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HETEROGENEITY AND NON-LINEARITIES

Kirstin Hubrich, Antonello D'Agostino, Marianna Červená, Matteo Ciccarelli, Paolo Guarda, Markus Haavio, Philippe Jeanfils, Caterina Mendicino, Eva Ortega, Maria Teresa Valderrama, Marianna Valentinyiné Endrész

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By K. Hubrich[1], A. D'Agostino, M. Červená, M. Ciccarelli, P. Guarda, M. Haavio, P. Jeanfils, C. Mendicino, E. Ortega, M. T. Valderrama, M. Valentinyiné Endrész

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ABSTRACT

This paper analyses the transmission of financial shocks to the macroeconomy. The role of macro-financial linkages is investigated from an empirical perspective for the euro area as a whole, for individual euro area member countries and for other EU and OECD countries. The following key economic questions are addressed: 1) Which financial shocks have the largest impact on output over the full sample on average? 2) Are financial developments leading real activity? 3) Is there heterogeneity or a common pattern in macro-financial linkages across the euro area and do these linkages vary over time? 4) Do cross-country spillovers matter? 5) Is the transmission of financial shocks different during episodes of high stress than it is in normal times, i.e. is there evidence of non-linearities? In summary, it is found that real asset prices are significant leading indicators of real activity whereas the latter leads loan developments. Furthermore, evidence is presented that macro-financial linkages are heterogeneous across countries – despite persistent commonalities – and time-varying. Moreover, they differ between euro area and other countries. Results also indicate that cross-country spillovers matter. Finally, important non-linearities in the transmission of financial shocks are documented, as the evidence suggests that the transmission differs in episodes of high stress compared with normal times.

JEL code: E 440, E320, C320

Keywords: macro-financial linkages, financial shocks, lead-lag relationships, heterogeneity, cross-country spillovers, non-linearities

NON-TECHNICAL SUMMARY

The recent financial crisis and the resulting recession have highlighted the links between financial factors and the real economy. The aim of this paper is to analyse the role of macro-financial linkages from an empirical perspective for the euro area as a whole, for individual euro area member countries and for other EU and OECD countries.

The paper is structured around the following key economic questions: 1) Which financial shocks have the greatest impact on output over the full sample on average? 2) Are financial developments leading real activity? 3) Is there heterogeneity or a common pattern in macro-financial linkages across the euro area and do these linkages vary over time? 4) Do cross-country spillovers matter? 5) Is the transmission of financial shocks different during episodes of high stress compared with normal times, i.e. is there evidence of non-linearities?

To investigate these questions, stylised facts are collected and various empirical models are estimated, concentrating on five financial variables: real stock prices, real house prices, the term spread, growth in loans to the private resident sector and banks' loans-to-deposits ratio. Three measures of real economic activity are considered: GDP, private consumption and total investment. The quarterly financial variables are complemented in the last section by a financial stress indicator with broader coverage and monthly frequency.

Given the lack of consensus on macro-financial linkages, this paper adopts an empirical approach based on models that impose limited economic structure. It starts with standard country-specific vector autoregressions (VARs) with constant parameters. Subsequent parts of the paper use a euro area VAR that allows for time-varying parameters and volatility, a time-varying panel VAR that also captures cross-country linkages, and finally a regime-switching VAR that focuses on non-linearities.

The key findings of this study can be summarised as follows:

1. **Which financial shocks have the greatest impact on output over the full sample on average?**
   The contribution of financial shocks to real fluctuations is estimated based on country-specific, constant parameter models.

   - The combined contribution of the five financial variables to real fluctuations is rather large (33% of GDP variance, on average, across countries at the three-year horizon) compared with other results in the literature.

   - Among the financial variables considered, asset prices are the most important source of real fluctuations (real house prices account for about 9% of GDP variance at the three-year horizon and real stock prices for an additional 12%).

   - There is substantial heterogeneity across countries with respect to the overall importance of financial shocks and the ranking of these shocks by type.

   - The five financial shocks usually account for more fluctuations in investment than in private consumption.

- Historical decompositions indicate that the contributions of financial shocks are much more significant during episodes associated with financial imbalances. This suggests possible time variation or non-linearities in the macro-financial linkages addressed below.

2. **Do financial developments lead real activity?** Turning point analysis is used to compare financial cycles and business cycles.

   - Asset prices often lead real activity. In particular, peaks in real asset prices tend to lead recessions. This pattern is stronger for real house prices than for real stock prices.

   - Moreover, loan developments lag developments in real economic activity.

3. **Are macro-financial linkages heterogeneous across countries? Do they vary over time? Do they differ between euro area and other countries?** Constant and time-varying parameter models are estimated to address these questions.

   - Real effects of financial shocks are fairly heterogeneous across countries, confirming previous findings in the literature. Heterogeneity within the euro area is as important as it is across other OECD countries.

   - There is a statistically significant common component across real and financial variables in major economies. This component has appeared prominently in the recent recession. However, country-specific factors remain very important, consistent with observed heterogeneity. This finding holds whether the focus is on euro area countries or is broadened to include major advanced economies.

   - Time variation is an important feature of the data, especially for the link between GDP and real house prices, which has become stronger and more persistent over recent years.

4. **Do cross-country spillovers matter?** Time-varying parameter models with cross-country linkages are used to investigate this issue.

   - A negative shock to a financial variable in a given country significantly affects all other countries, especially if the shock has originated in Germany or the United States.

5. **Is the transmission of financial shocks different in episodes of high stress than it is in normal times?** Potential differences in the transmission are investigated with a non-linear model incorporating regime switching.

   - The response of real variables to financial shocks is much larger and more protracted during episodes of high financial stress. The difference compared with normal times is not only that shocks are more volatile, but also that the transmission is different.

The analyses presented in this paper have several **implications for economic modelling**:

- First, DSGE models that abstract from financial frictions may overestimate the contribution of more standard sources of fluctuations.

- Second, structural models of international business cycles should allow international spillovers of financial shocks to play a prominent role. Country-specific analyses that ignore these spillovers may underestimate the real effects of financial shocks.

- Third, euro area aggregates mask important cross-country heterogeneity.

- Fourth, non-linear methods are needed to account for the limited role of financial shocks in normal times, but have important real effects in episodes of high financial stress.

- Fifth, further research should focus on recent work to incorporate time variation and non-linearities in DSGE models with financial frictions and structural models that allow for non-linear amplification effects and instabilities.

The findings presented in this paper carry at least two **policy implications**:

- Despite considerable heterogeneity, countries share common financial shocks, suggesting that international financial markets are important in order to understand co-movements in economic activity. Policy-makers should pay attention to financial developments abroad.

- Non-linearities in macro-financial linkages carry important implications from a monetary policy perspective. Appropriate monetary policy needs to take into account possible changes in the transmission mechanism.

I INTRODUCTION

The recent financial crisis has highlighted the importance of financial factors for the real economy, among which the drastic rise and fall of house prices is often cited as having played an essential role in explaining earlier and recent crises and their effects on the macroeconomy. Moreover, asset prices in general are known to affect the real economy. In addition to house prices, stock prices and loans also sometimes trigger adverse macroeconomic developments. Recently, attention has focused on risk, uncertainty and bank leverage when considering the real effects of financial shocks. Prominent contributions to this literature include Borio and Lowe (2002, 2004), Claessens et al. (2009, 2011 a, b) and Gilchrist, Yankow and Zakrajsek (2009), among others. Against this background, the aim of this paper is to investigate the links between financial factors and the real economy, motivated by the recent financial crisis and the resulting recession.

This paper focuses on the following economic questions:

1) Which financial shocks have the greatest impact on output over the full sample on average?
2) Are financial developments leading real activity?
3) Are macro-financial linkages heterogeneous across countries? Do they vary over time? Do they differ between euro area and other countries?
4) Do cross-country spillovers matter?
5) Is the transmission of financial shocks different in episodes of high stress compared with normal times? Is there evidence of non-linearities?

To examine these questions, the analysis in the paper concentrates on five financial variables: real stock prices, real house prices, the term spread, loan growth and the loans-to-deposits ratio. It also considers three alternative measures of economic activity: GDP, private consumption and total investment. This analysis, based on quarterly data, is complemented in the last section by an analysis that includes a financial stress indicator with broader coverage of financial markets and monthly frequency.

The paper investigates relationships between financial and real economic variables in the euro area as a whole, euro area member countries individually and other EU and OECD countries. It also extends previous research along several dimensions. In particular, the paper: (i) includes evidence on EU new Member States (NMS); (ii) complements work with asset prices by incorporating further financial variables, such as the term spread, loan growth, the leverage ratio and a novel financial stress indicator; (iii) extends the sample period to include the recent crisis and the early 1980s; and (iv) employs a wide range of econometric techniques to address relevant economic questions. Macro-financial linkages in a large number of countries are investigated in a systematic way with a particular focus on how these linkages change over time, in particular whether they differ in times of recession and financial stress or in crisis episodes.

Considerable effort has been devoted to compiling a large database with broad country and variable coverage.[1] This database includes a large number of aggregate financial and macroeconomic variables comparable across a large number of economies, including the euro area aggregate, euro area countries, other EU countries (including NMS) and other major OECD countries. To allow for this broad country and variable coverage, the team has deliberately focused on rather aggregate data. For example, to approximate leverage we use the aggregate loans-to-deposits ratio for the banking sector.

1 The database underlying this study is available upon request.

The paper adopts an empirical perspective, estimating time series models that impose a limited economic structure to investigate macro-financial linkages. Given the lack of consensus in the literature on this subject, the results should provide useful insights for the development of structural economic models.

The paper is organised as follows. First, Section 2 describes the data used throughout the paper and presents some descriptive statistics often used in the literature to provide some **stylised facts** on macro-financial linkages. These should be relevant for both structural and reduced-form modelling. This section provides initial evidence on the questions regarding cross-country heterogeneity and time variation in macro-financial linkages.

To address the first question above, the contribution of financial shocks to fluctuations in the real economy is estimated by augmenting the standard monetary VAR model with five financial variables (real stock prices, real house prices, term spread, loan growth and the loans-to-deposits ratio). The VAR is estimated separately for 18 industrialised countries and the euro area between the first quarter of 1980 and the fourth quarter of 2010 using three alternative measures of economic activity: GDP, private consumption and total investment. The results from these **country-specific, constant-parameter VAR models** are presented in terms of variance decompositions and historical decompositions in Section 3.

Section 4 addresses the second question on lead-lag relationships in macro-financial linkages, carrying out **turning point analyses**. This section compares financial and business cycles in nine euro area countries and 17 OECD countries. The peaks and troughs of real house prices, real stock prices, real loans and real GDP are analysed.

Section 5 addresses part of the third question about possible time variation in macro-financial linkages. This requires an estimation of **time-varying VAR models**. The section presents time-varying correlations and impulse response functions from a VAR model with time-varying parameters and stochastic volatility, focusing on the relationship between real house prices and GDP at the euro area level.

Section 6 presents results on heterogeneity, time variation and cross-country spillovers using a **time-varying panel VAR** model which includes the real and financial variables from previous sections for the main euro area members, and also for other countries. This section therefore complements the country-specific VAR analysis in Section 3 by relaxing the assumptions of the absence of spillovers and constant parameters.

Finally, possible changes in the transmission of financial shocks during episodes of financial stress are investigated in Section 7. Results are presented for a richly parameterised **multivariate Markov-switching model** that is estimated to identify non-linearities in the interdependencies between real variables and financial stress, measured by an indicator that encompasses many different financial markets and financial intermediaries. This section relaxes the assumption of constant parameters in Section 3, by allowing for different regimes, and complements the evidence in previous sections by using a monthly financial indicator designed to capture the risk and uncertainty in financial markets.

Section 8 concludes by discussing the **policy implications** of the main findings. Furthermore, insights for existing macroeconomic models are provided and directions for further research are highlighted.

2 STYLISED FACTS OF MACRO-FINANCIAL LINKAGES

In this section, we describe a number of stylised facts pertaining to macro-financial linkages for a group of 37 countries contained in our sample. In order to shed some light on common patterns or on the degree of heterogeneity among these countries we examine a set of both financial and real variables, comparing average growth rates, cross-correlations (contemporaneous as well as at different leads and lags) and their relative volatility compared with the standard deviation of GDP growth.

We also use split-sample analysis to check for any significant changes in the linkages following the creation of the Economic and Monetary Union (EMU) in 1999. Although many countries in our sample do not belong to the euro area, it is fair to say that the EMU could have potentially influenced other parts of the world, in particular through financial markets. Thus, for most of the analysis we split the sample in 1999 and refer to these periods as pre-EMU and EMU.[2]

2.1 DATA (COMMON FOR ALL SECTIONS)

Variables used throughout the report include three real variables (GDP, private consumption and total investment), three price variables (consumer prices, stock prices and house prices), three interest rate variables (short and long-term interest rates as well as their spread) and, if available, three bank lending variables[3] (loans to non-financial corporations, loans to households and total loans). Note that all nominal variables (other than interest rates) were deflated by CPI prior to the calculation of year-on-year growth rates. For a broader picture, three ratios were also included: the loans-to-deposit ratio, loans-to-GDP ratio and credit impulse.[4] Of these, credit impulse, the ratios and the term spread are used in levels and the other variables as year-on-year growth rates.

The data used is quarterly,[5] covers 18 countries and the euro area[6] and ranges from the first quarter of 1980 to the fourth quarter of 2010, although some variables (such as loans by institutional sector) are not available for all countries. To increase the country set, we include 18 additional countries[7] for which the time span is shorter or for which some data, such as house or stock prices, may be missing.[8]

2.2 AVERAGE ANNUAL GROWTH RATES

We start by comparing average growth rates across variables. Owing to the large number of countries, we group the data in graphs comparing average growth in GDP, private consumption and total investment against average growth in financial variables, separating periods before and after 1999.[9] Note that all variables are deflated.

2 It would also be interesting to split the sample into pre-crisis and post-crisis periods. However, the time span since the onset of the financial crisis is too short for the techniques used in this section.

3 The split between loans to households and to non-financial corporations is available only for euro area member countries.

4 Construction of the credit impulse variable: $CI = 100 * \left[\frac{loan_t - loan_{t-1}}{YEN_t} - \frac{loan_{t-4} - loan_{t-5}}{YEN_{t-5}} \right]$

5 With the exception of Section 7 on non-linearities, which uses monthly data.

6 Belgium, Germany, Spain, Finland, France, Ireland, Italy, Luxembourg, Netherlands, the euro area, Sweden, Canada, Japan, US, UK, Australia, Switzerland, Norway, New Zealand.

7 Austria, Greece, Portugal, Denmark, Bulgaria, Czech Republic, Cyprus, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia, Slovenia, Iceland and South Korea.

8 For further information on data used and sources refer to the Appendix. The database is used throughout the report, except in section 7 on non-linearities.

9 The corresponding graphs can be found in the Appendix – Section 2, Figures A1, A2 and A3.

Lending (Figure A1). First, we compare average growth of GDP to average growth in total bank loans to the non-financial private sector,[10] stock prices and house prices. The total loans data, as mentioned earlier, is available only for euro area member countries.[11] In general we can say that higher growth rates in total loans are often accompanied by higher growth rates in GDP. However, some outliers appear for each period. For example, two pre-EMU outliers, Luxembourg and Portugal, combine high GDP growth and moderate growth in total loans, while Ireland stands out with very high GDP growth and by far the highest total loan growth. In the EMU period, three countries stand out for rather rapid growth in total loans despite low GDP growth (Italy, Malta and Portugal).

Comparing private consumption growth to growth in loans to households we find a similar pattern: for most countries, higher lending to households goes hand in hand with higher private consumption growth. In the pre-EMU era two countries stand out with very high growth in lending to households: Portugal and Ireland. Interestingly, we find that average growth rates in lending to households increased in the EMU period, and we see more countries with double-digit average annual growth rates (Slovakia, Slovenia, Greece, Spain, Ireland and Cyprus[12]).

On average, lending to non-financial corporations grew at rates similar to those of loans to households. However, we do not find a strong link to total investment growth. This may be due to the higher cross-country variation in average total investment growth and to the fact that firms can also access funding through capital markets and thus are less dependent on the banking system than households. However, it is worth noting that countries with higher growth in lending to households also tend to have higher growth in lending to non-financial corporations, especially in the EMU period. Moreover, in most cases, growth in lending to households was higher than growth in lending to non-financial corporations (with the exception of Ireland and Cyprus).

Stock prices (Figure A2). We plot average growth in stock prices against average growth in GDP. In this case, data is available for a majority of countries in our database.[13] In the pre-EMU era we see that while average GDP growth lies between -0.8% and 8.3%, average growth in stock prices varies between -16.1% (Czech Republic) and 92.7% (Poland). More than half of the countries in our sample experienced average GDP growth in double digits for the pre-EMU period but some large losses also stand out. The period after 1999 is characterised not only by slower GDP growth but also by more moderate growth in stock prices. Moreover, we find a number of countries (Ireland, Italy, New Zealand, Netherlands and United Kingdom) in which average growth in stock prices in the last ten years was negative, while countries like Bulgaria and Lithuania experienced average growth rates close to 30% per annum. Furthermore, we do not see a clear link between GDP and stock prices. In particular, in the EMU era some countries combined relatively high GDP growth with stagnation or even falling stock prices. When we compare growth in stock prices and total investment growth, a negative relationship appears in some cases. It is worth noting that countries with the largest gains in the stock market also experienced faster growth in total investment prior to 1999. In the EMU period, we find a loose but positive relationship between total investment growth and growth in stock prices, which is consistent with the fact that firms rely less on funding from the banking system, i.e. they can access financial markets directly and raise funds via issuing bonds or new shares. Moreover, stock prices and total investment both grew more moderately during this period.

10 The sum of loans to households and loans to non-financial corporations.
11 For Cyprus, Slovakia and Slovenia it is available only after 1999.
12 Data for Cyprus, Slovakia and Slovenia is not available before 1999.
13 For the pre-EMU period only Lithuania, Cyprus, Malta, Bulgaria and Romania are missing. For the EMU, it is Malta, Romania and Cyprus.

House prices (Figure A2). Turning to house prices, we find a moderate positive relationship with average growth in GDP, with four major outliers in the pre-EMU period: Estonia and Greece with very high increases in house prices and Bulgaria and Korea with negative average growth rates. In Bulgaria and Korea house prices fell but the economy grew rapidly, while in Greece the economy grew very moderately despite very high growth in house prices. In the EMU period, we find a stronger positive relationship between growth in house prices and growth in GDP or in private consumption (no major outliers).

Loan ratios (Figure A3). Taking the loans-to-deposits ratio as a measure of leverage, we find a loose positive relationship with real GDP growth in the pre-EMU period for euro area countries and OECD countries. For the NMS we find a rather negative relationship driven mainly by Lithuania and the Czech Republic, while for the other NMS this relationship is rather strongly positive in the pre-EMU period. In the EMU period, a clearer positive relationship appears between the loans-to-deposits ratio and GDP growth for all countries in our sample. In general we observe more dispersion across countries, but at the same time fewer outliers.

A related measure of leverage, namely the loans-to-GDP ratio, suggests a similar loose relationship with the GDP growth rate in the pre-EMU era. However, the extreme values observed for the loans-to-deposits ratio disappear. For the EMU period a very similar pattern can be detected. In particular, in the EMU period we find again that there is a larger dispersion of growth rates of the loans-to-GDP ratio across countries, while there are fewer outliers. Moreover, we find that in the EMU period the loose positive relationship is stronger and very similar for the NMS and OECD countries, while for the euro area countries we find a much lower correlation.

A third measure of leverage is the credit impulse variable. In Figure A3, we plot the credit impulse variable against year-on-year GDP growth rates and find that there is basically no relationship between the two variables, both in the pre- and EMU periods. The very high value of the credit impulse for the United States compared with the rest of the sample stands out.

2.3 CROSS-CORRELATIONS

To shed more light on some of these relationships, we report cross-correlations between GDP growth and growth in house prices at different leads and lags. A similar analysis has been conducted for the rest of the macro and financial variables. However, we have chosen to present only these results as house prices were found to matter in other sections of the report. Due to space constraints we report figures for only six (out of more than 30) countries in Appendix – Section 2, Figure A4.

Although there is a lot of heterogeneity across countries, in general cross-correlations between house prices and GDP growth are relatively low. Contemporaneous correlations tend to be positive (the exceptions being Austria, Japan and Switzerland in the EMU era), but lead and lag cross-correlations differ significantly across countries. In some cases, the largest correlation may even be negative. This could be due to the fact that housing cycles are longer than business cycles (as shown later in this report) and that the recovery after a housing price bust tends to lag the recovery in GDP.

Furthermore, by splitting the sample in 1999 we discover large differences in patterns for a number of countries. For Germany and Japan the cross-correlation pattern changed significantly after 1999. Cross-correlations went from (almost) always positive to negative at many leads and lags. In Japan

the cross-correlations went from positive and rather high before 1999 to negative at almost all leads and lags. Furthermore, the size of the correlation fell in both countries.

For France, real house prices were leading GDP (with the peak at three lags) prior to 1999. After EMU the cross-correlation increased but real house prices become coincident with GDP growth. On the contrary, for the United States a slightly leading relationship appears prior to 1999, although this correlation was very low (slightly below 0.5). However, after 1999 cross-correlations are the same for both leads and lags up to four quarters, making it difficult to draw any conclusion regarding leading or lagging relationships for the United States.

For most countries in our sample, the highest correlation is contemporaneous, or at most at a two-quarter lag or lead. There are only a few countries in which the highest correlation is found at higher leads or lags. For example, Germany pre-EMU saw a peak correlation when house prices were lagging GDP growth at four lags. For Japan after 1999, however, the largest correlation is at about six leads, but is negative. Italy also presents an interesting peak and trough pattern pre-EMU, but in the EMU era, the pattern is similar to most other countries.

Looking across countries, it is not possible to reach general conclusions about lead and lag relationships between GDP growth and house prices. This may be because of cross-country heterogeneity or because of time variation (as suggested by our split-sample analysis) or the presence of non-linearities. Section 5 confirms this hypothesis using time-varying correlations, as does Section 7 which finds evidence of non-linearities. The turning point analysis in Section 4 of this report focuses on the lead-lag relationship at peaks and troughs. This reveals very clearly that peaks in house prices lead recessions in GDP.

2.4 RELATIVE VOLATILITY

In this sub-section, we compare the volatility of a number of financial variables to that of GDP growth. Many structural models (i.e. dynamic stochastic general equilibrium (DSGE) models) focus on relative volatility measures which are used for calibration or validation. In order to have some benchmark against which we can gauge the relative volatility of financial variables, we first compare the standard deviation of growth in private consumption and total investment to the standard deviation of GDP growth.

As can be seen in the Appendix – Section 2, Figure A5, the relative volatility measure is much higher for total investment than private consumption, with large heterogeneity across countries. While the relative volatility of private consumption tends to be higher in NMS than in euro area countries, the United States and Japan, this pattern is not visible for total investment. Moreover, no major change is apparent between the pre- and EMU periods.

Turning to lending, where data is mostly limited to euro area countries, we see that the volatility of loan growth (total, households and non-financial corporations) is slightly higher than that of private consumption but lower than that of total investment. It is not clear which of the three types of lending is more volatile or whether there has been a significant change in volatility since the introduction of the single currency.

Turning to prices (stock prices and house prices), volatility is rather high in some countries. In line with expectations, volatility of real stock prices is generally much higher than that of consumer prices, except for those countries that experienced episodes of hyperinflation (Poland, Slovenia and

Bulgaria). Real stock prices are even more volatile than real house prices. Splitting the sample reveals that after the introduction of the single currency, volatility falls significantly for countries with periods of hyperinflation. In the EMU era, real house prices vary more than GDP growth and real stock prices are the most volatile.

Turning to interest rates, in the pre-EMU period the volatility of short-term interest rates tends to be higher than that of GDP. However, we find exceptions like Ireland, Norway, Korea, Cyprus and Malta. The volatility of long-term interest rates relative to that of GDP growth varies across countries. For some, it is found to be much higher, with the ratio being close to or above 2; for others, GDP is twice as volatile as the long-term interest rate. Countries with the highest relative volatility include Bulgaria, France, Italy, Spain, Denmark and the euro area as a whole. On the other hand, Estonia, Switzerland, Korea, Luxembourg and Germany are the countries where the lowest relative volatility is observed.

2.5 SUMMARY

In summary, there is important heterogeneity as regards macro-financial linkages across countries as well as across time. This is in line with the findings in other sections of this report. Moreover, we find that the linkages between real and financial variables changed following the creation of the EMU in 1999.

In general, we find a positive but low correlation between real and financial variables. Private consumption and lending to households are relatively highly correlated (at least for euro area countries), while total investment and lending to non-financial corporations are not. Instead, total investment is found to be positively correlated with real stock prices. For other financial variables it is not possible to discern a clear link with real variables, especially across the country groups. This finding is consistent with firms having better access to capital markets and being less dependent on lending by banks. However, this finding deserves further research. In the EMU period, we find a stronger positive relationship between real house prices and growth in GDP or private consumption. For other financial variables it is not possible to discern a clear link to real variables, especially across country groups.

