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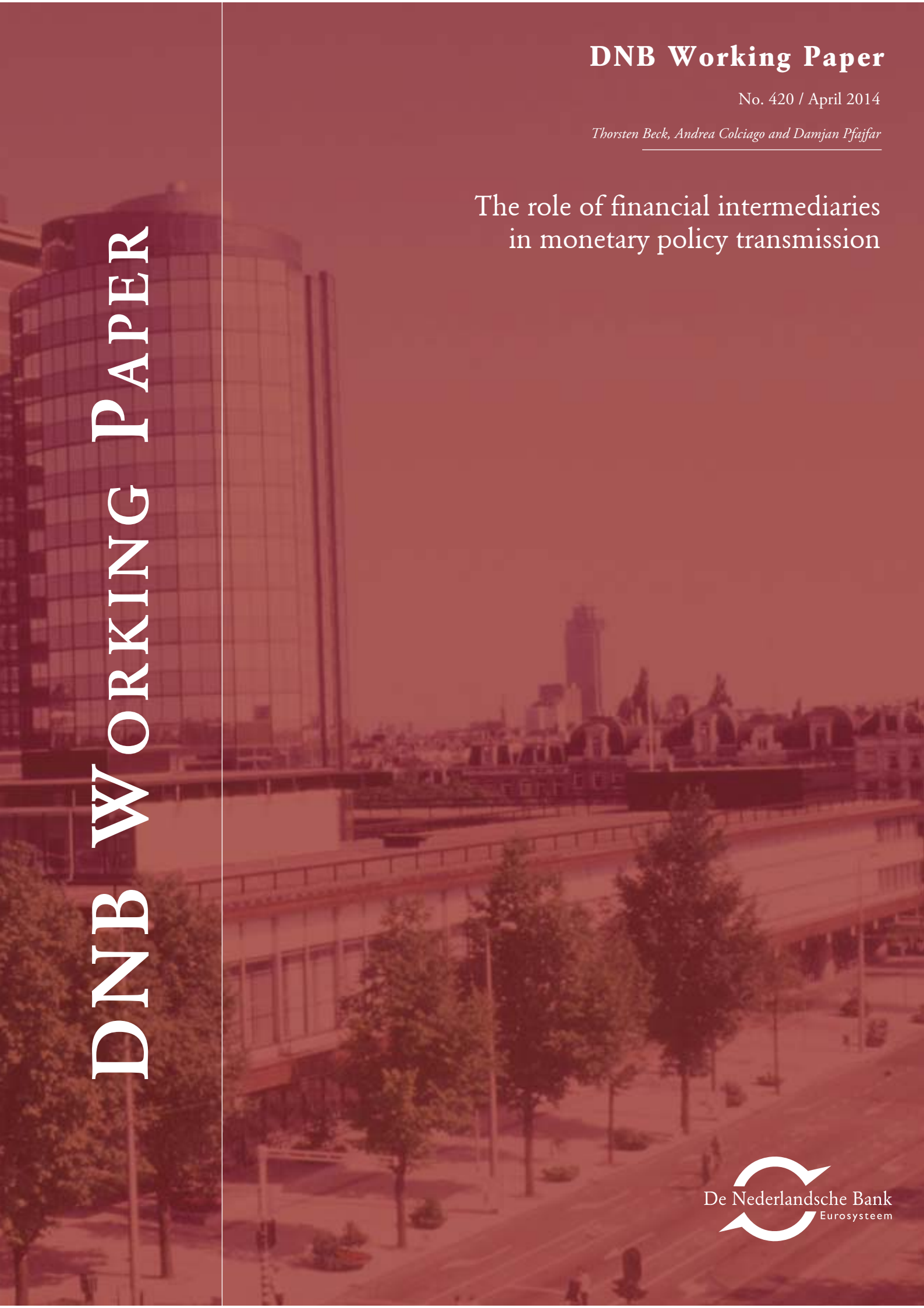

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The Role of Financial Intermediaries in Monetary Policy Transmission

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Abstract

The recent financial crisis has stimulated theoretical and empirical research on the propagation mechanisms underlying business cycles, in particular on the role of financial frictions. Many issues concerning the interactions between banking and monetary policy forced policy makers to redefine economic policies, and motivated macroeconomists to focus on the implications of financial intermediation constraints on asset price fluctuations, the behavior of non-financial firms, households, governments and in turn for real macroeconomic performance. This paper surveys research on the role of financial intermediaries and financial frictions in the transmission of monetary policy and discusses how to design both the new banking regulatory and supervisory structures and monetary policy in order to stabilize the economy. It also serves as an introduction to this special issue.

Keywords: Financial Intermediation, DSGE models, Financial Frictions JEL code: E40, E50, G20

1. Introduction

The recent crises have reignited the discussion on the role of financial intermediaries in monetary policy transmission, both in the presence of weak and fragile banks as in light of monetary policy at the zero-interest bound. While a growing theoretical and empirical literature has shown the relevance of financial frictions and consequently financial intermediaries in propagating monetary policy decisions to the real economy, the recent crisis has provided impetus for additional research, both explaining the build-up of risks during the Great Moderation as well as the functioning of monetary policy during crises and the recovery. One of the lessons of the recent experience is that financial and monetary stability cannot necessarily be targeted independently of each other and that monetary policy transmission mechanisms very much depend on the state of the banking system.

This special issue brings together a set of theoretical and empirical papers that advance the literature on financial intermediaries as a monetary policy transmission channel. The theoretical papers extend existing Dynamic Stochastic General Equilibrium (DSGE) models, explicitly modelling financial frictions, and use the analysis to gauge the interaction between monetary and financial stability. The empirical papers use an array of different data sources and methodologies to explore the role of financial frictions in the run-up to and during the crisis.

