Financial frictions, financial regulation and their impact on the macroeconomy

Daria Finocchiaro and Anna Grodecka*
Daria Finocchiaro works at the Monetary Policy Department and Anna Grodecka works at the Financial Stability Department of Sveriges Riksbank.

In the aftermath of the global financial crisis, increasing attention has been paid to the role played by financial factors in business cycle fluctuations. The crisis also led to the development of economic policies, beyond traditional microprudential regulation, that promote financial stability. Macroprudential policy is one such tool. It fosters a more resilient financial system by directly tackling systemic risk, that is the risk of a breakdown of the entire financial system with significant economic costs. Yet macroprudential policy is still in its 'infancy'. In this article, we first emphasize the importance of financial markets for our understanding of the real economy and how they have traditionally been incorporated in macroeconomic models. Then we discuss the rationale for macroprudential regulation and present a cost-benefit framework to evaluate the merits of different macroprudential instruments; the benefits include a more resilient financial system and stable economy, and the costs involve forgone lending and lower economic activity. We conclude by summarizing some of the remaining challenges in the field.

1 Introduction

> '*I have a simple explanation [for the first Modigliani-Miller proposition]. It's after the ball game, and the pizza man comes up to Yogi Berra and he says, "Yogi, how do you want me to cut this pizza, into quarters?" Yogi says, "No, cut it into eight pieces, I'm feeling hungry tonight." Now when I tell that story the usual reaction is, "And you mean to say that they gave you a [Nobel] prize for that?"*'
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> Merton Miller

The macroeconomic discipline has come under strong criticism after the global financial crisis of 2007–2008, mostly due to the negligence of financial factors in mainstream macroeconomic models.[1] The majority of models used by policymakers and central banks around the world before the crisis did not explicitly allow for well-articulated financial markets: they often assumed complete and efficient capital markets where firms' ownership and capital structures are irrelevant, and so are financial institutions.[2]

This is the case, for example, in the widely used New Keynesian workhorse DSGE[3] model by Smets and Wouters (2007). In this stylized model, households (and firms) have full access

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1 See the special issue of the Oxford Review Economic Policy 'Rebuilding Macroeconomic Theory".

2 Under complete markets, there exists a market with a price for every asset for all possible states of the world. Agents can buy, either directly or indirectly, any asset, that is there exist contracts to insure against all possible eventualities (see Gulko, 2008). Markets are furthermore efficient if prices fully reflect all available information (Fama, 1970).

3 Dynamic Stochastic General Equilibrium – a class of macroeconomic models widely used in central banking, but also in academia to assess the effects of different policies.

to financial markets and are perfectly insured against, for example, the risk of losing their jobs. It follows that financial institutions are redundant and a central bank's main role is to adjust the price of credit (see Vines and Willis, 2018). In reality, financial markets are far from this idealized world and these market imperfections, that is financial frictions, are also important for aggregate fluctuations. As a matter of fact, the disconnect between the financial and real sides of the economy is at odds with the data. As documented in Jermann and Quadrini (2012), financial flows were highly cyclical even during the tranquil time of the Great Moderation.[4]

The empirical relevance of macro-financial linkages is not a new discovery.[5] Economic classics, such as Keynes, Wicksell or Minsky were aware of the crucial role of credit in the economy. However, subsequent macroeconomic researchers shifted their focus away from the importance of financial markets for economic developments. In the 1960s, the revolutionary 'irrelevance propositions' of Modigliani and Miller (M&M henceforth) identified the necessary conditions through which financial factors would prove to be irrelevant from a theoretical perspective. In a nutshell, in a somewhat idealized world with perfectly functioning markets and absent corporate taxes, agency problems,[6] information frictions and bankruptcy costs, M&M state that a company's capital structure is irrelevant for its market value. As a result, debt and equity are only two different ways of slicing the same pizza, that is a firm's value. Kashyap and Zingales (2010) argue that the theorem, conceived to show an extreme benchmark, has over the years been (mis)used as a proof of the unimportance of corporate finance for our understanding of the real economy.

In the 1990s, some early macroeconomic studies (Bernanke and Gertler, 1989, and Kiyotaki and Moore, 1997 and Carlstrom and Fuerst, 1997) highlighted the importance of deviations from the M&M assumptions and explicitly incorporated financial factors into general equilibrium models. But together with other studies focusing on bubbles, panics and contagion, they belonged more to the periphery of the profession rather than to its core. For a very long time, financial intermediaries were treated as 'a veil' (Gertler and Kiyotaki, 2010) in mainstream macroeconomic models;[7] the increased economic stability in the prolonged period of the Great Moderation partly gave support to the notion that changes in financial conditions did not matter for macroeconomic outcomes.

The recent crisis became a wake-up call for the profession and it provided two main lessons.

First, financial intermediation is crucial for understanding business cycle dynamics. While in normal times the financial sector helps firms and households to smooth income fluctuations, it may lead to their amplification (Brunnermeier, Eisenbach and Sannikov, 2012) in crisis times. Some economists (see for example Jordà, Schularick and Taylor, 2013) argue that financial-crisis recessions are more costly than normal recessions in terms of lost output. The importance of financial factors and institutions for our understanding of the economy is further enhanced by the recognition that they could also have an impact on economic growth (see Levine, 2005).

Second, in a world where financial institutions are highly interconnected, microprudential measures should be accompanied by macroprudential ones; only the latter can explicitly take into account the systemic role of some financial actors and the resulting feedbacks between real and financial sectors in the economy. Microprudential policies (for example capital adequacy rules in the Basel accords) have been adopted by financial regulators for decades and

4 The Great Moderation denotes a time period, starting from the mid-1980s and interrupted by the Global Financial Crisis (2007–2008), characterized by low macroeconomic volatility experienced in many developed economies.

5 Macro-financial linkages are linkages between financial conditions and macroeconomic developments. See Appendix I of Claessens and Kose (2017) for the summary of the history of research on macro-financial linkages.

6 An agency problem describes those situations in which one party (the agent) acts on behalf on another (the principal), for example when a manager acts on behalf of shareholders. In such situations, conflicts of interests could arise if the incentives between the agent and the principal are not aligned.

7 For discussions of this, see Caballero (2010), Gertler and Kiyotaki (2010), Quadrini (2011) and Fernández-Villaverde (2012).

focus mainly on the risks of individual financial institutions. As such, they might be insufficient for maintaining financial stability. In contrast, macroprudential policy attempts to foster stronger resilience of the financial system (including, for example, banks, firms and households) and reduce systemic risk, that is the risk of a breakdown of the entire financial system triggering severe damage to the economy.[8] The explicit goals of such policies are to reduce the pro-cyclicality of credit flows and address the problem of 'too big to fail' institutions (that is banks systemically important due to their size and level of interconnectedness).[9] As a result, different macroprudential measures have both time series and cross-sectional components, that is they may affect the cyclical aspects of systemic risk and its development over time, and they may affect the distribution of risk among different market participants at a given point in time. Dynamic macroeconomic models operating in a representative agent framework – where all individuals are assumed to be identical, are well-suited for the assessment of general equilibrium effects of different policies and addressing the time dimension of systemic risk. As shown in this review, recent research has also made progress in tackling the cross-sectional dimension of systemic risk by explicitly taking into account the heterogeneity of financial actors in the economy (see Corbae and D'Erasmo, 2014 and Boissay and Collard, 2016, discussed in this review).