We reach similar conclusions by examining cross-correlations between real and financial variables at different leads and lags. There is no clear pattern across countries and much more heterogeneity than observed for average growth rates. Again, in some cases there are significant changes between pre-EMU and EMU data. The highest correlation is usually coincident or at one or two lags or leads. There are only a few countries in which the largest correlation is at higher leads or lags.

3 MACRO-FINANCIAL LINKAGES: COUNTRY-SPECIFIC ANALYSIS

This section uses standard reduced form methods (identified VARs) to address question 1 – on average, which financial shocks have the largest impact on output over the full sample? – and question 3 – is there heterogeneity across countries? VAR methods also provide quantitative answers to two more detailed questions. First, how much do financial shocks contribute to real economic fluctuations? Second, which components of output are most affected by financial shocks?

Using standard VARs and a country-by-country approach, the underlying assumptions in this section are that: (i) international spillovers can be ignored; (ii) non-linearities are negligible; and (iii) parameters are constant over time. These simplifications make it possible to consider a relatively wide set of 19 economies (most members of the euro area, the area-wide aggregate and the other main OECD countries), providing a range of answers to the main questions in this report.

Within the VAR reduced form approach, a financial shock is defined as a movement in a financial variable that cannot be predicted from previous information (an innovation) and is uncorrelated with contemporary movements in main macroeconomic variables (orthogonal). For each country, separate VARs are estimated using three different measures of real output: GDP, private consumption or total investment. Each VAR also includes a consumer price index, short-term interest rates, an international index of commodity prices and an indicator of foreign demand. VAR models based on this set of variables have become a standard tool to capture macroeconomic dynamics (Christiano et al., 1999). Structural shocks are identified through short-term restrictions, long-term restrictions, sign restrictions or a combination of these. Below, the standard Choleski decomposition of the innovation covariance matrix is used to impose short-term restrictions, implying a recursive exogeneity structure among the variables. Similar methods have been applied to study the transmission of monetary policy in euro area aggregates (e.g. Peersman & Smets, 2001) as well as in individual euro area countries (e.g. Mojon & Peersman, 2001).

Each VAR is augmented to also include five different financial variables: two asset prices (real house prices and real stock prices), the term spread (the difference between long and short-term interest rates) and two leverage indicators (changes in the ratio of private sector loans to GDP and the ratio of aggregate loans to aggregate deposits in the banking sector). The inclusion of asset prices is natural, given their impact on output through the financial accelerator. Changes in asset prices can act through borrowers' balance sheets, by affecting their net worth or collateral values, but also through banks' balance sheets, by affecting their leverage and their ability to raise new capital. Since stock prices adjust rapidly to incorporate new information, they are also often interpreted in terms of confidence shocks. Changes in the term spread (between short and long-term interest rates) also affect banks' balance sheets, given maturity mismatch between assets and liabilities. They also link to a separate literature on the slope of the yield curve as a predictor of economic activity (e.g. Ang, Piazzesi & Wei, 2006). Finally, credit channel effects (Bernanke & Gertler, 1995) may be captured more directly by changes in leverage indicators than by changes in asset prices. Measures of leverage also link to a separate literature on liquidity and the leverage cycle (e.g. Adrian & Shin, 2009).

Several other financial variables could have been considered but were eliminated because data were often available only for a short sample or a limited set of countries. It is also difficult to include more than five financial variables in a macroeconomic VAR given limited degrees of freedom. Therefore the analysis in this section does not consider credit spreads across different classes of borrowers, sovereign spreads across different countries, non-performing loans, loan-loss provisions

or other measures of liquidity or volatility. Still, the set of financial variables considered here is sufficiently broad to benefit from several advantages. First, the analysis can allow for possible interactions between financial variables as well as between real and financial variables. Second, the set of five different financial variables provides sharper identification since innovations are defined as fluctuations that are unpredictable from a larger information set. Third, joint analysis of several financial variables (especially including both house prices and loans) is important given the findings by Borio and Lowe (2002, 2004) that financial imbalances are better identified through a *combination* of different financial indicators.

There exists a growing literature extending the standard macroeconomic VAR to incorporate financial variables.[14] The analysis below extends this in three directions. First, as mentioned above, the analysis in this section simultaneously includes **five** different financial variables. Among the studies cited in the footnote, only Abildgren (2010) includes more than three financial variables. Second, this section provides a broader cross-country perspective, repeating the exercise for each of 19 industrialised economies (including euro area aggregate data) with comparable samples and variable definitions. The exercise was also extended to an additional set of 18 countries (including NMS) for which results are less comparable because samples are shorter or some variables are missing. Among the studies cited, only three are comparable in country coverage: Chirinko et al. (2004) consider 13 economies, Assenmacher-Wesche and Gerlach (2008) consider 17 economies and Fornari & Stracca (2010) consider 21 advanced economies. However, these authors only consider two or three financial variables. Third, this section uses a longer sample period to capture a greater number of financial imbalance episodes, starting in the first quarter of 1980 and ending in the fourth quarter of 2010, which includes the global financial crisis. Again, only Abildgren (2010) uses a longer sample, but limited to a single country (Denmark).

As is well known, shock identification by the standard Choleski decomposition[15] of the innovation covariance matrix assumes a recursive structure that is explicit in the ordering of variables in the VAR. Two external variables are placed at the top of this ordering (a country-specific foreign demand indicator[16] and an international commodities price index), treating them as more exogenous. These are followed by domestic output, inflation and interest rates, a fairly standard sequence in the literature going back to Christiano et al. (1999). The five financial variables are placed lower in the ordering, allowing them to react to contemporaneous shocks in all the macroeconomic variables. In particular, Assenmacher-Wesche & Gerlach (2008) argue that financial variables should follow interest rates because monetary policy only reacts to asset price movements if these are prolonged, while asset prices react immediately to changes in monetary policy. The exact ordering within the block of financial variables is less clear-cut. Goodhart & Hofmann (2008) suggest that house prices should appear first among the financial variables because they are probably stickier. The leverage indicators appear last among the financial variables as in Adalid & Detken (2007), Goodhart & Hofmann (2008) and Musso, Neri & Stracca (2010). These authors argue that this ordering implies a conservative approach to the endogeneity of money and loan growth, allowing them to react contemporaneously to shocks in all the other endogenous variables.[17]

14 For example, Iacoviello (2002), Giuliodori (2005), Neri (2004), Adalid & Detken (2007), Goodhart & Hofmann (2008), Chirinko et al. (2008), Assenmacher-Wesche & Gerlach (2008), Baumeister et al. (2008), Musso et al. (2010), Abildgren (2010) and Fornari & Stracca (2011).

15 This approach is also implemented by Giuliodori (2005), Adalid & Detken (2007), Goodhart & Hofmann (2008), Assenmacher-Wesche & Gerlach (2008), Abildgren (2010) and Musso et al. (2010).

16 For EU27 countries this was drawn from the BMPE trade consistency exercise. For non-EU countries it was constructed as a weighted average of real imports of trading partners, with the trade weights used to calculate effective exchange rates.

17 Results are robust to alternative orderings of the financial variables. Since there are five of these variables, there are 5!=120 possible orderings. The variance decomposition of each estimated VAR was repeated for all 120 of these orderings. Results presented in the text are close to average results across these 120 variance decompositions. The standard deviations of the contributions calculated across the 120 possible variance decompositions was below 1% in 90% of cases.

All VARs were estimated with two lags[18] of each of ten endogenous variables. The estimation sample usually[19] covered the second quarter of 1981 to the fourth quarter of 2010. With the exception of interest rates, the term spread and the loans-to-GDP ratio (expressed as a "credit growth" indicator[20]), all variables are expressed as four-quarter growth rates to eliminate any residual seasonality. As also observed in other studies, the loans and deposits data from the IMF's International Financial Statistics suffer from level shifts, so these were eliminated using the TRAMO_SEATS software package before the leverage ratios were calculated.

3.1 HOW MUCH DO FINANCIAL SHOCKS EXPLAIN AND WHICH ARE MORE IMPORTANT?

The forecast error variance decompositions from the VARs serve as a natural tool to compare the relative importance of different shocks across countries with different output volatility. Three results stand out. First, the contribution of financial variables to real fluctuations is fairly heterogeneous across countries (confirming findings in Chirinko et al., 2008). Second, the combined contribution from the five financial shocks is surprisingly high (more than 30% of GDP variance at the three-year horizon, averaging across countries) and increases with the horizon (see Table 1 below). Third, financial shocks to asset prices (see Table 2 for details) appear to contribute more to real fluctuations.

Averaging across countries, shocks to real stock prices contribute more than 12% of output variance at the three-year horizon, shocks to real house prices contribute 9%, shocks to the term spread 5% and shocks to the leverage ratios around 3%-4% each. However, this ranking of financial shocks is uncertain as differences are often small and may be insignificant. In addition, the ranking varies across countries, reflecting different institutional features and financial structures

18 The Schwarz Bayesian Information Criterion favours a single lag (out of a possible five) in almost all the estimated VARs.
19 For Italy, Denmark, Japan and New Zealand, quarterly house price series end in the third quarter of 2010. Loans data for Canada end in the fourth quarter of 2008. See Appendix for other countries.
20 See Biggs, Mayer & Pick (2009). The main conclusions are unaffected by using their "credit impulse" indicator instead.

Table 1 Combined effect on output of five financial shocks

Years	BE	DE	ES	FI	FR	IE	IT	LU	NL	EA	DK	UK	SE	AU	CA	CH	US	JP	NZ	AVG
Gross Domestic Product																				
1	28	36	35	29	25	18	14	14	32	35	23	24	32	32	18	14	23	16	27	25.0
2	35	45	39	36	32	29	19	18	40	37	34	27	34	40	24	27	26	30	34	31.9
3	34	44	39	36	37	30	20	19	39	40	40	25	37	43	31	25	29	32	35	33.4
6	34	45	40	39	37	32	21	19	39	43	39	30	39	43	34	26	29	34	37	34.7
Private Consumption																				
1	3	29	39	11	13	17	7	8	15	4	29	14	11	16	29	14	12	19	29	16.7
2	11	40	45	19	21	35	16	22	27	11	35	15	13	26	29	19	20	25	36	24.4
3	13	41	46	24	26	36	20	25	33	17	39	16	16	27	30	21	24	28	36	27.3
6	16	42	48	27	30	38	23	27	38	23	39	20	17	28	38	22	27	31	37	30.1
Gross Fixed Capital Formation																				
1	3	17	30	23	15	25	17	13	18	20	20	19	37	31	7	17	20	9	44	20.4
2	14	22	43	41	25	38	30	18	31	30	33	29	44	34	15	25	29	25	53	30.5
3	17	24	42	43	26	40	32	18	33	39	38	28	43	37	18	26	34	31	55	32.9
6	18	25	43	47	30	50	35	19	34	45	38	31	44	38	23	27	34	36	56	35.3

Notes: This table reports the percentage of output forecast error variance explained by the combined contribution of shocks to five financial variables (real house prices, real stock prices, long and short-term interest spread, loans-to-GDP ratio and loans-to-assets ratio). Each column refers to the country indicated by the label at the top. For each country, the panels correspond to the three VARs estimated with different measures of output (GDP, private consumption and gross fixed capital formation). Within each panel, the lines report the combined contribution of financial shocks to variance explained at different forecast horizons (1,2,3 and 6 years ahead).

(e.g. Assenmacher-Wesche & Gerlach, 2008). These institutional features may either dampen or amplify the impact of financial shocks on the behaviour of households and firms (Bernanke & Gertler, 1995).

Table 1 reports the combined impact of the five financial shocks on GDP, private consumption and gross fixed capital formation. Comparing columns, it is clear that there is substantial heterogeneity across countries. The final column reports the (unweighted) cross-country average, which suggests the combined contribution of the five financial shocks is slightly higher for GDP than for investment and is lower for consumption at all horizons. Comparing the impact on different measures of output across countries, there is no clear pattern, with the combined contribution sometimes similar across measures of output and sometimes very dissimilar. For some countries financial shocks contribute more to fluctuations in consumption and for others more to those in investment or GDP.

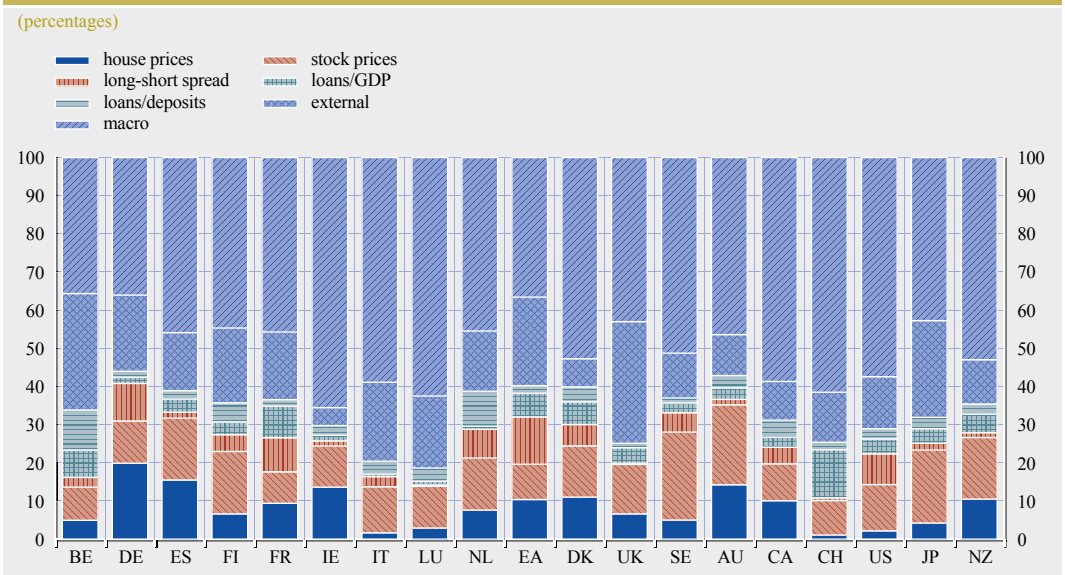
At first sight, it may seem surprising that the three countries known for their large financial sector (Switzerland, Luxembourg and the United Kingdom) appear to be among the least vulnerable to financial shocks. There are several explanations for this. First, these three countries export much of the financial services they produce. Insofar as financial shocks originate (or propagate) abroad, they may affect foreign demand for these services within the same period. Given the ordering in the Choleski decomposition, such a shock will then be classified as a foreign demand shock rather than a financial shock (foreign financial shocks are considered foreign shocks first and financial shocks second). Furthermore, to focus on the link between domestic financial shocks and domestic activity, the leverage ratios were constructed using bank loans to the *domestic* non-financial private sector, which reduces the size of the financial sector in these countries by excluding loans to non-residents (as well as loans to financial intermediaries).

Second, most of the financial shocks considered (house price shocks, stock price shocks and shocks to the term spread) can affect household and firm decisions directly even in the absence of a banking sector. As observed by Bernanke and Gertler (1995), the credit channel is an amplification mechanism, not really a separate channel.

Finally, the variance decomposition normalises the output volatility of different countries (in Ireland or Luxembourg it is eight to ten times larger than in France, Germany or the euro area), but significant differences remain within the decomposition (Chart 1). In Luxembourg and Switzerland the own-shock (exogenous) contribution to GDP growth is much higher. Presumably, this reflects higher measurement error, since in smaller economies idiosyncratic shocks to individual sectors or even individual firms are more likely to distort aggregate measures. The United Kingdom, on the other hand, ranks first in terms of the contribution from foreign shocks, consistent with its status as a larger open economy. Therefore the smaller contribution of financial shocks in these three countries partly reflects the larger role of exogenous or external factors in driving their GDP.

Another puzzling result is that Germany appears to have the highest combined contribution from financial shocks. In part this is explained by the remark above about openness: adjusting for the higher contribution of external shocks, Germany falls five places in the ranking. Germany also stands out because its contribution of financial shocks is much higher for private consumption than for investment (where the contribution actually falls below the cross-country average). This is consistent with the common view that German industry includes many small and medium-sized firms that finance their investment through long-standing banking relationships that insulate them from shocks. Moreover, private consumption fluctuations in Germany appear to be largely driven by real house price shocks (see below).

Chart 1 Impact on GDP by kind of shock



Note: For each country, the bar illustrates the contribution of different kinds of shocks to GDP forecast error variance after three years. The first five segments at the bottom represent the financial shocks. The two top segments are composite categories: "macro" combines shocks to output, consumer prices and interest rates, while "external" combines shocks to external demand and international commodity prices. The contributions in each bar add up to 100% of GDP variance. Financial shocks are a more important source of GDP fluctuations when the two top categories are smaller

Chart 1 indicates that the relative contribution of individual financial shocks varies across countries. It reports the forecast error decomposition for GDP at the three-year horizon. At the bottom of the graph are the financial variables: real house prices, real stock prices, long and short-term spread, bank loans/GDP and loans/deposits. Above this, the contributions from external variables (country-specific foreign demand indicator, international commodities price index) are combined. Finally, at the top of the graph are the combined contributions from domestic macroeconomic variables which include the own-shock of GDP, as well as shocks to consumer prices, and short-term interest rates.

The contribution from the own-shock to GDP reflects the exogenous component in output movements. This may be exaggerated by omitted variable bias and the particular identification scheme chosen (shocks to other domestic and financial variables that are contemporaneously correlated with those in output will be attributed to the first variable in the ordering). Conversely, since the financial variables appear last in the Choleski ordering (at the bottom of the graph) it is natural that they contribute relatively less to output fluctuations (they are only the residual component of innovations after accounting for correlation with contemporaneous shocks in all variables higher in the ordering). This "limitation" of the Choleski identification scheme as applied in this section suggests that the results only provide a lower bound estimate for the contribution of financial shocks to output fluctuations.

Table 2 reports the contributions of individual financial shocks to the GDP forecast error variance decomposition at a three-year horizon. Again, comparing columns there is substantial heterogeneity across countries. The (unweighted) cross-country average in the final column suggests that asset price shocks contribute much more to GDP fluctuations than the other financial variable shocks. Among asset prices, real stock price shocks appear to contribute more on average than

Table 2 Effect on output of individual financial shocks (three-year horizon)

	BE	DE	ES	FI	FR	IE	IT	LU	NL	EA	DK	UK	SE	AU	CA	CH	US	JP	NZ	AVG
Gross Domestic Product																				
House prices	6	22	18	9	7	16	1	4	8	12	11	5	5	15	13	1	3	7	12	9.2
Stock prices	9	10	14	15	7	8	11	10	14	8	12	14	23	19	7	9	10	20	14	12.4
Term spread	3	8	3	4	11	1	4	0	8	14	8	1	4	2	4	1	9	1	1	4.6
Loans/GDP	3	2	2	5	11	2	0	1	2	5	6	4	3	3	4	12	4	1	5	3.9
Loans/deposits	12	1	3	3	0	4	3	4	6	2	3	2	2	3	3	3	2	4	3	3.3
Private Consumption																				
House prices	3	18	14	6	10	25	2	2	0	9	7	6	3	15	15	2	1	5	11	8.0
Stock prices	2	10	15	5	3	5	8	11	12	0	20	9	8	6	4	5	5	15	11	8.2
Term spread	7	5	12	1	7	0	2	2	4	1	1	1	1	2	5	6	10	1	2	3.6
Loans/GDP	0	7	1	4	1	5	1	6	16	3	4	0	1	2	4	5	6	4	11	4.3
Loans/deposits	2	1	4	8	5	2	6	4	1	4	7	1	3	1	2	4	3	3	1	3.1
Gross Fixed Capital Formation																				
House prices	2	12	12	21	10	19	11	6	5	14	19	4	7	13	8	1	3	3	24	10.2
Stock prices	1	4	19	8	6	13	5	7	8	6	7	12	31	14	2	9	9	17	16	10.3
Term spread	8	1	7	6	4	1	4	1	10	2	6	3	3	5	1	0	7	1	3	3.8
Loans/GDP	0	5	3	2	6	4	6	2	6	16	2	0	1	1	2	8	12	3	6	4.4
Loans/deposits	6	2	1	5	1	3	7	2	4	1	3	8	1	4	5	8	3	8	5	4.1

Note: This table reports the percentage of output forecast error variance explained (at the 3-year horizon) by the individual financial shocks. Each column refers to the country indicated by the label at the top. For each country, the panels correspond to the three VARs estimated with different measures of output (GDP, private consumption and gross fixed capital formation). Within each panel, the lines report the share of variance explained by shocks to each of the five financial variables (real house prices, real stock prices, long-short interest spread, loans-to-GDP ratio and loans-to-assets ratio).

real house price shocks, although this is not the case in all countries. In fact, for Germany and Ireland the contribution of house prices is nearly twice that of stock prices, and it is also higher in Spain, Canada and the euro area aggregate. There is no a priori reason why house price shocks or stock price shocks should contribute more. This will depend on several characteristics of the economy in question, including the structure of firm and household finance,[21] the relative size of stock-market capitalisation and mortgage debt, and the distribution of stock ownership among households, corporations and non-residents. Institutional features of the housing market will also be of relevance, such as the typical loan-to-value ratio, use of fixed or variable mortgage rates, typical mortgage duration in years, mortgage equity withdrawal possibilities and the role of state mortgage companies.[22] The low contribution (on average) of the loan ratios are not necessarily surprising, given that loan aggregates are determined jointly by supply and demand, with loan demand containing "a significant countercyclical component" (Bernanke & Gertler, 1995). These results are based on changes to the stock of loans, but GDP may be more responsive to other data such as the flows of new loans or the amount of non-performing loans. Unfortunately, these were not available for such a long sample or on a harmonised basis across countries.

Focusing on the euro area aggregate and the United States, GDP fluctuations in the former are more sensitive to shocks to the term spread followed by shocks to real house prices and real stock prices. In the United States, real stock price shocks top the ranking, followed by shocks to the term spread.

In the middle panel of Table 2, when Private Consumption replaces GDP in the VAR as the indicator of economic activity, the leverage indicators for euro area countries were calculated using

21 See ECB (2007) and ECB (2009).
22 See Calza et al (2009), ECB (2003, 2009) and CGFS (2006).

long series on loans to households provided by the ECB.[23] For euro area aggregate data, fluctuations in consumption are explained more by shocks to real house prices and to the loans-to-deposits ratio. By contrast, in the United States, consumption fluctuations are explained more by shocks to the term spread and to the loans-to-GDP ratio.

The bottom panel provides the variance decomposition at the three-year horizon when investment replaces GDP in the VAR as the measure of economic activity. In this case, for euro area countries the loan ratios are calculated using loans to non-financial corporations. For the aggregate euro area data, fluctuations in investment are affected more by shocks to the loans-to-GDP ratio and to real house prices. In the case of the United States, investment fluctuations are also vulnerable to shocks to the loans-to-GDP ratio, but also to shocks to real stock prices (much less to real house price shocks).

For other EU countries including NMS, the sample period was shorter or some financial series were missing. This means that VAR results for these countries are not strictly comparable with those reported in this section. However, the variance decomposition graphs in the Appendix also suggest that financial shocks represent a non-negligible contribution to fluctuations in real output.

3.2 WHEN WERE FINANCIAL SHOCKS IMPORTANT?

While the forecast error variance decomposition provided an indication of the relative importance of financial shocks for output growth, historical decompositions can provide an indication of when in the sample those shocks were most present. In the figures below, euro area and US GDP growth are decomposed into the contributions of three groups of variables. The red bars represent the contribution of shocks to the macroeconomic variables (innovations to GDP and shocks to inflation

23 This may reduce the comparability of results for euro area countries to those for other countries, and also to euro area country results in Chart 1, which used IMF data on loans.

