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Growth-at-risk for macroprudential policy stance assessment: a survey

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Abstract

This is a survey of the literature on Growth-at-Risk (GaR) for macroprudential policy stance assessment. After acknowledging the main findings and contributions, we focus on the current challenges that are present in the literature. Key challenges are the measurement and intensity of the policy variable, and the mitigation of endogeneity issues. We suggest improvements on ways to measure the policy itself and its intensity, review policy endogeneity adjustment and different sources of data. Finally, we conclude the review providing insights on future pathways of GaR macroprudential methodology.

Key words: Systemic risk, financial conditions, quantile regression, policy assessment, policy stance.

JEL classification: C22, E32, E44, E58, G01, G28.

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1: INTRODUCTION

How effective is macroprudential policy (MP) and how to measure its stance? Measuring the size and effectiveness of monetary and fiscal policies has been heavily studied for several decades. Compared to them, macroprudential policy is still relatively new and much more work needs to be done to identify and evaluate its transmission channels (ESRB, 2021). Other reasons why we still do not have a consensus on the starting question here is that there exists a high degree of uncertainty surrounding the policy itself (Buch et al., 2018[1]), as the causal effects of MP have not yet been fully explored (due to data unavailability and definitions), the cost-benefit analysis being difficult to provide due to possible leakages of MP effects to other parts of the financial system, difficultness of quantifying financial stability (FS) risks in the first place, and general uncertainty of MP instruments due to their volatile model relationship with FS goals. Central banks define the macroprudential policy stance itself differently, as seen in survey of Arslan and Upper (2017): it could be observed as an unconditional definition (in monetary policy it would mean looking at the level of interest rates) or as a conditional one (again, in monetary policy it would mean looking at deviations from the neutral interest rates). Also, it is difficult to summarize multiple and often different instruments into one measure. Moreover, two thirds of central banks do not have a defined quantitative goal of financial stability as shown by Villar's (2017) survey.

One of the goals of MP is therefore to reduce the probability of a future financial crisis, and its spillover to the real sector, as financial crises are costly (see empirical findings of Jordá et al., 2013; Reinhart and Rogoff, 2009, Laeven and Valencia, 2012, 2013[2]). Reducing systemic risk in the financial system could result with a lower probability of a future financial crisis, alongside increasing the financial system's resilience (Sánchez and Röhn, 2016).

"At-risk" methodology has gained much attention in the last couple of years, both for policy purposes such as estimation inflation-at-risk in López-Salido and Loria (2021), bank capital-at-risk in Lang and Forletta (2019, 2020), house-price-at-risk in Deghi et al. (2020), Škrinjarić and Sabol (2023, 2024), and other general risk tracking such as unemployment-at-risk in Adams et al. (2020), capital flows-at-risk in Eguren-Martin et al. (2021) or Gelos et al. (2022), or labour-at-risk in Botehlo et al. (2023). It is not

[1] Authors try to draw parallel lines between monetary policy and MP, to learn from the experiences we already have in monetary policy conduct, which can be useful to employ in the case of MP.

[2] Interested readers on the topic of effects of financial crises on real economy can also read Papell and Prudan (2011), Claessens et al. (2012), Jordá et al. (2012), or Koh et al. (2020).

surprising, as this methodology enables us to track downside risks of many important variables, both for monetary and macroprudential policies.

Growth-at-Risk (GaR[3]) has been developed as a concept to measure the effectiveness of MP and its stance, by relating financial stability and MP instruments to the real economy. GaR links current macro-financial conditions in the economy with future GDP growth across its entire distribution. It has direct interpretability for policymakers[4], and it can be directly linked to the MP definition (see Prasad et al., 2019). The concept of GaR for measuring MP stance helps to identify the intertemporal trade-off of tightening or loosening of the policy itself, by comparing the "benefits" of MP in limiting extreme negative realisations of future growth to the "costs" of limiting other parts of the distribution of future growth (better realisations). GaR has an intuitive interpretation as it is in the same units as GDP growth, making it easier to relate to the economy's overall performance. Empirical research utilizes this approach to estimate the overall effects of MP on future economic growth, and to discuss the stance of the policy itself: we can talk about tighter or looser policy stance depending on the MP effects on the extreme negative realisations of future GDP growth versus the average ones. Thus, GaR captures the balance between policy instruments that have been applied and the financial stability objectives.

