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## Financial frictions and monetary policy conduct

Matthieu Darracq Paries

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UNIVERSITÉ PARIS-EST  
ÉCOLE DOCTORALE ORGANISATIONS, MARCHÉS, INSTITUTIONS  
LABORATOIRE ÉRUDITE

## Thèse pour le doctorat en Sciences Économiques

Présentée et soutenue par **Matthieu Darracq Pariès**

le 5 juin 2018

# MONETARY POLICY CONDUCT IN THE PRESENCE OF FINANCIAL FRICTIONS

Sous la direction du **Professeur Ferhat Mihoubi**

### MEMBRES DU JURY

PR Rafael Wouters	Rapporteur	Banque Nationale de Belgique
PR Thepthida Sopraseuth	Rapporteur	Université de Cergy-Pontoise
MCF Michel Juillard	Examineur	Banque de France
PR Vincent Bouvatier	Examineur	Université de Paris-Est
PR Ferhat Mihoubi	Directeur de Thèse	Université de Paris-Est

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## Executive summary

The Thesis aims at evaluating monetary policy in presence of financial frictions both from an empirical and structural perspective. Along those lines, multi-variate time-series framework as well as model with more explicit theoretical foundations will be deployed. The Thesis will present original contributions in various fields of monetary and financial macroeconomics.

The main motivations for the applied research studies presented in this Thesis are twofold. It responded both to the need for deeper research on macro-financial linkages and to the growing interest of policy institutions for the model-based policy advise. First, the Great recession and in particular, the typology of crisis episodes in Europe over the last decade, unveiled new challenges for monetary policy conduct, notably related to the prevalence of financial factors in cyclical fluctuations, the design of non-standard measures and the interactions with financial service policies. The second motivation has to do with the growing role for structural models in the preparation of monetary policy within central banks. Over the last decades, academic research and central bank practices have mutually benefitted from strong synergies, whereby quantitative methods and theoretical advances have had a lasting influence on main preparation avenues for monetary policy making.

The relevant literature to which the thesis is contributing is well-framed within the contextual elements exposed previously. First, inspired by the crisis-related economic and policy challenges, the macro-financial research took off in various directions. In particular, the role of banks in the transmission mechanism of monetary policy and through the business cycle was re-examined, challenging existing views on the interactions between monetary policy and financial stability. Second, the outreach of academic research to real-time policymaking has been facilitated by seminal contributions on the empirical validation of DSGE models as well as on the optimal design of monetary policy conduct in these frameworks.

In Chapter 1, a set of empirical studies intend to demonstrate the prevalence of financial shocks underlying the euro area macroeconomic performance during the Great recession. In particular, BVAR models can identify credit supply shocks and quantify their contribution to the various recessionary episodes over the last decade.

Thereafter, Chapter 2 explores more structurally the transmission mechanism of financial shocks together with their heterogeneity across the euro area through the lens of DSGE models featuring a relevant set of demand-side as well as supply-side credit frictions.

Against this background, the Thesis examine more normative aspects of monetary policy conduct starting with derivation of optimal monetary policy in selected DSGE models, which is the focus of Chapter 3. The Ramsey approach to optimal monetary provides a clear benchmark for formulating normative prescriptions. We analyse the main properties of the Ramsey allocation within a set of quantitative DSGE models, thereby bring new insight on various closed economy and open economy policy challenges.

At times of crisis, as financial-driven recessions bring the monetary policy interest rates to their effective lower bound, central bank deployed a set of non-standard measures in order to engineer the intended policy accommodation. Chapter 4 presents several studies which extend DSGE models to analyse the role of non-standard monetary policy measures like asset purchase programmes or long-term liquidity operations. The credit channel of those measures will be the focus of the analysis. From a more normative standpoint, the optimal central bank asset purchase strategy will be derived.

Finally, in Chapter 5, the normative assessment of monetary policy conduct in presence of financial frictions calls for considering strategic interactions with other policies, and notably macroprudential policy. Such interactions are all the more relevant when analysed in a monetary union context through multi-country DSGE models.

## Overview

### Chapter 1 Financial shocks and credit supply conditions in the euro area

1. Financial Condition Indices and the identification of credit supply shocks in the euro area
2. Loan supply, Credit markets and the euro area financial crisis
3. Credit supply and long-term liquidity operations in the euro area: evidence from a Panel-VAR including Bank Lending Survey information

### Chapter 2 DSGE models with supply and demand-side credit frictions

1. Estimating a euro area-wide medium-scale DSGE with a relevant role for the banking sector
2. Financial fragmentation in the euro area through the lens of a large-scale multi-country DSGE model

### Chapter 3 Optimal monetary policy conduct within quantitative New-Keynesian models

1. Ramsey approach to optimal monetary policy in the Smets and Wouters model
  - a. Ramsey policy in Smets and Wouters (2003)
  - b. Evaluating the optimality of historical policy conduct in Smets and Wouters (2007)
  - c. Ramsey policy and the term premia in Smets and Wouters (2007)
2. Open economy extensions
  - a. Optimal monetary policy cooperation in a two-country DSGE estimated for the US and the euro area
  - b. Optimal stabilisation of inefficient supply-side disturbances
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### Chapter 4 Non-standard monetary policy measures: transmission channels and strategic design

1. The credit channel of central bank asset purchases
2. Optimal conduct of central bank asset purchases
3. Financial heterogeneity and the transmission of central bank asset purchases through a monetary union

### Chapter 5 Interactions between Monetary and Macroprudential policies

1. Optimised monetary and macroprudential rules within an estimated DGSE model for the euro area
2. Quantifying the policy mix in a monetary union with national macroprudential policies
3. A theoretical model of the financial sector with endogenous size of the shadow banking sector: implications for macroprudential policies

## Featured papers of the Thesis

[1] Darracq Pariès, Matthieu and Roberto De Santis (2015). A non-standard monetary policy shock: The ECB's 3-year LTROs and the shift in credit supply, *Journal of International Money and Finance*, Elsevier, vol. 54(C), pages 1-34.

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[2] Darracq Pariès, Matthieu, Christoffer Kok and Diego Rodriguez-Palenzuela (2011). Macroeconomic Propagation under Different Regulatory Regimes: Evidence from an Estimated DSGE Model for the Euro Area, *International Journal of Central Banking*, vol. 7(4), 49-113.

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## Auxiliary papers reflected in the Thesis summary

[a] Moccero, Diego, Matthieu Darracq Pariès and Laurent Maurin (2014). Financial Conditions Index and Identification of Credit Supply Shocks for the Euro Area. *International Finance*, Wiley Blackwell, vol. 17(3), pages 297-321, December.

[b] Altavilla, Carlo, Matthieu Darracq Pariès and Giulio Nicoletti (2015) Loan supply, credit markets and the euro area financial crisis. *ECB Working Paper Series* no 1861, European Central Bank

[c] Darracq Pariès, Matthieu, Christoffer Kok and Diego Rodriguez-Palenzuela (2010). Macroeconomic propagation under different regulatory regimes: Evidence from an estimated DSGE model for the euro area. *ECB Working Paper Series* no 1251, European Central Bank

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- [g] Darracq Pariès, Matthieu and Alexis Loublier (2010). Epstein-Zin preferences and their use in macro-finance models: implications for optimal monetary policy. *ECB Working Paper Series* no 1209, European Central Bank
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- [i] Darracq Pariès, Matthieu (2007). International frictions and optimal monetary policy cooperation: analytical solutions. *ECB Working Paper Series* no 0834, European Central Bank
- [j] Adjemian, Stéphane and Matthieu Darracq Pariès (2008). Optimal monetary policy and the transmission of oil-supply shocks to the euro area under rational expectations. *ECB Working Paper Series* no 962, European Central Bank
- [k] Darracq Pariès, Matthieu and Alessandro Notarpietro (2008). Monetary policy and housing prices in an estimated DSGE for the US and the euro area. *ECB Working Paper Series* no 972, European Central Bank
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## Chapter 1 Financial shocks and credit supply conditions in the euro area

Since the outbreak of the financial crisis in 2007-2008 and the euro area sovereign debt crisis, the effectiveness of monetary policy has been hindered by factors which may have had a bearing on bank lending rates over and above the traditional pass-through of policy interest rates. The crisis brought to the fore the importance of the financial sector and its potential amplifying effects on business cycle fluctuations; for example, the importance of credit risk and risk perceptions, banks undercapitalisation or poor asset quality of their assets and fragmentation in bank funding conditions for bank lending rates and bank lending policies. As a response to increasing financial fragmentation, the ECB has introduced several standard and non-standard monetary policy measures. These “credit easing” measures have gone a long way towards alleviating financial market tensions in the euro area. However, in order to ensure the adequate transmission of monetary policy to financing conditions, it is essential that the fragmentation of euro area credit markets is reduced further and the resilience of banks strengthened where needed. Against this background, the chapter presents empirical evidence mainly based on time-series analysis, on the role of financial factors during the euro area recessions, as well as on the potential for liquidity-based non-standard measures to alleviate credit supply tensions.

In the first essay of this chapter, we implement a two-step approach to construct a financing conditions index (FCI) for the euro area and its four larger member states (Germany, France, Italy and Spain). The method, which follows Hatzius et al. (2010), is based on factor analysis and enables to summarise information on financing conditions from a large set of financial indicators, controlling for the level of policy interest rates, changes in output and inflation. We find that the FCI tracks successfully both worldwide and euro area specific financial events. Moreover, while the national FCIs are constructed independently, they display a similar pattern across the larger euro area economies over most of the sample period and varied more widely since the start of the sovereign debt crisis in 2010. Focusing on the euro area, we then incorporate the FCI in a VAR model comprising output, inflation, the monetary policy rate, bank loans and bank lending spreads. The credit supply shock extracted with sign restrictions is estimated to have caused around one fifth of the decline in euro area manufacturing production at the trough of the financial crisis and a rise in bank lending spreads of around 30 basis points. We also find that adding the FCI to the VAR enables an earlier detection of credit supply shocks.

In the second essay, we use bank-level information on lending practices from the euro area Bank Lending Survey to construct a new indicator of loans supply tightening controlling for both macroeconomic and bank-specific factors. Embedding this information as external instrument in a Bayesian vector autoregressive model (BVAR), we find that tighter bank loan supply to non-financial corporations leads to a protracted contraction in credit volumes and higher bank lending spreads. This fosters firms’ incentives to substitute bank loans with market finance, producing a significant increase in debt securities issuance and higher bond spreads. We also show that loans’ tightening shocks



explain a large fraction of the contraction in real activity and the widening of credit spreads especially over the recession which followed the euro area sovereign debt crisis.

In the third essay, we thrive for identifying a non-standard monetary policy shock: it is certainly not a trivial exercise, not least as it constitutes a new strategy adopted by central banks. The literature is far reach in instructing how to identify a monetary policy shock, but it is silent regarding non-standard monetary policy shocks. We argue that the 3-year long-term refinancing operations (LTROs) conducted by the ECB in December 2011 and February 2012 can be identified by focusing on the bank lending channel using the Bank Lending Survey (BLS), which was conducted ad hoc in mid-February 2012 for internal ECB purposes and is unpublished. The BLS information allows us to estimate the impact of the non-standard monetary policy measure on the macroeconomy. We show that the 3-year LTROs measure is associated with an increase in GDP, GDP deflator and loan volume to non-financial corporations amounting at pick to 0.6 percentage points by mid-2013, 0.14-0.18 percentage points by mid-2014, 1.8 percentage points by end-2014, respectively. Moreover, the lending rate to non-financial corporations net of the policy rate is expected to decline marginally by 14 basis points by end-2012. These expansionary results are confirmed when inferring them through the BLS published in April 2012.

## Literature review

This chapter relates to several strands of literature. First, in search for a synthetic indicator of financial tensions, several international organisations, central banks, investment banks and academics have developed Financing Conditions Indices (FCI) to assess the prospects of economic activity and inflation, the appropriateness of the macroeconomic policy stance, and to guide financial investment decisions. Extensive work has been done to analyse financial conditions in the United States, and to a lesser extent in the euro area. Some work has been done also on Japan, the United Kingdom, and groups of developed countries. In what follows, we review several FCIs developed in the literature, including: the St. Louis Fed's Financial Stress Index, the Chicago Fed National Financial Conditions Index (Brave and Butters, 2011), the ECB Global Index of Financial Turbulence (ECB, 2009), three indices constructed by the International Monetary Fund (IMF, 2008; Swiston, 2008; and Matheson, 2012); the OECD Financial Conditions Index (Guichard et al., 2009), the Goldman Sachs FCI, the Deutsche Bank FCI (Hooper et al., 2007 and 2010), the Bloomberg FCI (Rosenberg, 2009) and the Citi FCI (D'Antonio, 2008) and three indices developed in the academic literature (Hatzius et al., 2010; Hollo et al., 2011; and van Roye, 2011). Financing conditions indices are constructed in general as a weighted average of a number of financial variables. Financing conditions indices in the literature differ in several respects. The three most important differences lie in the methodology used to compute the weights attached to the variables, the control for endogeneity of the financial variables, and whether or not they include the policy interest rate among the financial indicators.

The second strand of literature focuses on the identification of the macroeconomic effects of credit supply shocks identified by bank lending standards as reported in surveys. Bassett et al. (2014) use

information from the Senior Loan Officer Opinion Survey collected by the Federal Reserve to construct a credit supply indicator. Lown and Morgan (2006) studied the macroeconomic impact of a shock to lending standards using information contained in the same survey. Ciccarelli et al. (2013, 2014) estimate a panel-VAR including variables from the BLS aggregated at country level and found that, especially in financially distressed countries, the credit channel (both the bank lending and the non-financial borrower balance-sheet channel) might act as an amplification mechanism for the impact of monetary policy on real economy. Darracq Paries and De Santis (2015) use a similar econometric framework and identify credit supply shocks using aggregated BLS information.

Another strand of literature focuses on the alternative financing sources of non-financial firms and their choice between bank and market financing in periods of financial distress. Early studies on the endogenous choice between banks versus market finance (Holmstrom and Tirole, 1997; Repullo and Suarez, 2000) argue that a contraction in firms' net worth, as observed during the crisis, should lead to a shift from bond to more bank finance. More related to our work, Becker and Ivashina (2014) highlight, instead, that banks' credit tightening can induce firms to substitute bank credit with stronger issuance of corporate bonds. A theoretical rationale for this evidence is proposed by Adrian et al. (2012). In their model, banks follow a "Value-at-Risk" approach. Under this constraint, when the default risk of NFCs increases, the bank's optimal choice is to deleverage sharply and thus contract lending. Given that the demand for credit from NFCs has limited elasticity, risk-averse bond investors need to be encouraged to increase their credit supply. This requires a widening of the spreads on corporate bonds. The substitution between bonds and loans is also found in De Fiore and Uhlig (2011) where the shift from bank loans to bonds can be the result of NFCs optimal financing choices in the face of a negative bank supply shock. In this model, firms have heterogeneous risks of default and can optimally choose the source of financing. Loans differ from bonds as banks can acquire information on a firm's default risk, while dispersed bond holders cannot. In this context, a shock that reduces the screening efficiency of banks relative to the market induces a shift from loans to bonds. However, bond financing becomes more costly, as the average risk of default for the larger pool of market-financed firms is higher. Regarding the macroeconomic impact, the effects of a bank supply shock are greatly amplified when firms cannot substitute bank finance with bond finance.

Other studies focuses on the role of corporate bond market indicators in predicting macroeconomic developments and identifying credit supply shocks. Gilchrist and Zakrajšek (2012a) introduced an indicator of Excess Bond Premium (EBP), interpreted as a credit supply shock, without distinction between bank lending and market financing. In a different paper, Gilchrist and Zakrajšek (2012b) explore in more details the transmission of a positive EBP shock to bank lending. Based on euro area data, Gilchrist and Mojon (2014) conduct an exercise similar to Gilchrist et al. (2009), estimating a factor-augmented VAR model where they identify a credit supply factor summarising the information on credit spreads (both for banks and non-financial corporations) that is orthogonal to the factors summarising the other variables.

Finally turning to the effects of the non-standard measures introduced by the ECB on macroeconomic variables, VAR methods are studied by Lenza, et al. (2010), Peersman (2011), Giannone, et al. (2012) and Gambacorta, et al. (2012). Lenza, et al. (2010) and Giannone, et al. (2012) study the impact of the non-standard measures by employing counterfactual simulations. Peersman (2011) and Gambacorta, et al. (2012) make use of structural VARs with sign restrictions. More in detail, Lenza, et al. (2010) identifies the non-standard measure shock indirectly assuming that the reduction in the spread between unsecured and secured money market rates observed between November 2008 and August 2009 was entirely due to the non-standard measures. Giannone, et al. (2012) instead makes use of the ECB bank balance sheet. By comparing the forecasts of the main macro variables conditional to the observed path of the ECB bank balance sheet and a no-policy scenario in which the ECB balance sheet is projected to develop conditional to the macroeconomic environment, they conclude that in the absence of the ECB intervention, the macroeconomic activity in the euro area would have been more depressed. By contrast, Peersman (2011) suggest to identify the non-standard measures using bank loans. Specifically, the non-standard monetary policy shock is identified as the innovation to credit supply (i.e. higher bank loans with lower lending rates) orthogonal to the policy rate. Gambacorta, et al. (2012), following the approach used by Peersman (2011), identify the non-standard measure using directly the central bank balance sheets and estimating a panel of eight advanced economies since the onset of the global financial crisis. To identify the shock, they assume that an unexpected increase in central banks' liquidity supply is associated with unexpected lower aggregate financial market volatility measured by the implied stock market volatility index (VIX).

## 1. Financial Condition Indices and the identification of credit supply shocks in the euro area

*Based on the auxiliary paper [a]*

The international financial crisis of 2008-09 and the euro area sovereign debt crisis have brought to the fore the importance of financial conditions to the macro-economy. Stress in financial markets impairs through different channels the normal flow of lending to consumers and corporations, depressing economic activity and inflation. Increasing borrowing costs and falling asset prices weight on consumption through both wealth and inter-temporal substitution effects. Higher external finance premium penalises capital expenditures. Consumption and investment are also affected by changes in risk perceptions and risk tolerance, that alter market risk premia, and by constraints in the supply of credit.

Because of the complexity of the financial sector, a wide range of financial variables is needed to fully characterise its functioning in real time. Combining these variables into a summary statistic of the financial environment for economic agents as well as the degree of strains in the financial system, namely a financing conditions index (FCI), is analytically challenging but operationally appealing for

monetary policy. An FCI can also be useful to assess the success of policy measures aimed at alleviating financial market tensions or impairments in the transmission channel of monetary policy.

### *Euro area FCI*

In this paper, we construct an FCI for the euro area and its larger economies. By construction, the indicator is broadly independent from the level of policy interest rates. It could therefore be interpreted as summarising the financial shocks which affect the economy over and beyond monetary policy impulses. In this sense, the indicator may also measure, through the crisis, the degree of impairment in the monetary policy transmission mechanism.

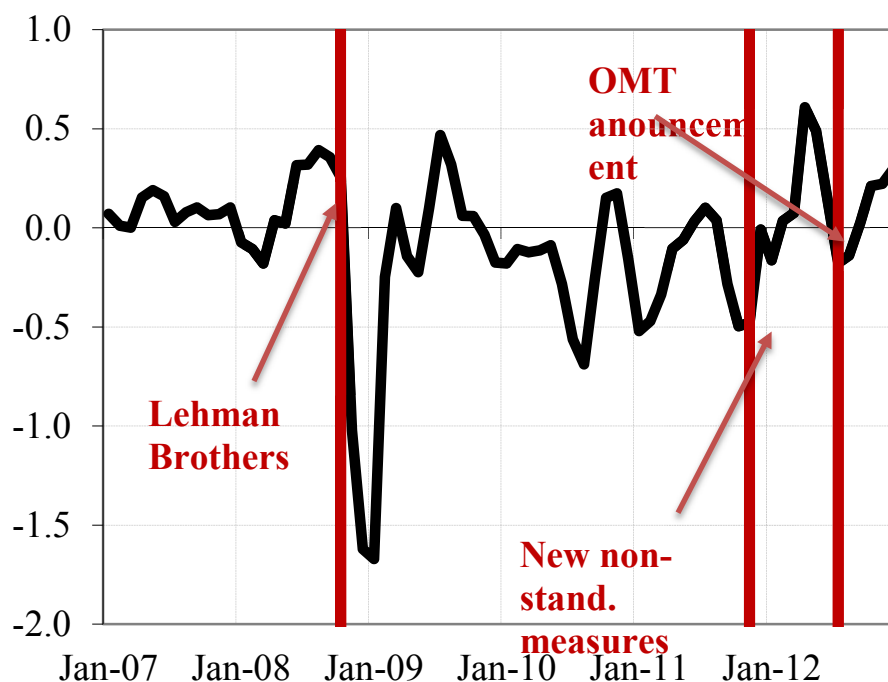
Country-specific panels of large datasets are setup for the euro area and its four larger member states (Germany, France, Italy and Spain). In each case, the bulk of the series capture conditions in financial markets for the three sources of firm's external finance, namely the banking sector, the fixed income market, and equity markets. Variables considered include: bank lending rates, MFI loans to households and non-financial corporations (NFCs), money growth, spreads between government bond yields of different maturities, bank capital and liquidity, equity and securities issuance by MFIs and NFCs, bank and corporate bond yields, stock market returns of financial and non-financial institutions, volatility in equity and exchange rate markets, and correlations among different financial variables, among others. Moreover, given the degree of external openness of euro area economies, the foreign exchange rate and the price of raw materials are also included in the dataset, along with the financial variables.

We implement a two-step approach to construct the FCI. First, each financial variable is purged from its response to developments in demand, prices and monetary policy to capture exogenous shifts in the financial environment. Second, the FCI is constructed as the common component of the movements in the large set of variables from the first step, using Principal Component Analysis (PCA).

The FCIs track successfully both worldwide and euro area specific financial events. More precisely, financial conditions deteriorated sharply during the financial crisis in 2008-09. The FCIs also point to significant tightening at the beginning of 2010, amid concerns on some euro area sovereigns, but the announcement of the Securities Market Programme by the ECB in May 2010 brought this deterioration to a halt. Triggered by renewed fiscal concerns, further tightening is recorded between mid-2011 and October 2011 which receded after the announcement and implementation of the very long-term refinancing operations (VLTROs) by the ECB. Finally, the FCI tightened again in the second and the third quarters of 2012 due to the re-intensification of tensions in some euro area sovereign debt markets, but announcement of the open market transactions programme (OMTs) by the ECB in the summer of 2012 has led to tangible signs of improvements.

More specifically, Charts 1.1 and 1.2 present the FCI computed for the euro area and the four larger economies, respectively, since the beginning of 2007. In both charts, a higher value of the FCI represents an improvement in the financial environment, i.e. less frictions in financial markets while a lower value of the FCI represents deterioration in the financial environment. The FCIs are de-meanned and standardised over the period. The FCIs track successfully both worldwide and euro area specific financial events.

**Chart 1.1 - Financing conditions index in the euro area since 2007**  
(three months moving sum)



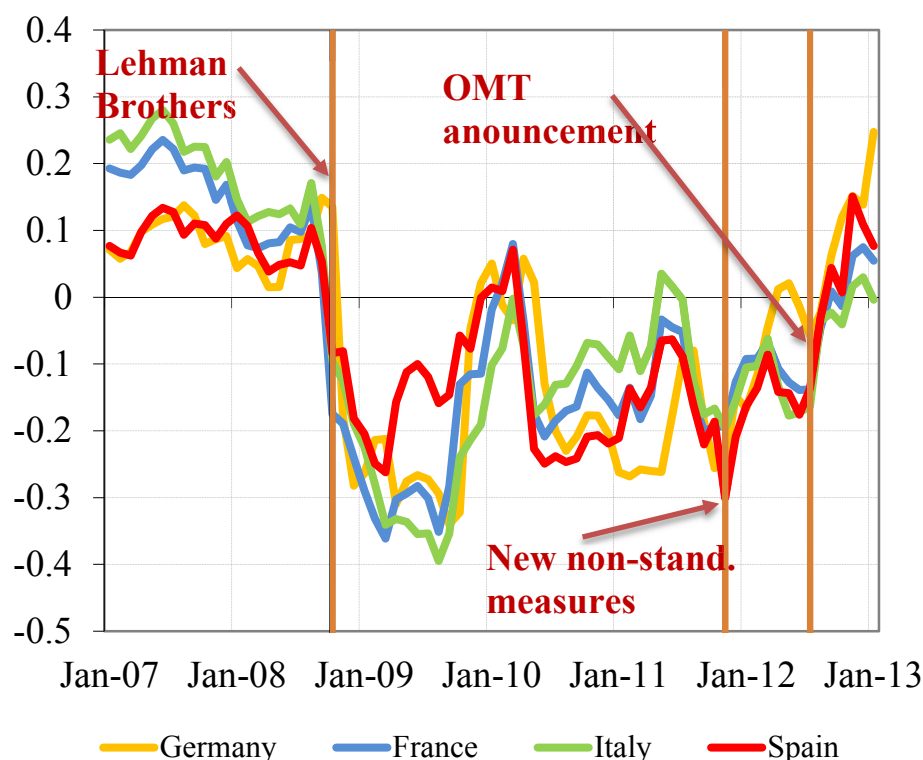
Note: A decline in the FCI signifies a tightening of financial conditions. By construction, the mean of the indices is zero and the standard deviation is one over the estimation period. Last observation is January 2013.

It can be seen that the FCIs vary across time and, to a much lesser extent across countries, possibly reflecting the integration of financial markets. Financial conditions are found to be exceptionally tight in the wake of the financial crisis, in 2008 and in 2009, as well as more recently in the wake of sovereign debt tensions in some countries in the euro area. In particular, financing conditions were relatively loose in 2007, above their average over the estimation period. They deteriorated sharply during the financial crisis in 2008 and in 2009, following the collapse of Bear Sterns in early 2008 and particularly after Lehman Brothers filed for bankruptcy in September 2008. The index for the euro area and the four larger economies reached a historical minimum in the beginning of 2009, when financial conditions started to loosen, following a worldwide relaxation in monetary policy. Financing conditions started to tighten again at the end of 2009 and the beginning of 2010, amid concerns on some euro area sovereigns, but the announcement of the Securities Market

Programme by the ECB in May 2010 brought this deterioration to a halt.