Chart 2 Euro area historical decomposition of year-on-year GDP growth

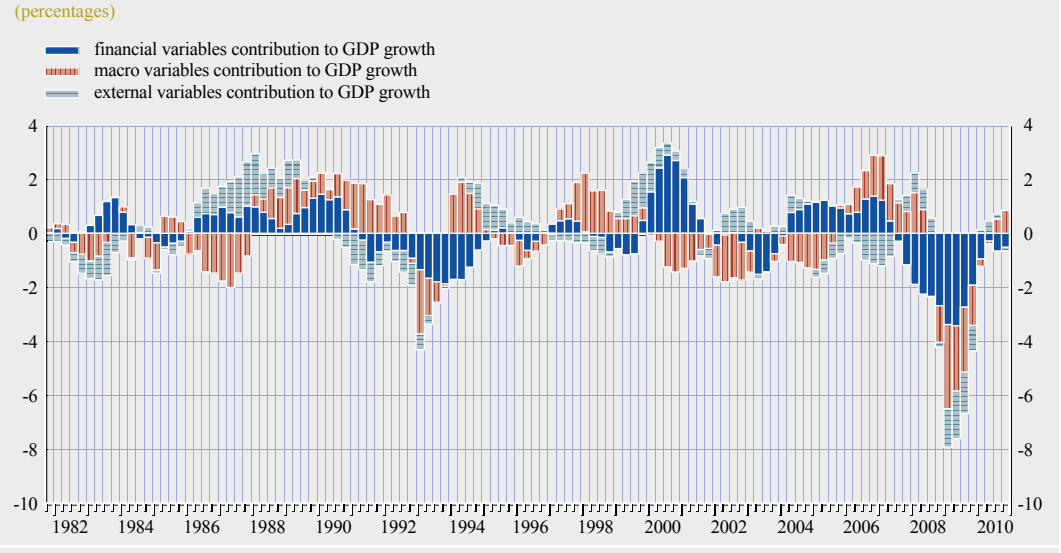
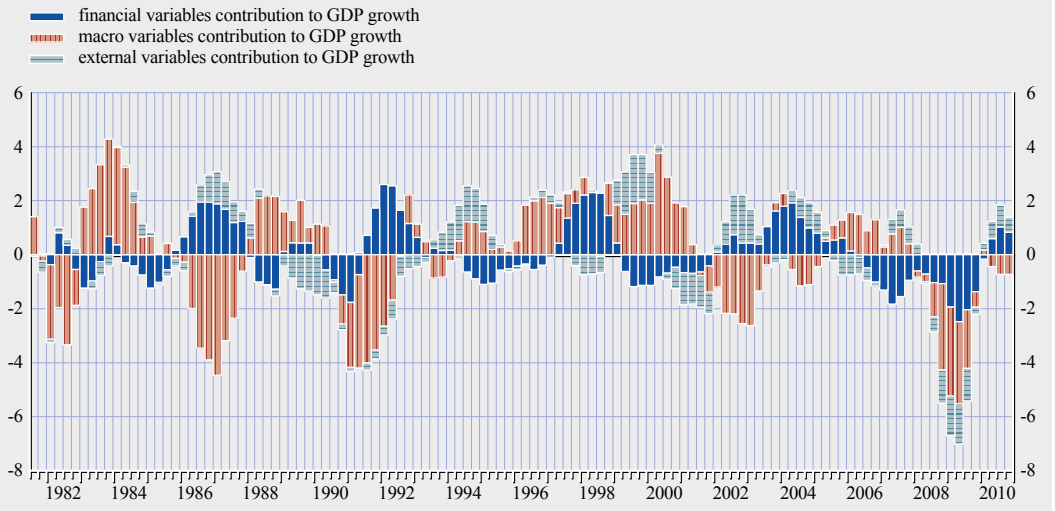


Chart 3 US historical decomposition of year-on-year GDP growth

(percentages)



and interest rates). The blue bars represent the combined contribution of the five financial variables and the light blue bars represent the contribution of the external variables (foreign demand and commodity prices). Contributions to GDP growth were calculated by recovering the residuals (innovations) from each equation, transforming these to structural shocks by multiplying by the Choleski factor and then using the resulting shocks at each point in time to scale the impulse response functions forward to the end of the sample. These impulses from shocks at different periods were then summed at each point in the sample so that the effect of the current shock and all past shocks were combined to obtain the contribution to growth from that particular kind of shock.

For the euro area, the contributions from financial variable shocks were limited in the early 1980s and tended to be positive following the peak in the US dollar resulting from the Plaza accord. The positive contributions picked up between the second quarter of 1989 and the third quarter of 1990 during the house price boom. The financial shock contributions turned negative in 1991 and plunged through the ERM crisis of September 1992 and the ensuing recession. From 1995 to 1999 the contribution to growth from financial shocks was limited, but it gained consistency during the "new technology" stock market bubble from the fourth quarter of 1999, peaking in the third quarter of 2000. In 2001 the stock market bubble burst and contributions fell to zero. There is another string of positive contributions starting in the second quarter of 2004 when real house prices boomed, which lasted until the first signs of financial turmoil in the second quarter of 2007. The contribution turned negative in the third quarter of 2007 and plunged until the second quarter of 2009 as GDP collapsed. The negative contribution to growth from financial shocks diminished until 2010, when they remained mildly negative.

In the United States, financial shocks contributed little to output fluctuations in the early 1980s. The Tax Reform Act of 1986 contributed to an end in the property price boom, reflected by a string of positive contributions from the fourth quarter of 1985 to the fourth quarter of 1987. The ensuing Savings & Loans Crisis is visible as negative contributions during 1988 and again from the second quarter of 1990 to the second quarter of 1991. The 1992 ERM crisis in Europe is not visible in the US data, although a string of positive contributions marks the recovery of house prices. However,

by the third quarter of 1994 the contribution turned negative as real asset prices stagnated and the term spread began to fall. A string of large positive contributions reappears, starting in the second quarter of 1997 when asset prices rallied and the term spread recovered. This episode peaked in the second quarter of 1998 as the term spread fell to zero and real stock prices paused. Macro variables seem to dominate during the ensuing "new technology" stock market bubble until it burst in 2001. Financial shocks provided no serious contribution to growth until the third quarter of 2003 when real stock prices recovered, although the contribution to growth peaked shortly afterwards in the second quarter of 2004 and then declined. By the second quarter of 2006 it was negative and weighed increasingly on growth during 2008, reaching a trough in the second quarter of 2009. Since the second quarter of 2010 the contribution to growth from financial shocks has been modestly positive.

3.3 SUMMARY

Conventional VAR methods estimated in a single country setting provide a standard and flexible framework to analyse the links between financial variables and real variables. Variance decompositions based on conventional Choleski identification assumptions suggest several conclusions. First, the contribution of financial variables to real fluctuations is fairly heterogeneous across countries. Second, on average across countries the contribution of financial shocks to real fluctuations is rather large (up to 30% of GDP variance) compared with the contribution of monetary policy typically reported in the related literature on monetary policy transmission. Third, shocks to real asset prices (house prices and stock prices) often have larger real effects than shocks to the term spread or to leverage (loans-to-GDP ratio or loans-to-deposits ratio). Fourth, comparing GDP, private consumption and investment, the latter is often most responsive to financial shocks. However, the results suggest that for some countries financial shocks may affect consumption more heavily than investment.

These conclusions should be relevant for researchers seeking to better integrate financial variables in DSGE models. They suggest financial shocks should play a significant role in driving real fluctuations, with financial frictions affecting consumption as well as investment. On average, the contribution of financial shocks to fluctuations in private consumption is almost as large as that for investment. This suggests that when introducing financial frictions in DSGE models, the modelling of firm and household decisions should reflect country-specific characteristics.

The main conclusions of this analysis are robust to several changes in specification, including using log levels instead of log differences, changing the number of lags, the estimation sample or the ordering of the financial variables. However, the analysis is also subject to several limitations that should be noted. First, the sample used is longer than in many previous studies in order to include as many financial shocks as possible, but this also increases the number of potential regime shifts (such as the creation of EMU). In addition, there are theoretical reasons to expect the relationship between real and financial variables to vary at different points in the business cycle. Both these remarks suggest that methods allowing for time-varying parameters may be more appropriate. Second, our approach ignores possible cross-country spillovers. Finally, our standard VAR framework is only a linear approximation to the data, while the relationship between real and financial variables may be subject to non-linearities. These assumptions will be relaxed in Sections 6 and 7.

4 FINANCIAL CYCLES AND BUSINESS CYCLES: TURNING POINT ANALYSIS

This section uses turning point analysis to study the linkages between financial cycles and business cycles. In particular, we want to establish whether developments in financial markets lead developments in the real economy. The main focus of the analysis is on recessions: arguably, financial frictions and constraints tend to bite more during economic downturns than during expansions.

We identify the peaks and troughs of real house prices, real stock prices, the loans-to-GDP ratio, the loans-to-deposits ratio and the spread between long and short-term interest rates using the Bry-Boschan (1971) algorithm (see also Harding and Pagan, 2002, and Mönch and Uhlig, 2005). Quite intuitively, a downturn phase in a financial time series is a period between a peak and a trough, while an upturn is a period starting with a trough and ending with a peak.[24] We then study how downturns in real house prices, real stock prices and the loans-to-GDP ratio are related to recessions in the real economy.[25] While the loans-to-GDP ratio is the principal measure of loan market developments in this section, we also consider the loans-to-deposits ratio and the spread between long and short-term interest rates. All these alternative measures yield similar conclusions.

This section consists of two parts. First, we analyse how financial cycles (in particular financial downturns) in nine euro area countries (Belgium, Germany, Spain, Finland, France, Ireland, Italy, Luxembourg, Netherlands) are related to euro area recessions.[26] In the second part, we study financial and business cycles in a larger set of countries (the nine euro area countries plus Denmark, United Kingdom, Sweden, Austria, Switzerland, New Zealand, United States, Japan).[27] In this latter part, not only financial but also business cycles are identified separately for each country using the Bry-Boschan algorithm; that is, we compare country-specific financial cycles with country-specific business cycles. Throughout the section, we use relatively simple analytical tools: graphical presentation, some simple summary statistics, and the concordance index (Harding and Pagan, 2002) with slight modifications.

4.1 FINANCIAL CYCLES AND EURO AREA RECESSIONS

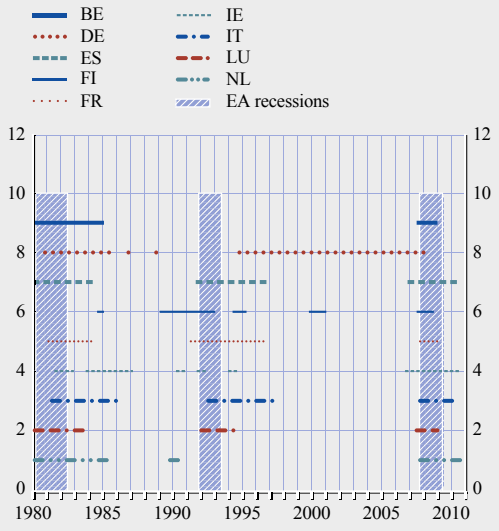
This subsection focuses on euro area recessions (as determined by the Centre for Economic Policy Research (CEPR)) and their relationship to downturns in real house prices, real stock prices, or the loans-to-GDP ratio. The sample period is from the first quarter of 1980 to the fourth quarter of 2010. We structure the presentation around two questions: (i) Do downward phases of the financial variables roughly coincide with euro area recessions? As a simple (initial) criterion, we use overlap. We say that a downturn in a financial variable overlaps with a euro area recession if there is at least one quarter when the financial variable is in a downturn and the euro area is in recession.

24 If the first turning point of the sample period is a peak (trough), the sample begins with an upturn (downturn).
25 We do not analyse the relationship between the turning points of different financial time series. These issues are addressed in the recent work on financial cycles by Claessens et al. (2011a).
26 The choice of countries is motivated by two considerations. First, for most of our sample (until the first quarter of 1999) the CEPR Euro Area Business Cycle Committee established a chronology of recessions and expansions of the EA12 countries (11 original euro area member countries plus Greece). Second, for the nine countries in the sample, we have data on house prices, stock prices and loans to households and non-financial corporations for the whole sample period (1980-2010), while some data for the remaining EA12 countries (Greece, Austria and Portugal) are missing.
27 For these 17 countries we have data on the financial variables for the whole sample period (1980-2010).

(ii) Do downturns of financial variables lead or lag euro area recessions? In particular, do the financial variables peak before euro area output starts contracting?[28]

Real house prices. There are 32 downturns in real house prices in our sample (see Chart 4). Of these episodes, 23 (or roughly 70%) overlap with euro area recessions. However, among these, Germany is arguably not related to a euro area recession between 1995 and 2008. This episode largely coincided with a long period of expanding output in the euro area, and it came to an end at the onset of the recession of 2008-09.[29] Even when we exclude Germany from 1995 to 2008, the remaining episodes that overlap with euro area recessions are, on average, considerably longer than the remaining nine episodes that do not overlap with euro area recessions.

Chart 4 Episodes of falling real house prices and euro area recessions (shaded areas)



To view the relationship between real house prices and euro area business cycles from a somewhat different angle, there are only four cases (out of 27 in our sample[30]), where the euro area was in recession without real house prices declining in any particular country at any point.[31]

Typically, real house prices start falling before a euro area recession. In our sample, this happened in 18 of the 22 episodes that overlapped with a euro area recession[32] (and also in the Netherlands in 1990), while there are only four cases where house prices peak during a euro area recession. Furthermore there are only two cases where real house prices peak in the aftermath of a euro area recession (within four quarters), and five cases where house prices peak within 12 quarters after the end of a recession. Based on these observations, we can conclude that peaks in real house prices tend to lead euro area recessions in our sample.

Periods of falling house prices tend to last longer than periods of output contraction (see, for example, Claessens et al., 2011). Given this background, it is hardly surprising that in many cases real house prices continue to fall (and sometimes for quite a while) when the real economy is already recovering from a recession. In our sample this happened in 15 out of the 18 overlapping

28 Evidently, recessions in individual member countries are not necessarily synchronised with euro area recessions. In particular, in the pre-EMU period there were marked differences between countries in the timing of business cycles. Hence, the evidence presented in this subsection should be treated as suggestive and illustrative. The choice to use euro area business cycles, rather than country-specific business cycles, is mainly a matter of exposition. We have also conducted the analysis with country-specific business cycles. While the use of country-specific business cycles reveals some new nuances, we nevertheless think that, with euro area recessions as a common benchmark, we can communicate the main message somewhat more clearly. Indeed, we reproduced Figures 4.1, 4.2 and 4.3 with country-specific recessions, but finally concluded that the relatively simple figures with euro area recessions are probably more useful for the reader. In Subsection 4.2 we compare country-specific financial cycles with country-specific business cycles.

29 On the other hand, two of the non-overlapping episodes (Netherlands 1990 and Ireland 1990) occurred in a period leading to the euro area recession of 1992-93, while one episode (Finland 1995) took place soon after the euro area recession of 1992-93.

30 Nine countries, three euro area recessions.

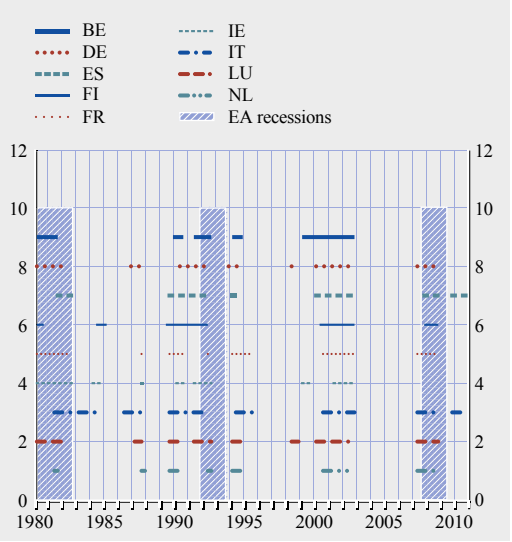
31 Finland in 1980-82, and Belgium, France and the Netherlands in 1992-93.

32 We exclude Germany from 1995 to 2008. However, we include four episodes when house prices were falling at the beginning of our sample. In these four cases it would be more accurate to say that real house prices peaked no later than euro area output.

episodes; in ten of these episodes the downward phase of house prices also started before the onset of the recession.

Real stock prices. There are far more turning points in real stock prices than in real house prices (Chart 5). The 62 downturns in real stock prices in our sample vastly outnumber the quarters when a country lived through a euro area recession. Given this background, it not surprising that less than half (27/62=44%) of the downturn phases in real stock prices overlap with euro area recessions.

Chart 5 Episodes of falling real stock prices and euro area recessions (shaded areas)



There are 27 episodes overlapping with euro area recessions, which is actually remarkably high in the sense that, in all nine countries in our sample, real stock prices were falling at some point in each of the three euro area recessions in our sample period (3 recessions * 9 countries = 27 episodes). It is also worth noting that nine episodes of falling real stock prices occurred at the turn of the millennium, coinciding with the bursting of the ICT bubble. While CEPR does not date this as a recession, it is a period of slow output growth in the euro area.

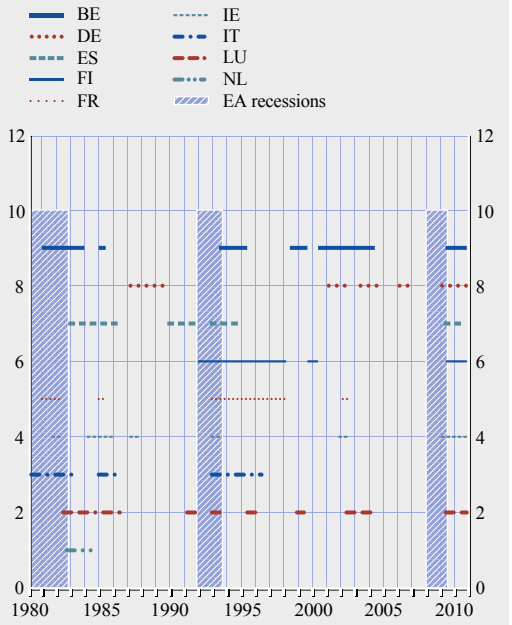
When a downturn in real stock prices overlaps with a euro area recession, stock prices typically start falling before euro area output. In our sample there are 22 such episodes, while there are only five episodes where real stock prices peak during a euro area recession. Furthermore, at the turn of the millennium, real stock prices peaked in all nine countries before output growth in the euro area slowed. Also, episodes of falling real stock prices that precede euro area recessions – or the period of slow output growth in the early 2000s – tend to be significantly longer than other downturns in stock prices. Finally we notice that real stock prices typically reach their trough at the beginning of a recession, so that in many cases real stock prices are rising while euro area output is still contracting.[33]

Loans-to-output ratio. There are 40 episodes when the loans-to-GDP ratio declined in our sample. Among these episodes, 17 (43%) overlap with euro area recessions (Chart 6). While (peaks of) real asset prices tend to lead euro area recessions, periods of contracting credit, as measured by the loans-to-GDP ratio, clearly lag the recessions. Of the 17 episodes overlapping with euro area recessions, only two begin before the onset of the recession, while in the remaining 15 cases, the loans-to-GDP ratio typically peaks towards the end of the recession. Moreover, most of the episodes that do not overlap with euro area recessions take place directly in their aftermath, or in the early 2000s (when output growth was slow).

We also used the loans-to-deposits ratio to analyse credit market developments. Periods of contracting credit lag euro area recessions even when this alternative measure is used; see Figure A9

33 While real stock prices typically start rising earlier than euro area real output, prices may dip again soon after the end of a recession. In our sample there are 12 cases where real stock prices peak within four quarters following a recession.

Chart 6 Episodes of falling loans-to-GDP ratio and euro area recessions (shaded areas)



in the Appendix. See also Figure A10 on episodes of *rising* interest rate spreads and euro area recessions.

Overall our analysis indicates that real house prices and real stock prices often peak before euro area recessions. Moreover, periods of contracting credit tend to lag euro area recessions.

Differences between countries (all financial variables). Although the exact timing of financial cycles varies among countries, in most countries the developments of financial markets vis-à-vis the euro area business cycle follow a broadly similar pattern, especially since the launch of EMU. The only exception is Germany, where the dynamics of real house prices and the loans-to-GDP ratio have clearly differed from financial developments in the other euro area countries in our sample. Finland was also something of an outlier in the 1980s, in terms of real house prices and the loans-to-GDP ratio.[34]

4.2 FINANCIAL AND BUSINESS CYCLES IN A SAMPLE OF 17 OECD COUNTRIES

In this subsection we focus on national business cycles and their link to financial cycles in an extended sample of 17 OECD countries (nine euro area countries plus DenmarK, United Kingdom, Sweden, Austria, Switzerland, New Zealand, United States, Japan). The sample period is from the first quarter of 1980 to the second quarter of 2010.

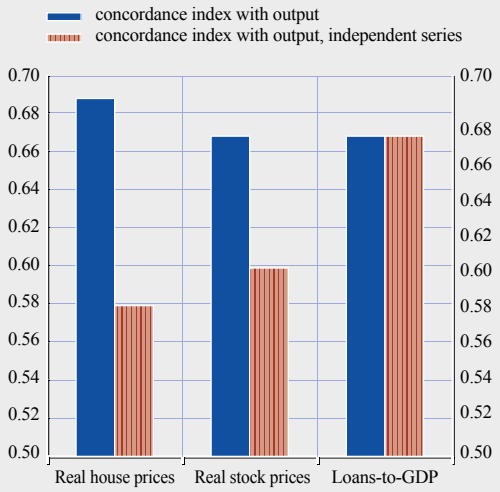
For each country, we identify the turning points of real output and of financial variables using the Bry-Boschan (1971) algorithm. In our sample, the unconditional probability (or the unconditional relative frequency) of a country being in recession in a given period is 0.12. The unconditional probability of the financial variables being in downturn phase is 0.39, 0.37 and 0.28 for real house prices, real stock prices and the loans-to-GDP ratio, respectively. Furthermore, the downturn phases of the financial variables tend to last considerably longer than the downturn phases of real GDP: the average length of a downturn phase is 11.7 quarters for real house prices, 6.1 quarters for real stock prices, 7.2 quarters for the loans-to-GDP ratio, and 3.8 quarters for real output. However, the expansion phases of both financial variables and real GDP are longer than the downturn phases: the average length is 17.6 quarters for real house prices, 10.2 quarters for real stock prices, 19.3 quarters for the loans-to-GDP ratio, and 23.7 quarters for real output.

The concordance index CI (Harding and Pagan, 2002) offers a relatively simple and flexible way to analyse the linkages between downturns in financial markets and the real economy. The concordance index provides a measure of the fraction of time the two time series are in the same phase (expansion or downturn) of their respective cycles. A (financial) variable is perfectly pro-cyclical

34 This probably reflects the fact that in the 1980s, Finnish business cycles were not synchronised with CEPR euro area business cycles.

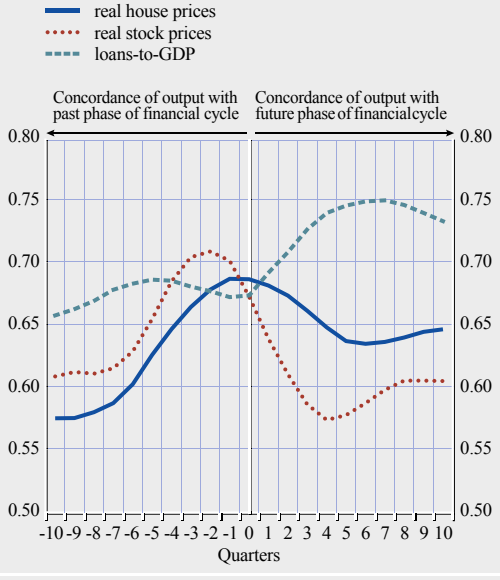
(countercyclical) if its concordance index with output is equal to unity (zero). As a further benchmark, consider a hypothetical case with independent cycles. If the phase of, say, real house prices were independent of the phase of output, the concordance index would take the value CI = 0.125 * 0.37 + (1-0.125) * (1-0.37) = 0.58 (given that the unconditional relative frequency of output contractions in our sample is 0.125, while the unconditional relative frequency of falling house prices is 0.37). The concordance indices shown in Chart 7 indicate that, in our sample, real house prices and real stock prices are (mildly) pro-cyclical: the value of the concordance index exceeds the value corresponding to independent cycles. On the contrary, the loans-to-GDP ratio is acyclical: the value of the concordance index matches the value corresponding to independent cycles.

Chart 7 Concordance of real output and financial variables



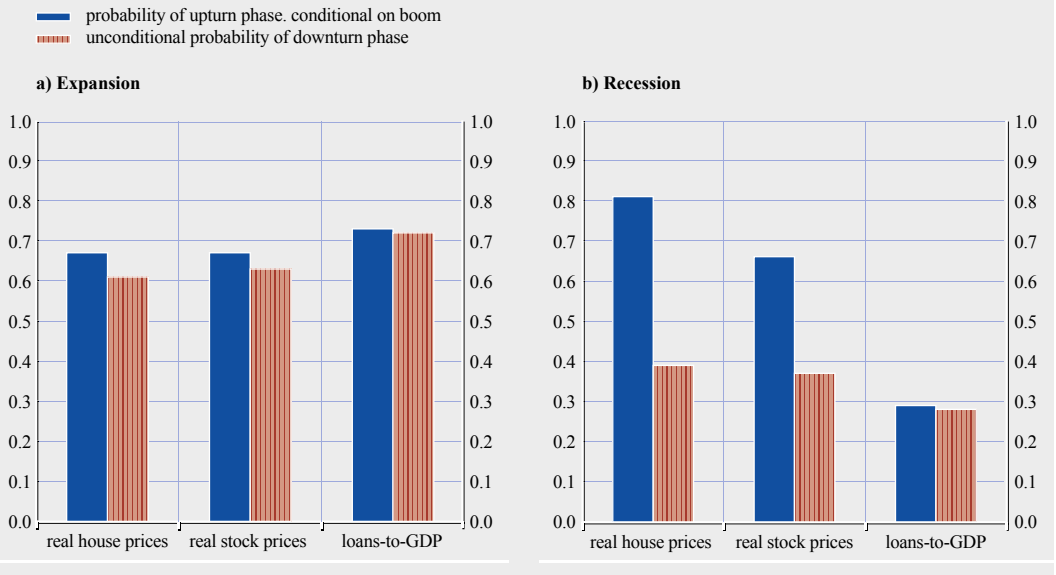
We also compute concordance indices of output with lags and leads of the financial variables (see Chart 8).This is a useful exercise, since our analysis of the euro area, in Section 4.1, suggests that the current phase of the real economy may be related to the past phase (for real stock prices) or to the future phase (for the loans-to-GDP ratio) of financial variables. Indeed, the concordance of current output with the past phase of real stock prices (lagged by two quarters) is somewhat higher than concordance with the current phase, while the concordance of output with the future phase of the loans-to GDP ratio (0.76 with an eight-quarter lead) is considerably higher than with the current phase (0.67). These findings indicate that stock markets tend to lead real activity, while developments in credit markets typically lag developments in the real economy. Finally, according to this indicator, developments in housing markets coincide with, or slightly lead, developments in the real economy.