The goal of this survey is to identify what has been done so far in this area, synthetize the results of the literature, extract important messages, and lay some ground information and recommendations for future work. The results of this survey can be helpful for policymakers. After reviewing the main findings of the macroprudential stance within the GaR setting, we comment on the main challenges so far: there is still a lack of consensus on defining the macroprudential policy variable that is used in empirical studies, and this needs to be resolved. Then, the endogeneity of the policy variable itself is still not addressed adequately, as only a couple of papers tackle this issue. Intensity of the policy itself is another challenge to be solved. In the current setting, analyses actually apply what is called the frequency of the measures, and not the intensity. There is also heterogeneity of other relevant variable definitions in the literature, which disables comparison purposes.

[3] The first paper to coin and define the term Growth-at-Risk is Wang and Yao (2001), however, Adrian et al. (2019) popularised the term recently.

[4] Central banks are already publishing this concept regularly in their financial stability reports (Bank of Japan, 2019; Banque centrale du Luxembourg, 2022; Deutsche Bundesbank, 2018; Central Bank of Ireland, 2022; ECB, 2019), regular IMF reports (e.g., see IMF, 2017 for earliest applications, or IMF 2022 for latest), ECB reports (ECB, 2019), and regular risk identification (see Banco de España, 2021).

Although there exist many introductory papers on the topic of GaR modelling, a comprehensive and a systematic overview of measuring macroprudential policy stance - with a focus on the GaR as a main measurement approach – does not exist. Most of the existing literature introduces the methodology of "at-risk" modelling via empirical applications in which results from seminal GaR papers are replicated on a panel of countries or country-specific analyses. Here, we synthetise these findings to find best practices for future work. Providing solutions to existing challenges highlighted in this paper gives a good starting point to obtain a coherent framework of macroprudential policy stance assessment, reduces policy inaction bias, and enhances the communication with the public.

The rest of the paper is structured as follows. The second section gives a brief background on general GaR modelling and refers interested readers to the seminal papers. In the third section, we review the main findings of the work that explicitly models macroprudential stance within the GaR setting. In order to identify challenges in the literature, we dissect them in the fourth section, which investigates the problems of measuring the policy variable, defining its intensity, dealing with endogeneity, incorporating Covid-19 effects, and other interesting challenges. Thus, sections four and five describe what is the current setting and issues with the macroprudential policy variable and the methodology, what has been done so far, and what can be done in future work to solve these challenges. Afterwards, section six closes the survey with general conclusions on what have we learnt from reading all these studies.

2: BACKGROUND

2.1. Getting up to speed

Introduction of the "at-risk" framework to measure macroprudential policy stance started out on the basis of two aligning areas of policy work. One was enhancing the forecasts of future GDP growth beyond simple approaches and instead focusing on downside risks of future growth alongside including specific macro-financial conditions (Adrian et al., 2019). As policymakers are more interested in bad realisations of future GDP growth compared to good ones, Adrian et al. (2019) examined the possibility of forecasting the entire distribution with help of additional financial conditions that have not been used before. The other area examines the predictability of financial crisis based on financial vulnerabilities indicators, as they reflect information about the financial cycle (Boyarchenko et al., 2022a), and financial crises having profound effects on future growth. Thus, Boyarchenko et al. (2022a) examined different potential candidate variables that could be used to evaluate their ability to forecast economic downturn.

Most common way to estimate GaR is to use quantile regression approach (Koenker, 2005; Davino et al., 2013, Koenker and Bassett, 1987), as it enables the researcher to estimate the effects of explanatory variables at different parts of the growth distribution. A special focus is paid to the left-tail ("at-risk" growth rate) of the distribution (i.e., the GaR value), which is the lower (5th or 10th) percentile growth rate reflecting the notion of sudden downturns in GDP dynamics that impose the significant financial stability risk.

GaR research has been extended subsequently by linking macro-financial conditions to the future dynamics of economic growth[5]. The results from those analyses are now considered as stylized facts about macro-financial linkages: systemic risk measures (like Covar, MES, SRISK, etc.) can enhance short-term GDP growth forecasts (Giglio et al., 2015, 2016); deteriorating financial conditions are related to a decrease in future average GDP growth with low upside "risks" regardless of today's financial conditions (Adrian et al., 2016, 2019); it is important to extend the GaR approach with measures of financial vulnerabilities for medium term forecasts as well (Aikman et al.,

[5] Besides the works that are examined below, it is worth mentioning other preceding research that link financial conditions and financial vulnerabilities to the real economy. A comprehensive overview is given in Boyarchenko et al. (2022a) and Škrinjarić (2022, 2023a).

2018), as these measures were heavily explored to affect future GDP growth[6]; and there exists a term structure of effects of explanatory variables on future growth (Adrian et al., 2018, 2022), i.e. effects on the future GDP growth differ not only with respect to the part of the growth distribution, but also with respect to short versus medium-term.

