STAFF MEMO

Macroprudential Regulation - What, Why and How?

NO 13 | 2014

AUTHORS:

HENRIK BORCHGREVINK

SIGMUND ELLINGSRUD

FRANK HANSEN

NORGES BANK

Staff Memos present reports and documentation written by staff members and affiliates of Norges Bank, the central bank of Norway. Views and conclusions expressed in Staff Memos should not be taken to represent the views of Norges Bank.

Staff Memo inneholder utredninger og dokumentasjon skrevet av Norges Banks ansatte og andre forfattere tilknyttet Norges Bank. Synspunkter og konklusjoner i arbeidene er ikke nødvendigvis representative for Norges Banks.

ISSN 1504-2596 (online only)

ISBN 978-82-7553-825-1 (online only) Normal

Macroprudential Regulation - What, Why and How?*

Henrik Borchgrevink
Norges Bank

Sigmund Ellingsrud
Norges Bank

Frank Hansen
Norges Bank

October 20, 2014

Abstract

This paper reviews recent literature on the theoretical foundations of macroprudential regulation. We identify six categories of market failures that give rise to macroprudential concerns; *pecuniary externalities, interconnectedness externalities, strategic complementarities, aggregate demand externalities, market for lemons* and *deviations from full rationality*. Because of the diversity of these categories, policy lessons diverge. There is yet no "workhorse"model for policy analysis. Nevertheless, we argue that two consensus pieces of general policy advice can be drawn from the core part of the literature on macroprudential regulation: First, the intensity of capital and liquidity regulation of banks should also depend on aggregate measures of risk in the financial system. Second, excessive borrowing should be curbed by a time-varying policy inducing borrowers to internalise the increased risk of a costly deleveraging process in the economy.

1 Introduction

Financial services are crucial to the market-based economy. Banks are important for channelling funds from savers to borrowers, for maturity transformation, payment services and the distribution of risk in the economy. However, the financial sector can also be a major source of vulnerability for the economy. Jorda et al. (2013) document that recessions assosiated with financial crises are deeper and more protracted than normal business cycle recessions. Financial institutions can also have incentives to take on excessive risk from society's point of view, because the owners and the management do not bear the full costs if the bank fails.

Regulation of financial services has traditionally concentrated on so-called *microprudential* regulation, which is geared towards controlling excessive risk-taking in individual

*We are grateful to Ragna Alstadheim, Ida Wolden Bache, Sigbjørn Atle Berg, Jin Cao, Sigurd, M. Galaasen, Karsten Gerdrup, Alfonso Irarrazabal, Gisle J. Natvik, Kjersti Næss Torstensen, Bent Vale and Pål Winje for valuable comments. This Staff Memo should not be reported as representing the views of Norges Bank. The views expressed are those of the authors and do not necessarily reflect those of Norges Bank.

banks. However, microprudential regulation does not always secure the robustness of the financial system as a whole. The recent crisis is a reminder in that regard. In the aftermath of the financial crisis of 2007-2009, a *macroprudential* approach to financial regulation has emerged. Macroprudential regulation is concerned with the risks at the level of the financial system (*systemic risk*) and recognizes the importance of general equilibrium effects, that is how the financial sector interacts with the real economy. The difference between micro- and macroprudential concerns can be illustrated as follows; if one small bank gets into financial difficulties, its depositors and other stakeholders can incur losses, but there will be no severe macroeconomic consequences as long as other banks are healthy and can serve the customers of the failing bank. The risk of such bank failures might be a microprudential problem, but is not a macroprudential one. However, if several banks at the same time get into trouble that induces them to reduce lending and sell assets, there is a macroprudential concern. The real economy might suffer through lower lending, investments and production. Ensuring that banks are well-capitalised normally supports both microprudential and macroprudential objectives. However, these objectives may clash, especially in a crisis state of the world: While from a microprudential perspective it could be optimal to maintain capital ratios to ensure the soundness of individual banks, a macroprudential regulator would typically allow capital levels in banks to be reduced so as to sustain the flow of credit to the real economy (Hanson et al. (2011)).

The rationale for regulation is market failures. Macroprudential regulation is rooted in the same fundamental market inefficiencies that rationalise microprudential interventions, for example limited enforcement, limited liability and asymmetric information that entail moral hazard. Microprudential regulation addresses such externalities between the stakeholders of an individual bank, while macroprudential regulation addresses such externalities between banks (or other financial institutions) and between the financial sector and the real economy.[1] A literature on macroprudential regulation is now emerging. It builds on existing strands of the banking and financial frictions literature, but is a distinct construction for the following reasons. First, as macroprudential regulation is concerned with macroeconomic general equilibrium effects, adopting the partial equilibrium insights of microprudential theory would not capture the interlinkages that macroprudential regulation is all about. Moreover, the theoretical foundation of microprudential regulation is not well established, although banks have been regulated for over 100 years (see e.g. Allen and Gale (2007)). Second, established theory on the interaction between the financial sector and the real economy, namely the financial frictions literature of the 1990s (see e.g. Bernanke and Gertler (1989); Kiyotaki and Moore (1997) and Bernanke et al. (1999)), does not give scope for macroprudential regulation.[2] This literature explains how financial frictions can amplify shocks to the economy and make a downturn more protracted, but does not explain why and how a regulator should intervene. Moreover, the financial frictions literature does not model the behaviour of the financial sector. Bank behaviour is important since a bank is simultaneously both a borrower and a lender. The supply of