Chart 8 Concordance of real output with past and future phases of financial cycle concordance with lags and leads



While the concordance index provides useful information about the interaction between the financial cycle and the business cycle over the whole sample, it downplays the stronger link between financial variables and real activity during recessions. To address this issue, we compute separate concordance indices, conditional on output expanding or on output contracting in a given period. The conditional concordance index of, say, real house prices and output is simply the conditional probability that house prices are rising during an output expansion, and falling during a contraction.

Chart 9 Conditional (contemporaneous) concordance of financial variables and real activity in expansions and recessions



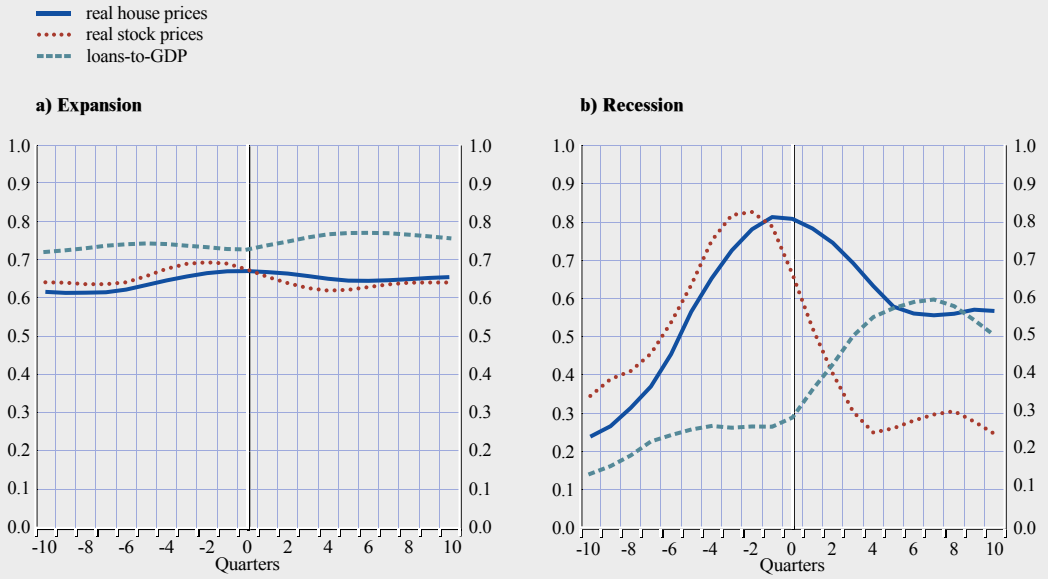
During an output expansion, the conditional probabilities that the financial variables are in an upturn phase do not differ much from the unconditional probabilities (left panel of Chart 9). During a recession, real output and real asset prices are much more tightly knit together (right panel of Chart 9). If real output is contracting in a certain period, say τ, then the conditional probability (or the conditional frequency in our sample) that real house prices are also falling in that period is 0.81, or roughly twice the unconditional frequency that house prices are in a downturn. The conditional frequency of real stock prices being in a downturn phase is 0.66. This is also clearly higher than the unconditional frequency (0.37). Remarkably, the conditional frequency of real stock prices being in a downward phase is still higher in periods preceding τ, with the highest value 0.8 reached in period τ-4 (Chart 10).

These findings call to mind our remarks on euro area recessions. First, we observed that it is highly unlikely that a country goes through a (euro area) recession without real asset prices falling at some point. This property also holds for country-specific recessions in the larger sample of countries. For any given time period when output is contracting, it is likely that real asset prices are also falling during that period. Second, we saw that while real stock prices tend to fall before euro area recessions, they often recover before the recession is over. This finding also holds for the larger set of countries. If we take an arbitrary recession, it is quite likely that the downturn phase of real stock prices has already passed (Chart 10).

The findings for the loans-to-GDP ratio are also intuitive (right panel of Chart 9 and Chart 10). If the economy is entering a recession, the downturn phase of credit is often still to come.

The probability of recession when financial cycles peak. Our previous analysis showed that peaks in real house prices and real stock prices tend to lead euro area recessions. We also observed that the loans-to-GDP ratio often peaks towards the end of a euro area recession, or even later. Next we show that similar results also hold for country-specific recessions in the larger sample of

Chart 10 Conditional concordance of real activity with past and future phases of financial cycles

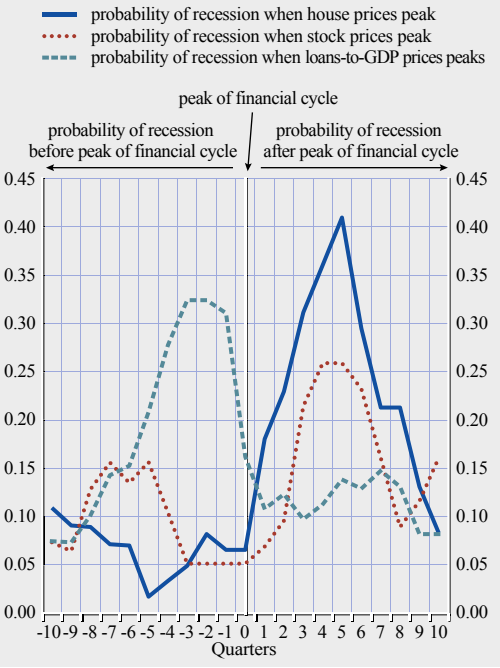


countries. In order to demonstrate this, we study the conditional frequency of recessions around peaks in real house prices, real stock prices and the loans-to-GDP ratio.

When real house prices or real stock prices peak, the (conditional) probability that the economy is in recession is very low (see Chart 11): at 0.05 it is roughly half the unconditional probability of recession (0.12).[35] However, once asset prices are in a downturn phase, the probability of a recession increases sharply, reaching 0.4 (almost four times the unconditional probability of 0.12) five quarters after the peak in house prices and 0.25 (roughly twice the unconditional probability of 0.12) five quarters after a stock market peak.

This observed time pattern reinforces the view that real asset prices lead real activity. This relationship is stronger for real house prices than for real stock prices. In a period when the loans-to-GDP ratio peaks, the conditional probability of the economy being in recession

Chart 11 The probability of a recession before and after the peak of a financial cycle

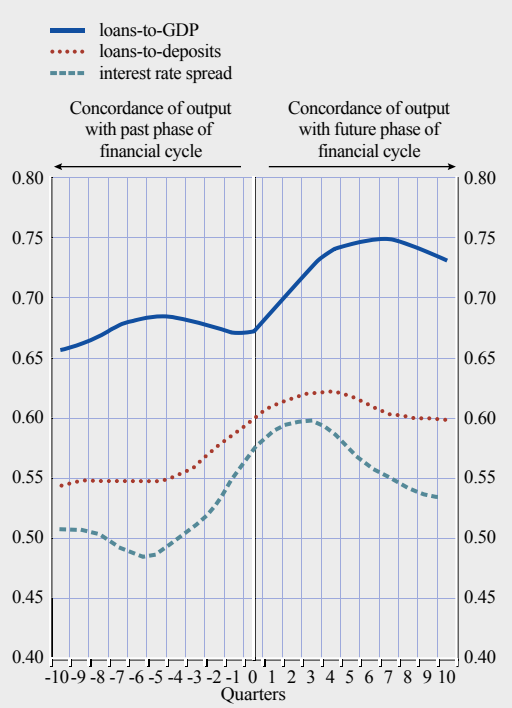


35 Work by Borio and Lowe (2002, 2004) and by Claessens et al. (2009, 2011b) suggests that it would be interesting to calculate the probability of recession based on the condition of several financial variables. However, we have too few episodes in our sample for this kind of analysis.

is 0.15, or roughly equal to the unconditional probability of an output contraction. Here the pattern is a mirror image of what we saw for real asset prices. The conditional probability of a recession reaches its highest value (0.35 or roughly three times the unconditional probability) four quarters before the peak in the loans-to-GDP ratio. Once again this finding indicates that movements in the loans-to-GDP ratio tend to lag movements in real activity.

Credit markets: Some alternative measures. In our analysis, we have used the loans-to-GDP ratio as the principal measure of loan market developments. Here we consider two alternative indicators: the loans-to-deposits ratio and the spreads between long-term and short-term interest rates.[36] The main finding of the section is robust to these measures: credit market developments tend to lag developments in the real economy, even when the loans-to-deposits ratio or spreads are used. This is illustrated in Chart 12, which reports the concordance indices of real output with lags and leads of the different measures of credit market cycles (cf. Chart 8).

Chart 12 Concordance of real activity with past and future phases of credit markets



4.3 SUMMARY

Overall, the findings of this section indicate that financial prices often lead real activity. In particular, peaks in real asset prices tend to lead recessions. This pattern is stronger for real house prices than for real stock prices. On the contrary, loan market developments tend to lag developments in real activity. These findings are consistent with the results established in other parts of this paper (see in particular Sections 3 and 6). Our results also suggest that there is a tighter connection between financial variables and real output during recessions than during booms. In a similar spirit, Section 7, on non-linearities, shows that the feedback between the financial sector and the real side of the economy is more pronounced in times of high financial stress than in normal times.

36 Notice that here the concordance is between: i) expansions and episodes of falling interest rate spreads; and ii) recessions and episodes of rising interest rate spreads.

5 TIME-VARYING LINKAGES BETWEEN ECONOMIC ACTIVITY AND FINANCIAL VARIABLES

Does the relationship between financial variables and economic activity change over time? This section addresses this question by estimating time-varying VARs with stochastic volatility for euro area variables. We focus on real house prices, since previous sections suggested they lead economic activity. First we use bivariate VARs to show that the unconditional (dynamic) correlation between GDP and real house prices changes significantly over time. Then we add inflation and interest rates to the VARs to calculate time-varying impulse responses to unexpected movements in real house prices or GDP.

There could be several reasons for time variation in the relationship between real and financial variables. The strength of macro-financial linkages could increase during asset price booms or when credit constraints become binding.

5.1 DYNAMIC CROSS-CORRELATIONS

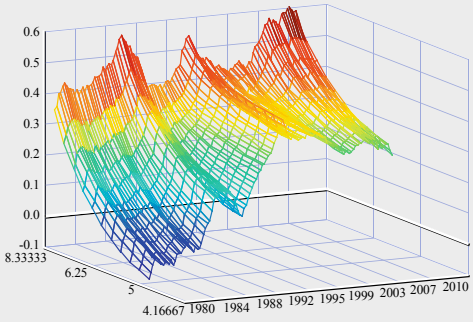
To compute the dynamic correlation between GDP and real house prices, we estimate a two-variable time-varying VAR as in D'Agostino et al. (2009). This not only allows the autoregressive coefficients to change over time, but also includes stochastic volatility to allow the innovation covariance matrix to drift. The estimated coefficients of the time-varying VAR are then used to compute the dynamic cross spectrum at each point in time as in Croux et al. (2001).[37]

Since the smoothing effect of calculating year-on-year growth rates eliminated much of the time variation, the VAR was estimated in quarter-on-quarter growth rates over the period from the third quarter of 1980 to the fourth quarter of 2010.

Figure 1.a reports the dynamic correlation between GDP and house prices. The x-axis ranges over time, the y-axis over business cycle frequencies, conventionally defined as fluctuations between three and eight years, and the z-axis reports the correlation at different periods in time and at different frequencies (long and short-term components). Moving along the y-axis, the unconditional correlation appears to be larger for long-term components. Chart 14 plots two cross-sections of Chart 13, focusing on the long-term component (ten years) and the short-term component (two years). For the long-term component, the highest correlation between house prices and GDP is observed around the peaks in the house prices previously identified in the first quarter of 1981, the fourth quarter of 1991 and the first quarter of 2007.[38] It is worth noting that after the most recent peak, the correlation fell and then increased after the recent sub-prime crisis.

Chart 14 also plots the confidence intervals, indicating that the correlation over the long term is always significantly different from zero,

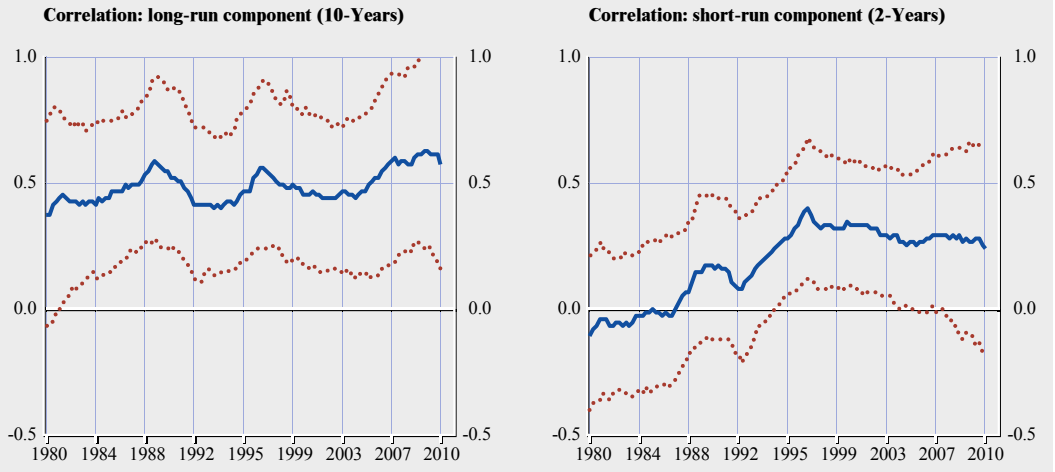
Chart 13 Dynamic correlation coefficient



Note: Business Cycle Frequencies.

37 An Appendix with the description of the methodology is available upon request.
38 Using the Bry-Boschan (1971) algorithm we identify three peaks in the euro area series for real house prices: 1981Q1, 1991Q4 and 2007Q1.

Chart 14 Confidence bands



whereas the correlation over the short term is significantly different from zero only for the 1994-2008 expansion in the euro area.[39]

5.2 TIME-VARYING IMPULSE RESPONSE FUNCTIONS

Previous sections indicated that real house prices tend to lead GDP. This section complements previous findings by analysing changes over time in the real house price-GDP linkage.

As in Section 2, we define a financial shock as a movement in a financial variable that is unpredictable from past information and is uncorrelated with contemporary shocks in the other variables. We extend the time-varying VAR to include real GDP, HICP inflation, and the short-term interest rate as well as real house prices.[40] The shocks are orthogonalised in the order: real GDP, consumer price inflation, house prices and short-term interest rate.[41]

Chart 15 reports the time-varying impulse responses to a shock to real house prices. Compared with the previous figures, the y-axis now represents the quarters after the shock (rather than the business cycle frequency) and the z-axis now represents the GDP response (rather than the correlation). Confidence intervals are not shown, but we find no significant time variation in the response of inflation and the interest rate. By contrast, the response of GDP to an unexpected change in real house prices has become stronger and more persistent over time. GDP displays the highest response in 2007, coinciding with the peak in house prices. The larger impact on GDP could be related to a variety of factors, including the process of mortgage market innovation[42] that increased the

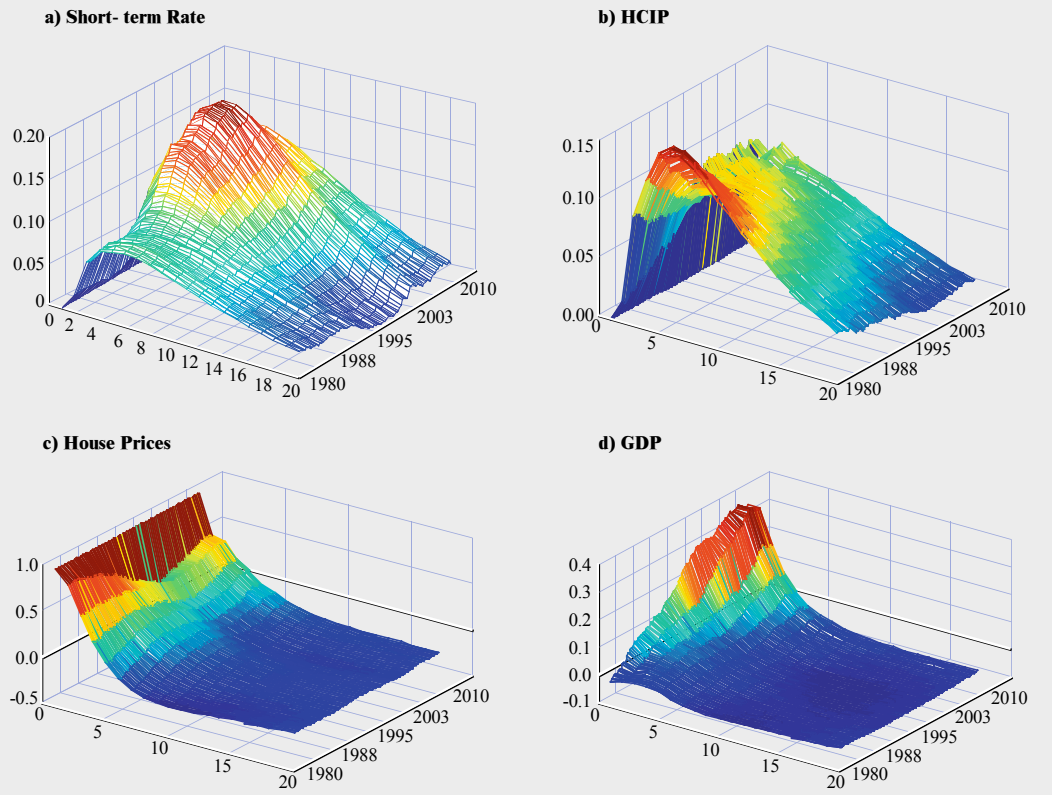
39 The CEPR Euro Area Business Cycle Dating Committee identified the third quarter of 1993 as the end of the recession of the early 90s, and the first quarter of 2008 as the beginning of the recession that ended in the second quarter of 2009. From the first quarter of 2003 to the second quarter of 2003 the Committee concluded that the euro area experienced a pause in economic growth, but not a recession.

40 The large number of parameters in the time-varying VAR precludes including further financial variables as done in Section 2.

41 See Iacoviello (2005) and Iacoviello and Minetti (2008).

42 Mortgage market innovation in EU countries includes the introduction of new products with floating rate and mixed fixed/floating rate characteristics, the greater use of second mortgages and foreign currency-linked mortgages, and the adoption of higher "loan-to-value" ratios.

Chart 15 House Price Shock



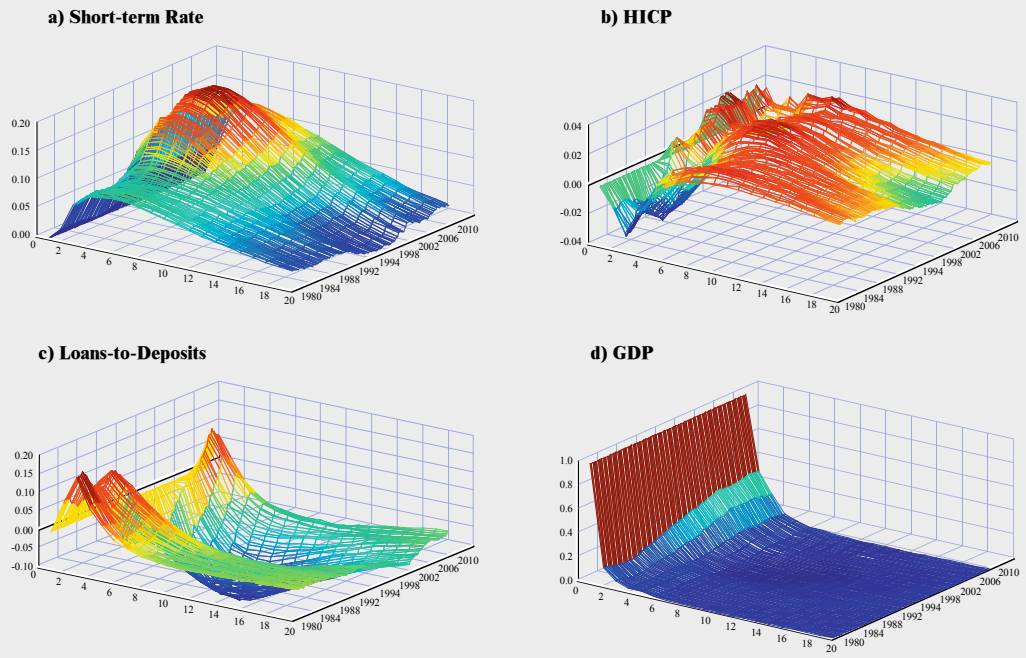
sensitivity of consumption and residential investment to house prices over time.[43] Chart 16 reports the house price response to an unexpected change in real GDP. Positive co-movement between house prices and GDP is greatest around the years of house price booms.

5.3 SUMMARY

Results from the time-varying analysis suggest that the unconditional correlation between cyclical components of real house prices and GDP varies over time. The link between GDP and real house prices has become stronger and the effect of shocks more persistent over recent years. In particular, the GDP response to an unexpected change in real house prices is stronger over the most recent period, whereas the house price response to unexpected changes in real GDP is generally higher in the quarters around house price peaks.

43 Iacoviello and Minetti (2008) find that the response of house prices to interest rate shocks is bigger and more persistent in periods of greater financial market liberalisation.

Chart 16 GDP Shock



6 HETEROGENEITY AND CROSS-COUNTRY SPILLOVERS OF REAL AND FINANCIAL SHOCKS

Is there heterogeneity or a common pattern in macro-financial linkages across the euro area? Has it changed over time? Do these linkages differ with respect to those prevailing in other economic areas?

The recent crisis was a worldwide phenomenon that revealed how deeply intertwined financial and real developments are across countries. Shocks to the financial system in one country or group of countries transmitted rapidly to the real economy, also in other countries.

To address these questions one needs an empirical model including both real and financial variables for the euro area and other countries. This section complements the country-specific VAR analysis in Section 3 by allowing for spillovers and time-varying parameters across a panel of time series and countries. The empirical approach applied identifies common movements for all variables and countries, or for groups of variables (e.g. real versus financial), or for country groups.

Such an econometric tool can explore additional issues, such as: (i) what is the role of country-specific versus common factors; (ii) how much has the transmission of shocks across countries mattered in the 2008-09 crisis; and (iii) do international spillovers affect the lead-lag relationship between financial and real variables found in Section 4? To our knowledge, this is the first attempt in the literature to address the issues of heterogeneity and spillovers in such a rich methodological framework.

6.1 METHODOLOGY

A time-varying Panel Bayesian VAR (of the type developed in Canova and Ciccarelli, 2009, and Canova et al., 2007) is first estimated for as many euro area countries as possible, and then for the main euro area countries and some other major countries. In both cases, the analysis includes both the core variables of the real business cycle and the set of financial series used previously in this paper. As in most parts of this paper, the sample period used is the first quarter of 1980 to the fourth quarter of 2010. We use year-on-year growth rates of the variables, which are further standardised in order to obtain meaningful aggregations of these heterogeneous series. The Schwarz Bayesian Information Criterion favours a single lag for the VAR dynamics.

The sample covers the biggest economies in the euro area as well as some of the smaller ones, including some that suffered most during the financial crisis. Beyond the euro area, three other EU countries (Denmark, Sweden and the United Kingdom) are included, as well as three non-EU countries (United States, Canada and Japan). In order to keep the estimation tractable we have split the sample in two different country sets and estimated the same statistical model for both groups. The first "euro area" set includes all nine euro area economies for which data were available for the whole sample period and also the United States.[44] The second "international" set restricts the euro area to its four largest economies (Germany, France, Italy and Spain) so that it is computationally feasible to include three non-euro EU economies (Denmark, Sweden and the United Kingdom) and three non-EU economies (United States, Canada and Japan). The choice of non-euro countries is again determined by data availability, as well as by the aim to capture the more relevant economies in the EU and the rest of the world.