2.2. Extending the approach

Subsequently, the literature included different variations of financial vulnerability indicators in the analysis, as MP tracks and obtains more helpful information about their medium-term predictive power of possible future risk materialization, as explored in Kygier and Vasi, (2021, 2022), and Plagborg-Møller et al. (2020). Others examined various definitions and transformations of variables used in the analysis for financial conditions in the model, as in Alessandri et al. (2019); measures of economic uncertainty in Busetti et al. (2020); national income instead of GDP in O'Brien and Wosser (2021). Some even focused on constructing a horse rase between different indicators that can be used in the GaR setting, such as Lang et al. (2023).

Some approaches played around with the GaR methodology and its extensions: different approaches to final GDP growth distribution fitting in Chicana and Nivin (2021); measures of downside and upside risks, entropy and other probabilities measures in De Lorenzo Buratta et al. (2022); comparing different methodological approaches to estimate the GaR value itself as in Brownlees and Souza (2021), and Kipriyanov (2022); or evaluating different measures of financial conditions and different methodological approaches to estimation, as in Szendrei and Varga (2023). Furthermore, as Hodula et al. (2023) show that countries with higher levels of specific structural risks have important role in explaining the severity of credit risk materialization and a stronger role of macroprudential policy, some papers try to deal with this fact, as found in O'Brien and Wosser (2022), and Gächter et al. (2022). Readers that are getting introduced to the concepts of this survey are referred to Tables A1 and A2 in the Appendix of this survey. They summarize the main findings and characteristics of the initial group of research to understand the concept of GaR and its purpose, whereas table A3 gives a summary on macroprudential policy stance from the theoretical point of view. Finally, a review of other related studies is given in Poghosyan (2020).

[6] Firstly, the ultimate objective of macroprudential policy is stability of the financial system, by increasing its resilience, taming the build-up of vulnerabilities in the system and smoothing out the financial cycle, which should ultimately contribute to economic growth (ESRB, 2021).

2.3. GaR and stress testing

Popularity of GaR approach has spilled over into stress testing (ST) as well. Currently, the ECB and IMF have particular approaches of using GaR within ST framework. We discuss most interesting outcomes in this section.

Although the GaR framework is now almost fully embedded in the IMF stress testing approach (see Ding et al., 2022; Adrian et al., 2020), it is used for scenario calibration purposes, and not for the MP stance evaluation. The basic idea is to utilize quantile regression (QR) to forecast different parts of the future GDP growth distribution, and to evaluate the probabilities of those realisations. These results are used in the scenario development phase, in order to check the plausibility of variable paths. It is expected that the approach will be extended on other relevant macro-financial variables, and to evaluate the MP stance in the future.

We observe an increasing number of ECB publications that utilize the GaR methodology. There exist a couple of initial studies that developed the models that are subsequently used in later work: White et al. (2015a, b) is one the first papers to introduce a multivariate approach to modelling quantile regression. The authors were motivated to develop a framework that could capture the interdependence between the tails of the distributions between all variables in the model. A multivariate quantile regression model is developed, with quasi-impulse response functions at each quantile. The quasi term means that such IRFs cannot be obtained as done within a linear VAR model. Instead, it is assumed that some intervention is done on one variable in the system at some point. Then, the effects of this intervention are observed to estimate quasi-IRFs. The application of this paper was not focused on the issues of GDP growth and financial conditions, but it provided the basis for the empirical work that followed.

Chavleishvili and Manganelli (2019/2020) and Chavleishvili et al. (2021a and b) are studies that are the multivariate counterpart to the seminal Adrian et al. (2016, 2019) papers. In the first paper, GaR is embedded in the broader literature of macroprudential policy, with a proposition of establishing a risk management framework. The second one provides technical details on the estimation approach used in the first. Authors developed a structural QVAR (quantile vector autoregression) model and applied it in a bivariate setting of an index of industrial production and financial stress indicator. Although MP variable was not included, the paper provided how basic stress testing simulations can be done within the setting, with counterfactual analysis, as this will become important for the papers that include MP subsequently.