Triggered by renewed fiscal concerns, financing conditions tightened again between mid-2011 and October 2011. The announcement of further non-standard measures by the ECB in the last of quarter of 2011 led to a clear improvement in financial market conditions. The financial environment appears to have tightened again in the second quarter of 2012, following the intensification of turmoil in euro area sovereign debt markets. However, the announcement of OMTs by the ECB in the summer of 2012 has led to tangible signs of improvements in financing conditions. Overall, these results support the view that non-standard measures have succeeded in alleviating financial market frictions in the euro area, thus helping to restore the functioning of the monetary policy transmission mechanism. At the same time, our FCI compares favourably with other financing conditions indices available for the euro area. In particular, our FCI co-moves considerably with the OECD indicator and the Goldman Sachs indicator over the longer term. All of the indices track successfully both worldwide and euro area-specific financial events. However, our FCI appears to vary much more strongly over the crisis period (from 2009 to 2011), reflecting that the important role played by financial factors over this period is, by construction, better captured in our FCI.

**Chart 1.2** - Financing conditions index for the four larger economies (twelve months moving sum)



Note: A decline in the FCI signifies a tightening of financial conditions. By construction, the mean of the indices is zero and the standard deviation is one over the estimation period. Last observation is January 2013.

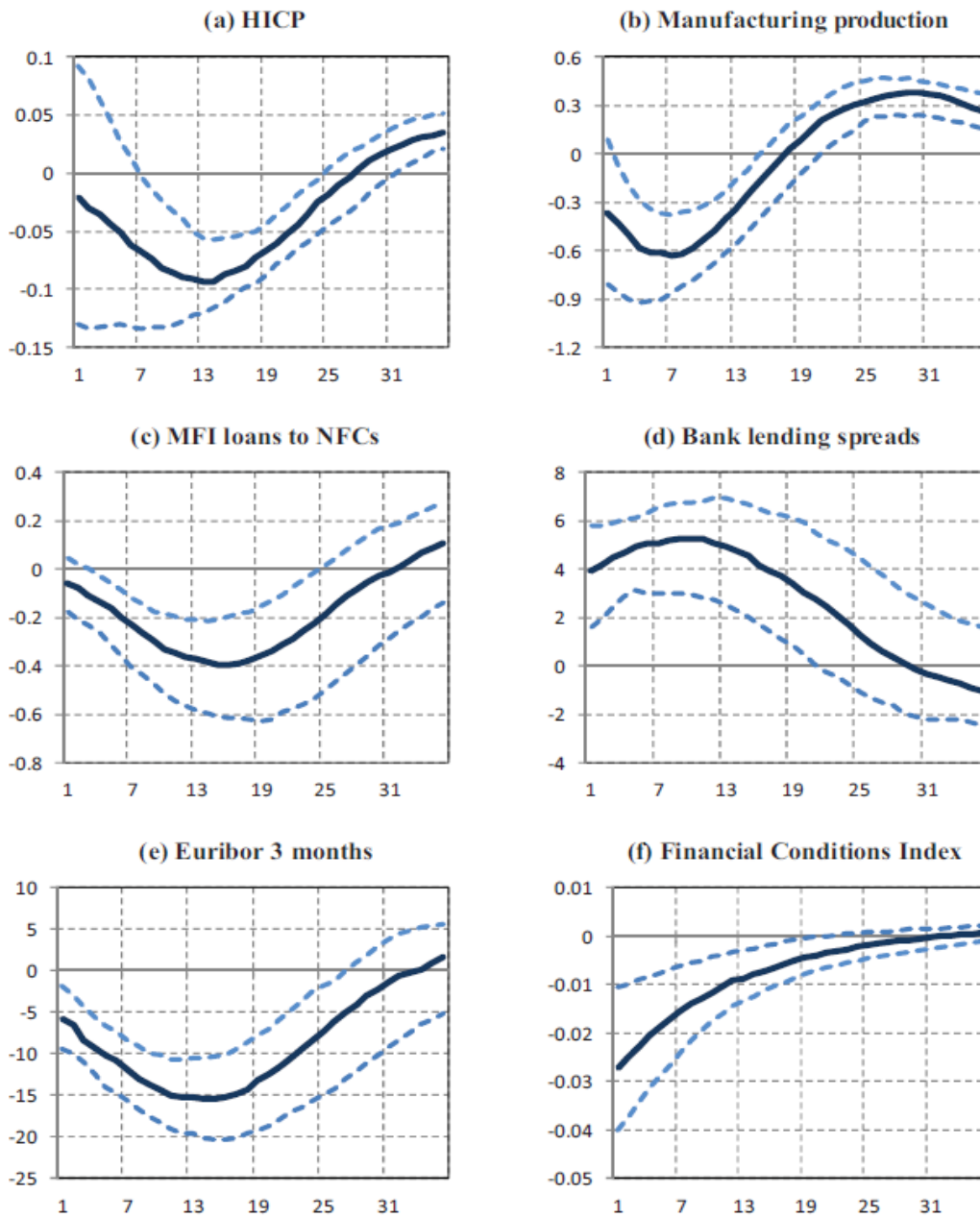
### *Credit supply shocks identification using the euro area FCI*

The FCI for the euro area as a whole is finally used to identify bank lending supply shocks from a VAR model comprising output, inflation, the monetary policy rate, bank loans and bank lending spreads. The VAR is estimated using monthly data over the period from January 2003 until January 2013. The composite cost of bank lending to NFCs used to compute the spread over the 3-month Euribor rate is based on an aggregation of interest rates on short-term loans and long term loans weighted by new business volume of loans. The number of lags retained is selected on the basis of an Akaike information criterion. To identify the credit supply shock, we use sign restrictions instead of the typical recursive decomposition. We follow the approaches of Canova and de Nicolo (2002) and Uhlig (2005) to identify the two shocks.

Chart 1.3 reports the response of the endogenous variables (the median estimate of the accepted draws) to a one standard deviation shock in the credit supply shock for the model augmented with the FCI. The median of the accepted draws is plotted, together with the confidence band at 10% and 90% level, symmetrically distributed and delimited by the dotted lines. Overall, the confidence bands remain relative large especially for the responses of the variables left unrestricted. Beyond the sign restrictions, the responses are generally of the expected magnitude and time profile.

A credit supply shock leads to a slowdown in industrial production and to a later decline in inflation in the euro area in most of the case. Indeed, as the reaction of inflation is not restricted, some of the draws accepted incorporate a positive reaction, but these remain marginal as shown by the upper confidence band (Chart 1.3). The impact on loans is even more delayed. All three responses display a hump-shape, with the impact on activity peaking four to eight months after the shock, that on prices 12 to 14 months after and that on loans 15 to 17 months after. The peak effect on manufacturing production, 0.6% is 50% higher than on loans – 0.4% and ten times stronger than on HICP inflation (0.06 p.p.). Bank lending spreads rise after the shock and reach a peak of around 5 b.p. eight months after the shock. To result in a lower bank lending rate, the decline in the monetary policy rate must be above the rise in the spread and it is what we found, with a peak decline of 15 b.p. in the 3-months EURIBOR. The effects of the credit supply shock are more persistent on loans, spread and the monetary policy rate, and disappear around two years after the shock. Overall, when comparing the time profile of the responses and the relative magnitude at the peak of each effect, the effect are largely plausible, especially between activity, loans and bank lending spreads, even though being on the low side between activity and prices.

**Chart 1.3** – Impulse response function of endogenous variables to a one standard deviation shock in credit supply conditions corresponding to a tightening. X-axis measured in months.



Note: Based on a VAR comprising the annual growth rate of manufacturing production, HICP inflation and bank loans to NFCs, as well as bank lending spreads on loans to NFCs, the 3-month Euribor and the FCI. The shocks are identified with sign restrictions (see Table 2). The response of HICP inflation, manufacturing production and loans are expressed in percentage points of annual growth while the Euribor and the bank lending spreads are reported in basis points. A decline in the FCI signifies tightened financial conditions. The magnitude of the credit supply shock is calibrated on the FCI.



The historical shock decomposition shows that at the trough of the financial crisis, in the middle of 2009, credit supply conditions are estimated to have weighted on manufacturing production by up to 4 p.p. on an annual basis, i.e., about one fifth of the recorded decline. The impact of credit supply shocks on bank lending spreads is estimated to account for about one half of the observed increase in bank lending spreads and for about one third of the decline in the rate of growth of bank lending to NFCs. Other than shock contributions, another exercise typically performed to compare shocks or models in a standard VAR context is variance decomposition. This exercise consists in determining the fraction of the forecast error of a variable that is attributable to a particular shock. It turns out that the credit supply shock explains a sizeable fraction of the forecast error of the variables. For example, at a horizon of one year, the share of the variance explained by this shock is between 23% and 44% for all the variables in the benchmark model. For most of the variables, the peak is reached between 1 quarter and 1 year ahead. These results confirm that bank-lending shocks are important drivers of business cycles at high frequencies. However, the relatively smooth profile of the macroeconomic series is difficult to match with the high volatility of the FCI and only a part of the FCI results from credit supply shocks identified mostly based on macroeconomic series.

## 2. Loan supply, Credit markets and the euro area financial crisis

*Based on auxiliary paper [b]*

This paper analyses the macroeconomic impact of credit supply shocks in the euro area. The eurozone has recently experienced two severe recessions. The first recession, usually referred to as the “Great Recession”, started in 2008 and took place in the context of the post-Lehman global financial crisis. The second recession started in 2011 and was instead mainly determined by euro area specific events following the so called “Euro area sovereign debt crisis”. Over the course of both economic downturns, bank loans rapidly decelerated, recording an extended period of contraction, and lending rate spreads substantially widened. Given the prominent role played by the financial intermediaries in financing the euro area firms, we attempt to assess the macroeconomic consequences of changes in the supply of loans extended by banks to non-financial corporations (NFCs).

The contraction in bank-intermediated credit and the surge in firms’ borrowing cost observed over the recessionary periods might be consistent with a change in the supply of loans. What is less clear, however, is how much the change in credit supply have contributed to the developments in the real economic activity, as many confounding factors mostly associated to general economic conditions were at play. In a context of falling aggregate demand and poor macroeconomic performance, for example, banks might be induced to protect their balance sheet by tightening the conditions at which credit is granted. Moreover, in periods of financial distress banks might optimally react to the increased level of perceived counterparty (borrower) risk by raising the price on new (wholesale and retail) credit lines. In this circumstances, banks could be seen as responding to already existing adverse economic conditions rather than generating them. These examples suggest that in order to assess the

macroeconomic impact of credit supply shock it is crucial to correctly identify the change in credit univocally stemming from the banks' lending behaviour not related to other confounding factors.

In order to identify loan supply shocks we make use of unique bank-level information on credit standards in the ECB's Bank Lending Survey (BLS) and construct a new indicator of bank credit supply conditions for the euro area, labelled Loan Supply Indicator (LSI). This indicator is derived from changes in bank credit standards which are not due to bank-specific demand factors and macro-financial conditions.

To disentangle the possible causal effect of a tightening in credit standards, we borrow from the literature on treatment effects (see Imbens, 2004) and use a propensity score method. We formulate a model explaining how likely is for each bank to tighten credit based on prevailing economic conditions. This information is then used to reweight each bank's response so as to mimic the conditions of a randomised experiment. The measure obtained by reweighting the individual credit standards responses is labelled Loan Supply Indicator measure for each individual bank "i", i.e.  $LSI_i$ . Finally, the  $LSI_i$  for all banks are aggregated across banks and across countries to obtain a measure of Loan Supply Indicator for the euro area. The aggregation method employed is the same as the one used to obtain the credit standards' net diffusion index for the BLS.

More precisely  $LSI_i$  (Loan Supply Indicator of bank i) is the inverse propensity weighted estimator of each bank response (see Imbens, 2004) and corresponds to:

$$LSI_i = \frac{i(\text{tight} = 1)}{P(\text{tight} = 1 | Z)}$$

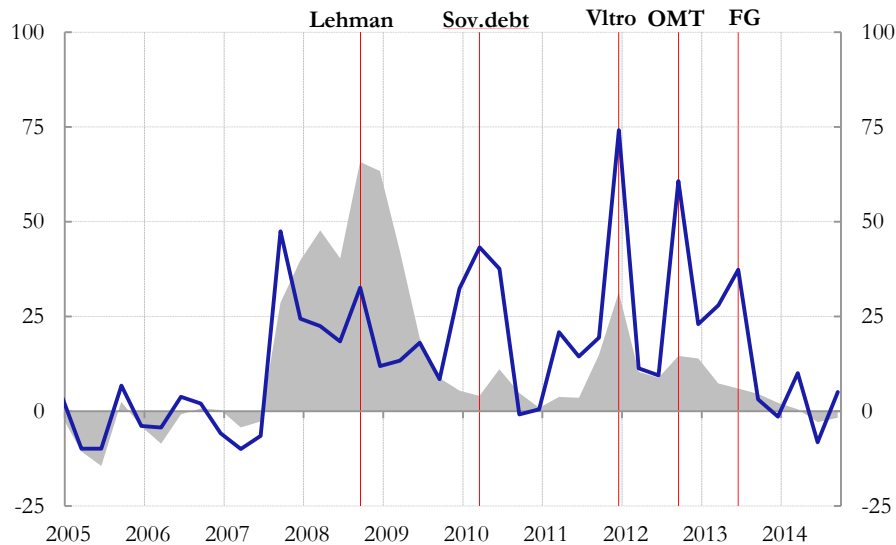
where  $i(\text{tight} = 1)$  is the indicator function of a (single) bank declaring tightening and  $P(\text{tight} = 1 | Z)$  is the probability (or propensity score) that the bank declares tightening given a set of conditioning variables  $Z$ .

To estimate the propensity score, we use a probit model of the individual bank answers on credit standards for which the main determinants are the lag of the BLS credit standards, the bank-level demand factor from the BLS, GDP growth and unemployment of the country of the reporting bank, expectations on economic activity, stock market volatility, and a proxy for the monetary policy stance. Finally, we incorporate a measure of market perception of risk of non-financial corporations above and beyond fundamentals: an Excess Bond Premium for euro area non-financial corporations.

### *Constructing a Loan Supply Indicator for the euro area*

We show that the LSI sheds new light on the relative tightness of bank loan supply over time and in particular across the two recessionary episodes. The LSI is plotted against the net percentage change of credit standards in Chart 1.4. The time profile of the two indicators appears to differ over the sample. The financial developments during the last decade through the lens of both indicators could be structured by the following sub-periods.

**Chart 1.4** – Loan Supply Indicator (LSI) (*blue line*) vs. BLS net tightening of credit standards on loans to enterprises (*shaded area*) - net percentage changes



Note: Individual BLS responses are corrected by taking into account bank-specific loan demand (BLS), macroeconomic conditions (actual and expected) at country level, the riskiness conditions of non-financial corporations in the euro area and monetary policy conditions (Eonia and forward rates). Correction is obtained using an Inverse Propensity Score Method; probit model estimated on pooled BLS data. Latest observation: October 2014 BLS.

First, from 2005 to mid-2007, credit standards were almost systematically easing in net terms. The LSI displayed a broadly similar profile with at the margin a relatively more pronounced loosening in the run-up to the crisis. Second, from summer-2007 to the third quarter of 2008, the financial crisis erupted initially as interbank liquidity tensions and culminated with the Lehman-Brothers default. Through this episode, credit standards were continuously tightened reaching a peak over the sample. By contrast, the LSI indicator jumped to its highest level over the sub-period, right after the summer 2007, moderating somewhat thereafter as the first batch of non-standard monetary policy measures was introduced. From this standpoint, the LSI anticipated bank vulnerabilities and contrary to the net percentage change of credit standards did not reach its maximum in 2008Q3. Third, from end-2008 to the beginning of 2010, the net tightening of credit standards moderated continuously, ending at mild levels by historical standards. Conversely, the LSI depicted the resurgence of financial tensions by end-2009, along with the first signs of the European sovereign debt crisis affecting smaller member countries. The LSI actually peaked in the first quarter of 2010 at the time the ECB started its Sovereign Market Programme (SMP). Fourth, from mid-2010 to end 2011, credit standards pictured negligible impact of financial tensions in the first part of the sub-period but increased afterwards significantly up until 2011Q4, which coincided with the exceptional liquidity measures taken by the ECB: two very long-term refinancing operations (VLTROs). In relative terms, the tightening of credit standards appeared then much smaller than the one recorded around end-2008. By comparison, the LSI displays a qualitatively similar picture but a much more accentuated pattern. In the fourth quarter of 2011, the LSI jumped to its highest reading over the last decade, reverting suddenly in the

next quarter. The acute tensions experienced by the euro area financial sector across almost all large member countries and the subsequent relief brought by the VLTROs are well-captured by the indicator. Fifth, from 2012 to mid-2013, the moderation of the net tightening of credit standards which started after the VLTROs was only temporarily interrupted in the summer-2012 before the decision of the ECB to introduce an Open Market Transaction (OMT) programme. Like in the previous sub-period, the LSI depicts a much sharper reaction, indicating heightened financial tensions at time of the OMT, which receded somehow but persisted till the second half of 2013. Finally, from mid-2013 onwards, the credit standards tightened by less and less, ultimately turning to net easing. Comparatively, the LSI declined much more strongly in the second half of 2013, alongside with the normalisation witnessed in various financial market segments and further easing of the monetary policy stance, notably through forward guidance.

Overall, the LSI index tends to be higher in historical episodes of bank-related stress that were less likely to be driven by pre-existing economic conditions. The time profile of the LSI seems to provide an accurate dating of the main events of the financial crisis and sheds new light on the relative tightness of loan supply across the various sub-periods. In summary, when correcting the credit standards for bank-specific and country-wide demand factors, the LSI signals that the waves of financial distress that occurred from 2011 to 2013 were more related to loan supply conditions than the ones experienced from 2007 to 2009. In comparison, a face value interpretation of the net percentage change of credit standard would reach an opposite conclusion.

The indicator of supply condition is then used as external instrument in a Bayesian VAR model to identify loan supply shocks. Results suggest that adverse loan supply shocks lead to a protracted contraction in credit volumes and higher bank lending spreads, which fosters firms' incentives to substitute bank loans for market finance, producing a significant increase in debt securities issuance and higher bond spreads. Moreover, tighter bank loan supply to non-financial corporations explains a large fraction of the recession following the euro area sovereign crisis. During this latter period, banks' supply tightening is also able to explain both the increases in credit spreads and the substitution between loans and bonds issued by firms.

Finally, we complement our analysis by constructing an indicator of Excess Bond Premia (EBP, as in Gilchrist and Zakrajšek, 2012a) from corporate bond level data to extract a signal from the risk attitude of financial market participants. We shed light on how much information from bank credit supply disruptions, as indicated by our loan supply indicator, differs from the information available from financial market, as indicated by the EBP. Expanding on the seminal contributions of Gilchrist et al. (2009) and Gilchrist and Zakrajšek (2012a, 2012b, 2013), we investigate the impact of unanticipated shocks to the EBP and their relative ability to explain macroeconomic developments, above and beyond the bank-related supply shocks. Our results show that during the Great Recession, the information from financial markets not explained by the tightening of euro area banks credit explains a large fraction of macroeconomic developments.

### *Role of financial shocks through the euro area recessions*

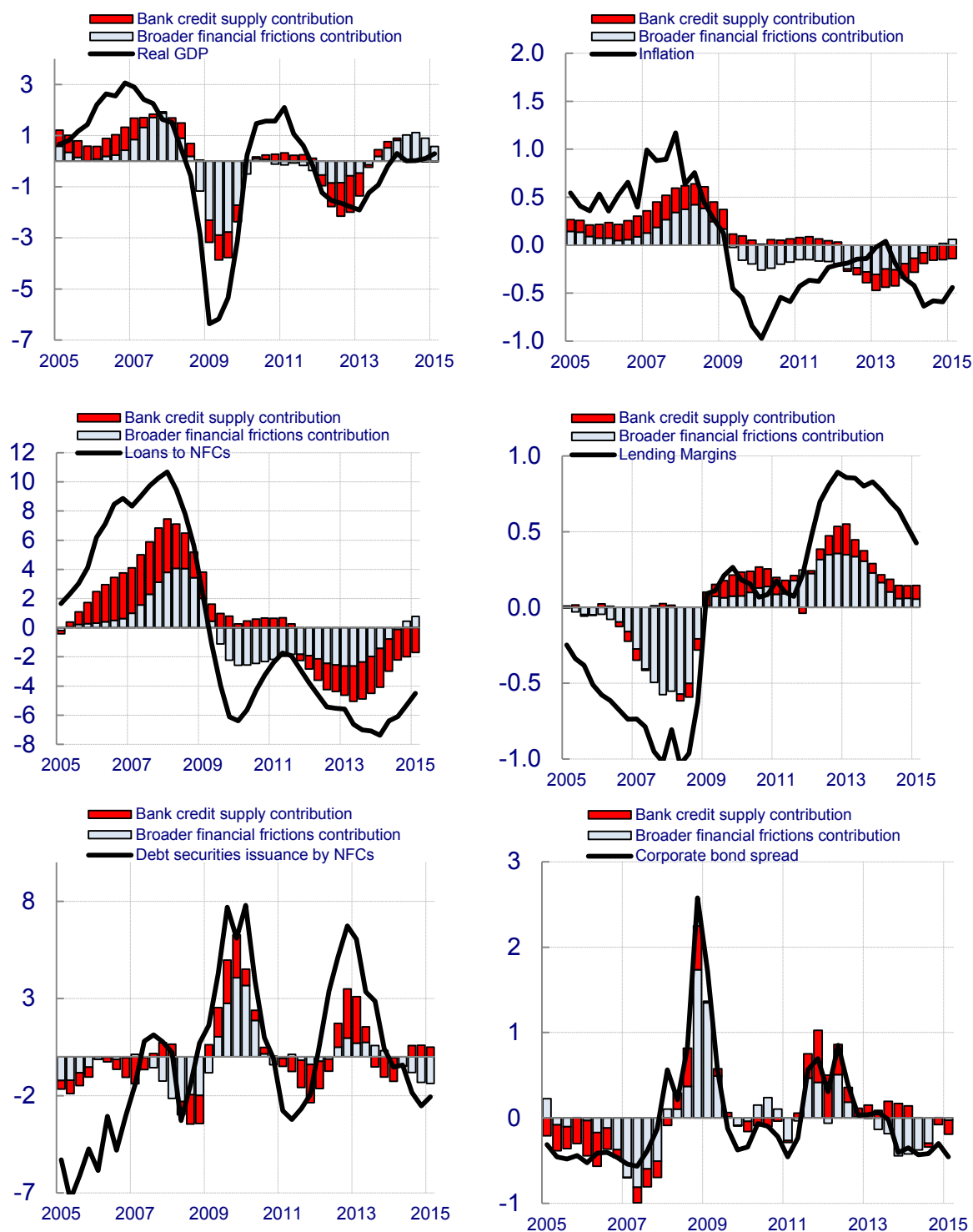
Chart 1.5 displays the contribution of shocks to output, inflation and credit variables since 2005. We focus first on the contribution of the LSI-based external instrument. Through the pre-crisis period, loan supply shocks contributed to annual GDP growth positively from 2005 to 2007, peaking at around 1 percentage points in the course of 2006 and receding thereafter. The associated effects on price dynamics reached 0.3 percentage points. Turning to credit variables, up to 3 p.p. of annual loan growth was explained by supportive loan supply factors by end-2007 while lending rate spreads were compressed by almost 30 basis points.

From 2008 to 2010, the positive contribution of loan supply factors to GDP growth was rapidly reabsorbed and turned negative. In mid-2009, the contribution reached -1 p.p. getting back to a neutral contribution by the end of 2010. While significant, the loan supply effects do not explain the overall contraction in GDP over this period. Overall, the positive contribution to annual loan growth receded from 3% in the beginning of 2008 to almost zero in 2010 while the negative contribution to lending rate spreads halved, reaching -15 basis points. Regarding market-based finance, the loan supply shocks explains 30 basis points of the sharp increase in corporate bond spreads during the turn of the year 2009, and more than 2 percentage points of the surge in bond issuance recorded in 2009-2010.

Thereafter, the resurrection of financial tensions, since mid-2011, led to some turn around in the contribution of the loan supply shocks weighting on annual GDP growth by -1.5 p.p. in 2012. The drag on loan dynamics reached 3 p.p. and the contribution to lending rate spreads increased up to 30 basis points. The loan supply shocks also explains a significant part of the corporate bond spread increases recorded in 2011 and 2012 with its contribution reaching 60 basis points at the peak. Similarly, the rebound of debt securities issuance was supported by the contribution of the loan supply shocks recovering from -3 percentage points in mid-2011 to 2.5 percentage points in mid-2013. By comparison with the initial phases of the crisis, the contributions of loan supply disturbances are much stronger for the last part of the sample, in line with the picture portrayed by the narrative description of the LSI.

Overall, the ability of loan supply shocks to explain the BBB-AA spreads appears to be limited over the 2008-2009 recessionary period. This might suggest that the rise in credit spreads for euro area non-financial corporations might have been driven by other sources additional to tightening of loan supply. With this result in mind, we analyse whether the Great Recession can be explained by other factors not related to our measure of bank credit tightness. This is done in two steps. First, we construct a measure of Excess Bond Premium (EBP) for non-financial corporations in the euro area. Second, we assess the macroeconomic impact associated with the EBP dynamics not explained by loans supply tightening.

Chart 1.5 – Historical decomposition of selected macroeconomic variables



Note: The panels of the figure depict the contribution of the credit supply shock (red bars) and excess bond premium shock (light blue bars) to the historical developments of selected macroeconomic variables.

Indeed, it appears that financial frictions measured by the EBP have a strong role in the initial phases of the crisis. From mid-2007 to mid-2009, the contribution to annual GDP growth went from 2 p.p. to -2.5 p.p. and drove corporate bond spreads almost 200 bps higher. For the other variables, a

similar pattern is observed with two to three quarters lag: the EBP shock explains 0.5 p.p. of the moderation in annual inflation from the beginning of 2008 to end-2009, more than 5 p.p. of the decline in the annual growth rate of loans, around 5 p.p. of the increase in the annual growth rate of debt issuance and 70 bps in the rise of lending rate spreads.