44 The United States is added to this set as a control variable for the world economy developments; it will be key to assess the relative spillovers of financial shocks across euro area economies, whether they come from inside or outside the euro area. For the other results, in particular the estimated common, country and variable-type components, the same model for the euro area set without the United States delivers the same results.

The time-varying Panel Bayesian VAR has three main advantages in this context. First, it can handle large dynamic panels displaying unit-specific dynamics and cross-country lagged interdependencies. Second, it allows for time variation in the correlation structure across variables and across countries, which appropriately captures the changing nature of real-financial interactions as well as cross-country linkages. Third, it features a simple structure which provides measures of common, national and variable-type components by factorising the matrix of time-varying coefficients into a reduced set of parameters.[45] This decomposition provides an assessment of the relative (and time-varying) importance of common, country-specific and variable-type components for fluctuations in the dependent variables. In other words, the proposed factorisation estimates a common component shared by all variables and countries over time, a set of country-specific components shared by all variables within each country, and a set of type-of-variable components shared by all real variables, or by all financial prices or by all loan ratios across countries and over time.

6.2 COMMON, COUNTRY AND VARIABLE-TYPE COMPONENTS

These common, country-specific and variable-type components quantify the relative contributions of commonalities and heterogeneities in macro-financial linkages. Do euro area economies share a significant common component in macro-financial interactions? Or do country-specific heterogeneities matter more? How does this balance compare with other economic areas?

Different specifications were estimated, but for both country sets the likelihood was maximised when including one common component for all series, one country-specific component for each economy and three variable-type components: one shared by all real variables across countries, another shared by loan ratios across countries, and a third shared by asset prices and term spreads across countries.[46]

The common component is significant and especially prominent during the last recession. This links all real and financial series across all countries, consistent with findings in the previous sections and in the literature. Chart 17 displays the evolution of this common factor for each of the two country sets considered, expressed in standard deviations from the historical average of annual growth rates.[47] The estimated common component appropriately captures the 1992-94 recession during the ERM crisis, which is obviously more visible in the euro area set, and also identifies the mild recession of 2001-02. The recent crisis stands out as the largest common fluctuation in both country sets, but it is more prominent in the more international country set.

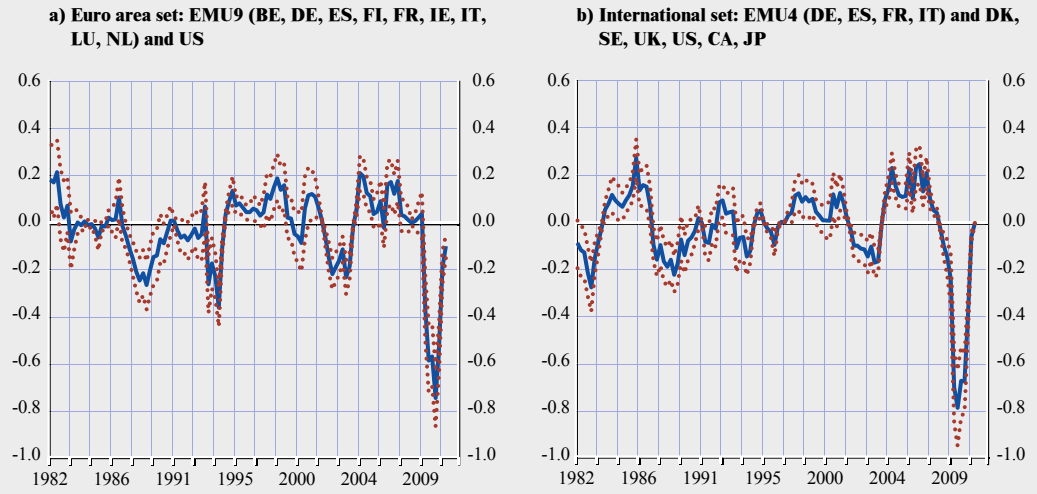
However, the country-specific components (common to both real and financial variables within each country) remain significant, and this explains some of the heterogeneity observed over time and across countries. Chart 18 shows the country-specific components from both country sets. These indicators are very precisely estimated, as is found in other empirical work with similar common factors (see, for example, Kose et al., 2003).

45 This uses shrinkage techniques that reduce the problem of estimating too many coefficients to one of estimating only a few factors characterising their dynamics. The factorisation transforms an over-parameterised panel VAR into a parsimonious SUR model where regressors are averages of certain right-hand side variables. For technical details, see Canova and Ciccarelli (2009).

46 An alternative specification with only two variable-type factors (one for the real variables and one for the financial variables) delivered a lower marginal likelihood for both sets. Another specification with no variable-type factors, i.e. only a common component and a set of country-specific factors, had an even lower marginal likelihood.

47 The solid black line represents the posterior median of the estimated distribution for the common factor at each point in time. The two dotted lines limit the 68% confidence interval. The estimation of such a model requires Bayesian techniques, hence the posterior distribution.

Chart 17 Evolution of the common component of macroeconomic and financial variables over time

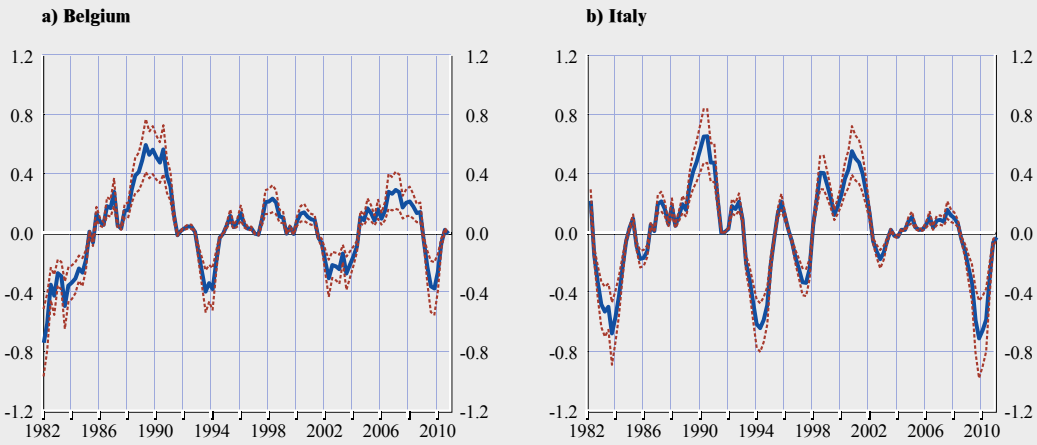


Notes: The charts plot the common factors of all macroeconomic and financial variables expressed in standard deviations from the historical average of annual growth rates. The solid blue line represents the posterior median of the estimated distribution for the common factor at each point in time. The red dotted lines limit the 68% confidence interval. The estimation of such a model requires Bayesian techniques, hence the posterior distribution. See Canova and Ciccarelli (2009) for details.

The figures also show that countries differ substantially in the amplitude and duration of the cycle phases and, in some cases, in their timing. For some countries the common component shared by fluctuations in their real and financial series are significant, as the 68% confidence intervals lie well above zero. In other countries this national component is not statistically different from zero or even statistically negative. Differences across countries in the joint evolution of real and financial

Chart 18 Evolution of the country component of macroeconomic and financial variables over time

(from both the euro area set and the international set estimations)



Notes: The charts plot the country factors of all macroeconomic and financial variables expressed in standard deviations from the historical average of annual growth rates. The solid blue line represents the posterior median of the estimated distribution for the common factor at each point in time. The red dotted lines limit the 68% confidence interval. The estimation of such a model requires Bayesian techniques, hence the posterior distribution. See Canova and Ciccarelli (2009) for details.

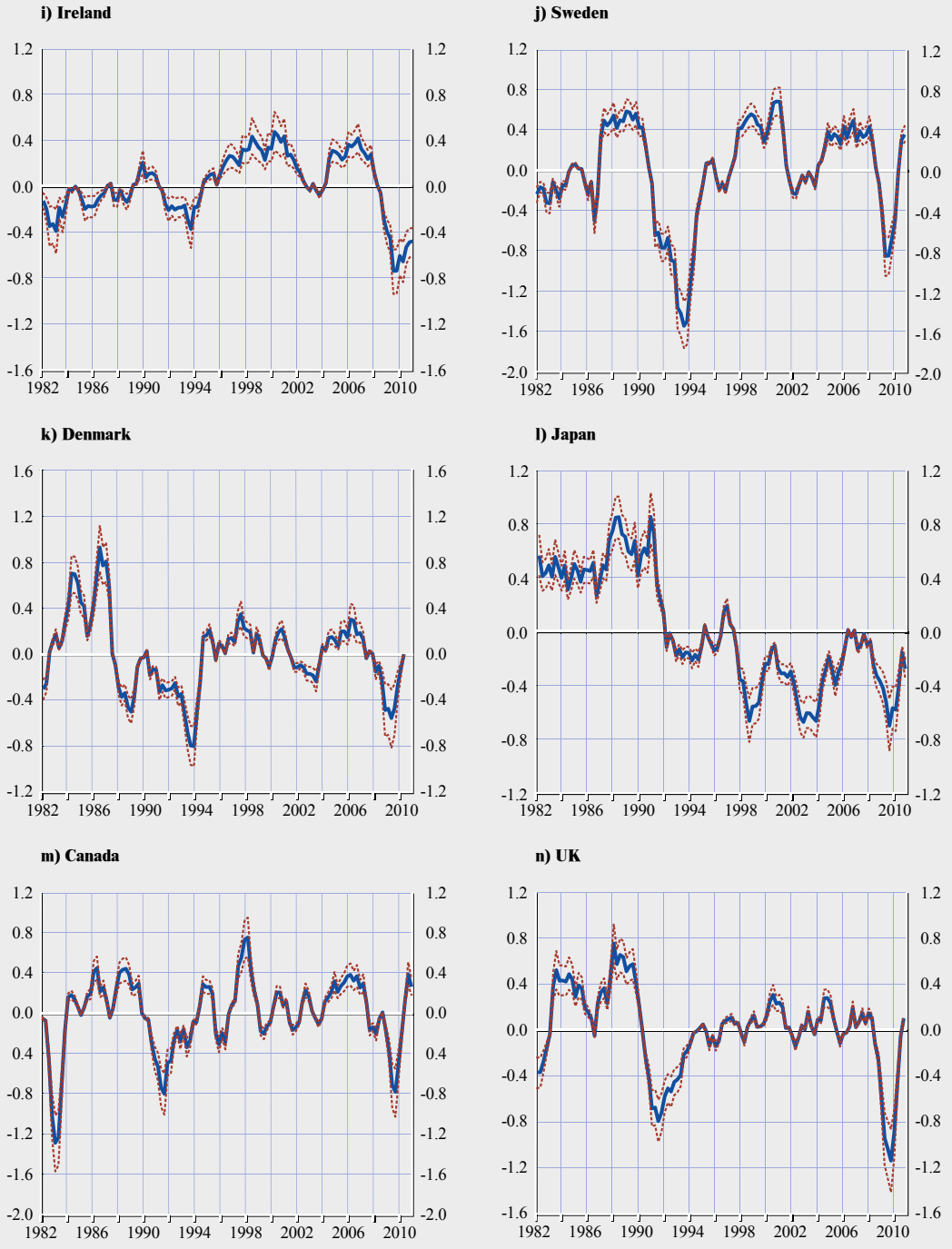
Chart 18 Evolution of the country component of macroeconomic and financial variables over time (cont'd)

(from both the euro area set and the international set estimations)

Notes: The charts plot the country factors of all macroeconomic and financial variables expressed in standard deviations from the historical average of annual growth rates. The solid blue line represents the posterior median of the estimated distribution for the common factor at each point in time. The red dotted lines limit the 68% confidence interval. The estimation of such a model requires Bayesian techniques, hence the posterior distribution. See Canova and Ciccarelli (2009) for details.

Chart 18 Evolution of the country component of macroeconomic and financial variables over time (cont'd)

(from both the euro area set and the international set estimations.)



Notes: The charts plot the country factors of all macroeconomic and financial variables expressed in standard deviations from the historical average of annual growth rates. The solid blue line represents the posterior median of the estimated distribution for the common factor at each point in time. The red dotted lines limit the 68% confidence interval. The estimation of such a model requires Bayesian techniques, hence the posterior distribution. See Canova and Ciccarelli (2009) for details.

variables could reflect non-synchronised business cycles if heterogeneity is due mainly to real economy developments, or financial bubbles in one country that are absent in others if heterogeneity is mainly attributable to financial variables.

The amplitude of the crisis in the early 1990s is remarkable in Finland (as well as in France and Spain) and in the two non-euro Nordic countries in the international set (Denmark and especially Sweden). On the contrary, the recession around 2002 was strongest in Germany and the Netherlands, and weaker in the United States, France and Belgium.

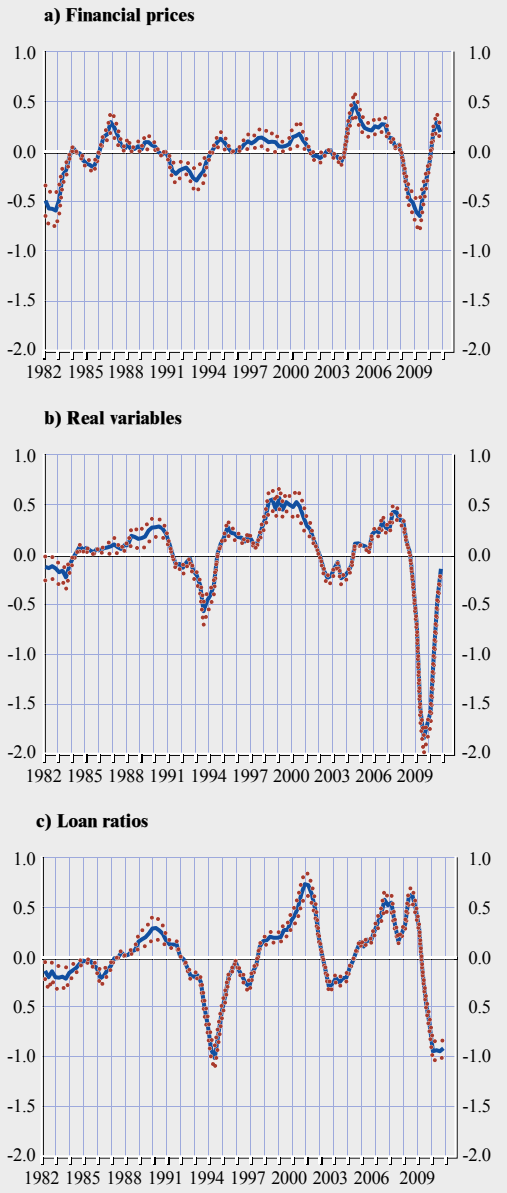
Also of interest is the long period of almost uninterrupted growth (nominal and real) in Ireland and, especially, Spain prior to the sharp fall in both economies during the last recession. This contrasts with the relatively weak performance of the Italian economy during most of that same period, and with the clear underperformance of the Japanese economy throughout the last two decades. The last recession remains the more common fluctuation across countries, albeit with different amplitudes.

For both country sets, three distinct variable-type components are identified, one common to all real variables (GDP, private consumption and gross fixed capital formation), one common to all financial prices (real stock and housing prices and interest rate spread) and one common to all loan ratios (loans-to-deposits and loans-to-GDP ratios). The charts in Chart 19 show that they are statistically significant for most of the sample period, i.e. the whole 68% posterior confidence interval is above or below zero. This implies that each type of variable shares a common component across the euro area.[48]

The contribution of each variable-type component to explain fluctuations in the main real and financial series depends on the estimated

Chart 19 Evolution of the variable components over time

(euro area set: EMU9 (BE, DE, ES, FI, FR, IE, IT, LU, NL) and US)



Notes: The charts plot the variable factors across all countries expressed in standard deviations from the historical average of annual growth rates. The solid blue line represents the posterior median of the estimated distribution for the common factor at each point in time. The red dotted lines limit the 68% confidence interval. The estimation of such a model requires Bayesian techniques, hence the posterior distribution. See Canova and Ciccarelli (2009) for details.

48 Results are reported only for the first set of countries (euro area plus the United States), as both country sets show remarkably similar patterns of the three variable-type components, except that in the more international set loan ratios fluctuated somewhat less in the last recession and the real variables recovered by the fourth quarter of 2010, which was not yet the case for the euro area set.

coefficients. A historical decomposition exercise (not reported) comparing the 2008-09 recession with two previous recessions shows that all three variable-type components played a significant role in the latest crisis, especially the drop in real variables (much less present in previous recessions) and the fall in financial prices. The role of the latter in explaining GDP movements during the 2008-09 crisis is much more pronounced in the international country set than in the euro area set. This suggests that the last recession saw stronger financial-real cross-country interdependencies around the world than within the euro area.

The analysis by variable groupings confirms that for the real economy the 2008-09 recession was unique from a historical perspective. Chart 19 illustrates how this crisis produced larger fluctuations in both country sets than those observed in the preceding three decades. This is true for all three variable types, but especially for real variables. Loan ratios fell as early as 2007, coinciding with the credit supply tightening documented by the bank lending survey (BLS),[49] then rose temporarily in 2008, coinciding with the initial fall in activity and income in national accounts data. Loan ratios dropped again after 2009, when the BLS also reported reductions in both credit demand and supply. Ciccarelli et al. (2010) found similar results using a panel VAR analysis combining similar macro data with BLS credit supply and demand indicators over 2007-10. Both country sets show remarkably similar patterns in the three variable-type estimated components, except that in the more international set (not reported) the loan ratios component fluctuated somewhat less in the 2008-09 recession and the real variables component recovered by the fourth quarter of 2010, which was not yet the case for the euro area set estimations.

This analysis by variable groups confirms the leading properties of financial prices found in Section 4. Both across countries and periods, financial prices lead real variables, while loan ratios are lagging. Giannone et al. (2010) confirm this result with a different methodology.

Comparing the evolution of these three variable-type components, in most recessions financial prices are usually the first to fall and to recover, followed by real variables and finally by loan ratios. An interpretation of the latter phenomenon could be that lower activity shrinks credit demand but also credit supply, partly because non-performing loans rise. Simple lead-lag cross-correlations among the three estimated factors suggest that financial prices lead real activity (with a maximum correlation coefficient of 0.75 at a three-quarter lead for the euro area set and 0.8 at a two-quarter lead for the international set). In turn, real variables appear to lead loan ratios (correlation peaks at 0.56 with a lead of six quarters in the euro area set and at 0.6 with a four-quarter lead in the international set). This lead-lag pattern across variables was also observed in the 2008-09 recession.

Among these three variable-type components, the real economy component is the more highly correlated with the component common to all countries and variables. The contemporaneous correlation between these two series is the largest, with values as high as 0.7 in the case of the euro area set and 0.8 for the international set. In a sense, this could be interpreted as an indication that real variables dominate the common business cycle that emerges across countries. Indeed, the consensus in the international business cycle literature is that the strongest co-movements are among real aggregates, both within a country and across countries (see, among others, Crucini et al., 2011).

49 The Bank Lending Survey is a quarterly survey that, since the fourth quarter of 2002, has been asking financial institutions in the euro area about current and expected future changes in the demand for credit and in the conditions for the concession of credit, both in the case of credit to households (for consumption and for house purchases) and to firms. A similar survey (Senior Loan Officer Survey) has been conducted for a longer period in the United States, starting in 1967. A brief description of both surveys can be found in Ciccarelli et al. (2010).

6.3 CROSS-COUNTRY TRANSMISSION OF SHOCKS IN THE 2008-09 RECESSION

Since the Panel Bayesian VAR combines real and financial series for several countries, it can assess the role of cross-country spillovers within the euro area and across other economic zones. Impulse response functions can track how changes in a financial variable in a given country affect real variables in other countries. Spillovers across countries and between financial and real variables were especially relevant in the 2008-09 recession, so we focus on this period using generalised impulse response functions for the euro area set. In particular, we assess whether a negative financial shock in one country affects the real economy across the euro area, and whether the strength of transmission depends on the origin of the shock.

The spillovers were measured as follows. We focus on GDP for each country. The generalised impulse response is computed as the difference between the GDP forecast, conditional on the observed fluctuation in a given financial variable (the "shock variable"), and its unconditional forecast during the last recession. By construction, the shock to the financial series is the difference between its observed evolution and what the model would have predicted unconditionally. It starts at the observed peak of the series that is being shocked and lasts until its observed trough. The choice is somewhat arbitrary and can differ among variables shocked and country of origin. Moreover, it allows the shock to be measured according to what has actually occurred and is a convenient tool that does not require the identification of "structural shocks", as typical in the VAR literature.[50]

Given the volatility and interdependencies of international financial markets since 2007, several impulse response functions are potentially interesting. As a good example of interdependencies between the rest of the world and euro area countries, panel a in Chart 20 shows the generalised impulse response functions of GDP across the euro area to a financial shock in the United States. The financial shock is defined as the unexpected part of the drop in US real stock prices in the period from the third quarter of 2007 (peak) to the fourth quarter of 2008 (trough). For illustration purposes, the responses to a real US shock are also shown in the b panel, where the shock is the unexpected part of the fall in US GDP growth between the third quarter of 2007 (peak) and the second quarter of 2009 (trough).

The extent of cross-country interdependence is clear from the charts, as the fall in US variables beyond the unconditional forecast (the units are standard deviations, since all series are standardised) causes a fall in the real economy in every other country, sometimes by almost as much as in the United States.

The following figures show the GDP response in different countries to a shock to a particular financial series in a given euro area country. First we focus on the impact of the unexpected drop in real house prices in Spain and Ireland. Chart 21 shows that most economies suffered a drop in GDP growth following the Irish shock – defined as the period from the third quarter of 2007 to the fourth quarter of 2009 – and the Spanish shock – defined as the period from the third quarter of 2008 to the fourth quarter of 2010.

The range of responses is somewhat less than a quarter of the responses in the country of origin. However, although the drop in house prices over those periods was 12% for Spain and 28% for

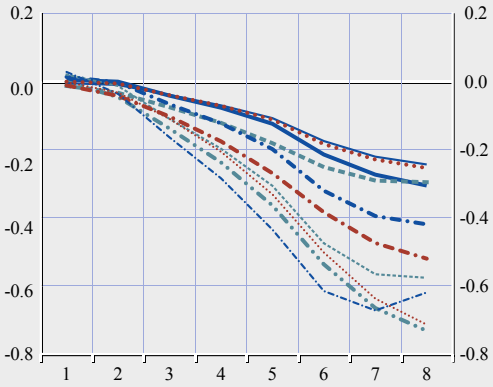
50 See also Section 3 of this report for the definition of structural shocks. For a definition and application to VAR models of generalised impulse response functions see Pesaran and Shin (1998).

Chart 20 Generalised impulse response functions of GDP growth to US shocks

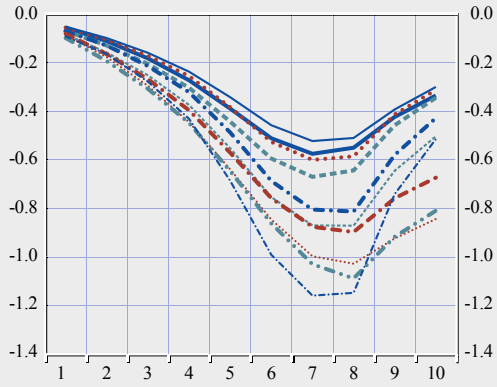
(euro area set: EMU9 (BE, DE, ES, FI, FR, IE, IT, LU, NL) and US)

Belgium
Italy
Finland
Luxembourg
France
Netherlands
Germany
Spain
Ireland
US

a) Shock to US real stock prices



b) Shock to US GDP growth



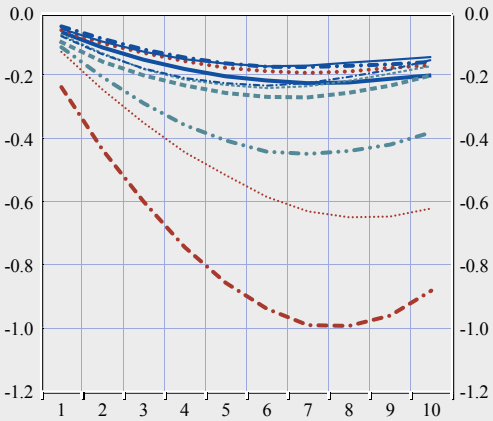
Notes: The charts plot the generalised impulse responses of country GDP to US shocks. Each response is computed as the difference between the GDP forecast, conditional on the observed fluctuation in the "shock variable" (US stock or US GDP), and its unconditional forecast during the periods 2007Q3-2008Q4 for the stock price shock and 2007Q3-2009Q2 for the GDP shock.