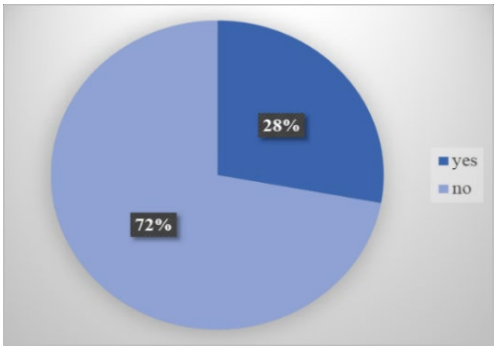
Later ECB papers incorporated GaR into BEAST (Banking euro area Stress Test). One application is found in Budnik et al. (2021), where the impact of Basel III finalisation in the euro area is observed. The model includes over 90 banks in 19-euro area economies, and the costs and benefits of Basel reforms are contrasted. Findings show that although short-term costs exist in lower average growth and reduced credit dynamics, they are outweighed by GaR benefits in the long term. Boucherie et al. (2022) focused more on the macroprudential policy stance assessment. Besides estimating GaR, lending-at-risk (LaR) is also examined due to the rich data structure of the ECB modelling approach. The authors found that the macroprudential policy stance tightened before 2019, which was interrupted during the Covid-19 crisis. Afterward in 2021, the stance was tighter again. Since the model is nested within the BEAST framework, it also tracks the interaction between monetary and macroprudential policies. We expect that in future, more empirical ECB studies that use the multivariate approach of evaluating macroprudential policy stance will emerge.

2.4. Papers in focus of this survey

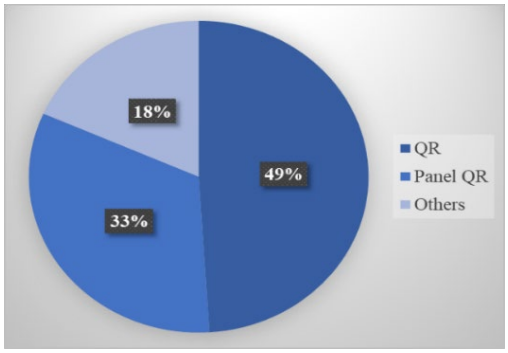
As this survey focuses on papers that try to measure MP stance, the rest of this review will focus on those that include macroprudential policy as a variable in the analysis. Papers that do so are currently scarce. Reasoning is found in data unavailability, as majority of economies introduced MP measures more formally after GFC. Moreover, in many cases the infrequent number and adjustment of the measures also contributes to the lack of studies that utilize MP variable.

Figure 1: Basic structure of literature

Panel A: Macroprudential policy included?



Panel B: Type of analysis



By reading majority of the papers important for this study, we realized that only ~28% of them actually include MP variable in the analysis in order to evaluate the policy

stance (Figure 1, panel a), of which half are a single country analysis (QR – quantile regression, Figure 1, panel b), whereas the other half refers to panel quantile regression and other approaches that included the policy variable, but did not have the GaR approach. In the rest of the paper, we focus on the GaR approach, whereas the "other" approaches in panel b of Figure 1 are summarized in Table A2 in the Appendix.

3: MAIN FINDINGS ON MACROPRUDENTIAL POLICY STANCE

In this section we examine main findings of GaR papers that evaluate the MP stance, to understand the current state of the literature, and to identify the main challenges. Natural grouping of papers emerged in the following order. Several papers extended the original approach of Adrian et al. (2016) by including capital requirements as an additional variable in the analysis. Afterwards, research started to use the full macroprudential policy index as an indicator of the policy itself, both within a single-country and panel setting. Another stream started to compare the effects of capital-based measures (CBM) to the borrower-based ones (BBM). Part of the literature[7] has shown that it is important to observe interactions of monetary and macroprudential policies, so there already exist several papers that try to incorporate this in in the analysis. We give an overview of these papers, with focusing on some of the main results. Challenges of these papers are then discussed in section 4.

3.1. Capital requirements

The primary indicator used to measure macroprudential policy stance is a form of an index (see section 4.1. for details). However, there exist some exceptions, in which authors focus on a narrower set of tools related to capital requirements. Since the regulators prescribed this tool to increase capital adequacy of the banking systems, it can be observed as an individual macroprudential policy measure, and when looking into formal MP tool databases, it is included in the formal index as an individual tool. Thus, it makes sense to observe capital requirement (ratio) as a (partial) MP indicator. After GFC, this was one of the main instruments to increase the resilience of financial systems in many countries. Capital ratio as a variable has been used in Aikman et al. (2019 a, b), Lloyd et al. (2022, 2023), and Boyarchenko et al. (2022b), however authors call it a measure of resilience instead of a policy tool. We could say that the resilience of the system is a consequence of increasing capital requirements. Although, it is not easy to disentangle the resilience of the system, as it depends on macro and microprudential capital requirements, and the management/preferences of individual credit institutions (see ESRB, 2021).