While the traditional literature on financial intermediaries as monetary transmission channel has focused on the impact of monetary policy decisions on overall loan supply (exploiting frictions on banks' funding models or agency problems between lenders and borrowers) the post-crisis literature has focused on the risk-taking channel of monetary policy, which postulates that low interest rates lead to lending to riskier borrowers and lower risk premiums. This channel most clearly highlights the close interaction between financial and monetary stability. The macroeconomic literature using DSGE models has modelled the financial sector mostly as a pass-through mechanism, not taking into account financial frictions and their role as amplifier of monetary policy decisions. Post-crisis, there has been an attempt in this literature to incorporate endogenous financial intermediation and thus model the interaction between financial frictions and monetary policy. Most importantly, the recent crisis experience has incentivized financial and

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macro-economists to bridge the gap between the two strands of economics, where the former have traditionally focused on financial institutions but without explicitly considering the interaction with macroeconomic developments, while the latter have focused on macroeconomic policies while ignoring their interaction with the financial system. While macro- and financial economists will continue using different methodologies and techniques, as can also be seen in this special issue, there are attempts to bring these two strands of economics closer together.

This introductory chapter sets the stage by surveying the recent theoretical and empirical literature on banking and its role in monetary policy transmission and recent theoretical and empirical advances in DSGE models with a banking sector. Specifically, we discuss both the traditional literatures and how recent advances, motivated and informed by the crisis, have pushed this literature forward. We link the discussion on papers included in this special issue to the different strands of literature they contribute to and link them to other recent studies. Gertler and Kiyotaki (2010), Shin (2010), Quadrini (2011), Brunnermeier et al. (2012), and Smets (2013), inter alia, also provide extensive surveys about the role of the financial system and of financial frictions for economic outcomes. Brunnermeier et al. (2012) discuss how financial frictions can propagate and amplify shocks at the macro-level, while Quadrini (2011) takes a different perspective and discusses the role of credit and financial shocks as a source of business cycle fluctuations in general equilibrium models. Shin (2010) focuses on the link between securitization, financial innovation and financial stability. Gertler and Kiyotaki (2010) study the real consequences of a breakdown in financial intermediation and Smets (2013) discusses the joint design of monetary and macro-prudential policies.

The remainder of this paper is structured as follows. Section 2 reviews the theoretical literature on banking and its role in the transmission of monetary policy, including recent advances, while section 3 focuses on empirical contributions in this literature. Section 4 discusses theoretical developments of DSGE models with financial frictions, while section 5 discusses the empirical performance of DSGE models with banking. Section 6 relates this recent literature to the current policy debate and looks forward to new research challenges.

2. Recent theoretical literature on banking and its role in the transmission process of monetary policy

The traditional view of monetary policy transmission has focused on the interest rate channel and the substitutability of different asset classes by investors, including banks, as discussed, for example, by Tobin (1969). Through open market operations, the central bank can influence reserve holdings by banks. A tightening of reservable deposits will result in an increase in the interest rates on accounts not subject to reserve requirements, which in turn translates into higher lending interest rates and thus affects the real economy. The condition for this channel to work is that prices do not adjust immediately to changes in money supply. The traditional view of monetary policy transmission views financial intermediaries more as a pass-through mechanism but not as an actor in itself.

The credit channel of monetary policy focuses on interest rate changes affecting loan supply through credit market frictions with an amplifying effect. It thus builds on a very rich literature on the role of financial frictions and financial intermediaries in the real economy and over the business cycle. Starting with Bernanke and Gertler (1989),

this literature has shown that information asymmetries between borrowers and lenders and the resulting agency problems translate in a wedge between the cost of external and internal finance. The size of the external finance premium depends on the quality of the balance sheet of the borrower and varies with the level of interest rates as set by monetary authorities. Amplification comes through a financial accelerator effect. Namely, as the balance sheet quality improves, due to better economic conditions, the external finance premium declines. This allows increases borrowing and investment, which feeds the boom. In this setting a crisis can be generated by a decline in asset values, which deteriorates the conditions of the balance sheet of borrowers, leading to an increase in the external finance premium and hence to lower investment and to reduced economic activity.

The credit channel literature distinguishes between two different mechanisms, the firm balance sheet and the bank lending channels. Through their impact on borrowers' profitability, asset value and thus collateral, interest rate changes directly affect borrowers' ability to borrow (balance sheet effect). The supply of loanable funds is affected if banks cannot easily replace deposit liabilities with non-deposit funding, i.e. different funding sources are not perfectly substitutable (bank lending channel).

Both mechanisms of the credit channel of monetary policy transmission rely on certain frictions in the real world, in addition to limited price flexibility mentioned above. First, reservable and non-reservable liabilities are not perfect substitutes for banks, which implies that a reduction in reservable liabilities translates into a reduction in loan supply by banks. Second, bank and non-bank funding sources are not perfect substitutes for users, i.e. firms and households.

