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What Do We Know About the Effects of Macroprudential Policy?

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The literature on the effectiveness of macroprudential policy tools is still in its infancy and has so far provided only limited guidance for policy decisions. In recent years, however, increasing efforts have been made to fill this gap. Progress has been made in embedding macroprudential policy in theoretical models. There is increasing empirical work on the effect of some macroprudential tools on a range of target variables, such as quantities and prices of credit, asset prices, and on the amplitude of the financial cycle and financial stability. In this paper we provide a critical review of recent progress in theoretical and empirical research on the effectiveness of macroprudential instruments.

INTRODUCTION

> The application of these so-called macroprudential policies is still very much at the developmental stage. When the Bank gained operational responsibility for monetary policy in 1997, there was a long history of practical experience, together with a vast theoretical and empirical literature for us to draw on. That didn't make setting monetary policy easy, but it certainly helped. By comparison, we are still in the Stone Age in respect of deploying macroprudential policies. There is lots of scope for academia to help us out here, on both the theoretical and empirical fronts. (Bean 2012)

The global financial crisis has highlighted the need to go beyond a purely micro-based approach to financial regulation and supervision. With the benefit of hindsight, there has been a fundamental lack of understanding of system-wide risk.

There is a growing consensus among policymakers that a macroprudential approach to regulation and supervision should be adopted. In a very influential speech, Ben Bernanke (2011) stated that: 'Financial stability policy encompasses, as the first line of defense at least, a range of microprudential and macroprudential tools, both structural and varying over the cycle, supported by enhanced monitoring and analysis of potential risks to systemic stability.' Policymakers around the globe are currently working on implementing macroprudential policy tools and frameworks. These efforts involve coordination among central banks, governments and regulatory authorities (which may also be the central bank). At the same time, analysis is still needed about the appropriate macroprudential tools, their transmission mechanism and their effects.

Theoretical models of macroprudential policy are still in their infancy and therefore provide only limited guidance on how to think about its impact. However, major efforts have been undertaken over the past years to pursue this line of research. Empirical evidence on the effects of macroprudential instruments is still scarce, given that they have become standard policy tools only in recent years. In advanced countries, the experience with macroprudential policy is fairly recent, although some measures to support the domestic financial system and to influence the supply of credit taken in the 1930s and 1950s have been viewed as macroprudential tools (Haldane 2011). By contrast, central

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banks in emerging market countries have been regular practitioners of macroprudential policy, without calling it by this name (McCauley 2009).

This paper aims to tie together theoretical and empirical contributions to the literature on macroprudential policy. The aim is to provide guidance on how to think about the effectiveness of macroprudential tools and how they are transmitted to financial intermediation and macroeconomic activity. In our analysis we focus on effectiveness in terms of achieving stated intermediary goals of macroprudential policy.

The remainder of the paper is organized as follows. Section I discusses the market failures that macroprudential tools are meant to solve. We structure this discussion around the distinction between objectives, intermediate targets and instruments that is common in the literature on monetary policy. Section II provides an overview of the usage of macroprudential tools, including an overview of the historical experience. Section III reviews alternative theoretical and empirical approaches to gauging the effectiveness of macroprudential tools. Section IV discusses the main issues affecting the effectiveness of macroprudential instruments, and Section V concludes.

I. Macroprudential Policy: from Goals to Instruments

To structure our discussion of the effectiveness of macroprudential policy, we use the distinction common in the monetary policy literature between objectives, intermediate targets, and instruments.[1] This framework has recently also been introduced formally in the literature on macroprudential policy (Schoenmaker and Wierts 2011).[2] The current state of knowledge about the framework of these two policies is, however, very different. There has been a clear consensus on the goals and instruments of monetary policy since the 1980s, even though the global financial crisis has triggered a rethinking of the predominant framework.[3] This is not the case for macroprudential policy, whose goals and instruments are less well-defined.[4] In this section, we discuss recent advances in research that underpin a classification of objectives, targets and instruments of macroprudential policy.[5] Table A1 in the Appendix illustrates this classification.

Objectives

In a nutshell, the objective of macroprudential policy is to use prudential means to enhance system-wide financial stability, with a view to limiting macroeconomic costs from financial distress.[6] The vulnerability to distress is endemic to the financial system because of a fundamental externality in financial intermediation: what is prudent from the perspective of an individual financial intermediary might be imprudent from a macro perspective.[7] This idea explains a key difference between the traditional microprudential perspective on regulation and the perspective of macroprudential policy. The former aims at enhancing the safety and soundness of individual financial institutions in an effort to protect depositors. The latter instead focuses on the stability of the financial system as a whole.

These two perspectives reflect two fundamentally distinct views on the nature of risk in the financial system. It is taken as exogenous under the microprudential perspective, while the macroprudential perspective emphasizes the endogenous nature of systemic risk. In turn, this endogenous systemic risk has two dimensions: a time-varying dimension, which captures the procyclicality of the financial system; and a 'structural'

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dimension, which focuses on the interconnectedness of individual financial institutions and markets, as well as their common exposure to economic risk factors.[8]

Intermediate targets

The intermediate targets of macroprudential policy can be related to externalities that arise along these two dimensions of systemic risk.[9] In the time-series dimension, macroprudential policy counters financial booms by addressing externalities generated by collateralized borrowing.[10] These externalities arise because individual borrowers do not internalize the effect of their borrowing decisions on asset prices, and hence the impact of their increasing leverage in good times on their deleveraging during bad times (Bianchi and Mendoza 2010; Bianchi *et al*. 2012; Jeanne and Korinek 2010; Benigno *et al*. 2013). This leads to swings in credit and asset prices, and ultimately can result in fire sales.[11] These swings can be amplified by herding behaviour as a result of 'strategic complementarities', that is, externalities that reflect strategic interactions of financial institutions (De Nicolò *et al*. 2012; Aikman *et al*. 2015). In addition, excess risk-taking and leverage can arise because individual borrowers take on insufficient insurance against deleveraging episodes associated with a liquidity trap (Korinek and Simsek 2016).

In the structural dimension of systemic risk, macroprudential policy aims at strengthening the resilience of the financial system by addressing externalities arising from market structure—interconnectedness, size, and position in the market—and in the financial infrastructure.[12] These externalities exist because financial institutions do not internalize the impact of their exposures in the interbank market or other financial market segments on systemic risk. This impact is particularly strong for systemically important financial institutions.

An important distinction, which cuts through the time-series and structural dimensions of systemic risk, is between externalities on the supply side and on the demand side of credit. Jeanne and Korinek (2014) argue that in practice, macroprudential policy has mainly been designed to regulate banks, in an attempt to influence indirectly the actions of non-financial borrowers. They stress that important externalities also arise on the demand side, for example because borrowers endogenously accumulate leverage even though they are aware that borrowing constraints will be tightened in the future. Macroprudential policy can be welfare improving to the extent that it provides incentives to borrowers to take on more insurance against deleveraging episodes (Korinek and Simsek 2016).

Instruments

In order to relate macroprudential instruments to intermediate targets, it is important to first define their perimeter. In contrast to the literature on monetary policy with its clear-cut consensus on the role of different instruments, the literature on macroprudential policy has looked at a wide range of possible tools without a primary instrument emerging. It has only recently been converging towards a common understanding of its perimeter.

A recent survey conducted among central banks reveals that there are three grey areas in regard to what counts as a macroprudential instrument: capital controls, measures that focus on the infrastructure of the financial system, and crisis management and resolution (Committee on the Global Financial System (CGFS) 2010). We follow IMF (2011b) and consider capital controls as macroprudential instruments if they are

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geared towards systemic risk and are underpinned by strict governance arrangements.[13] We also look at measures geared towards strengthening the resilience of the infrastructure of the financial system, in line with current consensus (e.g. Group of Thirty 2010; BIS/FSB/IMF 2011a,b; Schoenmaker and Wierts 2011). By contrast, we exclude crisis management and resolution from our analysis, on the grounds that these measures are reactive rather than preventive (see, for example, IMF 2013a,b; Osiński *et al*. 2013).

Once this perimeter is determined, macroprudential instruments can be classified according to the externalities they can address, and in particular those generated by collateralized borrowing, by strategic complementarities, and those related to market structure and infrastructure. De Nicolò *et al*. (2012) present a systematic mapping of different externalities into instruments. They argue that alternative macroprudential tools are often complementary, suggesting that there is no one-to-one mapping between externality and instrument. This line of research therefore suggests that a combination of tools is likely to be more effective in tackling a market failure.

Furthermore, it is possible to distinguish macroprudential tools according to whether they address externalities on the lender or the borrower side. Recent systematic empirical analyses of the effects of macroprudential instruments follow this distinction (Claessens *et al*. 2013; Cerutti *et al*. 2015). These papers classify macroprudential tools into borrower-targeted policies (those aimed at borrowers' leverage and financial positions) and financial-institutions-targeted policies (those aimed at financial institutions' assets or liabilities). The former include caps on the debt-to-income (DTI) ratio and the loan-to-value (LTV) ratio.[14] The latter include limits on domestic currency loans, limits on foreign currency loans, countercyclical capital buffers, the leverage ratio for banks, time-varying (dynamic) loan-loss provisioning, margining requirements on secured financing and derivative transactions, reserve requirement ratios, a levy on financial institutions, capital surcharges on systemically important financial institutions, limits on interbank exposures, concentration limits, limits on open foreign exchange positions or currency mismatches, liquidity requirements/buffers, and loan-to-deposit ratios.

For presentational purposes, throughout the paper we distinguish macroprudential instruments in terms of the dimension of systemic risk towards which they are primarily geared—the time series or the structural dimension. We also follow the distinction between borrower-based and lender-based instruments.

II. Experiences with Macroprudential Instruments

Since the outbreak of the global financial crisis, macroprudential policy has come to play a key role in the policy debate, but the experience with macroprudential instruments goes back as far as the 1930s.[15] Some of the tools that are currently being used or proposed as part of the macroprudential toolset were originally used with microprudential objectives. Others were seen as monetary policy instruments to influence the supply of credit and growth (Bank of England 2009), often focusing on macroeconomic stabilization in the presence of large capital flows and a volatile exchange rate (Cordella *et al*. 2014).