Aikman et al. (2019 a, b) included different variables of medium-term vulnerabilities in the financial system in their analysis, to evaluate growth predictability. Besides the usual macro-financial conditions that are used in GaR forecasting, capital requirements dynamics is included as a somewhat indicator of resilience of the financial system. Main results of this research indicate that greater capital requirements led to a 0.9 p.p. cumulative improvement of the GDP-at-risk over three

[7] See IMF (2013) or Revelo and Levieuge (2022) for more details.

years. This prompted the authors to make a CCyB (countercyclical capital buffer) simulation as an example of increasing the capital requirements before GFC hit. Not surprisingly, the results showed that having such requirements in the pre-GFC setting would offset the GDP-at-risk significantly. We could generalise these findings such that if macroprudential policy imposes higher capital requirements in the system, the resulting MP stance would be tightened, as it can positively affect the future GaR values. This is called a macroprudential intervention in the paper itself.

Lloyd et al. (2022, 2023) focus on the importance of foreign factors that contribute to the analysis (focusing on advanced economies) and find that foreign vulnerabilities significantly and robustly affect the conditional distribution of future domestic GDP growth, even after controlling for domestic indicators. The authors have included the capital ratio as a measure of the resilience of the banking system. Higher the ratio, lower is the one quarter ahead GaR forecast, which is similar to the aforementioned study. Boyarchenko et al. (2022) also talk about higher capital ratios representing increased resilience and found that that higher capital ratio growth significantly and sharply reduces the likelihood of the worst outcomes for the credit growth and financial conditions. Regarding the impact on future GaR, authors found a further direct impact of capital ratio growth on top of what authors call indirect impact through credit growth and financial conditions. No relationship was found for the median growth, which authors explain by several reasons: banks are not the only providers of credit to the real economy, not all banks increase or decrease capital at the same time, and banks do not have to sacrifice credit provision to the economy when building capital, as they built it during economic expansion so they can use capital growth for this purpose.

Several things to note here are the fact that these analyses include the post-GFC period where the capital requirements were increasing. There is lack of research how decrease of requirements would affect the future growth. In the future, one could draw from the literature that observed how cutting the CCyB rate during the COVID-19 crisis affected lending (see Mathur et al., 2023, or Couaillier et al., 2024) and include this period in the analysis as well. However, there are some challenges when including the pandemic period (see section 4.4.).

3.2. Full macroprudential policy indicator

Capital requirements are not the only tool macroprudential policy can use, other tools include LTV (loan to value) limits, limits to credit growth, and many more (17 categories in total in Alam et al., 2019). There have been several attempts to collate all of the tools across countries and time (see section 4.1.) and now research has several comprehensive databases of MP tools from which a full macroprudential policy

indicator is derived and used to measure the MP stance. Majority of papers utilize a full MPI (macroprudential policy index/indicator) variable in the empirical analysis. This means that all of the tools that had macroprudential character are used to construct MPI. Reason is simple: majority of tools individually do not have enough datapoints to pursue the analysis, even at a panel-based approach. Thus, the easiest way is to talk about all of the tools and instrument MP can apply in order to evaluate the effectiveness on future GDP growth.

Some countries have enough data on the policy variable in order to conduct a single-country approach. These are usually countries that had active macroprudential policy since 1990s. There are several reasons why a single-country approach can sometimes be better than the panel approach: Ampudia et al. (2021) show that country-specific analysis represents a deep dive into policies at the single country level compared to a panel; and papers utilize financial cycle variables that are not well synchronized as found in literature (Oman, 2019; ECB, 2014; Samarina et al., 2017). When the resulting model can be used to evaluate the effects of borrower based measures, single-country studies provide a more focused analysis on the impact of these measures (Signorini, 2022). However, it seems that at best, results are currently inconclusive (see Škrinjarić, 2023b), and the reasons could be data definitions, the lack of MP index variable intensity adjustment and general lack of data that refers to extreme events (single country analyses do not have enough datapoints in the extreme tail of the distribution in order to have reliable estimates). Surprisingly, there are not many papers that utilise panel analysis. EU countries are the ones that are most commonly examined, as international databases on macroprudential policy tools have the best coverage on exactly those countries. In summary, borrower-based measures are found to be the ones that seem to have significant results so far.

When focusing on specific findings, there are a couple of interesting papers as follows. Brandao-Marques et al. (2020) estimate panel quantile regression (period: 1990-2016) to evaluate policy effects not only on GDP growth, but also inflation. The analysis includes policy surprises by looking at deviations of policy variable from estimated policy rule. The authors found evidence of policy trade-offs regarding lowering mean growth and increasing the GaR growth. One could say that this is the "textbook" example of results as described from the theoretical point of view in ESRB (2019a, 2021). When focusing on the effects on inflation, no intertemporal trade-offs are found, which authors explain with well anchored inflation expectations in the countries that are included in the analysis.

