	0.41	10	1.00	10

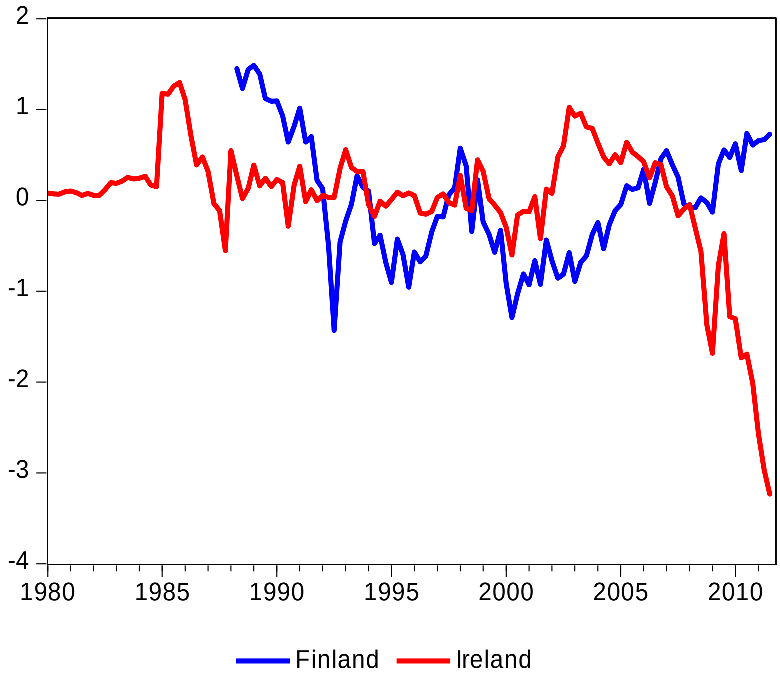
Note: The table reports sample averages of the chosen structural indicators. 'Low' is the average of the countries which are below the median, and 'High' the number of countries which are above the median. The median values are computed on the longest available sample for each country. Computing averages over the longest joint sample leads to very similar results.

FIGURE 1. Relative share price of the financial sector vs. non-financial sector in the United States, in logs



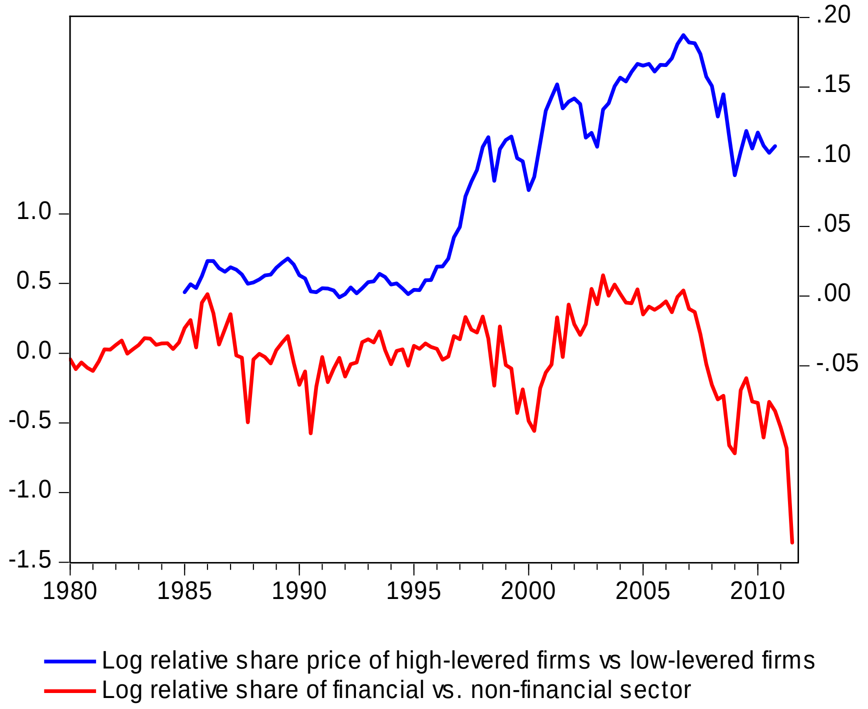
Source: Thomson Reuters.