Chart 21 Generalised impulse response functions of GDP growth to real house price shocks in Spain and Ireland

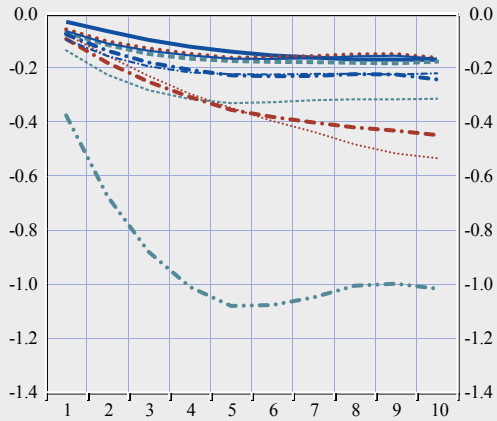
(euro area set: EMU9 (BE, DE, ES, FI, FR, IE, IT, LU, NL) and US)

Belgium
Italy
Finland
Luxembourg
France
Netherlands
Germany
Spain
Ireland
US

a) Shock to Spanish real house prices



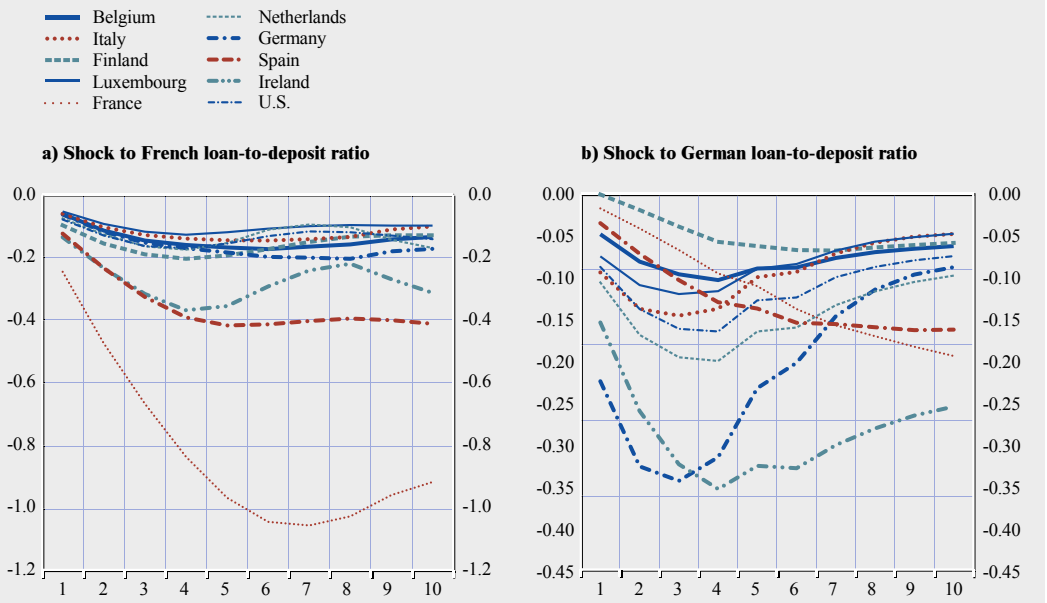
b) Shock to Irish real house prices



Notes: The charts plot the generalised impulse responses of country GDP to real house price shocks in Spain and Ireland. Each response is computed as the difference between the GDP forecast, conditional on the observed fluctuation in the "shock variable" (Spanish or Irish real house prices), and its unconditional forecast during the periods 2008Q3-2010Q4 (for the Spanish shock) and 2007Q3-2009Q4 (for the Irish shock).

Chart 22 Generalised impulse response functions of GDP growth to loan-to-deposit ratio shocks in France and Germany

(euro area set: EMU9 (BE, DE, ES, FI, FR, IE, IT, LU, NL) and US)



Notes: The charts plot the generalised impulse responses of country GDP to loan-to-deposit shocks in France and Germany. Each response is computed as the difference between the GDP forecast, conditional on the observed fluctuation in the "shock variable" (French or German loan-to-deposit ratio), and its unconditional forecast during the periods 2008Q3-2009Q4 for both shocks.

Ireland, the impact of Spanish house prices on some economies is much greater, possibly reflecting the larger size of the Spanish economy and its stronger links to other euro area economies. The largest responses are observed in France and Ireland, possibly owing to the similarities in the boom-bust patterns of their respective housing sectors.

Turning to the impact on real variables of shocks to the loan ratios in the largest euro area economies, Chart 22 shows that a shock in France – defined as the sample from the third quarter of 2008 to the fourth quarter of 2009 – has similar dynamics to the real house price shocks shown previously. However, when this shock occurs in Germany, over the same period, the responses in other economies are as large as those in Germany itself, although the unexpected fall in Germany was smaller. This suggests that when the shocks originate in Germany or the United States, they may be amplified in transmission.

Interesting questions, such as what are the likely economic channels behind the transmission of house price shocks, whether through bank balance sheets, and hence the supply of credit, or through direct wealth effects, are left unanswered by this analysis. A full macroeconomic model is required, which should not only include explicit modelling of consumer and firm decisions but their interaction through the financial system and with the rest of the world.

6.4 SUMMARY

Summing up, the evidence in this section confirms the need to allow for cross-country and cross-variable interdependence when studying real-financial linkages. An empirical model including real and financial variables for most of the euro area economies, as well as for other

major EU and OECD economies, identifies a statistically significant common component in the 2008-09 recession. However, country-specific factors remain very important, which explains the heterogeneous behaviour observed at times. In addition, there are common components to real variables across countries, as there are for loan ratios and for financial prices such as housing, stocks and interest rate spreads. As in other recessions, financial prices seem to enter the most recent recession somewhat earlier, while real variables suffered a greater fall. Finally, spillovers are found to matter: a negative shock to a financial variable in a given country also affects all other euro area countries and the United States. Cross-country transmission may even amplify shocks if they originate in Germany or the United States.

These results put into perspective the findings of the previous sections from two points of view. First, although heterogeneity across countries matters, common business cycle fluctuations across countries remain a prominent feature of the data. This is also in line with the recent literature on international business cycles, which finds that both group-specific and global factors drive world cyclical fluctuations. This phenomenon seems to be a robust feature of the data, i.e. it is not limited to countries in any particular geographic region and is not a mechanical effect of episodes of crises (see, for example, Kose et al., 2008).

Second, financial shocks matter in the explanation of real developments and, perhaps more importantly, they spill over in a heterogeneous way across countries. This is consistent with the results in Section 3, although the joint estimation here combines many countries and might yield stronger linkages than those obtained in country-by-country VAR analyses. In fact, the international panel VARs of this section allow possible amplification effects through spillovers.

7 NON-LINEARITIES IN MACRO-FINANCIAL LINKAGES

This section investigates possible non-linearities in the interaction between financial market conditions and macroeconomic variables. The importance of financial factors for the real economy became particularly clear when the deterioration in financial conditions in 2007-08 was followed by the most severe recession in post-war history.

Why do we expect non-linearities to play a role in this context? During times of high financial stress or during financial crises we expect more pronounced feedback between the financial sector and the real side of the economy. For instance, the deterioration of borrowers' balance sheets changes lenders' attitudes towards risk, raising risk spreads and the volatility of bond and stock prices. This motivates the focus on a financial stress indicator in this section. Financial stress affects real-financial linkages because asymmetric information and uncertainty impede borrower-lender relationships and can induce credit rationing. This might imply asymmetric effects and transmission of financial shocks across regimes.

There are a few recent attempts in the theoretical literature to better capture the role of the financial sector in macroeconomic models by allowing for non-linear dynamics, volatility effects and possible multiple equilibria. For instance, Brunnermeier and Sannikov (2010) show how to solve a model globally instead of in the neighbourhood of a steady state. They allow for instabilities and occasionally volatile episodes, emphasising the highly non-linear amplification effects caused by leverage and feedback effects from asset prices. He and Krishnamurthy (2011) include occasionally binding capital constraints that can generate potentially destabilising asset price dynamics. This section complements these theoretical models by presenting results from an estimated multivariate regime-switching model to analyse the interaction between financial stress and the euro area economy. Empirical evidence for non-linearities is provided from a macro model that incorporates systemic financial instabilities and is estimated to the data.

7.1 ECONOMETRIC MODEL

This section draws on the analysis in Hartmann, Hubrich, Kremer and Tetlow (2012) for the euro area, which builds on the analysis in Hubrich and Tetlow (2012) for the United States, introducing a financial stress index within a richly specified Markov-switching Bayesian VAR (MS-BVAR)[51] to investigate non-linearities in the interaction between financial instabilities and the macroeconomy for the euro area. The authors allow for both changes in the variances of the shocks that affect the economy and in the parameters that govern the transmission of these shocks.

The Markov-switching VAR is particularly appropriate for modelling abrupt, discrete changes in economic dynamics as observed during the recent crisis and in previous episodes of high financial stress. In particular, the build-up of imbalances in the financial sector can trigger sudden changes in agent behaviour, which is modelled as discrete regime changes.

The Markov-switching framework has several further advantages. First, it provides a formal framework to investigate non-linearities. Second, it can assess whether non-linearities can be attributed to different regimes in the volatility of shocks only, or also to differences in the transmission of financial shocks to the real economy. Regime switching in the transmission would

51 Recently developed methods to estimate and evaluate these large dimensional, richly specified models by Sims and Zha (2006) and Sims, Waggoner and Zha (2008) are employed.

suggest that agents change their behaviour substantially during episodes of high financial stress. Third, the framework also provides a comparison of how financial variables affect the real economy in both low and high financial stress regimes.

7.2 FINANCIAL STRESS AND MACRO DATA

This section uses higher frequency (monthly) data and draws on information from a broader set of financial variables than in the previous sections.[52] The approach is related to Hubrich and Tetlow (2012) who used a financial stress index constructed by the staff of the Federal Reserve Board to analyse the US economy in real time during the financial crisis. The euro area analysis by Hartmann et al. (2012) emphasises the potential systemic nature of financial stress by using the euro area composite indicator of systemic stress, referred to as "CISS", which combines a variety of volatility measures and spreads across different financial markets. The indicator is built to capture high stress in all major financial markets and intermediation sectors, broadening the perspective relative to the more aggregate financial variables in other parts of this paper. Consistent with portfolio theory, the CISS accounts for correlations between markets; accordingly, this financial stress indicator is higher in situations when stress is prevalent in several markets at the same time, capturing the potential systemic dimension of financial stress.[53]

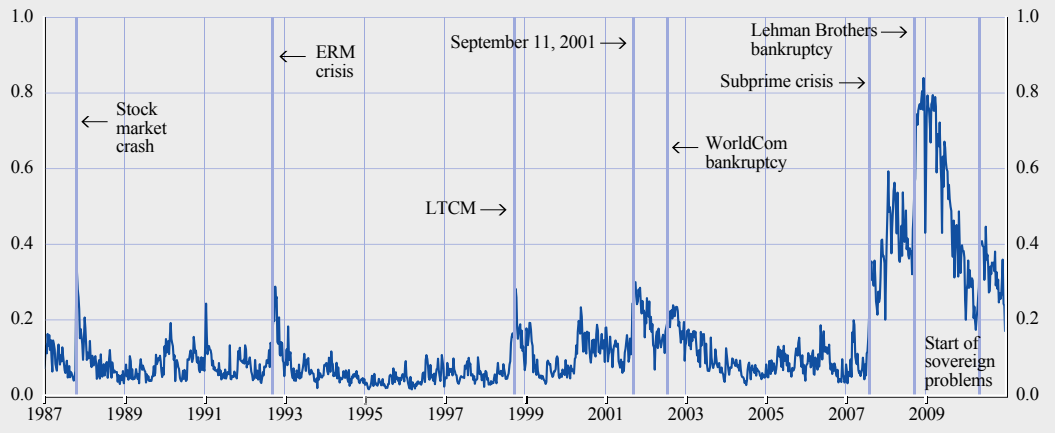
Data availability limits the start date of the monthly index to January 1987; the last observation used is December 2010. Chart 23 illustrates how the financial stress indicator captures episodes of financial stress in the euro area fairly well.

The other variables we employ in the MS-BVAR are growth in industrial production, inflation and the change in aggregate nominal loans, as well as a short-term interest rate (nominal Euribor). All variables except the interest rates and the financial stress indicator are seasonally adjusted and are expressed as year-on-year growth rates.

52 A different approach is chosen in the literature on the credit channel where, for example, Balke (2000) estimates a two-regime threshold VAR model where the regime depends on conditions in the credit market. Using US data, he finds that shocks have larger effects in the "tight" credit regime. Kaufmann and Valderrama (2008, 2010) present a Markov-switching analysis of the bank lending channel and the role of credit and asset prices in the transmission of shocks to the real economy.

53 For details, see Hollo, Lo Duca and Kremer (2012).

Chart 23 Euro area composite indicator of systemic stress – CISS



7.3 EVIDENCE OF NON-LINEARITIES

The five-variable MS-VAR estimated with three lags is identified using the Choleski decomposition. Since asset prices generally respond instantaneously to all relevant information, the financial stress indicator is ordered last. The other variables are entered in the following order: output growth, inflation, short-term interest rate, and loans. The interest rate is ordered before loans on the grounds that it is a policy variable.

Initially we examine statistical evidence for non-linearities. Various specifications with two regimes in the coefficients are estimated, allowing for different transmission of shocks through the economy during episodes of high financial stress and in normal times. In addition, the variances of the shocks are allowed to change between regimes.[54] These estimates are compared with a constant parameter model using marginal data densities.[55] The constant parameter model is found to be clearly outperformed by all the Markov-switching models considered.

The preferred specification is selected according to both statistical, namely marginal data densities, as well as economic criteria. In particular, we investigate whether the statistically preferred specification provides economically sensible results on the transmission of financial shocks in periods of high stress and normal times. The results are presented in Section 7.4. Furthermore, we analyse whether the probability of being in a high stress state that can be computed from this non-linear model corresponds well with known financial stress episodes and their effects on the macroeconomy. We find that the probability of being in a high stress state does correspond well with known stress episodes in our sample, such as the EMS crisis, the 9/11 terrorist attacks in 2001, the 2008-09 financial crisis episode and the sovereign debt crisis (see Hartmann et al. (2012) for more details and further results).

A sensitivity analysis regarding the variable ordering has been carried out and the Eonia interest rate has been used instead of the Euribor. Regarding the ordering, loans and the interest rate were switched and the results were found to be almost unchanged. Using Eonia instead of Euribor was considered because the two rates diverged during the recent crisis and some argued that the latter was distorted by market conditions. However, the results remained essentially the same.

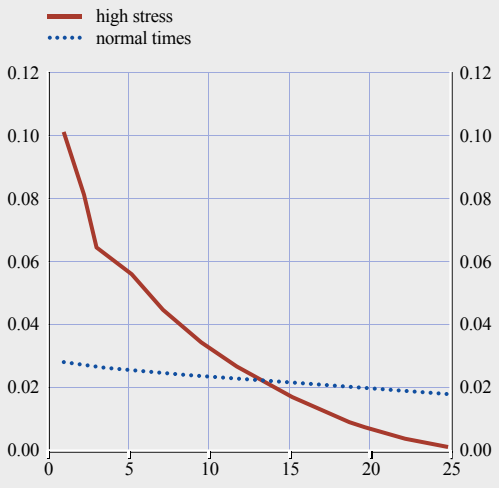
7.4 TRANSMISSION OF FINANCIAL STRESS TO THE REAL ECONOMY

The transmission of a financial stress shock to the real economy is analysed by means of impulse response functions (IRFs). The IRFs presented below correspond to the preferred specification of the Markov-switching VAR model that allows for two different regimes in the coefficients.[56,57]

The focus of the following discussion is on a one standard deviation shock to financial stress to illustrate how the transmission of financial shocks differs between regimes. Two impulse responses are shown on each graph below, corresponding to the high financial stress regime and the low stress regime ("normal times"). This allows the differences in the transmission of a financial stress shock owing to different coefficients across regimes to be compared. The IRFs are calculated on the assumption that the economy stays in the regime prevailing when the shock occurred.

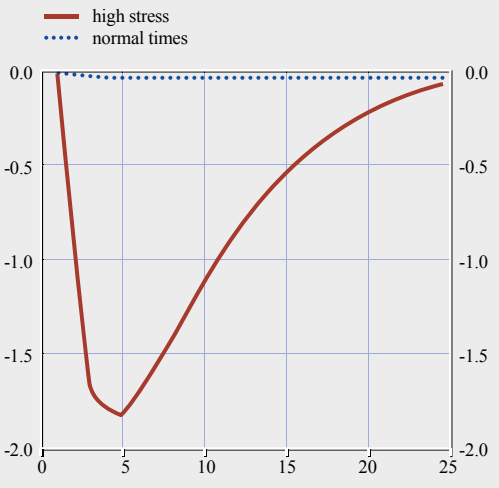
54 This allows for one form of heteroskedasticity in the error terms as their variance differs across regimes.
55 Model selection on the basis of relative marginal data densities is common practice in the Bayesian framework.
56 The preferred specification has also three variance regimes. The impulse responses are presented for the high stress variance regime.
57 More details of this analysis are presented in Hartmann, Hubrich, Kremer and Tetlow (2012).

Chart 24 Impulse responses of financial stress to its own shock



Note: Blue dotted line: normal times; Red solid line: high stress regime.

Chart 25 Impulse responses of growth of industrial production to financial stress shocks



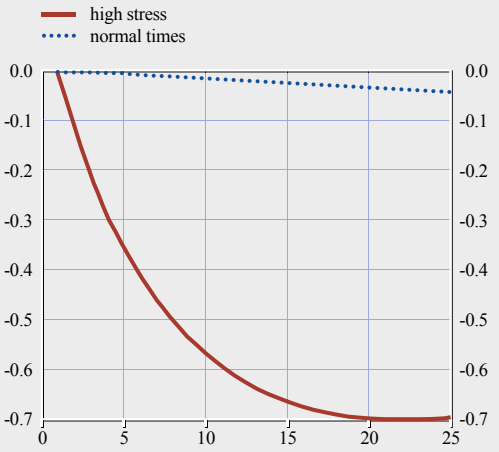
Note: Blue dotted line: normal times; Red solid line: high stress regime.

Chart 24 displays the impulse response of financial stress to its own shock. The financial shock is smaller in normal times than during episodes of high financial stress. However, it is also more persistent in normal times than during high financial stress. This may seem surprising at first, but can be explained as follows. In high stress episodes there are large immediate real effects. Monetary policy counteracts, as seen during the recent crisis and in our estimated interest rate response to a financial stress shock, rapidly reducing financial stress.

For industrial production (Chart 25), a large shock in financial stress leads to a severe drop in output growth in high stress episodes that might reflect increased risk aversion and/or uncertainty among lenders and non-financial corporations facing irreversible investment decisions. The effect on output growth is long-lasting when stress is high, whereas it dies out quickly in normal times.

Chart 26 shows that in high stress regimes, financial stress shocks also have a sizeable effect on loan supply (and/or loan demand). This might reflect a credit channel in the transmission of financial stress to output growth. Nominal loan growth falls substantially in high stress regimes, reinforcing other more direct effects, for example via a change in attitudes towards risk.

Chart 26 Impulse responses of loan growth to financial stress shocks



Note: Blue dotted line: normal times; Red solid line: high stress regime.

To conclude, these figures show that shocks to the level of financial stress have much more pronounced and durable effects for the euro area macroeconomy in high stress episodes than in normal times. The analysis in Hubrich and Tetlow (2012) draws similar conclusions for the United States.

7.5 SUMMARY

The results from this model allowing for non-linearities in macro-financial linkages provide evidence that macro dynamics in the euro area differ during episodes of financial stress and in "normal times". There appears to be evidence for switching in the coefficients of the model as well as in the volatility of the shocks. Statistical and economic evidence confirms that the *transmission* changes in addition to a change in the nature of the shocks. The probability of being in a high stress episode estimated from the model corresponds well with economic events over the sample period considered. The impulse response analysis presented indicates that the response of real variables to financial shocks was much larger and more protracted during episodes of high financial stress than during normal times.

The results presented in this section suggest that the analysis of macro-financial linkages requires models that allow for the presence of non-linearities. Such non-linearities carry important implications from a modelling and a monetary policy perspective. Monetary policy must take such changes in the transmission of shocks during crises into account, since that has potentially different policy implications than just enhanced volatility.

8 CONCLUSIONS AND IMPLICATIONS FOR ECONOMIC MODELLING AND POLICY ANALYSIS

The recent financial crisis and the resulting recession highlighted the links between financial factors and the real economy. This paper analyses the transmission of financial shocks to real variables from an empirical perspective for the euro area as a whole, individual euro area member countries and other EU and OECD countries.

The focus is on the following five questions: 1) Which financial shocks are important over the full sample, on average? 2) Are financial developments leading real activity? 3) Is there heterogeneity or a common pattern in macro-financial linkages across the euro area and do these linkages vary over time? 4) Are cross-country spillovers important? 5) Is the transmission of financial shocks different in episodes of high stress compared with normal times, i.e. is there evidence of non-linearities? First, stylised facts are analysed and then empirical models are estimated linking different real macroeconomic variables to several financial variables.

The key findings can be summarised as follows: a) financial shocks tend to be more important than often implied by standard DSGE models; b) financial prices often lead real activity; c) there is substantial heterogeneity in macro-financial linkages both across countries (within and outside the euro area) and over time; d) there is also substantial commonality and spillover effects are significant; e) non-linearities in macro-financial linkages capture changes in the transmission of financial shocks during episodes of high financial stress.

The analyses presented in this paper have several implications for economic modelling:

- First, DSGE models that abstract from financial frictions may overestimate the importance of alternative sources of fluctuations.

- Second, structural models of international business cycles should allow international spillovers from financial shocks to play a prominent role.

- Third, euro area aggregates mask important cross-country heterogeneity.

- Fourth, non-linear methods can account for financial shocks that only play a limited role in normal times but have important real effects during episodes of high financial stress. Results seem to confirm changes in both the variance of the shocks and the transmission mechanism.

- Fifth, further research should build on recent work to incorporate time variation and non-linearities in DSGE models with financial frictions and to develop structural models that allow both for non-linear amplification effects and instabilities and for instabilities in the economy and occasionally volatile episodes.

Clearly, the findings presented here raise interesting questions beyond the scope of this paper. The different versions of VAR models estimated in this paper that impose a limited economic structure can provide very useful insights, given the lack of consensus on macro-financial linkages. However, they face some challenges and limitations in explaining: (i) the different reactions of the various countries to a common shock; (ii) the transmission channels which allow shocks to spill over to different countries; (iii) the causality between macro and finance in non-structural time-varying panel VARs; and (iv) the importance of economic and institutional factors in driving

the transmission of a shock, for example the role of the structure of financial markets in explaining the different transmission of shocks across countries. These issues provide interesting avenues for future research.

The findings presented in this paper also carry important implications from a policy perspective:

- Despite important heterogeneity, countries share common financial shocks, suggesting that international financial markets are important to understand co-movements in economic activity. Policy-makers need to monitor foreign financial developments. Second, since national policy affects the national component more than the common component, policies designed to counteract world conditions may be ineffective.

- Evidence of time variation suggests important asymmetries in the shape and dynamics of international cycles, so linear models may miss policy-relevant features of the data.

- Non-linearities in macro-financial linkages carry important implications from a monetary policy perspective. Appropriate monetary policy needs to take into account possible changes in the transmission of financial shocks. Appropriate monetary policy responses to a financial stress shock in a high stress episode might be very different from monetary policy responses in normal times.

Future research might investigate the interaction between monetary policy and macro-prudential policy in models that capture the empirical aspects of macro-financial linkages documented in this paper. The appropriate monetary policy reaction in terms of standard and non-standard policy instruments is a prominent ongoing research agenda in this context.