Galán and Rodríguez-Moreno (2020) is an application to both GaR and HaR for 27 EU countries, with quarterly data from 1970 to 2019. Novelty of this study is utilising the

financial cycle as an additional explanatory variable in the analysis, such that the effects of MP measures are examined with respect to the phase of the financial cycle. Authors find heterogeneity of results across quantiles and phases of the cycle itself: there is a positive impact of MP tightening during expansion of the financial cycle, whereas MP loosening has a positive effect on GaR during the contractions, with the effects being more prominent in the short term. Drenkovska and Volčjak (2022) is a recent study of GaR for the Slovenian case (period 2003-2020). The authors are motivated to develop a macroprudential policy framework in which the MPI is included in the GaR analysis and was found to be non-significant in the analysis. Thus, the authors comment that this analysis should be improved in future work and practice.

Recent study of Fernández-Gallardo et al. (2023) of twelve advanced economies (period: 1990Q1 to 2017Q4) gives some insights into causal effects of MP instruments. Authors use a narrative-identification strategy and find that MP does not have effects on the median growth of future GDP growth but tightening MP results in benefits via reducing variance of the growth itself and increasing the left tail of the distribution towards the center. Another important finding is that MP affects the composition of credit: tighter MP is effective at preventing both household and business credit booms. Authors explore the effects of MP on credit growth and house prices as well, and find that tighter MP decreases the right tail of the future credit-growth distribution (both household and corporate).

We can learn several conclusions from these studies: when utilizing a panel QR approach, there exists enough data to evaluate the MP effectiveness in a more reliable way. There are only few such studies, with time series that ended in 2019. Future analyses should extend the time series, not only to evaluate the effects of the pandemic period, but also to see how the new turning of the financial cycle in the last two years affects the results as well. Moreover, studies in this group of research did not factor in important structural differences between economies that are included in the panel setting. We already mentioned papers that try to deal with this fact (O'Brien and Wosser, 2022; and Gächter et al., 2022), but those analyses do not evaluate MP stance. Future work could focus more on these refinements, so that the robustness of the results could be confirmed.

3.3. Specific MP tools: capital versus borrower based measures

There exist a couple of studies that examine the effects of the capital-based measures (CBM) separately compared to the borrower-based ones (BBM). This makes sense, as previous non-GaR empirical findings on general effectiveness of macroprudential policy (see table A2 in the Appendix) did find different effects of those two types of

MP measures on average growth and lending in general. Also, from the conceptual point of view, borrower-based measures should have different effects on the final outcome as they affect both the supply and demand side of lending, whereas capital-based measures are specifically targeted on the supply side (see Alam et al., 2019). Obtaining information on potential different effectiveness of BBM versus CBM measures can be very useful for policymakers, as they can tailor specific tools accordingly.

Galán (2020a, b) utilizes the same data as Galán and Rodríguez-Moreno (2020) (see previous sub-section), and extends it to evaluate CBM versus BBM based indicator, alongside testing for different model specifications and robustness checking. Author makes several conclusions based on the results. Macroprudential policy has significant positive effects on reducing GaR values, whereas negative effects were found for the case of median growth. Interaction with the financial cycle indicator had the same results as in the previous findings of Galán and Rodríguez-Moreno (2020). When distinguishing between CBM and BBM measures, it was found that latter are better to alleviate the future GaR values, whereas former ones are more effective in normal and expansionary times. That is why Galán (2020a, b) concludes that it would be better for the policymaker to utilize CBM measures early in the financial cycle, whereas BBM ones can be applied in advanced stages. Brandao-Marques et al. (2020) also evaluate effects of BBM separately to the CBM measures within a panel setting. Authors find benefits of BBM effects on GaR values, whereas CBM were found to be better for building the financial system's resilience (i.e. by finding that they do not affect negatively the median growth in good times when the capital is built up).

Belkhir et al. (2020, 2022) focus on the likelihood of financial crises besides the growth variable, as a bit different approach to the cost-benefit analysis. Authors evaluate a panel of countries, but divide it into emerging (EE) and advanced economies (AE), as EE countries had various policies to strengthen the resilience of the financial system before GFC, which can affect the overall results. The effects of macroprudential policy on likelihood of crises is observed as the benefit part of the analysis, as it is shown that MP reduces future likelihood of such crises. On the other side, effects on mean growth rate are considered as costs. The main results show that the benefits have outweighed the costs, and the results are more prominent for EEs. Authors also evaluate differences between BBM and CBM measures. BBM measures, such as LTV (loan to value ratio), were found to have a greater beneficial effect than financial-based measures. Cucic et al. (2022) is a short empirical case study of Denmark's GaR and HaR (period: 1982-2022). where BBM and CBM measures are also examined separately as in previous papers. The authors conclude that BBM measures shift the entire

growth distribution right, whereas CBM measures have a trade-off between GaR and median.