Early experiences

In discussing experiences with macroprudential policy, it is useful to distinguish these historical experiences further in the past from recent experiences. Haldane (2011) identifies a first phase in the 1930s, when policymakers adopted a variety of measures to support the domestic financial system and to influence the supply of credit. According to

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Haldane (2011), macroprudential policy was used as early as 1938 in the USA, in a successful effort by Roosevelt to boost lending and growth, as the country was facing a double-dip recession, with banks being criticized for not lending more to the real economy. These measures took the form of a relaxation of prudential and valuation standards for US banks in the Uniform Agreement on Bank Supervisory Procedures, whose explicit goal was to support lending and activity in the real economy: 'the activist goal of liberalizing bank examinations to make them dynamically adjustable to current economic policies' (Simonson and Hempel 1993, as cited in Haldane 2011).

Following this interpretation, one could view restrictions introduced on both the asset side and the liability side of US banks' balance sheets in the 1930s and in the following decades—in an effort to support the domestic banking system—as macroprudential measures. In the USA, these include interest rate ceilings, interstate banking restrictions, and the Glass–Steagall separation of commercial and investment banking. They also include selective credit controls introduced in the 1950s with the aim of influencing the housing cycle (Grebler 1960) and used throughout the 1970s (Schreft 1990). Elliott *et al.* (2013) provide a detailed review of financial regulatory tools used by US policymakers since the First World War in an effort to slow or accelerate credit growth in the economy as a whole or in major sectors. They argue that these actions at times match the current definition of cyclical macroprudential instruments—in our taxonomy, tools that address externalities arising in the time dimension of systemic risk. At other times, the regulatory tools were less clearly distinct from monetary policy instruments aimed either at containing inflation or strengthening its transmission mechanism.

Similar measures were taken in the 1960s and 1970s in other countries.[16] Well-known examples are the direct credit ceilings and the special deposit scheme known as 'the corset' introduced in the UK in an effort to counter the rapid growth in domestic banks' exposures and its destabilizing effect. Similar policies were also present in the Netherlands between the 1960s and 1980s, where different forms of instruments were employed to contain credit creation by banks (de Greef *et al.* 1996). Another example is Sweden, where the Swedish Riksbank introduced domestic credit controls in the 1950s, which were supported by exchange controls (Jonung 1993). It has been argued that these policies helped to prevent financial crises (Englund 1999). Most of these measures were phased out in the 1980s and 1990s, as deregulation and globalization changed the global financial landscape, reflecting policymakers' concerns over the viability of traditional banking in the face of pressure from non-bank financial institutions (Hellwig 1994, 1995).

Recent experiences

In the second phase, which started in the 1990s, macroprudential tools were (re-)adopted with the goal of strengthening the resilience of the domestic financial system. The experiences with these instruments across countries have been documented systematically in a number of surveys conducted among central banks and other national authorities. Table A2 in the Appendix provides details of these surveys. These surveys show that the use of macroprudential policy instruments—whether or not they were called by their name—has been most widespread in emerging market countries, followed by developing economies and advanced economies. In emerging market countries, central banks have applied macroprudential policies at least since the aftermath of crises that they faced in the 1990s, in an effort to strengthen the resilience of their domestic financial system.

Figures 1 and 2, based on data in the online appendix of Cerutti *et al.* (2015), highlight the rising global trend of the adoption of both lender-targeted and borrower-

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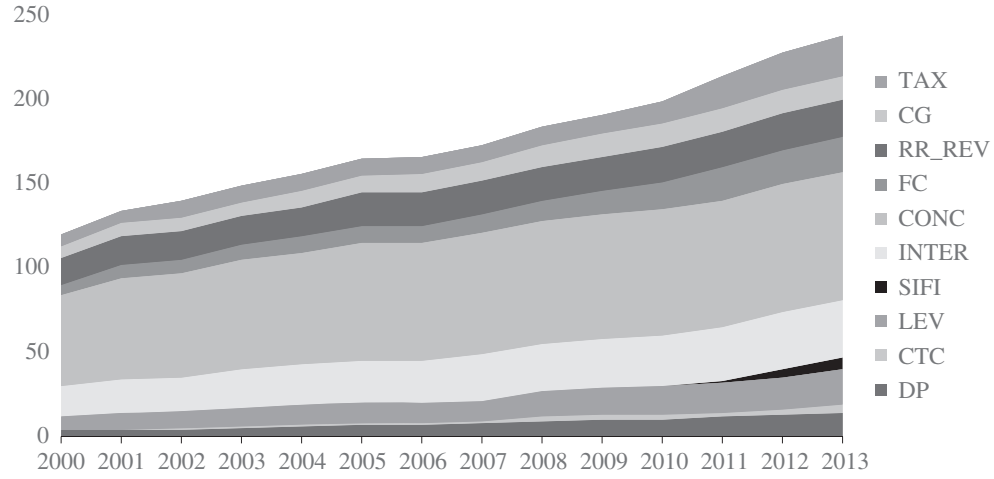

FIGURE 1. Borrower-targeted macroprudential policies.
Notes: Number of countries in which a given tool was in usage. Tools: TAX: levy/tax on financial institutions; CG: limits on domestic currency loans; RR_REV: subset of reserve requirement measures that impose a specific wedge on foreign currency deposits or are adjusted countercyclically; FC: limits on foreign currency loans; CONC: concentration limits; INTER: limits on interbank exposures; SIFI: capital surcharges on SIFIs; LEV: leverage ratio for banks; CTC: general countercyclical capital buffer/requirement; DP: time-varying/dynamic loan-loss provisioning.
Source: Online appendix of Cerutti *et al*. (2015), version of 24 February 2015, authors' calculations.

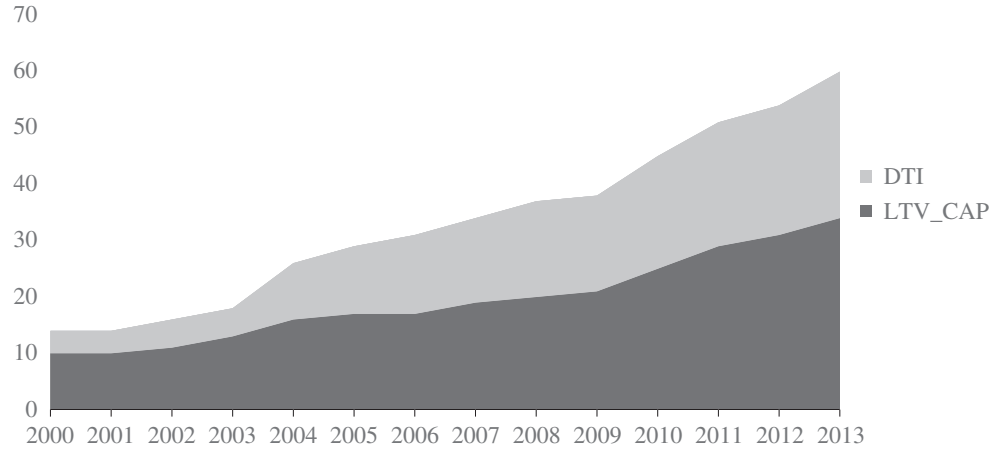

FIGURE 2. Financial-institutions-targeted macroprudential policies.
Notes: Number of countries in which a given tool was in usage. Tools: DTI: debt-to-income ratio; LTV_CAP: subset of LTV measures used as a strict cap on new loans, as opposed to a loose guideline or merely an announcement of risk weights.
Source: Online appendix of Cerutti *et al*. (2015), version of 24 February 2015, authors' calculations.

targeted macroprudential tools.[17] Among lender-targeted macroprudential policies, they find that reserve requirements (that impose a specific wedge on foreign currency deposits or are adjusted countercyclically) and limits on foreign currency loans have been used relatively more by emerging economies; and time-varying/dynamic loan-loss

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provisioning and limits on domestic currency loans have been used relatively more by developing countries (Cerutti *et al*. 2015). The most popular borrower-targeted tools have been caps on LTV ratios or DTI ratios aimed at restricting mortgage lending, and Cerutti *et al*. (2015) find that LTV ratios have been used relatively more by advanced economies.

In advanced countries, macroprudential tools have not been much applied on a system-wide basis before the global financial crisis. An important exception is dynamic provisioning in Spain, which was introduced to make the domestic banking system more resilient to shocks by increasing its shock absorption capacity (Saurina 2009a,b).

In recent years, measures that target the size or the composition of bank balance sheets—e.g. loan-to-deposit (LTD) ceilings, institution-specific capital add-ons or time-varying capital charges—have gained in importance in both advanced and emerging market countries.[18] Systemically important financial institution buffers are the most common institution-specific capital add-ons.

III. Alternative Approaches to Investigate the Effectiveness of Macroprudential Policy and its Transmission Mechanism

It has been argued that the transmission mechanism through which macroprudential policy and monetary policy work is similar to the extent that both work through the bank lending and balance sheet channels, and both are geared towards modifying private agents' behaviour (Beau *et al*. 2012). In fact, the literature on the monetary transmission mechanism can also offer insights on how macroprudential tools can work. In contrast to the monetary policy literature, however, the effectiveness and the transmission mechanism of macroprudential policy tools are not yet well understood. From a theoretical point of view, a main reason is that there is no agreed modelling framework of the interaction between the financial system and the macroeconomy (see Galati and Moessner 2013). From an empirical perspective, macroprudential tools have to a large extent been introduced only in response to the recent crisis, which makes it difficult to assess their effectiveness and transmission channels empirically and guide the design of macroprudential tools going forward (see Turner 2010).

Complicating the analysis is that macroprudential measures have typically been taken not in isolation, but in combination with other policies. Moreover, as emphasized in CGFS (2010), the transmission mechanism is likely to change over time as the result of changes in financial intermediation practices and in the structure of the financial system. In particular, there is uncertainty about how financial innovation, consolidation in the financial sector and changes in the balance between institution- and market-based credit affect systemic risk over time.

For all these reasons, the literature on the effectiveness and the transmission mechanism of macroprudential policy is still in its infancy and has so far provided only limited guidance for policy decisions. In recent years, however, much effort has been put into filling this gap. Progress has been made in embedding macroprudential policy in different types of theoretical models. There is increasing empirical work on the effect of some macroprudential tools on a range of intermediate target variables, such as quantities and prices of credit, asset prices, the amplitude of the financial cycle, and on output growth.