FIGURE 2. Relative share price of the financial sector vs. non-financial sector in Ireland and Finland, in logs



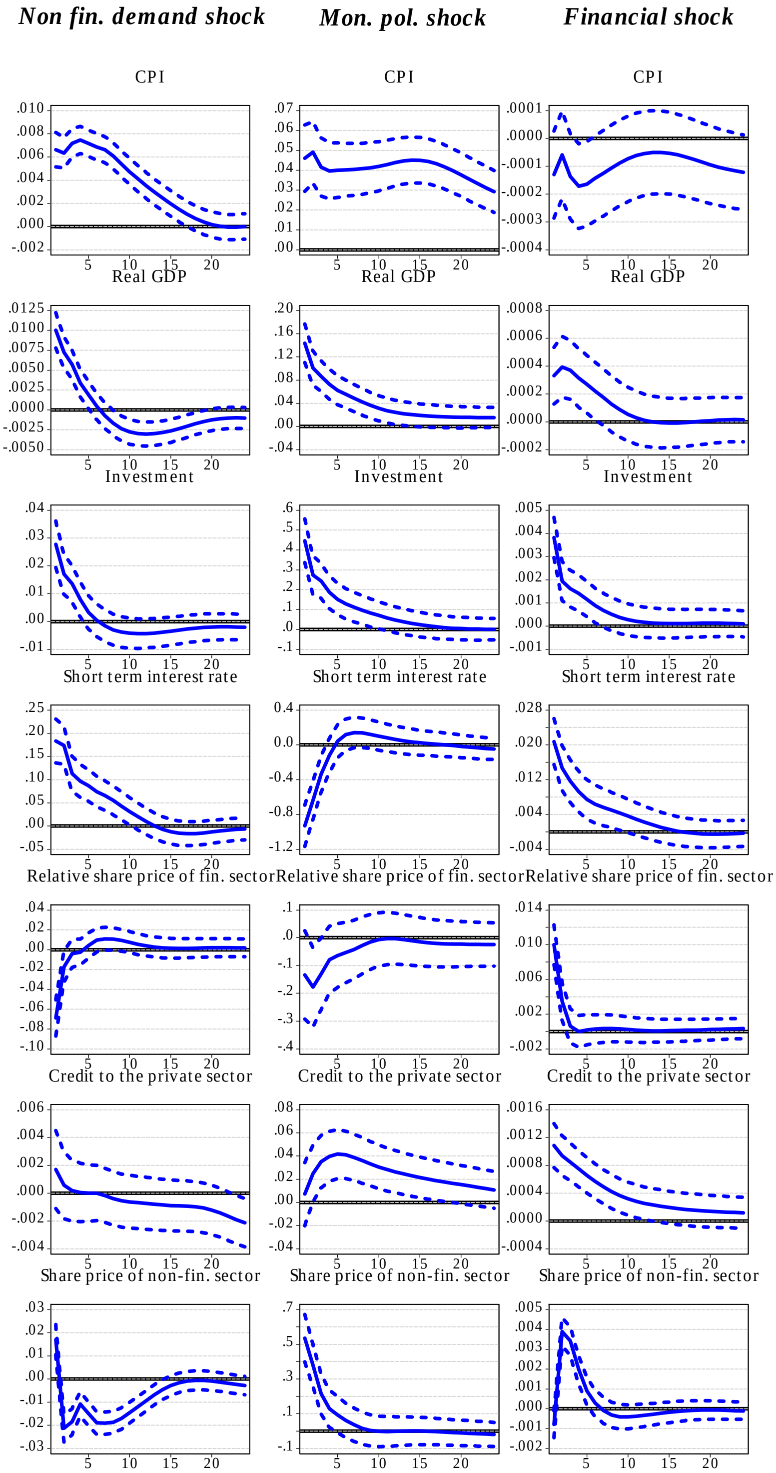
Source: Thomson Reuters.