To conclude, the results in this group of papers so far indicate that there are some differences in the MP effectiveness with respect to measures being classified as BBM or CBM. BBMs are found to have greater effect on future growth compared to CBM, however this depends on the phase of the financial cycle an economy is in. CBM measures were found to be more useful to build up the resilience of the system in the early phase of the vulnerabilities build up. This gives policymakers information that not only should different MP tools be applied at different phases of the financial cycle, but also that it is important to correctly estimate the financial cycle of an economy (for more details, see Lang et al., 2019, or Škrinjarić, 2023b).

Furthermore, there are differences in the results with respect to advanced versus emerging economies. This is not surprising, as emerging economies had many different tools in practice even before GFC hit. So far, it seems that BBM measures were more effective in emerging economies, whereas CBMs were more useful in reducing probability of banking crises in the advanced ones. Other country-specific characteristics also affect the results: more open countries and more financially developed countries have less effective macroprudential policies (Boar et al. 2017). Least amount of information and research is given for loosening MP. As years will pass by and policymakers will adjust tools to loosen and tighten MP again, such analyses should be redone so we have a better understanding of such behavior.

3.4. Including other policies in the analysis

Due to the high interest rate environment at the time this paper was written, there is a lot of talk on the interaction between the monetary and macroprudential policy again[8]. We found a couple of studies that look at effects of other policies or even look at their interactions in the GaR setting. Perhaps the most interesting analysis is on the interaction between monetary and macroprudential policy, as the debate on this interaction is quite extensive from the theoretical point of view. One way of thinking claims that if loose financial conditions in form of deterioration of credit quality in the economy result in the build-up of financial vulnerabilities, only macroprudential policy can be effective, as it can affect the quality of credit origination, which monetary policy cannot (Collard et al., 2017). Others claim that it is better that both policies work simultaneously: after loosening of the financial conditions, macroprudential policy is not enough to deal with its consequences. Thus, monetary policy needs to help to

[8] This interaction has been interesting for some time already, see Martin et al. (2021), Laeven et al. (2022), Nier and Kang (2016), IMF (2012), etc.

offset easing of financial conditions and reduce the provision of credit (Stein, 2013). Empirical work started to test these considerations in the last couple of years[9].

Sánchez and Röhn (2016) is probably the earliest study important within the context of this group of papers, with the focus on OECD countries in a panel setting (for period 1970-2014). Authors evaluated various policies and their effects on future growth: besides the MP, labour market, external policy, supervision and even quality of the institutions have been evaluated. However, it should be noted that this study examined their effects one by one, i.e. the interactions between policies are not observed. Rather, growth is forecasted based on using individual policies as explanatory variables. When focusing on macroprudential policy, the main results showed that future mean output growth is reduced when the policy is tightened, but the tail risk is also reduced. Overall macroprudential policy, as well as the subset of borrower-targeted instruments are significantly negatively correlated with GDP growth at higher GDP growth quantiles, suggesting that tightening of MP instruments is associated with smaller positive growth shocks. However, due to this policy being relatively new compared to others, it was concluded that this should be explored more in the future. When looking at the prudential banking supervision policy, findings show that countries with more effective supervision eventually experience less severe negative growth shocks. Overall, authors conclude that their findings are in line with literature that claims that macroprudential policy is meant to reduce the boom phase of the cycle.

Duprey and Ueberfeldt (2018, 2020) include simultaneously monetary and macroprudential policy effects on real growth for the Canadian case (for period 1992 to 2020). The approach taken in these papers is twofold: the interaction between the two policies is examined both from the theoretical and empirical point of view. The authors showed that macroprudential tightening is more effective in reducing downside risks of future growth compared to monetary policy tightening. Both policies reduce left tail risks by not affecting the median growth and increase the 5th percentile growth via the credit channel of banks. This study is (to the knowledge of the author) the only one in this area of research that does both empirical analysis, and a calibration of a theoretical model of MP effects. Authors develop a model and simulate the choice set of the macroprudential policymaker, showing how the benefits would be achieved if a tighter stance was taken, which was in line with real policy decisions in 2018.

Another paper that includes monetary policy alongside macroprudential is Franta and Gambacorta (2020). This study applies the GaR concept on a sample of 56 countries in

[9] Interested readers on these interactions in general are referred to Bussière et al. (2020).

the period 1980-2012 to evaluate effects of inflation, monetary policy rate and MPI. Other control variables were not included, so some caution needs to be taken when interpreting these results. The authors focused on LTV (loan to value) and loan loss provisioning aspects in MPI to see their effects on future GDP growth. The results show that LTV narrows the whole future distribution of the growth, whereas loan loss provisions only move the left tail of the distribution upward. This is a very short study, and the results regarding inclusion of monetary policy are not presented.

