Journal Pre-proof

Preventing financial disasters: Macroprudential policy and financial crises

Alvaro Fernandez-Gallardo

PII: S0014-2921(22)00230-6
DOI: https://doi.org/10.1016/j.euroecorev.2022.104350
Reference: EER 104350

To appear in: *European Economic Review*

Received date : 13 January 2022
Revised date : 11 November 2022
Accepted date : 16 November 2022

Please cite this article as: A. Fernandez-Gallardo, Preventing financial disasters: Macroprudential policy and financial crises. *European Economic Review* (2022), doi: https://doi.org/10.1016/j.euroecorev.2022.104350.

Preventing Financial Disasters: Macroprudential Policy and Financial Crises

Alvaro Fernandez-Gallardo[1]

[1]Departamento Fundamentos Análisis Económico, Universidad Alicante, Spain.

November 11, 2022

Abstract

The ultimate goal of macroprudential policy is to prevent and reduce the costs of systemic financial crises, and thus contribute to promoting sustainable economic growth. However, despite the active role played by such policies in recent decades, there is still limited empirical evidence regarding whether prudential regulation is effective to enhance financial stability by preventing and mitigating crisis risk. This paper seeks to close that gap by studying the relationship between macroprudential policy and both the likelihood and severity of financial crises. The contribution of the paper is twofold. First, I show that macroprudential policy tightenings are successful at reducing the frequency of systemic financial crises. Moreover, this result holds even if macroprudential policies are implemented when the economy is already experiencing a financial boom or when monetary conditions are rather accommodative. I point to the prevention and mitigation of financial booms as the main transmission mechanism through which macroprudential policy defuses crisis risk. Second, I find that macroprudential policy enhances the resilience of the financial system, by dampening the output losses associated with future systemic financial crises. The latter result implies that macroprudential policy not only makes financial crises less likely, but also less painful.

Keywords: macroprudential policy, systemic financial crises, local projections.

JEL codes: E58, E61, G01, G28,

Acknowledgements: I am indebted to my advisor Iván Payá for his invaluable guidance and support. I thank the editor, three anonymous referees, Simon Lloyd and participants of the 46th Symposium of the Spanish Economic Association (SAEe) 2021, 14th FIW Research Conference "International Economics" 2022, 25th Conference "Theories and Methods in Macroeconomics" (T2M) 2022 for useful comments and suggestions.

1 Introduction

Reducing the likelihood and magnitude of financial crises is key from a policymaker's perspective. The economic costs of financial crises have been shown to be even greater than normal crises (Jordà *et al.*, 2013). Recent studies have found that financial crises are more likely to occur when preceded by private credit booms (Schularick and Taylor, 2012; Jordà *et al.*, 2013). At the same time, such booms are likely to emerge in low volatility environments (Danielsson *et al.*, 2018) or when monetary conditions are rather accommodative (Jordà *et al.*, 2015).

While there is growing research on the factors driving financial crises, the empirical evidence is more limited on the policies that central banks should employ to reduce the frequency and the macroeconomic costs of such financial disasters. Since the Great Financial Crisis (GFC) the issue of whether monetary policy should address risks to financial stability has re-emerged in the debate among policymakers and researchers. This discussion centres around the difficulties faced by central banks when they try to achieve multiple goals with few instruments. In this regard, recent research by Schularick *et al.* (2021) shows that the leaning against the wind (LAW) policy is more likely to trigger than prevent crises. The triggering effect seems to be particularly strong in periods of financial booms, when the likelihood of a financial crisis is higher. This empirical evidence is in line with the theoretical literature that argues that the costs associated with LAW policy outweigh its benefits (Bernanke and Gertler, 2001; Svensson, 2017; Adrian and Liang, 2017). One of the main corollaries of this research, therefore, is that macroprudential policy aimed at preventing and mitigating crisis risk remains the main candidate to address threats to financial stability.

Yet, despite the active role played by these policies in recent decades, there is still relatively little empirical evidence on the effectiveness of macroprudential policy at achieving its ultimate goal. This paper aims to close this gap by studying the relationship between prudential regulation and both crisis prevention and crisis severity. For that purpose, I use macroprudential policies and financial crises databases for a panel of 11 advanced countries over the last 30 years. The identification strategy in this paper relies on narrative methods, in which only macroprudential policy actions that do not systematically respond to short-term economic fluctuations - and therefore can be regarded as plausibly exogenous to the business cycle and financial cycle - are used to shed light on the following questions: (i) Does macroprudential policy reduce the frequency of systemic financial crises?; (ii) Does the effectiveness of macroprudential policy reveal state-dependencies regarding financial or monetary conditions?; (iii) If successful, what is the main transmission channel through which macroprudential policy can achieve its objective?; and (iv) Does the pre-crisis macroprudential policy stance affect financial crisis severity?

The results of the paper and main implications can be summarised as follows. First, the key empirical finding is that macroprudential policies are successful at reducing the frequency of systemic financial crises. This result is agnostic with respect to the channel at work. That is, the use of a financial crisis database allows crisis dates to be identified. I am, therefore, able to directly test whether prudential regulation is effective at dampening crisis risk. This approach overcomes any potential limitations of focusing on a specific channel through which macroprudential policy enhances financial stability, e.g., the credit-channel.[1] The credit channel approach, used by most of the studies in the literature, relies on macroprudential policy preventing and mitigating financial crises to the extent that it curbs pre-crisis credit growth. However, the success of macroprudential policy in reducing the frequency and the magnitude of financial crises may depend on multiple, complex and interrelated channels (e.g., lending, capitalization, profitability, risk-taking, expectations, income, asset prices, etc.).

In addition to the previous result, I find that the efficacy of macroprudential policy at reducing crisis risk holds even if the economy is already in a financial boom. That is, macroprudential policy remains effective defusing systemic crisis risk, regardless of whether there is a credit boom, a housing boom or a combination of the two. This result is key for macroprudential regulators given that the crisis probability during credit booms and credit-fuelled housing booms is systematically higher, within my sample, than in the remaining periods (almost twice as high). Furthermore, I find that macroprudential policy is still very effective in periods in which monetary conditions are rather accommodative. This result is in line with most of the recent empirical literature that has favoured their complementarity (Maddaloni and Peydró, 2013; Kim and Mehrotra, 2017; Fernandez-Gallardo and Paya, 2020; Altavilla *et al.*, 2020). Moreover, this finding is par-

[1]The choice of this channel is motivated by the idea that credit booms systematically originate an increase in financial leverage and, therefore, it creates vulnerabilities in the financial system (Schularick and Taylor, 2012; Jordà *et al.*, 2013).

ticularly encouraging in the current context. Since the GFC, many advanced economies, particularly in Europe, have been characterised by periods of loosening monetary conditions and tightening financial conditions. Indeed, a low-rates environment in advanced economies is likely to prevail in the longer term (Gourinchas and Rey, 2019; Kiley, 2020). Therefore, this evidence suggests that an accommodative monetary policy, when needed, will not interfere with the ability of macroprudential policies to reduce financial crisis risk.

Why does macroprudential policy reduce crisis risk? To answer this question, I study the underlying transmission mechanism through which macroprudential policy operates to complement my previous analysis. In particular, I propose the prevention and mitigation of financial booms as the main channel through which macroprudential policy achieves its objective. I show that tightening financial regulation is accompanied by reductions in credit growth and house-price growth, and that this effect is not weakened when the economy is already in a financial boom. This result suggests that, if the economy is already in a credit or housing boom, macroprudential regulators can dampen the boom by tightening financial regulation. This proposed transmission mechanism is in line with most of the literature pointing to financial booms as key precursors of financial disasters.

Finally, I find that macroprudential policy enhances the resilience of the financial system, by dampening the output losses associated with systemic financial crises. Specifically, with all else being equal, when there is a tighter macroprudential policy stance in the economy pre-crisis, the output path in the aftermath of financial crises is characterised by lower losses and faster recoveries. The latter result implies that macroprudential policy not only makes financial crises less likely, but also less painful.[2] The message is clear: macroprudential policy is effective at achieving its ultimate goal of financial stability and should, therefore, be the main policy of central banks to safeguard the financial system.

LITERATURE. This paper relates to three strands of the economic literature. One strand is the empirical evidence on the relationship between macroprudential policy and financial stability. This literature has grown exponentially in recent years due to the emergence of new databases that provide detailed information on macroprudential policies. Some of these studies rely on panel data from both emerging and advanced countries (Cerutti *et al.*, 2017; Alam *et al.*, 2019; Richter *et al.*, 2019; Frost *et al.*, 2020), while others

[2] Those findings are robust to different sensitivity analyses. In particular, I examine a discrete definition of the macroprudential policy index, different alternatives to identify financial booms, a potential threat to identification such as anticipation effects, and non-linearities.

focus on particular regions (e.g., Vandenbussche *et al.*, 2015 analyse Central Eastern and South Eastern European (CESEE) countries; Bruno *et al.*, 2017, Kim and Mehrotra, 2017 and Kim and Mehrotra, 2018 Asia-Pacific countries; De Schryder and Opitz, 2021 and Budnik, 2020 European Union Member States; Fernandez-Gallardo and Paya, 2020 the euro area; Rojas *et al.*, 2020 Latin American countries; and Budnik and Rünstler, 2020 study the case of the US). The consensus is that macroprudential policies are successful at addressing financial stability risks, regardless of the econometric framework used and the specific regions involved in the analysis. These studies demonstrate the effectiveness of macroprudential policies by showing that they are able to enhance financial stability as measured by different intermediate target variables, e.g., private credit growth. However, the fact that macroprudential policies are effective at targeting those intermediate financial variables does not necessarily imply that they are successful at preventing the materialization of tail risks such as the outbreak of a systemic financial crisis. Moreover, the choice of an intermediate variable to act as a proxy of financial stability implicitly assumes a specific channel of transmission mechanism of financial risks, i.e., the credit channel. This contrasts with the fact that systemic risks are multiple, complex, and difficult to measure.[3] Therefore, providing formal empirical evidence on the effectiveness of macroprudential regulation to achieve its ultimate objective of financial crisis prevention seems necessary, without the need to assume any specific channel at work. This is the gap that this paper aims to fill.

This paper complements theoretical research that seeks to quantify the efficacy of macroprudential policy to reduce the likelihood and the costs of financial crises. The main conclusion from this literature is that macroprudential policy is effective at defusing crisis risk as well as at reducing the negative impact of financial crises (e.g., Lorenzoni, 2008; Benigno *et al.*, 2013; Bianchi and Mendoza, 2018; Van der Ghote, 2021). Moreover, the ability of optimal macroprudential policy to bust "bad" credit booms seems to be the main channel at work which dramatically lessens the likelihood of a financial crisis (Gertler *et al.*, 2020). The consensus on the theory side on the efficacy of macroprudential to prevent financial disasters, contrasts with the limited empirical evidence on the subject. This paper is, to the best of my knowledge, the first to provide a causal relationship between

[3]See Hartwig *et al.* (2021) for a comparison of the capacity of different current available indicators to measure systemic risk as well as the empirical difficulties of measuring systemic risk using a single financial indicator.

macroprudential policy and both financial crisis prevention and financial crisis severity.

The last strand to which this paper is related is the empirical economic literature on the determinants of financial crises. This literature has relied on historical data for multiple countries in order to gain statistical power, as financial crises are rather rare events. Most of the research has focused on identifying which economic indicators are major precursors of financial crises. The empirical evidence has shown, unambiguously, that financial booms, particularly credit booms, are the main predictor of those financial disasters (Schularick and Taylor, 2012; Jordà *et al.*, 2013). However, no association between bank capital ratios and the frequency of systemic financial crises has been found (Jordà *et al.*, 2021).[4]

The growing research on financial crises-predictors contrasts with the scarce empirical evidence on the policies that financial authorities can employ to reduce the likelihood and the magnitude of such financial disasters. Recent empirical research by Schularick *et al.* (2021) finds that tightening monetary policy is more likely to trigger than prevent crises. They also show that the LAW policy is ineffective at reducing the macroeconomic costs associated with the outbreak of a financial crisis. In this paper, I extend the existing empirical evidence by showing that macroprudential policy is effective at preventing and mitigating financial booms, and consequently it manages to succeed at mitigating crisis risk and crisis severity.

OUTLINE. Section 2 describes the construction of the macroprudential policy index and introduces the data on financial crises. Section 3 highlights that not all financial crises are alike, and that systemic crises are much more painful than other residual financial crises. Section 4 discusses the identification of macroprudential policy shocks and explains the empirical strategy. Section 5 presents the main results. Section 6 concludes.

2 Data

2.1 Macroprudential Policy Index

I use the MacroPrudential Policies Evaluation Database (MaPPED) to construct a macroprudential Policy index (*mpp*). The database contains around 460 policy actions between 1987 and 2017 for the following advanced economies: Belgium, Denmark, Germany, Ire-

[4]This muted effect of capital structure on crisis probability in Jordà *et al.* (2021)'s paper, however, contrasts with the success of banks capitalization to limit the economic fallout of financial crises.

land, Spain, France, Italy, Netherlands, Finland, Sweden, and the UK.[5] MaPPED provides information on policy actions related to the following 11 different macroprudential policy tools (or instruments): capital buffers, lending standards, levy/tax on financial institutions, limits on credit growth, exposure limits, liquidity rules, loan loss provisions, minimum capital requirements, risk weights, leverage ratio, and the final one labelled 'Other Measures'.

MaPPED offers certain advantages over other macroprudential databases in the literature. First, MaPPED provides details on the life-cycle implementation of each policy instrument. That is, it contains information on the activation date, recalibrations such as changes in the scope or the level of the policy, and deactivations. Second, MaPPED is designed so that policy actions are perfectly comparable across countries. This feature avoids potential biases that could arise due to lack of harmonization in open-text questionnaires (Budnik and Kleibl, 2018). Third, MaPPED provides a rich set of information on each policy action such as the announcement date and the enforcement date of the policy, the stance (loosening, tightening, or ambiguous), and whether or not it has a countercyclical design. The latter will be important for the identification strategy as shown below.[6] I refer the reader to Budnik and Kleibl (2018) for more detailed information on the advantages of this database.