FIGURE 3. Log relative share price of the financial sector (blue line) and log relative share price of the high-leverage firms vs. low-leverage firms (red line)



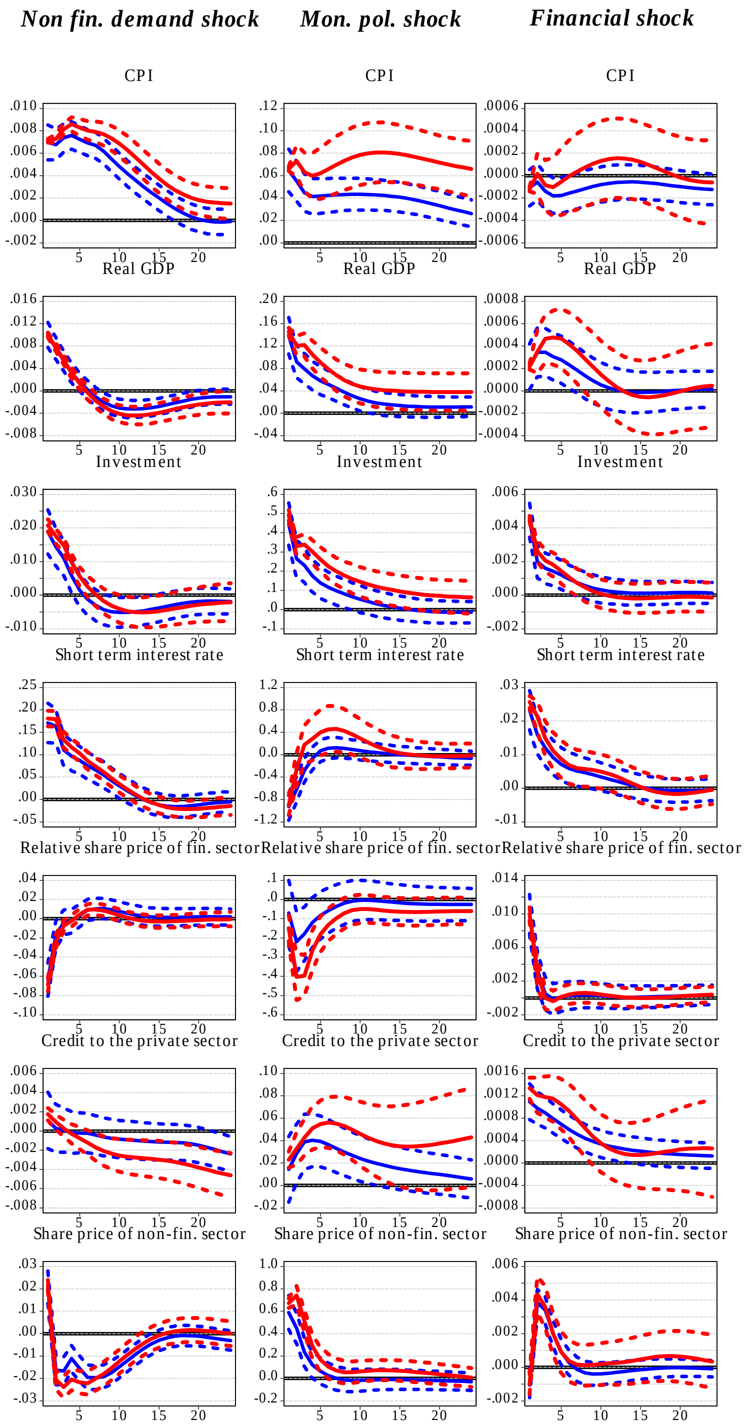
Note: The relative share price of the financial sector is reported on the right axis, the relative share price of high-leverage firms on the left axis.
Source: Thomson Reuters.