All in all, our results suggest two shocks (bank credit supply and EBP) are important to explain credit market developments in the euro area. This result is consistent with the counterfactual analysis of De Fiore and Uhlig (2014) showing that, in a DSGE with micro-founded corporate financing choices between bank loans and market debt, two sets of shocks are needed to match the changes in credit variables. The first shock is related to bank efficiency, which might resemble our loan supply shock. The second shock is instead related to uncertainty or risk, which would correspond more to our Excess Bond Premium shock.

### **3. Credit supply and long-term liquidity operations in the euro area: evidence from a Panel-VAR including Bank Lending Survey information**

*Summary of featured paper [1]*

In the second half of 2011, the euro area sovereign debt crisis exacerbated, funding and deleveraging pressures on euro area banks raised the risk of credit supply disruptions affecting the financing of firms and households. Against this background, the ECB increased the length of the refinancing operations with fixed rate tenders and full allotment in December 2011 and February 2012 to 3-years with the aim to support bank lending and counteract the risks of disorderly bank deleveraging process.

This study aims at assessing the macroeconomic implications of the 3-year long-term refinancing operations (LTROs) conducted by the ECB in December 2011 and February 2012, identifying the implied non-standard monetary policy shock through the Bank Lending Survey (BLS) information for the beginning of 2012. The empirical analysis on the impact of the 3-year LTROs assumes that the main transmission channel of this non-standard monetary policy measure works through the mitigation of liquidity and funding risks in the euro area banking system. This ultimately contributes to prevent any disorderly deleveraging process and supports the financing of the economy at large. More specifically, the BLS suggests that non-standard liquidity measures have been successful in limiting the tightening of credit standards to households and firms due to liquidity risks and access to funding. This also supports the view that the 3-year LTROs can be interpreted as a favorable credit supply shock.

Compared with the most likely developments one could have expected at the end of 2011 when financial tensions culminated, the model-based counterfactual experiments suggest that the 3-year LTROs are expansionary and associated with increases in GDP, loan volume to non-financial corporations and a compression of lending rate spreads over a two-to-three year horizon. The

economic support of the non-standard measure is only gradually reflected in loan dynamics while the benefits on output materialize earlier. Moreover, given the moderate response of spreads compared to loans, the 3-year LTROs are estimated to importantly act on the economy through quantitative credit easing.

Overall, our paper brings an empirical contribution to the literature on the effectiveness of unconventional monetary policy at times of financial distress. The quantitative findings show that in the presence of acute tensions, exceptional central bank liquidity measures could help supporting the provision of bank lending to the economy and avoid an abrupt dry-up of credit supply. This assessment is consistent with the view that non-standard monetary policy measures like the one analyzed in this paper are complementary to interest rate decisions and are essentially predicated on the basis of emerging financial frictions in the credit intermediation sector.

The success of the 3-year LTROs in reducing funding risk in the banking sector can also be demonstrated by the developments of the 3-month EURIBOR-OIS spread in the first half of 2012. Despite the renewed tensions in some euro area sovereign debt markets in the second quarter of 2012 owing to several country-specific factors, this measure of interbank credit risk declined from 100 basis points on the day of announcement (8 December 2011) to 40 basis points at the end of March 2012 and fluctuated around it since then until the speech on the convertibility risk by the ECB President Draghi on 26 July 2012. After the speech, the interbank credit risk continued its declining trend reaching 12 basis points on 26 November 2012; such low level was obtained on 8 August 2007, the day before the ECB had to cope with the first signal of dislocation of the money market.

This money market resilience is consistent with the fact that bank funding risks were effectively reduced by the ECB measures announced on 8 December 2011, because the 3-year LTROs provided a window of opportunity for banks to deleverage in a more orderly fashion and to increase their liquidity and capital buffers in a sustainable manner.



## Chapter 2 DSGE models with supply and demand-side credit frictions

This chapter presents two DSGE models with a granular set of financial frictions which can bring a structural perspective on the salient features of the euro area crisis. Accounting for real-financial interactions in a DSGE model could encompass several dimensions. First and foremost, the financial crisis has brought to the forefront the role of the financial system as an autonomous source of economic disturbances. Widening lending rate spreads and rising cross-country dispersion of bank lending rates are pervasive and constitute a powerful shock to the economy at large, with sizeable effects on spending decisions and inflation dynamics. Second, the banking system may amplify the impact of shocks to the economy and the business cycle, particularly in periods of lacklustre economic activity and fragile balance sheets in the corporate sector. In a bank-based economy such as the euro area, the compensation of risk priced in lending rates is a powerful propagation mechanism of adverse demand shocks. Third, impairments to the monetary policy transmission mechanism and cross-country heterogeneity in bank lending rates across the euro area are holding back economic momentum.

The financial crisis clearly illuminated the potential amplifying role of financial factors on macroeconomic developments. Indeed, the heavy impairments of banks' balance sheets brought to the fore the banking sector's ability to provide a smooth flow of credit to the real economy. However, most existing structural macroeconomic models fail to take into account the crucial role of banks' balance sheet adjustment in the propagation of shocks to the economy. The first essay of this chapter contributes to fill this gap, analysing the role of credit market frictions in business cycle fluctuations and in the transmission of monetary policy. We estimate a closed-economy dynamic stochastic general equilibrium (DSGE) model for the euro area with financially-constrained households and firms and embedding an oligopolistic banking sector facing capital constraints. Using this setup we examine the macroeconomic implications of various financial frictions on the supply and demand of credit, and in particular we assess the effects of introducing risk-sensitive and more stringent capital requirements.

The euro area experience during the financial crisis highlighted the importance of financial and sovereign risk factors in macroeconomic propagation, as well as the constraints that bank lending fragmentation would pose for monetary policy conduct in a currency union. In the second essay, we design a 6-region multi-country DSGE model which provides a structural interpretation of the salient features of these developments. The model spans the relevant "financial wedges" at play during the crisis, together with its cross-country heterogeneity within the euro area, focusing on Germany, France, Italy, Spain, and rest-of-euro area. We construct three stylised macro-financial scenarios as a synopsis of the euro area financial crisis and argue that the adverse interactions between sovereign, banking and corporate risk, can account to large extent for the financial repression and poor economic performance observed in some parts of the euro area.

## Literature review

The specification of the domestic financial frictions is related to various strands of modelling literature which consider both supply and demand-side credit frictions, introduce risky banks and sovereign default. The introduction of financial frictions in DSGE models is usually done through credit demand frictions, with the usual financial accelerator (Bernanke et al. (1999), hereafter BGG, Christiano et al. (2010) and Kumhof et al. (2010)) or borrowing constraints a la Iacoviello (2005).

Financing frictions arising in the context of asymmetric information between borrowers and lenders are often suggested as a prime candidate for endogenously amplifying and increasing the persistence of even small transitory exogenous shocks. In the spirit of the traditional financial accelerator literature, the presence of credit constraints can generate a procyclical feedback between the financial health of borrowing firms or households and output fluctuations. Such real-financial linkages can arise from the demand side of the credit markets. More specifically, as regards the household sector, a strand of literature, like Kiyotaki and Moore (1997), Iacoviello (2005) or Iacoviello and Neri (2009) considers a dual structure, with agents belonging to two different groups according to their intertemporal discount factor. Households' heterogeneity generates equilibrium debt as the result of intertemporal borrowing between more and less impatient agents. For what concerns the non-financial corporate sector, seminal contributions encompass Bernanke et al. (1999), Carlstrom and Fuerst (1997), Christiano et al. (2007,2010), Christensen and Dib (2008) and Liu et al. (2009) who introduced equilibrium default of firms into DSGE models.

Some other studies put the emphasis on credit supply frictions and develop an explicit banking sector within DSGE modelling frameworks: among others, you will find Van den Heuvel (2008), Meh and Moren (2008), De Walque et al. (2009), Dib (2009), Gerali et al. (2010), Aguiar and Drumond (2009), Agenor and Pereira da Silva (2009), Agenor and Alper (2009), Gertler and Karadi (2011, 2013), Covas and Fujita (2009), Angeloni and Faia (2009) and Christiano et al. (2010). In particular, the role of liquidity and capital frictions have deserved specific attention through the work of Bernanke and Lown (1991), Peek and Rosengren (1995), Kashyap and Stein (2000), Van den Heuvel (2002), Gambacorta and Mistrulli (2004), and Kishan and Opiela (2006).

The procyclicality of risk-sensitive requirements have been examined in Danielsson et al. (2001), Catarineau-Rabell et al. (2005), Kashyap and Stein (2004), Gordy and Howells (2006), and Brunnermeier et al. (2009) (see also Drumond (2008) for an overview of the literature). At the same time, risk-sensitive capital requirements can ex ante deter excessive risk taking, as advocated by Borio and Zhu (2008), Zhu (2008), Repullo and Suarez (2009), Jokivuolle et al. (2009), and Boissay and Kok Sørensen (2009).

Banks are having some degree of market power, which may derive from banks being "special" in the sense of being able to reduce (by acting as "delegated monitors") the information gap between savers and borrowers of funds, as in Diamond and Dybvig (1983), Diamond (1984) and Diamond and Rajan (2001). There is ample empirical evidence for the existence of a sluggish bank interest rate pass-

through in the euro area, notably from the work of Mojon (2001), De Bondt (2005), Sander and Kleimeier (2006), Kok Sørensen and Werner (2006) and Gropp et al. (2007). And there are recent studies that embed features of an incomplete bank interest rate pass-through into a DSGE model framework, see e.g. Kobayashi (2008), Agenor and Alper (2009), Hülsewig et al. (2009)

Some models do bridge these perspectives Gerali et al. (2010) introduce a segmented banking sector with a bank capital channel and monopolistic lending rate setting into a DSGE model with financial frictions like. Darracq Paries et al. (2011) propose a comprehensive representation of the banking system allowing frictions on both credit demand and supply with both firms and households default. More recent contributions also feature risky banks within segmented banking models. Clerc et al. (2015) considers a real model with three layers of borrower defaults where simultaneously impatient households borrow from banks through mortgages to finance housing purchases; entrepreneurs borrow from banks to finance capital accumulation and banks borrow from patient households through deposits. The IMF has recently proposed the MAPMOD model (Benes and Kumhof (2011); Benes et al. (2014b,a)) designed to study vulnerabilities associated with excessive credit expansions. The model depicts a small open economy with a financial sector consisting of a representative competitive bank where risky loan exposures can impair bank capital position. Banks respond to losses through higher spreads and rapid credit cutbacks, with adverse effects for the real economy.

Finally, some papers analyse sovereign defaults in a DSGE models with financial frictions. Corsetti et al. (2013) propose a New Keynesian model of a two-region monetary union that introduces a sovereign risk channel to credit spread in the private sector. van der Kwaak and van Wijnbergen (2014) introduce sovereign default risk in the model of Gertler and Karadi (2013) and analyse the link between sovereign solvency and financial fragility. In our model, the sovereign-bank nexus is dealt with in reduced-form manner, albeit with more structure than Corsetti et al. (2013): risky banks do not directly hold government debt but are exposed to sovereign default risk through their funding costs. A more microfounded treatment of sovereign bank interactions in the spirit of van der Kwaak and van Wijnbergen (2014) is left for future research.

The most recent literature proposes multi-country DSGE models (generally in a two-country setup) allowing various international propagation channels based on global banks which are either lending internationally to the private sector (Fujiwara and Teranishi, 2010) or investing in foreign government bonds (Guerrieri et al. (2012)). Fujiwara and Teranishi (2010) incorporate staggered loan contracts into a two country model to study the dynamics of the real exchange rate. In their model, banks collect deposits from households and provide loans to firms to finance their factor expenditures in advance. However, there are two types of banks in each country: local banks intermediate between domestic households and domestic firms while international banks intermediate between domestic households and foreign firms. In a more stylized manner Kollmann et al. (2011) and Kalemli-Ozcan et al. (2012) are also considering a two-country environment with a global banking sector. When a shock

erodes the capitalisation of global banks, it reduces credit supply and depresses economic activity in both countries.

Guerrieri et al. (2012) study the international propagation of sovereign debt default. They propose a two-block economy where capital constrained banks grant loans to firms and invest in bonds issued by the domestic and the foreign government. The model economy is calibrated to data from Europe, with the two blocks representing the Periphery (Greece, Italy, Portugal and Spain) and the Core, respectively. Interestingly, they find sizeable spillover effects of default from Periphery to the Core through a drop in the volume of credit extended by the banking sector. From a quite different perspective, Mendoza and Quadrini (2010) consider an open-economy model with a different degree of financial development in each country and investigate cross-country spillovers effects of shocks to bank capital. They show that financial integration leads to a sharp rise in net credit in the most financially developed country and to large asset price spillovers of country-specific shocks to bank capital. The impact of these shocks on asset prices are amplified by bank capital requirements based on mark-to-market.

## 1. Estimating a euro area-wide medium-scale DSGE with a relevant role for the banking sector

*Based on featured paper [2] and auxiliary papers [c], [d]*

This paper analyses the role of credit market frictions in business cycle fluctuations and in the transmission of monetary policy. We estimate a closed-economy dynamic stochastic general equilibrium (DSGE) model for the euro area with financially-constrained households and firms and embedding an oligopolistic banking sector facing capital constraints. Using this setup we examine the monetary policy implications of the various financial frictions to credit supply and demand and furthermore examine the real economic implications of increasing capital requirements and of introducing risk-sensitive capital requirements. Moreover, the potential for introducing counter-cyclical bank capital rules and aligning macro-prudential tools with standard monetary policy tools is examined.

The financial crisis which started in 2007 brought to the fore the importance of the financial sector and its potential amplifying effects on business cycle fluctuations. The massive write-downs and losses that banks had to incur over this period significantly impaired their liquidity and capital positions, which in turn forced many banks to cut back on activities and to shed assets. This deleveraging process in the banking sector may have hampered the access to financing for some bank-dependent borrowers and thereby reduced their ability to consume and invest, potentially reinforcing the economic downturn. Whereas in the macroeconomic literature it has long been recognized that financial intermediation may play a role in economic fluctuations through the financial accelerator mechanism relating to the banks' borrowers, the possible amplifying impact on the business cycle of shocks directly hitting the financial intermediaries has only recently been taken up by the literature.

The importance of the banks' balance sheet situation in transmitting shocks to monetary policy (and other types of shocks) has, however, long been recognized in the empirical literature. For example, it has been pointed out that more liquid and well-capitalized banks are better able to absorb shocks hitting the macroeconomic environment (including changes in monetary policy) than more capital and liquidity-constrained banks. Furthermore, the financial crisis has reinforced interest in macro-prudential tools and policies that might be applied by policy makers to reduce the risks of financial boom and bust cycles and thereby lead to a more stable path of real economic growth.

In addition to the attention on the role of financial intermediaries brought forward by the financial crisis, the introduction of more risk-sensitive capital requirements (i.e. the Basel II capital adequacy framework) has reinforced the concerns that financial intermediation by itself might have substantial feedback effects on the real economy. In particular, it has been argued that by introducing capital requirements that are sensitive to the state of the economy, the inherent cyclicity in banks' lending behaviour is likely to be reinforced. Hence, as bank capital requirements will be less strict when risks are perceived to be benign and, vice versa, will be tighter when the quality of the assets is deteriorating, banks are likely to engage in riskier lending during economic upturns and to contract credit supply during economic downturns. To the extent that some firms and households are dependent on having access to bank financing in their investment and spending decisions, more cyclical capital requirements would be expected to reinforce the propagation mechanism between the financial system and the real economy. In other words, *ceteris paribus*, a risk-sensitive capital requirements regime is expected to have pro-cyclical effects. It has, however, been argued that by inducing a more forward-looking behaviour in banks' risk-taking, a risk-sensitive capital adequacy framework may also include some mitigating elements with respect to its overall pro-cyclical effects. While the extent to which a risk-sensitive capital adequacy framework introduces amplifying pro-cyclical effects is ultimately an empirical question, the analysis of such effects needs to be placed in a broader context whereby the feedback mechanism between the financial and the real sector as well as the forward-looking, strategic behaviour of financial intermediaries are properly taken into account. In other words, a general equilibrium framework is needed to appropriately account for the interlinkages between financial and real economic factors. Moreover, as a consequence of the financial crisis, the Basel Committee on Banking Supervision (BCBS) has already proposed amendments to the bank regulatory framework (i.e. Basel III) with the aim of strengthening capital requirements. Our model is also well-suited for analysing the potential costs (and benefits) of moving towards higher capital ratio targets and the role of monetary policy during such a transition.

Against this background, we propose a closed-economy DSGE model with financial frictions including a segmented banking sector which faces monopolistic competition and is subject to capital constraints. In the model, financial intermediation is determined by a series wedges and is affected by a variety of exogenous "shocks". Focusing specifically loan origination, bank lending rates originate mainly from three distinct layers related to the demand and the supply of credit:

*Riskiness of borrowers:* The possibility for households and firms to default on their loans means that lending rates compensate for the associated credit risk. While default rates vary endogenously in the model as a result of fluctuations in asset prices, the time-varying nature of the riskiness of borrowers is induced in the model by considering specific credit risk shocks. In turn, this triggers time variation in the credit risk premium and hence in bank lending rates.

*Imperfect competition and nominal rigidities in lending rate setting:* One segment of the model's banking system consists of loan book financing branches which receive funding from the wholesale branches and allocate them to the commercial lending branches. Operating under some degree of market power, monopolistically competitive loans book branches set staggered nominal lending rates, which are subject to exogenous mark-up shocks. This source of time variation in the mark-up over the marginal cost manifests itself ultimately in the lending rates that commercial branches apply on loans to households and firms.

*Bank capital:* Conditions related to bank balance sheet positions also influence lending rate setting behaviour. The pressure by market disciplining forces and regulatory requirements on banks to hold adequate capital buffers is captured in the model by assuming adjustment costs on bank's leverage. Technically speaking, such costs constrain banks' decisions on deposits and loans. When facing adverse shocks to their capital base, banks react by exploiting their market power and raising their lending margins, so as to ensure stable profits and hence preserve adequate capital buffers.

Using our model setup we document the role of financial frictions in amplifying shocks to the economy. For example, via the collateral channel housing-specific shocks generate sizeable effects on non-residential consumption and investment. Moreover, it is shown that the specification where borrowing constraints are always binding produces more pronounced propagation than benchmark model with endogenous defaults. Furthermore, capital constraints and costs related to capital adjustments are shown to amplify the macroeconomic propagation of exogenous shocks. In addition, it is shown that risk-sensitive capital requirements imply marginally more volatility in the economy than a fixed-rate capital requirement regime. However, the degree of macroeconomic volatility varies with types of shocks, with especially risk shocks and financial shocks are found to have amplifying impact when capital requirements are risk sensitive. At the same time, banks are found to actively reshuffle their portfolios when faced with credit risk shocks which somewhat mitigates the pro-cyclical implications. As regards the introduction of more stringent capital requirements (as proposed under Basel III), we show that it would lead to a transitory negative impact on output. The costs related to introducing the new capital requirements are, however, reduced the later the implementation date and may furthermore be mitigated by monetary policy accommodation.

Counterfactual simulations from the model also suggest that higher lending rates have propagated to the broader economy by depressing economic activity and inflation. Financial shocks have also contributed to amplify business cycles in the euro area through the financial sector. Simulation analysis shows that financial factors have played a key role during the crisis, dampening euro area

GDP growth at the peak of the crisis, namely around mid-2009. After receding in the first quarters of 2011, financial factors subsequently weighed on economic activity in 2012, on the back of heightening financial market tensions and the sovereign debt crisis in some parts of the euro area.

### *Inspecting the typology of real-financial linkages through the euro area recessions*

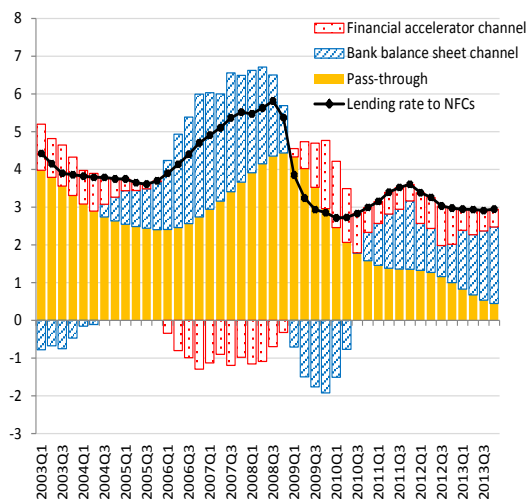
The model can indeed be used to disentangle the actual quantitative contribution of financial factors to euro area business cycle fluctuations. Real-financial interactions refer to the amplification of certain shocks through the interplay between financial variables (such as asset prices, firms' net worth and the external financial premium) and real variables (such as investment and economic activity). Such amplification mechanisms arise because of the presence of financial frictions, notably in the form of informational frictions in credit intermediation. One prominent type of real-financial interaction, commonly formalised in macroeconomic models, is the "financial accelerator" mechanism. Intuitively, a negative shock hitting a firm's net worth constrains the firm's ability to borrow via its adverse impact on creditworthiness and a higher external finance premium. The resulting adverse impact on investment leads, in turn, to a further deterioration in the firm's net worth and thus to a more severe impact on economic activity. In essence, the main implication of this channel is that large and persistent fluctuations in economic activity may arise from seemingly small shocks because of real-financial feedback loops.

In addition to these real-financial interactions stemming from the side of borrowers, the procyclicality of the financial system may also be exacerbated by a second channel, related to bank-specific vulnerabilities in the form of weak capital positions and funding constraints. This second channel could be referred to as the "bank balance sheet" channel.

Estimated on euro area data, the model makes it possible to decompose a number of macroeconomic variables into the contributions of various structural (unobserved) shocks, including financial shocks. This enables us to bring some quantitative perspective on the typology of real-financial linkages through the euro area crisis.

Chart 2.1 reports the decomposition of bank lending rates to non-financial corporations into different wedges representing the financial accelerator and the bank balance sheet channels, as well as the pass-through from policy interest rates. Regarding the latter, it can be seen that policy interest rates contributed to downward pressure on bank lending rates to non-financial corporations following the worldwide relaxation in monetary policy that started in late 2008. However, bank lending rates to non-financial corporations did not contract to the same extent and even increased between 2010 and 2011 owing to vulnerabilities associated with banks' balance sheets and borrowers' increased riskiness (bank balance sheet and financial accelerator channel).

**Chart 2.1** – “Financial wedges” and lending rate to non-financial corporations (annual rate, in %)



**Chart 2.2** – Contribution of “financial shocks” to real GDP growth (annual growth in percentage points)

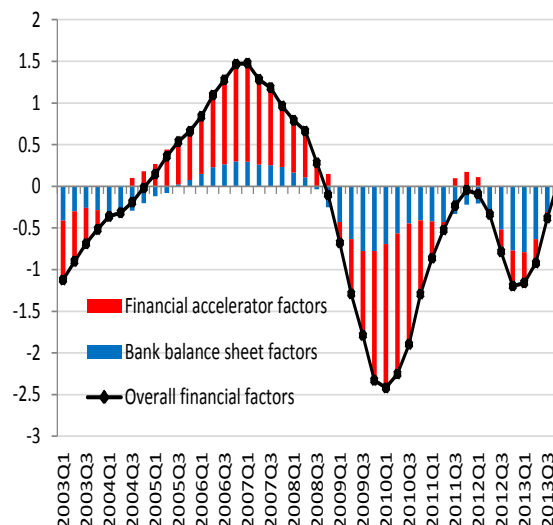


Chart 2.2 depicts the contribution of financial shocks to real GDP growth, together with the two sub-categories of financial accelerator factors (red bars) and bank balance-sheet factors (blue bars). Overall, financial factors (black line), which mainly operate through bank lending rate spreads, appear to have played a key role during the crisis. Specifically, their contribution to euro area real GDP growth is estimated to amount to -2.5 percentage points at the peak of the crisis, namely around mid-2009. At that time, the adverse impact of financial factors can be equally attributed to financial accelerator factors (related to borrowers’ probability of default and associated external finance premium) and bank balance sheet factors (related to bank capital and cost of bank funding factors). After receding in the first quarters of 2011, financial factors subsequently have weighed on economic activity in 2012, on the back of heightening financial market tensions and sovereign debt crisis in some parts of the euro area, mainly captured by adverse bank balance-sheet factors.

## 2. Financial fragmentation in the euro area through the lens of a large-scale multi-country DSGE model

*Summary of featured paper [3]*

The main contribution of this paper is to design a multi-country dynamic stochastic general equilibrium (DSGE) model for the euro area which provides a structural interpretation of the salient features of the euro area bank lending fragmentation. We extend their work by introducing more granular financial and banking frictions, and by considering wider cross-country heterogeneity through a 6-region global model. The model features a reduced-form sovereign-bank nexus, risky banks acting in a monopolistic manner, financial frictions associated with corporate default and cross-border lending. It allows us to analyse the observed heterogeneity in bank lending rates observed across euro area countries and the role of sovereign and financial spillovers in the international propagation of shocks.



We develop macro-financial scenarios which are certainly not mutually exclusive, but give some meaningful synopsis of the various phases of the euro area financial crisis. The macroeconomic cost of financial fragmentation lies in the interplay between sovereign, banking and corporate credit risk. So the first experiment considers the transmission through credit channels, of the sovereign market tensions which are calibrated to reproduce the surge in sovereign spreads as observed from 2010 to 2013. This source of financial fragmentation is amplified by the observed contagion to bank funding conditions in jurisdictions less affected by the turbulence in sovereign segments. The macroeconomic multipliers are strong in countries under stress and spillovers within the euro area are sizeable. In itself, this counterfactual experiment would explain a large part of lending rate dispersion and poor economic performance in the euro area over the period.

The second experiment focuses on the vicious circle that was activated through the crisis, from rising corporate default, bank asset quality and credit constraints. We simulate a cross-country increase in corporate risk to match available evidence on default frequency and non-performing loans within the euro area. These conditions propagate more forcefully through the intermediation chain of jurisdictions where banks are under-capitalised and risk-averse. The scenario adequately portrays another important source of financial fragmentation and shows to which extent such real-financial feedback loops could contribute to impair the monetary policy transmission channel in countries like Spain and Italy.