More recently, the literature has pointed to an additional credit channel of monetary policy, beyond changing credit supply and that is through the risk profile of banks' credit decisions. Nicolò et al. (2010) discuss three different channels through which low interest rates can increase risk. First, a low yield on safe assets incentivizes financial intermediaries to substitute them for riskier assets. Second, low interest rates can stimulate a search for yield of long-term savings institutions such as pension funds with long-term return commitments, again resulting in investment in riskier assets. A third channel involves procyclical leverage ratios: as asset prices boom, risk-weighted assets drop, resulting in expansion of banks' balance sheets towards riskier assets as they try to maintain a constant leverage ratio. Dell'Ariccia et al. (2010) present a theoretical model that illustrates some of these channels. They show that if a bank's capital structure is fixed, monitoring depends on the degree of bank capitalization; well capitalized banks decrease monitoring, while highly levered banks increase it. With endogenous bank capital, however, a monetary easing always leads to greater leverage and lower monitoring, thus ultimately higher risk-taking

In addition, financial intermediaries might increase credit risk as a consequence of additional availability of liquidity lowering the sensitivity of bankers' payoffs to downside risks and inducing excessive credit volume and asset price bubbles (Acharya and Naqvi, 2012). While many of these theoretical advances are post Global Financial Crisis and informed by the boom-bust periods of the 2000s, they link to pre-crisis warnings of such mechanisms, most prominently Rajan (2005) and Borio and Zhu (2012).

3. Recent empirical literature on banking and its role in the transmission process of monetary policy

The empirical literature has faced two constraints when testing the impact of monetary policy. First, the supply of credit needs to be disentangled from its demand, as monetary policy changes can affect both. Second, monetary policy decisions might be a reaction to developments in the real economy, including lower credit demand, so that there is an identification challenge when estimating the real impact of monetary policy changes.

The empirical literature has relied on two verifiable assumptions as identification strategies. Specifically, the non-substitutability of different funding sources for banks can be turned into a testable hypothesis that banks with different access to non-deposit funding should also react differently to monetary policy changes. As one example, smaller banks are more likely to reduce their loan supply when monetary policy tightens as they have more limited access to non-deposit sources of funding. Using disaggregated U.S. bank balance sheet data over the period 1976 to 1992, Kashyap and Stein (1995) find that smaller banks' loan supply is more affected by monetary policy changes, while Kashyap and Stein (2000) find evidence that the loan portfolios of smaller, more illiquid banks are the most responsive to monetary policy shocks. Other work has used variation in capital asset ratios and publicly traded vs. non-traded banks as differential characteristics (Kishan and Opiela, 2000, Holod and Peek, 2007 and Peek and Rosengren, 1995) to show differential reactions of banks to monetary policy changes.

The literature has also tested the firm balance sheet mechanism of the credit channel. Kashyap et al. (1993) show that monetary policy tightening results in a reduction of bank loans but in an increase in commercial paper issues, indicating that it was lower loan supply rather than lower loan demand following monetary policy tightening that resulted in lower loan volume. Similarly as the bank balance sheet literature, this literature has used differences across firms to test the firm balance sheet mechanism of the credit channel. As shown by an extensive literature, there is a large variation across firms in the extent to which they suffer from information asymmetries and agency problems, a variation that can be exploited to test the firm balance sheet mechanism. Gertler and Gilchrist (1994) find that the investment of an aggregate of small firms is more responsive to changes in monetary policy than is the investment of an aggregate of large firms, a set of firms that presumably is less bank dependent.

The recent literature has also tested the risk taking channel of monetary policy. Empirical work in this area has used monetary policy decisions exogenous to the economy under study as identification strategy and loan-/borrower-level data to gauge risk differentials. Jimenez et al. (2012), for example, use Spanish credit registry data, rely on the fact that Euro interest rates are exogenous to the country, and exploit cross-bank variation in capitalization and cross-firm variation in riskiness. Their results suggest that looser monetary policy leads less capitalized banks to extend more credit and to riskier firms. Using loan application data, Jimenez et al. (2012) can distinguish between demand and supply side effects and show that the effect of monetary policy on risk-taking works indeed through the supply side through variation in loan granting by banks with different capital or liquidity ratios. Work for Bolivia shows similar results, with funding costs for this dollarized banking system being effectively determined by Federal Reserve decisions (Ioannidou et al., 2009). Specifically, the authors find that a decrease in the policy rate

spurs the granting of riskier loans, i.e., to borrowers with worse credit histories, lower internal ratings, and worse ex- post performance. The negative performance effect is stronger when the rate subsequently increases.

Buch et al. (this issue) use US data for the period 1997 to 2008 to assess the impact of monetary policy on bank risk taking. Using a factor-augmented vector autoregressive model (FAVAR) and information from the Federal Reserve's Survey of Terms of Business Lending (STBL), they show that small domestic banks increase their exposure to risk after expansionary monetary policy shocks. Large domestic banks give out more new high risk loans, but the composition of their loan portfolios does not change significantly. Changes in the risk composition of loan portfolios, however, are not compensated by higher risk premia. This seems therefore clear evidence in favor of the risk-taking channel of monetary policy. These results are consistent with findings by Dell'Ariccia et al. (2013) who combine loan-level data from the STBL with call report data on banks and show a similar risk-taking effect of loose monetary policy that is stronger for less capitalized banks.

While the traditional credit channel literature has focused on firm credit, household credit has become more and more important across the developed world in recent decades (Beck et al., 2012). This implies that there can also be important effects of monetary policy on aggregate demand through households' balance sheets and thus spending patterns. Haltenhof et al. (this issue) explore households' balance sheets as additional channel through which the recent financial crisis in the U.S. has impacted employment. Specifically, they distinguish between four different channels, through the supply of commercial and industrial loans to firms and home equity lines of credit to small business owners, through the supply of consumer instalment loans and access to home equity lines for consumption purposes. Exploring differences in the degree of external finance dependence and of asset tangibility across manufacturing industries and in the sensitivity of these industries' output to changes in the supply of consumer credit, they show that during the recent crisis household access to bank loans mattered more for employment than firm access to local bank loans.