FIGURE 4. Impulse responses to structural shocks



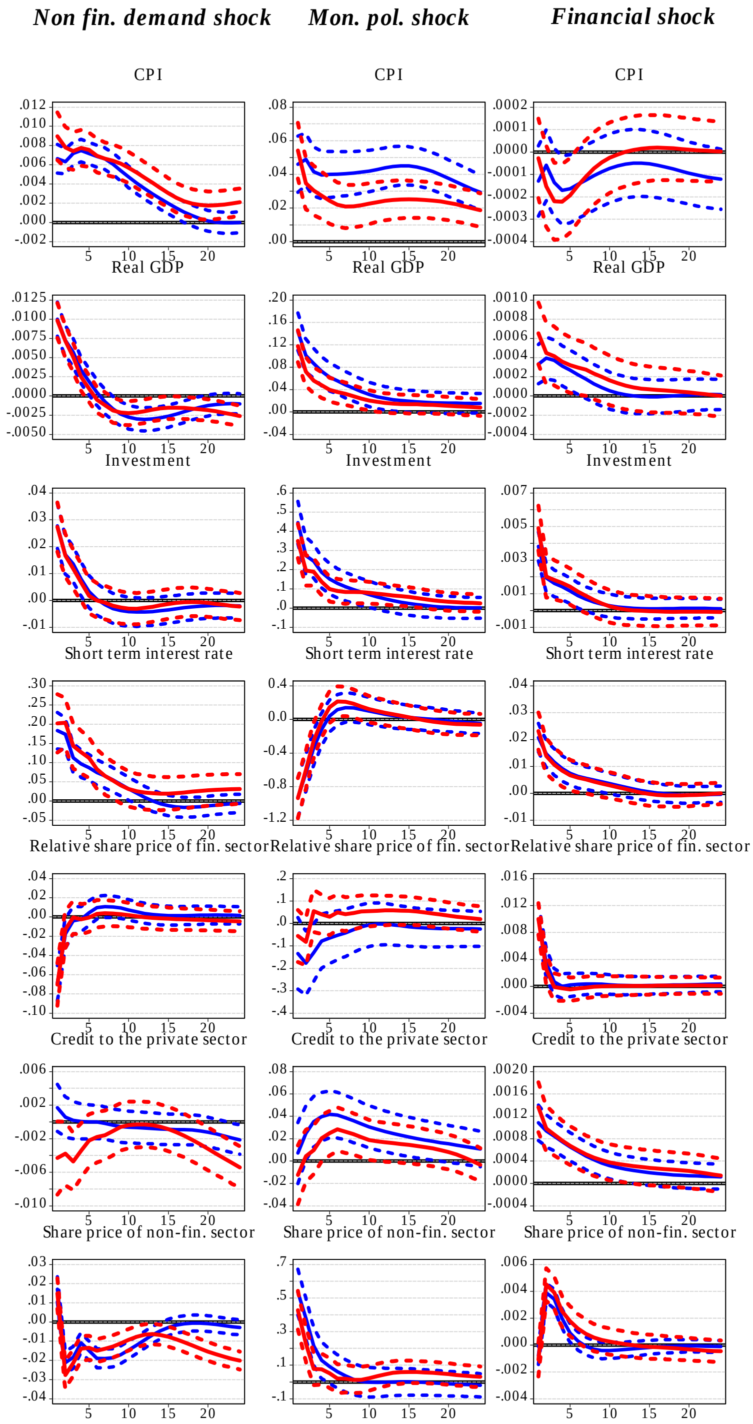
Note: The chart reports impulse responses to structural shocks identified by applying sign restrictions as in Rubio-Ramirez, Waggoner and Zha (2010). The size of the shocks is 100 basis points of the interest rate for the monetary policy shock; a rise by 1% of the standardised level of real GDP for the demand shock; and a rise of 1% of the standardised level of the relative share price of the financial sector for the financial shock. The impulse responses are based on a VAR model estimated on quarterly data from 1985:1 to 2011:2 for 21 countries, and after aggregating cross country impulse responses by applying the stochastic pooling approach (see main text and Annex for further explanation).

FIGURE 5. Impulse responses to structural shocks, <u>stochastic pooling</u> (thin blue lines) vs. <u>simple average</u> (thick red line)