Many micro- and macroprudential policies aim at lowering leverage, either of the banking system or that of private borrowers. While it is very hard to establish what the appropriate level of leverage should be, it cannot be disputed that some of the existing regulations (for example limited liability and deposit insurance for banks, interest tax deductions for corporations and households) encourage borrowing and introduce a wedge between private and social costs of debt, a so-called externality.[10] A too highly leveraged economy may lead to debt overhang problems.[11] In difficult times, highly leveraged agents tend to deleverage quickly, and this likely has a significant negative impact on consumption and output. As emphasized by Turner (2016), once leverage is high, it is difficult to reduce it without adverse economic effects. During the global financial crisis of 2007–2008, many existing debt contracts were actually not repaid, but shifted around the system, from the private sector to the public sector, both in the US and in Europe. Pre-emptive actions aiming at curbing the build-up of excessive leverage are therefore crucial.

In reality, policy makers face an important trade-off between the costs of systemic risk which materialize only in crisis times, and the level of economic activity in tranquil times, which is likely to be lower under stricter regulation. The 'Greenspan doctrine' was the consensus view before the global financial crisis: preemptive financial regulation was perceived as too costly and too blunt a tool (see Jeanne and Korinek, 2017) and the appropriate policy intervention was believed to be 'ex-post', that is at the time of the crisis. The crisis significantly changed our views on this trade-off but also further stressed the need to assess the costs of financial regulations ahead of the introduction of a given measure. This can only be done if the underlying market failure – the specific source of deviation from the ideal efficient market benchmark that needs to be corrected – is well identified. Thus, the design of an appropriate policy toolkit should ideally:

8 Although there is no consensus yet on this issue, our definition of systemic risk is in line with the one of the European Central Bank: 'Systemic risk can best be described as the risk that the provision of necessary financial products and services by the financial system will be impaired to a point where economic growth and welfare may be materially affected' (ECB, 2018). See also Braconier and Palmqvist (2017) on this issue.

9 A detailed description of micro- and macroprudential policies is provided in Freixas, Laeven and Peydró (2015).

10 In economics, an externality denotes a situation where the actions of one party impact on another party and such interaction is not taken into account by agents nor reflected in market prices. Passive smoking and the related health costs are a textbook example of negative externality. Individual excessive indebtedness and its impact on (socially) expensive financial crises are another one. As such, an externality constitutes a market failure, that is a deviation from the ideal market.

11 See Myers (1977) and Lamont (1995) for the discussion of corporate debt overhang and Mian and Sufi (2014) and Melzer (2017) for household debt overhang.

i. Identify the source of market failure to address,

ii. Rely on an adequate cost and benefit analysis,

iii. Assess the effectiveness of different tools.

Macro models with well-articulated financial sectors are well suited to conduct policy experiments by taking into account all the above in general equilibrium set-ups.

In what follows, we first review the most recent attempts in the literature to incorporate financial frictions, that is deviations from the idealized M&M world with perfectly functioning capital markets, in otherwise standard theoretical macro models. Then we evaluate through the lens of various models both the costs, that is forgone lending and economic activity, and the benefits, that is a more resilient financial system and stable economy, of different macroprudential tools.[12]

2 Modelling financial frictions

In the models reviewed in this article, financial markets deviate from the idealized M&M world for various reasons. Sometimes it is assumed that only some assets can be traded in capital markets. In other set-ups, some sort of agency problem usually limits access to credit markets. This can happen because lenders and borrowers are asymmetrically informed (informational frictions) or if lenders cannot force borrowers to fulfil their contractual agreements (enforcement problems, see Quadrini, 2011).

An important distinction in the existing literature is whether risk is exogenous, that is not influenced by economic agents' decisions, or endogenous. Systemic risk falls into the second category and it is one of the primary reasons for regulating financial institutions. In a nutshell, under-capitalization of the financial system leads to risks not being internalized by financial market participants, which can severely amplify the subsequent economic downturn or even cause a recession. Understanding the underlying source of market failure is crucial when designing an efficient instrument or combination of tools to address it.[13] De Nicolò, Favara and Ratnovski (2012) classify these externalities into three main categories:[14]

i. *Strategic complementarities – interactions* between banks inducing them to take excessive risk (Farhi and Tirole, 2011), that is banks might find it optimal to correlate their portfolios with each other's because they anticipate that in a crisis event they will be bailed-out by the government;

ii. *Pecuniary externalities*, that is over-indebtedness among households, corporations or banks might induce fire sales during a downturn. The resulting negative impact of falling prices on their balance sheets can amplify the slump (Lorenzoni, 2008 and Bianchi, 2011); these effects on prices are not privately internalized, thereby inducing agents to take on too much debt.

iii. Externalities related to *interconnectedness*, that is one distressed bank could jeopardize the stability of other financial institutions (Allen and Gale, 2000).

Recently, Farhi and Werning (2016) put forth a different source of externality, a demand externality, which provides a justification for macroprudential policies in environments where output is demand-driven. Financial decisions of economic agents influence the wealth distribution in the economy, which, through different marginal propensities to consume among agents, affects the aggregate demand in the presence of nominal rigidities.

12 Although monetary policy could also impact on financial stability, in this article we leave a discussion of the interactions between monetary and macroprudential policies out. See International Monetary Fund [IMF] (2005) on this issue.

13 In reality, over-indebtedness or excessive risk taking can also be the result of behavioral factors. Although, there is a vast literature explicitly taking into account those factors, in this article we focus on studies which do not consider deviations from rationality.

14 Although De Nicolò, Favara and Ratnovski (2012) mainly focus on externalities affecting financial institutions, here we broaden their definitions also to other financial markets participants, for example borrowing households and firms.

Households usually do not take into account the impact of their financial decisions on the wealth distribution and aggregate capacity of the economy. Macroprudential policies that internalize this impact could potentially improve the welfare of the economy. As an illustration, one could imagine a sudden credit crunch in a world with borrowers and savers where monetary policy is constrained by the zero lower bound. By restricting borrowing before the crisis, a regulator could improve the spending capacity of borrowers during the crash, thereby stabilizing the economy. These stabilization benefits are not taken into account by private agents, thus justifying the regulatory intervention.

For the ease of exposition, in what follows we distinguish whether the financial friction impairs the supply or demand of credit.

2.1 Credit-demand frictions

Early attempts in the literature to incorporate deviations from the M&M irrelevance proposition into macro models focus on the demand side of credit. In those studies, macro financial linkages arise because firms and/or households are financially constrained, that is capital markets are not perfectly functioning. Specifically, limited access to credit markets creates a link between firms' and households' balance sheet conditions and the real economy. Such a link can act both as an amplification tool and as a source of business cycle fluctuations, as further explained below. In this respect, studying financial frictions helps to address two of the central issues in macroeconomics: *i)* understanding how even moderate changes in economic fundamentals can have large macroeconomic consequences *ii)* explaining the origins of business cycles.