The final experiment explores the potential for bank deleveraging process, on the back of unprecedented regulatory reform, to explain the pervasively high bank lending rates and the lacklustre credit dynamics in some countries, beyond the forces analysed in the previous two experiments.

Even if our experiments could potentially overlap, not least as their quantitative calibration is not based on structural estimations, they do reflect independent forces at play during the crisis. A face value reading of the simulations, taken all together, would imply dramatic effects on lending rate dispersion, potentially beyond what was observed in reality both for stressed and non-stressed countries. This should not be seen as questioning the plausibility of our experiments but instead, it implicit points to mitigating factors which partially shielded some jurisdictions. A crucial one has been non-standard monetary policy measures.

## Chapter 3 Optimal monetary policy conduct within quantitative New-Keynesian models

The objective of this Chapter is to examine the main features of optimal monetary policy within a micro-founded macroeconometric framework. The first section summarises research contributions focusing on closed-economy DSGE models, while the second section extend the analysis to open economy issues.

In the first section, we estimate a medium scale closed economy DSGE for the euro area, very close to Smets and Wouters (2003). Then, we study the properties of the Ramsey allocation through impulse response, variance decomposition and counterfactual analysis. We also present simple monetary policy rules which can “approximate” and implement the Ramsey allocation reasonably well. Overall, the Ramsey policy together with its simple rule approximations seem to deliver consistent policy messages and may constitute some useful normative benchmarks within medium to large scale estimated DSGE framework.

Thereafter, using US data over the Volker-Greenspan sample, we perform a DGSE-VAR estimation of a medium-scale DSGE model very close to Smets and Wouters (2007) specification, where monetary policy is set according to a Ramsey-planner decision problem. Those results are then contrasted with the DSGE-VAR estimation of the same model featuring a Taylor-type interest rate rule. Our results show in particular that the restrictions imposed by the welfare-maximizing Ramsey policy deteriorates the empirical performance with respect to a Taylor rule specification. However, it turns out that, along selected conditional dimensions, and notably for productivity shocks, the Ramsey policy and the estimated Taylor rule deliver similar economic propagation.

Finally, we investigate the impact of Epstein-Zin preferences on the Ramsey approach to monetary policy within a medium-scale model based on Smets and Wouters (2007). After setting an empirical benchmark that generates a mean value of 100 bp for the ten-year term premium, we show that Epstein-Zin preferences significantly affect the macroeconomic outcome when optimal policy is considered. The level and the dynamic pattern of risk premia are also markedly altered. We show that the effect of Epstein-Zin preferences is extremely sensitive to the presence of real rigidities in the form of quasi-kinked demands. We also analyse how this effect can be linked to a combined effect of capital accumulation and wage rigidities.

In the second section, we estimate a two-country dynamic stochastic general equilibrium (DSGE) model for the United States (US) and the euro area (EA). The main features of the new open economy macroeconomics (NOEM) are embodied in our framework: in particular, imperfect exchange rate pass-through and incomplete financial markets internationally. Each country model incorporates the wide range of nominal and real frictions found in the closed-economy literature: staggered price and wage settings, variable capital utilization and fixed costs in production. Then, using the estimated parameters and disturbances, we study the properties of the optimal monetary policy cooperation

through welfare analysis, impulse responses and variance decompositions.

Furthermore, we investigate the optimal resolution of the policy tradeoffs emanating from oil-price disturbances within an estimated two-country model for the euro area. Our simulations show that the inflationary forces related to the use of oil as an intermediate good seem to require specific policy actions in the optimal allocation. However, the direct effects of oil prices should be allowed to exert their mechanical influence on CPI inflation and wage dynamics through the indexation schemes. Through the various expectation channels, economic agents facilitate the necessary adjustments and optimal monetary policy can still tolerate the direct effects of oil price changes on CPI inflation as well as some degree of underlying inflationary pressures in the view of easing partly the burden of downward real wage shifts.

However, once introducing imperfect knowledge by which price and wage setters wrongly doubt about the determination of the central bank to leave unchanged its long-term inflation objective in the face of inflationary shocks, the achievable stabilization outcomes deteriorate significantly. The magnitude of private sector learning has been calibrated to match the volatility of US inflation expectations at long horizons. Given such illustrative calibrations, we find that the costs of maintaining a given inflation volatility under weak credibility could amount to 0.25 pp of output gap standard deviation.

Finally, we estimate a two-country DSGE model for the US and the euro area including relevant housing market features and examine the monetary policy implications of housing-related disturbances. In particular, we derive the optimal monetary policy cooperation consistent with the structural specification of the model. We find that allowing for some degree of monetary policy response to fluctuations in the price of residential goods improves the empirical fit of the model and is consistent with the main features of optimal monetary policy response to housing-related shocks.

## 1. Ramsey approach to optimal monetary policy in the Smets and Wouters model

### Ramsey policy in Smets and Wouters (2003)

*Based on auxiliary paper [e]*

The objective of this paper is to examine the main features of optimal monetary policy within an empirically plausible micro-founded macroeconomic framework for the euro area. This paper contributes to the burgeoning literature related to the theory of monetary stabilization policy which investigates the design of optimal monetary policy and consider how such policy can be implemented.

The closed-economy medium-scale model we use is similar to the one estimated by Smets and Wouters (2003) which accounts relatively well for euro area business cycles. Aside various real and nominal frictions, the theoretical framework features eight structural disturbances driving economic

fluctuations. Three efficient supply shocks are associated with technological progress, investment specific productivity and labor supply. Consumer preference and public expenditure disturbances constitute two efficient demand shocks. Time-varying labor income and firm revenue taxes generate price and wage markup shocks. Finally, we introduce an additional markup fluctuation related to the external finance premium.

The typology of the structural disturbances embodied in the model is first guided by our objective to bring the theoretical model to the data but also reflects the need to analyze the optimal response to both efficient and inefficient, product and labor market shocks. In particular, the estimated residuals obtained from the econometric estimation of the first-order DSGE approximation will be used as structural sources of uncertainty to assess the stabilization properties of optimal policy. The limitations of such approach are twofold. In order to fit a relevant number of data, the range of shocks generally considered in the theoretical literature has to be extended, sometimes in directions which obviously lack sound micro-foundations. At the same time, alternative micro-foundation of disturbances can lead to observationally equivalent first order DSGE approximation. In that case, the estimation strategy will not be able to identify in a decisive manner some source of fluctuations which can have crucially different normative properties. In this paper, we intend to illustrate those points by fully deriving the normative implications of the first-order estimation of the model.

Concerning the computation of the optimal policy, we solve the equilibrium conditions of the Ramsey allocation using second-order approximations to the policy functions. The numerical strategy is based on perturbation methods and is well-suited for our modeling framework, given the large number of state variables. This general method to derive the second-order approximation of the Ramsey solution allow us in principle to depart from some widespread restrictions used in the literature to rely on undistorted non-stochastic steady state. In addition, contrary to the linear-quadratic approach of Benigno and Woodford (2006) which approximates the Ramsey problem by a linear quadratic one, the second-order approximation of the Ramsey allocation performed in this paper allows to depart from certainty equivalence and analyze the effect of policies on the first moment of the state variables. In the paper, since we intend to focus on the macroeconomic stabilization properties of the Ramsey policy in a medium-scale modeling framework, the constraint of efficient steady state is imposed to ex ante avoid creating additional policy tradeoffs due to the inefficient steady state. In doing so we want to concentrate on the implications of the already rich structure of frictions and shocks on optimal policy.

The issue of implementing the Ramsey policy with an interest rate rule is addressed in the following way. First, a fully-fledged derivation of the robust interest rate rule in the sense of Giannoni and Woodford (2003a) is beyond the scope of this paper and would probably prove difficult to interpret given the number of state variable likely to enter the target criteria. Second, we restrict our attention to interest-rate rules which satisfy the following requirements. The interest rate is set as a function of a limited number of economic variables and concepts. We allow the model output gap to

enter the feedback rule since its volatility has a strong impact on the welfare, and it remains a relevant economic concept for the stylized policy analysis pursued in this paper. In addition, the policy rule should induce a determinate equilibrium which satisfies the lower bound on nominal interest rate.

The most closely related paper to our study is Levin et al. (2005) which examined the Ramsey allocation within an estimated DSGE on the US data and explored its implementation with simple rules. We share more specifically the inclusion in the normative analysis of a full set of disturbance processes. Such feature is of importance in our analysis since welfare computations and optimal simple rules that we provide in this paper, crucially depend on the structure of shocks and therefore should be computed with the appropriate exogenous sources of business cycles fluctuations. On this point we differ from Schmitt-Grohe and Uribe (2005) and Schmitt-Grohe and Uribe (2004) which only take into account three shocks.

The original contributions of our paper cover several dimensions. First, we make a special effort to illustrate the empirical properties of the Ramsey allocation for the euro area. Among the properties of the optimal monetary policy, we focus in particular on the driving factors of the Ramsey allocation dynamics compared with the one derived from using the estimated interest rate rule. Obviously we first compare impulse response functions and variance decompositions for the historical rule and the Ramsey policy. This allows us to study the stabilization properties of the optimal policy across the different type of shocks. In addition, using counterfactual experiments based on the historical shocks for the euro area, we investigate the optimal policy reaction to fluctuations observed in the past and analyze the role of the various shocks in explaining the counterfactual dynamics.

A second novelty of our paper is that, unlike Levin et al. (2005), we incorporate the zero lower bound constraint into the analysis. We try to draw conclusions on the likelihood of occurrence of this constraint and more interestingly, on its normative implications. Our results indicate that contrary to what is shown in Schmitt-Grohe and Uribe (2005), the Ramsey policy is not operational in the sense that it induces a high probability to tilt the zero bound. This again points to the importance of taking into account a full set of structural shocks. A more striking result is the negligible welfare cost of imposing the zero lower bound, meaning that even if the volatility of the policy instrument is highly constrained, monetary policy is still effective in improving the welfare of agents.

Third, the paper highlights the need to improve the economic micro-foundation and the econometric identification of the structural disturbances when bringing together estimated models and optimal policy analysis. In particular, we show that efficient labor supply shocks and inefficient wage markup shocks are observationally equivalent from the empirical perspective while they have crucially different implications for optimal policy. The labor supply shocks are indeed fully accommodated in the Ramsey allocation whereas the wage markup shocks are fully allowed to pass-through wage and price dynamics. Therefore, a better understanding of the labor market sources of fluctuation is required.

Finally, we consider the implementation of the Ramsey allocation through simple optimal rules. We show in particular that such optimal rules presents some similarities with the robust optimal rule in the sense of Giannoni and Woodford (2003a) which exactly replicates the Ramsey allocation in a simplified model with price and wage stickiness. Moreover, we computed alternative simple operational interest-rate rule like Schmitt-Grohe and Uribe (2005). Both exercises clearly indicate that such simple rules can relatively well approximate the Ramsey allocation but are crucially sensitive to the structure of economic disturbances. In doing so, we propose a method which only relies on the first order approximation of the model. A traditional approach in the literature concerning the derivation of optimal simple rules, has been to apply a grid search on the parameters of rules which maximise the welfare evaluated on the basis of the second order perturbation of the model. Instead, we directly estimate the parameters of the rule on simulated data generated from the Ramsey allocation, constraining the other behavioral parameters as well as the stochastic properties of the structural shocks to be the same as in the Ramsey model. The estimation strategy is the same as the one used for the direct estimation of the DSGE model. Our method is relatively more tractable than a grid search with more sophisticated interest-rate rules.

## **Evaluating the optimality of historical policy conduct in Smets and Wouters (2007)**

*Based on auxiliary paper [f]*

In this paper, we estimate a DSGE model under welfare-maximizing monetary policy setting and compare its empirical performance with the one implied by more traditional description of historical policy conduct. Using bayesian estimation techniques, Smets and Wouters (2007) in particular have successfully brought to 7 macroeconomic series a closed-economy DSGE model for the US economy which could advantageously compare with vector autoregressions in terms of marginal data density and out-of-sample forecasts. In this model, monetary policy is specified as an interest rate feedback rule. At the same time, computational methods allow to easily derive optimal monetary policy concepts. The Ramsey approach to optimal monetary policy is calculated by formulating an infinite-horizon Lagrangian problem of maximizing the conditional aggregate welfare, subject to the full set of non-linear constraints forming the competitive equilibrium of the model. We solve the equilibrium conditions of the optimal allocation using second-order approximations to the policy function. Examples of Ramsey policy analysis in estimated closed-economy models can be found in Levin et al. (2005) for the US or Adjemian et al. (2007) for the euro area. Finally, a recent literature, led by the seminal work of Del Negro and Schorfheide (2004), has proposed an interesting metric to evaluate the potential misspecifications of DSGE models: the approach uses the DSGE model to shape the prior odds for a Bayesian VAR and provide an identification scheme consistent with the theoretical model. In this set-up, the optimal weight on the DSGE model for the BVAR priors as well as the comparison of impulse responses between the structural BVAR (or DSGE-VAR) and the DSGE constitute key dimensions to assess the validity of economic restrictions implied by the structural model.

Against this background, we perform here a DGSE-VAR estimation on US data of a medium-scale DSGE model very close to Smets and Wouters (2007) specification where monetary policy is set according to a Ramsey planner decision problem. Those results are then contrasted with the DSGE-VAR estimation of the same model with a Taylor rule specification (including terms on lagged inflation, lagged output gap and its first difference), for the latter can be considered *ex ante* as the best-performing structural description of the data generating process.

Primarily, the paper provides a contribution on the estimation of structural models subject to the restriction that policy behaves optimally, in the vein of Salemi (2006), Dennis (2006) or Favero and Rovelli (2003). In contrast to these studies which generally assume that the monetary authority minimizes a specified loss function, our approach explicitly tackles the welfare-maximizing monetary policy. Then, the DSGE-VAR methodology used in this paper enables us to investigate in which direction the model may be misspecified and consequently assess the “distance” between the Ramsey policy and historical monetary policy conduct for certain types of economic disturbances. Such analysis relates to the literature which uses partial information inference from minimum distance techniques, in order to test the similarity of the macroeconomic transmission of technological shocks in particular, between DSGE models embedding welfare-maximizing policy setting and structural VARs. Our approach notably improves upon the existing studies by investigating this issue for a wider set of structural shocks. Finally, by allowing for a ranking of policies based on empirical criteria, we provide a consistent framework to pursue counterfactual analysis and assess the welfare costs of historical policy conduct. Such a counterfactual approach to revealing the social optimality of monetary policy was initiated by the seminal contribution of Rotemberg and Woodford (1997).

Beyond the methodological contribution of the paper, our results applied to US dataset over the Volker-Greenspan period can be summarized as follows. The DSGE-VAR estimations suggest that the Taylor rule specification provides a better description of US time series than the Ramsey model over the last two decades. At the same time, in terms of moments, the Ramsey model performs relatively well. Moreover, the deterioration in empirical performance coming from the restrictions imposed by the welfare-maximizing policy is commensurate to the one obtained by using detrended output instead of the output gap in the Taylor rule.

Then, the comparison of impulse response functions in the DSGE-VAR and the DSGE for the Ramsey and the Taylor rule models brings a conditional perspective on their relative empirical relevance. Interestingly, it turns out that the transmission of a productivity shock is very similar both between the Ramsey and the Taylor rule models, and between each DSGE and its associated DSGE-VAR. This strong result echoes findings from the partial information literature supporting the view that the historical monetary policy response to technological shock has been consistent with the Ramsey policy one. However, the conclusion does not hold for other type of disturbances like consumer preference or price markup shocks for example where the Ramsey policy delivers

propagation mechanisms at odds with the transmission portrayed by its associated DSGE-VAR and the Taylor rule model.

Finally, while the statistical inference supports the Taylor rule model, counterfactual analysis points to relatively modest welfare costs of such a policy compared with the Ramsey allocation. Such results should nonetheless be taken cautiously given the lack of robustness of welfare calculations.

## **Ramsey policy and the term premia in Smets and Wouters (2007)**

*Based on auxiliary paper [g]*

The paper examines the implications of Epstein-Zin preferences for both asset pricing and macroeconomic dynamics when monetary policy maximizes the social welfare under commitment. The quantitative effects of Epstein-Zin preferences are explored within a medium-scale model which embeds a wide range of nominal and real frictions and has proven to be relevant for quantitative business cycle analysis.

The Macro-finance literature aims at studying the interactions between the macroeconomy and the pricing of financial claims (yield curve, equity). A structural approach consists in using DSGE models as a representation of the macroeconomy and then deriving model-consistent non arbitrage constraints so as to price financial assets (see Rudebusch and Swanson, (2008,2009), De Graeve, Emiris and Wouters (2009), Ravenna and Seppala (2006), Doh (2009), Amisano and Tristani (2010)). We can divide the macro-finance literature into three categories. First, numerous papers deal with a purely statistical approach which involves a non-structural representation of the macroeconomy associated with an ad-hoc pricing-kernel (see Ang et al (2006) for example). Second, some models are built on a structural modelling of the economy but keep the specification of the pricing-kernel ad-hoc (see Hordhal et al. (2007)). In spite of the ability of DSGE models to match a satisfactory level of macroeconomic data coherence, their weak performance on the financial side clearly calls for further improvement (see Rudebusch and Swanson, 2008 for example and Tovar, 2008 for a survey). Mainstream structural macroeconomic models generate risk premia that are too small and too little volatile compared with non-structural measures (see Rudebusch, Sack and Swanson (2007) for a survey). As emphasized by Cochrane (2007) and Rudebusch and Swanson (2008), asset pricing and macroeconomic behaviours are inextricably linked so that unsatisfactory implications of standard DSGE frameworks for the financial side may reveal crucial misspecifications.

In order to cope with the need to obtain both macroeconomic and financial coherence, papers by Andreasen (2009), Rudebusch and Swanson (2009), Guvenen (2009), Amisano and Tristani (2010) -- among others -- have made use of non time-separable preferences, namely Epstein-Zin preferences, in the structural specification of agents' utility, within New Keynesian frameworks. As explicitly shown by Swanson (2010), Epstein-Zin preferences provide an additional degree of freedom that allows to increase risk aversion and hence generate substantial time-varying risk premia. In this respect,



Rudebusch and Swanson (2009) augment a baseline New Keynesian model with such preferences and are then able to match both macroeconomic and financial moments, including a 106 basis points term premium average for the U.S. ten-year nominal bond. Likewise, Andreasen (2009) provides a joint quadratic estimation of a DSGE macro-model including Epstein-Zin preferences along with a consistent derivation of the yield curve. Epstein-Zin preferences help him generate a mean value of 69 basis points for the term premium. In both papers, the same conclusion holds: Epstein-Zin preferences are a key component to make the link between the macroeconomy and the financial side, as they improve the fit with financial data without significantly deteriorating the already well fitted macroeconomic dynamic. Such appealing features certainly hold for structural modelling frameworks where monetary policy is set according to Taylor-type rule or seeks to minimize an ad hoc loss function under commitment. However, Epstein-Zin preferences may have significant quantitative implications for both asset pricing and macroeconomic allocation under a welfare-based monetary policy conduct. As explored by Levin et al (2008), models relying on Epstein-Zin preferences may yield some microeconomic dissonance: to a first order approximation, the underlying microeconomic difference in the agents' preferences may affect the macroeconomic allocations under Ramsey policy. Therefore, if Epstein-Zin preferences are to become broadly used within DSGE models -- for example, recent papers like Binsbergen et al. (2008), Caldara et al. (2009) provide a methodology to solve and estimate DSGE with non-standard preferences -- an analysis of the non-linear properties through their impact on the welfare and the optimal policy is a relevant research avenue.

Against this background, our paper aims to shed light on the influence of Epstein-Zin preferences on asset pricing and optimal monetary policy within a calibrated medium-scale DSGE model based on Smets and Wouters (2007) and De Graeve et al. (2009). Our study is therefore related to diverse areas of economic research to which we make several contributions. First, our paper contributes to the empirical literature dedicated to the analysis of the implications of macroeconomic models on asset pricing, and especially on the evaluation of the term premium. Our methodology regarding the analysis of the term premium is close to that of Rudebusch, Sack and Swanson (2007), Rudebusch and Swanson (2008, 2009), De Graeve et al. (2009b) and to the second approach presented in Rudebusch (2010). In order to get non-zero term premia, we use sufficiently high order approximation to a model which juxtaposes the macroeconomic dynamic and a consistent derivation of the yield curve. Unlike Jerman (1998), Wu (2006), De Graeve et al. (2009a), Doh (2009), Andreasen (2009) or Amisano and Tristani (2010), this approach does not rely on additional assumptions such as stochastic volatility or the joint-lognormality of pricing kernels and bond prices. We contribute to this literature by using a much richer baseline model than that of Rudebusch and Swanson (2009). We show how a fully specified model like Smets and Wouters (2007) can also be augmented with Epstein-Zin preferences so as to generate a ten-year term premium of 100 bp on average. In doing so, we follow up the approach of De Graeve et al. (2009a) who claim that medium-scale DSGE models can describe bond yield dynamics in a satisfactory manner. We also analyse how our calibration of the Epstein-Zin parameter ( $\rho$ ) crucially depends on the intertemporal elasticity of substitution and the deterministic discount

factor associated with detrended variables. This helps us explain the wide dispersion of values found in the empirical literature.

Second, our paper is linked to the literature analysing the optimal monetary policy within DSGE models. Specifically we focus on the link between Epstein-Zin preferences and optimal policy. To our knowledge only Levin et al. (2008) attempt to assess the influence of Epstein-Zin preferences on optimal macroeconomic allocations. They consider a small stylised New Keynesian model with one shock and they explicitly show that Epstein-Zin preferences enter the first-order approximation of the Ramsey policymaker's first order conditions. Instead, we derive the optimal policy in a medium-scale model including Epstein-Zin preferences. Compared with Levin et al. (2008), we add many specifications that have proven to be empirically relevant: several structural shocks, endogenous capital accumulation with adjustment costs on investment and variable capital utilisation, wage rigidities and real frictions. This improvement of the model constitutes an important contribution of our paper since no analytical characterisation of the optimal policy with Epstein-Zin preferences has been so far established.

In line with the conclusions of Levin et al. (2008), we provide numerical evidence that in general Epstein-Zin preferences have a substantial impact on the first order dynamic of the macroeconomic outcome under optimal monetary policy. In other words, Epstein-Zin preferences strongly affect the tradeoffs faced by the optimizing policymaker. Our analysis allows to highlight two features. First, the effect of Epstein-Zin preferences is strongly affected by the presence of quasi-kinked demands. Our paper is therefore related to the analysis of strategic complementarities -- quasi-kinked demands or firm-specific factors -- and their implications for monetary policy and welfare as conducted by Levin et al. (2007, 2008). Considering relatively small New Keynesian models, they prove that the specific form of strategic complementarities has crucial consequences on the optimal policy. Here we focus on the quasi-kinked demands assumed by Smets and Wouters (2007). As a first attempt to study strategic complementarities in an Epstein-Zin world, we show that, in our empirical benchmark, the effect of Epstein-Zin preferences on the transmission of the optimal monetary policy is extremely sensitive to this form of real rigidities. This underscores that the implications of strategic complementarities for the design of monetary policy are even more crucial in an Epstein-Zin world. Second, we investigate the role of capital accumulation and nominal rigidities. We show that, in a world with Dixit Stiglitz aggregators, with price rigidities only, the deviation from price stability is amplified by Epstein-Zin preferences, be it with capital or not. Adding wage rigidities tend to reduce this amplification. Finally, unlike both the traditional macro-finance approach and the literature on optimal policy, another novelty of our paper consists in analysing of the behaviour of the term premium under optimal monetary policy. We find that the effect of Epstein-Zin preferences on the level and the dynamics of the term premium is much stronger under optimal policy and is qualitatively different from the Taylor rule case: the term premium is a non-linear function of the Epstein-Zin parameter and we show how it is substantially shifted up in presence of quasi-kinked demands.

## 2. Open economy extensions

### Optimal monetary policy cooperation in a two-country DSGE estimated for the US and the euro area

*Based on auxiliary paper, [h], [i]*

The main objective of this paper is to analyze the design of optimal monetary cooperation between the US and the euro area, using an estimated two-country DSGE framework. In doing so, we intend to bring together the literature on optimal policy in estimated closed-economy models (like Levin et al. (2005) for the US or Adjemian et al. (2007) for the euro area) and papers estimating two-country models (like De Walque et al. (2005), Rabanal and Tuesta (2006), Bergin (2006) or Adolfson et al. (2005)). The focus of our study will then be on the implications of optimal policy for international business cycle properties.

Following the closed-economy work of Smets and Wouters [2003] the model embodies a larger range of frictions and shocks that improve the model's ability to capture the time series properties of the main macro-economic data. In addition, we use an explicit two country US-euro area framework that allows for estimating and testing structural differences across the two areas. In contrast to the small open economy specification of Adolfson et al. (2005), it also allows for two-way economic and financial interaction between the two areas.

The model shares many features common in open-economy DSGE models. Exchange rate pass-through is incomplete due to some nominal rigidity in the buyer's currency. The specification is flexible enough to let the data discriminate between the polar cases of local-currency-pricing (LCP) and producer-currency-pricing (PCP). Financial markets are incomplete internationally and a risk premium on external borrowing is related to the net foreign asset position. Finally, even under flexible prices and wages, purchasing power parity does not hold due to a home bias in aggregate domestic demand. As in Christiano et al. (2005) we introduce a number of nominal and real frictions such as sticky prices, sticky wages, variable capital utilization costs and habit persistence. In addition, following Smets and Wouters (2003) a large set of structural shocks enters the model. The open economy dimension also requires additional disturbances. We add a shock to the uncovered interest rate parity condition (UIP) as it is usually done in the open economy literature, a preference shock on the relative home bias and two shocks to the distribution sector markups (affecting the CPI equations).