The macroprudential policy index (*mpp*) is constructed for each country in the sample using the same procedure as Fernandez-Gallardo and Paya (2020). First, I only include policies that are 'binding' and therefore, I do not include ones that are mere recommendations. Second, I use the announcement date of the policy to assign a particular value to a particular policy action.[7] Third, I follow the scheme proposed by Meuleman and Vander Vennet (2020) to sign and weight policy actions. I assign a positive value to tight-

[5]The year 1987 is the earliest possible date to start the sample due to financial data availability. MaPPED dataset contains policy actions before 1995 provided those policies were still in force in 1995, i.e., policies that have not been enforced and deactivated before 1995. There are two main reasons to argue that the vast majority, if not all, policies implemented up to 1994 have been kept in the sample. First, deactivations represent a very small percentage of total policy actions, only 2% (see Figure A.1 in Appendix A). Second, when deactivated, prudential policies in MaPPED have an average duration of around 14 years. Therefore, it is very unlikely that during those seven years, 1987-1994, policies were enforced and deactivated prior to 1995. In any case, I have performed a robustness exercise in which only the post-1995 period is considered, and the results remain qualitatively the same.

[6]In MaPPED database, an instrument is said to have a countercyclical design if: (i) its level automatically tightens when systemic risks intensify and loosens when they fade, or (ii) it is regularly (e.g., quarterly) revised and calibrated along with the intensity of cyclical systemic risk (Budnik and Kleibl, 2018).

[7]MaPPED does not provide the announcement date for around 20% of the sample of interest. I assume that the announcement date coincides with the enforcement date for those policy actions with a missing announcement.

ening actions, a negative value to loosening actions, and a value of zero to policy actions that have an ambiguous impact or if no macroprudential policy action was announced in that period. Policy actions are given different weights based on perceived importance. First-time policy activations receive the highest weight and a lower value is assigned to re-calibrations. In particular, changes in the level receive the second-highest weight, whereas a lower weight is given to changes in the scope. Finally, the lowest weight is given to maintaining the existing level and scope of a policy tool. Once the tool is deactivated, the cumulative index drops to zero.[8] A description of this weighting scheme applied to each macroprudential policy instrument can be found in Appendix A.

After completing the steps explained above, I obtain an index for each policy action in a given country. Next, I construct a cumulative index for each policy instrument in a given country using the sum of the measures taken during the period from which the specific policy is activated until it is deactivated, using the weighting scheme described above. Finally, equal weight is given to all instruments.[9] That is, I construct an index for each country by simply adding up the indices of all the policy instruments implemented within a particular country. Hence, the resulted index reflects the macroprudential policy stance for a given country in a particular period, where a higher value of the index reflects a tightening stance of the macroprudential policy. The resulting indexes can be found in Appendix B.

2.2 Financial crises

I use the ECB/ESRB EU crisis database to identify financial crises in the economy. This database, launched in 2017, was developed by European institutions such as the Financial Stability Committee (FSC) of the Eurosystem and the Advisory Technical Committee (ATC) of the European Systemic Risk Board (ESRB). The main objective of this database is to provide precise chronological definitions of crisis periods and very detailed information on such events. Specifically, it contains crisis events for all EU Member States, the UK, and Norway for the period 1970-2016.[10]

[8]Therefore, the weight given to deactivations depends on the policy-specific life cycle. Note that having only 2% of deactivations prevents us from exploring asymmetric effects of deactivations.

[9]This is the common method used in the literature to deal with macroprudential policy instruments heterogeneity because of the difficulty to predict the type of policies that more effectively achieve their goal (e.g., Cerutti *et al.*, 2017 or Alam *et al.*, 2019)

[10]This database is updated regularly. Therefore, I expand the sample period using information up to 2017.

In the ECB/ESRB EU crisis database, the crisis identification method relies on a two-step approach that combines both quantitative and qualitative information. This contrasts with previous databases that only consider one of the two to extract a list of crisis events.[11] In a first step, a financial stress index is used to identify historical episodes of elevated financial distress which were also associated with economic slowdowns, extracting a preliminary list of potential crisis events. In a second step, qualitative information based on common criteria and expert judgement from national and European authorities is introduced in order to separate systemic from residual events. Thus, a systemic crisis is identified when at least one of the following three criteria is met: (i) the financial system played a role in originating or amplifying shocks, thereby contributing substantially to negative economic outcomes. (ii) the financial system was distressed (e.g., bankruptcies among large financial institutions), (iii) substantial crisis management policy interventions were activated (e.g., external support or liquidity tools). Therefore, a financial instability episode is labelled as a residual event when the financial stress indicator detects a period of financial distress, but it does not meet any of the conditions to be considered as systemic. For the empirical analysis, I only consider those financial crisis events that took place after 1987, and involved one of the aforementioned selected countries. The result is a total of twenty-seven potential crisis events to study the relationship between macroprudential regulation and crisis prevention. A list of the financial events considered in this paper can be found in Appendix A.

It is worth remarking that, even though the number of financial crisis events included in this paper could be (ideally) larger, it covers the near universe of crisis events experienced by the selected advanced economies since post-WWII, as no financial crisis occurred from after WWII to the 1980s. Moreover, data scarcity on financial crisis episodes is not an exception relative to empirical works involving these financial instability episodes as financial crises are, by their very nature, rare events.[12] In any case, lengthening the time or the cross-sectional dimension to include a larger number of financial events is not advis-

[11]Qualitative methods to delimit crises are employed for instance by Laeven and Valencia (2013) and Reinhart and Rogoff (2008, 2009), whereas a more quantitative approach is used by Frankel and Rose (1996) or Duca and Peltonen (2013).

[12]For instance, Fouliard *et al.* (2021) use the same database as in this paper to predict systemic financial crises in a few selected advanced economies. Jordà *et al.* (2013), in turn, exploit a sample of around thirty-five financial crises for 14 advanced countries over the last 140 years to draw conclusions on credit booms as main precursors of financial crises. Romer and Romer (2017) also cover around thirty-five financial distress episodes (considering both moderate and systemic crises) for 24 countries over the last 50 years to show that one of the main drivers of the variation in the aftermath of financial crisis is the severity and persistence of the financial distress itself.

able in this setting for three main reasons. First, the implementation of macroprudential policies was largely residual prior to the late 1980s. Their inclusion could, therefore, contaminate the estimated relationship between these policies and financial crises. Second, although a historical perspective would be of interest, the radical changes in the financial and economic sectors since the late 1980s could imply that the results obtained and their implications would have to be taken with greater caution. Third, an alternative possibility would be to expand the number of crisis events by including both emerging and advanced countries. However, this would be problematic as well. The identification of macroprudential policy shocks would become more difficult as emerging countries have been shown to be more active in the implementation of macroprudential policies (Cerutti *et al.*, 2017), mostly motivated by reactions to the economic cycle (Federico *et al.*, 2014). Indeed, identification would become even harder because other macroprudential policy databases that cover both emerging and developed countries do not contain narrative information. Therefore, the inclusion of emerging economies would undermine the possibility of making causal claims in this setting.[13] Given those caveats, I pursue a balance in this paper between having enough variation to yield economically and statistically significant results and having the appropriate sample to identify policy shocks and claim causal relationships.

3 Systemic crises versus Residual events

The main objective of this paper is to test empirically whether macroprudential policies are effective at defusing crisis risk and lessening crisis costs. Therefore, a first step is to identify periods of high financial distress that can be regarded as a major financial crisis.[14] Most of the existing surveys formally define crises as those events where there is a *financial crisis in the banking sector*, i.e., systemically-large banking crises (Sufi and Taylor, 2021). Consequently, the empirical research that relies on such surveys usually uses a binary classification, in which the dummy variable takes value 1 on the date where the financial crisis takes place. However, while some events are so large in magnitude that there is no doubt about those disasters being labelled as a systemically-large banking crisis,

[13]Moreover, recent research by Canova (2020) has shown that the inclusion of very heterogeneous cross-section units can ultimately lead to inconsistent results.

[14]See Sufi and Taylor (2021) for a complete discussion of the existing approaches to measuring and identifying a financial crisis event.

there are some borderline cases in which such a definition relies inevitably on subjective judgement (Sufi and Taylor, 2021). As mentioned in the previous section, the ECB/ESRB EU crisis database deals with this caveat by explicitly distinguishing between elevated periods of financial distress that can be regarded as 'systemic events' and others considered as 'residual events'. The classification criteria are based on two main features: (i) the financial stress associated with each event, and (ii) whether any policies were introduced to mitigate the negative effects of the crisis. However, their classification criteria do not take into account, at least not explicitly, whether there are differences in the economic costs associated with each type of event in terms of size and duration. Therefore, it is natural to wonder whether we should define a binary indicator that includes all crisis events, regardless of their type, in order to empirically test if prudential policies have an effect on both crisis risk and crisis severity, or we should instead only focus on those events considered as systemic by the ECB/ESRB EU crisis database.[15] Note that finding significant differences in the costs associated with alternative crisis types, i.e., systemic vs residual events, would imply that a binary variable definition that jointly considers all financial crises would lead to a misspecification of the relationship of interest as we would be treating financial crisis events as equal, but whose macroeconomics costs are very different.

I test whether systemic and residual events are characterised by important differences in economic costs to shed light on this issue. In particular, I compare the specific path followed by different real and financial macroeconomic variables in the aftermath of crisis periods to detect deviations from their usual path after non-crisis periods. The crisis periods are differentiated according to whether they are regarded as systemic or residual events. Specifically, I estimate the following local projections (Jordà, 2005):

$$\Delta^h y_{i,t+h} = \alpha_{i,h} + \theta_h^S S_{i,t} + \theta_h^R R_{i,t} + \varepsilon_{i,t+h}, \tag{1}$$

where $\alpha_{i,h}$ makes reference to the country-specific path of the outcome of interest in non-crisis periods. $S_{i,t}$ is a dummy variable that takes value 1 if a systemic crisis occurs in country i at time t and zero otherwise, while $R_{i,t}$ refers to a dummy variable that takes

[15] The difficulty in discerning which events should be considered as major financial crises is exemplified by Lo Duca *et al.* (2017), who note that some events classified as residuals periods of elevated financial distress by the ECB/ESRB EU crisis database are included as systemic events in other databases widely employed in the economic literature (e.g., Reinhart and Rogoff, 2008, 2009 or Laeven and Valencia, 2013).

value 1 if a residual crisis occurs in country i at time t and zero otherwise. Therefore, θ_h^S traces how the path of the variable of interest, e.g., real GDP, after systemic financial crises deviates from its usual path after non-crisis periods, while θ_h^R traces how the path of the variable of interest, e.g., real GDP, after residual financial crises deviates from its usual path after non-crisis periods. I formally test whether there are significant differences between such paths, that is $\theta_h^S = \theta_h^R$.

Table 1: Macroeconomic differences in the aftermath of systemic crises and residual events

Cumulative log level effect of crisis vs noncrisis trend, for:	h=4	h=8	h=12	h=16	h=20
Log real GDP (Systemic)	-3.698***	-5.604***	-5.192***	-6.182***	-5.968***
	(0.466)	(0.482)	(0.556)	(1.019)	(1.137)
Log real GDP (Residual)	-2.692***	-2.564***	-2.314***	-1.572	-0.829
	(0.661)	(0.495)	(0.545)	(0.968)	(1.409)
Systemic=Residual, p-value	0.252	0.001	0.006	0.019	0.046
Log price level (Systemic)	-0.314	-0.648	-0.693	-0.418	-0.975
	(0.666)	(0.754)	(0.750)	(0.855)	(1.003)
Log price level (Residual)	0.240	0.322	0.194	-0.273	-0.927
	(0.512)	(0.651)	(0.739)	(0.685)	(0.728)
Systemic=Residual, p-value	0.542	0.406	0.472	0.903	0.971
Log total credit (Systemic)	-3.909	-13.79**	-16.01**	-20.90**	-25.34***
	(1.934)	(3.969)	(4.182)	(5.037)	(4.950)
Log total credit (Residual)	-2.944	3.197	6.145	4.786	5.669
	(3.287)	(3.300)	(3.973)	(6.219)	(6.512)
Systemic=Residual, p-value	0.818	0.012	0.003	0.005	0.003
Log house prices (Systemic)	-9.162***	-15.660***	-20.278***	-26.085***	-29.378***
	(1.867)	(2.741)	(3.901)	(5.048)	(5.288)
Log house prices (Residual)	-0.169	1.083	2.232	3.215	2.804
	(1.171)	(2.212)	(2891)	(3.518)	(4.149)
Systemic=Residual, p-value	0.007	0.002	0.001	0.001	0.001
Log stock prices (Systemic)	-34.500**	-36.483**	-23.174*	-33.021**	-27.621**
	(7.816)	(8.103)	(9.912)	(9.592)	(8.299)
Log stock prices (Residual)	-35.560**	-37.929**	-36.786*	-33.169	-18.577
	(8.349)	(10.783)	(13.721)	(18.245)	(20.517)
Systemic=Residual, p-value	0.915	0.926	0.518	0.995	0.730
	Obs	Mean	Std	Min	Max
Systemic	17	18.23	6.91	7	30
Residual	10	8.80	4.02	4	15

Notes: This table presents the path followed by different real and financial variables in deviations to their path in non-crisis periods during the aftermath of systemic events and residual events. Descriptive statistics (mean, std, min and max) refer to crisis duration on a quarterly basis. Horizons, h = 4, 8, 12, 16 are displayed. Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

The main conclusion to be drawn from Table 1 is that not all financial crises are alike, and that systemic crises are more painful than the other events classified as residuals by the ECB/ESRB EU crisis database. In particular, the differences between both types of crises can be summarised as follows. First, systemic crises are associated with larger output losses than residual events, both in terms of intensity and duration. While the peak of the fall in output for residual events is reached in the first year (-2.7%), this peak is not reached in the case of systemic events until the fourth year (-6.2%). Second, the most significant differences between crisis types are found in the path followed by credit and house prices. Systemic crises seem to be characterised by a progressive and long-lasting fall of both credit and house prices. The peaks are found in the fifth year, with a drop in credit and housing prices that accounts for 25.4% and 29.4% respectively. Regarding residual events, I find that they have a negligible impact on credit and house prices. This contrast in the financial costs associated with both types of crises was expected since, by definition, systemic crises are defined as events of larger financial stress. However, it is worth noting that periods of high financial stress, even if labelled as residual events, are followed by a relatively small drop in these intermediate financial stability variables. Third and lastly, the most similar elements between crisis types are the evolution of general prices and stock prices. With regard to the former, those events are followed by periods of deflation. Nonetheless, in both cases the drop in prices is not sufficient to be statistically different from zero. Regarding the latter, both systemic events and residual events are characterised by a sustained drop in financial asset prices over time. The fact that both residual events and systemic events show a similar path in stock prices is not surprising, as the former events include some dot-com financial crises in the early 2000s, which were particularly characterised by a considerable collapse of financial assets.[16]

Two main conclusions can be extracted from this exercise. First, this finding reinforces that the prevention of systemic crises should be one of the main objectives of monetary authorities due to the large economic costs associated with such events. Second, this result highlights the importance of discerning between systemic events and residual events in this and similar empirical settings. Therefore, only systemic crisis events are included in the analysis to empirically test whether macroprudential policies are successful at addressing crisis risk and reducing crisis economic costs.