APPENDICES

I DATA

Table A1

	Description	Sources
CPI	Consumer Prices	OECD, Eurostat, IMF, ECB
YER	Gross Domestic Product (real)	OECD, Eurostat, NCB data
PCR	Private Final Consumption (real)	OECD, Eurostat, NCB data
ITR	Gross Capital Formation (real)	OECD, Eurostat, NCB data
STN	Short-term (interbank) interest rate	OECD, IMF, ECB
LTN	Long-term Interest Rate (nominal)	OECD, IMF, ECB
SP	Stock prices	OECD, IMF, ECB, NCB calculations
HP	House prices	OECD, ECB, NCB
Loan	Loans to private sector	IMF, ECB
LHH	Loans to households	ECB
LNFC	Loans to nonfinancial corporations	ECB
Fin1	Interest rate spread	difference between short-term/long-term interest rates
Fin2	Loan/GDP ratios	calculated by team members
CI	Credit impulse	calculated by team members
Fin3	Loan/Deposit ratios	calculated by team members

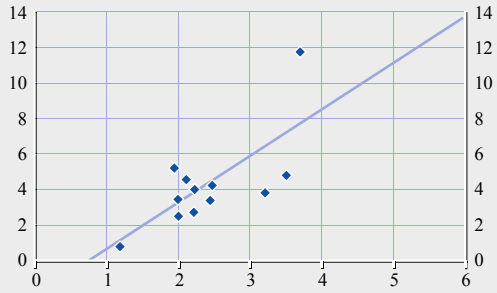
2 SECTION 2

Chart A1 Average real growth rates of loans and output variables

Pre-EMU

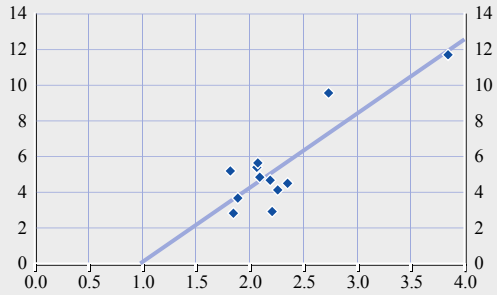
Average real growth rates in GDP and total loans euro area countries

x-axis: GDP
y-axis: total loans



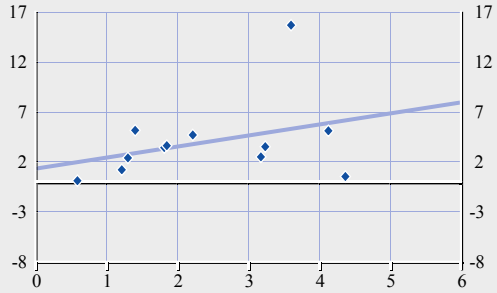
Average real growth rates in private consumption and loans to households, euro area countries

x-axis: LHH
y-axis: PCR



Average real growth rates in total investment and loans to firms euro area countries

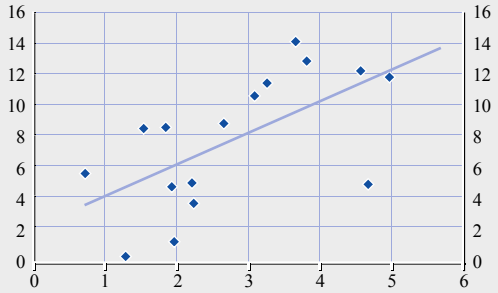
x-axis: LNFC
y-axis: ITR



EMU

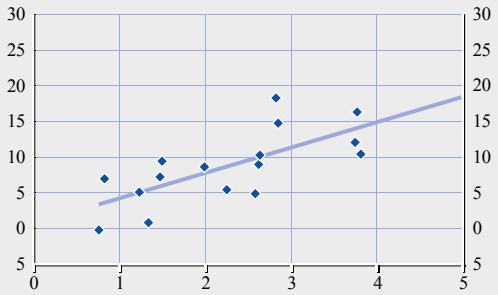
Average real growth rates in GDP and total loans euro area countries

x-axis: GDP
y-axis: loan



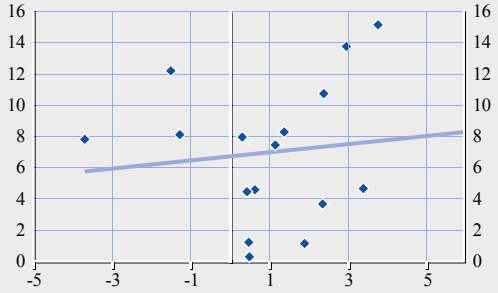
Average real growth rates in private consumption and loans to households, euro area countries

x-axis: LHH
y-axis: PCR



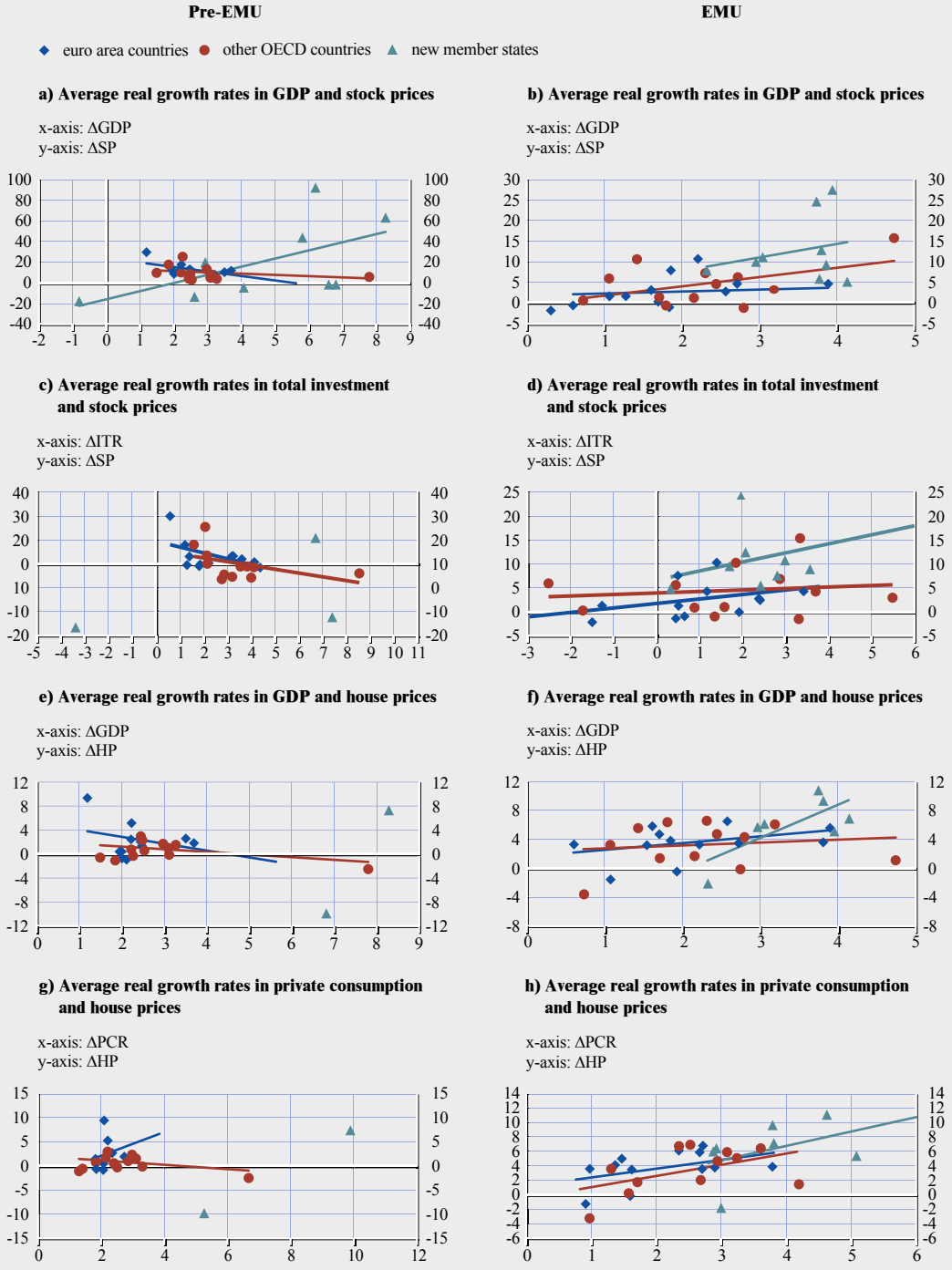
Average real growth rates in total investment and loans to firms, euro area countries

x-axis: LNFC
y-axis: ITR



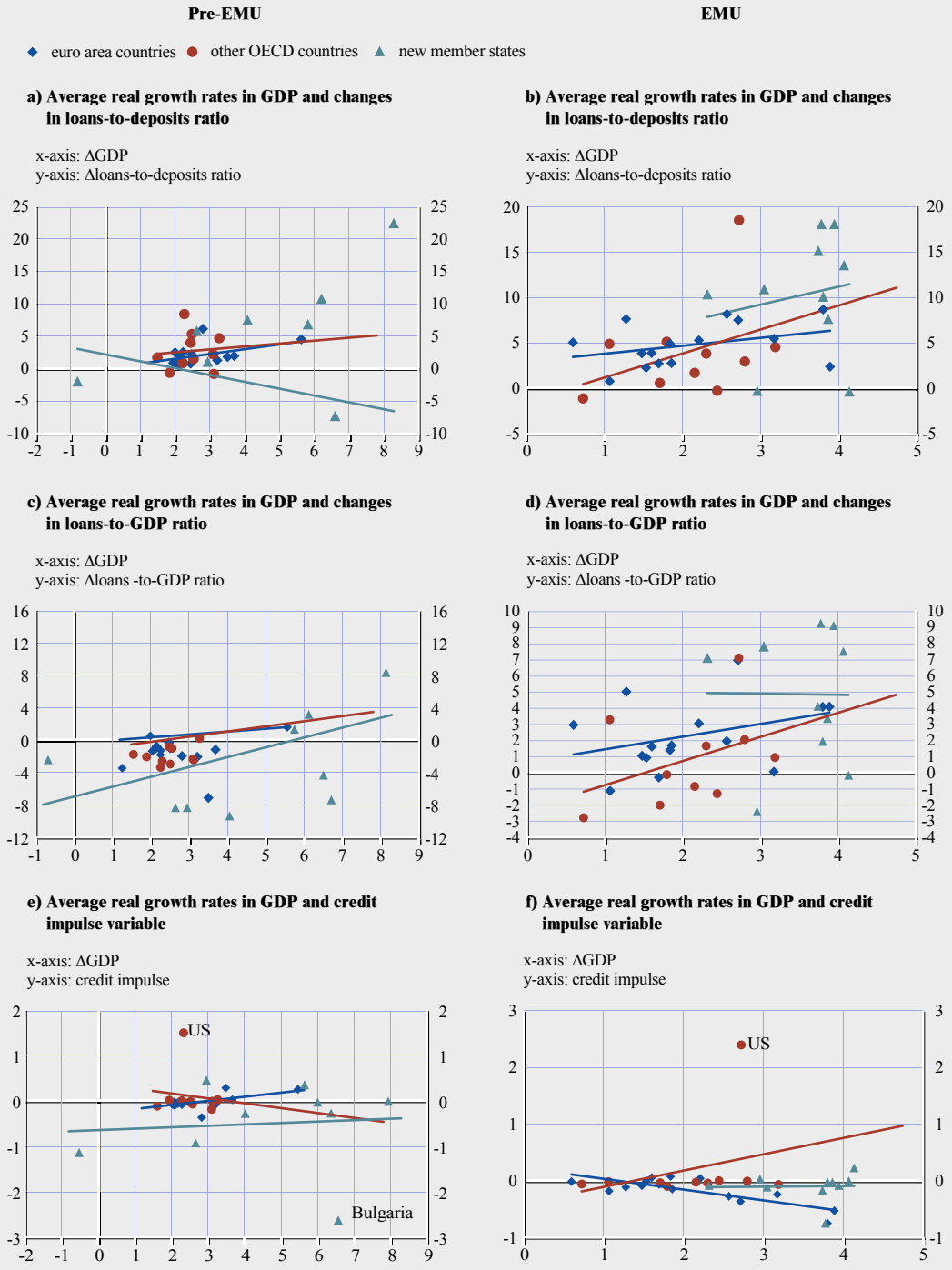
Note: Figures show year-on-year average growth rates of loans (total and disaggregated) against GDP (and its components) for old euro area member countries in the pre-EMU period and for the same countries plus new Member States (Cyprus, Malta, Slovenia and Slovakia) in the EMU period. Pre-EMU period is from 1980Q1 to 1998Q4 whenever available. Cut-off date for data is 2010Q4. All variables are deflated.

Chart A2 Average real growth rates of price and output variables



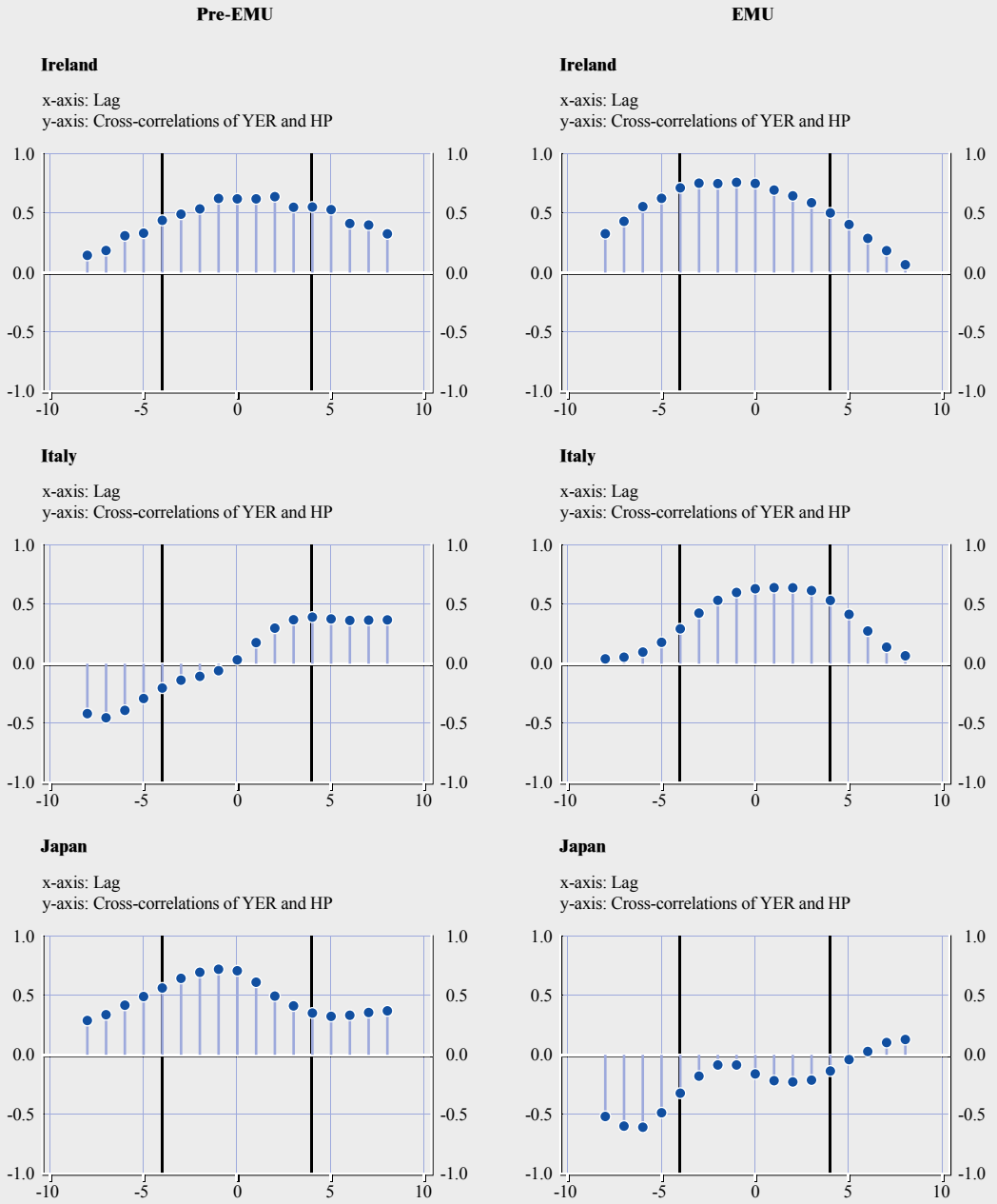
Notes: Figures show year-on-year average growth rates for old euro area member countries, other OECD countries and new euro area member countries. There is no stock price data for Cyprus, Malta and Romania and no house price data for Cyprus, Portugal, Iceland, Latvia, Poland and Romania. In the pre-EMU period there is no stock price data for Bulgaria and Lithuania. In the pre-EMU period there is no house price data for Malta, Czech Republic, Hungary, Lithuania, Slovenia and Slovakia. Pre-EMU period is from 1980Q1 to 1998Q4 whenever available. Cut-off date for data is 2010Q4. All variables are deflated.

Chart A3 Average real growth rates of leverage and output variables



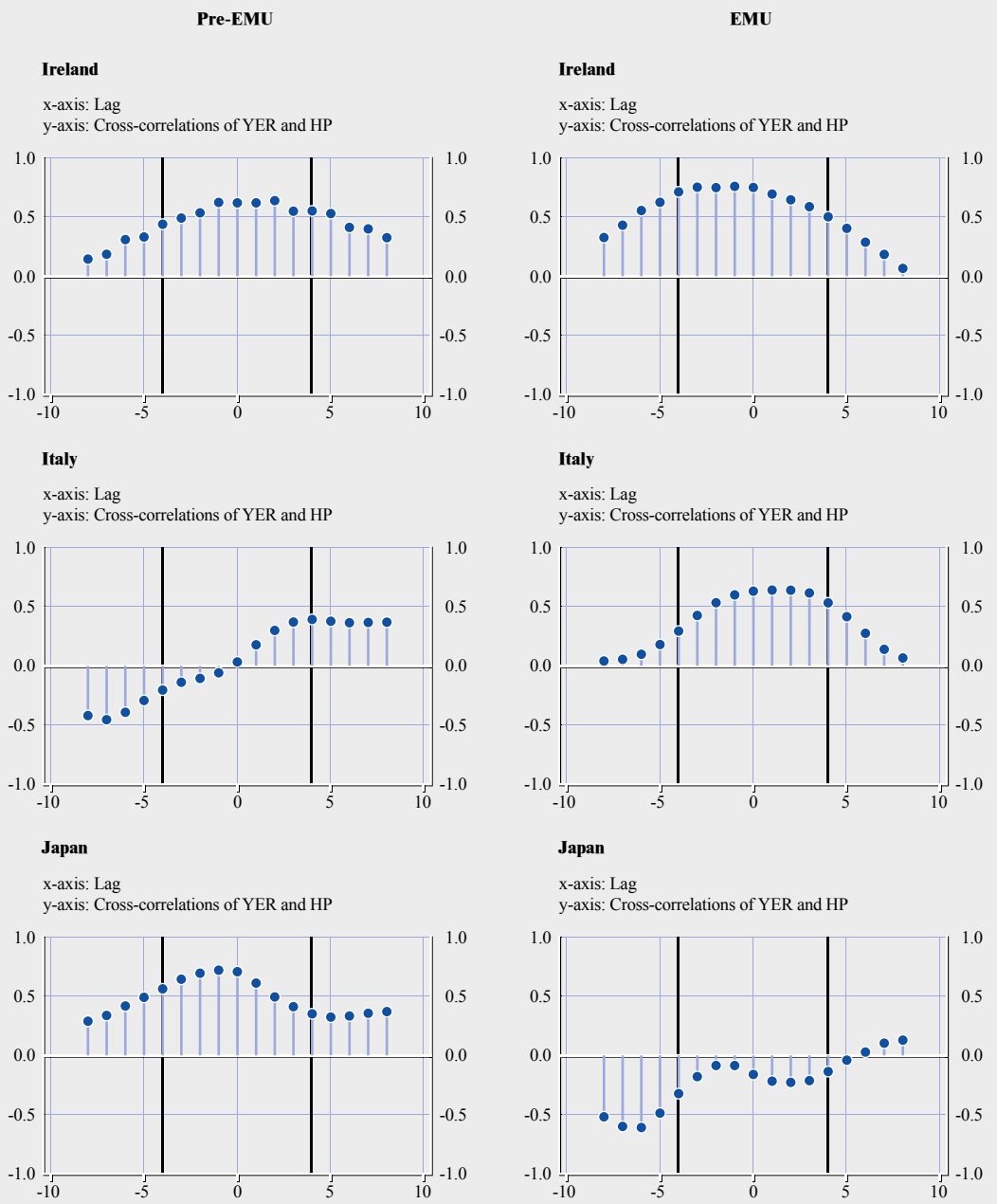
Note: Figures show year-on-year average growth rates for old euro area member countries, other OECD countries and new euro area member countries. Credit impulse variable is in levels. There is no loan data for Korea and Norway. Data for loans-to-deposits ratio and for the credit impulse is missing for Greece in the pre-EMU period. Pre-EMU period is from 1980Q1 to 1998Q4 whenever available. Cut-off date for data is 2010Q4.

Chart A4 Cross correlations between output growth and growth in house prices



Notes: The red vertical bar on left marks the correlation when real house prices lead GDP by four quarters, while the one on the right indicates when it lags activity by four quarters.

Chart A4 Cross correlations between output growth and growth in house prices (cont'd)



Notes: The red vertical bar on left marks the correlation when real house prices lead GDP by four quarters, while the one on the right indicates when it lags activity by four quarters.

Chart A5 Ratio of standard deviations to GDP growth standard deviation

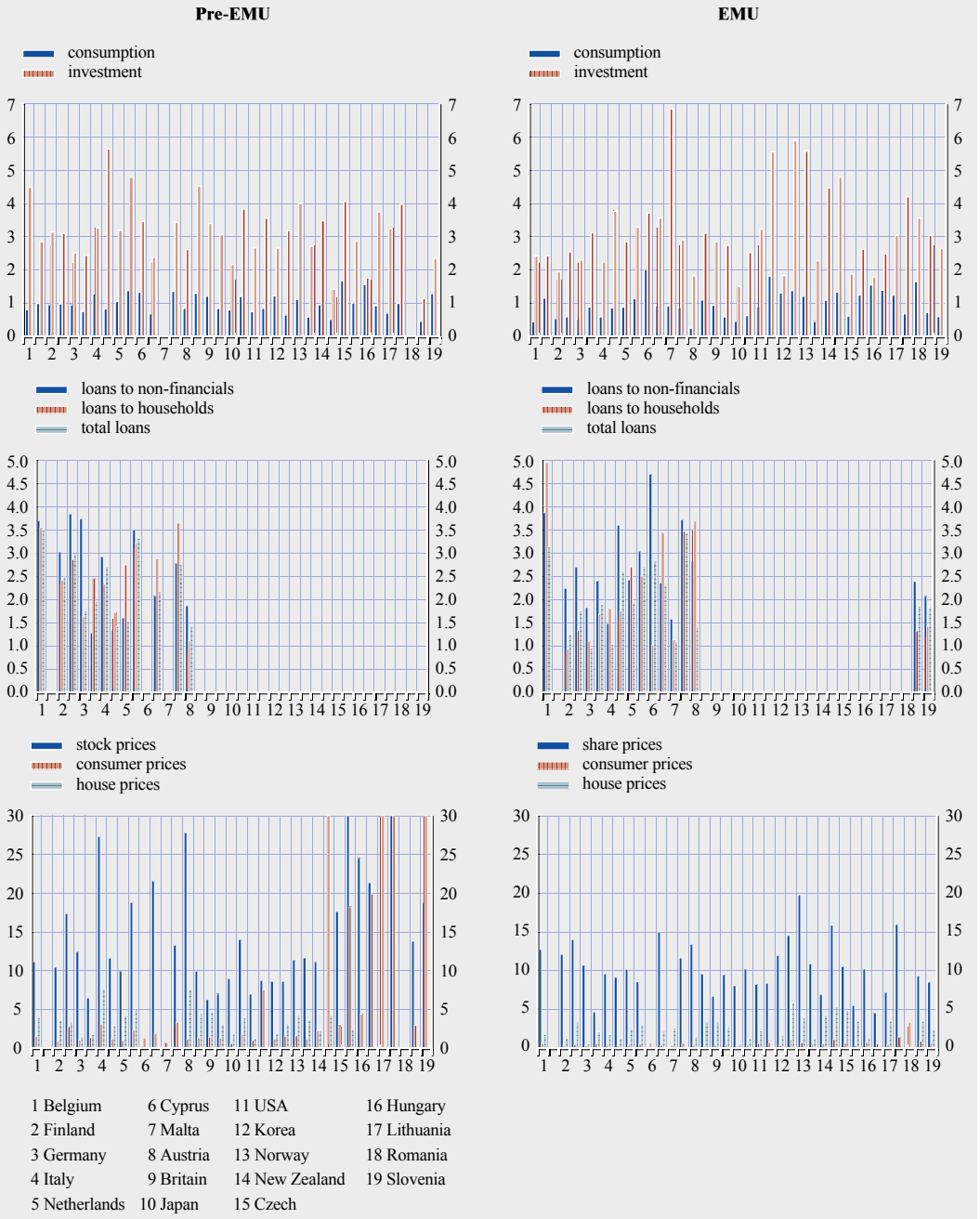
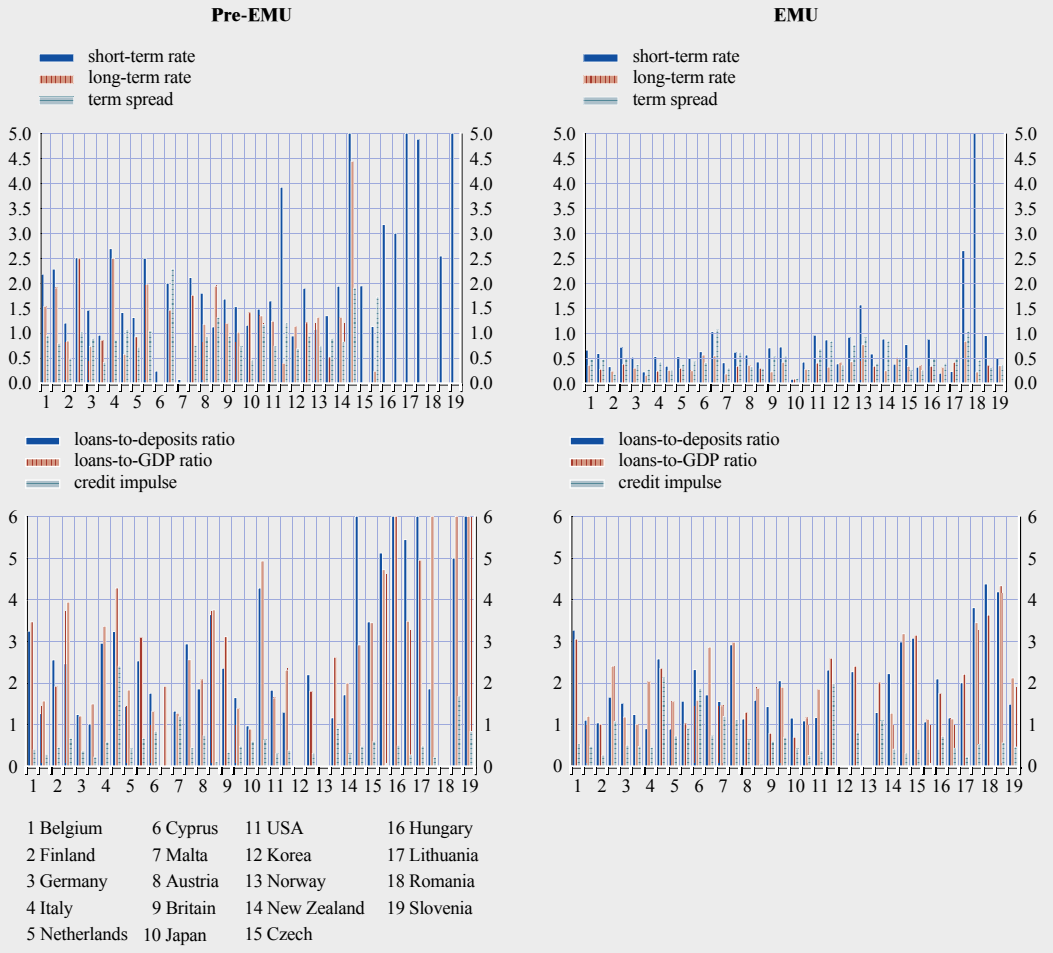


Chart A5 Ratio of standard deviations to GDP growth standard deviation (cont'd)



3 ADDITIONAL COUNTRIES WITH MISSING VARIABLES OR PERIODS

This appendix repeats the exercise in Section 3 for 18 additional countries where some of the financial variables are missing from the VAR or the time period covered is much shorter than the first quarter of 1980 to the fourth quarter of 2010. These additional countries include seven euro area Member States (AT, CY, GR, MT, PT, SI and SK), eight non-euro area EU countries (BG, CZ, EE, HU, LT, LV, PL, RO) and three non-EU OECD countries (IS, KR, NO). The missing variables can be identified in the graphs; the sample periods are reported in Table A2 below. Results are not strictly comparable with those in the main text (or even across countries within this appendix).