Obviously, the use of a two-country framework implies that the rest of the world is ignored. An alternative approach, pursued for example by De Walque et al. (2005), is to include a rest-of-the-world block which is designed to explicitly capture the role of third-market effects in the interaction between the euro area and the US. Such a rest-of-the-world block can also be used as a source of common shocks such as oil price shocks. Second, for comparison purposes, we tried to stick as closely as

possible to the modelling framework of Smets and Wouters (2003), while at the same time introducing the most important New Open Economics Macroeconomics (NOEM) features. Of course, a number of important open economy features were not included such as the slow adjustment of import and export shares following expenditure switching shocks or the fact that import shares of different aggregate demand components may differ. As a result, given the relatively simple trade structure underlying our model, we did not explicitly include bilateral export and import quantities and prices in our set of macro variables to be used in the estimation. Empirically, the transmission channels of the various shocks that work through trade quantities and prices will be captured in a reduced form by their effects on relative aggregate demand, consumer versus producer prices and the current account. But a clear advantage of such a parsimonious specification of international frictions will be gained in the analysis of optimal monetary policy cooperation as it will become easier to understand the role of the few key parameters driving those international features on the design of optimal policy.

Concerning optimal policy, the Ramsey approach to optimal monetary policy cooperation is computed by formulating an infinite-horizon Lagrangian problem of maximizing the conditional aggregate welfare of both countries subject to the full set of non-linear constraints forming the competitive equilibrium of the model. We solve the equilibrium conditions of the optimal allocation using second-order approximations to the policy function. The numerical strategy is based on perturbation methods and is well-suited for our modeling framework, given the large number of state variables. This general method to derive the second-order approximation of the Ramsey solution allows us to depart from some widespread restrictions used in the literature to rely on undistorted non-stochastic steady state. In addition, contrary to the linear-quadratic approach of Benigno and Woodford (2006) which approximates the Ramsey problem by a linear quadratic one, the second-order approximation of the optimal allocation performed in this paper enables us in principle to depart from the certainty equivalence and analyze the effect of policies on the first moment of the state variables. In the paper, since we intend to focus on the macroeconomic stabilization properties of the optimal policy within a relatively sophisticated modeling framework, the constraint of efficient steady state is imposed to ex ante avoid creating additional policy tradeoffs due to the inefficient steady state and concentrate on the implications of the already rich structure of frictions and shocks on optimal monetary policy cooperation.

The original contributions of the paper, cover several dimensions. First, as in Adjemian et al. (2007), we incorporate the zero lower bound constraint into the analysis. In this respect, the optimal monetary policy cooperation is not operational given that it generates a high probability to tilt the zero bound. This result is of course related to the fact that we use an estimated two-country DSGE incorporating a full set of structural shocks. However, it turns out that, accounting for the zero lower bound has a marginal impact on welfare cost and on the stabilization properties of the optimal policy. In particular, when constraining the volatility of the policy instrument in the optimal allocation, only the second-order moment of the nominal exchange rate is affected.

Second, we make a special effort to illustrate the empirical properties of the optimal allocation for the US and the euro area, focusing on the driving factors of the Ramsey allocation dynamics compared with the one derived from using the estimated interest rate rules. We first compare some selected moments under the different policy regimes. Then we explore the structural decomposition of those moments and complement the analysis by looking at impulse response functions. This allows us to study the stabilization properties of the optimal policy across the different type of shocks.

Our conclusions on the business cycle properties of the optimal monetary policy cooperation are twofold. First of all, we confirm most of the results obtained in the closed-economy literature based on estimated medium-scale DGSE. The volatility in the optimal allocation is higher for real aggregates but lower for nominal variables than in the estimated model. The optimal policy is increasing the impact of supply shocks on activity while limiting the role of demand disturbances. On inflation, optimal stabilization only allows the markup shocks to generate fluctuations. Compared with the estimated Taylor rules, the optimal monetary policy cooperation features strong differences as regards the reaction to labor market shocks.

Moreover, concerning international business cycle dynamics, we show that the optimal policy significantly reduces the size of international spillovers on economic activity. More specifically, cross-country output correlation as well as the contribution of foreign shocks to domestic output fluctuations are much lower in the optimal allocation than in the estimated model: notably, the positive transmission on output of demand shocks is more limited or short-lived with the optimal policy whereas the negative transmission of labor market shocks is much stronger at short horizons.

In addition, while under the estimated rules, the conditional correlation between relative consumption and the real exchange rate is negative at all horizons (therefore accounting for the consumption-real exchange rate anomaly), the covariance is first positive and turns negative beyond the 5-year horizon in the optimal allocation. This is partly due to a less negative contribution of the home bias shock and more positive contributions of labor market shocks at horizons below three years under the optimal monetary policy cooperation. Regarding exchange rate dynamics, volatility is higher in the optimal allocation despite the constraints introduced to limit the standard deviations of policy instruments. This reflects notably a more pronounced overshooting pattern of nominal exchange rate after labor market and preference shocks.

A final dimension of the paper also investigates whether some properties of optimal monetary policy cooperation found in some theoretical contributions (see for example Darracq Pariès (2007) or Benigno and Benigno (2006)) can be extended to more general modeling framework.

## Optimal stabilisation of inefficient supply-side disturbances

*Based auxiliary paper [j] and featured paper [4]*

The main objective of this paper is to explore the monetary policy prescriptions from optimal policy conduct in a DSGE framework which provides satisfying data coherence for the euro area. An abundant literature has examined the macroeconomic implications of oil price fluctuations from both an empirical as well as structural perspective. Somewhat related to our work, Blanchard and Galí (2007) notably provided monetary policy considerations regarding the appropriate stabilization of oil price shocks. For the euro area, Jacquinot et al. (2009) developed a calibrated large scale DSGE model with a special focus on the energy sector while De Fiore and Lombardo (2008) explore the gains from international monetary policy cooperation in response to oil-price disturbances.

The core foundations of the present model are inherited from Adjemian et al. (2008) who brought to data a two-country DSGE model for the US and the euro area. The model shares many features common in open-economy DSGE models. Notably, exchange rate pass-through is incomplete due to some partial nominal rigidity in the buyer's currency. We also introduce a number of nominal and real frictions such as sticky prices, sticky wages, variable capital utilization costs and habit persistence, following the seminal contribution from Smets and Wouters (2003). Regarding the inclusion of oil, four main channels have been identified: oil is serving final consumption; it is also used as an intermediate input in domestic firms' production; we allow for a mechanical real income effect of oil price changes through rule-of-thumb consumers, which spend a fixed proportion of their real income each period; finally, we account for the "recycling" of oil revenues into euro area and rest-of-the-world (ROW) exports through the introduction of a reduced-form oil-producing block. Obviously, the description of the oil-market functioning used in this paper is very stylized. However, the simplifying assumptions should not significantly affect the main results of the paper regarding the optimal design of monetary policy in the face of exogenous oil-supply shocks.

Concerning optimal policy, the Ramsey approach to optimal monetary policy cooperation is computed by formulating an infinite-horizon Lagrangian problem of maximizing the conditional aggregate welfare of both countries subject to the full set of non-linear constraints forming the competitive equilibrium of the model. We solve the equilibrium conditions of the optimal allocation using second-order approximations to the policy function. We consider two concepts of optimal policy: one is the fully optimal monetary policy cooperation; the other consists in maximizing euro area welfare conditional on monetary policy in the ROW following the estimated Taylor rule. We thereby put into perspective the optimal international monetary policy cooperation with an optimal policy from an euro area perspective, treating the ROW block as a reduced-form one.

The original contributions of the paper cover several dimensions. First, we provide some evidence on the macroeconomic transmission of oil price shocks to the euro area within an open-economy structural modeling framework featuring rational expectations. The estimated model points to implications of oil price shocks for economic activity which are on the lower bound of available

estimates, mostly based on empirical agnostic models. We provide evidence that the rational expectations and perfect central bank credibility assumptions may explain such more moderate propagation to real variables. In terms of structural inference, we estimate the share of rule-of-thumb consumers for the euro area to be around 20%. While estimated shares of oil absorption in the economy are reasonable, the elasticities of substitution of oil as input in final consumption and aggregate production prove to be weakly identified with the macroeconomic dataset used.

Second, we compare the stabilization properties of the estimated rules to the ones implied by optimal monetary policy conduct. Under both policy regimes, the direct effects of oil prices should be allowed to exert their mechanical influence on CPI inflation and wage dynamics through the indexation schemes. However, the optimal monetary policy would call for a more pronounced contraction of economic activity in order to mitigate significantly the indirect inflationary pressures at the producer level, notably through weaker wage responses. In addition, the optimal cooperation would activate a stronger exchange rate channel to ease the cost pressures generated by oil-price increases. We also illustrate that any fine-tuning strategy which attempts to counteract the direct effects of oil-price changes in headline inflation would prove counterproductive both in terms of stabilization of underlying inflation and by factoring unnecessary volatility in the macroeconomic landscape. Finally, we explore the optimal policy response to an expected oil-price surge. It appears that perfect foresight on future oil price developments leads to a more rapid absorption of the steady state decline in purchasing power and real national income.

The previous analysis has studied monetary policy stabilization under rational expectations and perfect central bank credibility. In this context, a monetary authority committed to deliver price stability can successfully steer expectations in the face of inflationary disturbances and achieve appropriate inflation volatility at reasonable output costs. However, a less extreme description of the macroeconomic landscape would have to account for imperfect credibility of the central bank: credibility is an asset which is built and preserved over time, and could for example be undermined by an adverse sequence of inflationary shocks which, taken individually, would not have required specific policy actions.

We intend to illustrate such a configuration within a medium-scale DSGE model for the US economy where price and wage setters question the determination of the monetary authority to deliver price stability in the face of cost-push shocks. More specifically, we specify an ad hoc filtering problem where price and wage setters do not observe the central bank's inflation target and the "true" inflationary shock separately.

This phenomenon would strongly amplify the transmission of the price shock, notably through stronger wage claims: monetary policy will face a higher sacrifice ratio in its attempt to bring down inflation volatility. The deterioration of achievable stabilization outcomes due to our imperfect credibility specification has some resemblance with the implications of backward indexation in price and wage settings.

## Optimal monetary policy and house price fluctuations in a two-country DSGE estimated for the US and the euro area

*Based auxiliary paper [k]*

This paper aims at analyzing the importance of housing markets and household credit frictions on monetary policy conduct within an open-economy framework. In doing so, our contribution intends to bridge a gap between the growing strand of literature focusing on credit frictions in closed economies characterized by the presence of nominal rigidities (see Iacoviello (2005), Iacoviello and Neri (2007) and Monacelli (2006) among others), and the existing estimated New Open Economy Macroeconomics models (see Adjemian et al. (2008), Adolfson et al. (2005), De Walque et al. (2005), and Rabanal and Tuesta (2006)). We estimate a two-country DSGE model for the US and the euro area including relevant housing market features and examine the monetary policy implications of housing-related disturbances.

The macroeconomic literature has recently shown a particular interest in understanding the role played by credit market frictions faced by households in determining business cycle dynamics. More specifically, the conduct of monetary policy in the presence of such frictions has attracted a special attention. A common feature across the existing theoretical frameworks is the influence of housing collateral on households consumption decisions. The empirical evidence suggests the existence of a fraction of consumers in the economy who face binding collateral constraints when approaching loans and mortgage markets. As a result, institutional arrangements in such markets, as well as different housing market structures can potentially affect households' home-purchasing and consumption decisions in a significant way. Most of the existing literature has been focusing on a closed-economy setup, thus abstracting from international factors and cross-country spillovers (an exception being Christensen et al. (2007) who estimate a small open economy model for Canada).

In modeling the closed economy setup, we follow a recent strand of literature which - like Kiyotaki and Moore (1997) - considers a dual structure on the household side, with agents belonging to two different groups according to their intertemporal discount factor. Households' heterogeneity generates equilibrium debt as the result of intertemporal borrowing between more and less impatient agents. Building on Iacoviello and Neri (2007), we define a two-agent, two-sector economy for each country, where the impatient agents face collateral requirements when asking for mortgages or loans. Firms produce nondurable consumption goods (which can be traded internationally) and residential goods (which are considered non-tradable). The latter serve two purposes: they can be directly consumed, thus providing utility services as any durable good, or they can be used as collateral in the credit market, to obtain extra funds for financing consumption. The role of collateral constraints in closed economies has been estimated in DSGE models by Iacoviello and Neri (2007), who report the relevance of housing market shocks in shaping consumption dynamics in the US. We focus here on the role of housing market factors and credit frictions in explaining both closed and open-economy fluctuations. In particular, we estimate structural parameters such as the relative share of borrowers in the two economies, and we show how they affect the transmission mechanism of housing market



and monetary policy shocks both domestically and internationally.

The use of an explicit two-country setup allows for estimating and testing for the existence of structural differences across the two continental economies. On the open-economy side, we introduce most of the common features of estimated open-economy DSGE models, following closely Adjémian, Darracq and Smets (2008). In particular, we assume that financial markets are incomplete internationally. However, we do not allow for international trade of private debt, so that the borrowers can only access domestic credit markets; the savers can instead trade two nominal risk-less bonds denominated in the domestic and foreign currency respectively. The model is estimated on US and euro area quarterly data, over the period 1981 I: 2005 IV, by making use of full-information Bayesian techniques.

Moreover, in order to put into perspective the monetary policy response to economic disturbances originating in the housing sector, we derive the optimal monetary policy cooperation consistent with the structural specification of the model. As in Adjémian, Darracq and Smets (2008), the Ramsey approach to optimal monetary policy cooperation is computed by formulating an infinite-horizon Lagrangian problem of maximizing the conditional aggregate welfare of both countries subject to the full set of non-linear constraints forming the competitive equilibrium of the model. We solve the equilibrium conditions of the optimal allocation using second-order approximations to the policy function. In this paper, we restrict our analysis to the assessment of the optimal policy tolerance for relative house price fluctuations. We do not intend to explore systematically all the factors which shape optimal policy in our modeling framework. Such an exercise would go beyond the scope of the present contribution and is left for further research. Instead, we consider the optimal monetary policy response to housing-related shocks which, under standard Taylor rules, generate strong relative house price changes and ample asymmetry between savers' and borrowers' reactions.

The main contributions of the paper cover several dimensions. First, our results reinforce the existing evidence on the role of housing and mortgage markets for the US and provide new evidence on the importance of the collateral channel in the euro area. In particular, we estimate different versions of the model, considering high or low shares of borrowers in the economy. Our results suggest notably that the share of impatient households is higher in the US than in the euro area. We also find that the estimated shares of borrowers are quite sensitive to the specification of a priori distributions, which ultimately should be set based on appropriate economic grounds.

Second, in terms of economic propagation of non-housing related shocks, the presence of credit frictions alters significantly the relative responses of aggregate consumption and non-residential investment. Moreover, we find that structural housing-related shocks have significant spillovers on non-residential consumption through the collateral channel and the share of borrowers in the economy. Nonetheless, the residential sector is somewhat unaffected by shifts in the share of borrowers due to its dual nature of flexible-price, non-traded goods producing sector. In terms of international spillovers, the transmission of housing preference shocks on economic activity is found to

be relatively limited and lower than in the case of demand shocks affecting the tradable sector. Finally, housing shocks play a key role in generating negative comovement across countries for both real housing prices and residential investment.

Third, we find that allowing for a monetary policy response to house prices improves the empirical fit of the model, and paves the way for a deeper analysis of optimal monetary policy cooperation in the proposed framework. From a normative perspective, some degree of monetary policy reaction to fluctuations in the price of residential goods is consistent with the main features of optimal monetary policy response to housing-related shocks. Based on welfare computations when only housing shocks are allowed, the estimated Taylor rule augmented with real housing prices turns out to be welfare-improving compared with the benchmark case, in particular for the US economy. Beyond this, the optimal allocation suggests that the heterogeneous responses across households and the associated welfare losses in terms of imperfect risk sharing should be counteracted, even at the cost of short term inflation volatility. Compared with the estimated rules, our results indicate noticeably that the optimal international transmission of positive housing-related shocks leads to a more pronounced monetary policy tightening in the foreign country and to a negative adjustment of housing prices and quantities as well as domestic demand for non-residential goods.

## Chapter 4 Non-standard monetary policy measures: transmission channels and strategic design

In the aftermath of the outbreak of the global financial crisis in 2007-2008 and the recent prolonged period of low inflation, while short-term policy rates have been close to their effective lower bound, several central banks adopted a number of non-standard measures in an attempt to reignite economic activity. With the aim of reigniting inflation in the euro area, in early 2015 the ECB embarked on a large-scale asset purchase programme. This chapter intend to shed some light on non-standard monetary policy measures through the lens of estimated DSGE models for the euro area, exploring both positive and normative perspectives.

In first essay of this chapter, we analyse the macroeconomic effects of the Asset Purchase Programme via the banking system, exploiting the cross-section of individual bank portfolio decisions. For this purpose, a DSGE model featuring a segmented banking sector, is estimated for the euro area and combined with a bank portfolio optimisation approach using granular bank level data. An important feature of our modelling approach is that it captures the heterogeneity of banks' responses to yield curve shocks, due to individual banks' balance sheet structure, different capital and liquidity constraints as well as different credit and market risk characteristics. The deep parameters of the DSGE model which control the transmission channel of central bank asset purchases are then adjusted to reproduce the easing of lending conditions consistent with the bank-level portfolio optimisation. Our macroeconomic simulations suggest that such unconventional policies have the potential to strongly support the growth momentum in the euro area and significantly lift inflation prospects. The paper also illustrates that the benefits of the measure crucially hinge on banks' ability and incentives to ease their lending conditions, which can vary significantly across jurisdictions and segments of the banking system.

In the second essay, we study the optimal conduct of central bank government bond purchases within the same estimated DSGE model for the euro area. In the model, central bank asset purchases are relevant in so far as agency costs distort banks asset allocation between loans and bonds, and households face transaction costs when trading government bonds. Such frictions in the banking sector induce inefficient time-variation in the term premia and open up for a credit channel of central bank government bond purchases. Considering first ad hoc asset purchase programmes like the one implemented by the ECB, we show that their macroeconomic multipliers are stronger as the lower bound on the policy rate becomes binding and when the purchasing path is fully communicated and anticipated by economic agents. From a more normative standpoint, interest rate policy and asset purchases feature strong strategic complementarities during both normal and crisis times. In a lower bound environment, optimal policy conduct features long lower bound periods and activist asset purchase policy. Our results also point to a clear sequencing of the exit strategy, stopping first the asset purchases and later on, lifting off the policy rate. In terms of macroeconomic stabilisation,

optimal asset purchase strategies bring sizeable benefits and have the potential to largely offset the costs of the lower bound on the policy rate.

In the third essay, we introduce a six-region multi-country DSGE model which can provide a framework for analysing the country-specific macroeconomic transmissions of non-standard measures, focusing mostly on the bank credit and the exchange rate channels and the cross-border spillovers emerging via trade and financial linkages. The importance of the macroeconomic environment is stressed through simulations that independently, firstly assume that deposit interest rates have reached their effective lower bound, and secondly assume global portfolio frictions through which the rest of world is able to trade euro area government bonds, opening up further the exchange rate channel of purchases. In the end, it performs a policy evaluation of two of the legs of the euro area APP, the Public sector purchase programme and the second series of the targeted longer-term refinancing operations.

## Literature review

There are several transmission channels through which asset purchase programmes may affect the economy, such as direct effects on the price of assets in the targeted market segment (see e.g. Meaning and Zhu (2011), Hamilton and Wu (2011), D'Amico and King (2013), D'Amico et al. (2012) and Hancock and Passmore (2011)), changes in expectations due to the signalling effect of the programmes (see inter alia Krishnamurthy and Vissing-Jorgensen (2011), Gagnon et al. (2011), Swanson (2011), Wright (2011), Gilchrist and Zakrajsek (2013) and Joyce et al. (2011b)) and the more indirect effects they may have on the portfolio behaviour of banks and other financial institutions. On the latter effect, while some studies have examined the effect of purchase programmes on bank profitability (see e.g. Lambert and Ueda (2014) and Montecino and Epstein (2014)) they have been inconclusive as to the “second-round” effect on credit supply and real economic activity which ultimately hinges upon how purchase programmes may affect banks’ behaviour. Studies which focus on central bank asset purchases through the household portfolio rebalancing channel include Burlon et al. (2015) and Cova et al. (2015), with the latter allowing for holdings of international government bonds across countries.

A number of mainly US and UK-based studies have attempted to quantify the macroeconomic implications of central bank asset purchase programmes using either VAR-type models or DSGE models, with overall rather wide-ranging outcomes in terms of the effects on output and prices but mostly suggesting that the asset purchase programmes have been effective in supporting economic growth. For instance, “US-based studies” include Chung et al. (2012), Fuhrer and Olivei (2011), Negro et al. (2011), Chen et al. (2012), Gertler and Karadi (2013), while “UK-based studies” include Joyce et al. (2011a), Goodhart and Ashworth (2012), Kapetanios et al. (2012), Bridges and Thomas (2012) and Pesaran and Smith (2012). For the euro area experiences, a few early studies include Lenza et al. (2010), Peersman (2011) and Altavilla et al. (2014). See also Martin and Milas (2012) for a survey. While many of these studies take a broad-based view of the impact of unconventional monetary

policies including signalling, confidence and exchange rate effects, in this paper we take a somewhat narrower approach focusing on the bank credit channel via the portfolio rebalancing that central bank asset purchases may induce banks to undertake.

A small but emerging strand of the literature analyses banks' portfolio choices in macro models, such as Adrian and Shin (2010), Gertler et al. (2012), Aoki and Sudo (2012), Aoki and Sudo (2013), He and Krishnamyrthu (2013), Adrian and Boyarchenko (2013a), Adrian and Boyarchenko (2013b), Benes et al. (2014a) and Benes et al. (2014b). In line with the risk management literature (see for example Adam (2008)), Halaj (2015) capture banks' heterogeneous responses in a partial equilibrium setting, using a multi-period model of a bank maximising its risk-adjusted return on capital given liquidity and solvency constraints.

Turning to normative prescription, the debate on monetary policy frameworks has been intensified through the crisis. At the beginning of this discussion, Eggertsson and Woodford (2003) dismissed the usefulness of "pure" quantitative easing policies (i.e. policies aiming at replacing short-term assets with excess reserves) at the lower bound of interest rates provided that some appropriate form of forward guidance was implemented. Later on, Curdia and Woodford (2011) revisited the potential benefits of targeted asset purchases, to the extent that the financial system was significantly disrupted and the unconventional policies could deliver adequate credit easing. Ellison and Tischbirek (2014) or Jones and Kulish (2013) then provide arguments for using an active asset purchase strategy as an additional instrument in normal times and when the policy rate hits the effective lower bound. Optimal policy concepts similar to Eggertsson and Woodford (2003) can be extended to derive a path for government bond purchases. Optimal paths for government bonds and the short rate are constructed under commitment (similar to Adam and Billi (2006)).

## 1. The credit channel of central bank asset purchases

*Based auxiliary paper [1]*

In the aftermath of the global financial crisis, central banks have embarked on various forms of unconventional monetary policies to help reignite economic activity. One of the key instruments of this unconventional policy toolkit has been asset purchase (or quantitative easing) programmes, such as the Large-Scale Asset Purchase programmes of the US Federal Reserve, the Asset Purchase Facilities of the Bank of England and more recently the ECB's Asset Purchase Programme (henceforth APP).

There are several transmission channels through which central bank asset purchase programmes may affect the economy, such as direct effects on the asset price dynamics in the targeted market segments, changes in expectations due to the signalling effect of the programmes and more indirect effects they may have on the portfolio behaviour of banks and other financial institutions. On the latter, while some studies have examined the effect of purchase programmes on bank profitability,

they have been inconclusive regarding potential “second-round” effects on credit supply and real economic activity which ultimately hinges upon bank portfolio allocation behaviour.

There are three main transmission channels through which a central bank asset purchase programme would affect bank balance sheets and ultimately the bank credit channel: (i) valuation effects on bank capital, (ii) income effects via a pass-through to funding costs and (iii) portfolio rebalancing effects as securities holdings become less attractive compared to other assets (e.g. loans). In terms of banks' credit supply responses to these three effects, we here focus on the price channel via effects on lending rates (as compared to quantity effects).

Against this background, we argue in this paper that the financial propagation of the APP crucially depends on banks' incentives to rebalance their asset structure towards lending activity and the impact on their lending conditions, notably through lower lending margins. Following the sovereign yield compression that can be expected from the APP, banks can benefit from capital relief via positive valuation effects on their bond portfolios and lower funding costs. Besides, lower yields on new bond purchases would decrease the relative profitability of bond portfolios and therefore, encourage banks to expand lending and offer reduced lending margins. In order to quantify these effects for the euro area banking sector and ultimately for the economy at large, a portfolio optimisation model with heterogeneous banks is used to calibrate an APP counterfactual scenario in a medium-scale DSGE model with financial frictions.

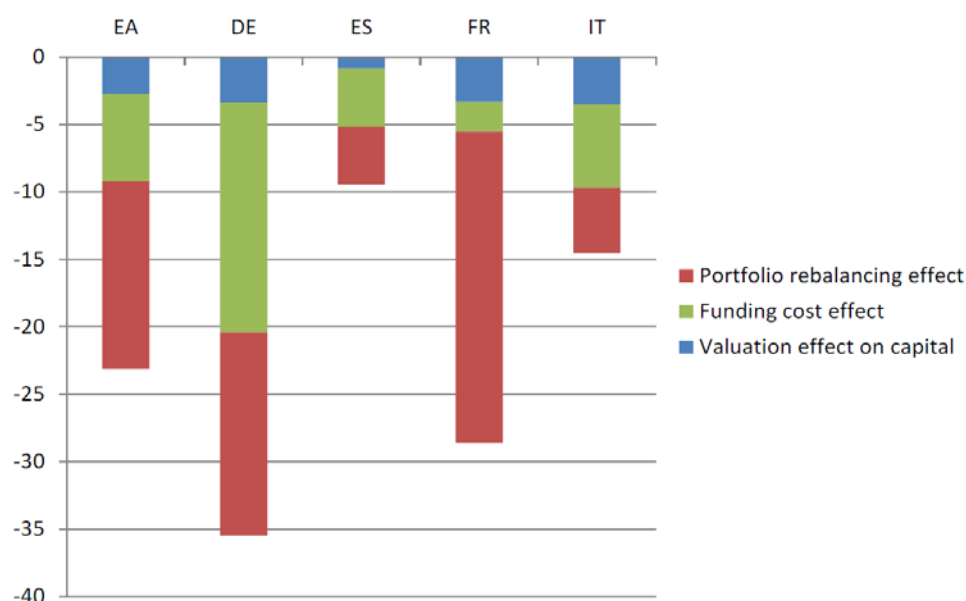
#### *Credit channel of APP in partial equilibrium*

In order to capture banks' heterogeneous responses in a partial equilibrium setting, we use a multi-period model of a bank maximising its risk-adjusted return on capital given liquidity and solvency constraints: banks are described as constrained portfolio managers maximising risk-adjusted returns (from loans and securities and taking into account funding costs) on capital subject to capital and liquidity constraints. The asset side of bank balance sheets consists of loans paying interest and subject to credit risk and securities characterized by the expected return and volatility parameters. On the liability side, two sources of funding are considered: customer and wholesale deposits paying fixed interest and subject to outflow (roll-over) risk and capital. The model reflects the regulatory risk constraint imposed on banks as well as the internal model-based risk limits: i) regulatory constraint on the minimum capital ratio (RWA/Capital); ii) Value-at-Risk: capital has to cover losses in 99% of the distribution of losses; iii) Liquidity-at-Risk: liquidity buffer (securities after haircut) has to cover 99% of funding outflows. Banks' objective is to optimise the risk-adjusted return on capital, aggregated within the horizon of the optimisation, by choosing the lending volume and the purchase of securities, taking the risk-return profile of exposures as given.