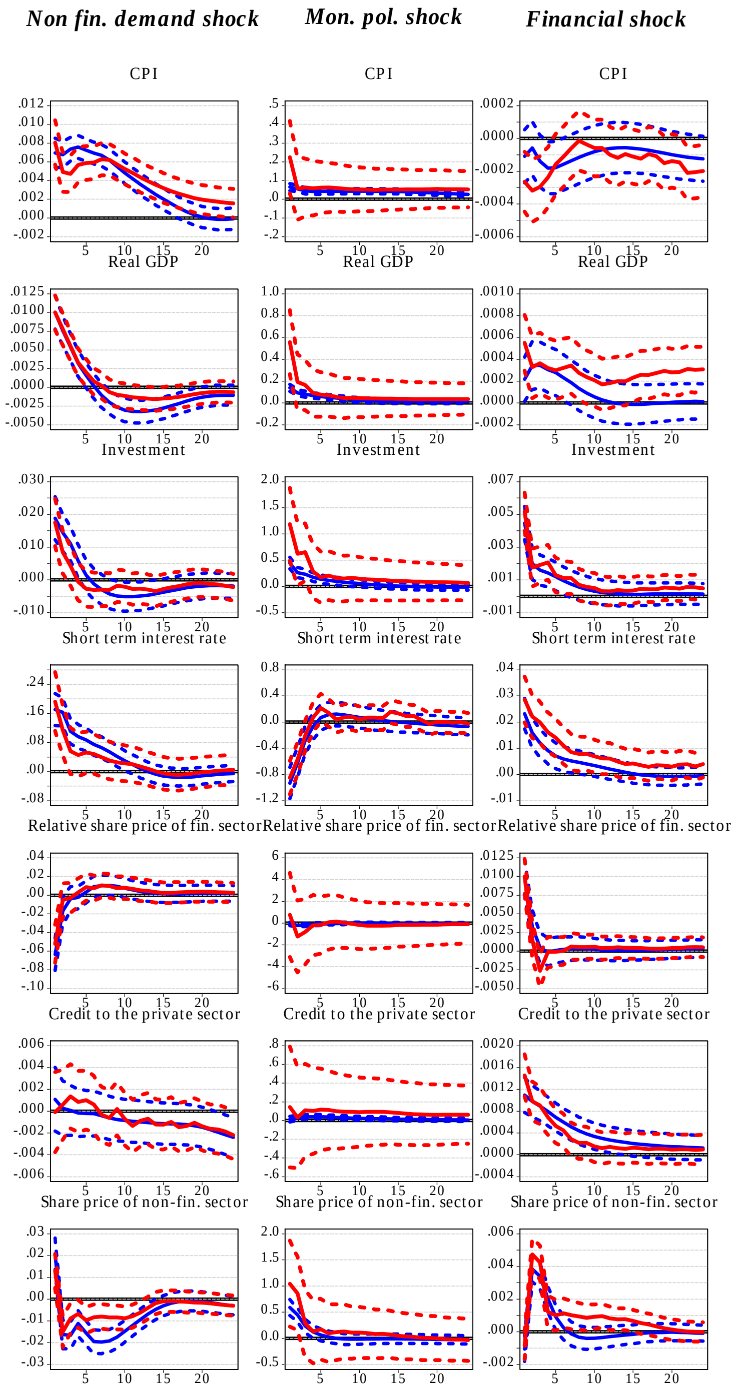
Note: <u>Thin, blue lines</u> are impulse responses to structural shocks identified by applying sign restrictions as in Rubio-Ramirez, Waggoner and Zha (2010) and aggregated across countries using the stochastic pooling approach. The size of the shocks is 100 basis points of the interest rate for the monetary policy shock; a rise by 1% of the standardised level of real GDP for the demand shock; and a rise of 1% of the standardised level of the relative share price of the financial sector for the financial shock. The impulse responses are based on a VAR model estimated on quarterly data from 1985:1 to 2011:2 on 21 countries, and after aggregating cross country impulse responses by applying the stochastic pooling approach (see main text and Annex for further explanation). The <u>thick red lines</u> report the same impulse responses which are aggregated across countries by taking the arithmetic average across them without any further adjustment, and assuming that countries are independent among each other.

FIGURE 6. Impulse responses to structural shocks, <u>full sample</u> (thin blue lines) vs. <u>excluding the 2007-09 global financial crisis</u> (thick red line)