[1] While we find this differentiation instructive, it is not absolute. In the case of systemically important banks, the externalities between the stakeholders of an individual bank can have macroeconomic effects due to the size of the bank, and thus should also be a macroprudential concern.

[2] See Brunnermeier et al. (2012) for an extensive survey on financial frictions in macroeconomics.

credit will be impaired when the bank itself becomes constrained.[3] Adrian et al. (2012) provide empirical evidence suggesting that financial shocks (i.e. shocks originating within the financial sector) were important during the 2007-09 US financial crisis.

In this paper we provide some key insights from the literature on the rationale for macroprudential regulation. We present a taxonomy of market failures that builds on that of De Nicolo et al. (2012), but is extended with three more market failures.[4] We also discuss general policy lessons from the literature. The review is not exhaustive. In particular, we do not cover the interaction between macroprudential regulation and monetary policy (see Smets (2014) for a survey on this issue). Other recent policy-oriented surveys of the literature are e.g. Galati and Moessner (2013, 2014) and IMF (2013). For an empirically oriented study, see e.g. Lim et al. (2011).

The paper is organised as follows. Section 2 presents a taxonomy of market failures that can justify macroprudential policy interventions. Section 3 discusses some general policy lessons from the literature and Section 4 concludes.

2 Why macroregulate?

Regulatory interventions of any kind should be justified by market failures. In this section, we discuss different market failures that give rise to macroprudential concerns. These market failures generate systemic risk through interactions between financial institutions and/or between the financial sector and the real economy. This focus explains why we do not include moral hazard as a distinct category in the taxonomy below. The standard moral hazard story in the financial sector is a conflict between the owners and the creditors of an individual bank and calls for microprudential regulation. Strictly speaking, it is not a reason to macroregulate, even though public funds may be used to cover creditors' losses. However, banks that *coordinate* to exploit the public safety net (e.g. bail-outs or liquidity support) is a reason to macroregulate – covered in the category *strategic complementarities* below.

Building on De Nicolo et al. (2012) we identify six categories of market failures that give rise to macroprudential concerns; *pecuniary externalities*, *interconnectedness externalities*, *strategic complementarities*, *aggregate demand externalities*, *market for lemons* and *deviations from full rationality*.[5] The three first categories constitute the taxonomy in De Nicolo et al. (2012). The fourth, *aggregate demand externalities*, has received more attention the last few years. We argue that the last two categories, *market for lemons* and *deviations from full rationality*, can also give rise to macroprudential concerns and

[3] See e.g. Gertler and Kiyotaki (2010) and Gertler and Karadi (2011) who expand the financial frictions literature with banks and introduce bank net worth as a crucial determinant for efficient financial intermediation, thus introducing scope for ex post policies (e.g. equity injections) to help intermediation when bank net worth is too low. We do not include this strand of the literature in our paper as it focuses on macroeconomic effects of a weak banking sector rather than how systemic risk arises.

[4] For a more thorough survey on the foundations for macroprudential regulation, see de la Torre and Ize (2013).

[5] Note that these are broad categories. There may thus be overlaps between the different categories. Note also that our taxonomy does not fully capture all aspects of macroprudential concerns, namely the presence of aggregate risk (or incomplete markets for insurance) and the fact that banks do not readily raise new equity because they deem it to be more costly than the alternatives. See e.g. de la Torre and Ize (2013) and Admati et al. (2013) respectively for discussion of these issues.

should be included, even if they have been emphasised less than the others, both in the academic literature and in the policy sphere.[6] We see at least two possible reasons for giving these two less attention: It is difficult to test their empirical validity, and they are less likely to provide general policy lessons (confer Section 3).

2.1 Pecuniary externalities

Pecuniary externalities are externalities that work through prices. They occur when the action of one agent, for instance through the sale of an asset, reduces the price of similar assets held by other agents in the economy. The fall in prices reduce the wealth of these agents. In a frictionless world, pecuniary externalities are by themselves not a source of inefficiency. They affect the distribution of wealth among agents, but entail no welfare losses. However, when markets are incomplete, pecuniary externalities can have real welfare effects (Greenwald and Stiglitz (1986)). Asymmetric information or limited enforcement induces lenders to demand collateral from borrowers, which limits the amount of debt to the value of their collateral. A shock that causes agents to sell assets can lead to a deterioration of collateral values. As a consequence, borrowers become more credit constrained and some profitable investments will not be carried out; the real economy suffers a loss.