While the literature has typically assessed the firm balance sheet and bank lending channels separately, Meisenzahl (this issue) offers a horserace between the two. Calibrating the Townsend (1979) and the Holmstrom and Tirole (1997) models of these two agency problems against a comprehensive data set of U.S. small business credit contracts from the FRB's Survey of Small Business Finances (SSBF), he finds strong support for the firm balance sheet channel but only little support for the bank lending channel. A complementary regression analysis confirms this result, as variation in firms' net worth can explain variation in the amount and cost of external finance, while banks' balance sheet items cannot. His results is consistent with previous work by Ciccarelli, Maddaloni and Peydro (2010, 2013) who use US and Eurozone lending surveys and a VAR model and find evidence for transmission through banks', firms' and households' balance sheets. They also find a stronger effect of the balance sheet mechanism during normal times, while the bank lending channels gains importance during the crisis. Exploring the relative importance of these different mechanisms is important not only for the quantification of expected real effects of monetary policy changes but also the importance of different banking market structures and firm size distributions across economies in the transmission.

One important condition for the effectiveness of monetary policy transmission is

banks' motives for holding reserves beyond the regulatory minimum. If on the one hand, excess reserves simply reflect the lack of investment opportunities, this would make the transmission channel of monetary policy ineffective and call for non-monetary policy levers to increase real investment. If, on the other hand, excess reserves reflect uncertainty and ultimately a liquidity trap, provision of certainty can be an important tool for monetary policy makers to restore the effectiveness of monetary policy transmission. During the crisis, there were concerns that the rapid increase in reserves held by banks connected to the unprecedented increase in the Fed's balance sheet would undermine the transmission of loose monetary policy into higher bank lending and ultimately economic recovery. Chang et al. (this issue) find evidence for a precautionary motive for reserve accumulation due to weak bank balance sheets, uncertainty about access to short-term liquidity on the market and the perceived lack of lending opportunities to low-risk borrowers. They also show that the Capital Purchase Program of the Troubled Asset Relief Program (TARP) that was used by the Fed to purchase preferred stock and warrants in financial institutions did have a positive impact on lending, as institutions benefiting from this program accumulated fewer excess reserves than comparable financial institutions.

In response to the financial crisis that began in the summer of 2007 and the increasing liquidity problems, central banks around the world have increasingly resorted to non-standard policy measures, including unlimited discount windows and longer-maturity asset purchases. Carpenter et al. (this issue) show that liquidity risk, as measured by the intra-day funding volatility is negatively associated with lower loan supply. They find that most non-standard measures were successful in reducing bank liquidity risk and in doing so have significantly contributed to safeguard the transmission of monetary policy to the respective economies, with the effect being stronger in the US than in Europe. This might be explained by the fact that bank recapitalization proceeded much more swiftly in the U.S. than in Europe

Financial innovation might have also played an important role in the transmission of monetary policy, as argued by many observers (e.g., Smets, 2013). Securitization might have increased risk-taking incentives provided by low interest rates further, as might have the increasing use of different derivatives. Norden et al. (this issue) explore different hypotheses on the effect of credit derivatives on banks' behavior. They find evidence that banks passed on risk management benefits of credit derivatives to corporate borrowers in the U.S. They also find that the magnitude of this effect remained the same during the Global Financial Crisis and that banks with larger holdings of credit derivatives cut their lending by less than other banks and faced lower non-performing assets. This clearly points to positive effects of this specific form of financial innovation and speaks to the current debate on regulating financial innovation.

How has the effectiveness of monetary policy transmission changed over the Great Moderation and the Global Financial Crisis, including with the introduction of non-conventional monetary policy tools? This has been the focus of an increasing number of studies in recent years. Ciccarelli et al. (2013), for example, point to an important interaction between sovereign distress and the effectiveness of monetary policy within the Eurozone. A related question is how the transmission channel of monetary policy has worked during the current recovery phase and will work in the future. One concern in the current zero-interest environment is that low rates and high liquidity encourage yet again aggressive risk-taking. This might become a key concern for systemic risk during current attempts of the Federal Reserve to taper with quantitative easing and to eventually raise

monetary policy rates from the historically low levels seen today to their normal levels. Several of the papers cited above show that too low monetary policy rates for too long followed by strong and fast monetary hikes may imply financial instability.

How effective will monetary policy be in the future? The fact that many assets (once off-loaded to special investment vehicles) have found their way back on banks' balance sheets and the transformation of some investment banks into commercial banks, thus widening the regulatory perimeter, suggests an even stronger monetary policy transmission role of the banking sector. A similar trend might come from the increasing restrictions on cross-border bank flows that have been imposed by regulatory authorities and that thus avoid "leakages" of monetary and macro-prudential policy decisions. On the other hand, if these trends are temporary and crisis-contingent and will reverse later into an increasing importance of alternative funding channels for the real economy, this would suggest a lower efficiency of monetary policy transmission. Similarly, the continuously strong importance of shadow banking systems across the developed world makes monetary policy a continuously tricky exercise.

4. Theoretical developments of DSGE models with financial frictions

In the last twenty years financial factors have been mostly neglected by mainstream business cycle models. Although past episodes such as the U.S. Great Depression, or the Japanese recession in the 90s point to the importance of financial frictions for the business cycle, finance was considered a factor of second order of importance when trying to explain aggregate fluctuations.

Common practice in policy institutions was to conduct business cycle analysis on the basis of large scale DSGE models characterized by price and wage stickiness together with frictions on multiple margins of adjustments. Prominent examples of policy oriented DSGE models are Christiano et al. (2005) and Smets and Wouters (2003, 2007). In both cases the financial sector plays no role. This comes as a surprise in light of the fact that general equilibrium theory recognized the importance of financial frictions for business cycle fluctuations already a long time ago. Bernanke and Gertler (1989), Kiyotaki and Moore (1997) and Bernanke et al. (1999) taught us the importance of financial factors for business cycle fluctuations adopting general equilibrium models.