4 Identification and Empirical Strategy

I first need to identify non-systematic movements in macroprudential policies to establish causal relationships between macroprudential policies and both the prevention and mitigation of financial crises. While most monetary policy changes are systematic responses to the business cycle (Ramey, 2016), the evidence for macroprudential policies in this regard, although scarce, seems to suggest that this is not the case in advanced economies.[17]

[16] Residual events include, among other events, the burst of the IT bubble in France, Sweden, Netherlands and Finland. In the latter country, for instance, stock prices (all share index) collapsed over 70 % between 2000-06 and 2002-08 (Lo Duca *et al.*, 2017).

[17] Fernandez-Gallardo and Paya (2020) point out that, at least within the euro area, most of these policies are implemented to enhance long-term financial stability or long-term economic growth rather than for

As mentioned in Subsection 2.1, MaPPED classifies each macroprudential policy action as being motivated by either cyclical or non-cyclical considerations. This classification of the policy events therefore distinguishes between implementations primarily motivated by the current business and financial cycle, and those that are plausibly free of such contemporaneous influences. In this paper, I only consider the latter interventions to study the effects of macroprudential policy on crisis risk and crisis severity. That is, I rely on a narrative identification approach to formally assess whether macroprudential policies have an effect on both the frequency and the costs of financial crises.[18] I again construct a macroprudential index for each country using the steps described in Subsection 2.1. I refer to this index as the narrative measure of the *mpp*. Consequently, this index does not include those policies that have a specific countercyclical design, as those interventions have short-term stabilization motives as the primary objective.[19]

Within this setting, I argue that, after excluding countercyclically-motivated policies, the remaining prudential actions are legitimate observations for identifying causal effects because such policies do not systematically respond to short-term economic conditions and therefore are not systematically correlated with other underlying factors affecting crisis risk and crisis severity.

I carry out the following two exercises to provide empirical evidence to support the argument that the policies included in the narrative measure of the *mpp* index can be regarded as plausibly exogenous to the business cycle. First, while countercyclical policies, as defined by the MaPPED database, respond to increases in financial distress, it is worth wondering if (non-countercyclical) prudential regulation systematically reacts to the most severe episodes of financial distress such as financial crises. Note that, if that were the case, this would imply evidence against financial authorities implementing macroprudential policies motivated by long-term objectives. Under that scenario, macroprudential policies would be systematically responding to the financial crisis itself and, therefore, to the economic and financial cycle. Therefore, in order to provide empirical evidence on how

reasons related to the economic or financial cycle. Their argument is reinforced by the fact that, for the selected set of advanced economies used in this paper, countercyclical policies in the MaPPED database only represent around 10% of the total set of policies covered by the database.

[18] Narrative identification has been employed for macroprudential policy by, for instance, Eickmeier *et al.* (2018), Richter *et al.* (2019), Budnik and Rünstler (2020), Fernandez-Gallardo and Paya (2020) and Rojas *et al.* (2020).

[19] The fact that most of these policies do not respond systematically to the business cycle does not mean that the identification of macroprudential shocks may be threatened by other issues such as anticipation effects (Fernandez-Gallardo and Paya, 2020). This type of problem is addressed in the robustness section.

macroprudential policy evolves in the aftermath of financial crises, I repeat the exercise in the previous section but this time analysing how macroprudential policies react to the outbreak of financial crises in deviations from its usual path in non-crisis periods. Monetary policy is also included to explore differences between the two policies.

Table 2 shows the results of this first exercise. I note that, regardless of the type of financial crisis, there are no significant differences in the path followed by macroprudential policies in the aftermath of financial crises with respect to its usual path in non-crisis periods. It is therefore evident that these policies are not systematically tightened or loosened after the outbreak of financial crises. This contrasts with a systematic expansive deviation of monetary policy in the aftermath of systemic crises. While this result confirms the difficulty of identifying monetary policy shocks due to the significant systematic component of this policy, it suggests that this seems not to be the case for non-countercyclical macroprudential policies in advanced economies. This result reinforces the argument that, except for some identifiable systematic components such as countercyclical policies, prudential implementations in this sample tend to be motivated by long-term concerns rather than to business or financial cycles.

Table 2: Macroprudential policy in the aftermath of financial crises

Cumulative log level effect of crisis vs noncrisis trend, for:	h=4	h=8	h=12	h=16	h=20
Macroprudential Policy Index (Systemic)	-0.308	0.661	1.052	1.264	1.575*
	(0.157)	(0.694)	(0.724)	(0.614)	(0.595)
Macroprudential Policy Index (Residual)	0.026	-0.256	-0.292	-0.388	-0.615
	(0.276)	(0.268)	(0.481)	(0.494)	(0.440)
Systemic=Residual, p-value	0.203	0.226	0.158	0.100	0.032
Short term rate (Systemic)	-0.469	-2.712***	-2.546***	-1.829***	-2.232***
	(0.554)	(0.388)	(0.389)	(0.387)	(0.462)
Short term rate (Residual)	-1.292**	-1.195	-1.198*	-1.434	-0.986
	(0.404)	(0.541)	(0.514)	(0.723)	(0.895)
Systemic=Residual, p-value	0.354	0.052	0.084	0.656	0.321

Notes: This table presents the path followed by macroprudential policies and monetary policy in deviations to their path in non-crisis periods during the aftermath of systemic events and residual events. Horizons, h = 4, 8, 12, 16 are displayed. Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Second, I further test the predictability of those policies to show additional evidence about the exogeneity of the policies included in the narrative measure of the *mpp*. In particular, I test whether macroprudential policy changes, after excluding countercyclical policies, can be predicted by several real, financial and monetary variables, which are used to proxy for short-term economic conditions. Some of these factors have been shown to be major predictors of financial crises, e.g., private credit growth or house-price growth. More specifically, I regress the narrative macroprudential policy index on one-period lagged annual real GDP growth, annual CPI inflation, annual real total credit growth, annual real house-price growth, annual real stock-price growth, changes in the short-term and long-term interest rates.

Table 3: Prediction of macroprudential policy changes.

Predictors	Dependent variable: Δmpp_t
Annual real GDP growth$_{t-1}$	0.084
	(0.238)
Annual inflation$_{t-1}$	-0.761
	(1.173)
Short term rate$_{t-1}$	0.017
	(0.016)
Long term rate$_{t-1}$	0.030
	(0.023)
Annual real stock-price growth$_{t-1}$	-0.027
	(0.064)
Annual real house-price growth$_{t-1}$	0.388
	(0.811)
Annual real total credit growth$_{t-1}$	-0.014
	(0.087)
F-test, all coefficients equal to zero, p-value	0.227
Observations	1319

Notes: This table reports the predictability tests of macroprudential policy changes without including countercyclical design policies. Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3 shows the main findings from this second exercise. The results confirm that none of the predictors are systematically related to changes in the narrative macroprudential policy index. This reinforces the argument that macroprudential policies included in the narrative measure of the *mpp* are not systematically correlated with short-term economic and financial fluctuations.[20] The fact that macroprudential policies included in the narrative measure of the *mpp* index are orthogonal to the economic and financial cycle is, therefore, the key identification assumption in this setting.

Having argued the potential identification issues, I now explain the empirical specification. I estimate impulse response functions (IRFs) through local projections to compute the effect of a macroprudential policy change on crisis risk. Particularly, I use the specification proposed by Schularick *et al.* (2021) to estimate a sequence of linear crisis probability models through which I can evaluate how macroprudential policies impact crisis risk.[21]

[20] An alternative procedure that has also been used to obtain macroprudential policy exogenous variations relies on a propensity score method (e.g., Richter *et al.*, 2019, Alam *et al.*, 2019 or Frost *et al.*, 2020). The inverse probability weighting (IPW) estimation employs a two-step approach in which a larger weight is given to policy changes that are difficult to predict based on a set of economic variables. In particular, the predictability of policy changes comes from a first stage in which policy variations are regressed on a set of predictors. Note that, within this sample, the fact macroprudential changes are not predicted by a long set of economic, financial, and monetary predictors implies that the employment of a propensity score framework in this context is not necessary. Appendix C presents this analysis in detail.

[21] A disaggregated analysis of the effects of macroprudential policies on crisis risk by prudential tool

$$C_{i,t+h} = \alpha_{i,h} + \beta_h \Delta mpp_{i,t} + \sum_{l=1}^{L} \Gamma_{h,l} X_{i,t-l} + \sum_{l=1}^{L} \Phi_{h,l} C_{i,t-l} + \varepsilon_{i,t+h}, \tag{2}$$

where $\alpha_{i,h}$ is the country fixed effects, $\Delta mpp_{i,t}$ denotes the quarterly change of the narrative measure of the macroprudential policy index, and $X_{i,t}$ includes lagged annual real GDP growth, annual CPI inflation, annual real total credit growth, and changes in the short-term interest rate. In addition, $X_{i,t}$ includes the lagged US Economic Policy Uncertainty (EPU) indicator of Baker *et al.* (2016). The latter is included to account for global risk and potential spillover effects from the US. Finally, the dependent variable is a dummy, $C_{i,t}$, taking value 1 if a systemic financial crisis occurs in country i at quarter t or in the following seven quarters.[22] I standardise the mpp to ease interpretation of results. The coefficient β_h traces the response of crisis risk at horizon h, to a +1 standard deviation (std) increase in the macroprudential policy index. The model is estimated on a quarterly basis. The sample period span from 1987:Q4 until 2017:Q4. I include two lags of $X_{i,t}$, that is, $L = 2$. Horizons, $h = 0, 4, 8, 12, 16$ are displayed to ease visual inspection of the responses. The maximum horizon considered is $h = 16$. I follow the lag-augmentation approach proposed by Montiel Olea and Plagborg-Møller (2021) for inference. That is, I augment the controls by including lags and computing the usual heteroskedasticity-robust standard errors.

5 Empirical Results

Do macroprudential policies reduce the frequency of financial crises? Do financial or monetary conditions influence the effectiveness of macroprudential policies to defuse crisis risk? If successful, what is the main channel through which macroprudential policies operate? This section provides empirical answers to these questions. In a second step, I also explore to what extent the output path in the aftermath of a financial crisis depends on the pre-crisis macroprudential policy stance.

Baseline result

category (11 categories according to MaPPED) can be found in Appendix D.

[22] This dummy definition follows from Schularick *et al.* (2021). It reflects that although the possibility of predicting the exact moment in which a financial crisis will occur is difficult, it is possible to forecast the moment in which an economy enters a *danger zone* in which financial crises are more likely to happen (Kaminsky and Reinhart, 1999; Ward, 2017). For instance, Ward (2017) shows that the out of sample forecasting performance of considering a 2-year or 3-year window within which crises happen, substantially surpasses current best practice logit specifications.

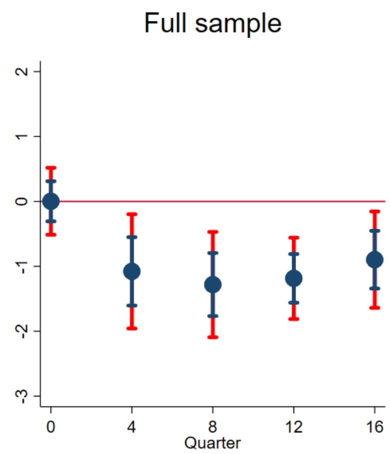

Figure 1: Change in the two-year crisis probability following a macroprudential policy shock. Horizons, $h = 0, 4, 8, 12, 16$. 90% (red line) and 68% (blue line) confidence bands are displayed.

The main result is presented in Figure 1. It shows that tightening macroprudential policy actions defuse crisis risk in the short and in the medium term. In particular, while a +1 std in the macroprudential policy index has a muted effect on crisis risk on impact, it has a significant effect at the remaining horizons. The peak of the impact, -1.5 percentage points (ppts), is reached eight quarters following the macroprudential policy shock. The size of the effect is non-negligible, given that the two-year crisis risk probability within the sample is around 9.5%. Therefore, a tightening macroprudential policy reduces the unconditional probability of having a systemic financial crisis from 9.5% to 8% over the medium term.[23]

The fact that macroprudential policies are shown, on average, to be effective at reducing the frequency of financial crises sheds light on Jordà *et al.* (2021)'s findings. Specifically, this result shows that, as suggested by Jordà *et al.* (2021), addressing crisis risk depends on the implementation of different macroprudential policy instruments, e.g., policies targeting credit growth and maturity mismatch, and not only on the bank capital structure. This finding, therefore, points to different macroprudential policy instruments acting as complements at the time of addressing different financial risks.[24]

[23]This mid-term effect of macroprudential policy on crisis risk contrasts with the short-term effect of monetary policy (Schularick *et al.*, 2021). In particular, Schularick *et al.* (2021) shows that monetary policy contractions only have an impact on crisis risk up to two years after the interest rate hike, and have no significant impact afterwards. However, the crisis risk responses to a macroprudential policy shock still remain significant four years following the prudential policy shock.