Pecuniary externalities and "overborrowing"

There is a general consensus that excessive credit expansions are one of the main drivers of financial crises (see e.g. Reinhart and Rogoff (2008); Schularick and Taylor (2012) and Gourinchas and Obstfeld (2012)). However, there is still a question of *why* credit becomes excessive. Pecuniary externalities are one possible answer, as emphasised in Lorenzoni (2008), Jeanne and Korinek (2010), Bianchi (2011) and Bianchi and Mendoza (2013). The key factor is that agents do not internalise the general equilibrium effects that their borrowing decisions have on prices and thus on the economy through collateral constraints. Consider for example a set of agents who borrow and invest in some asset (factors of production, real estate etc.) using the asset as collateral for the loan. If a negative aggregate shock hits, asset prices fall. Agents will face losses and need to reduce their leverage. Some agents will be forced to sell some of their assets in order to obey their debt constraint. These asset sales will, however, cause a further drop in asset values, which implies that more agents become constrained, forcing them to sell off assets and so on. While agents correctly perceive the risks and benefits of their private borrowing decisions, they nevertheless fail to internalise the general equilibrium effects on prices, and thus on other agents' collateral constraints. As a result, they accumulate too much debt compared to the social optimum.[7] Restricting borrowing ex ante will limit the decline in prices and thus mitigate the need to sell assets in adverse states of the world. This may improve welfare. Thus, pecuniary externalities are, in incomplete markets, a source of

[6] Confer e.g. the European Systemic Risk Board's list of sources of systemic risk (European Systemic Risk Board (2014)).

[7] Note that in general, collateral constraints lead to borrowing below the first best level. However, with a sufficiently severe pecuniary externality, a reduction in borrowing can still increase welfare.

overborrowing.[8]

Pecuniary externalities and maturity mismatches

Pecuniary externalities are, as emphasised in Stein (2012), also a possible source of excessive *maturity mismatches* in the financial sector, i.e. excessive reliance on short-term debt. Short-term debt is a cheap form of financing for banks. However, while banks capture the benefits from cheap debt financing, they fail to internalise all of its costs. In a crisis, banks must sell must sell assets at fire sale prices to honour their short-term debt. When a bank chooses its initial level of debt, it does not take into account that a fire sale of its assets lowers the liquidation value of assets held by other institutions in the economy. The failure to internalise this general equilibrium effect results in excessive levels of short-term debt in the financial sector, which leaves the financial system too vulnerable to financial stress.[9]

The pecuniary externality resulting from a marketwide liquidation of assets in the financial sector may be reinforced by margin (or haircut) spirals, as shown by Brunnermeier and Pedersen (2009). The margin, which is the difference between a security's price and its collateral value, generally increases in periods of financial stress. An initial fall in asset prices causes risk measures to increase, leading to higher margins, higher external funding costs, further deleveraging at fire sale prices, leading to higher margins and so on.[10] Brunnermeier and Sannikov (2014) bring these ideas into a macro model and show how agents' risk-taking can lead to high (endogenous) systemic risk even in an environment with low (external) aggregate risk.

2.2 Interconnectedness externalities

Interconnectedness is in general associated with two problems. First, correlated portfolios expose banks to the same risks, implying that more banks will be hit directly by the same shock. Second, balance sheet interlinkages (e.g. through interbank exposures) and correlated assets increase the risk of direct and indirect contagion. By contagion we mean that adverse shocks to one bank affect other institutions. Direct contagion could be a result of interbank exposures (see e.g. Allen and Gale (2000) and Gai et al. (2011)). If one bank suffers losses, this can directly affect other banks that have claims on the troubled bank. Indirect contagion work through price effects (confer the pecuniary externalities discussed above). If a bank in distress liquidates its assets at fire sale prices, the market value of similar assets may also be reduced in other banks. Thus, other banks are negatively affected even in the absence of direct exposures. A third possible problem from interconnectedness is expectational spill-overs. When some banks are in trouble,

[8] With pecuniary externalities at work more implicitly in the background, Geanakoplos (2010) emphasises how heterogeneous beliefs can strongly amplify swings in asset prices and borrowing; leveraged optimists drive prices up in the boom phase, but are forced to sell at low prices to less leveraged pessimists in the bust following a negative shock to asset values. Note that with the heterogeneous beliefs, the existence of asymmetric information is not necessary for these leverage cycles.

[9] See e.g. Shin and Shin (2011) and Hahm et al. (2013) for empirical evidence on the relationship between banks' non-core funding and the occurrence of financial crises.