The bank portfolio decision model can indirectly provide the partial equilibrium lending supply reaction of individual banks following the sovereign yield compression due to the APP. The approach taken to quantify the adjustment of bank lending policies to customers consists in finding the bank-

specific lending rate spread decline that would stabilize banks market shares to the levels preceding the APP impact sovereign yields. The pass-through of sovereign yield declines to lending rate spreads is computed in two steps. First the APP related yield compression affects the capital position of banks, their funding costs and the yield on new bond purchases, which condition the optimal structure of bank balance sheets via three channels: i) a valuation effect on capital, ii) a funding cost effect and iii) a portfolio rebalancing effect. Second, we simulate for each bank in our sample the impact of the three factors mentioned above on their portfolio decisions and numerically search for the changes in lending spreads which stabilise the loan market share to its pre-APP shock level.

**Chart 4.1** – Decomposition of the factors behind the lending rate response to 50 bps (annual rate, in basis points)



Illustrating the importance of bank heterogeneity at the country aggregate level, Chart 4.1 shows the simulated pass-through of a uniform -50 bps shock to sovereign yields to lending rate spreads for the largest four euro area member states and decomposing the lending rate response into the three channels mentioned previously. As expected, the consequences of the APP-related sovereign yield compression would give significant scope for banks to compress their lending rate margins, although with notable differences across banks in the four countries. Overall, the impact of a 50 bps negative shock to sovereign bond yields has the strongest aggregate impact on the lending rates of German and French banks which are reduced by around 35 bps and 29 bps, respectively. By comparison, the lending rate declines for Spain and Italy are below 10 bps and 15 bps respectively. A first factor behind these responses is the stronger portfolio rebalancing effect for banks in France and to a lesser extent, in Germany. Turning now to the role of the funding cost channel, the funding shock has a stronger effect on the lending rate response in Germany. This is partly due to the relatively high

reliance on wholesale funding of banks in Germany, which implies a strong sensitivity of the loan portfolio decisions to changes in funding conditions. Finally, the valuation effect of bank capital position contributes to asymmetric lending rate responses across the largest euro area countries. In particular, Spanish banks stand out to be the least affected through this channel.

### *Macroeconomic impact assessment*

For the assessment of the broader macroeconomic implications of the heterogeneous reactions of individual banks we employ a DSGE model including a segmented banking sector. Our modelling strategy consists in introducing the minimal set of frictions into existing DSGE models so that the model provides some micro-foundations for bank portfolio decisions between sovereign holdings and loan contracts, and has sufficient data consistency to provide a relevant quantification of Asset Purchase Program macroeconomic multipliers. The DSGE model is estimated on euro area data. The main purpose of the empirical exercise is not to conduct an exhaustive review of the structural determinants of the euro area business cycle and evaluate the statistical performance of the model. Instead, by making use of the insights derived from our granular bank level optimisation approach we aim at narrowing down the plausible ranges for the deep parameters of the model, notably those to which the APP transmission would be most sensitive, and bring a satisfactory level of data consistency for the macroeconomic multipliers used in the quantitative exercises. In particular, we illustrate the sensitivity of the asset purchase propagation mechanism to three relevant dimensions of the parameter space: credit demand frictions, staggered lending rate setting, and frictions on portfolio decisions for households and bankers.

Overall, exploiting both the lending rate experiments derived from the cross-section of bank portfolio decisions as well as alternative estimations of the macroeconomic model, we conducted various counterfactual simulations on the impact of the APP for the euro area. The ranges of outcomes of our simulations suggest that such unconventional policies have the potential to strongly support the growth momentum in the euro area and significantly lift inflation prospects. The benefits of the APP rest on banks' ability and incentive to ease their lending conditions. The strength of the portfolio re-balancing channel through the banking system proves highly dependent on bank balance sheet conditions, and from this perspective, can have diverse impacts across jurisdictions and segments of the euro area banking system. Our findings suggest that such unconventional policies have the potential to strongly support the growth momentum in the euro area and significantly lift inflation prospects. The benefits of the policy measure rest on banks' ability and incentive to ease their lending conditions. The strength of the portfolio rebalancing channel through the banking system proves highly dependent on bank balance sheet conditions, and from this perspective, can have diverse impacts across euro area countries.

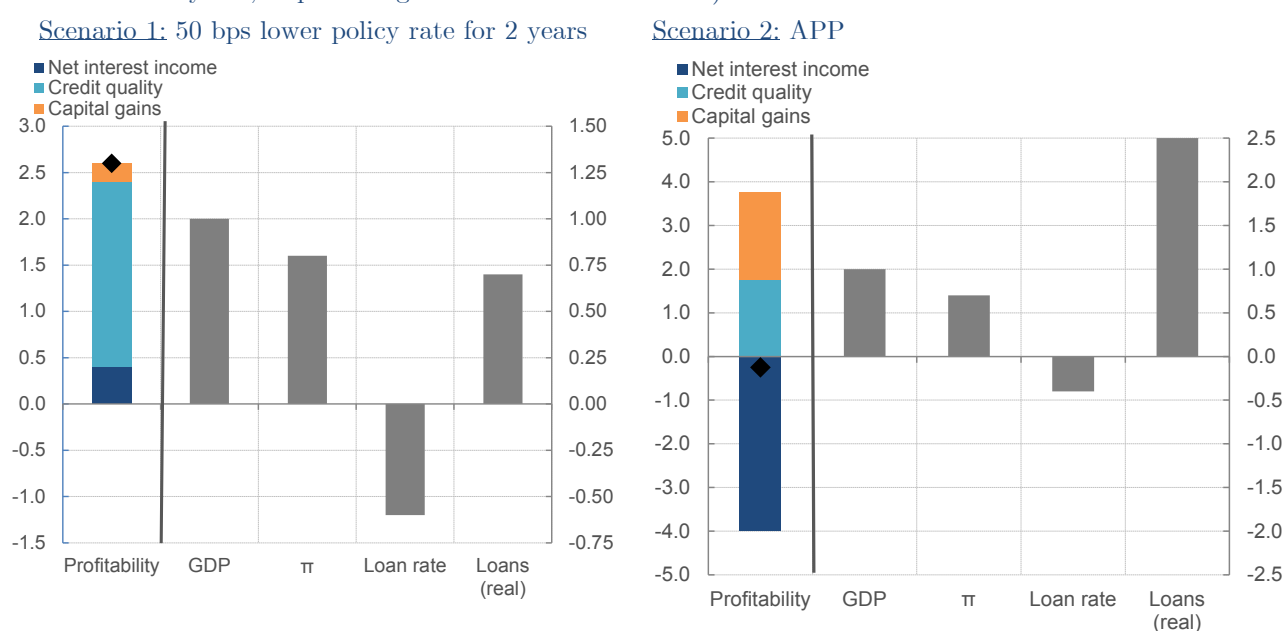
In order to illustrate the model properties, we focus on standard monetary policy accommodation on the one hand and central bank asset purchases on the other which lead to different credit channels



and bank balance sheet conditions. Two policy scenarios are contrasted regarding their transmission to the broad macroeconomic landscape, together with bank profitability and capital position. In the first one, the central bank lowers its key interest rates by 50 basis points, sustained for a two-year period. In the second one, the central bank implements an asset purchase programme calibrated like the APP. The shock process for the central bank purchases follows an AR(2) that is consistent with the purchase strategy and central bank balance sheet impact of the APP. The results of the scenarios are reported in Chart 4.2.

**Chart 4.2** – Comparison of standard and non-standard monetary policy accommodation

(Left hand scale: profitability factors in percent of steady state bank equity; right hand scale: peak macro effects within 2 years, in percentage deviations from baseline)



Notes: In each chart, the effects on profitability are reported on the left hand scale, are cumulated over three years and are expressed in percentage of bank equity; the impact of GDP, annual inflation, lending rate and loans are reported on the right hand scale, correspond to the peak effects within two years, in percentage deviation from steady state. In scenario 1, the decline in the policy interest rate is engineered through a sequence of unexpected shocks on the residual of the estimated interest rate policy rule. In scenario 2, the policy rate is left unchanged for two years.

In normal times, policy rate cuts are favourable to bank profitability both through higher net interest income as well as general equilibrium effects. Temporarily lower short-term interest rates shift and steepen the term structure and directly support the profitability of maturity transformation activities of the banking system. In the model, lending rates respond sluggishly to money market rates due to nominal rigidities in lending rate setting. Over the first two years of the simulation, net interest income of banks increases by less than 0.5% of equity. This positive impact would of course be muted by lending rate indexation schemes on short money market rates or weaker bank funding cost relief from the monetary accommodation. Besides, the decline in short-term interest rates leads to

higher price of sovereign bonds which provides some mild holding gains for the banks. Finally, improving economic conditions and increasing asset prices are beneficial to firms' creditworthiness, with receding delinquency rates. Such favourable developments in credit quality allow banks to scale down provisioning by almost 2% of equity, in cumulated terms over the first two years of the simulation. Turning to the macroeconomic stimulus of the measures, output increases by 1 p.p. at the peak while annual inflation ends up 0.8 p.p. higher. Standard monetary policy interventions entail powerful transmission channels beyond the banking system, on the real side through the intertemporal substitution of spending decisions, and on the financial side, through the discount factor of asset pricing decisions. Therefore the credit multiplier is relatively low with real loans increasing by 0.7 p.p. while corporate lending rates moderate by more than 50 basis points, as the pass-through is almost full over two-years in the model and credit risk compensation is lower.

By contrast, the APP entails a strong portfolio rebalancing channel, incentivising banks to ease credit conditions, foregoing profit margins on loans and originating more credit exposures. The modelled frictions in bank capital structure decisions embed a constrained portfolio allocation between securities and loans. In this context, the central bank asset purchases do have an impact on government bond yields and compress the excess return on this asset class. Banks therefore benefit from sizeable holding gains on their securities portfolio, by around 2% of "economic" capital. Lower government bond yields urge banks to shed sovereign bonds and increase loan exposures. This rebalancing mechanism leads in equilibrium to narrower "required" excess return on loan books by intermediaries. Credit expansion through lower borrowing cost is a key propagation mechanism of the central asset purchases in the model, compared with standard monetary policy easing. Net interest income therefore declines by a cumulated 4% of equity over the first two years of the simulation. As with the standard monetary policy shock, credit quality improves alongside with economic activity and asset prices, which contributes to bank profitability by less than 2% of equity in cumulated terms over two years. All in all, the model-based propagation of the APP would have a marginal effect on bank "economic" capital as lower net interest income is compensated by higher credit quality and valuation gains on securities held (and/or sold).

## 2. Optimal conduct of central bank asset purchases

### *Summary of featured paper [5]*

Through the global financial crisis, central banks have embarked on various forms of unconventional monetary policies, one of which being asset purchase programmes. In most cases, central bank asset purchases were deployed once the room for more accommodative monetary policy stance through interest rate cuts was exhausted. Moreover, evidence has built up on the effectiveness of such unconventional policies in affecting financial prices, credit conditions and expenditure decisions through a variety of channels. In the euro area, which would constitute the empirical case for this paper, the pass-through of asset purchases on sovereign yields and on broader financing costs, notably

bank lending rates, appeared significant and might put the emphasis on bank-based transmission channels. From a normative standpoint, whereas the early literature largely dismissed the usefulness of quantitative easing policies at the lower bound of interest rates, the potential benefits of targeted asset purchases have been revisited and more recently, some contributions would even explore the scope for active asset purchase strategies also in normal times.

Against this background, the aim of this paper is to discuss the optimal conduct of unconventional monetary policies within an estimated DSGE model for the euro area. In our model, central bank asset purchases are relevant in so far as agency costs distort banks asset allocation between loans and bonds, and households face transaction costs when trading government bonds. The banking frictions indeed limit arbitrage in the sovereign bond market and lead to endogenous time-variation in the term premium which might complicate macroeconomic stabilisation through conventional monetary policy. In this case, central bank asset purchases can be used as an instrument of monetary policy to affect long-term rates.

In the first part of the paper we evaluate the macroeconomic effects of ad hoc central bank asset purchase programmes when the policy rate reached its effective lower bound. Such an occasionally binding constraint brings some non-linearity into the model and makes the macroeconomic multipliers quite sensitive to the underlying crisis scenario. It turns out that central bank asset purchases are more powerful in a lower bound environment, and the longer the duration of the lower bound period. Besides, at the lower bound, the programme is more effective when fully communicated and anticipated and when complemented by forward guidance extending the lift-off date for the policy rate.

In the second part, we take a normative perspective and derive an optimal rule-based portfolio management strategy by the central bank which would be conditional on the state of the economy. The optimal policy conduct exploits the strategic complementarities between the two policy instruments. Within the confines of the model validity, the optimal allocation in the presence of the effective lower bound on interest rate displays long period of binding lower bound constraint, a strong use of forward guidance and activist asset purchase strategies. The model also points to a sequencing of the exit strategy, stopping first asset purchases and later on lifting off the policy rate. In terms of macroeconomic stabilisation, optimal asset purchase strategy brings sizeable benefits and has the potential to largely offset the costs associated with the lower bound constraint on the policy rate.

### **3. Financial heterogeneity and the transmission of non-standard measures through the monetary union**

*Based auxiliary paper [m]*

We extend the model presented in Chapter 2 section 2 to include a role central bank asset purchases: due to agency costs, banks face an additional constraint similar to the one introduced in

the model of sections 1 and 2 of this Chapter.

In the aftermath of the outbreak of the global financial crisis in 2007-2008 and the euro area sovereign debt crisis, many countries have experienced a prolonged period of low inflation with high levels of private and government debt, while short-term policy rates have been close to their effective lower bound (henceforth, ELB). To help reignite economic activity central banks have embarked on various forms of non-standard (unconventional) monetary policies with the main key tools being central bank asset purchase programmes (or quantitative easing), such as the Large-Scale Asset Purchase programmes of the US Federal Reserve, the Asset Purchase Facilities of the Bank of England and more recently the ECB's Asset Purchase Programme (henceforth, APP). Although the starting point for all programs shares the same commonalities and objectives, there is a long debate about their macroeconomic effectiveness and the strength of the country-specific transmission mechanism.

Indeed, euro area cross-country heterogeneity brings to the front the question on whether the transmission of non-standard measures differs across jurisdiction. Country-specific macroeconomic specificities are also of great importance in the evaluation the strength of these measures. As observed, the degree of cross-country heterogeneity in the euro area is high, especially between vulnerable and less-vulnerable countries, with subsequent implications on the effectiveness of the APP. The domestic government bond holdings by MFIs (other than the Eurosystem) as percentage of loans is very heterogeneous across countries. Prior to the start of the APP, vulnerable countries (like Italy and Spain) tended to hold a high percentage of domestic government bonds to main loans. Another important dimension is related to international linkages, both in trade and in financial transactions, since they are non-negligible but rather sizeable in the euro area. The implementation of non-standard measures been done in a homogeneous manner, i.e. with central bank asset purchases from all eligible euro area countries simultaneously and according to their GDP share in the euro area (capital key), raises significant questions on the cross-country spillover effects taking place both through trade and financial linkages.

Consequently, it has become important and imperative the need to have appropriate tools and models leading to a more accurate evaluation of the various channels in a cross-country specific manner. The construction of these tools has become even more challenging due to the specific non-linear macroeconomic environment which involves the existence of the effective lower bound constraint on interest rates.

Against this background, the first contribution of this paper is to design a multi-country dynamic stochastic general equilibrium (DSGE) model for the euro area which can provide a framework for analysing the macroeconomic transmission of non-standard measures, focusing mostly on the bank credit and the exchange rate channels. Our specification for financial frictions spans the relevant typology of financial wedges in a six-region global DSGE multi-country model, while the latter reinforced the bank credit channel of the model in order to introduce intermediation balance sheet

constraints which are important for the analysis of central bank asset purchases. These frictions include sovereign risk with sovereign-banking nexus, risky banks facing capital constraints in a segmented banking specification, oligopolistic retail banking segments, and risky debt contracts to firms which can span the relevant typology of financial wedges. Furthermore, the model introduces quadratic adjustments costs in purchases of government bonds by the ricardian households. This specification allows for more generic portfolio rebalancing in the economy irrespective to the banking sector but rather originated also from households who have access to several type of assets (i.e. deposits to financial intermediaries, domestic government and private bonds and internationally traded bonds).

The second contribution of the paper is to try to identify the country-specific empirical regularities which have implications to the effectiveness of the APP. In this respect, the model covers six regions, Germany, France, Italy, Spain, rest of euro area and rest of the world, containing enough cross-country heterogeneity observed within the euro area, emerging from country specific set of financial frictions. The largest four euro area countries are well-suited to evaluate the quantitative relevance of financial factors underlying cross-country implications on the effectiveness of unconventional monetary policies.

The third contribution, which involves the cross-country dimension of our analysis, calls for a review of the direct financial spillovers within the monetary union and the relevant canals emerging from trade and financial international linkages. For the sake of clarity and given the sophistication in the design of domestic and international financial frictions, we consider cross-country spillover effects arising first from international trade and secondly from international trade of private bonds. Lastly, we allow for global portfolio frictions emerging from trading of euro area government bonds internationally.

Lastly, the fourth contribution of this paper is to evaluate the impact of forward guidance in combination with the APP program. In our context, forward guidance is implemented as a credible commitment on the path of future monetary policy rate where it is constrained at the effective lower bound for a given number of period. This is implemented by imposing a lower threshold on the monetary policy rule, allowing the central bank to exit from the ELB in an endogenous manner i.e. every period the bank has a choice to either stay or exit according to the outcome of the rule. If the outcome of the rule is above the threshold then it is considered as an exit from the ELB.

Ultimately, the paper tries to perform a policy evaluation of two legs of ECB's non-standard measures: the Public sector purchase programme and the second series of the targeted longer-term refinancing operations (TLTRO-II). The stock of assets in the build-up phase of the Eurosystem's asset portfolio is assumed to evolve to the Governing Council communication. It is also assumed that the assets are held to maturity and agents know the path of the balance sheet and regard it as fully credible. On the other hand, via TLTROs, the ECB is able to provide large amounts of four-year funding to banks at rates that can be as low as the rate on the deposit facility, having an appreciable

downward impact on banks' average funding costs, which is expected to enable a further reduction in bank lending rates without unduly compressing bank margins further. Both legs of the euro area APP are simulated by allowing for euro area governments been traded internationally and by assuming that deposit interest rates reached their effective lower bound.

#### *The credit channel of the APP across the monetary union*

In order to illustrate the properties of the model, we focus on the initial ECB's Private Sector Purchase Programme (PSPP1) as part of the expanded asset purchase programme. First, we highlight the credit channels of asset purchases assuming that the deposit interest rates reached their effective lower bound. In this context, the multi-country nature of the model is exploited in order to evaluate the cross-border spillovers from the asset purchases, through trade and financial linkages.

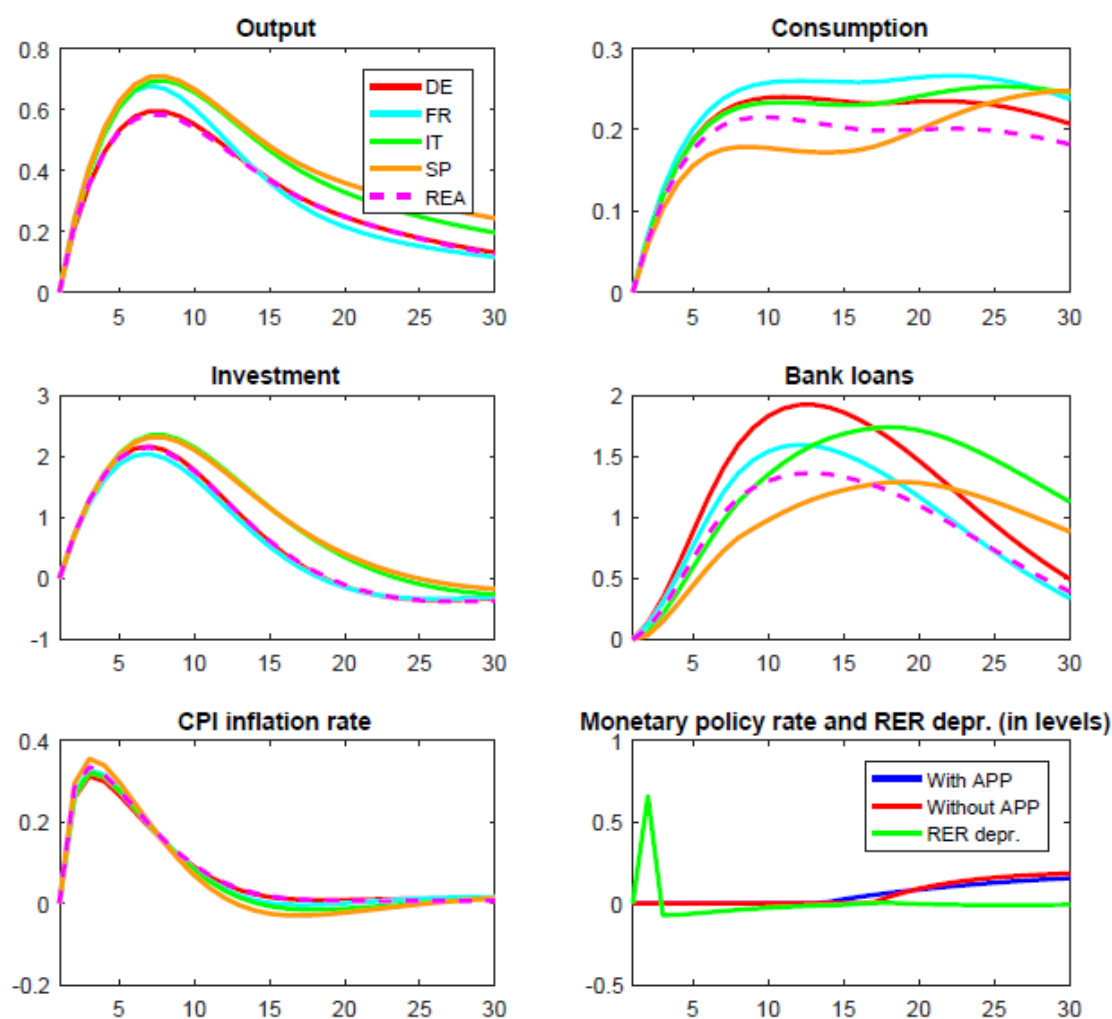
Starting from the initiation of the APP program, we assumed that purchases are symmetric across euro area countries/regions and are carried out every period for approximately a bit less than two years, with the sovereign bond portfolios peaking at approximately 9.6% of annual GDP per country. Our calibration of households portfolio adjustment costs are homogenous across regions and imply that at the peak of the central bank portfolio, domestic banks bear 60% of adjustments in sovereign bond holdings. In line with available event studies, we induce heterogeneity in the drop of sovereign yields through the calibration of portfolio frictions for bankers, so that the sovereign yields and term spreads decline more in Spain and Italy than in France and Germany. The impact of the programme on the main macroeconomic variables is plotted in Chart 4.3.

Portfolio frictions within the banking system create a pass-through of term spread decline into lending rate spreads, and bring about a sizeable and persistent easing of financing conditions. Such a credit easing channel spurs capital expenditures. The peak response of investment reaches around 2% and is relatively similar across regions with France being on the low side, whereas the expansionary effects turn out more persistent in Italy and Spain. The heterogeneity in the increase of corporate loans appears more significant. In Italy and Spain where firms are more risky and indebtedness is higher, the response of loans is milder and more protracted. Turning to consumption, the response across countries is positive even in the short term as the policy interest rate remains at the ELB, increasing to around 0.2% over the medium term.

Of course the constraint on the policy rate actually leads to a strong amplification of the asset purchases impact on output and inflation. The increase in economic activity culminates between 0.6% and 0.7% across regions, which is actually more than twice the effect reported under endogenous standard monetary policy. Indeed, the international trade channels become more supportive as the real effective exchange rate of the euro depreciates by 0.6% (against a marginal appreciation in the endogenous policy case). Across regions, the impact on output turns out stronger and more persistent for Italy and Spain but somewhat lower at the peak for Germany and less persistent for France. The relative weakness of Germany on output effect despite its high investment response is partially due to

less favourable trade spillover both intra-euro area and extra-euro area. The amplification on inflation turns out to be even more pronounced, with CPI inflation increasing by around 0.3% for all regions, against 0.06 p.p. under endogenous monetary policy. The inflation response is marginally less pronounced but also less volatile in Germany. Regarding the course of standard monetary policy instrument, the economic stimulus from the purchase programme enables to start removing some policy accommodation earlier, with the lift-off date for the short-term interest rate being brought forward by three quarter.