The recent financial turmoil served as a wakeup call, and economists in academic and policy institutions are now striving to recover this neglected tradition by incorporating financial frictions into standard macroeconomic models.[4] This seems a promising avenue of research. Del Negro et al. (2013) estimate a DSGE model similar to that by Smets and Wouters (2007) extended to include financial frictions a la Bernanke et al. (1999) with data up to 2008 (so the model is not estimated to fit the post-2008 data). They show that as soon as the financial stress increased in 2008, the model successfully predicts a sharp contraction in economic activity. A modest and persistent decline in inflation is also obtained if state dependent nominal rigidities are introduced.

[4] Gerke et al. (2013) compare the properties of five medium-sized general equilibrium models used by central banks in the Eurosystem that incorporate financial frictions. A medium-scale DSGE model is a standard three equation NK model augmented with a set of additional features such as capital accumulation or public debt dynamics. This additional features usually improve the performance of the baseline NK model at replicating inflation, consumption and investment dynamics.

In this section we provide a brief review of the main approaches to model financial frictions in general equilibrium models used for policy analysis.[5] As argued by Gertler and Kiyotaki (2010) the current crisis has witnessed a significant disruption of financial intermediation, bringing the analysis of the role played by financial intermediaries for business cycle fluctuations at the forefront of research. The papers collected in this issue provide a step forward in this area by explicitly considering the role of financial intermediation in general equilibrium. On the contrary, the bulk of the literature developed before the crises emphasized credit market constraints on non-financial borrowers and treated intermediaries as a veil.

We classify the papers we review into the following two categories. The first one includes papers which impose a credit constraint on non-financial borrowers; the second one includes papers where the credit constraint is imposed on financial intermediaries. We find this distinction relevant from both an expositional and a historical perspective. Furthermore, since monetary and fiscal authorities in many countries have employed various unconventional policy measures that involve some forms of direct lending in credit markets we discussing these measures along the way.

4.1. Credit constraints faced by non-financial borrowers

Bernanke and Gertler (1989) and Carlstrom and Fuerst (1997), *inter alia*, endogenize financial frictions by introducing an agency problem between the lender and the borrower. Essentially, these models depart from the standard Real Business Cycle (RBC) setting assuming the presence of two agents: consumers and entrepreneurs. In this setting entrepreneurs have the opportunity to create capital from the consumption good. To finance this production they invest their own wealth and borrow funds from households subject to a friction. The friction is that the idiosyncratic productivity of entrepreneurs is not readily observable by others. Consumers can observe the productivity of entrepreneurs at a cost. The optimal contract between the households and the entrepreneur that takes the form of debt ensures that the latter does not take advantage of his superior information. The entrepreneur is audited by the lender solely if he fails to repay. As mentioned above, this agency problem introduces a wedge between the internal and the external cost of finance and implies a financial accelerator effect in general equilibrium.

Kiyotaki and Moore (1997) depart from the costly state verification by adopting a collateral constraint on borrowing. In their economy credit constraints arise because lenders cannot force borrowers to repay their debt, unless debt is secured. Therefore credit constraints take the form of collateral constraints. The flow of funds from lenders to borrowers is motivated by the preference heterogeneity: the lender is more patient–i.e. he has a higher discount factor–than the borrower. In their framework a durable asset (land) is used both as a production input and as collateral for borrowing. Creditors protect themselves against the risk of default by collateralizing the borrower's land. The borrower gets the loan equal to the value of his collateralizable assets–i.e. the present value of his current landholding–and thus facing a financing constraint. As a consequence, production depends upon collateralizable wealth: the higher net worth, the higher the volume of credit extended, investment, and production. The interaction between credit

[5] Williamson (2012) integrates financial intermediation theory also with a New Monetarist monetary framework using a model of public and private liquidity.

limits and asset prices is a powerful transmission mechanism through which the effects of shocks persist, amplify, and spread out. In a similar spirit, Iacoviello (2005) introduces a collateral constraint in a New Keynesian (NK) DSGE model. In his model households derive utility from housing services. Impatient households and entrepreneurs borrow from patient households in order to purchase housing. The amount they can borrow today is limited to a fraction of the discounted value their housing stock will have tomorrow. Importantly, contracts are expressed in nominal terms. A conditional financial accelerator mechanism characterizes models adopting this framework. Shocks that stimulate aggregate demand lead to a higher consumption and asset prices. This positively affects the borrowing capacity of debtors, allowing them to spend and invest more. Since contracts are in nominal terms, the rise of consumer prices reduces the real value of debtors' obligations, positively affecting their net worth. Given borrowers have a higher propensity to spend than lenders, the net effect on demand is positive and acts as an amplification mechanism of demand shocks. On the contrary, it dampens the effects of those shocks that lead to a negative correlation between output and inflation, such as aggregate technology shocks. For this reason we label this mechanism as a conditional financial accelerator: the amplification depends on the source of uncertainty.

Iacoviello and Neri (2010) extend the approach by Iacoviello (2005) to a medium scale NK model. They find that the fluctuations in the housing market contributed substantially to the variability of consumption growth in the period 1989-2006. Moreover, they show that the wealth effect on consumption increases with the fraction of households who use their home as collateral. Using the same model, Guerrieri and Iacoviello (2013) study asymmetric responses to house price changes. Recent contributions in this vein of literature that models heterogeneous agents with occasionally binding constraints also include, among others, Mendoza (2010), Justiniano et al. (2013), and Liu et al. (2013). Calza et al. (2013) study, in a similar setting, the implications of housing finance for the monetary transmission mechanism. Jensen et al. (2013) examine financial liberalization in a model with multiple credit constraints. Softer equity requirements in their model lead to higher macroeconomic volatility, stronger comovement between debt and output, and more asymmetric business cycles, thus casting doubts about the financial liberalization story of the Great Moderation. Optimal policy in a setting with occasionally binding constraints modelled in line with Mendoza (2010) is studied in Benigno et al. (2012). They focus on the questions whether the policy maker should wait and intervene after the start of the financial crisis or rather act in a preemptive manner. Sheedy (2014) shows that the functioning of incomplete financial markets when incomplete contracts are written in terms of money can be improved with a monetary policy targeting nominal GDP.