Table A2 Estimation sample for country-specific VARs

	Real GDP	Real private consumption	Real gross fixed capital formation
Belgium	1981Q3 2010Q4	1981Q4 2010Q4	1981Q4 2010Q4
Germany	1981Q3 2010Q4	1981Q4 2010Q4	1981Q4 2010Q4
Spain	1981Q3 2010Q4	1981Q4 2010Q4	1981Q4 2010Q4
Finland	1981Q3 2010Q4	1981Q4 2010Q4	1981Q4 2010Q4
France	1981Q3 2010Q4	1981Q4 2010Q4	1981Q4 2010Q4
Ireland	1981Q3 2010Q4	1981Q4 2010Q4	1981Q4 2010Q4
Italy	1981Q3 2010Q3	1981Q4 2010Q3	1981Q4 2010Q3
Luxembourg	1981Q3 2010Q4	1981Q4 2010Q4	1981Q4 2010Q4
Netherlands	1981Q3 2010Q4	1981Q4 2010Q4	1981Q4 2010Q4
Euro area	1981Q4 2010Q4	1981Q4 2010Q4	1981Q4 2010Q4
Denmark	1981Q3 2010Q3	1981Q4 2010Q3	1981Q4 2010Q3
United Kingdom	1981Q3 2010Q4	1981Q3 2010Q4	1981Q3 2010Q4
Sweden	1981Q3 2010Q4	1981Q3 2010Q4	1981Q3 2010Q4
Australia	1981Q3 2010Q4	1981Q3 2010Q4	1981Q3 2010Q4
Canada	1981Q3 2008Q4	1983Q3 2008Q4	1983Q3 2008Q4
Switzerland	1981Q3 2010Q4	1981Q3 2010Q4	1981Q3 2010Q4
United States	1981Q3 2010Q4	1981Q3 2010Q4	1981Q3 2010Q4
Japan	1981Q3 2010Q3	1981Q4 2010Q3	1981Q4 2010Q3
New Zealand	1981Q3 2010Q3	1981Q4 2010Q3	1981Q4 2010Q3
Austria	1988Q1 2010Q4	1988Q1 2010Q4	1988Q1 2010Q4
Bulgaria	1998Q3 2010Q4	1998Q3 2010Q4	1998Q3 2010Q4
Czech Republic	1997Q3 2010Q4	1997Q3 2010Q4	1997Q3 2010Q4
Cyprus	1996Q3 2010Q4	1996Q3 2010Q4	1996Q3 2010Q4
Estonia	1998Q1 2010Q4	1998Q1 2010Q4	1998Q1 2010Q4
Greece	1998Q3 2010Q4	1998Q3 2010Q3	1998Q3 2010Q3
Hungary	1996Q3 2010Q4	1996Q3 2010Q4	1996Q3 2010Q4
Iceland	1994Q3 2007Q2	1994Q3 2007Q2	1994Q3 2007Q2
South Korea	1987Q3 2010Q4	1987Q3 2010Q4	1987Q3 2010Q4
Lithuania	1996Q3 2010Q4	1996Q3 2010Q4	1996Q3 2010Q4
Latvia	1997Q4 2010Q4	1997Q4 2010Q4	1997Q4 2010Q4
Malta	1997Q3 2007Q4	2001Q2 2007Q4	2001Q2 2007Q4
Norway	1981Q3 2010Q4	1981Q3 2010Q4	1981Q3 2010Q4
Poland	1996Q3 2010Q4	1996Q3 2010Q4	1996Q3 2010Q4
Portugal	1989Q3 2010Q4	1989Q3 2010Q4	1989Q3 2010Q4
Romania	2001Q3 2010Q4	2001Q3 2010Q4	2001Q3 2010Q4
Slovenia	1997Q3 2010Q3	1998Q3 2010Q4	1997Q3 2010Q4
Slovakia	1998Q3 2008Q4	1998Q3 2008Q4	1998Q3 2008Q4

Chart A6 GDP

(percentage of variance explained after 3 years – additional countries)

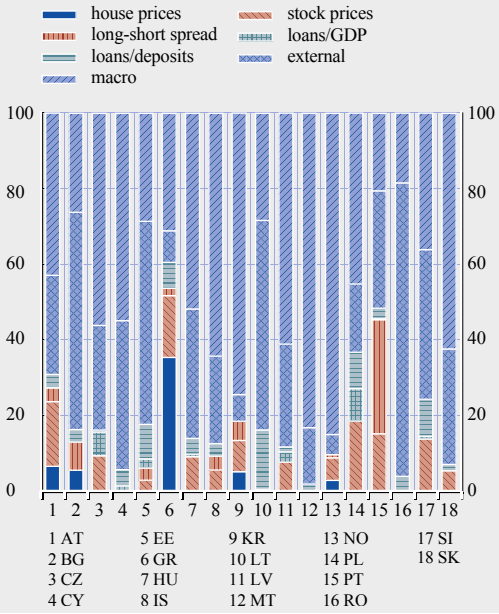


Chart A7 Consumption

(percentage of variance explained after 3 years – additional countries)

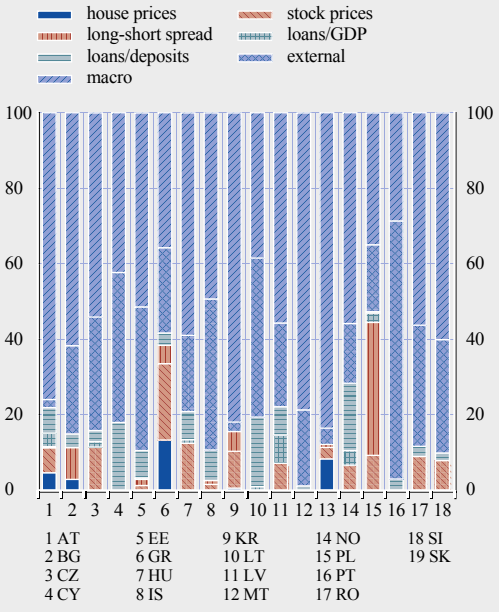
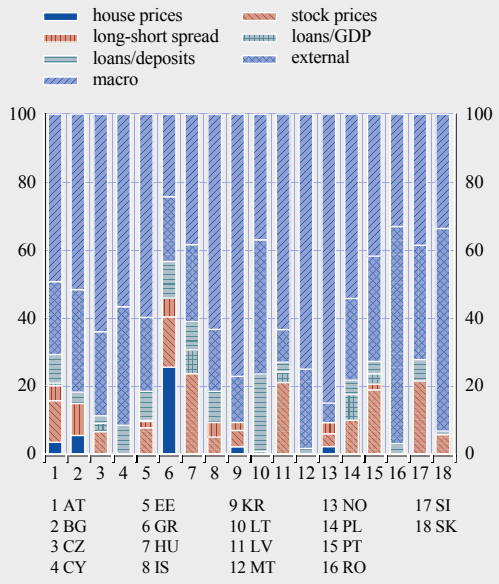


Chart A8 Investment

(percentage of variance explained after 3 years – additional countries)



APPENDIX 4

Chart A9 Episodes of falling loans-to-deposits ratio and euro area recessions

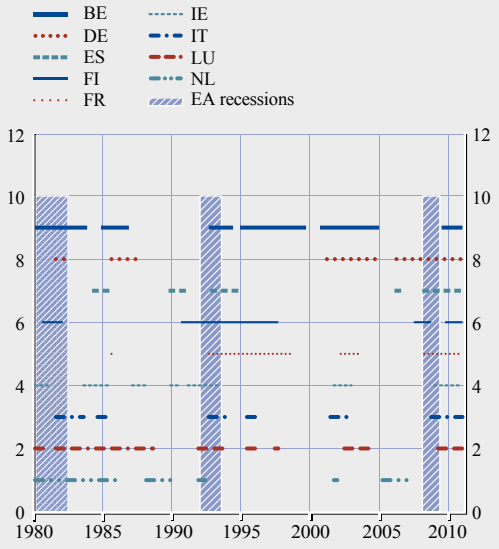


Chart A10 Episodes of rising interest rate spreads and euro area recessions

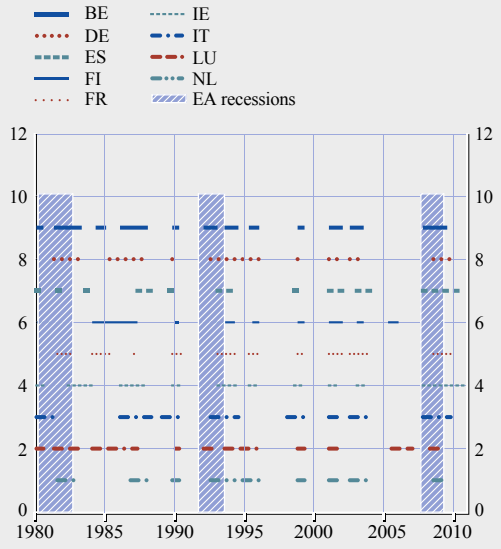


Chart A11 Unconditional probability of a downturn

(17 OECD countries)

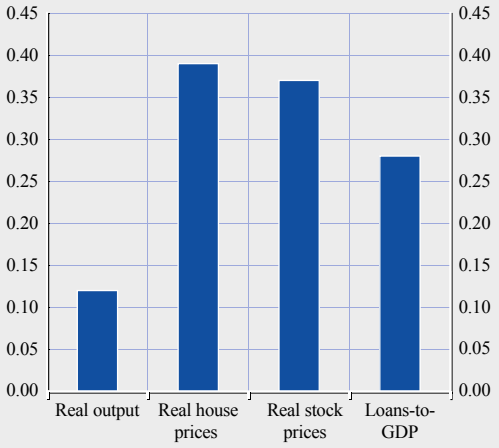


Chart A12 Average number of downturn and upturn phases per country

(17 OECD countries)

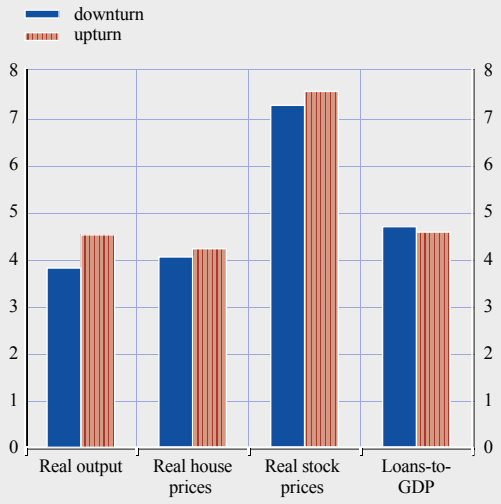
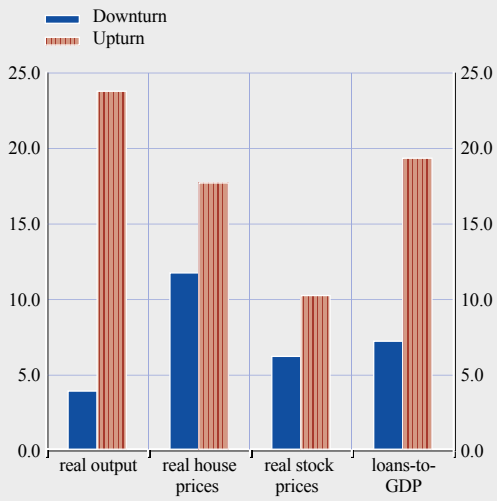


Chart A13 Average length of downturn and upturn phases, quarters

(17 OECD countries)



REFERENCES

Abildgren, K. (2010), "Business cycles, monetary transmission and shocks to financial stability", *Danmarks Nationalbanken Working Paper*, 2010/71.

Adalid, R. & Detken, C. (2007), "Liquidity shocks and asset price boom/bust cycles", *Working Paper Series*, No 732, ECB, Frankfurt am Main, February.

Adrian, T. & Shin H.-S. (2006), "Liquidity and leverage", *Journal of Financial Intermediation*, Volume 19, Issue 3, pp. 418-37.

Ang, A., Piazzesi, M. & Wei, M. (2006), "What does the yield curve tell us about GDP growth?", *Journal of Econometrics*, 131:359-403.

Assenmacher-Wesche, K. & Gerlach, S. (2009), "Financial structure and the impact of monetary policy on asset prices", *Swiss National Bank Working Paper,* 2008-16 (also CEPR Discussion Paper 6773).

Balke, N. (2000), "Credit and economic activity: Credit regimes and nonlinear propagation of shocks", *The Review of Economics and Statistics* 82, pp. 344-49.

Baumeister, C., Durinck, E. & Peersman, G. (2008), "Liquidity, inflation and asset prices in a time-varying framework for the euro area", *National Bank of Belgium Working Paper* 142.

Bernanke, B. & Blinder, A. (1992), "The Federal Funds rate and the channels of monetary transmission", *American Economic Review*, 82(4):901-921.

Bernanke, B. & Gertler, A. (1995), "Inside the black box: the credit channel of monetary transmission", *Journal of Economic Perspectives*, Volume 9, Number 4, pp. 27-48.

Biggs, M., Mayer, T. & Pick, A. (2009), "Credit and Economic Recovery", *De Nederlandsche Bank Working Paper,* No 218, July.

Borio, C. & Lowe, P. (2002), "Asset prices, financial and monetary stability: exploring the nexus", *Bank for International Settlements Working Papers,* No 114, July.

Borio, C. & Lowe, P. (2004), "Securing sustainable price stability: should credit come back from the wilderness?", *Bank for International Settlements Working Papers,* No 157, July.

Brunnermeier, M.K. and Sannikov, Y. (2011), "A macroeconomic model with a financial sector", unpublished manuscript, Princeton University (February).

Bry, G. and Boschan, C. (1971), "Cyclical analysis of time series: Selected procedures and computer programs", *NBER Technical Paper* 20.

Calza, A., Monacelli, T. & Stracca, L. (2009), "Housing finance and monetary policy", *Working Paper Series*, No 1069, ECB, Frankfurt am Main, July.

Canova, F. and Ciccarelli, M. (2009), "Estimating multi-country VAR models", *International Economic Review*, 50, pp. 929-61.

Canova, F., Ciccarelli, M. and Ortega, E. (2007), "Similarities and Convergence in G-7 Cycles", *Journal of Monetary Economics*, 54, pp. 850-78.

Canova, F. & Pappa, E. (2007), "Price differentials in monetary unions: The role of fiscal shocks", *Economic Journal*, Volume 117, pp. 713-37.

Chirinko, R.S., de Haan, L. & Sterken, E. (2008), "Asset price shocks, real expenditures, and financial structure: A multi-country analysis", *CESifo Working Paper Series* 2342.

Christiano, L. J., Eichenbaum, M. & Evans, C.L. (1999), "Monetary policy shocks: What have we learned and to what end?", Chapter 2 in Taylor, J.B. and Woodford, M. (eds.), *Handbook of Macroeconomics*, Elsevier Science, Volume I, pp. 65-148.

Ciccarelli, M., Maddaloni, A. and Peydró, J.L. (2010), "Trusting the bankers: a new look at the credit channel of monetary policy", *Working Paper Series*, No 1228, ECB, Frankfurt am Main, July.

Claessens, S., Kose, M.A. and Terrones, M.E. (2011a), "Financial cycles: What? How? When?", *IMF Working Paper 11/76.*

Claessens, S., Kose, M.A. and Terrones, M.E. (2011b), "How do business and financial cycles interact?", *CEPR Discussion Paper 8396.*

Claessens, S., Kose, M.A. and Terrones, M.E. (2009), "What happens during recessions, crunches and busts?" *Economic Policy 24,* pp. 653-700.

Committee on the Global Financial System (2006), "Housing finance in the global financial market", CGFS Papers No 26, January.

Croux, C., Forni, M. and Reichlin, L. (2001), "A Measure of Comovement for Economic Variables: Theory and Empirics", *The Review of Economics and Statistics*, Vol. 83, Nr 2, pp. 232-41.

Crucini, M., Kose, A. and Otrok, C. (2011), "What are the driving forces of international business cycles?", *Review of Economic Dynamics*, Elsevier for the Society for Economic Dynamics, vol. 14(1), pp. 156-75.

D'Agostino, A., Gambetti, L. and Giannone, D. (2009), "Macroeconomic Forecasting and Structural Change", *ECARES Working Paper* 20.

European Central Bank (2003), "Structural factors in the EU housing markets", ECB, Frankfurt am Main, March.

European Central Bank (2009), "Housing finance in the euro area", *Occasional Paper Series*, No 101, ECB, Frankfurt am Main, March.

European Central Bank (2007), "Corporate finance in the euro area", *Occasional Paper Series*, No 63, ECB, Frankfurt am Main, June.

Faust, J. & Leeper, E. (1997), "When do long-run identifying restrictions give reliable results?", *Journal of the American Statistical Association*, 15(3), pp. 345-53.

Fornari, F. & Stracca, L. (2011), "The Minsky moment: Do financial shocks matter?" mimeo ECB, presented at Economic Policy 53rd panel meeting, Budapest 15-16 April 2011.

Giannone, D., Lenza, M. and Reichlin, L. (2010), "Money, credit, monetary policy and the business cycle in the euro area", in Papademos, L. and Stark, J. (eds.), *Enhancing monetary analysis*, ECB, Frankfurt am Main, October 2010, pp. 252-62.

Gilchrist, S., Yankow, V. & Zakrajsek, E. (2009), "Credit market shocks and economic fluctuations: Evidence from corporate bond and stock markets", *Journal of Monetary Economics*, 56:471-493.

Giuliodori, M. (2005), "The role of house prices in the monetary transmission mechanism across European countries", *Scottish Economic Journal*, Vol. 52(4), pp. 519-43 (also *DNB Working Paper* No 15).

Goodhart, C. & Hofmann, B. (2008), "House prices, money, credit and the macroeconomy", *Oxford Review of Economic Policy*, 24(1), pp.180-205 (also *ECB Working Paper* No 888).

Harding, D. and Pagan, A. (2002), "Dissecting the cycle: a methodological investigation", *Journal of Monetary Economics 49,* pp. 365-81.

Hartmann, P., Hubrich, K., Kremer, M. and Tetlow, R.J. (2012), "Systemic financial instabilities and macro dynamics in the euro area", European Central Bank, mimeo, presented at the European Economic Association Meeting 2012.

He, Z. and Krishnamurthy, A. (2011), "A Model of Capital and Crises", *Review of Economic Studies* (forthcoming).

Hollo, D., Kremer, M. and Lo Duca, M. (2012), "CISS - A composite indicator of systemic stress in the financial system", *Working Paper Series*, No 1426, ECB, Frankfurt am Main, March.

Hubrich, K. and Tetlow, R.J. (2012), "Financial Stress and Economic Dynamics: The Transmission of Crises", Finance and Economics Discussion Paper Series 2012-82, Federal Reserve Board.

Iacoviello, M. (2002), "House prices and business cycles in Europe: a VAR analysis", Boston College Working Papers in Economics 540, Boston College Department of Economics (also *ECB Working Paper* No 18).

Iacoviello, M. (2005). "House Prices, Borrowing Constraints and Monetary Policy in the Business Cycle", *American Economic Review*, Vol. 95, No 3 (June), pp. 739-64.

Iacoviello, M. and Minetti, R. (2008), "The Credit Channel of Monetary Policy: Evidence from the Housing Market", *Journal of Macroeconomics*, Vol. 30, No 1 (March), pp. 69-96.

Kaufmann, S. and Valderrama, M.T. (2008), "Bank lending in Germany and the UK: Are there differences between a bank-based and a market-based country?", *International Journal of Finance and Economics*, Volume 13, pp. 266-79.

Kaufmann, S. and Valderrama, M.T. (2010), "The role of credit aggregates and asset prices in the transmission mechanism: A comparison between the euro area and the USA", Manchester School, Volume 78, pp. 345-77.

Kose, A., Otrok, C. and Whiteman, C.H. (2003), "International Business Cycles: World, Region, and Country-Specific Factors", *American Economic Review* Volume 93, pp. 1216-39.

Kose A., Otrok, C. and Prasad, E.S. (2008), "Global Business Cycles: Convergence or Decoupling?", *NBER Working Papers,* No 14292.

Mönch, E. and Uhlig, H. (2005), "Towards a monthly business cycle chronology for the euro area", *Journal of Business Cycle Analysis and Measurement Vol. 2005, Issue 1.*

Mojon, B. & Peersman, G. (2001), "A VAR description of the effects of monetary policy in the individual countries of the euro area", *Working Paper Series*, No 92, ECB, Frankfurt am Main, December.

Musso, A., Neri, S. & Stracca, L. (2010), "Housing, consumption and monetary policy – How different are the US and the euro area?", *Working Paper Series*, No 1161, ECB, Frankfurt am Main, February.

Neri, S. (2004), "Monetary policy and stock prices: theory and evidence", Temi di discussione, Bank of Italy, 513, Economic Research Department.

Peersman, G. & Smets, F. (2001), "The monetary transmission mechanism in the euro area: more evidence from VAR analysis", *Working Paper Series*, No 91, ECB, Frankfurt am Main, December.

Pesaran, H. and Shin, Y. (1998), "Generalized impulse response analysis in linear multivariate models", *Economics Letters,* Volume 58, January, pp. 17-29.

Sims, C., Waggoner, D. and Zha, T. (2008), "Methods for inference in large multi-equation Markov-switching models", *Journal of Econometrics*, Volume 146, Issue 2, October, pp. 255-74.

Sims, C. and Zha, T. (2006), "Were there regimes shifts in U.S. monetary policy?", *American Economic Review*, Volume 96(1), March, pp. 54-81.

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