**Chart 4.3** – Central bank asset purchases subject to the effective lower bound



Note: Central bank asset purchases approximately amounting to 9.6 percent of annual real GDP in eight quarters (equivalent to the January 2015 PSPP) subject to the effective lower bound and with global portfolio frictions. Horizontal axis: quarters. Vertical axis: percentage deviations from baseline, except for inflation, monetary policy rate and real exchange rate depreciation as annual percentage-point deviations. GDP, its components and banks loans are reported in real terms. DE = Germany; FR = France; IT = Italy; SP = Spain; REA = Rest of euro area.

The multi-country dimension of the model is appropriate for investigating cross-country spillover of asset purchases through the monetary union, stemming from either international trade or financial linkages. We measure the cross-country spillovers on a given region as the difference between two scenarios: one in which the sovereign bonds from all euro area jurisdictions are purchased, and one in which only the region-specific ones are purchased. Focusing on economic activity, the peak spillover effects range from 20% of the overall impact for Germany, to 40% for the rest-of-the-euro area. For France, Italy and Spain, output spillovers are between 25% to 30% of the total effect. On inflation, the spillovers are also sizeable, being more limited in Germany given its large country size and net export position. Overall, the international transmission of asset purchases from one jurisdiction to the other is significant within the monetary union, and even so for a large country like Germany.

#### *External versus domestic channels of the APP: scope for exchange rate adjustment*

We turn now to the model extension incorporating global portfolio frictions through which the rest of world is able to trade euro area bonds. In this case, any sellings of euro area bonds from the rest of the world, as part of the public purchase programme, opens up an exchange rate channel of the purchases, amplifying the euro depreciation vis-à-vis the rest-of-the-world, thereby rebalancing the transmission mechanism towards trade channels.

Charts 4.4 show the impact of benchmark asset purchase programme the presence of the global portfolio frictions and subject to the constraint of the effective lower bound. We calibrated the adjustment cost parameters in the trading on international assets such that the effective exchange rate depreciation of the euro reaches 3%. This magnitude is on low side but qualitatively in line with available event studies. In comparison of previous simulation, the global portfolio frictions have a significant influence on the magnitude of the macroeconomic multipliers as well as on the typology of the transmission mechanism.

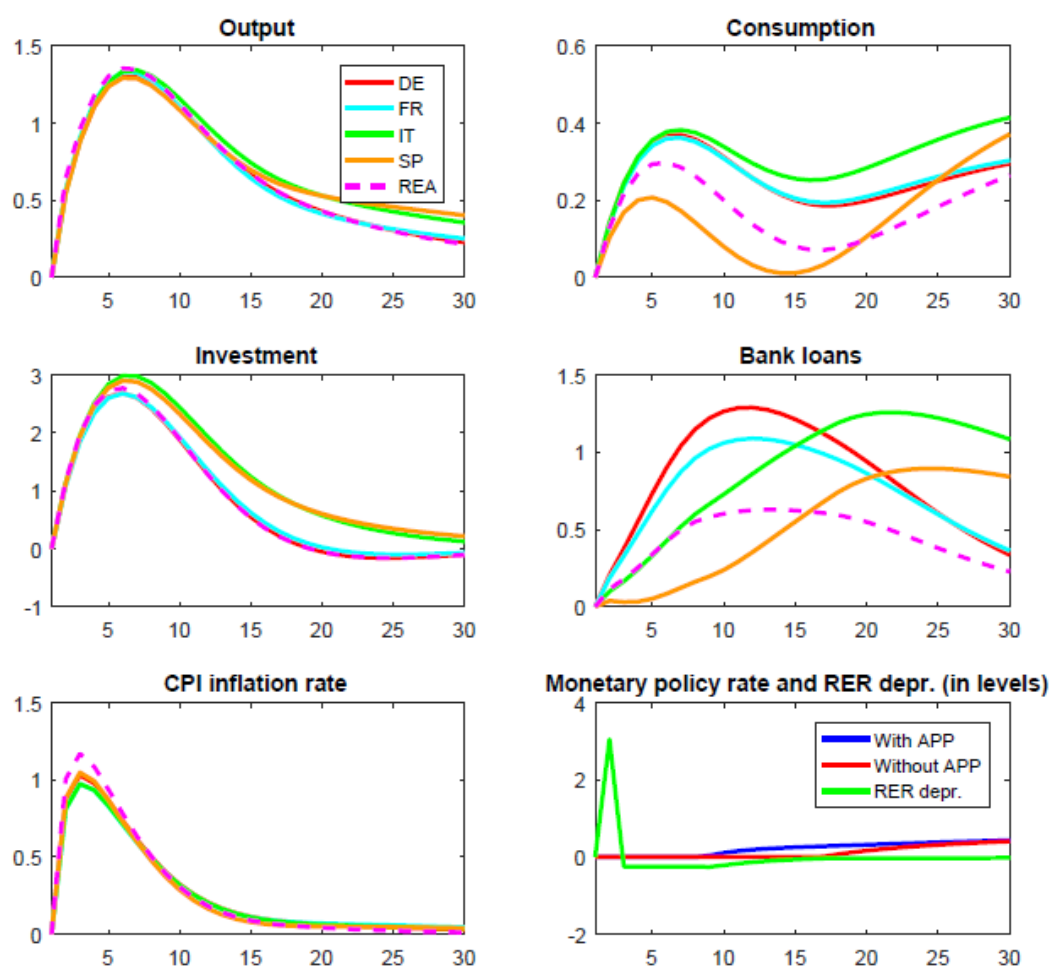
Focusing first on the sovereign bond market, it turns out that the rest-of-the-world now accommodates one fourth of the central bank purchases at the peak of the portfolio build up, domestic banks bearing less than 40% of the adjustment in holdings. Consequently, the strength of the bank-centric term spread channel weakens so that the compression of sovereign yields becomes smaller and much less persistent. Further down in the intermediation chain, the peak easing effect on bank lending rate spreads is reduced and the investment boom becomes less credit-intensive. The global portfolio frictions are overall dampening the credit channel of asset purchases.

However, on the real side, the expansionary impact of the purchase programme is reinforced. Investment increases by almost 3% at the peak for all regions, compared with 2% in the absence of global portfolio frictions. Due to stronger external impulse (which particularly benefits Germany) the output increase becomes twice larger, reaching 1.3% at the peak and is relatively homogenous across regions. On consumption, heterogenous import content across regions generates more asymmetric profiles due to varying imported inflation effects. The inflationary impact of the programme is also



dramatically amplified by the exchange rate depreciation, bringing the maximum CPI inflation increase to almost 1%. Such macroeconomic conditions imply a significant shortening of the period when the ELB binds: in this scenario, the lift-off date is brought forward by more than 6 quarters. This feature is of course very much dependent of the inflation rate that enters the monetary policy rule. Should one specify the rule in terms of domestic inflation instead of CPI inflation, the course of interest rate policy might be less affected.

**Chart 4.4** – Central bank asset purchases and global portfolio frictions subject to the effective lower bound



Note: Central bank asset purchases approximately amounting to 9.6 percent of annual real GDP in eight quarters (equivalent to the January 2015 PSPP) subject to the effective lower bound and with global portfolio frictions. Horizontal axis: quarters. Vertical axis: percentage deviations from baseline, except for inflation, monetary policy rate and real exchange rate depreciation as annual percentage-point deviations. GDP, its components and banks loans are reported in real terms. DE = Germany; FR = France; IT = Italy; SP = Spain; REA = Rest of euro area.

## Chapter 5 Interactions between Monetary and Macroprudential policies

The financial crisis highlighted the importance of systemic risks and of policies that can be employed to prevent and mitigate them. Several recent initiatives aim at establishing institutional frameworks for macro-prudential policy. As this process advances further, substantial uncertainties remain regarding the transmission channels of macro-prudential instruments as well as the interactions with other policy functions, and monetary policy in particular. The first essay of this chapter provides an overview and some illustrative model simulations using an estimated DSGE model for the euro area of the macroeconomic interdependence between macro-prudential instruments and monetary policy. We find that macroprudential policy can be more effective than monetary policy in addressing destabilising fluctuations in the credit markets, thereby alleviating somewhat the need for monetary policy to lean against the wind.

In a monetary union, targeted national macroprudential policies can be necessary to address asymmetric financial developments that are outside the scope of the single monetary policy. The second essay discusses the complicated interactions between a single monetary policy and jurisdiction-specific macroprudential policies. We analyse the interaction between monetary and macroprudential policies in the euro area by means of a two-country DSGE model with financial frictions and cross-border spillover effects. We calibrate the model for the four largest euro area countries (i.e. Germany, France, Italy, and Spain), with particular attention to the calibration of cross-country financial and trade linkages and of country specific banking sector and frictions. We find that countercyclical macroprudential interventions are supportive to monetary policy conduct through the cycle. This complementarity is significantly reinforced when there are asymmetric financial cycles across the monetary union. We also provide quantitative illustrations for the potentially beneficial role of country-focused macroprudential policies and especially their ability to cater for financial imbalances that may arise in the context of unconventional monetary policies and policy rates being constraint by the zero lower bound.

In the third essay, we present a general equilibrium banking model in which shadow banking arises endogenously and undermines market discipline on traditional banks. Depositors' ability to re-optimize in response to crises imposes market discipline on traditional banks: these banks optimally commit to a safe portfolio strategy to prevent early withdrawals. With costly commitment, shadow banking emerges as an alternative banking strategy that combines high risk-taking with early liquidation in times of crisis. We bring the model to bear on the 2007-09 financial crisis in the United States, during which shadow banks experienced a sudden dry-up of funding and liquidated their assets. We derive an equilibrium in which the shadow banking sector expands to a size where its liquidation causes a .re-sale and exposes traditional banks to liquidity risk. Higher deposit rates in compensation for liquidity risk also weaken threats of early withdrawal and traditional banks pursue risky portfolios that may leave them in default. Policy interventions aimed at alleviating .resales fuel

further expansion of shadow banking. Financial stability can be achieved with a tax on shadow bank profits or collateralized liquidity support to traditional banks.

## Literature review

Starting with the empirical studies, a general finding as regards the impact of changes to bank capital, is that banks, when faced with higher capital requirements (or capital shortfalls), are likely to adjust not only their equity levels (via retained earnings and the raising of capital), but also their lending decisions and credit conditions: see, for example, Berrospide and Edge (2010), Francis and Osborne (2012), Maurin and Toivanen (2012) and Schepens and Kok (2012). Underlying such reactions is the assumption that banks target a specific capital (or leverage) ratio and hence deviations from this target will trigger balance sheet adjustments, as in Berger et al. (2008), Flannery and Rangan (2008), and Gropp and Heider (2010). Martin-Oliver et al. (2013) argue that such behaviours may, vary across individual banks so that decisions on capital-based macro-prudential interventions should take heterogeneity into account. Besides, analysing the experience with dynamic loan provisioning in Spain, Jimenez et al. (2012a) find that counter-cyclical capital buffer requirements (as reflected in the dynamic provisioning) tend to smoothen the credit cycle and can have positive real economic effects.

Turning to asset-side macro-prudential instruments, there is some (albeit limited) evidence that they can increase the resilience of banks by improving the creditworthiness of borrowers. Specifically, several studies find that tighter loan-to-value ratio caps reduce the sensitivity of households to income and property price shocks. See, for example, Wong et al. (2011). Finally, Lim et al. (2011) suggest that several of the commonly used macro-prudential instruments reduce pro-cyclicality in the financial system. The analysis also suggests that the type of shocks do matter. Different types of risks call for the use of different instruments.

Apart from the empirical studies cited above, the theoretical literature on the assessment of the impact of macro-prudential policy has also been promising over the recent past, but the knowledge gap in this respect remains substantial. There is a small but resurgent body of literature on macro-prudential policy impact assessments. Some prominent early contributions identified the relevance of incorporating system-wide financial stability aspects in the overall institutional policy framework governing the monetary and financial system. Crockett (2000) provided an early seminal contribution, followed by Borio et al. (2001) and Borio (2003). This insight was rooted in the recognition that financial systems are inherently pro-cyclical and the fact that financial cycles in general are longer than real business cycles, as advocated in Drehmann et al. (2012) for example. Hence, there is a risk that financial developments become detached from fundamental real economic developments, which may lead to the build-up of unsustainable financial imbalances whose unravelling ("sudden busts") could have detrimental short and long-run implications for economic growth. This, it is argued, provides a role not only for monetary policy, but also for macro-prudential policy to mitigate the risks

of such divergences between the real and financial cycles. Arguably, however, the identification of financial cycles (and booms in particular) is inherently difficult, which in turn implies that the operationalisation of macro-prudential policies targeting financial cycle stabilisation is challenging.

The pro-cyclicality of the financial system can be traced to the various distortions inherent in financial relationships stemming from the existence of asymmetric information (e.g. between banks and their borrowers), resulting in adverse selection and moral hazard problems, and limited enforcement technologies, whereby borrowing is constrained by the loss given default and leads to collateral constraints. Few recent references along those lines are Lorenzoni (2008), Mendoza (2010), Bianchi (2010) and Adrian and Shin (2011). The build-up of imbalances within the financial system can actually be endogenous and, in the case of an adverse event, could give rise to a systemic event. This is for example the case in Brunnermeier and Sannikov (2012) or Boissay et al. (2012). Similarly, once built-up imbalances start to unravel and banks' balance sheets become impaired, banks deleveraging process could give rise to a credit crunch and asset fire sales that are likely to further amplify the initial shock, as in Shleifer and Vishny (2010), Diamond and Rajan (2011) and Hanson et al. (2011).

Since systemic risks can take many forms, the macro-prudential toolkit requires several policy instruments covering both the time dimension and the cross-section dimension of systemic risk. Focusing mainly on the time dimension, Angelini et al. (2014) provide a comprehensive overview of existing modelling approaches to macro-prudential policy analysis. On the cross-section dimension, a notable contribution is Goodhart et al. (2007). A common thread among recent studies seems to be that macro-prudential and monetary policies in many instances can be expected to either complement or substitute each other. This underlines the need to ensure an appropriate institutional framework with effective coordination mechanisms among the different policy functions, as advocated in Cecchetti and Kohler (2012) or Ueda and Valencia (2012).

At the more conceptual level, for what concerns the interaction between macroprudential and monetary policies there are conflicting views about the extent to which in particular monetary policy should provide some support to help achieving financial stability objectives. Two opposing viewpoints call for either keeping the two policy functions separate which also implies that pre-crisis price stability-oriented monetary policy frameworks should remain largely unaffected or to fully merge the monetary policy and macroprudential policy objectives. For proponents of the former viewpoint see e.g. Bean et al (2010) and Svensson (2012). For proponents of the latter viewpoint see e.g. Brunnermeier and Sannikov (2013). In between those polar views, arguments can be made for assigning some role for monetary policy to complement the new macroprudential policies. This owes to strong mutual dependencies between the two policy functions and reflects uncertainty about whether macroprudential policy will be able to fulfil all its objectives and get into all the cracks of the financial system: see notably Woodford (2012), Stein (2012), Borio (2014) and Habermeier et al (2015). In the same vein, according to Smets (2014), the need for incorporating a role (albeit secondary) for financial

stability concerns among the monetary policy objectives hinges on (i) the effectiveness of macroprudential policies (e.g. the ability to manage the financial cycle); (ii) the extent to which monetary policy (incl. conventional and unconventional measures) can be a source of financial instability for example by incentivising bank risk-taking; and (iii) the extent to which monetary policy can avoid being drawn into financial stability concerns, especially in crisis times. To the extent that an extended monetary policy mandate including financial stability concerns, as a complement to macro-prudential policies, can help prevent the build-up of excessive debt overhangs in pre-crisis periods it could alleviate the need for monetary policy to engage in post-crisis resolution policies; see also Borio (2014).

In several studies, the investigation of the strategic interaction between macro-prudential and monetary policy has predominantly been carried out using DSGE models incorporating financial frictions. For instance, the early contribution by Angeloni and Faia (2013) finds that, in a DSGE model where banks can be subject to runs, the optimal policy mix offers some role for monetary policy to lean against asset prices or bank leverage in combination with a counter-cyclical capital buffer rule. Another early paper, which focused on housing bubbles, is Kannan et al. (2009). However, the specific calibration (design and magnitude) of the macro-prudential rule determines its effectiveness in contributing to macroeconomic stabilisation. Angelini et al. (2014) likewise find that the mutual interaction of monetary policy and macro-prudential policy can be beneficial, especially during times when the economy is subject to large shocks, while a lack of coordination between the two policy functions can lead to conflicts of interest. Beau et al. (2012) or Christensen et al. (2011) in turn emphasise that the extent to which monetary policy and macro-prudential oversight conflict largely depends on the nature of the underlying shocks affecting the economy at a given juncture. Moreover, Lambertini et al. (2013) suggest that using a lean-against-the-wind monetary policy or a counter-cyclical macro-prudential policy can have different welfare implications for different economic agents. For a comparable study incorporating intra-sectoral distributional effects, see also Rubio (2014). In a similar vein, Gertler et al (2012) show that macroprudential policy in the form of a pigouvian-type subsidy on banks' outside equity can help alleviate the need for monetary policy to lean against the cycle. Gelain et al (2013), in a DSGE model with housing and imperfect expectations, show that monetary policy rules together with macroprudential interventions such as debt-to-income and LTV ratios, can help reduce macroeconomic volatility. De Paoli (2013) furthermore highlights the welfare benefits of coordinated action by monetary and macroprudential policies. While a number of studies have analysed the macroprudential and monetary policy interactions in closed economy settings, there are only few studies to date that extend the analysis to a multi-country, monetary union setting. A few recent exceptions include Quint and Rabanal (2014) or Brzoza-Brzezina et al (2013).

The rapid growth of shadow banking in recent decades is well documented (see e.g. Claessens et al., 2012; Pozsar et al., 2013). Gennaioli et al. (2013) emphasize the ability of shadow banks to generate safe assets through securitization. They show that shadow banks become excessively exposed to systemic risk when low probability tail events are neglected by investors. In a similar vein, Moreira

and Savov (2017) focus on liquidity transformation whereby shadow banks create money-like assets that become illiquid in times of high uncertainty. Harris et al. (2014), Plantin (2015), and Ordoñez (2017) highlight the role of regulatory arbitrage as a primary cause of shadow banking. In these studies, regulatory constraints restrict intermediation by traditional banks and create opportunities for unregulated shadow banks.

A recent strand of literature analyses the interactions between traditional and shadow banks. Gornicka (2016) considers traditional banks' incentives to gain off-balance sheet exposure by extending implicit guarantees to shadow banks. Hanson et al. (2015) present a framework where shadow and traditional banks have access to a common pool of liquidity. They show that traditional banks have a comparative advantage in holding illiquid assets with low fundamental risk when they are protected by deposit insurance guarantees. In a similar environment, Luck and Schempp (2016) find that shadow banking grows excessively large from a social viewpoint due to pecuniary externalities similar to the .re-sale externalities considered here.

Acharya et al. (2013) document the collapse in the market for asset-backed commercial papers at the onset of the crisis while Gorton and Metrick (2012) and Krishnamurty et al. (2014) show a similar contraction in repo markets. Together, these two markets accounted for the vast majority of funding for shadow banks. Covitz et al. (2013) find that the dry-up in funding for shadow banks was associated with a rise in macro-financial risks such as uncertainty about sub-prime mortgages values. Re-sales caused by the liquidation of shadow banks then play a key role in the spread of financial instability to traditional banks. Shleifer and Vishny (2011) provide an extensive review of the literature on .re-sales while Krishnamurthy (2010), Merrill et al. (2012), and Mitchell and Pulvino (2012) provide empirical evidence for .re-sales during the financial crisis. In Diamond and Rajan (2005) (shadow) bank failures cause contagion by aggravating liquidity shortages in the rest of the financial sector. Finally, Diamond and Rajan (2011) find that illiquidity leads to greater risk-taking by traditional banks, due to risk-shifting distortions.

## **1. Optimised monetary and macroprudential rules within an estimated DGSE model for the euro area**

*Based on auxiliary paper [n] and featured paper [2]*

This paper first surveys the recent literature on the conduct of macro-prudential policy and, in particular, explores its nexus with monetary policy, focusing on the objective of stabilising the financial cycle. In order to investigate the interaction between monetary and macro-prudential policies, we conduct various simulation exercises based on the DSGE model presented in section 1 of Chapter 2. The assessment is organised around two distinct, but interrelated dimensions. First, the focus is on the transmission mechanism of individual macro-prudential instruments from a system-wide perspective. Second, the emphasis is placed on the strategic complementarities in leaning against the financial cycle as well as in exceptional crisis circumstances.

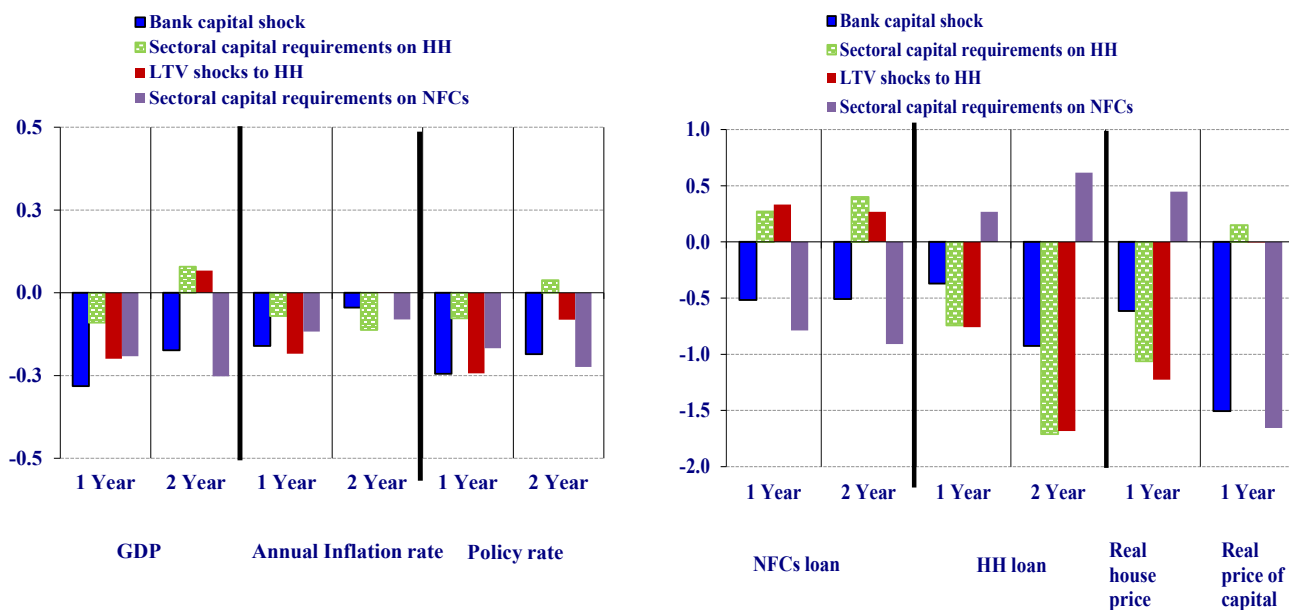
The propagation of macro-prudential instruments is likely to interact with the transmission mechanism of monetary policy decisions, not least as they both affect the behaviour of financial intermediaries. In supporting the stability of the financial system and in seeking to dampen its procyclical tendency, macro-prudential instruments generally involve significant balance sheet adjustments within the financial sector, with effects on credit provision, asset prices and overall financing conditions for households and firms. Those factors may influence the transmission of the monetary policy stance and ultimately the outlook for price stability. Conversely, monetary policy will be relevant for macro-prudential oversight as it can affect agents' decisions on risk-taking, leverage, and composition of assets and liabilities. For instance, the risk-taking channel of monetary policy transmission underlines how protracted loose monetary conditions can foster incentives for financial institutions to take on more risk, thus encouraging leverage and paving the way to the build-up of financial imbalances. More broadly, changes in the monetary policy stance influence borrowers' decisions on taking on debt by affecting the tightness of their borrowing constraints, via the impact on asset prices and borrowers' net worth, and hence on the cost of external financing for borrowers.

A first step in exploring the interaction between macro-prudential oversight and monetary policy is to analyse the macroeconomic propagation of selected macro-prudential instruments, namely: (i) system-wide bank capital requirements; (ii) sectoral capital requirements; and (iii) loan-to-value ratio restrictions. Intuitively, the aim of system-wide capital requirements is to increase the resilience of the banking system as a whole by ensuring adequate buffers to cope with potential sizeable losses. Sectoral capital requirements make lending to certain classes of borrowers more costly and hence prompt banks to reduce their activity in that segment. Third, restrictions on loan-to-value ratios pertain to the assets side of the banking system, directly affecting the borrowing constraints of banks' customers, and hence make the banking system less vulnerable to borrower defaults.

#### *Macroeconomic transmission of selected Macro-Prudential instruments*

An illustration of the transmission mechanism associated with these three key macro-prudential tools is provided using the DSGE model described in the first essay of Chapter 2, where monetary policy in the model is formalised in terms of an interest rate rule that prescribes a response to inflation, output growth and asset prices. The macroeconomic implications of the three macroprudential interventions are presented in Chart 5.1.

**Chart 5.1:** Transmission of selected MPIs through credit and asset prices  
(percentage point deviation from baseline)



Source: own calculations.

Note: The size of the increase in the capital requirement is normalised so that the impact on loans to households in the second year is -1pp compared to the baseline. House price and Price of capital are in real terms.

First, faced with an *increase in system-wide capital requirements* (calibrated as a 1.5 percentage point change in the capital ratio), banks react by charging higher margins on new loans and curtailing the provision of credit symmetrically to both households and non-financial corporations, albeit to different extents (see Figures 4 and 5). In addition, the resulting contraction in both investment and consumption expenditure depresses capital and house prices, which exacerbates the propagation effects through financial accelerator mechanisms (as the decline in collateral values tightens borrowing constraints). The impact on economic activity and inflation is mitigated by a significant monetary policy accommodation. Therefore, the monetary policy response may thus provide a significant shield for macroeconomic allocations, provided monetary policy has scope to accompany the bank balance sheet adjustment at times of increasing capital buffers. Conversely, the concomitant increase in capital requirements and the monetary policy rate can be expected to effectively curb bank lending and slow down economic activity.