[10] See Krishnamurthy (2010) and Shleifer and Vishny (2011) for a description of fire sales and the financial crisis of 2007-09.

people expect that other banks will also run into trouble ahead due to interconnectedness. As a result, financially sound banks may find it hard to obtain funding, and liquidity can dry up (see e.g. Caballero and Simsek (2009)). Financial intermediaries typically do not take into account how their actions affect the risk in other institutions and the financial system as a whole.[11] Interconnectedness externalities can excessively expose the financial system to shocks and contagion. For example, when banks diversify they do not take into account that their portfolios tend to become more similar and therefore more correlated (Wagner (2010)).

2.3 Strategic complementarities

Strategic complementarities may amplify the effects discussed above by encouraging correlated behaviour. Strategic complementarities are present when the agents want to "do more when others do more".[12]

Strategic complementarities are key to classic bank runs (see e.g. Diamond and Dybvig (1983)). Agents withdraw their deposits early because other agents do so (or are expected to do so). Bank runs may lead to a complete shut-down of the financial system, where a run on one troubled bank can lead to similar runs on other banks simply because depositors (and other creditors) expect the other banks to be in similar difficulties (confer expectational spillovers under *Interconnectedness externalities*). The other key ingredient in bank runs is fire sales (confer *Pecuniary externalities* above). The loss incurred when banks sell assets at fire sale prices creates an incentive for depositors (or other creditors) to run on the bank, to make sure they are paid before the bank has lost too much value. Angeloni and Faia (2013), Gertler and Kiyotaki (2013) and Kashyap et al. (2014) combine bank runs with a real economy. The runs typically have two types of costs. First, the real loss incurred when a bank sells the asset in a fire sale to agents that are less able to extract value from the asset. Second, because lending rates increase as the banks' creditors demand higher risk premia to compensate for the risk of runs, there can be a loss resulting from lower financial intermediation.

Explicit government guarantees (deposit insurance) and implicit government guarantees (e.g. prospects of government bail-outs) may reduce the risk of bank runs, but come at the cost of increasing moral hazard problems, including moral hazard with strategic complementarities involved. Implicit government guarantees give banks incentives to engage in excessive maturity mismatches and correlate assets ex ante to maximise the likelihood of a joint failure in case of an aggregate shock. Fahri and Tirole (2012) argue that wide-scale maturity mismatch is closely related to expectations of crisis interventions by central banks and governments. It is ill advised to be in a minority of institutions exposed to the shock as policymakers will then be reluctant to intervene. In contrast, when everybody engages in maturity mismatches, the government may have little choice but to intervene (see also Acharya and Yorulmazer (2007) for a similar argument).

Short-term reputational concerns and the incentive structure of bank managers may also induce correlated behaviour (see e.g. Rajan (1994)). Bankers know that the capital

[11] Note also that financial institutions may strategically correlate their portfolios to exploit the public safety net (see section on strategic complementarities below).

[12] More formally that agents will respond to an increase in the strategies of the other agents with an increase in their own strategy (Vives (2005)).

market may be more forgiving if it knows that the entire financial sector has been hit by an adverse shock. This gives bankers incentives to correlate risk and engage in excessive risk-taking. If the investments turn out good, he gets awarded; if they turn out bad, and the losses are systemic, he will be evaluated leniently by the market.

Liquidity hoarding is another phenomenon that was arguably prevalent during the 2007-2009 financial crisis. If banks believe it will be hard to raise liquidity in the markets tomorrow, they will compensate by hoarding liquidity today. Hoarding inevitably reduces the liquidity in the market and thus increases the incentives for other banks to hoard liquidity (see e.g. Gale and Yorulmazer (2013)). Bebchuk and Goldstein (2011) apply a similar idea to credit crunches: A bank may abstain from lending to a firm because the bank expects other banks to reduce lending to the economy, with possibly adverse effects to the future profits of the firm in question. The result is a self-fulfilling credit crunch.

2.4 Aggregate demand externalities

The dominant theoretical justifications for macroprudential interventions involve a variant of the mechanisms discussed above, perhaps in particular the combination of pecuniary externalities and incomplete financial markets. Farhi and Werning (2013) and Korinek and Simsek (2014) give an explanation of overborrowing that is complementary to pecuniary externalities and that does not hinge on financial markets being incomplete. They show that financial market interventions can be justified by an *aggregate demand externality* when there are nominal price and wage rigidities and macroeconomic stabilisation constraints in the form of a zero lower bound for monetary policy or a fixed exchange rate regime. The underlying idea is that household deleveraging can throw the economy into a liquidity trap (see e.g. Eggertsson and Krugman (2012) and Guerrieri and Lorenzoni (2011)). The deleveraging acts as forced savings and pushes the equilibrium interest rates down to induce unconstrained agents to make up for the lost aggregate demand. However, if the deleveraging is strong enough, nominal interest rates might hit the zero lower bound, leading the economy into a *liquidity trap*. When prices are sticky, the lower bound on nominal interest rates also prevents real interest rates from declining, and the economy is led into a demand-driven recession. Farhi and Werning (2013) and Korinek and Simsek (2014) show that borrowers do not internalise the increased risk of excessive deleveraging generated by their borrowing decision, i.e. debt creates an aggregate demand externality where more ex ante debt leads to a greater ex post reduction in demand and thus a deeper recession. Policies that restrict borrowing in the boom phase can improve future welfare.