In this section, we review recent progress along two lines of research on the effectiveness and transmission mechanism of macroprudential instruments. The first consists of alternative theoretical frameworks for modelling macroprudential policy and

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its impact on financial and real variables. These include banking/finance models and macroeconomic models.[19] The second line of research uses different strategies to empirically assess the effectiveness of macroprudential policy tools.

Theory-based approaches

There exists by now a large body of research on the interaction between the macroeconomy and financial stability, which offers analytical tools to investigate the possible impact of macroprudential policy. Many contributions have been reviewed elsewhere (e.g. Brunnermeier *et al*. 2013; Benigno 2013; Galati and Moessner 2013; Beck *et al*. 2014) and we therefore do not provide an in-depth discussion of these contributions. Instead, this subsection focuses on what theoretical approaches appear most promising in offering insights on the impact and transmission mechanism of macroprudential tools. It reviews the main elements, insights and modelling challenges of these approaches. For the ease of exposition, we group these approaches into three types of models: banking/finance models; three-period banking or dynamic stochastic general equilibrium (DSGE) macro models; and infinite-horizon general equilibrium macro models.

Banking/finance models Banking/finance models capture the state-dependent nature of assets and contracts (e.g. Diamond and Dybvig 1983; Diamond and Rajan 2001). In these models, financial contracts are affected by informational asymmetries, commitment and incentives problems that can result in default. Financial instability can then result from self-fulfilling equilibria generated by exogenous shocks (e.g. a large change in beliefs triggered by sunspots), or from small shocks that propagate through the financial system through informational and balance sheet linkages.

One important advantage of these models is that they can explain the complex interaction between borrowers and lenders. They have therefore offered important insights on the impact of macroprudential policy tools that address externalities that arise in the cross-sectional dimension of systemic risk. One important example is the paper by Perotti and Suarez (2011), which compares price-based and quantity-based regulation of systemic externalities originating in banks' short-term funding. This distinction between price- and quantity-based tools plays a key role in the current policy debate.[20] The paper shows that a combination of a Pigouvian tax on short-term funding with a net stable funding ratio or a liquidity coverage ratio might be optimal for regulators, depending on the nature of heterogeneity across banks.

At the same time, these models have two important shortcomings. First, to be tractable, these models typically neglect the role of time and the business cycle, which makes it more difficult to study macroprudential tools that address externalities related to the procyclicality of the financial system. Second, they are mostly partial equilibrium models, and the existence of many feedback mechanisms between the behaviour of different types of agents and regulatory instruments calls for a general equilibrium framework (Kashyap *et al*. 2014).

Three-period general equilibrium models A fruitful way to address these issues is the research that uses stylized three-period general equilibrium models to study the interaction between asset prices and financial distress in the corporate and financial sectors. These papers analyse the risk-taking behaviour of heterogeneous agents in an economy that is vulnerable to systemic risk and in which default can occur. This line of

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research allows one to investigate in a general equilibrium setting fire sale externalities and strategic complementarities, which underpin the need for macroprudential policy.

One type of such models has the key feature that financial amplification during credit booms and busts involves externalities (e.g. Lorenzoni 2008; Gersbach and Rochet 2012a,b; Goodhart *et al.* 2012; Bhattacharya *et al.* 2015). These externalities arise because individual agents take financial decisions without taking into account the general equilibrium effect of their actions. During times of stress, agents neglect the effect of their asset sales on aggregate prices. As a result, agents take on socially excessive exposure to risk and over-borrow, eventually creating feedback loops of falling asset prices, tightening financial constraints and fire sales.

Although these models are highly stylized, they can be used to study the impact of macroprudential tools geared towards preventing fire sales and credit crunches, which are found to be critical for increasing financial stability and improving the welfare of savers and borrowers (Goodhart *et al.* 2013). Such tools include loan to value ratios, capital requirements for banks, liquidity coverage ratios for banks, dynamic loan loss provisioning for banks, and margin requirements on repurchase agreements used by shadow banks.

Another type of three-period general equilibrium model captures the different roles that banks play in the economy—providing liquidity insurance for savers, improving the risk-sharing opportunities for savers, increasing the amount of funding available to borrowers (Kashyap *et al.* 2014). These models can be used to analyse alternative causes of the global financial crisis—excessive risk-taking by under-capitalized banks that were exploiting taxpayer support, funding vulnerabilities in the financial system and bank runs —and regulatory tools that can help to prevent future crises.

The possibility of analysing the effects of alternative macroprudential tools in a general equilibrium setting makes these types of model very promising. A novel finding of this type of research is that macroprudential tools that address the time dimension of systemic risk can thwart the effectiveness of instruments geared towards the structural dimension of systemic risk. As shown by Horváth and Wagner (2013), countercyclical bank regulation can insulate banks from sector-wide fluctuations, but this can come at the expense of banks being more exposed to idiosyncratic risks. This provides banks with an incentive to take correlated risk exposures, which in turn increases systemic risk.

At the same time, these types of models face two important challenges. First, for tractability reasons they are very stylized. Second, a three-period setting is not ideal for capturing the procyclicality of systemic risk that underlies booms and busts in the financial system.

Infinite-horizon macroeconomic models with financial factors Infinite-horizon DSGE models augmented with financial frictions—which build on seminal work on the financial accelerator mechanism by Kiyotaki and Moore (1997) and Bernanke *et al.* (1999)—have the potential to investigate the effects of macroprudential tools that focus on the time dimension of systemic risk. Their general equilibrium nature and the fact that they are particularly suitable for simulations makes them attractive for policy analysis. In fact, frictions related to financial intermediaries and the role of bank capital in the monetary transmission mechanism have been studied with these types of models (e.g. Goodfriend and McCallum 2007). Earlier vintage models of this type suffered from several important drawbacks, which limited their use in studying the effectiveness and transmission mechanism of macroprudential instruments. First, being traditionally solved by linearization, these infinite-horizon models were not well suited to incorporate

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state-contingency in a meaningful way and hence to analyse systemic crises or the impact of changes in regulation. Second, with very few recent exceptions, these models generally assumed complete markets and implicitly assumed that defaults either do not occur or are exogenous (see, for example, Cúrdia and Woodford 2010). Third, as argued forcefully by Geanakoplos (2011), they ignored endogenous leverage. By construction, therefore, these types of DSGE models with financial frictions describe financial crises as big negative shocks that are amplified. They cannot capture the fact that crises are rare events resulting from 'credit booms gone wrong' that are followed by deep and long recessions (Schularick and Taylor 2012).

Since the global financial crisis, however, much effort has been undertaken to address these shortcomings and extend infinite-horizon DSGE models to include a richer characterization of real-financial linkages. An interesting example of how a DSGE model with an elaborate representation of bank balance sheets can trace the transmission mechanism of different macroprudential tools over time is the paper by Darracq Pariès *et al*. (2011). Their model includes loans to financially constrained households and firms (with time-varying borrower risk) that are subject to strategic default and to LTV restrictions, while banks are subject to alternative types of (risk-sensitive) capital regulation.

Compared to standard DSGE models, these models have multiple equilibria, and are used to analyse non-linearity and externalities. They feature more elaborate amplification mechanisms. Several lines of research provide a promising framework to evaluate macroprudential (or monetary) policies, and in particular those that address externalities along the time dimension of systemic risk.

The first line of research analyses endogenous procyclical movements in bank balance sheets that cause countercyclical movements in the cost of bank credit, which ultimately can lead to a crisis (see Gertler and Karadi 2011; Gertler and Kiyotaki 2011).[21] Gertler and Kiyotaki (2015) and Gertler *et al*. (2016) take this analysis one step further and show that balance sheet conditions not only affect the cost of bank credit but also determine whether bank runs are possible. The authors develop a simple macroeconomic model of banking instability that features both a financial accelerator mechanism and bank runs, which importantly are complementary in nature. These types of models can lend themselves—albeit with the caveat that constraints are always binding and that they are mostly simulated to first-order approximation—to macroprudential policy analysis. Aoki *et al*. (2016), for example, use such a framework to study the macroeconomic effects of macroprudential instruments (bank capital requirements and a tax on foreign currency borrowing) and their interaction with monetary policy in the case of a small open economy.

The second line of research relies on infinite-horizon DSGE models in discrete time with borrowers (households or firms) facing occasionally binding endogenous constraints.[22] These models have been used to explain the mechanism of financial amplification in terms of the interaction of falling asset prices, declining net worth, tightening financial constraints and macroeconomic contraction. These models can be used to examine macroprudential policies over booms and busts, and determine the optimal magnitude of specific instruments.

This line of research has been called 'Neo-Fisherian', since the financial amplification that it describes captures features of Fisher's (1933) debt-deflation spiral. The borrowing constraint is occasionally binding, depending on private agents' and policymakers' choices, which determine the state of the economy (Bianchi and Mendoza 2010; Jeanne and Korinek 2013; Benigno *et al*. 2013). In crisis times the constraint is binding, whereas

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in tranquil states it is not. The borrowing constraint is endogenous and depends on asset prices such as the price of land.

The third line of research studies global dynamics in models with financial frictions in a continuous time setting with occasionally binding constraints (He and Krishnamurthy 2012, 2013; Brunnermeier and Sannikov 2014; Adrian and Boyarchenko 2012). Macroeconomic factors and the financial system are integrated in an analysis that is not confined around the steady state, which provides important insights on the mechanisms that can lead to financial crises.

The key idea is that the financial sector does not internalize all the costs associated with risk-taking, which results in excessive leverage and maturity mismatch (Brunnermeier and Sannikov 2014). While securitization allows the financial sector to offload some of the risk, it exacerbates excessive risk-taking. In this type of model, systemic risk and volatility dynamics are endogenous due to adverse feedback loops between financial and real factors. The model thus portrays an economy with low volatility and 'reasonable' growth around the steady state but with high volatility and large output losses away from the steady state. The economy is inherently unstable because leverage and risk-taking are endogenous. The model embeds key non-linearities: small shocks keep the economy near the stable steady state, but large shocks lead to an unstable crisis regime characterized by liquidity spirals.

An important feature of this type of model is the so-called 'volatility paradox': as aggregate risk declines, equilibrium leverage goes up and amplification becomes more severe. This paradox goes back to Minsky's financial instability hypothesis, according to which economic agents interpret the presence of a low-risk environment as an incentive to increase risk-taking.[23] This hypothesis has been supported empirically in recent work by Danielsson *et al*. (2016).