Financial frictions can amplify the impact of economic disturbances via their impact on households' and firms' balance sheets. This is the case in the seminal work of Kiyotaki and Moore (1997) and Bernanke, Gertler and Gilchrist (1999). In the first paper, lenders cannot force borrowers to repay their debt unless it is collateralized. Hence, in their work, capital is both a factor of production and it has collateral value, and both aspects are reflected in its price. In a bust, due for example to disruptions originating in the production sector of the economy, so-called supply shocks, movements in the price of capital further impair borrowers' collateral capacity, thereby aggravating the effects of the initial shock. Therefore, the interaction between credit limits and asset prices amplifies and spreads the effects of the initial negative shock to other sectors. In Bernanke, Gertler and Gilchrist (1999), there are information asymmetries between borrowers and lenders and monitoring is costly. This agency problem creates an interest rate spread between internal and external funding proportional to borrowers' net worth. In a downturn, the market value of firms' net worth deteriorates. As a result, agency costs increase countercyclically, thereby further reducing firms' borrowing ability. This last channel triggers a contraction in investments and a further deepening of the crisis. This is the so-called 'financial accelerator'. Iacoviello (2005) builds on Kiyotaki and Moore (1997) in a model where housing has a dual role as a consumption good as well as a collateralizable asset. In that framework, housing price dips can considerably depress aggregate demand.

Furthermore, financial frictions can also be a source of business cycles rather than a mere amplification tool, as shown in Jermann and Quadrini (2012). Also in their set-up, firms could default on their debts and this limits their ability to borrow. Moreover, debt is preferred to equity because interest rate expenditures are tax deductible. Crucially, it is further assumed that firms cannot easily change their capital structure, that is the composition of debt and equity. As a result, a sudden deterioration of firms' financing conditions, a so-called negative financial shock, will force them to cut employment and depress aggregate demand. According to the estimates in Christiano Motto and Rostagno (2003), a 'liquidity shock' induced households to accumulate currency at the expenses of deposits during the Great Depression. In their set-up, financial factors are important for the real economy because a financial accelerator à la Bernanke, Gertler and Gilchrist (1999) is at work.

2.2 Credit supply frictions

More recently, banks have been explicitly incorporated into macro models in order to explore the impact of credit supply imperfections on financial intermediation and the real side on the economy. In this strand of literature, *financial intermediaries'* balance sheet conditions matter for business cycles fluctuations.

In reality, banks fulfil multiple functions. They contribute to the efficiency of the payment system, channel funds between savers and investors, provide liquidity (demand deposits) and engage in maturity transformation, loan monitoring and risk management (see Friexas, Laeven and Peydró, 2015). In the existing theoretical literature, financial intermediaries can provide one or more of the above mentioned services. However, the well-functioning of the financial system can be disrupted by the excessive risk-taking (of bankers) or by poor financial regulations.

In Gertler and Karadi (2011), banks channel funds from savers to investors and are involved in maturity transformation, that is they hold long-term assets financed by short-term deposits. A *moral hazard* [15] problem in the funding markets creates a spread between lending and deposit rates. Specifically, as bankers can choose to divert available funds, their liabilities are constrained by their equity capital. As a result, movements in financial intermediaries' balance sheets will spread to the rest of the economy and amplify business cycles. A similar transmission mechanism is at work in Gertler and Kiyotaki (2010), where different financial intermediaries interact in the interbank market and are subject to shocks that can lead to bank-runs. In both models, the demand side of credit works in a frictionless manner, that is firms' borrowing is not restrained by collateral constraints.

Moral hazard problems could be multi-layered. They can, for example, arise between depositors and banks, but also between entrepreneurs and financial intermediaries. Meh and Moran (2010) build on the double moral hazard framework of Holmstrom and Tirole (1997). In their set-up, banks can more efficiently channel resources between investors and entrepreneurs by monitoring the quality of different investment projects. At the same time, to induce banks to properly monitor and not invest in a too risky loan portfolio, investors require banks to invest their own capital, that is to have some skin in the game. It follows that bank capital positions influence the business cycle though a bank channel transmission mechanism, that is the effects of supply-side disturbances are amplified and propagate to the real side of the economy.

Borrowers' and financial intermediaries' balance sheet conditions interact with each other. In Iacoviello (2015) and Mendicino et al. (2016), both the demand and supply side of credit are impaired. In Iacoviello (2015), household and entrepreneurs' borrowing is collateralized by real estate, as in Iacoviello (2005). Banks intermediate funds between savers and borrowers and are subject to a capital adequacy constraint, that is their ability to raise funds in the deposit market is constrained by the amount of equity capital. In Mendicino et al. (2016), the banking side features two key distortions. First, banks operate under limited liability and deposits are partially insured by the government. Second, uninsured bank debt is priced according to the expected economy-wide bank failure risk, thereby creating an incentive for banks to relax their lending standards. On the demand side of credit, both households and entrepreneurs can default on their credit and the cost of external funding is tied to their balance sheet conditions, as in Bernanke, Gertler and Gilchrist (1999).

Finally, the degree of competition in the banking sector can also play a role for macroeconomic stability. In Gerali et al. (2010), banks issue collateralized loans to both households and firms, obtain funding via deposits, and accumulate capital out of retained earnings. Financial intermediaries operate in a market with imperfect competition and can adjust rates only infrequently. This market set-up creates interest spreads which depend on

15 Moral hazard describes those situations in which a contract creates a conflict of interests between the parties involved. For example, an insurance contract could prompt the insured to take on more risk because she is protected.

the banks' capital-to-assets ratio and the degree of interest rate 'stickiness'. Households', firms' and banks' balance sheet conditions matter for how disturbances propagate in the economy. Similarly, Andres and Arce (2012), develop a framework where investors' credit capacity is tied to the value of their real estate holdings. Lending margins are optimally set by banks in a market with imperfect competition and have a significant effect on aggregate variables. Their findings show that in the long run, stronger banking competition increases output by reallocating the available collateral towards investors. At the same time, competition increases the short-run response of output, credit and housing prices to disturbances.

3 Macroprudential tools: a costs and benefits analysis

This section evaluates the economic impact of several macroprudential measures through the lens of different theoretical macroeconomic models.[16] Following the structure of section 2, we start by discussing macroprudential measures that mostly affect credit demand, although some of these measures have implications for credit supply, too. We then end this section by discussing bank capital regulation that directly affects credit supply.

Many of the reviewed papers address the problem of excessive household indebtedness that, along with low capital ratios of banks, increases the overall leverage of the system.[17] As explained in the previous sections, too high leverage can considerably increase macroeconomic volatility, thereby motivating the need for regulations. Table 1 summarizes the main quantitative findings of the discussed papers. Some papers mentioned in this section provide mainly qualitative insights and as such, they are not considered in Table 1.

Table 1. Quantitative findings of discussed papers.