Jermann and Quadrini (2012) propose a model with financial frictions, in the tradition of Kiyotaki and Moore (1997) and Bernanke et al. (1999), which in contrast to the traditional approach, aims at reproducing the cyclical behavior of financial flows. They distinguish three sources of funding for non-financial firms, i.e. intraperiod loans (also referred to as working capital loans), intertemporal debt, and equity. In this setting, debt and equity are close substitutes, with a clear preference by firms for debt (following the pecking order theory of corporate finance). The ability to borrow, however, is limited by the enforcement constraint. They treat the enforcement constraint not only as a financial friction, which plays the role of a propagation mechanism for real shocks, but also as a source of financial shocks. Their results indicate that a model with only a financial shock

mimics the US data closer than a model with only a technology shock.

Models discussed so far focus on the demand side of the credit market. As mentioned above the financial crisis has shown how changes in credit supply can have a fundamental role for macroeconomic fluctuations. For this reason, more recent contributions consider the role of financial intermediaries and the general equilibrium effects spreading from the deterioration of their balance sheets and from the presence of capital requirements. We discuss these models in the next section. Most of the papers in this issue build on the contributions we have just sketched to improve our understanding of the role played by financial intermediaries for aggregate fluctuations.

4.2. Credit constraints faced by financial borrowers

In the models described in the previous section credit transactions are market based and do not assign any role to financial intermediation. However, financial intermediaries play a prominent role in modern financial systems. As reported by Gerali et al. (2010) in 2006 bank deposits in the euro area accounted for more than three quarters of household short-term financial wealth. For firms bank lending accounted for almost 90 per cent of total corporate liabilities in 2005.

Christiano et al. (2010) and Goodfriend and McCallum (2007) augment a standard DSGE model with a competitive banking sector and a multiplicity of financial assets which differ in their returns. Gerali et al. (2010) and Aslam and Santoro (2008) take a further step augmenting a DSGE model with a monopolistically competitive banking sector. In this setting banks have the market power to set interest rates, such that a spread between deposit and lending rates arises. Banks supply loans to the private sector using either deposit or bank capital and are subject to an exogenous leverage ratio. This implies that bank capital has a fundamental role in determining credit supply conditions. Since bank capital is accumulated through retained earnings, a shock negatively hitting the profitability of banks will impair their ability of raising new capital. As a result of their deteriorated financial position banks may reduce the amount of loans they are willing to supply, thus deepening the initial contraction. Gerali et al. (2010) estimate the model with Bayesian techniques and evaluate the contribution of shocks in the banking sector to the slowdown of 2008. They find that shocks in credit supply can have dramatic real effects. A reduction in bank capital forces banks to raise interest rates which results in a lower demand for loans by households and firms, who in turn are forced to reduce consumption and investment. The model has also implications for the transmission of monetary policy. Since banks face quadratic adjustment costs for changing the rates they charge on loans, the model features imperfect bank pass through. While financial frictions amplify the effects of monetary shocks compared to what can be observed in a standard NK model, imperfect bank pass through dampens the effects of changes in the real rate of interest. Gertler and Karadi (2011) propose a quantitative model of unconventional monetary policy. In their model financial intermediaries face endogenous financial constraints due to the presence of a moral hazard problem. Specifically, after collecting household deposits, the banks' managers can divert a fraction of the assets and declare bankruptcy. Hence banks collect households' deposits if their expected value is such that there is no incentive to divert assets. This implies that the ability of a bank to attract deposits and to extend loans to firms is positively related to its current net worth and to its expected future earnings. As a result intermediaries' leverage ratios are endogenously constrained. In this framework a shock that disrupts banks' capital

reduces lending and borrowing through increased credit costs that amplify the effects of a downturn. The design of unconventional monetary policy builds on the fact that the central bank acts as an intermediary by borrowing funds from savers and lending them to investors. Since the central bank is assumed to always honor its debt, it does not face constraints on its leverage ratio. In a period of financial distress, the central bank can support credit flows. However, it is assumed that private intermediation is more efficient than public intermediation. The authors find that as long as the efficiency costs of public interventions are limited, the welfare gains spreading from active credit policies may be quite significant.