While these papers have mostly provided qualitative insights, recent research has been able to match quantitatively the non-linearities that can be found in macroeconomic and financial data, and in particular the different dynamics across tranquil times, periods of stress and systemic crises (He and Krishnamurthy 2014).

A fourth line of research, pursued at the IMF, includes financial intermediaries' balance sheets into DSGE models to yield highly non-linear feedback effects between bank balance sheets, borrower balance sheets and the real economy during financial crises (Beneš *et al*. 2014a,b). Parameters in these models are calibrated to match basic stylized facts of financial cycles. This type of model provides a flexible tool to simulate the impact of specific macroprudential policy decisions, such as changes in countercyclical capital requirements, and a wide range of scenarios affecting the financial sector. It shares the problem faced by DSGE models with occasionally binding constraints that it cannot be estimated because of global non-linearities and changing financial sector policies, which would require unrealistically large samples.

Overall, research on infinite-horizon macroeconomic models with financial factors appears promising to study the effects of macroprudential policies on endogenous risk, on the depth of financial crises and on welfare. They have offered a number of insights to the policy debate on macroprudential instruments.

First, this research explains mechanisms through which real and financial factors interact, and how this interaction can generate systemic crises endogenously and typically when the economy, credit and the banking sector are booming and interest rates are low. In the paper by Boissay *et al*. (2016), for example, a string of positive, temporary supply shocks pushes up the productivity of capital, and leads to a demand-driven expansion of credit and an increase in corporate loan rates. As productivity returns back to its trend,

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firms' demand for credit falls but households continue to accumulate assets in order to smooth consumption, thus feeding the supply of credit by banks, while corporate loan rates decline. In this sense, the credit boom turns supply-driven. Lower lending rates give banks an incentive to take more risks at a time when the size of their balance sheet increases. Ultimately, this will lead to a collapse in the interbank market and a systemic crisis.

Second, calibrations of these models improve our understanding of the role of regulation in reducing the incidence of financial crises. Based on a quantitative analysis of their model calibrated to US data, for example, Bianchi and Mendoza (2010) show that in the absence of regulation, financial crises are significantly more frequent and more severe.

Third, these models can be used to construct policy rules that address externalities associated with fire sales of assets that have large adverse macroeconomic effects. Bianchi and Mendoza (2010), for example, show how state-contingent taxes can play an important role in supporting financial stability. In their paper, a regulator can replicate exactly its equilibrium allocations as a decentralized equilibrium, and thus neutralize the credit externality and increase welfare, by imposing state-contingent taxes on debt and dividends. These Pigouvian taxes are higher during periods when leverage is building up and the economy is becoming vulnerable to a financial crisis. The idea is that such taxes induce agents to value more the accumulation of precautionary savings with respect to the competitive equilibrium without taxes.

Fourth, these types of models allow characterizing the optimal mix of *ex ante* macroprudential policy and *ex post* policy (i.e. bailouts) in response to financial crises. Jeanne and Korinek (2010), for example, compare *ex ante* prudential taxation to a bailout insurance fund that accumulates resources during booms and transfers them to constrained borrowers in a bust. They find that a bailout fund increases welfare only if it accumulates resources in good times through the optimal Pigouvian tax.

Finally, this research can help to identify unintended consequences of macroprudential policies. For example, Brunnermeier and Sannikov (2014) provide numerical exercises that quantify how capital requirements or restrictions on dividend payments may have negative effects on welfare, if they bind in busts but have little constraining effect on leverage during booms.

While the literature on macro finance models described in this subsection offers interesting insights on how macroprudential policy might work, such models also face several major challenges. The different classes of models with incomplete asset markets, aggregate shocks, heterogeneous agents facing occasionally binding constraints and endogenous systemic risk are very complex. The quantitative analysis is therefore typically based on calibration rather than estimation.

From a computational point of view, the models rely on non-linear global solution methods to evaluate short- and long-run effects of financial frictions. These solution methods cannot be easily implemented for large models. The analysis is therefore mostly restricted to a limited set of shocks and states. Importantly, for tractability reasons, the representations of the banking sector and its intermediation activity in these models are still very stylized.

Finally, most of these models do not incorporate money, which makes it impossible to derive insights on the interaction between monetary policy and macroprudential policy.

Empirical work on effects of macroprudential tools

In parallel to the literature that has used theoretical frameworks for modelling macroprudential policy and its impact on financial and real variables, an increasing

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number of empirical studies have provided evidence on the impact of macroprudential instruments. In this subsection we provide an overview and critique of the main empirical approaches to studying the effects of macroprudential policy tools and of key papers, and an overview of the main findings on the effects of macroprudential tools.

Methods Empirical analysis on macroprudential instruments is difficult because of the lack of established models of the interaction between the financial system and the macroeconomy, as well as the scarcity of data needed to conduct empirical tests.

The literature has broadly followed four approaches in assessing the effects of macroprudential tools: reduced-form regression analysis conducted using cross-country panel regressions; reduced-form regression analysis based on microdata, for example on individual banks' balance sheet items; event studies; and assessments of authorities or outside observers.

There are a number of challenges in analysing the effectiveness of macroprudential policy tools empirically. The first and most important is the problem of endogeneity (how to identify the impact of macroprudential tools on macroeconomic and financial variables, and related to this, the problem of distinguishing correlation and causation): macroprudential policy tools could be adopted in response to developments in macroeconomic and financial variables considered in the analysis. A second problem is distinguishing the effect of macroprudential tools from those of other policies, which are often used in conjunction with macroprudential tools (including monetary policy, fiscal policy). A third problem is controlling for global and local factors.

In this subsection we discuss the most promising methods for studying the effects of macroprudential tools so far, namely reduced-form regression analysis using cross-country panel regressions, reduced-form regression analysis based on microdata, and event studies.

A promising approach for estimating the effect of macroprudential policies is based on cross-country panel studies or panel regressions using microdata addressing the endogeneity problem, controlling for other policies, and for global and local factors. Panel regressions using microdata have the advantage over cross-country regressions that they face a less severe endogeneity problem, since macroprudential policies are less likely to be changed in response to developments at an individual bank, than to developments at the aggregate country level (as in Claessens *et al*. 2013). But they have the disadvantage compared with cross-country regressions that they face the micro aggregation problem, so that it is not clear to what extent the results are applicable at the macro level.

Compared to event studies, reduced-form regression analysis allows more formal tests of the impact of macroprudential tools. However, it suffers from two main drawbacks. First, reduced-form models do not capture well the interaction between macroeconomic, financial and policy variables. Moreover, macroprudential tools have mostly been used in conjunction with other policies, such as monetary policy, so that it is difficult to isolate their effects. Furthermore, since in most cases macroprudential tools have been introduced only in recent years in the policymaker's toolkit, there are few data to assess their effectiveness and transmission channels empirically.

The most common approach for dealing with the endogeneity problem in panel regression studies is to include explanatory variables lagged once, and to use instrumental variables, in particular general method of moments (GMM) estimation (as in Cerutti *et al*. 2015; Zhang and Zoli 2014; Claessens *et al*. 2013). However, some of the endogeneity problem is likely to remain.

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Event studies tend to be able to do a better job in distinguishing between different policies than reduced-form regressions, especially if they are conducted at higher frequency. They are also particularly suited to analysing the impact of macroprudential instruments that have been implemented only in recent years. Kuttner and Shim (2016) use a conventional event study approach, where discrete events are identified, and the time series is divided into two mutually exclusive subsamples, namely a set of event windows spanning a certain period following the event, and a set of estimation windows over which a forecasting model is estimated.[24] The effects of the events are then calculated as the differences between the forecast values and the actual values during the event window. Since this event study method excludes event windows from the estimation of the econometric forecasting model, it has the advantage that the endogeneity problem is likely to be smaller than in standard cross-country panel regressions. A drawback of their approach is that they do not control for other (e.g. fiscal or monetary) policies, or for global or local factors. Another drawback is that in order to estimate a plausible forecasting model, only 13 out of 57 countries in the sample can be used; and the relatively small number of observations makes the results very sensitive to outliers. Reduced-form VAR and panel data methods have greater problems in identifying the effects of different policies, and shocks due to them, especially at lower (annual) frequency. One way to address this problem is to estimate a model that includes different policies with higher-frequency data, and to estimate structural, rather than reduced-form VAR models. An advantage of structural VAR (SVAR) models over reduced-form VAR models is that they are better able to identify fundamental economic shocks. This is because identification of such shocks requires additional assumptions, which can be made in SVARs by imposing structural economic relationships. SVARs can therefore estimate responses to fundamental economic shocks, whereas reduced-form VARs can only estimate responses to statistical innovations. Moreover, SVARs are also better able to capture the interaction between macroeconomic, financial and policy variables than reduced-form models. An interesting study of this kind is the paper by Mehrotra and Kim (2015), since it conducts structural VAR analysis that identifies both macroprudential and monetary policy shocks, and treats them in a unified framework, using quarterly data.

Cross-country panel data studies can do a relatively good job of controlling for global and local factors, by including a host of control variables in the regressions, as well as fixed effects to capture unobserved heterogeneity (as in Cerutti *et al*. 2015; Kuttner and Shim 2012). Such control variables often include global variables, such as the VIX, and local variables such as country-specific macroeconomic variables. Using cross-country data for 57 countries over the past three decades in panel regressions, Kuttner and Shim (2012) analyse the degree to which macroprudential policy tools have been effective in mitigating housing price and credit cycles, after controlling for country-specific structural factors and macroeconomic variables. They include controls for other factors affecting the housing market, such as rent, personal income and institutional features of the housing finance system, and for monetary policy. However, this study does not address the endogeneity problem, it does not control for other local or global factors, and it does not control for other policies besides monetary policy. Vandenbussche *et al*. (2015) perform cross-country panel regressions controlling for some local and global factors, but do not address the endogeneity problem using instrumental variables; instead, they estimate regressions separately for subgroups of macroprudential policy changes that they consider exogenous; but it is not clear that these subgroups truly are exogenous.