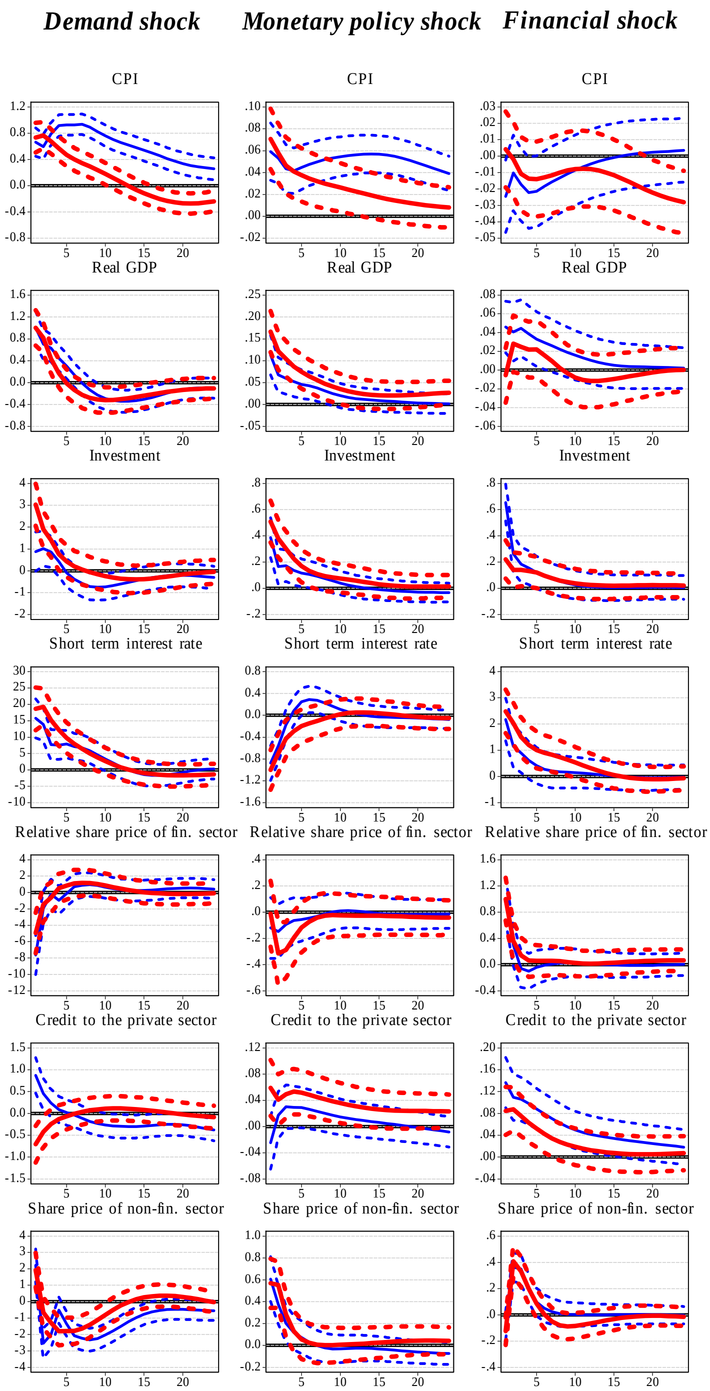
Note: <u>Thin, blue lines</u> are impulse responses to structural shocks identified by applying sign restrictions as in Rubio-Ramirez, Waggoner and Zha (2010) and aggregated across countries using the stochastic pooling approach. The size of the shocks is 100 basis points of the interest rate for the monetary policy shock; a rise by 1% of the standardised level of real GDP for the demand shock; and a rise of 1% of the standardised level of the relative share price of the financial sector for the financial shock. The impulse responses are based on a VAR model estimated on quarterly data from 1985:1 to 2011:2 on 21 countries, and after aggregating cross country impulse responses by applying the stochastic pooling approach (see main text and Annex for further explanation). The <u>thick red lines</u> report the same impulse responses when the VAR models are estimated up to <u>2007:2</u>.

FIGURE 7. Impulse responses to structural shocks, basedline vs. <u>excluding euro area countries from 1999</u> (baseline in thin blue lines, excluding euro area countries in thick red lines)