Paper	Findings
LTV regulation	
Gelain, Lansing and Mendicino (2013)	Lowering LTV from 0.7 to 0.5 lowers house price volatility by 4 percent and lowers household debt volatility by 27 percent under rational expectations. Under adaptive expectations, it lowers house price volatility by 2 percent and household debt volatility by 18 percent. The volatility of consumption, output or inflation is not affected.
Rubio and Carrasco-Gallego (2014)	Increasing a static LTV ratio up to 0.55 is welfare enhancing for borrowers and savers. Above LTV of 0.55, increasing LTV further decreases the welfare of borrowers and increases the welfare of savers, leading to an overall decrease in welfare. A countercyclical LTV ratio reacting to credit growth increases the total welfare.
Mendicino and Punzi (2014)	Coupled with an interest rate rule reacting to credit growth, a countercyclical LTV rule reacting to house prices almost doubles welfare, decreasing the volatility in the economy.
Chen and Columba (2016)	Lowering LTV from 85 to 80 percent leads to a short-run reduction in consumption and output. In the long-run, debt-to-income goes down by 10 percent, output by 0.5 percent and house prices by 0.2 percent. Stricter LTV rules improve welfare, but only marginally so below the 60% limit.
Finocchiaro, Jonsson, Nilsson and Strid (2016)	A reduction of the loan-to-income ratio by 10 percent in equilibrium requires lowering LTV from 75 to 69.5 percent (by 7.22 percent). On aggregate, housing and goods consumption do not change. GDP goes down by 0.4 percent.
Alpanda and Zubairy (2017)	Stricter LTV regulation is an effective tool (second-best) in reducing the household debt-to-GDP ratio at the expense of lower output and aggregate consumption in the short run. Higher levels of LTV induce more volatility and are welfare-detrimental for patient households, while they are preferred by impatient households. The optimal regulatory LTV ratio is at around 0.66.

16 See Guibourg and Lagerwall (2015) for a more general discussion of how macroprudential measures affect the economy.
17 See Emanuelsson, Melander and Molin (2015) for a discussion of risks linked to elevated household indebtedness and Sveriges Riksbank (2015) for a discussion of possible measures to manage financial risks in the household sector.

Grodecka (2017)	When borrowers are constrained by the LTV constraint only, lowering LTV by 5 percent from 85 percent reduces equilibrium debt to GDP by 8 percent, house prices by 2 percent and output by −0.2 percent. In the short run, the effects are stronger. Taking into account a realistic distribution of borrowers across different constraints in Sweden, where 60 percent of borrowers are constrained by LTV, lowering LTV lowers equilibrium debt to GDP by 3.09 percent, house prices by 3.17 percent and increases output by 0.09 percent in the long run.
LTI/DSTI regulation	
Gelain, Lansing and Mendicino (2013)	If lenders use an additive borrowing constraint, putting 75 percent of weight on labor income and 25 percent weight on the housing collateral value, the volatility of house prices increases by 3 percent and the volatility of household debt goes down by 44 percent under rational expectations, while it reduces the volatility of house prices by 5 percent and of household debt by 49 percent in the model with hybrid expectations. The volatility of consumption and output remain unchanged.
Finocchiaro, Jonsson, Nilsson and Strid (2016)	A reduction of the loan-to-income ratio by 10 percent in equilibrium requires lowering LTI from 251 to 226 percent (by 25 percentage points). The aggregate consumption goes down by 0.1 percent and GDP by 0.4.
Grodecka (2017)	When borrowers are constrained by the DSTI constraint only, lowering DSTI from 25 percent by 5 percent reduces equilibrium debt to GDP by 7 percent and output by −0.4 percent, without a negative effect on house prices. In the short run, negative output and house price effects are reduced compared to a similar LTV experiment. Taking into account a realistic distribution of borrowers across different constraints in Sweden, lowering DSTI lowers equilibrium debt to GDP by 3.09 percent, house prices by 0.21 percent and output by 0.07 percent in the long run.
Amortization regulation	
Chambers, Garriga and Schlagenhauf (2009b)	Mortgage products with flexible amortization schemes can increase homeownership up to 6 p.p., mostly among young and poor people. Their availability also increases average house size and residential investment.
Forlati and Lambertini (2012)	In a model with two-period mortgage loans, low early amortization leads to higher leverage, output and housing prices in equilibrium. The dynamic responses to shocks are amplified in that case.
Chen and Columba (2016)	Increasing the amortization pace from 50 to 45 years lowers output in the short and in the long run. Long-run output is lowered by 0.4 percent, house prices by 0.5 percent and debt-to-income ratio by around 10 percent. Welfare impact of stricter amortization regulation is non-linear.
Finocchiaro, Jonsson, Nilsson and Strid (2016)	A reduction of the loan-to-income ratio by 10 percent in equilibrium requires accelerating the amortization from 50 years to 44.9 years. The aggregate consumption does not change and GDP goes down by 0.3.
Svensson (2016)	In a model in which unconstrained borrowers follow their optimal future mortgage path, imposing a 2 percent amortization requirement over a 10 year horizon leads to an increase in initial and average debt from 7.6 to 20 percent, depending on the interest rate spread between the savings and mortgage rate and the refinancing possibilities of borrowers.
Hull (2017)	Stricter amortization rules have little impact on reducing debt-to-income ratios because optimizing households refinance to remain on their preferred optimization path.
Grodecka (2017)	Taking into account a realistic distribution of borrowers across different constraints in Sweden, increasing the amortization pace by 5 percent lowers debt to GDP by 4.2 percent, output by 0.09 percent and increases house prices by 0.13 percent. In the short run, house prices may fall under stricter amortization rules.
Tax deductibility of mortgage interest rates	
Gervais (2002)	Abolishing interest rate tax deductions or introducing taxation of imputed rents for home owners is welfare enhancing for all income quintiles. The abolition of tax deductibility of mortgage interest payments leads to a home ownership rate that is 4.2 percentage points lower, lower income taxes (by 2.2 percent under the assumption of constant government revenues) and almost unchanged output. If imputed rents were taxed at the same level as business capital income, the home ownership rate would be lower by 4.2 percentage points, housing capital would decline by 8.56 percent and business capital would rise by 6.64 percent. Income tax rate decreases by 14 percent.