2.5 Market for lemons

When there is asymmetric information about the quality of goods in a market, the market equilibrium price can become so low that nobody will sell the best types of goods on the market, as shown by Akerlof (1970). Bad news about asset quality will reduce market liquidity. The result can be severe illiquidity, as discussed in Tirole (2011). In an adverse selection model of liquidity, Malherbe (2014) argues that *why* an asset is put for sale will affect the market's expectation of the quality of the asset. When a bank holds more liquid assets (e.g. cash), the need to sell high-quality assets in order to meet liquidity

needs decreases. The expected quality of their future asset sales decreases, which puts downward pressure on the market price and the market for lemons effect becomes worse. In other words, the holding of liquid assets by some agents imposes a negative externality on other agents because it reduces future market liquidity. The problem is exacerbated by the fact that if you expect lower market liquidity, you want to hold more liquidity. The result may be a self-fulfilling liquidity dry-up. Market for lemons mechanisms have also been used as financial frictions in macro models, see e.g. Kurlat (2013) who considers adverse selection in the market where entrepreneurs obtain financing.

2.6 Deviations from full rationality

Deviations from full rationality may give a rationale for macroprudential regulation, complementary to the more classic market failures discussed above. In a model of shadow banking and securitisation, Gennaioli et al. (2013) derive a macroprudential problem based on the neglect of tail risk, which they argue was an important feature of the build-up phase to the 2007-2009 financial crisis.[13] In their model, diversification through securitisation of assets improves welfare under rational expectations. However, when tail risk is neglected, securitisation creates excesses: Financial intermediaries issue too much allegedly risk-less debt and invest too much in securitised assets that are exposed to the neglected risk. The securitisation also makes the financial intermediaries highly interconnected.

Caballero and Krishnamurthy (2008) also emphasise tail risk as an important factor behind episodes of financial instability. Caballero and Krishnamurthy argue that severe flight-to-quality events are often triggered by so called *Knightian uncertainty*, or immeasurable risk (see also Knight (1921)), leading agents to only consider the worst case scenario. Financial intermediaries become self-protective and hoard liquidity. Caballero and Krishnamurthy (2008) show that Knightian uncertainty leads to a *collective bias* in agents' actions, and that agents' conservative actions are socially costly.

3 General policy lessons from the literature

The previous section documents the diversity of theoretical modelling approaches for macroprudential concerns. There is no "workhorse"model. As a consequence, the policy prescriptions in the literature are also diverse.

The macroprudential literature both includes papers that propose ex post policies such as bail-outs (see e.g. Fahri and Tirole (2012) and Brunnermeier and Sannikov (2014)) and papers that study ex ante policies to improve the market outcome, e.g. introducing taxes (see e.g. Bianchi (2011)). However, in many papers there are only sketches of a policy prescription that appears as an extension to an argument for why macroprudential intervention is warranted.

Some broad policy lessons can be extracted from the literature in the three market failure categories *pecuniary externalities; interconnectedness externalities; strategic*

[13] In particular, sophisticated investors did not take into account the possibility of sharp declines in house prices (see Gerardi et al. (2008)).

complementarities. In the models that involve financial intermediaries, the policy prescription is typically to increase the financial system's resilience to shocks. Depending on the mechanism modelled, this is done through capital requirements (= less debt) or liquidity requirements (= less maturity mismatch). These are the same policy tools as in microprudential capital and liquidity regulation of banks. Yet there is a macroprudential twist to these policies, namely to let the intensity of the regulation depend on aggregate measures of risk (systemic risk). Acharya (2009) argues that capital requirements should be set contingent on the level of cross-correlation between banks. Fahri and Tirole (2012) suggest requirements should be based on aggregate leverage and liquidity. In Stein (2012) the optimal regulation sets an upper limit to money creation in the banking sector.

The macro approach to regulation is perhaps even clearer in models where financial institutions work more implicitly in the background, in the categories *pecuniary externalities* and *aggregate demand externalities*. The fundamental externalities differ between the two categories, but at the policy level, they are quite similar: In a boom, agents overborrow because they do not take into account that their borrowing decisions increase both the likelihood and the severity of a deleveraging process in the economy. The policy answer is to reduce debt levels, with e.g. a tax on debt that internalises the externality. However, the reduction in credit typically comes at the cost of output. Optimal policy will thus face a trade off between output and systemic risk. The optimal policy in these models is time-varying, as debt's marginal contribution to systemic risk will depend on the economic cycle.