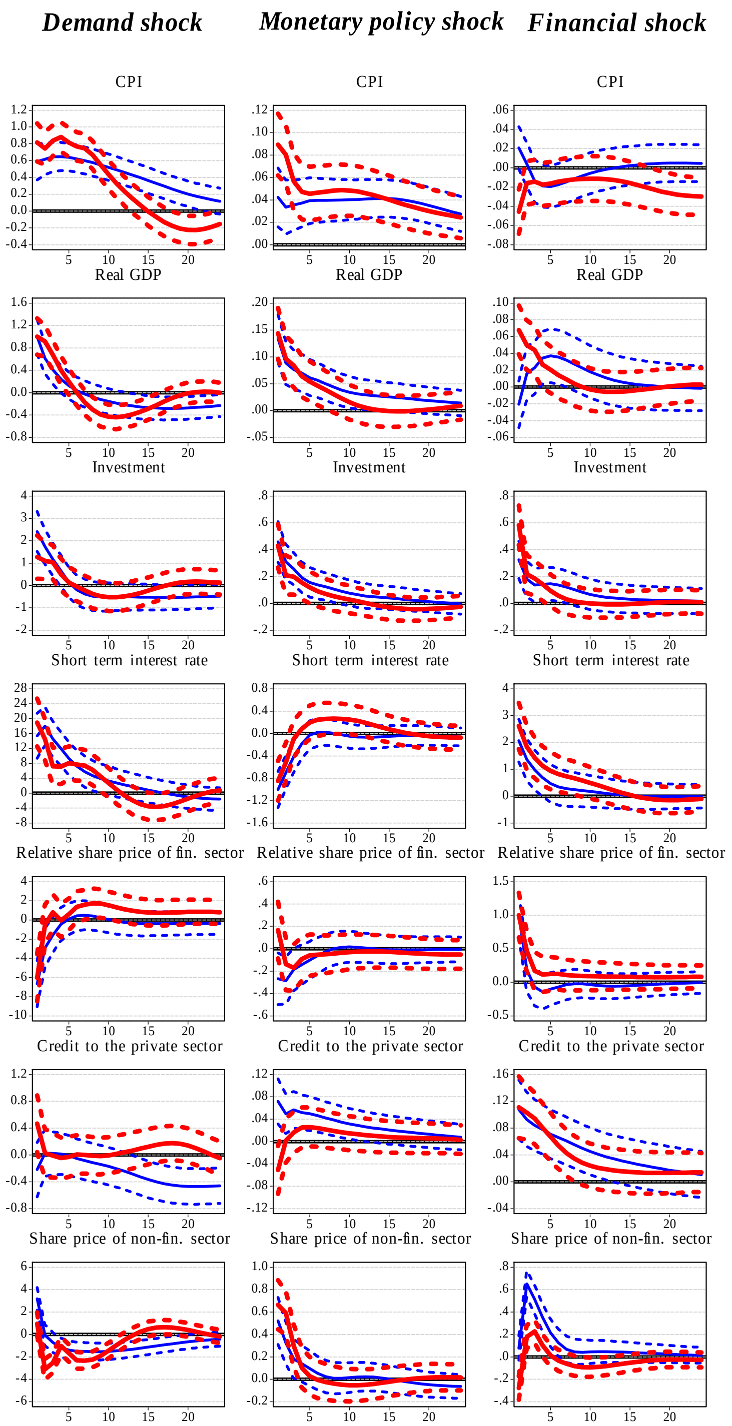
Note: <u>Thin, blue lines</u> are impulse responses to structural shocks identified by applying sign restrictions as in Rubio-Ramirez, Waggoner and Zha (2010) and aggregated across countries using the stochastic pooling approach. The size of the shocks is 100 basis points of the interest rate for the monetary policy shock; a rise by 1% of the standardised level of real GDP for the demand shock; and a rise of 1% of the standardised level of the relative share price of the financial sector for the financial shock. The impulse responses are based on a VAR model estimated on quarterly data from 1985:1 to 2011:2 on 21 countries, and after aggregating cross country impulse responses by applying the stochastic pooling approach (see main text and Annex for further explanation). The <u>thick red lines</u> report the same impulse responses when the VAR models are estimated after <u>excluding</u> observations for euro area countries after 1999..

FIGURE 8. Impulse responses to structural shocks, including foreign variables in the VAR, depending on countries' private credit to GDP ratio ('high' countries in thick red lines, 'low' countries in thin blue)