Chambers, Garriga and Schlagenhauf (2009a)	Abolishing interest rate tax deductibility increases the home ownership rate by 0.7 p.p., leads to a reduction in income taxes (under a constant government revenue) and increases welfare by 1 percent. When imputed rents from owning are equalized with taxes on income from rental units, resources are redistributed from housing to business capital. Average and marginal tax rates are reduced, increasing the income and homeownership rate (by 3 p.p.). Welfare increases by 3.3–3.7 percent.
Cho and Francis (2011)	Removing mortgage interest deductibility decreases home ownership by 0.07 p.p. and increases welfare by 0.16 percent. Applying the income tax rate to usually untaxed imputed rents, leads to a fall in home ownership by 34.73 p.p. and welfare increases of almost 10 percent. Tax incentives have little impact on wealth inequality.
Floetotto, Kirker and Stroebel (2016)	Abolishing interest rate tax deductions lowers house prices by up to 3 percent in the short run and by 1 percent in the long run. Home ownership rate drops by 14.76 p.p. (from 72.27 percent), and 17.8 percent of agents are worse off in the new steady state. Taxing imputed rents leads to a drop in home ownership rate by 32.29 percentage points, a short-run decrease in housing prices by 11 percent and a 4 percent decrease in the long run. 52.4 percent of agents are worse-off in the new steady state. Transition welfare costs are higher than steady state welfare costs.
Chen and Columba (2016)	Lowering tax deductibility of mortgage rates decreases welfare. Lowering tax deductibility from 30 to 35 percent decreases the debt-to-income ratio in the long run by 2.2 percent. If additional government revenue is redistributed to households, the policy change can have no effect on output.
Finocchiaro, Jonsson, Nilsson and Strid (2016)	All the experiments refer to a policy change lowering debt-to-income by 10 percent. If government transfers the additional revenue to borrowers and savers in proportion of their salary, tax deductibility has to be lowered from 30 percent to 2.8 percent, leading to an increase of goods consumption by 0.2 percent and a GDP lower by 0.3 percent. If the government transfers additional revenues only to borrowers, tax relief has to be lowered to −6 percent. Aggregate consumption goes down by 0.1 percent and GDP by 0.6 percent. The additional revenue can be used to boost public consumption. In that case, the government has to lower the tax deductibility to 6.2 percent. Aggregate consumption goes down but GDP increases by 0.3 percent.
Alpanda and Zubairy (2016)	A reduction of interest rate deductibility from 100 to 70 percent lowers the steady state output by 0.22 percent and borrowers' welfare by 0.59 percent, while savers gain 0.22 percent of welfare and renters 0.33 percent. Introducing a tax on imputed rent of 7.7 percent leads to a fall in the steady state of output by 0.26 percent, welfare losses for savers (−0.17 percent) and borrowers (−0.3 percent) and welfare gains for renters (+0.33 percent).
Alpanda and Zubairy (2017)	Abolishing tax deductibility of mortgage interest rates is welfare enhancing. Lowering the tax deductibility of mortgage rates is the most effective measure in terms of the reduction of household indebtedness per unit of lost output.
Sommer and Sullivan (2017)	Eliminating interest rate deductibility increases homeownership from 65 to 70 percent and lowers house prices by 4.2 percent. Mortgage debt goes down by 31 percent. Welfare is higher by 0.757 percent. In the transition to the new steady state, 58.4 percent of agents are better-off without mortgage tax deductions.
Capital regulation	
Gertler, Kiyotak and Queralto (2012)	Introducing a subsidy (0.0061) per unit of outside equity financed with a tax on total assets, which together has a flavor of countercyclical capital requirement for outside equity, leads to increase in welfare by 0.285 percent.
Angeloni and Faia (2013)	Regulatory capital ratios lower bank risk, defined as bank run probability. Mildly countercyclical capital ratios dampen the business cycle.
Corbae and D'Erasmo (2014)	Increasing the risk-weighted capital requirement from 4 to 6 percent leads to an increase in interest rates by 50 basis points, and 9 percent decline in lending and intermediated output. Deposit insurance decreases by 59 percent due to a decrease in bank exits.

Covas and Driscoll (2014)	Introducing a liquidity requirement lowers equilibrium loan supply by 3 percent, while increasing bank holdings of safe securities by 6 percent. Output declines by 0.3 percent and consumption by 0.1. When risk-based capital requirements are increased from 6 to 12 percent, bank securities holdings increase by 9 percent. Loan supply decreases by 1 percent, output and consumption by 0.1 percent.
Clerc et al. (2015)	There is an optimal risk-based capital ratio: 10.5 percent for business loans and 5.25 percent for mortgages. High bank leverage amplifies the business cycles. The effect of countercyclical capital ratios is ambiguous: may amplify or dampen the business cycle, depending on the level of capital ratio.
Chen and Columba (2016)	Increasing risk weights on households' mortgages from 25% to 30% lowers household debt in the short run by 0.5 percent and aggregate consumption by 0.05. In the long-run, the debt level is almost unchanged. In the steady state, the DTI ratio increases by 0.5 percent, aggregate consumption falls by 2 percent and output by 2.4 percent. Increasing risk weights on mortgages is welfare improving, with diminishing marginal effect above a risk weight of 40 percent.
Begenau (2016)	There is an optimal risk-based capital ratio: 14 percent for U.S. calibration. Higher risk ratios may lead to more, not less lending, due to households' demand for liquid banks' assets and its impact on bank funding costs. Lower bank leverage reduces output volatility.
Begenau and Landvoigt (2017)	There is an optimal capital ratio: 15%. Increase in capital requirements leads to a rise in the shadow banking. The aggregate banking system becomes safer under higher values of capital ratios.
Boissay and Collard (2016)	The need for regulation arises due to an agency problem on the market of interbank loans. Introducing capital and liquidity requirements is welfare enhancing. The optimal policy mix for U.S. calibration entails a leverage ratio of 17.35%, a liquidity ratio of 12.5% and a risk-weighted capital requirement of 19.83%.
Davydiuk (2017)	Optimal Ramsey policy requires a cyclical capital ratio, mostly in the range of 4 to 6 percent. It can raise above 6 percent in periods of abnormal economic growth.

3.1 Loan-to-value regulation

Loan-to-value (LTV) regulation is a very popular macroprudential tool, widely applied in advanced and emerging economies (see Akinci and Olmstead-Rumsey, 2018). The majority of theoretical macroeconomic studies evaluating the effectiveness of loan-to-value regulation focus on the time-dimension of systemic risk and operate in an environment with limited heterogeneity. In this class of models, agents are usually classified in two representative groups: borrowers or savers, and, as such, the cross-sectional aspects of borrowing limits are often left out from the analysis. Moreover, the existing studies mostly concentrate on LTV regulation in the context of mortgage borrowing. From a microprudential perspective, LTV constraints typically stem from moral hazard problems between borrowers and lenders and are designed to secure the lenders' payoff in the case of the borrowers' default. At the same time, an LTV constraint links debt to asset prices and creates collateral externalities thereby impacting on systemic risk, something that can be addressed by macroprudential interventions.

LTV regulation can address externalities arising both on the supply side and on the demand side of credit. From the perspective of lenders, LTV limits impose quantity restrictions on their asset allocation. This mitigates externalities connected to *strategic interactions* that could induce banks to reduce their lending standards and take large risk exposures. From the perspective of borrowers, LTV constraints address two main externalities: a *demand externality* and *pecuniary externalities*. Households taking on debt do not take into account how their behavior impacts wealth distribution in the economy, the development of housing prices, general debt level, and more broadly, output. Once

a negative shock hits the economy, foreclosures tend to lead to further house price falls, generating negative feedback loops (see Frame, 2010).

Aside from the collateral function, LTV regulation can be seen as protection of homeowners financing their houses with mortgages, given that it ensures a minimum equity stake in the home. This stake acts as a cushion against negative home equity. As Mian and Sufi (2014) explain, homeowners have a junior claim on home and take the first losses when house prices start to decline, which erodes their equity. Moreover, a house price collapse may lead to debt overhang of homeowners who start to reduce their consumption to maintain the debt service, which creates a big negative demand effect on the economy since their marginal propensity to consume is usually higher than for the rest of the population. As such, imposing LTV requirements, aside from securing lenders' payoff in the case of borrowers' default, protects borrowers as well, and, correcting for the demand externality, has far-reaching macroeconomic implications, beyond the distribution of losses between the lenders and borrowers. High LTV, meaning low borrowers' equity in the house, may also lower borrowers' incentives to honor their debt obligations, that is it may increase the probability of default when house prices start to fall, which will in turn negatively affect banks. Thus by lowering the leverage of the economy, LTV limits stabilize business fluctuations. However, too strict LTV requirements may be also negative for the output[18] or even welfare-detrimental, as discussed in this section.