[24]The complementarity between different macroprudential policy instruments has been previously discussed by De Nicoló *et al.* (2012). In particular, they argue that the correction of alternative financial externalities can be seen as intermediate targets for macroprudential policy. In their view, different prudential tools address different externalities so that all policy tools complement each other, ultimately preventing a market failure.

In sum, the empirical evidence presented in this section highlights that, agnostic with respect to the channel at work, macroprudential policy is successful at reducing the likelihood of financial crises.

Financial Booms

Financial booms have been shown to be major predictors of systemic financial crises (Schularick and Taylor, 2012; Jordà *et al.*, 2015). Based on this empirical evidence, a relevant question is whether macroprudential policies continue to be effective at defusing financial crisis risk conditional on the economy being already in a financial boom. I consider three types of booms: credit booms, housing booms, and credit+housing booms to provide evidence in this regard.

The financial boom indicator is constructed following Schularick *et al.* (2021). In particular, I create binary indicators for financial boom, $I_{i,t}$, based on credit, and house prices, $y_{i,t}$, separately. The boom indicators take a value of 1 when $y_{i,t}$ is above its trend level, $\bar{y}_i$, and show positive growth:

$$I_{i,t} = \begin{cases} 1 & \text{if} \quad y_{i,t} > \bar{y}_i \quad \wedge \quad \Delta y_{i,t} > 0 \\ 0 & \text{otherwise} \end{cases} \tag{3}$$

I follow Hamilton (2018) to obtain the cyclical component.[25] As explained above, I also consider a combination of credit and housing boom. This financial boom indicator takes value 1 when both credit and house prices fulfil condition 3. As a robustness check, in Subsection 5.3.2 I also consider a one-sided HP filter to separate the trend and the cyclical component.

I move from a linear to a nonlinear model to analyse the effect of macroprudential policy on crisis risk when the economy is already experiencing a financial boom. In particular, I estimate the following local projections:

[25] The Hamilton filter proposes an alternative to the HP filter that prevents spurious financial cycles (Schüler *et al.*, 2020). The main idea is that the cyclical component of a variable can be computed as the different between the realised value at date $t + h$ from the value that we could have predicted based on its historical behaviour on date t. The choice of h depends on the horizon attributed to the cyclical component. I choose a horizon, h, of eight quarters, as suggested in Hamilton (2018). The method relies on a linear projection of y_{t+h} on a constant and the four most recent values of y as of date t to predict the trend. Under this specification, the cyclical component, i.e., y^C_{t+8}, will come from the deviation of the realised value at y_{t+8} and the expectation, y^T_{t+8}, made at time t based on information from y_t, y_{t-1}, y_{t-2} and y_{t-3}.

$$
\begin{aligned}
C_{i,t+h} = \quad & I_{i,t} \quad \left[\alpha_{i,h}^{A} + \beta_h^A \Delta mpp_{i,t} + \sum_{l=1}^{L} \Gamma_{h,l}^{A} X_{i,t-l} + \sum_{l=1}^{L} \Phi_{h,l}^{A} C_{i,t-l}\right] + \\
& (1 - I_{i,t}) \left[\alpha_{i,h}^{B} + \beta_h^B \Delta mpp_{i,t} + \sum_{l=1}^{L} \Gamma_{h,l}^{B} X_{i,t-l} + \sum_{l=1}^{L} \Phi_{h,l}^{B} C_{i,t-l}\right] + \varepsilon_{i,t+h},
\end{aligned} \tag{4}
$$

where $I_{i,t}$ is a dummy variable that takes value 1 when the economy is in a financial boom and 0 otherwise. This specification allows us to search for state-dependency in the response of crisis risk to a macroprudential policy shock. In particular, β_h^A shows the crisis risk response in periods of financial booms, which is our coefficient of interest, whereas β_h^B traces the response in the remaining periods.

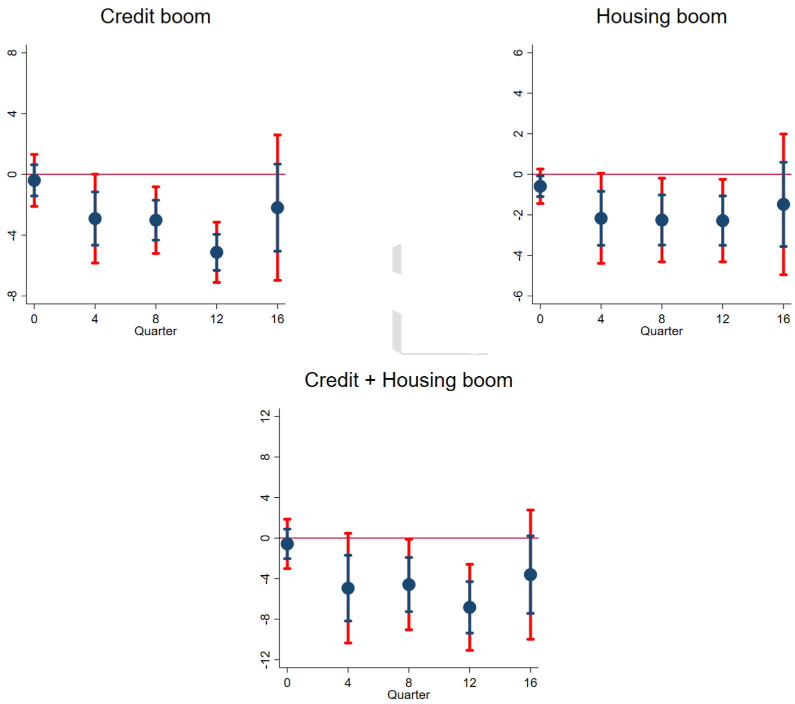

Figure 2: Change in the two-year crisis probability following a macroprudential policy shock during a boom. Horizons, $h = 0, 4, 8, 12, 16$. 90% (red line) and 68% (blue line) confidence bands are displayed.

Figure 2 presents the crisis risk responses for the different types of financial booms. The top-left panel shows that, in the credit boom subsample, the effect builds over time, moving from a reduction of almost 4ppts in crisis risk four quarters after the macroprudential policy shock to 6 ppts after twelve quarters. Nonetheless, the effect seems to dissipate in the last horizon, $h = 16$. This effect is particularly encouraging given that the two-year crisis probability during credit booms is almost twice as high as in the full sample. In particular, while for the latter the crisis probability risk is around 9.5%, for the former it rises to 17%. Therefore, conditional on the economy experiencing a credit boom, a +1std macroprudential policy shock reduces crisis probability from 17% to 11% over the medium term.

Can macroprudential policy mitigate crisis risk even during housing booms? The top-right panel suggests that a tightening macroprudential policy shock still remains successful in reducing crisis risk, even if the economy is already experiencing a housing boom. The peak of the effect is reached over the medium term, where a +1 std macroprudential policy shock is followed by a 2ppts fall in the probability of a financial crisis.

The result of the combination of credit and housing boom, in turn, is presented in the bottom panel. Conditional on that state, macroprudential policy is still able to make financial crises less likely. In particular, a +1 std macroprudential policy shock reduces crisis risk over the medium term between 6 and 8 ppts. The magnitude of the effect is economically meaningful, since the two-year crisis probability is almost 18% in that sub-sample. Consequently, a macroprudential policy tightening when the economy is already experiencing a combined boom in credit and house prices, implies a significant drop in crisis risk (from 18% to 10-12%). This finding is particularly relevant for macroprudential regulators, as credit-fuelled housing booms have been shown to be strongly associated with the occurrence of financial crises (Jordà *et al.*, 2015).

The results presented in this section are unambiguous. Even in very delicate economic situations such as financial booms, the implementation of macroprudential policy tightenings make systemic crises less likely.[26]

Monetary stance

The interaction between macroprudential policies and monetary policy is still one of the issues that is subject to debate among researchers and policymakers. Although recent studies suggest that the two policies can complement each other (Maddaloni and Peydró, 2013; Kim and Mehrotra, 2017; Fernandez-Gallardo and Paya, 2020; Altavilla *et al.*, 2020), there is a consensus that monetary policy can have adverse effects on financial stability (Jordà *et al.*, 2015; Schularick *et al.*, 2021). This complementarity issue has become partic-

[26]Note that the state-dependent results regarding financial booms reinforce the argument that policy shocks can be regarded as plausibly exogenous to the business cycle. In particular, if macroprudential policies were implemented in response to economic conditions, we would expect to have found a smaller effect in financial booms subsamples than that found in the full sample specification. The intuition is that, under that scenario, financial crisis episodes and macroprudential policies would be positively correlated with financial booms, and therefore the estimates during boom subsamples would suffer from downward bias.

ularly relevant since the GFC, as many advanced economies, particularly in Europe, have been characterised by periods of loosening monetary conditions and tightening financial conditions. To quote, Christian Noyer, Governor of the Banque de France at the time, in 2014: "We should however stress the possibility of a complementarity between these two policies: in the current European context, the European Central Bank has confirmed its decision to maintain an accommodative monetary policy stance for as long as necessary. Nevertheless, the risk entailed in this type of policy is that, in some euro area countries, financial imbalances may emerge in the form of asset price bubbles. The implementation of appropriate macroprudential policies in these countries should make it possible to prevent or contain such risks." Indeed, a low-rate environment is likely to prevail over the long-term (Gourinchas and Rey, 2019; Kiley, 2020). There is, therefore, a need to show whether the two policies act as a complement in such a way that looser monetary conditions do not interfere with the ability of macroprudential policy to address systemic crisis risk.

I estimate the previous specification to shed light on this issue, but this time with $I_{i,t}$ being a dummy variable that depends on the monetary policy stance. Specifically, I set $I_{i,t} = 1$ when the monetary policy stance in the economy can be regarded as loosening. Therefore, under this specification, β_h^A traces the crisis risk response in periods of loose monetary conditions. I follow Maddaloni and Peydró (2011, 2013) to proxy for monetary conditions in each country. In particular, for non-EMU countries and for EMU countries previous to 1999, I construct Taylor residuals by regressing the country-specific short-term interest rate on GDP growth and inflation. For euro area countries, after 1999, I estimate the residuals by means of panel regression using the EONIA rate as short-term rate. Moreover, in this regression I impose common coefficients for all countries, given the common monetary policy. As a result, negative residuals, $\eta_{i,t} < 0$, proxy for low rates (loose monetary conditions). The indicator variable is defined as follows:

$$I_{i,t} = \begin{cases} 1 & \text{if} \quad \eta_{i,t} < 0 \\ 0 & \text{otherwise} \end{cases} \tag{5}$$

Figure 3 presents the crisis risk response after a +1 std macroprudential policy shock conditional on the economy having accommodative monetary conditions, $\eta_{i,t} < 0$. Conditional on that state, a tightening macroprudential policy shock reduces crisis risk from

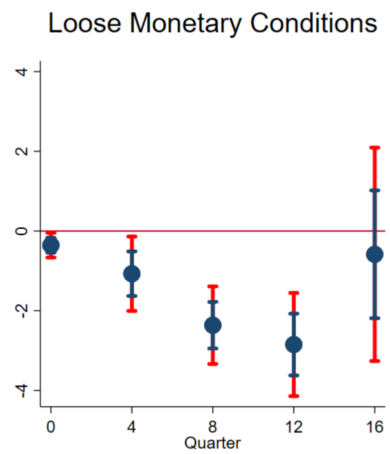

Figure 4: Change in the two-year crisis probability following a macroprudential policy shock. State-dependency: loose monetary conditions. Horizons, $h = 0, 4, 8, 12, 16$. 90% (red line) and 68% (blue line) confidence bands are displayed.

the short-term to the medium term. In particular, while crisis risk is reduced by around 1ppt after four quarters, the effect later accentuates, and it reaches its peak after eight quarters (-3ppts). Similar to the financial boom state-dependent results, the effect seems to dissipate after four years following the macroprudential policy shock. This result suggests that the risk-taking channel of monetary policy does not prevent macroprudential policy from achieving its objective. That is, the empirical evidence lends support to the idea that both policies complement each other. The main implication of this result is that an accommodative monetary policy, when needed, will not interfere with the ability of macroprudential policy to address financial crisis risk.

5.1 Why does macroprudential policy reduce crisis risk?

The previous empirical evidence in this paper highlighted that macroprudential policy is, agnostic with respect to the channel at work, effective at preventing financial crises. A relevant related question is regarding the transmission channel through which macroprudential policy achieves its objective. In this regard, most of the recent literature has shown that financial booms are major precursors of financial crises (Schularick and Taylor, 2012; Jordà *et al.*, 2013, 2015; Richter *et al.*, 2021). Therefore, the prevention of financial booms is a reasonable candidate for the main channel at work through which macroprudential policy defuses financial crisis risk. To explore this mechanism, I use local projections to estimate how real private credit and real house prices change following a macroprudential policy shock:

$$\Delta^h y_{i,t+h} = \alpha_{i,h} + \theta_h \Delta mpp_{i,t} + \sum_{l=1}^{L} \Gamma_{h,l} X_{i,t-l} + \sum_{l=1}^{L} \Phi_{h,l} y_{i,t-l} + \varepsilon_{i,t+h}, \tag{6}$$

where $\Delta^h y_{i,t+h}$ denotes, separately, the cumulative h-horizon change in credit and house prices (both in real terms). $\{\theta_h\}_{h=1}^{h=H}$ denotes the impact of a +1 std macroprudential change at time t on real credit and real house prices. The set of controls, $X_{i,t}$, are the same as in the previous section. Local projections are estimated separately for each of the two intermediate financial variables.