Second, *an increase in sectoral capital requirements* makes the price of lending to the targeted sector relatively more expensive. This triggers relative price and asset price adjustments together with substitution effects in bank lending, whereby loans decline in the target sector while lending to the non-target sector increases. Overall, the effects on real GDP and inflation are influenced by the intensity of this substitution and the sectoral distribution of the transmission mechanism. In relative terms, capital requirements targeting non-financial corporate loans appear to have stronger multipliers on real GDP and consumer price index inflation, thereby leading to a more accommodative monetary policy. Capital requirements targeting housing loans lead to a less clear-cut macroeconomic



configuration for monetary policy.

Finally, *a lower cap on loan-to-value ratios* on loans to households constrains the maximum loan that a bank is willing to grant against collateral. The transmission mechanism features some similarities with the case of sectoral capital requirements on housing loans. However, the adverse impact on housing investment and then on output and inflation is more pronounced, partly mitigated by a prompt loosening of the monetary stance.

Notably, the illustration of the real economic implications derived from these simulations reflects the effects of introducing each of the macro-prudential instruments in isolation, but does not account for the strategic complementarities between macro-prudential instruments and the benefits of combining them.

### *Optimised simple monetary and macro-prudential rules*

In order to study the appropriate policy mix between monetary policy and macro-prudential policies, we focus on the joint determination of two policy rules which maximize an ad hoc loss function under credible commitment. The inter-temporal quadratic loss function penalizes deviations from steady state for consumer price inflation, output growth and policy rate. Monetary policy conduct is described as an interest rate rule while macro-prudential policy is assumed to follow a capital requirement rule. Both rules feature policy inertia and respond to level and first difference of consumer inflation, de-trended output, and first difference of loans to households, loans to entrepreneurs, real housing prices and real equity prices. We chose to limit the analysis to a stylized loss function instead of a welfare-based objective as the "reduced-form" nature of the bank capital friction considered in this paper would weakly portray the welfare trade-offs faced by macro-prudential policy in particular. Consequently, we preferred to abstract from welfare calculations and gear the policy discussion towards general macroeconomic stabilization without investigating how the micro-foundations of the model influence the policy objectives.

A first exercise consists in optimizing the parameters of the monetary policy rule augmented or not with asset prices and credit variables, keeping capital requirements constant. The optimized monetary policy rule without credit and asset prices features a high level of interest rate inertia, a strong long-term response to inflation, stronger reaction to changes in output than in its level, and a specific role for housing prices. In terms of loss function, the augmented optimal rule improves upon the previous one, even if lower volatility obtained for output growth and the interest rate is counterbalanced by a higher standard deviation for inflation. This optimal rule still displays a high degree of interest rate inertia, a strong reaction to inflation and some specific role for housing prices. But in addition, the rule includes some positive response to household loans whereas the coefficients on loans to entrepreneurs and real equity prices are close to zero. Even without introducing asset prices or credit in the objective function, it turns out that the financial frictions on the household side vindicate some specific monetary policy focus on credit and asset prices.

In a second exercise, we allow now for time-varying capital requirements. Keeping the same loss function as in the previous experiments, the joint optimal determination of policy rules suggests that counter-cyclical regulation could provide a strong support to macroeconomic stabilization. The optimized capital requirement rule features some inertia and a very high positive response to output while the role for credit variables and asset prices seems negligible. The optimized monetary policy rule is very much affected by the introduction of counter-cyclical regulation: in particular, all coefficients on credit and asset prices become insignificant. Acting at the core of the financial system, regulatory policy seems to be relatively more effective than monetary policy in addressing destabilizing fluctuations in credit markets and intra-temporal wedges between financial costs, therefore alleviating somehow the need for monetary policy to "lean against the wind". The jointly determined policy rules deliver a superior macroeconomic outcome as the loss function gets close to zero, and output, inflation and interest volatilities decline. However, in the model, the main transmission channel of regulatory policy on the economy works through the adjustment of bank balance sheets and its impact on bank lending rates. Consequently, the macroeconomic stabilization support from the optimized capital requirement rule implies an almost fivefold increase in bank leverage volatility. Such a degree of counter-cyclical capital requirements would therefore be difficult to implement and lead to excessive volatility in bank balance sheets. If we constrain the regulatory framework by introducing a relatively small penalty for leverage volatility in the loss function, then the optimized capital requirement rule becomes only moderately time-varying and the monetary policy rule is more similar to the one obtained under constant capital requirements. Overall, while some counter-cyclical regulation seems suitable as far as macroeconomic stabilization is concerned, its design and magnitude should be carefully considered.

## 2. Quantifying the policy mix in a monetary union with national macroprudential policies

*Based auxiliary paper [o]*

In a monetary union, targeted national macroprudential policies can be necessary to address asymmetric financial developments that are outside the scope of the single monetary policy. This paper discusses the complicated interactions between a single monetary policy and jurisdiction-specific macroprudential policies. It also provides quantitative illustrations for the potentially beneficial role of country-focused macroprudential policies and especially their ability to cater for financial imbalances that may arise in the context of unconventional monetary policies and policy rates being constraint by the zero lower bound.

*Taming jurisdiction-specific financial cycles: stabilizing properties of macroprudential instruments in the monetary union*

A first step in exploring the interaction between macro-prudential oversight and monetary policy

in the euro area is to analyse the macroeconomic propagation within the monetary union of selected macro-prudential instruments (MPI), namely: (i) system-wide bank capital requirements; (ii) sectoral capital requirements; and (iii) loan-to-value ratio restrictions. Capital requirements increase the resilience of the banking system as a whole by ensuring adequate buffers to cope with losses. Sectoral capital requirements make lending to certain classes of borrowers more costly and hence prompt banks to reduce their activity in that segment. Restrictions on loan-to-value ratios pertain to the banks' assets side, directly affecting the borrowing constraints of their customers, and hence make the banking system less vulnerable to borrower defaults.

Intuitively, for given strategic arrangements between macroprudential and monetary policy, two prescriptions would nonetheless hold with respect to the use of alternative MPIs. First, from a domestic perspective, targeted instruments would be superior to non-targeted ones to address sector or financial-segment specific financial vulnerabilities. At the same time, broad-based signs of financial excesses or uncertainty on the main drivers of financial developments, would suggest exploiting instruments less intrusive in the asset composition of the banking system. Second, jurisdiction-specific instruments are best-suited to address asymmetric country-wide developments within the monetary union, thereby mitigating the "one size does not fit all" constraint for monetary policy.

The modelling exercises that follow aim at bringing some quantitative perspective on these aspects and elaborate further on the role of country characteristics, focusing on the largest five euro area members. For illustrative purposes, we compare the macroeconomic allocations corresponding to a temporary increase in system-wide capital requirements, with those resulting from temporary increases of (i) sectoral capital requirements on non-financial corporate loans and (ii) caps on the loan-to-value ratio.

Charts 5.2a and 5.2b show that impact of the macroprudential measures on the macroprudential allocations in the domestic and foreign economies, respectively. Only results for system-wide capital requirements and a sectoral risk weights are shown. The results for the loan-to-value ratio cap are qualitatively similar to the latter case.

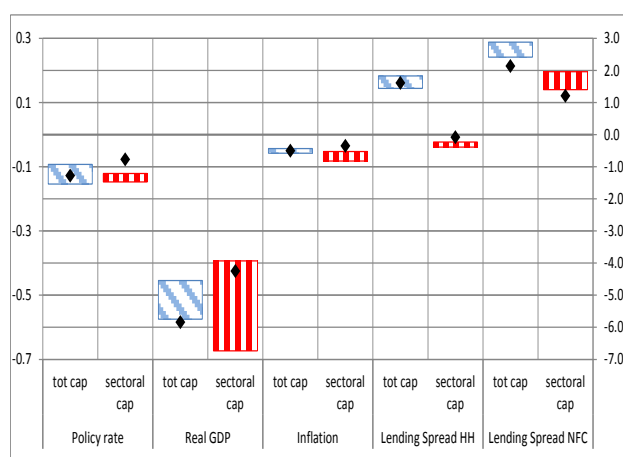
In response to higher regulatory system-wide capital requirements (i.e. broad-based capital buffer requirements, such as a countercyclical capital buffer, systemic risk buffer, G-SIFI buffer), banks react by charging higher margins on new loans and curtailing the provision of credit symmetrically to domestic households and firms, albeit to different degrees. The resulting contraction in both investment and private consumption depresses capital and house prices, which exacerbates the propagation effects through financial accelerator mechanisms (as the decline in collateral values tightens borrowing constraints). The impact on the economy of the macroprudential tightening is, however, mitigated by an accommodative response of monetary policy.

**Chart 5.2a**

Macroprudential tightening measures negatively affect economy...but impact mitigated by monetary policy

**Transmission of macroprudential policy measures in "home" country under endogenous single monetary policy**

(real GDP (per cent deviation from baseline, left-hand scale); inflation (percentage point deviation from baseline, left-hand scale), interest rates (in per cent, right-hand scale))



Source: ECB calculations.

Note: Coloured ranges indicate cross-country dispersion of results, black dots indicate the simple average impact across countries without taking into account financial cross-border linkages.

System-wide capital requirements measures have on average a larger effect on macroeconomic variables of the domestic and foreign economies than more targeted macroprudential measures. At the same time, it is notable that the sectoral risk weight measure targeting corporate loans result in more dispersed macroeconomic effects across countries. This feature can be explained by the current high dispersion of default probabilities (PD) of non-financial corporations across euro area countries. In particular, the negative effect of curtailing credit to firms has starkest effects on real GDP of southern European countries which are characterised by higher risk weights for these loans. PDs are less dispersed for what concerns the retail loan book and hence measures targeting the household sector (such as loan to value ratios or sectoral risk weights on mortgage loans) in general lead to less heterogeneous macroeconomic propagation across euro area countries.

In terms of cross-border spillovers, macroprudential measures in the targeted jurisdiction are transmitted to the rest of the euro area through various channels. Trade linkages propagate the expenditure slowdown for the domestic economy into weaker foreign demand for the other country (see black dots in Charts 5.2a-5.2b). Banks' cross-border loan exposures create direct financial spillovers: the deleveraging pressures of domestic banks lead to funding pressures on foreign banks

**Chart 5.2b**

...and produces non-negligible cross-border spillovers

**Transmission of macroprudential policy measures in "foreign" country under endogenous single monetary policy**

(real GDP (per cent deviation from baseline, left-hand scale); inflation (percentage point deviation from baseline, left-hand scale), interest rates (in per cent, right-hand scale))



Source: ECB calculations.

Note: Coloured ranges indicate cross-country dispersion of results, black dots indicate the simple average impact across countries without taking into account financial cross-border linkages.

which ultimately tighten the credit conditions to their local customers. Finally, in a monetary union, domestic shocks are transmitted abroad through the monetary policy reaction. In particular, the monetary policy response may provide a shield for macroeconomic allocations in the domestic economy, provided that the country is large enough and monetary policy has scope to accompany the bank balance sheet adjustment at times of increasing capital buffers. However, this may ease the liquidity conditions in the rest of the euro area and contribute to macroeconomic heterogeneity within the monetary union.

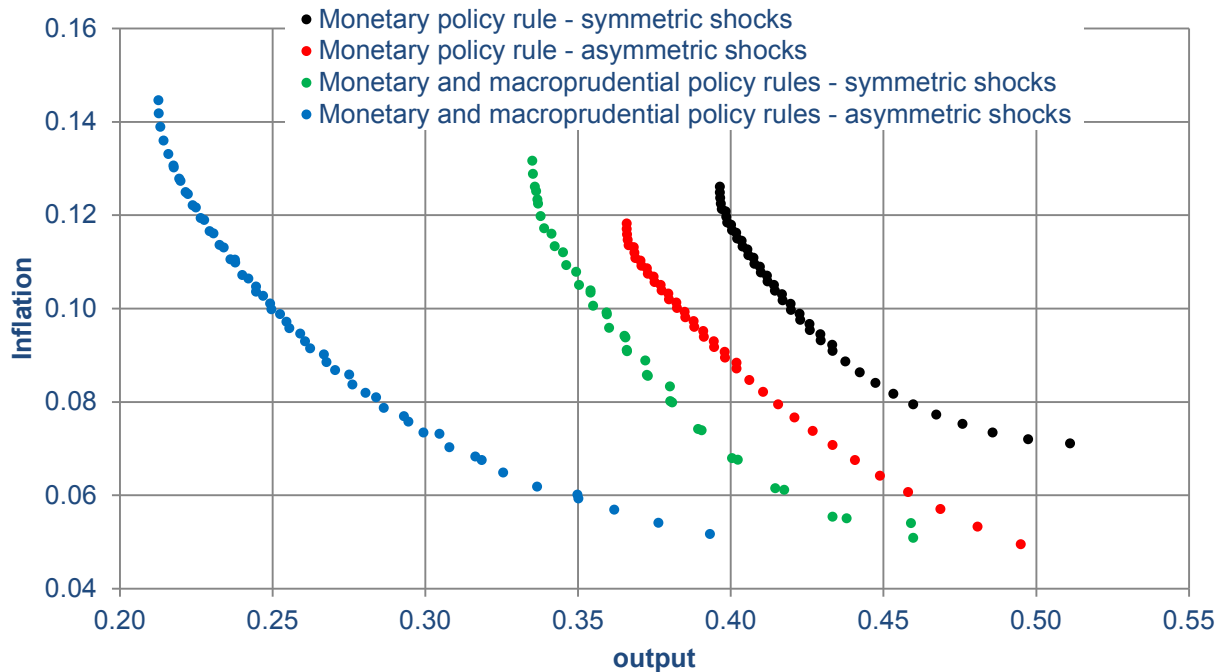
### *Cross-country heterogeneity and the scope for macroprudential support to monetary policy conduct through the cycle*

The potential strategic complementarities between monetary policy and macroprudential policies in a monetary union can be illustrated with the two-country DSGE model. The following theoretical normative prescriptions are to some extent model-specific and should be considered with caution. At the same time, they shed some light on the appropriate monetary and financial policy-mix through the cycle, also from the perspective of large and persistent cross-country heterogeneity within the monetary union.

The simulation exercise rely on a euro area calibration of the model for two regions: one region corresponds to the countries less affected by the financial crisis and the other region covers for the rest of the euro area. Within the confines of this theoretical framework, the scope for macroprudential policies is evaluated through the joint optimization of an interest rate policy rule for the single monetary policy and countercyclical capital rules for the two regional macroprudential authorities. We focus on cooperative policy arrangements. The monetary policy rule reflects the standard trade-off between inflation and output volatility, the macroprudential policy rules are country specific and countercyclical: the target capital ratio increases (decreases) in periods with high (low) credit-to-GDP gap.

In order to convey the stabilisation trade-offs, the results are presented in terms of efficiency policy frontier in the output and inflation volatility space: the efficiency frontier portrays for all sets of policymakers' preferences, the output and inflation volatility implied by the corresponding optimized rules. Four configurations are examined. First, we derive the efficiency frontier in the absence of macroprudential intervention, and with the full set of estimated business cycle shocks. This would span the reference set of macroeconomic allocations against which the benefits of macroprudential support could be assessed. The optimized monetary policy rule responds to output, inflation but also to debt and asset prices which could be interpreted as vindicating some degree of "leaning against the wind".

**Chart 5.3** – Efficiency policy frontiers  
(in %, standard deviations)



Notes: The inter-temporal quadratic loss function penalizes deviations from steady state for consumer price inflation, output growth and policy rate

Second, countercyclical capital rules are introduced, reacting to credit, asset prices dynamics and cyclical economic conditions. This induces an inward shift in the efficiency frontier: macroprudential support to monetary policy enables to achieve superior performance in terms of macroeconomic stabilisation. Besides, the introduction of countercyclical macroprudential policies limits the extent to which the central bank incorporates specific signals from credit and financial markets in its systematic monetary policy conduct through the cycle (i.e. the optimized Taylor rule coefficients on credit or asset prices). At the same time, the optimized counter-cyclical capital rules lead to excessive volatility in banks' balance sheet, which could be difficult (and sub-optimal) to implement in practice.

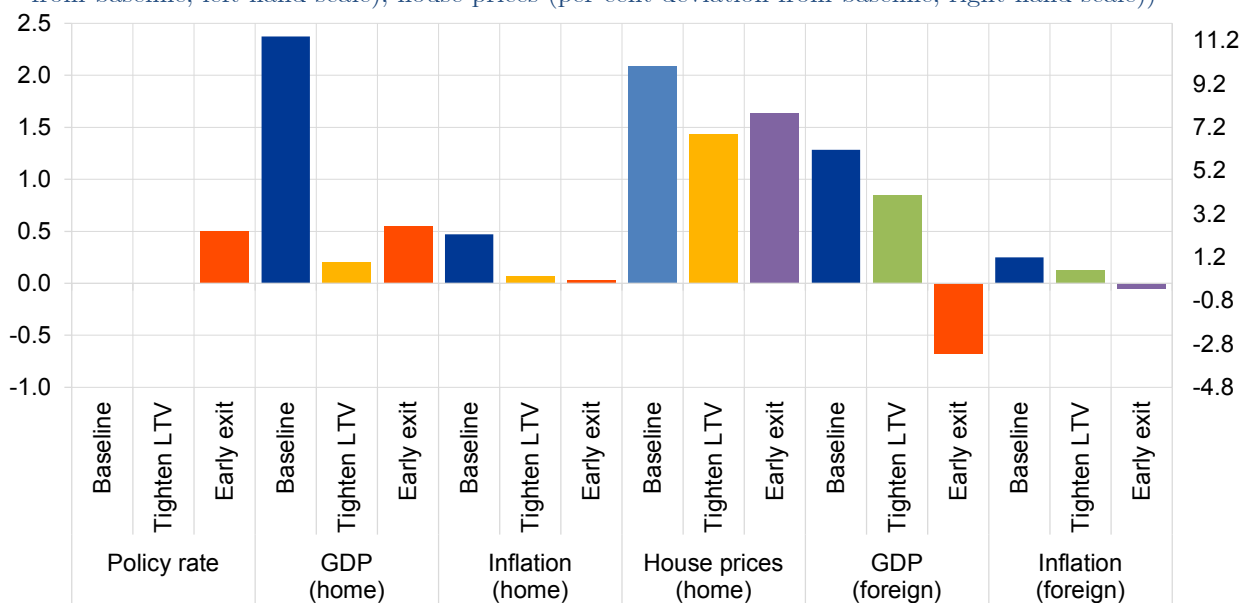
Consequently, the third exercise assumes that policymakers' loss functions also weight the fluctuations in bank leverage through the cycle. In this case, the inward shift in the associate efficiency frontier compared with the reference case, is much less pronounced. With some degree of macroprudential gradualism and implementation constraints, the case for monetary policy to "leaning against" financial factors would still be warranted.

The fourth and final exercise is the same as the previous one but only considering asymmetric financial shocks, as cyclical drivers. It reveals that within the monetary union macroprudential policy support to monetary policy is most suited in the presence of financial shocks (as compared to real and nominal shocks) and when shocks are asymmetric across countries. In those cases there is scope for targeted, countercyclical macroprudential policy to alleviate somewhat the need for monetary policy to "lean against the wind".

### *Curtailing the side effects of low interest rate environment*

The preceding analysis has shown that through the expansionary phase of the financial cycle, monetary and macroprudential policy may reinforce each other. In crisis times, however, they may conflict. The current low yield environment and non-standard monetary policy measures have brought the macro-financial landscape into uncharted territory. The side effects of abundant liquidity and exceptionally low interest rates across the maturity spectrum may well materialise through financial imbalances in some markets segments or jurisdictions.

**Chart 5.4** – Leaning against house price bubbles: LTV ratio measures versus monetary policy (real GDP (per cent deviation from baseline, left-hand scale); inflation (percentage point deviation from baseline, left-hand scale), house prices (per cent deviation from baseline, right-hand scale))



Notes: the scenarios all assume a region-specific gradual rise in housing prices by 10% over a two-year horizon, fueled by positive housing demand factors and loose credit supply conditions on loans for house purchases. In the first scenario, we assume that a countercyclical macroprudential intervention in the booming region through a cap on loan-to-value ratios is introduced while monetary policy is kept constant. In the second scenario, the early exit from the exceptionally loose monetary conditions is proxied by letting the policy rate rise three quarters before the assumption of the baseline scenario.

This constellation would probably require tighter macroprudential requirements at times when the central bank precisely intends to loosen its stance and circumvent the constraints due to the lower bound on interest rates. Such a policy mix implies paramount strategic and implementation challenges. Failing to act on the macroprudential side would lead to inferior outcomes. At the same time, the risk of an inefficient policy mix exists: with too lax monetary policy for the euro area as a whole and too tight macroprudential conditions in some parts of the euro area.

Admittedly, at the current juncture, signs of housing market overvaluation together with rapid credit expansion in some jurisdictions are not tangible. Nonetheless, we will illustrate here the situation in which macroprudential instruments can be efficiently set to mitigate the risks of overheating in some housing market segments, on the back of central bank asset purchase programme

and the policy rate at its lower bound. As shown in the previous section, targeted MPIS with the jurisdiction at risk would be appropriate to address this source of systemic risk.

The scenario analysis is based on the same model calibration as in the previous section. We consider the risk of a region-specific gradual rise in housing prices by 10% over a two-year horizon, fuelled by positive housing demand factors and loose credit supply conditions on loans for house purchases. In the model, buoyant construction activity together with the relaxation of financial constraints for the households sector, support the growth momentum and consumer spending in the booming region. The baseline simulation assumes that monetary policy is unchanged for two-years. Against this background, two situations are contrasted. In the first scenario, we assume that a countercyclical macroprudential intervention in the booming region through a cap on loan-to-value ratios is introduced while monetary policy is kept constant. In the second scenario, the early exit from the exceptionally loose monetary conditions is proxied by letting the policy rate rise three quarters before the assumption of the baseline scenario. The respective simulations are presented in Chart 5.4. It turns out that the macroprudential measures enable to contain the asset price increase in the booming region and to better shield the rest of the euro area. By comparison, the early tightening of monetary policy to mitigate house price growth in the domestic economy delivers significantly more cross-country heterogeneity and negative cross-border spillovers.

### **3. A theoretical model of the financial sector with endogenous size of the shadow banking sector: implications for macroprudential policies**

*Summary of featured paper [6]*

In the decade before the financial crisis, the shadow banking sectors in the United States and the euro area grew rapidly based on a business model that combined highly-leveraged, short-term funding through repos and asset-backed commercial papers with risky long-term investments such as mortgage lending. In the wake of the rise in sub-prime mortgage delinquency rates in the US, shadow banks experienced a sharp contraction in their funding which bore a strong resemblance to a bank-run. The ensuing turmoil in the shadow banking sector quickly spread to the traditional banking sector as well, leading to widespread panic and resulting in the deepest recession experienced by advanced economies since the Great Depression. After a brief decline in 2007-8, the shadow banking sectors in the US and the euro area have continued to grow in recent years, both in absolute terms and relative to the traditional banking sectors in these economies. This has led to concerns about financial stability, as well as policy design due to the still largely unregulated nature of shadow banking.

A theoretical framework which can account for the existence and expansion of the shadow banking sector alongside the traditional banking sector is crucial for our understanding of these recent events and for our ability to forestall future threats to financial stability. This paper constitutes a first step towards such a framework by presenting a model of the financial sector where shadow banking emerges as an alternative business strategy that entails higher leverage and risk-taking than



traditional banking. The size of the shadow banking sector relative to the traditional banking sector is determined endogenously in equilibrium.

Our model is capable of explaining the growth of the shadow banking sector and provides a novel perspective on its potential destabilizing impact on the financial sector as a whole. We find that during periods of stability such as the Great Moderation, the shadow banking sector grows to a size that makes it systemically important. A collapse of the shadow banking sector then triggers a sharp decline in asset prices that leaves traditional banks vulnerable to self-fulfilling bank runs.

In the model, shadow banks are vulnerable to negative signals about future asset returns. In such cases, they face a steep decline in their solvency prospects and are thus forced into early liquidation by their creditors. We refer to this as a fundamental run since it is triggered by a revision of expectations about banks' financial health. The traditional banking strategy consists of forming a portfolio of assets that is safe enough to avert fundamental runs. Market discipline on traditional banks thus arises endogenously in this framework through the threat of early liquidation. The relative size of the two sectors has systemic consequences due to the interaction of banks in a secondary market for assets. When the shadow banking sector is relatively small, secondary market purchases by traditional banks prevent fundamental runs from causing a downward spiral in asset prices. Shadow bank portfolios thus remain endogenously liquid and creditors reclaim most of their funds during a fundamental run. As a result, shadow banks retain the ability to borrow at low cost despite their high risk-taking and their profits surpass those of traditional banks, leading to further growth of the shadow banking sector.

When there is an extended period of stability without any fundamental runs, the shadow banking sector grows to a size where purchases by traditional banks are insufficient to prevent a collapse in asset prices in the case of its liquidation. When a fundamental run eventually takes place, the ensuing drop in asset prices leaves traditional banks illiquid and vulnerable to self-fulfilling bank-runs which we refer to as liquidity runs. The prospect of liquidity runs increases the borrowing costs of traditional banks and undermines market discipline as the promise of high interest rates raises creditors' tolerance to insolvency risk. This leads to greater risk-taking by traditional banks and increases the insolvency risk associated with them.

From a normative perspective, our paper offers two novel insights for policy design. First, we find that policy interventions may have significantly different implications when their impact on the size of the shadow banking sector is taken into account. We demonstrate this by considering an asset purchase scheme whereby the government leans against the collapse in asset prices by purchasing assets in the secondary market. We find that such an intervention is indeed effective when the size of the shadow banking sector is taken as given. However, the expectation of such asset purchases fuels further growth of the shadow banking sector in a manner that offsets the positive effects of the policy. Second, we show that financial stability can be achieved through the taxation of shadow bank profits. We find that such a tax policy deters entry into the shadow banking sector and can be used to

prevent it from reaching a size that is detrimental to financial stability.

Our findings are relevant for both the US and the euro area. The size of the shadow banking sector in the US is roughly equivalent to the traditional banking sector in terms of liabilities and assets. In the euro area, the shadow banking sector is smaller relative to the traditional banking sector but still significant, accounting for nearly half of the assets and a third of the lending of the banking system.

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