Most of the existing theoretical literature tackling this issue builds on Iacoviello (2005). Since stricter LTV limits reduce borrowers' leverage, a common finding in this strand of literature is that stricter LTV regulation is effective in reducing macroeconomic volatility (Gelain, Lansing and Mendicino, 2013; Rubio and Carrasco-Gallego, 2014 and Mendicino and Punzi, 2014) and household indebtedness (Chen and Columba, 2016, Finocchiaro et al., 2016, Alpanda and Zubairy, 2017 and Grodecka, 2017). These benefits come at the cost of lower output, aggregate consumption and, in some cases, borrowers' welfare (see Table 1 for the estimates).

LTV requirements can be explicitly designed to address the procyclicality of credit flows issue. Rubio and Carrasco-Gallego (2014) examine welfare implications of different static LTV levels, along with the effects of introducing a macroprudential Taylor-type rule that reacts to credit growth. They find that a countercyclical LTV rule that responds to changes in credit is welfare-enhancing. In a similar setup, Mendicino and Punzi (2014) study welfare implications of countercyclical LTV rules in a two-country model where monetary policy may respond to household indebtedness or house prices. The LTV policy maximizing social welfare depends on the assumed behavior of monetary policymakers. Largest welfare gains compared to static policies are obtained when LTV reacts countercyclically to house prices, while interest rate reacts to credit growth.

3.2 Loan-to-income/Debt-service-to-income regulation

Loan-to-income (LTI) and debt-service-to-income (DSTI) regulations impose a limit on borrowing or debt service in relation to disposable income, thereby directly targeting risky borrowers who might also raise macropudential concerns in the presence of *pecuniary* and *demand externalities*.[19] On the side of the lender, similarly to LTV regulation, these limits address the *strategic interaction externality*, preventing lenders from lowering their credit standards. Notably, DSTI limits, by directly linking interest rate expenses to debt, enhance the transmission mechanism from interest rates into credit growth, house prices and aggregate demand. LTI and DSTI limits can coexist and they complement both LTV caps and capital

18 Here and in what follows, we refer to 'output costs' in terms of GDP levels; the papers reviewed in this article are silent on the potential effects of different policies on growth rates.

19 See Alfelt, Lagerwall and Ölcer (2015) for the analysis of LTI as a policy measure, with the focus on Sweden.

adequacy requirements. Some of the reviewed papers specifically address the interactions between different regulations (see Greenwald, 2016 and Grodecka, 2017).

Lowering LTI and DSTI limits reduces household indebtedness (Finocchiaro, et al. 2016, Grodecka, 2017) and lowers the volatility of house prices and credit in the economy (Gelain, Lansing and Mendicino, 2013). This may however come at the cost of lower GDP.

While the literature considering LTV requirements for borrowing households is fairly extensive, theoretical models incorporating LTI or DSTI constraints are much rarer, despite their important role in the lending process in many countries (see Akinci and Olmstead-Rumsey, 2018). Some of the macroeconomic papers consider constraints applied to borrowers in separate models, without studying their coexistence and interaction. An example is Finocchiaro et al. (2016) who study the effects of macroprudential policies separately in a model where borrowers are subject to LTI constraints and in a model where borrowers are subject to LTV constraints. They find that stricter LTI limits are effective in lowering debt to GDP at the cost of lower output and consumption.

More research is needed on the interaction of different borrowing constraints that are applied to borrowers by lenders.[20] An early example of considering LTV and LTI limits in one general equilibrium model is the paper by Gelain, Lansing and Mendicino (2013) who study the impact of borrowing constraints on the volatility observed in the economy.[21] In one of their experiments, they augment their typical LTV borrowing constraint with a loan-to-income part, concluding that such a rule is effective in decreasing the volatility of debt in the economy. Two recent papers more explicitly account for the coexistence of different borrowing constraints (Greenwald, 2016, Grodecka, 2017), augmenting a typical Iacoviello (2005) style collateral constraint with a payment-to-income/debt-service-to-income constraint.[22] They conclude that the effectiveness of loan-to-value regulation as a macroprudential tool in such a framework is lowered, because not all borrowers in the economy are always bound by this constraint. DSTI limits seem to have a bigger impact on the economy in this setup.

3.3 Amortization regulation

Amortization rules specify the repayment of debt principal in the case of a long-term debt contract. As such, they directly affect the speed of deleveraging. The amortization pace impacts the evolution of the loan-to-value of a given contract, and hence, it can handle situations where households overborrow in the presence of, for example, *pecuniary* or *demand externalities* or behavioral factors. Amortization regulation can also introduce limitations for lending, influencing banks' assets and their composition, correcting therefore for externalities arising due to *strategic interactions*.

Traditional mortgage amortization schemes require a gradual repayment of the principle over time and these annuity mortgages are the most common form of amortization arrangements worldwide (for an international comparison of mortgage terms see the report by Lea, 2010). However, some countries allow for more flexible schemes under which amortization payments vary over time and may be frontloaded or backloaded. In the U.S., before the crisis of 2007–2008, some loan contracts even allowed negative amortization; in such contracts, the monthly debt service did not cover interest payments, causing the

20 Models in the overlapping-generations framework often take into account a coexistence of two borrowing limits. However, their interaction is rarely a focus of the analysis. Moreover, some of them operate in a partial equilibrium context, excluding the analysis of general equilibrium effects.

21 The additive borrowing constraint in Gelain, Lansing and Mendicino (2013), putting 75 percent of weight on labour income and 25 percent weight on the housing collateral value, turns out to have no impact on the volatility of consumption or output. The decrease in the volatility of household debt is driven by the fact that including the income in the borrowing constraint induces countercyclicality of the loan-to-value ratio and stabilizes the debt.

22 While Greenwald (2016) focuses on a constraint-switching effect due to which borrowers switch between being bound by a DSTI or LTV constraint, Grodecka (2017) studies the interaction of two constraints in a model with occasionally binding constraints, including situations when borrowers are constrained by both LTV and DSTI regulation at the same time, or by neither of them.

principal to increase. In Sweden, but also for example Denmark, U.K. or Australia, interest-only mortgage contracts have also been/are popular, in which, for a certain period, only the interest on loans is paid. These amortization schemes, in practice, backload the principal payment, which means that borrowers' home equity is not increasing over time. This may reduce the incentives of the borrower to honor his debt obligation, as discussed in the LTV section. Chambers, Garriga and Schlagenhauf (2009b) show that flexible amortization schemes enable better matching of the life-cycle profiles of borrowers, potentially increasing the pool of borrowers and thus homeownership, mostly among young and poor people.[23]

While LTV rules mostly apply at the origination of the loan, traditional amortization schemes ensure that, over the duration of the loan contract, the LTV of existing homeowners goes down. Thus, similarly to stricter LTV or LTI ratios, stricter amortization rules reduce the leverage of the system and, accordingly, business cycle fluctuations (Forlati and Lambertini, 2012; Chen and Columba, 2016, Finocchiaro et al., 2016 and Grodecka, 2017). At the same time, they may not coincide with some borrowers' optimal repayment path, which can induce the borrowers to try to circumvent the forced amortization (Svensson, 2016 and Hull, 2017).[24] The cost of stricter amortization rules may also include lower output (Chen and Columba, 2016; Finocchiaro et al., 2016 and Grodecka, 2017). Besides their influence on the average LTV in the economy, amortization rules also have a direct impact on the bindingness of DSTI constraints, as stricter amortization rules increase the periodical debt service, which may be to a disadvantage for certain types of households.