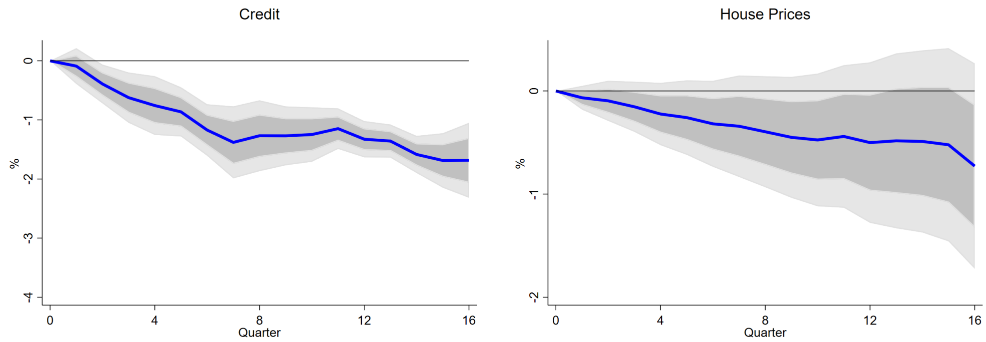

Figure 5: Impulse response function to a +1 std macroprudential policy shock. 90% (light grey) and 68% (dark grey) confidence bands are displayed.

Figure 5 shows the impulse responses of credit and house prices to +1 std macroprudential policy shock. The left panel shows that a contractionary change in the mpp lowers credit from the initial period. This effect later accelerates and persists over time, reaching a peak of around -2% after four years. Regarding house prices, tighter financial regulation generates a fall in real house prices that smoothly increases over time. In fact, the peak is reached in the last horizon, $h = 16$, with a drop in house prices of around 1%. The empirical evidence presented in Figure 5 speaks to the ability of macroprudential policy to prevent financial booms, either credit-driven or housing-driven, through tightening in financial regulation.

The state-dependent results on crisis risk presented in the previous section showed that tightening macroprudential policy remains successful in reducing the frequency of financial crises even when the economy is already experiencing a financial boom. I expand the previous specification to allow for state-dependencies in the effect of macroprudential policy on those intermediate financial variables, in order to explore in greater detail how the mechanism works in those periods. Specifically, I estimate the following local projections:

$$\Delta^h y_{i,t+h} = I_{i,t} \left[\alpha^A_{i,h} + \theta^A_h \Delta mpp_{i,t} + \sum_{l=1}^{L} \Gamma^A_{h,l} X_{i,t-l} + \sum_{l=1}^{L} \Phi^A_{h,l} y_{i,t-l}\right] + (1 - I_{i,t}) \left[\alpha^B_{i,h} + \theta^B_h \Delta mpp_{i,t} + \sum_{l=1}^{L} \Gamma^B_{h,l} X_{i,t-l} + \sum_{l=1}^{L} \Phi^B_{h,l} y_{i,t-l}\right] + \varepsilon_{i,t+h}, \tag{7}$$

where $I_{i,t}$ is defined as in 3. In particular, it is equal to 1 in the case of a credit boom or a housing boom, separately, and 0 otherwise. Local projections are estimated separately for periods of credit and housing booms. Therefore, under this specification, θ^A_h traces out the effect of tightening macroprudential regulation on both credit and house prices during financial booms periods.

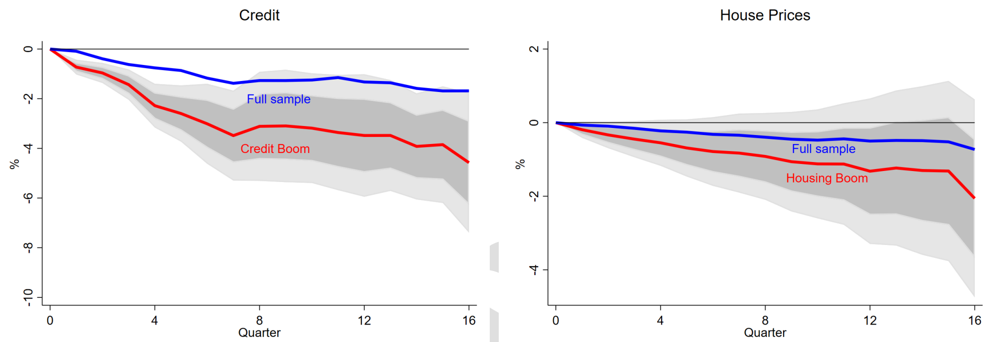

Figure 6: Impulse response function to a +1 std macroprudential policy shock. 90% (light grey) and 68% (dark grey) confidence bands for booms are displayed.

Figure 6 presents the effect of macroprudential policy on real credit and real house prices in periods of financial booms. Moreover, for comparative purposes, it includes the full sample estimates. Regarding the effect on credit, there is a clear contrast between the full sample estimate and the financial boom subsample estimate. Specifically, macroprudential policy becomes even more effective at curbing credit growth in latter periods. This result points to the ability of prudential policies to reduce credit growth even during credit-driven financial booms. In particular, since average credit growth rises from 1.1% in the full sample to 4.7% in credit booms, the large state-dependent estimates are consistent with macroprudential policy being effective at addressing crisis risk when the economy is already experiencing a credit-driven financial boom. The finding that macroprudential policy is successful at preventing and mitigating credit booms is particularly relevant as such a state have been shown to be a dangerous phenomenon for advanced economies from a financial stability perspective (Schularick and Taylor, 2012; Jordà *et al.*, 2013).

The state-dependent effects on house prices also show a difference with respect to the full sample estimates. In particular, conditional on the economy experiencing a housing-boom, macroprudential policy seems to have a larger impact on house prices during such a state. Therefore, the effect of macroprudential policies on house prices during housing booms seems to be sufficient to reduce crisis probability during such a state.

In sum, the state-dependent results on real credit and real house prices point not only to the prevention of financial booms, but also to their mitigation, as the main transmission channel through which macroprudential policy is effective at reducing crisis risk.

5.2 Building the resilience of the financial system

Apart from preventing systemic financial crises, macroprudential policy aims to increase the resilience of the financial system so that when the triggering of a financial crisis cannot be prevented, the costs associated with it are as low as possible. This section aims to assess whether macroprudential policy is successful at achieving this objective. In particular, I aim to quantify to what extent an ex-ante tighter macroprudential stance moderates the output losses associated with the next financial crisis. I first approximate the macroprudential policy stance from two-year to five-year horizon as the cumulative sum of macroprudential policies implementations over the same time period, i.e., $MPP^K_{i,t-1} = \sum_{k=1}^{K} \Delta mpp_{i,t-k}$, where $K = 8, 12, 16, 20$, specified on a quarterly basis.[27] In the second step, I define an indicator variable to approximate the macroprudential policy stance based on the distribution of $MPP^K_{i,t-1}$. In particular, I define a dummy variable, $Tighter_{i,t-1}$, based on whether a particular country, i, in a particular period $t-1$, is in the top quintile of MPP^K_i, compared with other observations for the same unit in different periods.

$$Tighter^K_{i,t-1} = \begin{cases} 1 & \text{if} \quad MPP^K_{i,t-1} > MPP^K_{i,80th} \\ 0 & \text{otherwise} \end{cases} \tag{8}$$

I then estimate the following local projections:

[27] The method to approximate the macroprudential policy stance is similar to the one used by Schularick *et al.* (2021) for the case of monetary policy, who construct different leaning-horizons as the sum of policy changes over the same horizon.

$$\Delta^h y_{i,t+h} = \alpha_{i,h} + \beta_h C_{i,t} + \theta_h C_{i,t} Tighter^K_{i,t-1} + \sum_{l=1}^{L} \Gamma_{h,l} X_{i,t-l} + \sum_{l=1}^{L} \Phi_{h,l} y_{i,t-l} + \varepsilon_{i,t+h}, \quad (9)$$

with $h = 1, 2, ..., H$, where H is 24 in this specification. $\Delta^h y_{i,t+h}$ denotes the cumulative h-horizon change in real GDP. $C_{i,t}$ is a dummy that takes value 1 if a systemic crisis occurs in country i at quarter t. $Tighter^K_{i,t-1}$ makes reference to the dummy as defined above. The set of controls, $X_{i,t}$, is defined as in previous specifications, but now also includes macroprudential policy changes, $\Delta mpp_{i,t}$, and the pre-crisis macroprudential policy stance, $Tighter^K_{i,t-1}$. The latter term controls for the effects of the macroprudential policy stance in non-crisis years. Under this specification, β_h defines how the real GDP path following a systemic financial crisis deviates from its non-crisis path when the previous macroprudential policy stance in the economy is not tight, according to the rule detailed in (8). Therefore, θ_h describes how the real GDP path following a systemic financial crisis is affected when the pre-crisis macroprudential policy stance can be regarded as tight. The confidence bands are computed using the lag-augmentation approach of Montiel Olea and Plagborg-Møller (2021). Note that, and opposite to previous specifications, the main treatment variable is not the macroprudential policy index but the interaction between the index and the crisis dummy. Therefore, this specification allows us to estimate how the pre-crisis macroprudential policy stance affects crisis severity.

Local projections are estimated separately for each of the four macroprudential policies implementation horizons considered for the construction of the macroprudential policy stance, $K = 8, 12, 16, 20$, on a quarterly basis. Exploring the sensitivity of the results to different implementation horizons, K, overcomes potential limitations of assuming a specific implementation horizon, e.g., $K = 8$, to approximate the pre-crisis macroprudential policy stance.

Figure 7 presents the output path in the aftermath of systemic financial crises, depending on the previous macroprudential policy stance. Regardless of the implementation horizon, K, a tighter pre-crisis macroprudential policy stance reduces crisis severity.[28] More particularly, with all else being equal, the aftermath of financial crises is characterised by lower output losses and faster recoveries if there was a tighter pre-crisis macropruden-

[28] For $K = 8$, a tighter pre-crisis macroprudential policy stance seems to be effective to limit the initial economic fallout of financial crises but not sufficient to have faster recoveries from the crises.

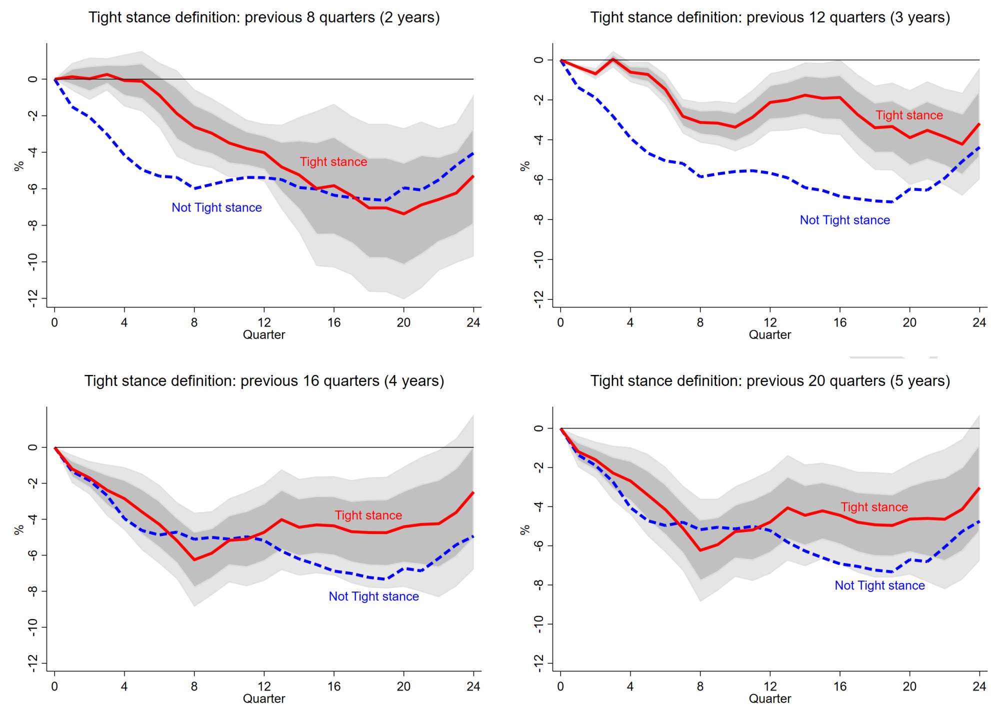

Figure 7: Output path in the aftermath of a systemic financial crisis, depending on the pre-crisis macroprudential policy stance. Macroprudential policy implementation horizons, $K = 8, 12, 16, 20$. 90% (light grey) and 68% (dark grey) confidence bands for tight stance are displayed.

tial policy.[29] This is particularly evident for pre-crisis macroprudential implementation horizons of three, four and five years. The main conclusion of this exercise is that macroprudential policy not only makes financial crises less likely, but also less painful.

5.3 Robustness Checks

5.3.1 A discrete macroprudential policy indicator

One of the advantages of the MaPPED database is that it allows macroprudential policies to be tracked over time, so that a different weight can be given to a policy that is implemented for the first time than to a subsequent recalibration of the policy. However, most of the macroprudential databases used in the literature do not allow for distinguishing between the type of policy actions. This means that most of the existing literature continues to use discrete variables that quantify the stance (sign) of the policy, but not the type (weight) of policy action. While this type of discrete indicator does not allow for quantifying macroprudential policy changes, it may be useful for capturing average effects.

[29]This result is consistent with Jordà *et al.* (2021). Focusing on capital requirements for a panel of 17 advances countries over the last 150 years, they find that a weaker capitalized financial sector is associated with a deeper recession and a slower recovery.

To connect the results to the existing literature on macroprudential policy, I transform the *mpp* index into a discrete three-value variable using the following criteria:

$$D_{i,t} = \begin{cases} 1 & \text{if} \quad \Delta mpp_{i,t} > 0 \\ 0 & \text{if} \quad \Delta mpp_{i,t} = 0 \\ -1 & \text{if} \quad \Delta mpp_{i,t} < 0 \end{cases} \tag{10}$$

Moreover, $D_{i,t}$ is also standardised for comparisons with the baseline results using the continuous index. The results with the discrete macroprudential policy index are qualitatively similar to the baseline results. The main difference between the three-value index specification and the continuous index comes from the monetary state-dependent results. In particular, using a discrete index definition, I find that the impact of macroprudential policy on crisis risk becomes smaller, conditional on the economy having accommodative monetary conditions. Nonetheless, regardless of the index specification, macroprudential policy is shown, overall, to be successful in defusing crisis risk over the medium term.