Policy instruments other than a tax could be used to curb a credit boom, e.g. loan-to-value restrictions and capital requirements. Goodhart et al. (2013) study several policy instruments including their interplay, but it remains to be seen whether their results carry over to a more general and dynamic setting than their two-period, calibrated model. Other papers typically do not provide any rigorous comparison of the pros and cons of the different instruments. For example Bianchi (2011) briefly shows that the socially optimal amount of debt can be reached by capital requirements, which raise funding costs for banks and thus work as a tax. However, without any bank behaviour in the model, he cannot account for the other positive effect of capital requirements, i.e. that they make banks more robust and thus lower the likelihood of a credit crunch. Clerc et al. (2014) include bank behaviour in a macro model, where both effects from capital requirements are included. However, in this model the reason for excessive credit is not pecuniary externalities, but banks' incentive to take on too much risk because their creditors are partly guaranteed by a deposit guarantee scheme. This fundamental difference implies different policy lessons: While any increase in credit marginally increases systemic risk when pecuniary externalities are present, only credit expansions that follow from increased risk-taking lead to more systemic risk in Clerc et al. (2014). This divergence is typical for the literature at this juncture – different explanatory stories yield different policy advice.

For the last two categories of market failures in the previous section, *market for lemons* and *deviations from full rationality*, few general policy lessons can be extracted. In the market for lemons category, the only policy that really helps is to (somehow) provide more

credible information to alleviate the adverse selection problem.[14] In particular, Malherbe (2014) argues that standard liquidity requirements on financial institutions may lead to adverse unintended consequences in markets that are prone to adverse selection. The category of models based on deviations from full rationality potentially include very different model mechanisms. Robust general statements on policy are therefore hard to provide - except that the policy maker should intervene if he is less prone to irrational behaviour than market participants.

Identifying and understanding the most important explanations of systemic risk is still the greatest challenge going forward. Building good models is part of this challenge. To understand the trade-offs in macroprudential policy you need to model both the financial sector and the real economy comprehensively. There are so far few models with both an explicit macroprudential policy instrument geared towards the financial sector and a thorough welfare analysis. In models with different types of agents, e.g. households and bankers, assigning the weights that social welfare should put on the different agents is a difficult, but crucial question (see e.g. Kashyap et al. (2014)). Another challenge is the need to model crises. The costs and benefits of macroprudential policy accrue in states where the economy potentially functions very differently. The costs are paid in normal times, while the benefits are reaped in crisis times. To model the cost-benefit trade-off therefore requires an asymmetric model of the economy. In addition, there are severe data limitations to calibration, due to financial crises being rare events. Another strategy is to measure systemic risk and how policy changes the risk. Unfortunately, this is not an easy way out either. First, the causes of systemic risk is not yet well understood, as this paper documents. Second, systemic risk is a latent variable that we cannot measure directly in real time or in retrospect. In sum, it is reasonable to expect economic models to deliver only broad advice on the trade-offs to be made in macroprudential policy.

4 Concluding Remarks

This paper has documented the diversity in the theoretical literature's approaches for rationalising macroprudential regulation. As a guide for a policy maker, we sort the different approaches into six categories of market failures that are important for understanding macroprudential concerns: *Pecuniary externalities, interconnectedness externalities, strategic complementarities, aggregate demand externalities, market for lemons* and *deviations from full rationality*. Because of the diversity in these categories, the policy lessons are also diverse. Nevertheless, we argue that some broad policy lessons can be extracted from the literature: First, the intensity of capital and liquidity regulation of banks should also depend on aggregate measures of risk in the financial system. Second, excessive borrowing should be curbed by a time-varying policy inducing borrowers to internalise the increased risk of a costly deleveraging process they impose on the economy. Which policy instruments that are best suited is a tougher question. The answer depends both on which theory model you believe in and on the empirical calibration. Calibra-

[14] Bigelow (1990) shows that the Akerlof (1970) market for lemons model is constrained Pareto efficient, i.e. the market outcome is already at second best. Kurlat (2013) informally discusses the possibility of using a tax to neutralise the inefficient wedge between return on savings and the cost of funding in his market for lemons macro model. However, he notes that such a tax will be akin to a subsidy to transactions and can result in perverse incentives.

tion of the trade-offs in macroprudential policy are also prone to fundamental challenges. The macroprudential theory literature has made progress over the last few years, but the models are not yet implementable for policymakers.

References

Acharya, V. V. (2009). A theory of systemic risk and design of prudential bank regulation. *Journal of Financial Stability 5*, 224–255.

Acharya, V. V. and T. Yorulmazer (2007). Too many to fail - an analysis of time-inconsistency in bank closure policies. *Journal of Financial Intermediation 16*, 1–31.

Admati, A. R., P. M. DeMarzo, M. F. Hellwig, and P. Pfleiderer (2013). Fallacies, irrelevant facts and myths in the discussion of capital regulation: Why bank equity is not socially expensive. *Working Paper*.