Cúrdia and Woodford (2011) extend an otherwise standard NK model to consider financial intermediation. In their paper intermediation happens among households and not between households and firms. Due to different rates of patience some of the households are borrowers while others are lenders. The financial imperfection in their model takes the form of a wedge between borrowing and lending rates, which may be either due to the use of resources in intermediation, or due to the market power of intermediaries. An increase in the wedge, at the same average interest rate, decreases the lending rate and increases the borrowing rate. As a result lenders reduce their savings and borrowers their borrowing. As observed by Blanchard (2008), this has both a redistribution effect and an aggregate effect. Redistribution between the two groups of households results in a higher consumption by lenders and a lower consumption by borrowers. Since lenders have lower consumption than borrowers, they account for a smaller fraction of the total demand for goods. Thus, their higher consumption is more than offset by the lower consumption of the borrowers and aggregate demand declines. Importantly, the aggregate effect tends to be small. In their framework the central bank can still affect the lending rate, and for a given wedge, the borrowing rate. Cutting the policy rate to maintain a roughly constant borrowing rate can be, depending on the underlying source of uncertainty, a good policy. On the basis of these findings the policy implemented by the Federal Reserve over the last few years is, thus, to be praised. Angeloni and Faia (2013) present a framework with optimizing banks subject to runs and study its interplay with the bank capital regulation when banks are risky and expansions increase bank leverage and risk. They find that risk-based capital requirements amplify the cycle and thus are not desirable from the welfare perspective. They argue that from a pool of simple policy rules, in their environment the best combination includes mildly anticyclical capital ratios (as in Basel III) and monetary policy responding to asset prices or bank leverage. Collard et al. (2012) present a jointly optimal (Ramsey) setting of monetary and prudential policies in a model where financial fragility arises from socially excessive risk-taking by banks due to limited liability and deposit insurance. Optimal policy assigns the prudential instrument to preventing inefficient risk-taking by banks while it assigns the interest rate policy to managing business cycles. They point out that the latter, under certain assumptions, cannot serve as the first line of defense against financial instability.

Gambacorta and Signoretti (this issue) also study the design of monetary policy in a model with financial frictions. Using a simplified version of Gerali et al. (2010) they examine the performance of augmented Taylor rules that adjust the policy rate in response to asset prices and credit indicators, comparing them to standard rules that

feature either strict or flexible inflation targeting.[6] The key result is that even if financial stability does not represent an explicit policy target, monetary policy rules that enhance financial stability may be desirable in the presence of supply-side shocks. This is so since financial frictions crucially affect the trade-offs faced by monetary policy. Further, the gains with respect to strict inflation targeting and to inflation targeting are substantially amplified in the presence of high private sector indebtness.

While Gambacorta and Signoretti (this issue) focus on interest rate policies Kiley and Sim (this issue) evaluate different public policies designed to address balance sheet problems at financial institutions. The key ingredient in their model is that financial intermediaries are required to make investment commitments before the realization of risk. Then, they make the dividend payout/equity issuance decisions. This friction implies that balance sheet conditions of financial institution affect the real economy. The authors use their framework to evaluate several public policies. In the short run, they find that capital injections may be more effective than direct lending or asset purchases. Also they find that higher capital requirements should be introduced gradually as they can have a sizeable short run impact.

During the financial turmoil, the monetary and fiscal authorities in many countries have employed various unconventional policy measures that involve some forms of direct lending in credit markets. Ellison and Tischbirek (this issue) examine the effectiveness of unconventional monetary policies. The analysis builds on a preferred habitat assumption, which considers preferences of investors for specific asset maturities. Specifically, long and short-term government bonds are treated as imperfect substitutes. In this case the central bank is endowed with a wider set of policy instruments and economic variables are affected by the entire yield curve. It is shown that, under specific conditions, the careful management of both the short-term and the long-term rates leads to significant welfare gains with respect to the case where the central bank uses only one instrument. Aksoy and Basso (2014) also study unconventional monetary policies and the interaction with spread movements. Their DSGE model with banking produces endogenous variations in term spreads as a result of changes in banks' portfolio decisions and their appetite to bear the risk of maturity transformation. The unconventional monetary policy considered in their paper is allowing banks to sell assets to the central bank. They suggest that these types of interventions exploit a new channel of policy transmission through banks' portfolio choice and thus affecting the yield curve.[7]

Similarly to Woodford (1998, 1998) and Gertler and Karadi (2013) also van der Kwaak and van Wijnbergen (this issue) allow financial intermediaries to hold long term government bonds. They study the interaction between sovereign debt and the credit market, allowing for the possibility of a government default. This framework is particularly well suited to describe the current Eurozone situation. Their model generates a channel of transmission from financial shocks to the real side of the economy working through the interaction between credit markets and public debt. Suppose that banks face an adverse shock that deteriorates their balance sheet and thus increases credit spreads. If the public sector is indebted, interest rates also rise due to no arbitrage. However, if the default

[6] Carlstrom and Fuerst (2007) study the implications of responding to asset prices in a standard NK framework, while Pfajfar and Santoro (2014) in a framework with credit market distortions.

[7] For empirical studies on the efficacy of unconventional monetary policy see, e.g., Hanson and Stein (2012), Gertler and Karadi (2014) and Gilchrist et al. (2013).

probability depends to some extent on the real service of debt and the same public debt is in the same balance sheet of banks, the effect of the initial financial shock might be amplified by government's default. The amplification mechanism is further enhanced if long term government bonds are introduced.

The article by Dewachter and Wouters (this issue) builds on recent contributions by He and Krishnamurthy (2014), Mendoza (2010) and Brunnermeier and Sannikov (2014) to develop a model where financial intermediaries face occasionally binding capital constraints; empirical support for these can be found in Gilchrist and Zakrajšek (2012a) and Adrian and Boyarchenko (2012). These models are usually spelled out in continuous time and solved with global solution methods. It is well known that discrete-time models with occasionally binding constraints are difficult to solve in the presence of a large state space. Dewachter and Wouters (this issue) propose a third order perturbation-based method to solve for a local approximation of these class of models and carefully compare the approximate solution with the global one. Thus, they provide a useful approximate solution method for the class of models with endogenous financial risk.