5.3.2 Additional robustness checks

– Anticipation effects: A potential threat to identification could come from the possibility that macroprudential policy shocks are partially anticipated. In this regard, Fernandez-Gallardo and Paya (2020) show that macroprudential policies, at least in the EMU, are partially anticipated by economic agents mainly through forward guidance. The partial anticipation of these policies could imply the incorrect identification of macroprudential shocks, as some of them may be "old news" from the point of view of economic agents. I increase the above specifications by adding up to 8 leads $\Delta mpp_{i,t}$ to control for this potential anticipation effects. In that way, I allow for those changes to have an effect up to 8 quarters prior to the announcement of the macroprudential policy. The choice of the number of leads is determined by the anticipation period identified by Fernandez-Gallardo and Paya (2020), who suggest that the anticipation period in the EMU, whose countries are the majority within my sample, is around 2 years prior to the announcement of the policy. After controlling for anticipation effects, the results barely change. This robustness exercise confirms that the identification of macroprudential policy shocks in the baseline specification was not contaminated by potential anticipation effects.

– A different definition of financial booms: In the baseline model I use a Hamilton filter to detect financial booms given the caveats associated with the Hodrick-Prescott (HP) (Hamilton, 2018; Schüler *et al.*, 2020). Despite this criticism, the HP filter still remains as one of the most used methods in the literature to separate trend and cyclical component from an economic variable. Moreover, it has been explicitly recommended by Basel III to estimate credit cycles (e.g., Drehmann and Yetman, 2018). Therefore, this robustness analysis aims to show that the state-dependent results regarding financial booms are not sensitive to the filter used. I use a one-sided HP-filter with a smoothing parameter, λ, equal to 1600 as is customary for quarterly data, to obtain the cyclical component. The main conclusion is that the results are qualitatively the same, regardless of the filter employed. First, I find almost no difference from the baseline specification with regard to the impulse response functions of real credit and real house prices after a +1std macroprudential policy shock. Second, regarding crisis risk, I still find that macroprudential policy is effective at reducing the frequency of financial crises, conditional on the economy being in a financial boom. The only difference is that when using the HP filter, I find that the impact of macroprudential policy on crisis probability takes longer to become statistically significant.

– Non-linearities: Another issue is whether the effect of macroprudential policies on financial crisis risk depends on the initial level of macroprudential regulation. If that were the case, the linear model used in the baseline might not correctly estimate the relationship between macroprudential policy and financial crisis risk. I expand the baseline model, adding a square in the narrative measure of the macroprudential policy index *mpp*, to explore this possibility. In particular, I estimate the following local projection:

$$C_{i,t+h} = \alpha_{i,h} + \beta_h \Delta mpp_{i,t} + \gamma_h \Delta mpp_{i,t}^2 + \sum_{l=1}^{L} \Gamma_{h,l} X_{i,t-l} + \sum_{l=1}^{L} \Phi_{h,l} C_{i,t-l} + \varepsilon_{i,t+h}, \quad (11)$$

With $\gamma_h < 0$ corresponding to the case where the impact on crisis risk of equal increases in the mpp decreases as the mpp increases; $\gamma_h > 0$ corresponds to the opposite case. I find that there is a negative point estimate of γ_h at most horizons, which suggests a decreasing return on the effect of macroprudential regulation on crisis risk.[30] Nonetheless, the average magnitude of γ_h is very small and non-significant. This implies that the baseline linear specification is sufficient to capture the effect of interest.

6 Conclusion

Does macroprudential policy reduce the likelihood of systemic financial crises? Does it make systemic financial crises less painful? This paper provides answers to these questions by using macroprudential policies and financial crises databases for 11 advanced economies over the last 30 years.

In particular, this paper shows that macroprudential policy is successful at defusing crisis risk. Moreover, this result holds even if macroprudential policy tightenings are implemented when the economy is already experiencing a financial boom or when monetary conditions are accommodative. This empirical finding lends support to the view that macroprudential policy should be the main tool employed by central banks to enhance financial stability. Moreover, the absence of interference from monetary policy, in turn, generates good expectations in a post-pandemic context where low interest rates and tightening financial conditions are expected to be part of the policy mix of monetary authorities in many advanced economies. In addition, the prevention and the mitigation of financial booms is suggested as an underlying mechanism as the main channel at work through which macroprudential policy makes financial crises less likely. This evidence is particularly of interest for macroprudential regulators, given that recent research has shown that financial booms and financial crises can be detected in real time (Richter *et al.*, 2021; Greenwood *et al.*, 2020; Fouliard *et al.*, 2021). Last but not least, I find that macroprudential policy enhances the resilience of the financial system to adverse economic shocks. In particular, I show that, all else being equal, a pre-crisis tighter macroprudential policy stance makes future systemic financial crises less painful. The latter result points

[30] This result is consistent with Alam *et al.* (2019) who focus on the impact of Loan-to-value (LTV) instruments on credit. Covering a shorter time period but exploiting a significant larger cross-section variability, they find that when LTV limits are already tight, the effects of additional tightening on credit is dampened.

to macroprudential policy not only being effective at reducing the frequency of systemic financial crises, but also at lessening the severity of such financial disasters.

I would end by noting that while the paper's main results are obtained using data from advanced economies, the policy implications may be useful as well to emerging market economies. In particular, since the macroprudential policy toolkit is similar in both developed and emerging countries, our findings indicate that prudential regulators in emerging economies can reduce the frequency of financial crises, regardless of the source of the crisis risk (e.g., crisis risk arising from foreign shocks), by tightening domestic financial regulation.

References

Adrian, T. and Liang, N. (2017) Monetary policy, financial conditions, and financial stability, *International Journal of Central Banking*, **14(1)**, 73–131.

Alam, Z., Alter, M. A., Eiseman, J., Gelos, M. R., Kang, M. H., Narita, M. M., Nier, E. and Wang, N. (2019) *Digging Deeper–Evidence on the Effects of Macroprudential Policies from a New Database*, 19/66, IMF Working Papers, 1.

Altavilla, C., Laeven, L. and Peydró, J.-L. (2020) Monetary and Macroprudential Policy Complementarities: Evidence from European credit registers, *ECB Working Paper No. 20202504.*

Baker, S. R., Bloom, N. and Davis, S. J. (2016) Measuring economic policy uncertainty, *The Quarterly Journal of Economics*, **131**, 1593–1636.

Benigno, G., Chen, H., Otrok, C., Rebucci, A. and Young, E. R. (2013) Financial crises and macro-prudential policies, *Journal of International Economics*, **89**, 453–470.

Bernanke, B. S. and Gertler, M. (2001) Should central banks respond to movements in asset prices?, *American Economic Review*, **91**, 253–257.

Bianchi, J. and Mendoza, E. G. (2018) Optimal time-consistent macroprudential policy, *Journal of Political Economy*, **126**, 588–634.

Bruno, V., Shim, I. and Shin, H. S. (2017) Comparative assessment of macroprudential policies, *Journal of Financial Stability*, **28**, 183–202.

Budnik, K. B. (2020) The effect of macroprudential policies on credit developments in Europe 1995-2017.

Budnik, K. B. and Kleibl, J. (2018) Macroprudential regulation in the European Union in 1995-2014: Introducing a new data set on policy actions of a macroprudential nature, *ECB Working Paper No 2123.*

Budnik, K. B. and Rünstler, G. (2020) Identifying svars from sparse narrative instruments: dynamic effects of us macroprudential policies, *ECB Working Paper No 2353.*

Canova, F. (2020) Should we trust cross sectional multiplier estimates?, *CEPR Discussion Papers 15330.*

Cerutti, E., Claessens, S. and Laeven, L. (2017) The use and effectiveness of macroprudential policies: New evidence, *Journal of Financial Stability*, **28**, 203–224.

Danielsson, J., Valenzuela, M. and Zer, I. (2018) Learning from history: Volatility and financial crises, *The Review of Financial Studies*, **31**, 2774–2805.

De Nicoló, M. G., Favara, G. and Ratnovski, M. L. (2012) *Externalities and macroprudential policy*, International Monetary Fund.

De Schryder, S. and Opitz, F. (2021) Macroprudential policy and its impact on the credit cycle, *Journal of Financial Stability*, **53**, 100818.

Drehmann, M. and Yetman, J. (2018) Why you should use the Hodrick-Prescott filter - at least to generate credit gaps, *BIS Working Paper No. 744.*

Duca, M. L. and Peltonen, T. A. (2013) Assessing systemic risks and predicting systemic events, *Journal of Banking & Finance*, **37**, 2183–2195.

Eickmeier, S., Kolb, B. and Prieto, E. (2018) Effects of bank capital requirement tightenings on inequality, *Deutsche Bundesbank Discussion Paper No. 54/2018.*

Federico, P., Vegh, C. A. and Vuletin, G. (2014) Reserve requirement policy over the business cycle, Tech. rep., National Bureau of economic research.

Fernandez-Gallardo, A. and Paya, I. (2020) Macroprudential policy in the euro area, *Working Papers 307121127, Lancaster University Management School, Economics Department.*

Fouliard, J., Howell, M. and Rey, H. (2021) Answering the queen: Machine learning and financial crises, Tech. rep., National Bureau of Economic Research.

Frankel, J. A. and Rose, A. K. (1996) Currency crashes in emerging markets: An empirical treatment, *Journal of international Economics*, **41**, 351–366.

Frost, J., Ito, H. and Van Stralen, R. (2020) The effectiveness of macroprudential policies and capital controls against volatile capital inflows.

Gertler, M., Kiyotaki, N. and Prestipino, A. (2020) Credit booms, financial crises, and macroprudential policy, *Review of Economic Dynamics*, **37**, S8–S33.

Gourinchas, P.-O. and Rey, H. (2019) Global real rates: A secular approach, *BIS Working Paper No. 793*.

Greenwood, R., Hanson, S. G., Shleifer, A. and Sørensen, J. A. (2020) Predictable financial crises, Tech. rep., National Bureau of Economic Research.

Hamilton, J. D. (2018) Why you should never use the Hodrick-Prescott filter, *Review of Economics and Statistics*, **100**, 831–843.

Hartwig, B., Meinerding, C. and Schüler, Y. (2021) Identifying indicators of systemic risk, *Journal of International Economics*, p. 103512.

Jordà, Ò. (2005) Estimation and inference of impulse responses by local projections, *American Economic Review*, **95**, 161–182.

Jordà, Ò., Richter, B., Schularick, M. and Taylor, A. M. (2021) Bank capital redux: solvency, liquidity, and crisis, *The Review of Economic Studies*, **88**, 260–286.

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

Jordà, Ò., Schularick, M. and Taylor, A. M. (2015) Betting the house, *Journal of International Economics*, **96**, S2–S18.

Kaminsky, G. L. and Reinhart, C. M. (1999) The twin crises: the causes of banking and balance-of-payments problems, *American Economic Review*, **89**, 473–500.

Kiley, M. T. (2020) The global equilibrium real interest rate: concepts, estimates, and challenges, *Annual Review of Financial Economics*, **12**, 305–326.

Kim, S. and Mehrotra, A. (2017) Managing price and financial stability objectives in inflation targeting economies in Asia and the Pacific, *Journal of Financial Stability*, **29**, 106–116.

Kim, S. and Mehrotra, A. (2018) Effects of monetary and macroprudential policies—evidence from four inflation targeting economies, *Journal of Money, Credit and Banking*, **50**, 967–992.

Laeven, L. and Valencia, F. (2013) Systemic banking crises database, *IMF Economic Review*, **61**, 225–270.

Lo Duca, M., Koban, A., Basten, M., Bengtsson, E., Klaus, B., Kusmierczyk, P., Lang, J. H., Detken, C. and Peltonen, T. A. (2017) A new database for financial crises in European countries: ECB/ESRB EU crises database, *ECB occasional paper.*

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

Maddaloni, A. and Peydró, J.-L. (2011) Bank risk-taking, securitization, supervision, and low interest rates: Evidence from the euro-area and the us lending standards, *The Review of Financial Studies*, **24**, 2121–2165.

Maddaloni, A. and Peydró, J.-L. (2013) Monetary policy, macroprudential policy and banking stability: evidence from the euro area, *ECB Working Paper No 1560.*

Meuleman, E. and Vander Vennet, R. (2020) Macroprudential policy and bank systemic risk, *Journal of Financial Stability*, **47**, 100724.

Montiel Olea, J. L. and Plagborg-Møller, M. (2021) Local projection inference is simpler and more robust than you think, *Econometrica*, **89**, 1789–1823.

Ramey, V. A. (2016) Macroeconomic shocks and their propagation, in *Handbook of macroeconomics*, Elsevier, vol. 2, pp. 71–162.

Reinhart, C. M. and Rogoff, K. S. (2008) This time is different: A panoramic view of eight centuries of financial crises, Tech. rep., National Bureau of Economic Research.

Reinhart, C. M. and Rogoff, K. S. (2009) The aftermath of financial crises, *American Economic Review*, **99**, 466–72.

Richter, B., Schularick, M. and Shim, I. (2019) The costs of macroprudential policy, *Journal of International Economics*, **118**, 263–282.

Richter, B., Schularick, M. and Wachtel, P. (2021) When to lean against the wind, *Journal of Money, Credit and Banking*, **53**, 5–39.

Rojas, D., Vegh, C. A. and Vuletin, G. (2020) The macroeconomic effects of macroprudential policy: Evidence from a narrative approach, Tech. rep., National Bureau of Economic Research.

Romer, C. D. and Romer, D. H. (2017) New evidence on the aftermath of financial crises in advanced countries, *American Economic Review*, **107**, 3072–3118.

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

Schularick, M., ter Steege, L. and Ward, F. (2021) Leaning against the wind and crisis risk, *American Economic Review: Insights*, **3**, 199–214.

Schüler, Y. S., Hiebert, P. P. and Peltonen, T. A. (2020) Financial cycles: Characterisation and real-time measurement, *Journal of International Money and Finance*, **100**, 102082.