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A novel and promising approach to address the endogeneity problem when analysing cross-country panels is to use high-frequency data and apply propensity-score matching, a method commonly used in medical and labour economics. This method consists of several steps. First, the probability that a country changes a particular type of macroprudential policy is estimated with a discrete choice model using high-frequency (e.g. weekly) data, based on a set of observable domestic and global variables. The results are then used to estimate propensity scores, that is, the probability that each country changes its macroprudential policy in each week as a function of observable variables. The propensity scores are next used to match countries that have a change in macroprudential policy (treated group) to a set of countries that do not (control group), based on a set of observable country characteristics. The matched samples of treated group and control group are then used to estimate the average treatment effect of each macroprudential measure on a range of outcome variables. An advantage of propensity-score estimation is that it is not necessary to assume a functional form between any of the variables and the outcomes, which is particularly useful when the underlying model is unclear, including regarding endogeneity. As shown by Angrist and Kuersteiner (2011), the propensity-score methodology is well suited to estimate the impact of policy changes in the presence of endogeneity.

Possible practical problems with this approach include the lack of a sufficient number of changes in observed policy variables and of 'similar' observations to form a control group, especially for low-frequency (annual) data, and a dependence of the results on the algorithm used to match the treated group with the control group. Other possible practical problems include the need to use high-frequency data, and to convert lower-frequency data to such a higher frequency.

Forbes *et al.* (2014) are the first to study the effects of macroprudential (capital flow management) tools with this method. Their weekly dataset covers 60 countries over a three-year period (2009–11). It would be interesting to apply this method to longer sample periods. There are trade-offs due to data limitations, between comprehensive country coverage at low frequency over longer periods (annual data), as in Cerutti *et al.* (2015) and Ostry *et al.* (2012), versus narrower country coverage at higher frequency over shorter periods (quarterly, monthly, or even weekly data, as in Forbes *et al.* (2014)). There is also a trade-off between comprehensive country coverage with less information about more macroprudential measures (e.g. only dummy variables for whether measures are in place, without information about tightening/loosening nature or intensity, as in Cerutti *et al.* (2015)), versus more detailed information about tightening/loosening nature or intensity of macroprudential measures for fewer countries and fewer macroprudential instruments. Moreover, for some variables, such as bank leverage, aggregate data tend to be poor, so using micro firm-level data can be useful, as in Zhang and Zoli (2014). The cross-country panel regressions study by Cerutti *et al.* (2015) is interesting since it uses the most comprehensive coverage of countries, for a large number (12) of macroprudential tools, based on the Global Macroprudential Policy Instruments (GMPI) survey of country authorities for 2000–13 by the IMF; they control for a large number of local and global factors; and they address the endogeneity problem. Drawbacks of this study are that: they do not distinguish between tightening/loosening of macroprudential tools or consider their intensity, but include the tools only as dummy variables; and they use a low (annual) frequency of data, but higher-frequency data would make it easier to distinguish the effects of macroprudential policies from those of other policies. It would be very interesting to quantify the intensity (or tightening/loosening) of macroprudential tools of this survey in future work, rather than using dummy variables.

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Claessens *et al*. (2013) is an interesting study that uses panel regressions for balance sheet data of around 2800 banks in 48 countries over the period 2000–10. Advantages of their approach are that they further address the endogeneity problem via GMM panel estimation. They also include a range of variables to control for global and local factors, such as real GDP growth, the exchange rate regime, the degree of openness, and measures of a country's financial structure, for example of bank versus market financing. They also control for monetary policy by including changes in interest rates, and for the room to conduct countercyclical fiscal policy by including the public debt to GDP ratio.

Overall, each method—reduced-form regression analysis using cross-country panel regressions or microdata, and event studies—has advantages and disadvantages. Two approaches appear most suitable in addressing the main problem, namely endogeneity—panel data regression with microdata on bank balance sheets and propensity-score matching using high-frequency data. There therefore remains a need for a suite of methods to estimate the effects of macroprudential tools. A good example of the suite-of-models approach is Zhang and Zoli (2014), who use event study, macro panel regressions, and micro panel regressions focusing on Asia.

Evidence Empirical evidence is most comprehensive and clearest on the effects of borrower-targeted macroprudential policies on intermediate targets in the time dimension. Many different studies using a range of methods (cross-country panel regressions, microdata panel regressions, event studies) find some evidence of borrower-targeted macroprudential policies having some effects on intermediate targets of these macroprudential policies, namely house price growth and housing credit growth. Kuttner and Shim (2012) find that decreases in LTV ratios are associated with lower house price growth, and that limiting debt-service-to-income ratios attenuates housing credit growth. Cerutti *et al*. (2015) find that borrower-based macroprudential measures are associated with lower growth in credit to households, especially in emerging market economies, but also significantly so for advanced countries. Zhang and Zoli (2014) find that housing-related macroprudential measures (especially caps on LTV ratios and housing tax measures) helped to curb house price growth, bank loan growth and bank leverage. Kuttner and Shim (2016) find that a decrease in the debt-service-to-income ratio reduces housing credit growth by around 4 percentage points, which is somewhat smaller but not very different from their results using a cross-country panel regression approach. They also find that an increase in housing-related taxes reduces house price growth.[25] Claessens *et al*. (2013) find that borrower-target macroprudential policies (LTV and DTI ratios) are effective in reducing leverage, asset growth and non-core to core liabilities growth; they are also effective in reducing the severity of the cycles in leverage and non-core to core liabilities.

There is evidence that these macroprudential tools are effective across different exchange rate regimes. Using panel regressions for data from a 2010 IMF survey of the cross-country use of macroprudential policies, Ahuja and Nabar (2011) find that LTV caps decelerate property price growth, that both LTV and DTI caps slow property lending growth, and that LTV caps also affect a broader range of financial stability indicators in economies with pegged exchange rates and currency boards. These findings are in line with the work by Wong *et al*. (2011), who find based on panel regressions with data from 13 economies that maximum LTV ratios are effective in reducing systemic risk stemming from the boom-and-bust cycle of property markets, with the effect on household leverage being more apparent than the effect on property market activity.[26]

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Empirical evidence on the effects of financial-institutions-based macroprudential policies is less conclusive and more mixed. Studies using different methods or different samples and sample periods often find different results, and much more work on the effects of these measures is desirable. Cerutti *et al.* (2015) find that financial-institutions-targeted macroprudential policies as a group are significantly associated with lower credit growth, especially in emerging economies, but that they do not have a significant effect on credit growth in advanced economies. For financial-institutions-targeted tools, Claessens *et al.* (2013) find mixed results. Limits on credit growth and foreign currency lending are also found to be effective in reducing leverage, asset and non-core to core liabilities growth during boom times. While countercyclical buffers (such as reserve requirements, limits on profit distribution, and dynamic provisioning) are also found to help to mitigate increases in bank leverage and asset growth, few policies help to stop declines in adverse times. Using firm-level data on bank leverage and bank loan growth for Asia, Zhang and Zoli (2014) find that changes in reserve requirements and capital regulation did not have any significant effect on bank loan growth and bank leverage in Asia. Kuttner and Shim (2012) find that increasing loan loss provisioning requirements attenuate housing credit growth.

Several studies find significant effects from reserve requirements, one of the financial-institutions-based macroprudential policies. Based on panel data regressions, Vandenbussche *et al.* (2015) find that non-standard liquidity measures, namely marginal reserve requirements on foreign funding and marginal reserve requirements linked to credit growth, had some impact on house price inflation in central, eastern and south-eastern European countries. Within VAR analysis, Federico *et al.* (2012) find that exogenous changes in legal reserve requirements lead to falls in output in Argentina, Brazil, Colombia and Uruguay, and Glocker and Towbin (2012) find that a discretionary tightening of reserve requirements leads to a decline in domestic credit in Brazil.

There is mixed evidence in the literature on whether macroprudential policy targeted at procyclicality works symmetrically in booms and busts. Using cross-country data in panel regressions, and consistent with Lim *et al.* (2011), Dell'Ariccia *et al.* (2012) find that macroprudential policy tools can reduce the incidence of credit booms and decrease the likelihood that booms end up badly. Ostry *et al.* (2012) conclude that the experience from the global financial crisis suggests that prudential policies in place during the boom enhanced economic resilience during the bust.

But there is also evidence of asymmetry in the effects of macroprudential tools. Cerutti *et al.* (2015) find that while macroprudential tools can help to manage financial cycles, they work less well in busts. Claessens *et al.* (2013) find that while countercyclical buffers (such as reserve requirements, limits on profit distribution, and dynamic provisioning) help to mitigate increases in bank leverage and assets, few policies help to stop declines in adverse times. Kuttner and Shim (2016) find that while an increase in housing-related taxes reduces house price growth, a decrease has no significant effect.

There has been particularly limited empirical work on the effects of macroprudential policy tools addressing externalities in the structural dimension, with data limitations being one reason for this. Using data on individual banks' loan books, risk exposures, and interbank linkages including over-the-counter derivatives for the Canadian banking system, Gauthier *et al.* (2012) find that macroprudential capital allocation mechanisms reduce default probabilities of individual banks as well as the probability of a systemic crisis by about 25%, suggesting that macroprudential capital buffers can substantially improve financial stability. Liao *et al.* (2015) find for the Netherlands that macroprudential capital requirements under five systemic risk-allocation frameworks

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substantially reduce banks' default probabilities, and that capital requirements based on ΔCoVaR allocation lead to the lowest default probabilities, with the average probability of bank defaults decreasing from 6.49% to 5.39%, a 17% reduction in risk. They also find that macroprudential capital requirements decrease the risk of multiple bank failures significantly, with the probability of three or four bank defaults decreasing from 4.22% to 3.09% based on Shapley value VaR allocation, corresponding to a 26% decrease in the risk of a financial crisis. Alter *et al*. (2015) find using German credit register data that macroprudential capital reallocation rules, using network-based centrality measures that combine individual bank characteristics and interconnectivity measures of interbank lending, can save about 15% in expected bankruptcy costs. By contrast, using an agent-based computational economic model of the financial sector, Krug *et al*. (2014) find that surcharges on systemically important banks do not seem to contribute to the resilience of the financial system.

Effects of macroprudential capital flow management tools Empirical evidence on the effects of macroprudential capital flow management tools (which is a subset of financial-institutions-based macroprudential policies) is also less conclusive and more mixed. The distinction between macroprudential policies aimed at capital flow management and capital control policies is discussed in the second paragraph of the subsection entitled 'Instruments' in Section I.