Adrian, T., P. Colla, and H. S. Shin (2012). Which financial frictions? Parsing the evidence from the financial crisis of 2007 to 2009. In *NBER Macroeconomics Annual*, Volume 27 of *NBER Chapters*, pp. 159–214. National Bureau of Economic Research.

Akerlof, G. A. (1970). The market for "lemons": Quality uncertainty and the market mechanism. *The Quarterly Journal of Economics 84*(3), 488–500.

Allen, F. and D. Gale (2000). Financial contagion. *Journal of Political Economy 108*(1), 1–33.

Allen, F. and D. Gale (2007). *Understanding Financial Crises*. Oxford University Press.

Angeloni, I. and E. Faia (2013). Capital regulation and monetary policy with fragile banks. *Journal of Monetary Economics 60*, 311–324.

Bebchuk, L. A. and I. Goldstein (2011). Self-fulfilling credit market freezes. *The Review of Financial Studies 24*(11).

Bernanke, B. and M. Gertler (1989). Agency costs, net worth, and business fluctuations. *American Economic Review 79*(1), 14–31.

Bernanke, B. S., M. Gertler, and S. Gilchrist (1999). The financial accelerator in a quantitative business cycle framework. *Handbook of Macroeconomics 1*, 1341–1393.

Bianchi, J. (2011). Overborrowing and systemic externalities in the business cycle. *American Economic Review 101*, 3400–3426.

Bianchi, J. and E. G. Mendoza (2013). Optimal time-consistent macroprudential policy. Working Paper 19704, National Bureau of Economic Research.

Bigelow, J. P. (1990). Efficiency and adverse selection. *Journal of Economic Theory 52*.

Brunnermeier, M. K., T. M. Eisenbach, and Y. Sannikov (2012). Macroeconomics with financial frictions: A survey. Working Paper 18102, National Bureau of Economic Research.

Brunnermeier, M. K. and L. H. Pedersen (2009). Market liquidity and funding liquidity. *Review of Financial Studies 22*(6), 2201–2238.

Brunnermeier, M. K. and Y. Sannikov (2014). A macroeconomic model with a financial sector. *American Economic Review 104*(2), 379–421.

Caballero, R. J. and A. Krishnamurthy (2008). Collective risk management in a flight to quality episode. *The Journal of Finance 63*(5), 2195–2230.

Caballero, R. J. and A. Simsek (2009). Complexity and financial panics. Working Paper 14997, National Bureau of Economic Research.

Clerc, L., A. Derviz, C. Mendicino, S. Moyen, K. Nikolov, L. Stracca, and J. Suarez (2014). Capital regulation in a macroeconomic model with three layers of default. Working paper.

de la Torre, A. and A. Ize (2013). The foundations of macroprudential regulation - a conceptual roadmap. *World Bank Policy Research Paper 6575*.

De Nicolo, G., G. Favara, and L. Ratnovski (2012). Externalities and macroprudential policy. *IMF Staff Discussion Note*.

Diamond, D. W. and P. H. Dybvig (1983). Bank runs, deposit insurance, and liquidity. *Journal of Political Economy 91*(3), 401–419.

Eggertsson, G. B. and P. Krugman (2012). Debt, deleveraging, and the liquidity trap: A Fisher-Minsky-Koo approach. *The Quarterly Journal of Economics 127*(3), 1469–1513.

European Systemic Risk Board (2014). The ESRB handbook on operationalising macroprudential policy in the banking sector. *European Systemic Risk Board*.

Fahri, E. and J. Tirole (2012). Collective moral hazard, maturity mismatch and systemic bailouts. *American Economic Review 102*(1), 60–93.

Farhi, E. and I. Werning (2013). A theory of macroprudential policies in the presence of nominal rigidities. Working Paper 19313, National Bureau of Economic Research.

Gai, P., A. Haldane, and S. Kapadia (2011). Complexity, concentration and contagion. *Journal of Monetary Economics 58*(5), 453–470.

Galati, G. and R. Moessner (2013). Macroprudential policy - a literature review. *Journal of Economic Surveys 27*(5), 846–878.

Galati, G. and R. Moessner (2014). What do we know about the effects of macroprudential policy? Working Paper 440, De Nederlandsche Bank.

Gale, D. and T. Yorulmazer (2013). Liquidity hoarding. *Theoretical Economics 8*(2), 291–324.

Geanakoplos, J. (2010). The leverage cycle. *Cowles Foundation Discussion Paper 1715R*.

Gennaioli, N., A. Shleifer, and R. W. Vishny (2013). A model of shadow banking. *The Journal of Finance 68*(4).

Gerardi, K., A. Lehnert, S. Sherlund, and P. Willen (2008). Making sense of the subprime crisis. *Brookings Papers on Economic Activity*, 69–145.