3.4 Housing-related tax policy measures

Housing-related tax policy measures usually aim at promoting homeownership. However, as a by-product, through the preferential tax treatment of home owners, they also incentivize household leverage and hence interact with other macroprudential tools that aim at addressing overborrowing. Among all the measures considered in this article, the conclusions of research on tax-related measures are the most disparate. Existing studies usually focus on the impact of these policies on home ownership rates and welfare. In what follows, we focus on the research that tackles the issue of mortgage interest rate tax deductibility and the taxation of imputed rents. In most countries, there is no tax deduction on mortgage interest payments and imputed rents are not taxed (see OECD, 2017 and Andrews, Caldera and Johansson, 2011). However, mortgage interest tax deductions are relatively more popular than taxing imputed rents and some countries allow for the full deduction of interest payments from taxable income.

How would the abolition of interest rate deductibility impact on home ownership and welfare? According to Gervais (2002), Cho and Francis (2011) and Floetotto, Kirker and Stroebel (2016), operating in an overlapping generations framework (OLG),[25] such a policy would reduce the homeownership rate, but increase welfare in the economy. Tax deductions lower the revenue of the government which could be spent on lowering for example labor taxes in the economy. Thus, it is not obvious which effects the abolition of tax deductions would have. Infinite horizon models mostly focus on the cost side of stricter tax policies: Chen and Columba (2016) and Finocchiaro et al. (2016) show that the steady state impact of abolishing interest rate deductions depends on how the government decides to spend the additional tax revenue. Chen and Columba (2016) conclude that lowering mortgage interest

23 However, this flexibility does not have obvious implications for the volatility of borrowers' consumption, whose effect depends on the level of inflation in economy.

24 Svensson (2016) shows that unconstrained households can react to an amortization requirement by increasing, not decreasing their debt: they will initially borrow more than planned, invest the superfluous amount in a savings account and use the withdrawals from this account to satisfy the regulation. On a related note, Hull (2017) shows that introducing stricter amortization requirements in a setup where borrowers have access to consumer loans lowers the aggregate debt-to-income ratio only slightly. This is due to the fact that, even if an amortization path is suggested by the regulation, people can still refinance and use the obtained funds to nullify previous periods' amortization in order to follow their optimal amortization path.

25 In overlapping generation models, agents in different phases of their life, that is young and old, interact with each other.

rate tax deductibility reduces welfare, Alpanda and Zubairy (2016) and Alpanda and Zubairy (2017) confirm this conclusion, but only for the borrowers in the economy. Another set of studies, finds opposite effects of house-related tax incentives on the home ownership rate in OLG set-ups. Chambers (2009a) find that eliminating the interest rate tax deduction leads to a small, but positive effect on the home ownership rate.[26] The welfare effects from abolishing tax deductibility in Chambers, Garriga and Schlagenhauf (2009a) are positive. Sommer and Sullivan (2017) second these results.

The impact of introducing taxation on imputed rents[27] is mostly qualitatively similar to the effects of lower interest tax deductibility. Gervais (2002), and Cho and Francis (2011) conclude that introducing taxation of imputed rents has stronger negative effects on home ownership rates than abolishing interest rate tax deductibility. Floetotto, Kirker and Stroebel (2016) confirm the results for home ownership, but in contrast to the other studies, find that introducing a tax on imputed rents turns out to be welfare detrimental. Chambers, Garriga and Schlagenhauf (2009a) conclude that introducing imputed rents taxation can increase the home ownership rate and is welfare improving. Alpanda and Zubairy (2016) show that it is mostly renters that benefit from taxing imputed rents, while homeowners suffer from this policy.

Apart from home ownership and welfare, housing-related taxation also influences business decisions of firms. If home ownership is promoted, more resources are allocated to the construction sector. Gervais (2002) and Chambers, Garriga and Schlagenhauf (2009a) find that when these tax incentives are lowered, resources are redistributed from housing to business capital.

Through their impact on household leverage, housing-related taxes can also impact the debt level in the economy. Lower levels of interest rate tax deductibility are effective in reducing household debt (Chen and Columba, 2016, Finocchiaro, et al., 2016, Alpanda and Zubairy, 2017). Lower household leverage may come at a cost of lower output in the economy, but this mostly depends on how the government spends the additional revenue, as discussed in the earlier part of this subsection.

To sum-up, the conclusions from the literature on housing-related tax policy measures vary greatly and depend to a large extent on the assumptions regarding households' heterogeneity, OLG versus representative agents' frameworks, and different aspects of the rental market.

3.5 Capital regulation

Capital regulation directly affects the supply of credit in the economy and it is widely used worldwide (see Kara, 2016). Most of the macroeconomic models studying capital regulation focus on the time-dimension of systemic risk and the procyclicality of bank lending. Banks are highly leveraged, hence both changes on the asset side of their balance sheets (loan defaults, falling prices of collateral) and on the liability side (rollover problems, bank runs by depositors) can easily lead to a disruption in bank activities and bank distress or even bankruptcies. The procyclicality of financial flows is heightened in the presence of externalities defined in section 2. When banks have correlated portfolios (due to *strategic interactions*), they will likely want to liquidate their portfolios at the same time, creating the fire sales problem and downward pricing spirals (*pecuniary externalities*). Due to the *interconnectedness* of banks, problems in one institution can spread to others, amplifying the initial crisis. In this case, microprudential regulation complements macroprudential

26 This is due to the fact that declining demand for mortgages and owner-occupied housing after the abolition results in an increase of the demand for rental units, which raises their price. Moreover, under the assumption of constant government revenue, income taxes in the model will be lowered, which all together has a slight positive impact on the home ownership rate.
27 Imputed rent refers to the implied income that a homeowner makes because he does not have to pay rent to a landlord compared to a renter that has to pay rental costs. In some countries, the imputed rent, as a rent that the homeowner pays to himself, is taxed.

regulation and helps to mitigate systemic risk (see Freixas, Laeven and Peydró, 2015). If each individual banking institution is less leveraged due to individually imposed capital requirements, it is likely that less macroprudential regulation will be needed.