A very useful systematic study of the effects of macroprudential capital flow management tools is Ostry *et al*. (2012). This is a very useful study since it analyses separately the effects of macroprudential capital flow management tools and capital controls, and constructs indices for the use of these policies for a large number of countries (51), much larger than had previously been available. They study the effects of macroprudential capital flow management tools on the financial stability risks associated with capital flows. They find that foreign-exchange-related prudential measures affect the composition of capital flows; they are associated with a lower proportion of foreign exchange lending in total domestic bank credit, and with a lower proportion of portfolio debt in total external liabilities.

The capital flow management policy indices of Ostry *et al*. (2012) have been extended by Beirne and Friedrich (2014) to more countries (139), including advanced economies, from 1999 to 2009. They study their impact on aggregate capital inflows, rather than the composition of capital flows studied in Ostry *et al*. (2012), and find only a limited effect of capital flow management policies.

Bruno and Shin (2014) use panel data analysis to study the impact on capital flows of macroprudential policies introduced by Korea in 2010 in comparison with 48 other countries. They find that the sensitivity of capital flows to Korea to global financial conditions decreased following the introduction of macroprudential policies, compared with other countries. The intuition behind this result is that there is a link between capital flows and leverage, with the driving force behind banking sector capital flows being the leverage cycle of the banking sector, through the interaction of the supply and demand of wholesale bank funding. It is consistent with the relevance of gross capital flows between countries for determining financial conditions, especially the gross flows intermediated by the banking sector. Forbes *et al*. (2014) study the effects of macroprudential capital flow management tools, analysing separately the effects of macroprudential capital flow management tools and capital controls. They find that macroprudential capital flow management tools can reduce some measures of financial fragility, including bank leverage, bank credit growth, and exposure to portfolio liabilities (gross inflows). They

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also find that macroprudential capital flow management tools do not have a significant effect on net capital flows. Like Bruno and Shin (2014), they find evidence for a link between macroprudential tools and bank leverage, and evidence for the relevance of gross flows.

IV. Continued Challenges Regarding the Effectiveness of Macroprudential Instruments

The policy debate has highlighted two major issues that influence the effectiveness of macroprudential policy—regulatory arbitrage and the interaction with monetary policy.[27] While the research literature has offered some interesting insights on these issues, they remain important avenues for future research.

Regulatory arbitrage

Regulatory arbitrage arises because the negative externalities in financial intermediation that justify macroprudential policy can occur both within and outside the (traditional) domestic banking sector. The introduction of macroprudential instruments can cause risk-taking and exposures to move outside the regulated banking sector, while remaining systemically important.[28] If macroprudential objectives encompass different regulatory jurisdictions but tools affect only a subset of these jurisdictions, and in particular the traditional banking sector, then a gap opens between objectives and instruments of macroprudential policy (Jeanne and Korinek 2014). This gap limits the effectiveness of these tools. The role of mortgage lending—in particular in the subprime sector—that had bypassed the traditional banking sector in the 2008–9 crisis in the USA is a case in point.

Most of the existing research has concentrated on forms of regulatory arbitrage that result from the increasing international integration of banking systems, as borrowers get access to funding from foreign banks (either directly or through their domestic branches). When macroprudential tools are applied to financial institutions operating in a country without reciprocal arrangements with home country regulators, domestically-regulated banks are more constrained in their risk-taking and credit supply compared to foreign branches and cross-border lenders. Borrowers can therefore avoid macroprudential policy to the extent that they can shift their funding to foreign banks.

The mechanics of regulatory arbitrage and what it implies for macroprudential policy are illustrated in a paper by Bengui and Bianchi (2014). They examine an environment where macroprudential regulators are unable to apply a Pigouvian tax on borrowing—which they interpret as a form of capital flow management—to an exogenously fixed subset of borrowers. In their model, regulated agents respond by lowering their risk-taking in response to the controls, while unregulated agents respond to a safer environment by taking more risk. This increase in risk undermines the effect of the policy.

A calibration of this model to data from Argentina reveals two important findings. First, even in the presence of leakages, macroprudential policy (in the form of capital flow management) significantly reduces the probability and severity of crises. However, higher leakages imply a greater vulnerability of an economy to sudden stops. Second, macroprudential policy can have significant redistributive effects between regulated and unregulated borrowers. In particular, unregulated agents benefit much more than regulated agents from macroprudential policy, and benefit the most when the shadow economy is small.

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Regulatory arbitrage matters empirically. Suggestive evidence that both forms of regulatory arbitrage—through cross-border banking and through non-bank financial institutions—matter comes from empirical work based on aggregate cross-country data. Cerutti *et al.* (2015) find a weaker association between macroprudential policies and credit developments in financially more open economies, and in economies with deeper and more sophisticated financial systems. More conclusive evidence requires a combination of data on macroprudential actions, and aggregate data on international banking flows or bank level data on lending flows for individual countries.

The empirical literature has highlighted that leakages differ across macroprudential tools.[29] As Reinhardt and Sowerbutts (2015) argue, the scope for leakages is largest for capital requirements and smallest for lending standards regulation. In principle, capital requirements increase the weighted average cost of capital for both domestic banks and foreign subsidiaries, but lending through foreign branches and cross-border lending will not be affected. The resulting funding advantage of foreign branches and foreign banks undertaking cross-border lending may at least in part be passed through to domestic borrowers, and result in an increase in borrowing from these financial institutions.

In the same vein, changes in reserve requirements, which have been used for macroprudential purposes mostly in emerging market countries, also tend to affect the competitive advantage of foreign banks vis-à-vis domestic banks. The reason is that foreign banks—particularly in emerging market countries—typically find it easier to smoothe the negative impact of an increase in reserve requirements on their funding by tapping the foreign interbank market.

By contrast, lending standards regulation typically affects all financial products sold in a country, regardless of whether they are sold by a foreign or a domestic bank. *Ceteris paribus*, a change in lending standards regulation will therefore not create a competitive advantage for foreign banks and will not increase their lending activity.

Using data on international lending flows for 68 countries and over 1000 macroprudential actions, Reinhardt and Sowerbutts (2015) show that leakages are indeed biggest for changes in capital requirements, which induce some shift in borrowing from domestic to foreign banks, while no such effect is found for a tightening in lending standards. The results for reserve requirements are mixed.

This result has been documented also in studies on microdata. The advantage of these studies is that they can identify a control group that was not subject to the regulation, against which the group of banks affected by the regulation can be compared. Danisewicz *et al.* (2015) use data on foreign banks' branches and subsidiaries of multinational banking organizations operating in the UK to show the different impact of macroprudential actions adopted in foreign banks' home countries. They find that following a tightening of capital regulation, interbank lending by branches of multinational banks operating in the UK grows less compared to lending by subsidiaries of the same banking group. By contrast, lending by branches and subsidiaries operating in the UK is similarly affected by changes in lending standards or reserve requirements decided by regulatory authorities in their home country. This result is consistent with work by Aiyar *et al.* (2015), who find that during 1998–2007, when regulators imposed time-varying bank-specific minimum capital requirements on banks regulated in the UK, UK-regulated banks reduced lending in response to tighter capital requirements, but non UK-regulated banks (resident foreign branches) increased lending compared with a reference group of regulated banks.

The results for capital requirements carry over to dynamic provisioning. An example that has been documented carefully in the literature is the introduction of dynamic

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provisioning in Spain, whose effectiveness is controversial. On the one hand, it has been argued that it made the banking system more resilient to shocks by increasing its shock-absorption capacity (Saurina 2009a,b). On the other hand, it arguably did not prevent a major bubble in the domestic housing market and large problems in the domestic banking sector once the real estate boom unwound in 2007 (e.g. Mahapatra 2012). One conjecture is that countercyclical dynamic provisioning was insufficiently effective because of regulatory arbitrage. Jiménez *et al*. (2013) find that this macroprudential tool smoothed cycles in the supply of credit in bad times and upheld firm financing and performance, but did little to stop the credit boom to firms in good times as firms switched to non-regulated banks—foreign branches—or less affected banks.

In contrast to regulatory arbitrage involving foreign banks, very little is known about leakages through non-bank financial institutions within the domestic financial sector that are either unregulated or not given the same regulatory treatment as banks. This is all the more important given the key role played by the shadow banking system in the global financial crisis, and the fact that most of the macroprudential tools that have been implemented are bank-focused (Pozsar *et al*. 2010; Borio 2015).

To our knowledge, Cizel *et al*. (2016) is the only paper that investigates the substitution from bank-based financial intermediation to non-banking intermediation in response to macroprudential measures. They use data on bank and non-bank credit to the private non-financial sector for a selection of 40 economies over the last 40 years, taken from the Bank for International Settlements (BIS) private credit database and the World Bank's Financial Development Database. These data are matched with lender-based and borrower-based macroprudential instruments reported in Cerutti *et al*. (2015). The authors find that macroprudential actions are associated with a slowdown of bank credit to non-financial borrowers but an increase of lending by non-bank financial intermediaries, and in particular by investment funds. As expected, this effect is found to be stronger in advanced economies.

Coordination between macroprudential policy and monetary policy

A key issue in both the academic literature and the policy debate is how macroprudential policy interacts with monetary policy. This issue is most relevant for macroprudential policies that address externalities in the time dimension of systemic risk. Should monetary policy be regarded as a complement or even a substitute for macroprudential policy in choking off a potential credit boom? As argued forcefully by Smets (2014) and in an influential speech by Stein (2013), the interaction between macroprudential and monetary policies hinges on two questions. First, are macroprudential policy instruments effective on their own or do they benefit from monetary policy? Second, does monetary policy geared exclusively towards price stability affect financial stability? A rich literature has looked at these questions. In this subsection we review the main theoretical and empirical insights.[30]

There are two alternative views on the first question. According to one view, discussed by Stein (2013), macroprudential policy has imperfect tools to counter threats to financial stability that emerge in an environment characterized by strong incentives for risk-taking. Compared to macroprudential policy, monetary policy has one important advantage that 'it gets in all of the cracks' (Stein 2013). An equally relevant and alternative view is the view that monetary policy is too blunt a tool for addressing financial stability risks exactly because 'it gets in all of the cracks'. An influential elaboration of this view is presented in Bernanke (2015). He argues that even in those

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circumstances where linkages between monetary policy and financial stability are apparent, such as in the case of housing bubbles, a very strong monetary policy response would be needed. This reaction would likely come at the cost of substantial deviations of output, employment and inflation from policymakers' objectives. IMF (2015) stresses that in practice, this trade-off hinges on country-specific characteristics. Moreover, views on the complementarity of macroprudential and monetary policy might evolve as our knowledge of the relationship between monetary policy and financial risks evolves and circumstances change.