Gertler, M. and P. Karadi (2011). A model of unconventional monetary policy. *Journal of Monetary Economics 58*(1), 17–34.

Gertler, M. and N. Kiyotaki (2010). Chapter 11 - Financial intermediation and credit policy in business cycle analysis. Volume 3 of *Handbook of Monetary Economics*, pp. 547 – 599. Elsevier.

Gertler, M. and N. Kiyotaki (2013). Banking, liquidity and bank runs in an infinite-horizon economy. Working Paper 19129, National Bureau of Economic Research.

Goodhart, C. A. E., A. K. Kashyap, D. P. Tsomocos, and A. P. Vardoulakis (2013). An integrated framework for analyzing multiple financial regulations. *International Journal of Central Banking 9*(1), 109–144.

Gourinchas, P.-O. and M. Obstfeld (2012). Stories of the twentieth century for the twenty-first. *American Economic Journal - Macroeconomics 4*(4), 226–265.

Greenwald, B. C. and J. E. Stiglitz (1986). Externalities in economies with imperfect information and incomplete markets. *The Quarterly Journal of Economics 101*(2), 229–264.

Guerrieri, V. and G. Lorenzoni (2011). Credit crises, precautionary savings, and the liquidity trap. Working Paper 17583, National Bureau of Economic Research.

Hahm, J.-H., H. S. Shin, and K. Shin (2013). Noncore bank liabilities and financial vulnerability. *Journal of Money, Credit and Banking 45*(s1), 3–36.

Hanson, S. G., A. K. Kashyap, and J. C. Stein (2011). A macroprudential approach to financial regulation. *Journal of Economic Perspectives 25*(1), 3–28.

IMF (2013). Key aspects of macroprudential policy. IMF Policy Paper.

Jeanne, O. and A. Korinek (2010). Managing credit booms and busts: A pigouvian taxation approach. Working Paper 16377, National Bureau of Economic Research.

Jorda, O., M. Schularick, and A. M. Taylor (2013). When credit bites back. *Journal of Money, Credit and Banking 45*(s2), 3–28.

Kashyap, A. K., D. P. Tsomocos, and A. P. Vardoulakis (2014). How does macroprudential regulation change bank credit supply? Working Paper 20165, National Bureau of Economic Research.

Kiyotaki, N. and J. Moore (1997). Credit cycles. *Journal of Political Economy 105*(2), 211–248.

Knight, F. (1921). *Risk, Uncertainty and Profit*. Boston, MA: Hart, Schaffner & Marx; Houghton Mifflin Co.

Korinek, A. and A. Simsek (2014). Liquidity trap and excessive leverage. Working Paper 19970, National Bureau of Economic Research.

Krishnamurthy, A. (2010). How debt markets have malfunctioned in the crisis. *Journal of Economic Perspectives 24*(1), 3–28.

Kurlat, P. (2013). Lemons market and the transmission of aggregate shocks. *American Economic Review 103*(4).

Lim, C., F. Columba, A. Costa, P. Kongsamut, A. Otani, M. Saiyid, T. Wezel, and X. Wu (2011). Macroprudential policy: What instruments and how to use them? *IMF Working Paper 238*.

Lorenzoni, G. (2008). Inefficient credit booms. *The Review of Economic Studies 75*(3), 809–833.

Malherbe, F. (2014). Self-fulfilling liquidity dry-ups. *Journal of Finance 69*(2), 947–970.

Rajan, R. (1994). Why bank credit policies fluctuate: A theory and some evidence. *The Quarterly Journal of Economics 109*(2), 399–441.

Reinhart, C. M. and K. S. Rogoff (2008). Is the 2007 US sub-prime financial crisis so different? An international historical comparison. *American Economic Review 98*(2), 339–44.

Schularick, M. and A. M. Taylor (2012). Credit booms gone bust: Monetary policy, leverage cycles, and financial crises, 1870-2008. *American Economic Review 102*(2), 1029–61.

Shin, H. S. and K. Shin (2011). Procyclicality and monetary aggregates. Working Paper 16836, National Bureau of Economic Research.

Shleifer, A. and R. W. Vishny (2011). Fire sales in finance and macroeconomics. *Journal of Economic Perspectives 25*(1), 29–48.

Smets, F. (2014). Financial stability and monetary policy: How closely interlinked? *International Journal of Central Banking 10*(2), 263–300.

Stein, J. C. (2012). Monetary policy as financial-stability regulation. *Quarterly Journal of Economics 127*(1), 57–95.

Tirole, J. (2011). Illiquidity and all its friends. *Journal of Economic Literature 49*, 287–325.

Vives, X. (2005). Complementarities and games: New developments. *Journal of Economic Literature 43*(2), 437–479.

Wagner, W. (2010). Diversification at financial institutions and systemic crises. *Journal of Financial Intermediation 19*(3), 373–386.