Capital requirements, often considered from today's perspective as macroprudential tools, were first designed for microprudential purposes, since they ensure that bank shareholders put 'skin in the game', lowering the incentives for risk taking on the side of the bankers and increasing public confidence in the banking business. This helps to obtain funds that can be channeled to the productive sector in the economy, which in turn fosters growth (Meh and Moran, 2010). In an event of bank distress, bank capital acts as a buffer and prevents problems in one financial institution from spreading to the rest of the system. In the absence of capital regulation, bank leverage can be above the socially optimal level due to existing frictions, such as preferential tax treatment of debt, deposit insurance or the corporate structure of banks that implies limited liability of shareholders, which all lead to a high leverage of the banking sector. An appropriate capital regulation has to find a compromise between its benefits, that is reducing banks' failure risk, lowering the costs of recessions by mitigating capital crunch and fostering optimal allocation of credit, and its costs, that is curbing economic activity.[28]

Which are the channels through which capital regulation can contribute to financial stability and what are the costs? The existing macroeconomic literature provides many insights into this. Capital requirements can improve banks' solvency prospects, making bank runs and liquidity problems less likely. High leverage and maturity mismatch lie at the heart of the modern banking business, which makes banks vulnerable to rollover risk.[29] The greater the leverage of the bank, the greater this risk (Angeloni and Faia, 2013). Thus, capital regulation can reduce the probability of a bank run (Angeloni and Faia, 2013 and Gertler and Kiyotaki, 2015).[30] However, this increase in financial stability comes at a cost, that is capital requirements can lower bank intermediation, and thus output and consumption in the economy (Corbae and D'Erasmo, 2014 and Chen and Columba, 2016). This is often the result of increased bank funding costs (if equity is more expensive than debt due, for example, to tax reasons). The resulting surge in lending spreads curbs lending (Almenberg et al., 2017).[31] Given the trade-off between higher financial stability and lower credit intermediation, some researchers conclude that the social welfare gains are a hump-shaped function of capital requirements (Clerc et al., 2015; Chen and Columba, 2016; Begenau, 2016 and Boissay and Collard, 2016). That is, above a certain level of capital regulation, the costs induced by reduced credit intermediation are higher than the benefits from making the banking sector more resilient to failures.

Despite their benefits, fixed capital (and liquidity) requirements can lead to excessive credit contraction in crisis times, because highly leveraged banks reduce their lending to meet regulatory limits. Massive deleveraging can lead to collateral fire sales that drive asset prices down and put further strain on banks' balance sheets. Fixed capital requirements can thus increase the cyclicality of bank lending. In such a situation, countercyclical tools may be welfare-enhancing, as they may contribute to the stabilization of the aggregate output. This is confirmed by Gertler, Kiyotaki and Queralto (2012), Angeloni and Faia (2013) and Davydiuk (2017). Clerc et al. (2015) show instead that countercyclical capital ratios add stability to the economy at high levels of capital requirements but, at low levels of capital requirements, they amplify the business cycles.

28 See Freixas, Laeven and Peydró (2015) and Almenberg et al. (2017).

29 Rollover risk is the risk associated with the refinancing of debt. In the case of banks, this risk refers to a situation in which banks need to renew their maturing funding, but they cannot do so due to for example market freeze.

30 Liquidity requirements (Covas and Driscoll, 2014) and deposit insurance (Diamond and Dybvig, 1983) are other tools to reduce problems linked to maturity mismatch and reduce the occurrence of bank runs.

31 In a model in which households have a preference for holding safe and liquid assets provided by the banks, Begenau (2016) shows that bank funding costs do not have to go up under higher capital requirements.

As discussed in the introduction, macroeconomic models are well-suited to study the overall benefits and costs of banking regulation due to their general equilibrium focus that takes into account feedbacks between different sectors of the economy. However, most of these models are built as 'closed systems', and cannot predict the consequences of capital regulation on financial institutions outside the radar of the regulatory authorities, the so-called 'shadow banking' sector. Specifically, high capital requirements could contribute to the development of a shadow banking sector whose riskiness exceeds the riskiness of a low-regulated banking sector, contributing to financial instability. However, this does not necessarily need to happen. Begenau and Landvoigt (2017) show that raising capital ratios from the status quo indeed increases the size of the shadow banking sector, which expands its operations by scaling up, but not by increasing its leverage. Hence, their study concludes that despite the rise in the shadow banking activity, the aggregate banking system becomes safer.[32] More macroeconomic research on these possible 'unintended' consequences of banking regulation is needed, as well as on the interaction of different regulations.[33] Countercyclical capital buffers try to reduce the tension between micro and macro regulation, that is to maintain the risk sensitivity of the requirement for different financial institutions and, at the same time, mitigate the cyclicality of the regulation. Models with many heterogeneous banks are particularly well suited to tackle this issue (see Corbae D'Erasmo, 2014, Boissay and Collard, 2016 and Grodecka, 2016).

4 Conclusions

The multifold aim of this article was to i) increase our understanding of the financial sector and its importance for the real economy, ii) review the most recent attempts in the literature to incorporate financial frictions in otherwise standard macro models and iii) evaluate both the costs (forgone lending and economic activity) and the benefits (a more resilient financial system) of macroprudential regulation. Systemic risk, the primary target of macroprudential policy, may arise from different sources of market failures. We have argued that identifying the exact source of market failure is key to designing the appropriate instrument to address it.

While traditional microprudential regulation has a long tradition in economic policy, macroprudential policy is still in its infancy (Galati and Moessner (2017). This poses a series of challenges that remain to be addressed by the existing economic literature.

Importantly, different policy measures coexist and interact with each other. Boissay and Collard (2016), Greenwald (2016) and Grodecka (2017) attempt to specifically take this interaction into account in a macroeconomic framework. Furthermore, too restrictive measures could create incentives for economic agents to circumvent regulation, thereby creating unintended side-effects of regulation. The development of alternative financing channels, such as the shadow banking system (see Begenau and Landvoigt, 2017) or a surge in unsecured credit in response to too strict LTV or LTI requirements exemplifies this problem. Finally, a comprehensive account of the benefits of financial regulation should explicitly consider the interaction between policy and the occurrences of financial crisis. In most of the existing literature, which operates in a linear framework, financial crises are the results of big exogenous 'financial shocks'. Some researchers (Mendoza, 2016) argue that, as a result, linear set-ups are ill-suited to capture the transition from regular times to times of financial distress and, therefore, the benefits of effective financial regulation. Furthermore, linear set-ups cannot handle the impact of risk on portfolio decisions of market participants

32 This happens because, contrary to the commercial banking sector, there is no deposit insurance in the shadow banking sector and shadow banks incorporate this 'bank run' probability while choosing their leverage. Moreover, higher capital requirements lower the funding costs of banks, which makes them more profitable.

33 The finance literature has studied the interactions between different forms of banking regulation, see for example Kashyap, Tsomocos and Vardoulakis (2014), Walther (2016) or Mankart, Michaelides and Pagratis (2017), but these aspects of regulation have not been covered extensively by the macroeconomic literature.

(Covas and Driscoll, 2014; Begenau and Landvoigt, 2017 and Laséen, Pescatori and Turunen, 2017 are notable exceptions). Nevertheless, non-linearities bear clear computational costs that need to be taken into account when evaluating the potential use of such models in policy analysis.

The decade after the unfolding of the worst financial crisis after the Great Depression has brought about a golden age in macro-finance research. While tremendous progress has been made, the road ahead is still full of challenges and opportunities in the direction of i) deepening our understanding of macro financial linkages and ii) building the right policy toolkit for financial regulators.

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