The second question boils down to the issue of whether monetary policy has a systematic impact on *ex ante* risk-taking in the financial sector, thereby influencing financial conditions and ultimately the real economy—the so-called 'risk-taking channel' of monetary policy (Borio and Zhu 2012). To the extent that such a channel is relevant, and that macroprudential policy influences the real economy by affecting financing conditions, both policies should be coordinated.

In the theoretical literature, different answers have been given to the two questions, depending on how the interaction between financial factors and the macroeconomy is modelled. Macro models that do not incorporate features of a credit cycle and a risk-taking channel of monetary policy, for example that by Collard *et al*. (2017) or Svensson (2013, 2016), typically predict that monetary policy does not complement macroprudential policy in addressing risks to financial stability. Ajello *et al*. (2016) qualify this conclusion by examining different forms of uncertainty faced by Bayesian and robust policymakers. They show that it is optimal for monetary authorities to adjust their policy rate more aggressively to financial conditions if a crisis as severe as the Great Depression occurs, or if the probability of a crisis is highly responsive to financial conditions. Optimal monetary policy will also be more responsive to credit conditions in the presence of parameter uncertainty about the effectiveness of the policy rate in reducing the probability of a crisis and about the severity of a crisis.

By contrast, models in which monetary policy does have a meaningful impact on risk-taking by financial intermediaries (such as those in Angelini *et al*. 2013; Beau *et al*. 2012; Kannan *et al*. 2012; Angeloni and Faia 2013; Angeloni *et al*. 2015; Agur and Demertzis 2015) predict that monetary authorities explicitly include financial stability objectives. In these models, macroprudential policy and monetary policy are complementary and benefit from coordination.

In general, the coordination of macroprudential and monetary policy is modelled in a linear-quadratic framework with financial constraints that are always binding, because it is more tractable and allows a simpler welfare analysis of alternative policy approaches. Although models in a non-linear framework with occasionally binding constraints offer important insights on the impact of macroprudential policy, they are much harder to extend to the analysis of policy coordination by different authorities (De Paoli and Paustian 2013).

An important exception is 'The I theory of money' by Brunnermeier and Sannikov (2016), which provides a theoretical underpinning for policy coordination within a non-linear framework. In this framework, the supply of credit by financial intermediaries and money creation are endogenous. Both monetary and macroprudential policy address three crucial inefficiencies that can arise in equilibrium. First, there is inefficient sharing of idiosyncratic risk, which can be mitigated with the use of money but at the expense of creating investment distortions. Second, there is inefficient sharing of aggregate risk, which can cause particular sectors (e.g. intermediaries) to be undercapitalized. Third, even at the steady state, production can be inefficient if some sectors are

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undercapitalized. Monetary policy can help reduce endogenous risk and thereby increase welfare but cannot be used to target risk premia separately from risk-taking. In contrast, macroprudential policy, by controlling quantities rather than prices, can affect risk premia independently of risk-taking. Brunnermeier and Sannikov (2016) show that welfare is significantly improved by a combination of macroprudential policy and monetary policy.

In the empirical literature, there is no consensus on the first question mentioned above, while there is broad consensus on the second question.

On the first question, the evidence on whether macroprudential and monetary policies are complements or substitutes seems to be sensitive to the empirical approach that is followed. One empirical approach that is most frequently used relies on aggregate data to explain the impact of monetary policy or macroprudential policy on intermediate targets for macroprudential policy (e.g. credit growth or international capital flows, mortgage growth or house prices). In these studies, both changes in interest rates and other instruments are typically used to capture monetary policy actions, while macroprudential tools comprise both domestic measures and capital flow measures. Two main empirical strategies are followed to identify macroprudential and monetary policy shocks, and treat them in a unified framework while addressing endogeneity and reverse causality. The first applies VAR analysis to time series for individual countries (e.g. Glocker and Towbin 2012; Tovar *et al*. 2012; Mehrotra and Kim 2015). The second uses panel regressions and GMM estimation for data for a set of (typically emerging market) countries (e.g. Maddaloni and Peydró 2013; Bruno *et al*. 2016). These studies find that the effects of changes in policy interest rates and macroprudential actions tend to reinforce each other.

The robustness of results obtained from empirical methods based on aggregate data hinges on their ability to address the endogeneity issue discussed in Section III, and a paper by Federico *et al*. (2012) suggests that this ability may be limited. They follow a novel, narrative approach to identify exogenous shocks to reserve requirements, in the spirit of the work done by Romer and Romer (2004) for monetary policy shocks. Using historical documents, they classify changes in reserve requirements into those that are endogenous—in the sense that they are intentionally responding to current or projected fluctuations in output—and those that are exogenous, which were triggered by microprudential factors that are exogenous to the business cycle. When macroprudential shocks are identified through this narrative analysis, they find that reserve requirement policy acted as a substitute for monetary policy rather than a complement. The assumption that reserve requirement changes aimed at stabilizing output are a macroprudential tool is, however, very strong. Macroprudential policy is about curbing financial imbalances during a boom and strengthening the resilience of the financial system, so some endogenous changes in reserve requirements may not be macroprudential, while some exogenous changes might.

A promising empirical approach to studying the interaction of monetary policy and macroprudential policy relies on bank-level data. Research based on this type of data also suggests that the two policies are not complementary. Aiyar *et al*. (2016) study the interaction of monetary policy and macroprudential policy using data on discretionary, time-varying capital requirements imposed on 88 regulated banks in the UK, together with changes of the Bank of England's policy rate during the sample period of 1998–2007. They find that tighter capital requirements or tighter monetary policy are associated with a decline in credit supply. At the same time, the impact on lending differs significantly across types of banks. Large banks adjust lending substantially to capital

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requirement changes but not to monetary policy changes, whereas credit supply by small banks reacts to both types of policies. In their empirical model, Aiyar *et al*. (2016) include an interaction term between changes in the capital requirements and changes in the monetary policy rate, which is allowed to vary with bank-specific size and liquidity. The coefficient on this interaction term is found to be not statistically significant. They conclude that while both capital requirements and monetary policy have independent effects on credit, there is little evidence of interaction between these two policy instruments. This is seen as consistent with the view that monetary policy should focus on price stability, while prudential tools such as capital requirements are more effectively geared towards financial stability.

On the second question mentioned above, a growing body of empirical research has documented that monetary policy affects financial stability through a risk-taking channel.[31] This conclusion is based mainly on empirical work using microdata on changes in bank lending standards around monetary policy actions (Maddaloni and Peydró 2011; Jiménez *et al*. 2014; Dell'Ariccia *et al*. 2016). While much of this work has focused on the operation through the domestic banking sector of the risk-taking channel, a recent paper by Bruno and Shin (2015) highlights that this channel has an important international dimension. The paper examines the impact of US monetary policy shocks on measures of cross-border lending by global banks (taken from the BIS banking statistics) and their leverage (taken from the US Flow of Funds). Bruno and Shin (2015) find evidence that an expansionary shock to US monetary policy increases cross-border bank capital flows through higher leverage of international banks, and leads to a sustained depreciation of the US dollar.

V. Conclusions

While the literature on the effectiveness of macroprudential policy tools has so far provided only limited guidance for policy decisions, increasing efforts have been made to fill this gap. Important progress has been made in embedding macroprudential policy in theoretical models. At the same time, for tractability reasons the representations of intermediation activity in these models is still very stylized. Even so, the existing different classes of models with incomplete asset markets, aggregate shocks, heterogeneous agents and endogenous systemic risk are very complex, and are typically calibrated rather than estimated. Moreover, existing solution methods cannot be easily implemented for large models.

There is increasing empirical work on the effects of some macroprudential tools on a range of intermediate target variables—such as quantities and prices of credit, asset prices, or the amplitude of the financial cycle—and financial stability. Empirical evidence is most comprehensive and clearest for borrower-targeted macroprudential policies. Many different studies using a range of methods (cross-country panel regressions, microdata panel regressions, event studies) find some evidence of borrower-targeted macroprudential policies having some effects on intermediate targets of these macroprudential policies, namely house price growth and housing credit growth. By contrast, empirical evidence on the effects of financial-institutions-based macroprudential policies is less conclusive and more mixed. Similarly, empirical evidence on the effects of macroprudential capital flow management tools (which is a subset of financial-institutions-based macroprudential policies) is also less conclusive and more mixed.

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Two important issues for further research are the substitution from bank-based financial intermediation to non-banking intermediation in response to macroprudential measures, and the interaction of macroprudential policy and monetary policy.

Since empirical evidence on the effectiveness of macroprudential policy tools is still limited, the use of macroprudential policy tools is likely to involve some experimentation, from which authorities setting these instruments can learn over time and which they can use to improve their mix of macroprudential policy tools.

APPENDIX

TABLE A1
GOALS, INTERMEDIATE OBJECTIVES AND INSTRUMENTS OF MACROPRUDENTIAL POLICY

Goal				
Use prudential means to enhance system-wide financial stability, with a view to limiting macroeconomic costs from financial distress				
Intermediate objectives				
Address externalities in the time-series dimension of systemic risk		*Address externalities in the structural (cross-section) dimension of systemic risk*		
Counter financial booms by addressing externalities generated by collateralized borrowing		Strengthen the resilience of the financial system by addressing externalities arising from market structure and in the financial infrastructure		
Fire sales	Strategic complementarities	Interconnectedness	Size and position in the market	Financial infrastructure
Instruments (examples)				
Capital requirements (time-varying surcharges)	Capital requirements (e.g. surcharge linked to aggregate credit growth)	Capital requirements (SIFI buffers)		CCP clearing (funding requirements for systemically important CCPs)
Liquidity requirements (NSFR, LCR)	Restrictions on activities, assets, or liabilities (e.g. DTI and LTV ratios)	Restrictions on activities, assets, or liabilities (e.g. Volcker Rule)		
Time-varying margining requirements		Taxation (e.g. Pigouvian tax on SIFIs dependent on interconnectedness)		
Taxation (e.g. Pigouvian tax on short-term funding)				

Sources: Borio (2009, 2014b), de Nicolò *et al*. (2012) and Houben *et al*. (2012).