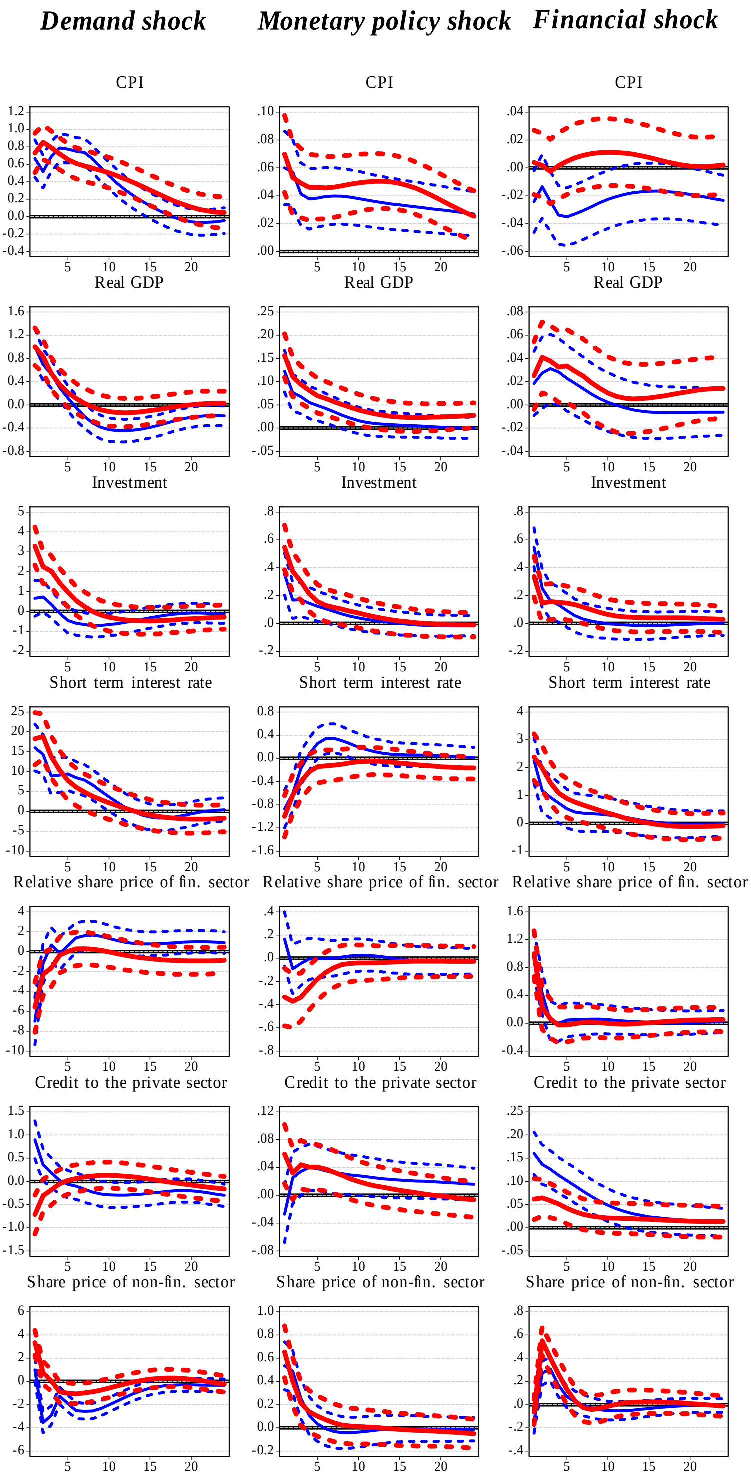
Note: See notes to Figure 5 on how impulse responses are computed. In this Figure, we divide countries in two groups according to whether they are above or below the median in terms of private credit to GDP ratio. Within each sub-group, countries are aggregated using the stochastic pooling approach (see main text for details). Impulse responses are shown in thin, blue lines for countries with a low reading of this structural indicator, and thick red lines for high readings.

FIGURE 9. Impulse responses to structural shocks, including foreign variables in the VAR, depending on countries' <u>financial openness</u> ('high' countries in thick red lines, 'low' countries in thin blue)



Note: See notes to Figure 5 on how impulse responses are computed. In this Figure, we divide countries in two groups according to whether they are above or below the median in terms of financial openness (sum of cross border financial assets and liabilities over GDP). Within each sub-group, countries are aggregated using the stochastic pooling approach (see main text for details). Impulse responses are shown in <u>thin, blue</u> lines for countries with a low reading of this structural indicator, and <u>thick red</u> lines for high readings.

FIGURE 10. Impulse responses to structural shocks, depending on countries' <u>stock market capitalisation to GDP ratio</u> ('high' countries in thick red lines, 'low' countries in thin blue)



Note: See notes to Figure 5 on how impulse responses are computed. In this Figure, we divide countries in two groups according to whether they are above or below the median in terms of stock market capitalisation to GDP ratio. Within each sub-group, countries are aggregated using the stochastic pooling approach (see main text for details). Impulse responses are shown in <u>thin, blue</u> lines for countries with a low reading of this structural indicator, and <u>thick red</u> lines for high readings.