Sufi, A. and Taylor, A. (2021) Financial crises: A survey, *NBER Working Paper 29155.*

Svensson, L. E. (2017) Cost-benefit analysis of leaning against the wind, *Journal of Monetary Economics*, **90**, 193–213.

Van der Ghote, A. (2021) Interactions and coordination between monetary and macroprudential policies, *American Economic Journal: Macroeconomics*, **13**, 1–34.

Vandenbussche, J., Vogel, U. and Detragiache, E. (2015) Macroprudential policies and housing prices: A new database and empirical evidence for Central, Eastern, and Southeastern Europe, *Journal of Money, Credit and Banking*, **47**, 343–377.

Ward, F. (2017) Spotting the danger zone: Forecasting financial crises with classification tree ensembles and many predictors, *Journal of Applied Econometrics*, **32**, 359–378.

Appendix A. Weighting scheme and financial crisis events

Table A1: Weighting scheme of a macroprudential policy tool

Type of Policy Action	Weight	Strengthening / Loosening	Sign	Final Weight
Activation	1	Tightening	+	1
		Other/ambiguous impact		0
		Loosening	-	-1
Change in the Level	0.25	Tightening	+	0.25
		Other/ambiguous impact		0
		Loosening	-	-0.25
Change in the Scope	0.10	Tightening	+	0.10
		Other/ambiguous impact		0
		Loosening	-	-0.10
Maintaning the Existing Level and Scope	0.05	Tightening	+	0.05
		Other/ambiguous impact		0
		Loosening	-	-0.05
Deactivation	Dependent on the life-cycle of the tool (cumulative index drops to zero)			

Notes: Description of the weights used to construct the cumulative index for each policy instrument based on Meuleman and Vander Vennet (2020).

Table A2: Financial crisis events: 1987-2017

Systemic Financial Crises	Residual Financial Crises
Belgium (2007-11)	Belgium (1990-08)
Germany (2001-01), (2007-08)	Germany (1992-07)
Denmark (1987-03), (2008-01)	-
France (1991-06), (2008-04)	France (2002-07), (2011-03)
Finland (1991-09)	Finland (2001-03), (2008-12)
Ireland (2008-09)	-
Italy (1991-09), (2011-08)	Italy (2008-01)
Netherlands (2008-01)	Netherlands (2002-06)
Spain (2009-03)	Spain (1993-09)
Sweden (1991-01), (2008-09)	Sweden (2000-10)
United Kingdom (1991-07), (2007-08)	-

Appendix B. Summary statistics and Sources

Table B1: Sources

Variables	Source
Gross Domestic product (GDP)	OECD database
Consumer Price Index (CPI)	Federal Bank Reserve of St.Louis (FRED)
Total Credit to the Private Non-Financial Sector	Bank for International Settlements (BIS)
House Prices	Bank for International Settlements (BIS)
Stock Prices	Federal Bank Reserve of St.Louis (FRED)
Economic Policy Uncertainty (EPU)	https://www.policyuncertainty.com
Financial Crises	ECB/ESRB EU crises database
Macroprudential Policy Index (*mpp*)	Authors' estimation using MaPPED database
Government bonds 10 years	International Financial Statistics (IFS)
3-Month or 90-day Rates and Yields: Interbank Rates	IFS + FRED
Euro Interbank Offered Rate (EONIA)	Statistical Data Warehouse

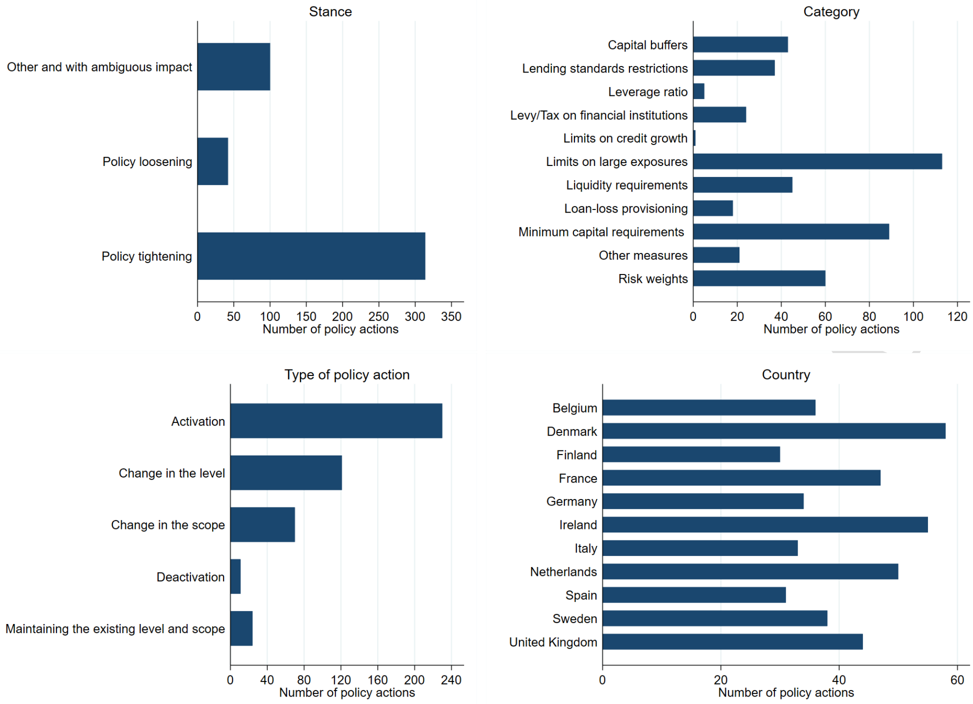

Figure B1: Number of policy actions by stance, category, type and country.

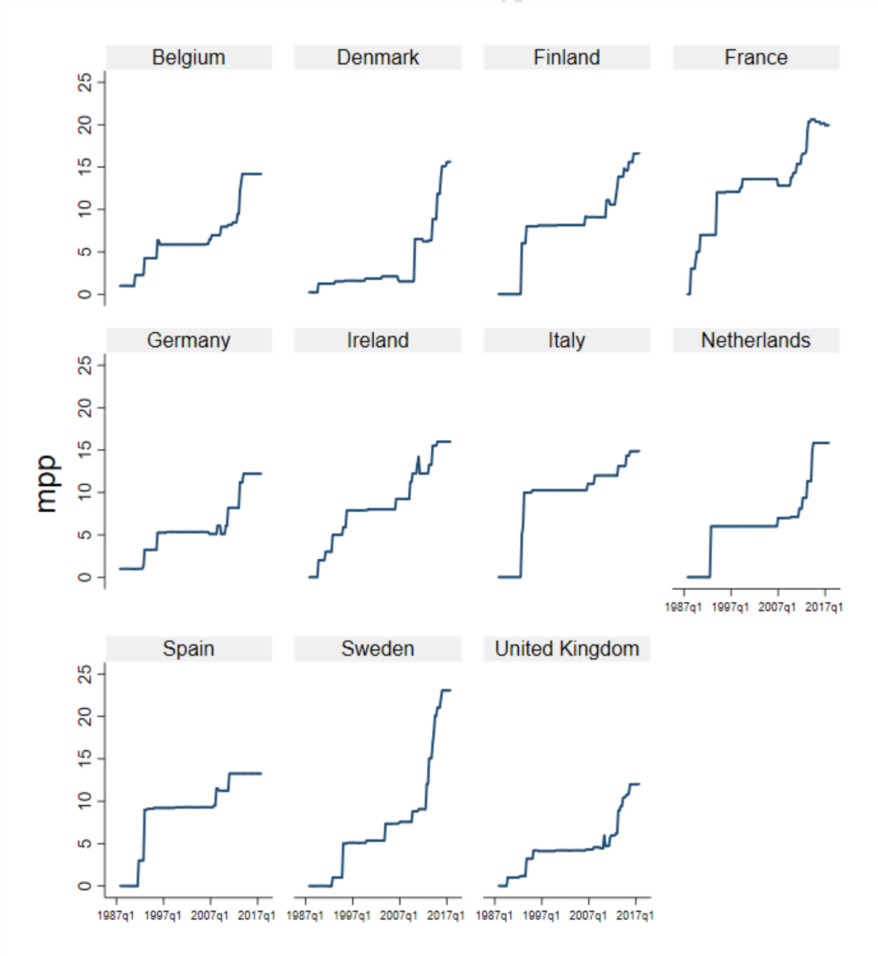

Figure B2: Macroprudential Policy Index (*mpp*). This figure plots the *mpp* over time for each country in the sample.

Appendix C. Additional Sensitivity Checks

In this Appendix, I explain in greater detail the reasons for which, after identifying narrative macroprudential shocks, an inverse probability weighting (IPW) framework within my empirical setting is not necessary. In addition, this appendix also reports results from the robustness section of the paper.

Appendix C1. An Inverse Probability Weighting Framework

An alternative approach that has also been used to obtain macroprudential policy exogenous variations relies on propensity score methods (e.g., Richter *et al.*, 2019, Alam *et al.*, 2019 or Frost *et al.*, 2020). The inverse probability weighting (IPW) estimation uses a two-step approach in which a larger weight is given to policy changes that are difficult to predict based on a set of economic variables. In particular, the predictability of policy changes comes from a first stage in which policy variations are regressed on a set of predictors. Such a framework, therefore, is only useful when macroprudential policy changes can be foreseen and the selected predictors contain information on future policy changes.

In order to reassure that the narrative identification performed in this paper has been successful at the time of identifying prudential shocks, I here run the first stage regression of the IPW framework, showing that the predictors do not have forecasting ability over tightening macroprudential regulation implementations. Note that this conclusion is consistent with the empirical evidence shown in Table 3 of Section 4.

In particular, I proceed as follows. First, I define an indicator variable for tightening macroprudential actions, to be used as the dependent variable in the first stage regression:

$$D_{i,t} = \begin{cases} 1 & \text{if} \quad \Delta mpp_{i,t} > 0 \\ 0 & \text{otherwise} \end{cases} \tag{12}$$

Second, I run the first stage regression of the IPW approach:

$$Prob(D_{it} = 1|\alpha_i, X_{it}) = \Phi\left(\alpha_i + \beta X_{it}\right), \tag{13}$$

where $D_{i,t}$ is a dummy variable as defined above and α_i are country fixed-effects. This model estimates the probability of a tightening regulation occurring in a country i, in a quarter t, as a function of predictors X. For the first stage, I consider two specifications.

Table C1.1: First Stage, Inverse Propensity Score Framework

Dependent variable: $D_{it} = 1$	With just country fixed effects	With country fixed effects and all predictors
Annual real GDP growth$_{t-1}$	-	0.055
		(0.128)
Annual inflation growth$_{t-1}$	-	-0.079
		(0.565)
Short term rate$_{t-1}$	-	0.003
		(0.011)
Long term rate$_{t-1}$	-	0.026
		(0.021)
Annual stock-price growth$_{t-1}$	-	-0.013
		(0.033)
Annual house-price growth$_{t-1}$	-	-0.082
		(0.233)
Annual total credit growth$_{t-1}$	-	0.006
		(0.043)
AUC	0.606	0.616
s.e.	0.025	0.025
Observations	1331	1319

Notes: This table tests the predictability of tightening macroprudential policy implementations. Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

I only include country fixed effects in the first specification. That is, apart from country fixed effects, no regressors are included to forecast tightening macroprudential policy implementations. This specification is used as our benchmark model to test whether there is additional gain from including economic and financial variables to predict macroprudential policy changes. In the second specification, the dummy is regressed on one-period lagged annual real GDP growth, annual CPI inflation, annual real total credit growth, annual real house-price growth, annual real stock-price growth, changes in the short-term and long-term interest rates. I then compute the associated AUC to each estimation to compare both specifications. The AUC is a statistic that takes value 1 for perfect prediction ability and 0.5 for total unpredictability or 'coin toss'. Moreover, it has a normal asymptotic distribution in large samples, making inference straightforward. As mentioned above, I use the AUC from the model with only fixed-effects as the null or benchmark value to measure whether there is added value from including the aforementioned economic and financial variables to predict macroprudential policy changes.

The results are shown in Table C1.1. The reported AUC with just country fixed effects is 0.606 (s.e. 0.025). Instead, the AUC takes value 0.616 in the specification that also includes all the predictors at the same time. Therefore, both AUCs (with and without predictors) are statistically the same (the null cannot be rejected even at the 10% level), meaning that the economic and financial predictors described above do not have prediction ability over the narrative policy shocks identified in the paper. This result further supports that the narrative identification performed in our empirical setting has been successful at the time of identifying prudential shocks and that, therefore, an IPW approach is not necessary within our framework.

Appendix C2. Other Sensitivity Checks

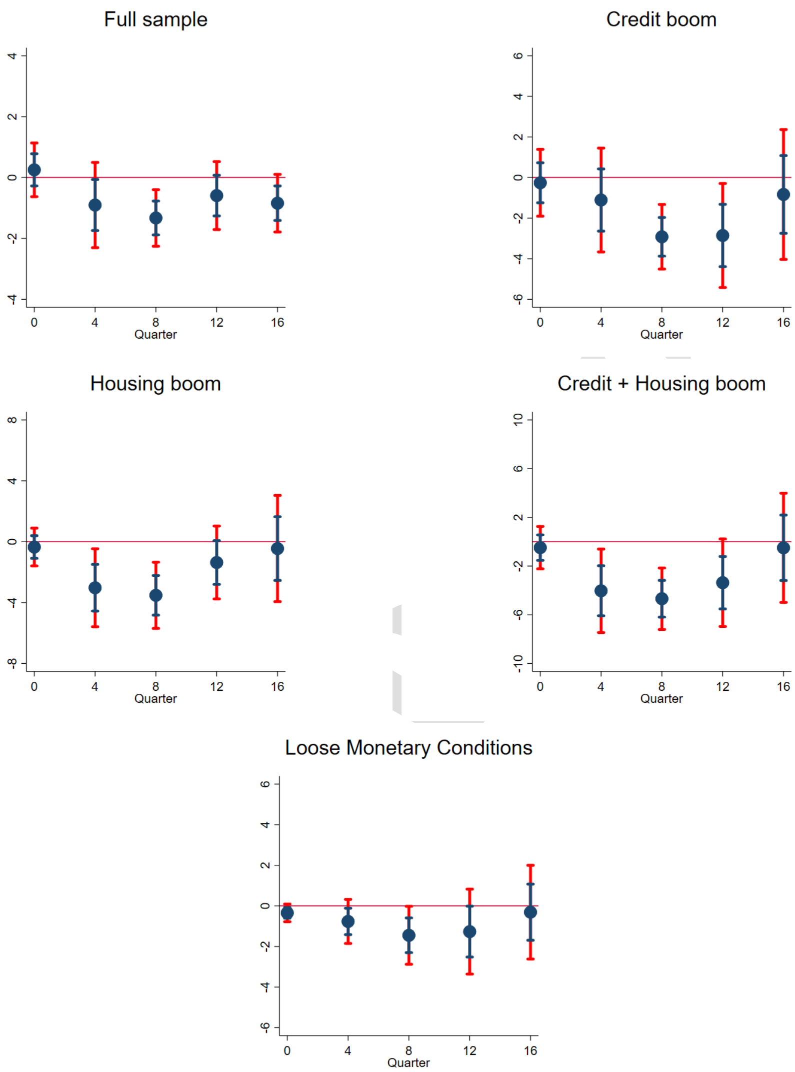

Figure C2.1: Three-value dummy specification. This figure displays the change in the two-year crisis probability following a macroprudential policy shock. Horizons, $h = 0, 4, 8, 12, 16$. 90% (red line) and 68% (blue line) confidence bands are displayed.