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TABLE A2
SELECTED STUDIES ON EXPERIENCES WITH MACROPRUDENTIAL POLICY

Study	Data source	Sample	Instruments
Hodgman (1973)	Central bank publications	6 European countries, 1945–73	Credit control measures
Hilbers *et al.* (2005)	IMF Country Reports, national central banks	18 central and eastern European countries, 1990–2005	Measures with potential impact on credit growth
Hilbers *et al.* (2007)	IMF Country Reports, national central banks	18 central and eastern European countries, before 2007	Measures with potential impact on credit growth
CGFS (2010)	Survey of central banks	33 countries, until 2009	Measures targeting credit growth (e.g. LTV caps), measures targeting size and composition of bank balance sheets (e.g. limits on interbank exposures)
Crowe *et al.* (2011)	Survey of central banks	40 countries, 2000–9	Measures targeted at housing booms
IMF (2011b)	Survey of central banks	51 countries, 1990–2010	Broad set of instruments
Lim *et al.* (2011)	IMF survey of country desk economists	42 countries, 2003–8	10 instruments related to credit (e.g. LTV caps), liquidity (e.g. limits on net open currency positions) or capital (e.g. countercyclical capital requirements)
Federico *et al.* (2014)	World Bank study (http://go.worldbank.org/D7JYE3SLS0)	52 countries, 1970–2011	Legal reserve requirements
Ostry *et al.* (2012)	Schindler (2009), IMF AEREAR, IMF country desk survey	51 emerging market countries, 1995–2008	Macroprudential capital flow management tools and capital controls
Tovar *et al.* (2012)	IMF staff based on national sources	5 Latin American countries, 1997–2011	Measures targeted at credit growth
Vandenbussche *et al.* (2015)	National authorities, IMF Staff Reports and FSAP documents, Enoch and Ötker-Robe (2007)	16 central and eastern European countries, 1997–2000	Wide range of macroprudential tools
Claessens *et al.* (2013)	See Lim *et al.* (2011)	46 countries, 2000–10	Tools aimed at borrowers (e.g. caps on DTI, LTV), lenders (e.g. limits on credit growth), and other tools (e.g. accounting changes)

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TABLE A2
CONTINUED

Study	Data source	Sample	Instruments
Elliott *et al.* (2013)	US national authorities	USA, since 1910	Credit tools ('underwriting standards'), stock margin requirements, selective credit controls on portfolios, reserve requirements, interest rate ceilings, capital requirements, supervisory guidance and 'direct pressure'
Izquierdo *et al.* (2013)	Central banks	6 Central American countries, 1995–2011	Reserve requirements, dynamic provisioning
Kuttner and Shim (2016)	Shim *et al.* (2013)	57 countries, 1980–2011	Monetary policy and macroprudential measures: LTV and DTI caps, risk weights on housing loans, loan loss provisioning applied to housing loans, limits on banks' exposure to the housing sector
Shim *et al.* (2013)	National sources	60 countries, 1990–2012	Monetary policy and macroprudential measures: LTV and DTI caps, risk weights on housing loans, loan loss provisioning applied to housing loans, limits on banks' exposure to the housing sector
Bruno *et al.* (2016)	BIS macroprudential database, and database of capital flow management policies	12 Asia–Pacific economies	Domestic macroprudential measures and capital flow measures
Beirne and Friedrich (2014)	Lim *et al.* (2011), Ostry *et al.* (2012)	139 countries, 1999–2009	8 macroprudential capital flow management tools and capital controls
Cordella *et al.* (2014)	Central banks and government agencies, research and policy papers	52 emerging market countries, 1970–2011	Reserve requirements
IMF GMPI survey (2014)	IMF survey among national authorities, IMF staff	119 countries, 2000–13	18 instruments
Zhang and Zoli (2014)	Lim *et al.* (2013), national sources, AREAER, country/regional studies	46 countries, 2000–13	Macroprudential tools, including capital flow management tools

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TABLE A2
CONTINUED

Study	Data source	Sample	Instruments
Akinci and Olmstead-Rumsey (2015)	Surveys conducted by the IMF, a BIS database, national authorities	57 countries, 2000–13	7 categories of macroprudential tools
Reinhardt and Sowerbutts (2015)	Lim *et al*. (2011), Borio and Shim (2007), Kuttner and Shim (2013), GMPI, national sources	37 countries, 2005–14	3 categories of macroprudential tools
Cerutti *et al*. (2015)	Subset of GMPI	119 countries, 2000–13	12 instruments: countercyclical capital buffers; leverage ratio for banks; time-varying/ dynamic loan-loss provisioning; LTV caps; DTI caps; limits on domestic currency loans; limits on foreign currency loans; reserve requirements; tax on financial institutions; capital surcharges on SIFIs; limits on interbank exposures; and concentration limits

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NOTES

1. See, for example, Walsh (2010).
2. For related discussions of objectives and instruments of macroprudential policy, see also Houben *et al*. (2012), Haldane (2013), IMF (2013b) and Buch (2015).
3. See, for example, Blanchard *et al*. (2010, 2013), Woodford (2012, 2013), Bayoumi *et al*. (2014) and Borio (2014a).
4. In 2013, Andrew Haldane argued that 'The state of knowledge about macroprudential regimes today is roughly where monetary policy was in the '40s' (Haldane 2013).
5. The extensive literature on operational targets of macroprudential policy, which mostly focuses on early warning indicators of financial crises, is beyond the scope of this paper. For an overview of the main contributions, see, for example, Galati and Moessner (2013) and papers cited therein.
6. See Crockett (2000), Haldane (2014) and Borio (2015).
7. Crockett (2000) and Borio and Crockett (2000) are early advocates of this idea. For a more formal discussion, see, for example, Jeanne and Korinek (2014) and Adrian and Brunnermeier (2016).

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8. This distinction was first introduced in Borio and Crockett (2000). For a more detailed discussion, see, for example, Borio (2009), Bank of England (2011) and IMF (2011a).
9. This approach has been followed also in practice. A notable example is the European Systemic Risk Board (ESRB), which is tasked with macroprudential oversight of the financial system within the European Union. The ESRB maps market failures—including externalities related to fire sales and interconnectedness—into intermediate objectives for macroprudential policy (ESRB 2014a,b).
10. For a recent summary of this literature, see Korinek and Simsek (2016).
11. A fire sale can be defined as a generalized sell-off of financial assets, which results in a sharp decline in asset prices and a deterioration of the balance sheets of financial intermediaries, thereby aggravating the fragility of the financial system (De Nicolò *et al*. 2012).
12. See Borio (2014b) for an overview. An influential example of research along these lines is the work by Hanson *et al*. (2011), which characterizes the macroprudential approach to capital regulation as an effort to control the social costs associated with excessive balance-sheet shrinkage on the part of multiple financial institutions hit with a common shock. There is still little research on systemic risk arising from vulnerabilities in the financial infrastructure and its implications for macroprudential policy (see Domanski *et al*. 2015). An exception is the paper by Menkveld (2015), which analyses financial stability risks of central counterparty clearing and real-time gross settlement systems.
13. We also include measures to limit system-wide currency mismatches in an effort to stem the domestic financial consequences of capital inflows, such as limits on open foreign exchange positions and constraints on the type of foreign currency assets. These tools are relevant since financial booms, especially in emerging market economies, have been found to be accompanied by a growing share of net foreign-currency financing (Borio and Shim 2007).
14. In the literature, the term debt-to-income is often used loosely to refer either to the ratio of debt to income or to the ratio of debt services to income.
15. Table A2 in the Appendix lists selected studies that document experiences with macroprudential policy.
16. Hodgman (1973) provides a survey of the use of credit controls in European countries. Shu *et al*. (2008) draw parallels with credit controls used by the People's Bank of China in the 2000s.
17. Cerutti *et al*. (2015) use data from the IMF's GMPI survey. Cerutti *et al*. (2016) construct a publicly available database of prudential policy instruments (with either microprudential or macroprudential objectives) using the IMF's GMPI survey and primary sources (e.g. central bank reports).
18. See, for example, Lim *et al*. (2011) and van den End (2016) for details.
19. For an overview of models of macroeconomic implications of financial frictions, see Brunnermeier *et al*. (2013).
20. For more details, see Galati and Moessner (2013).
21. In related work, Christiano *et al*. (2014) document the role of shocks that affect the quantity of net worth in the hands of entrepreneurs and thereby the demand side of the market for capital.
22. See Benigno (2013) for a detailed discussion of the modelling elements of this line of research.
23. Minsky (1992) describes his financial instability hypothesis in these terms: 'The first theorem of the financial instability hypothesis is that the economy has financing regimes under which it is stable, and financing regimes in which it is unstable. The second theorem of the financial instability hypothesis is that over periods of prolonged prosperity, the economy transits from financial relations that make for a stable system to financial relations that make for an unstable system.'
24. They also apply panel fixed effects and mean group regressions, but without addressing the endogeneity problem there, and also without controlling for other policies, global or local factors.
25. For an overview of event studies on the impact of macroprudential measures aimed at dealing with real estate booms, see Crowe *et al*. (2011), in particular Table 2 there.
26. See also Igan and Kang (2011), who use data from a survey of mortgages and housing demand by Korean households to examine the impact of LTV and DTI limits on house price dynamics and household leverage in Korea.
27. For an overview of the policy debate on challenges of macroprudential policy, see, for example, Haldane (2013), Borio (2015), Constâncio (2015) and Fischer (2015).
28. In the words of Goodhart (2008), macroprudential policy faces a 'boundary problem', as effective regulation is likely to penalize financial intermediaries within the regulated sector, relative to those just outside, causing substitution flows towards the unregulated.
29. See Arregui *et al*. (2013) for a detailed discussion.
30. For a detailed discussion of the contributions to this debate, we refer to the overviews in Angelini *et al*. (2013), De Paoli and Paustian (2013), IMF (2013c), Svensson (2013) and Smets (2014).
31. De Nicolò *et al*. (2010), Borio and Zhu (2012) and Smets (2014) provide overviews of this literature.

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