5. Empirical evaluation of DSGE models with financial frictions

The literature offers alternative microeconomic foundations for financial frictions. A crucial step is, thus, understanding which mechanism is favored by the data.[8] With respect to the empirical evidence discussed in Section 3, the empirical DSGE literature focuses on the direct test of alternative models. Christensen and Dib (2008) and Gilchrist and Zakrajšek (2012b) estimate a DSGE model with a financial accelerator mechanism, characterized by an external finance premium as in Carlstrom and Fuerst (1997) and Bernanke et al. (1999). They uncover a significant accelerator mechanism in U.S. fluctuations over the period 1973-2008. In particular, they find that increases in the external finance premium lead to significant and protracted declines in investment and output.

Their results are confirmed by Brzoza-Brzezina and Kolasa (2013), who compare three alternative DSGE models with Bayesian techniques. More precisely they consider as a benchmark the NK model by Smets and Wouters (2007) and compare it to a model characterized by an external finance premium and a model featuring a borrowing constraint as in Kiyotaki and Moore (1997). All models are estimated using U.S. quarterly data over the period 1973-2008. Evidence from marginal likelihoods shows that models with an external finance premium are more in line with the data than models with a collateral constraint, however a clear-cut improvement with respect to the benchmark NK model cannot be observed. Villa (2013) performs a similar exercise. She considers the NK model by Smets and Wouters (2007) and compares it to two alternative frameworks. The first one is a Smets and Wouters (2007)-type model augmented with costly state verification a là Bernanke et al. (1999); the second one is again a Smets and Wouters (2007)-type model augmented with financial frictions originating in financial intermediation as in Gertler and Karadi (2011). All models are estimated with Euro Area quarterly data over the period 1980-2008. The analysis shows that the Smets and Wouters framework augmented with frictions a là Gertler and Karadi (2011) delivers a series of the spread

[8] As financial and uncertainty shocks are often coinciding it is difficult to disentangle them. See, e.g., Caldara et al. (2013).

that comoves more strongly with its available proxies and outperforms the other models in terms of the predictive power of inflationary pressure.

Christiano et al. (2010) also consider a Smets and Wouters (2007)-type model augmented with a detailed description of the financial sector. In their model financial intermediaries finance working capital requirements by producers and entrepreneurs' long term projects. Loans are financed with deposits paying a non-contingent nominal rate. Entrepreneurs' projects are risky because they are subject to idiosyncratic shocks. As a result their model features both agency problems, which result in a financial accelerator mechanism, and liquidity constraints on banks. They estimate the model on Euro Area and U.S. data. The model is enriched with shocks to preferences, technologies and policies. Two financial shocks, which perturb the demand for capital, are considered: the "risk shock" perturbs the dispersion of returns on investment and affects the borrowing and lending propensities; the "financial wealth shock" changes the total value of equity of the economy. These shocks explain a substantial fraction of economic fluctuations. The risk shock, in particular, explains more than a third of the volatility of investment in the Euro area and over 60 per cent in the U.S. They also find that the amount of credit extended by financial intermediaries affects the behavior of the economy even in normal times. They argue that low growth since the second half of 2008 is partially the result of a shift in banks' preferences for liquidity. As already mentioned, Del Negro et al. (2013) show that a Smets and Wouters (2007) model augmented with an external finance premium originating from a Bernanke et al. (1999) agency problem can predict the recession as of the third quarter of 2008.

Jermann and Quadrini (2012) document that equity payouts and debt repayments are strongly correlated with GDP, and make an effort to capture this comovement in their model. As mentioned above they treat the enforcement constraint as a source of financial shocks. To empirically assess the relevance of this financial shock they estimate a Smets and Wouters (2007) model extended with the financial shock and a variable representing financial flows, debt repurchase. Variance decomposition of the estimated model shows that the financial shock contributes significantly to the volatility of real variables. Iacoviello (2014) using Bayesian methods estimates a model with banks and financially constrained households and firms. He studies the role of different financial shocks and frictions during the financial crisis, which is initiated by losses suffered by financial intermediaries and exacerbated by their inability to extend credit to the real economy. He concludes that financial shocks account for more than one half of the decline in private GDP during the last recession.

We conclude this session with a word of hope. DSGE models should not be dismissed on the basis on the fact that they could not predict the last recession. Results discussed so far suggest that DSGE model with financial frictions are a fertile and promising area of research.

6. Policy implications and looking forward

The 2007-8 crisis has not only led to a flurry of new studies in the role of financial intermediaries in monetary policy transmission as discussed in this paper, but, motivated by these advances, a discussion of monetary policy frameworks and their interaction with financial stability frameworks. The crisis experience has also given more prominence to

macro-prudential regulation as a policy tool to directly address the interaction between price and monetary stability.

But how do these three policy frameworks (monetary, macro- and micro-prudential) interact with each other? As discussed by Smets (2013), one can broadly distinguish between three different views on the interaction between price and financial stability. First, and building on the traditional view that monetary and financial stability objectives can be addressed separately, is the view that macro-prudential and monetary policy makers can address consumer and asset price stability with separate tools, with little interaction needed. A second view argues, based on the evidence of the risk-taking channel of monetary policy, that monetary policy has an important role to play in "leaning against the wind", although it might involve a certain trade-off in terms of too high an output gap (Woodford, 2012). A third view argues that monetary and financial stability cannot be separated and that the health of financial intermediaries determines money creation and monetary policy transmission (Brunnermeier and Sannikov, 2014). This academic debate has important repercussions for policy as it also implies different institutional structures. While the first view, referred to by Smets (2013) as the modified Jackson Hole consensus allows for separate institutions being responsible for monetary and macroprudential policies, the other views foresee a close, possibly institutional interaction between both policy areas.

As recent events have shown, there is a fundamental link between the real economy and the financial system. The study of instruments and policies aimed at isolating as much as possible the former from shocks originating in the latter is at heart of the current economic debate. The research discussed in this paper and the different papers included in this special issue point to further need for research in this area.

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