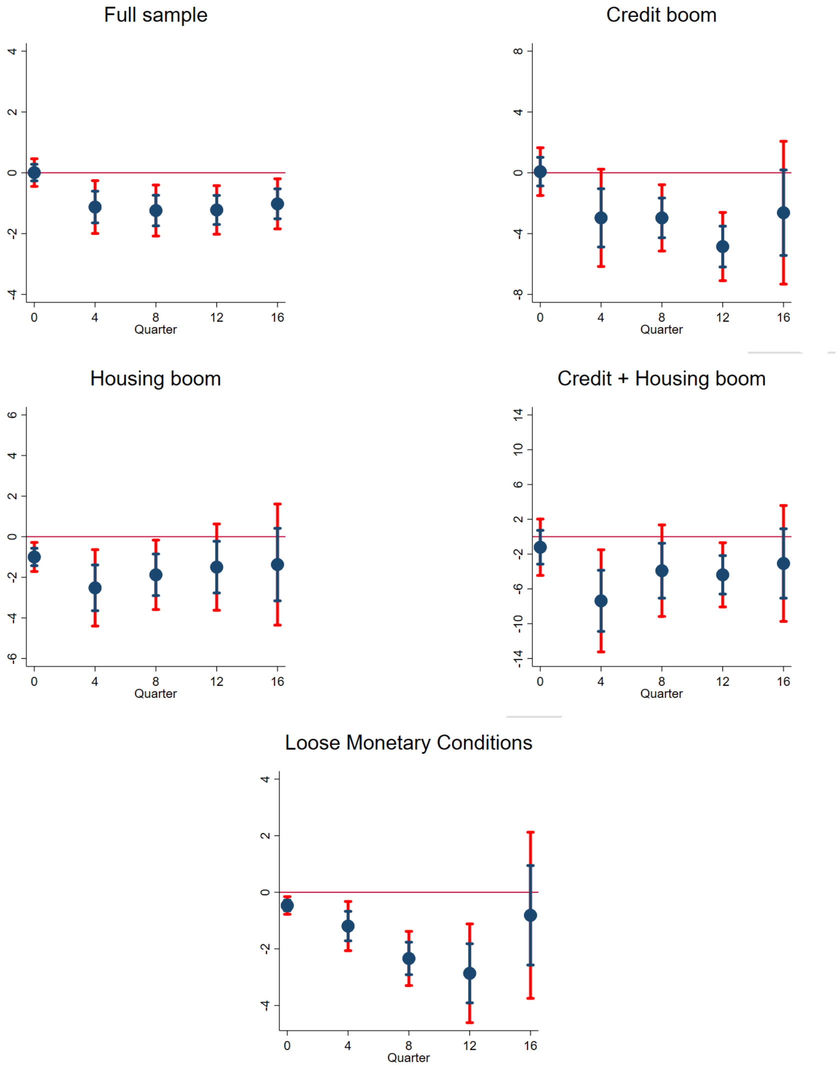

Figure C2.2: Anticipation effects. This figure displays the change in the two-year crisis probability following a macroprudential policy shock. Horizons, $h = 0, 4, 8, 12, 16$. 90% (red line) and 68% (blue line) confidence bands are displayed.

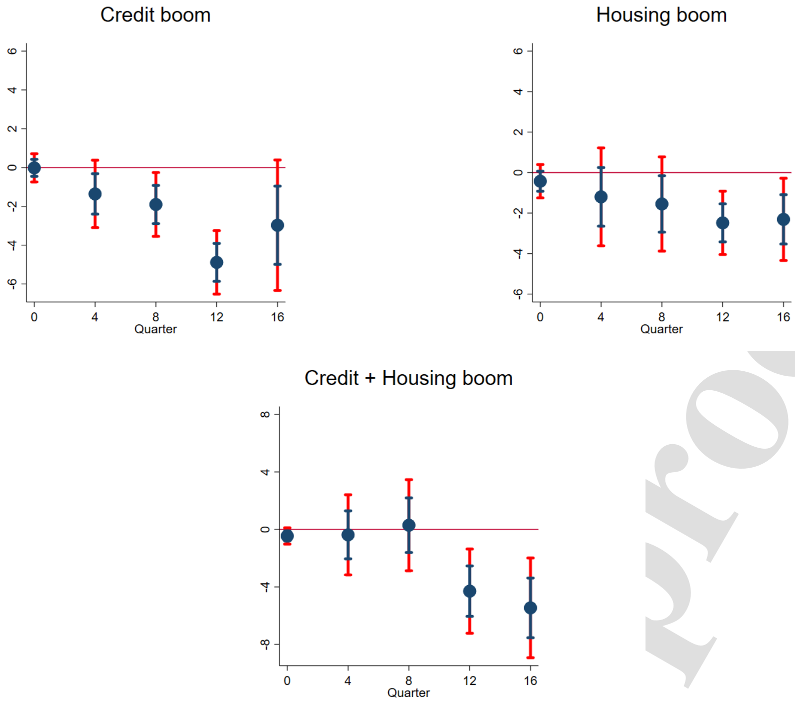

Figure C2.3: One-sided HP filter. This figure displays the change in the two-year crisis probability following a macroprudential policy shock during booms. Horizons, $h = 0, 4, 8, 12, 16$. 90% (red line) and 68% (blue line) confidence bands are displayed.

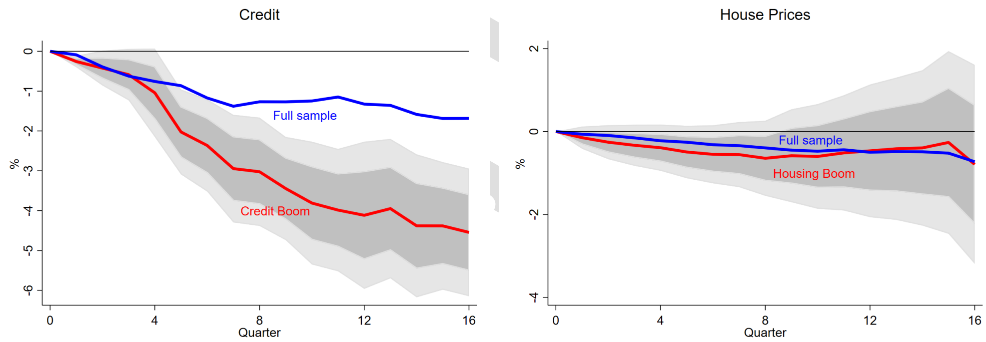

Figure C2.4: One-sided HP filter. Impulse response function to a +1 std macropruential policy shock. 90% (light grey) and 68% (dark grey) confidence bands for booms are displayed.

Appendix D. Individual Policy Instrument Analysis on Crisis Risk

In this Appendix, I aim to explore which categories drive the baseline results on crisis risk, from the 11 different macroprudential policy tools (or instruments) in which MaPPED classified macroprudential policy actions.

I repeat the steps detailed in Subsection 2.1 without performing the last step: adding up the indices of all the policy instruments implemented within a particular country. Therefore, I obtain a cumulative macroprudential policy index for each of the 11 categories per country in my sample. There is an empirical limitation, though. In particular, some categories have very few observations, making it unfeasible to perform an individual analysis in those cases. To overcome this issue, I group the five categories with the lowest observations into a single category labelled other policies. I then run the baseline regression on crisis risk using each one of the six categories with the highest number of observations and the *new* category labelled as other policies. All categories are placed at the same time into the regression to control for the effect of other types of measures introduced simultaneously. The six categories with the highest number of observations are: capital buffers, minimum capital requirements, exposure limits, lending standards, liquidity rules and risk weights. The five categories with the lowest number of observations, which are grouped into the category other policies, are: levy/tax on financial institutions, limits on credit growth, loan loss provisions, leverage ratio and other measures.

Figure D1 presents the main results from running the baseline regression on crisis risk for each of the categories detailed above. There are three points worth noting. First, I note that using an individual macroprudential policy index per tool implies lower variation, and therefore confidence intervals become very large at some horizons. Second, I also note that, in general, most of the categories in which MaPPED classified prudential instruments are effective at reducing the frequency of financial crises. Third, there is, however, some heterogeneity in the horizon at which they have an impact on crisis risk. In particular, while a prudential tool such as limit exposures, for instance, seems to have an effect particularly over the short- to medium-term, other tools such as capital requirements seem to be particularly effective to defuse crisis risk over the medium- to long-term. While such heterogeneity can be explained by different implementation lags or different transmission mechanisms of each type of instrument, this finding supports the idea of different prudential tools acting as complements at the time of addressing crisis risk.

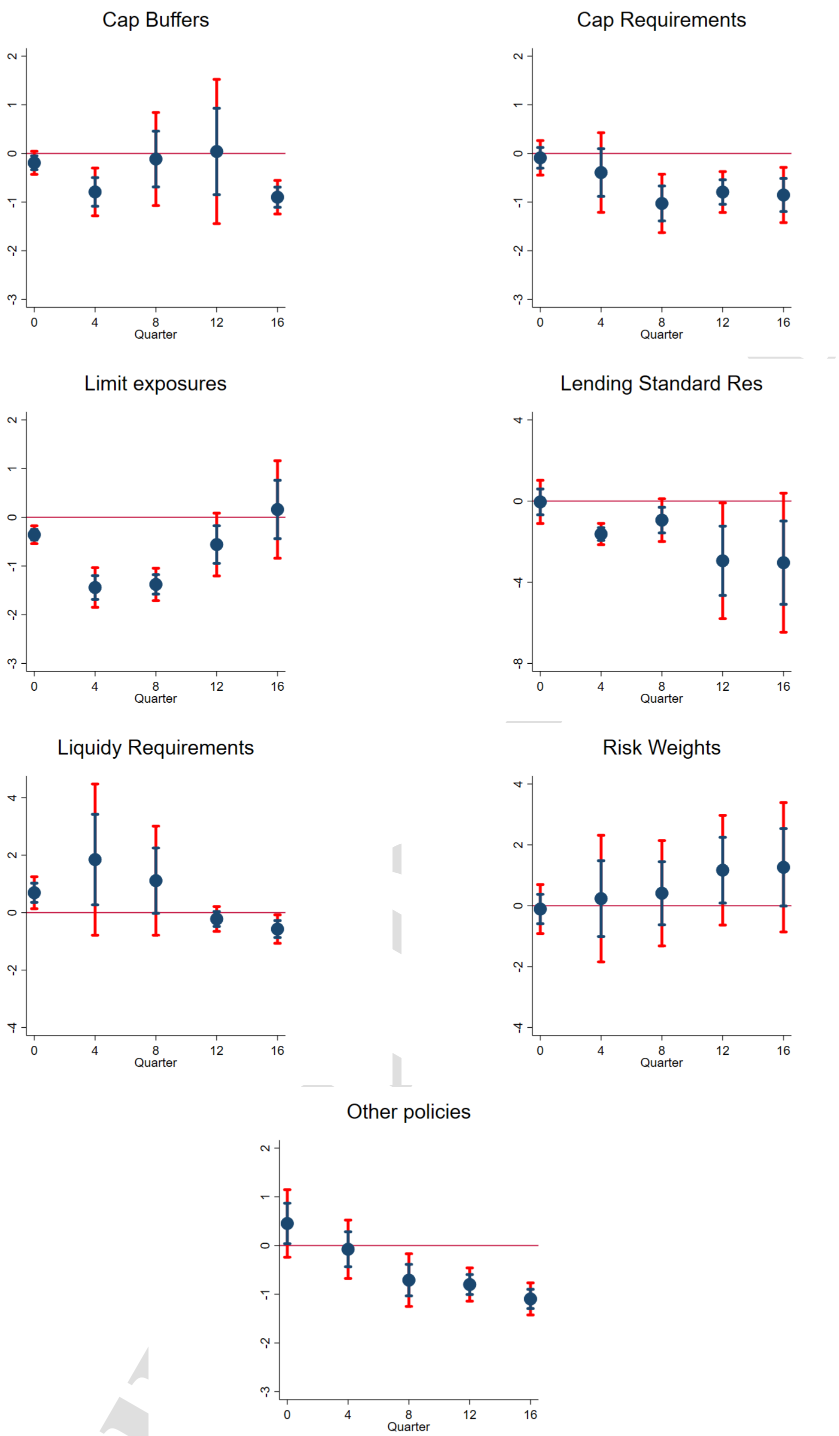

Figure D1: Crisis risk results using individual policy tools (7 categories). This figure displays the change in the two-year crisis probability following a macroprudential policy shock during booms. Horizons, $h = 0, 4, 8, 12, 16$. 90% (red line) and 68% (blue line) confidence bands are displayed.