Brandao-Marques et al. (2020), a study already mentioned above, also analyses interaction between monetary and macroprudential policies as well. Authors explain that central banks in practice are likely to use a combination of both policies at the same time. Thus, authors wanted to examine what were the overall effects of those interactions observed so far by including both policies as explanatory variables in the model. Results of the analysis show that there exist gains from combining the two policies. When the domestic financial conditions are looser, tightening of macroprudential policy accompanied by a looser monetary policy brings more benefits compared to both policies being tightened at the same time. This could be explained by benefits that come from a tighter macroprudential policy are erased by the costs that emerge from tighter monetary policy as a response to the eased financial conditions.

In summary, the interaction between the two policies depends on country specific characteristics, spillovers and leakages to the rest of the financial system and other factors. Future work should include more explicitly the interaction and tradeoffs between the two policies, in order to disentangle their effects and their magnitudes accordingly. We expect that in future more theoretical and empirical research will be done on this topic of interaction between the policies. E.g., ECB already started to incorporate the GaR approach in their stress testing and looking at interactions between monetary and macroprudential policy in Boucherie et al. (2022)[10]. This is especially relevant now in the new era of increased interest rates, as of writing this survey. However, some studies still omit key macro-financial variables as controls and measures of the build-up of systemic risk (such as Sánchez and Röhn, 2016). Also, not all papers evaluate the term-structure of the effects of MP and other variables in the model. It is important to examine the distribution of the effects of MP tools across time (see also section 5.2. for more details).

[10] More details on this study are given in section 2.3.

4: MACROPRUDENTIAL POLICY VARIABLE CHALLENGES

We comment on several challenges that are still present in the related literature, which we came across in this survey. This section deals with probably the most important and challenging issue – correct definition and measurement of macroprudential policy variable. Another important topic is the methodological challenge of GaR itself, which we comment on in the next section.

4.1. Different sources of MPI data

Macroprudential policy consists of many different measures and tools that have been introduced in the last 25 years. Different databases on macroprudential policy tools have been developed in the last couple of years, so it is easier to track and use MP data in empirical analyses. ECB (2018) and IMF (2022) databases are commonly used ones, not only in GaR literature, but in other empirical applications that utilize MP as a variable in the anallysis. The ECB database, called MaPPED, is a comprehensive dataset, with probably 1500 hundred policy actions for EU countries since 1995. Prudential authorities have submitted measures, their descriptions and other relevant information. Since MP has somewhat formalized after the GFC, other measures before it has been retroactively categorized to fit the macroprudential nature. It also includes changes in measures, i.e., if fine tuning was done, so it presents a good starting point to use in analysis. In order to define the MP variable itself, we need to collect the data on MP tools/instruments activation or deactivation, their frequency, and other relevant information, such as the intention of the tool and dates of announcements and stepping into force.

The IMF database, iMaPP, combines information from various sources, including Macroprudential Policy Survey, and the IMF member countries that submit information on a yearly basis. This database also has a detailed description of each submitted measure, alongside detailed classification, but some caveats are that not every measure is included (those that were introduced before the sample period started), and only those measures that were cross checked with official documents were included (this means that earlier measures that were not publicly announced in English language were probably not included in the database). IMF does not take into consideration some measures that could be broadly classified as "other", but which had macroprudential character, whereas ECB did. More information, and other sources are given in table A4 in the Appendix.

Up until writing this survey, no comments were found in related literature on this problem, apart from the discussion in Škrinjarić (2023), who has shown great

differences in constructing a cumulative MPI measure for a fairly active MP country, depending on if we use the ECB, IMF or fully cross-checked database from the internal base of the central bank alongside the two sources. Authors usually collect the MPI data without checking it additionally. This could also affect the results within the GaR model, as some measures could be wrongly classified, could have wrong dates of announcements or started being active, and other possible errors. Thus, it is advised to do a cross-checking of these datasets in the future.

4.2. Measuring macroprudential policy variable

Another challenge in measuring MP stance is the definition and measurement of the MP variable itself. Macroprudential policy variable involves many different instruments, of which some are broad based, others are specific targeted ones, some are actually non-macroprudential ones that were adapted into macroprudential purposes after the GFC. There is also a difference between the effects of a tool being introduced for the first time, versus later fine-tuning of the instrument itself.

Definition of the MP variable. There is still a lack of consensus on the definition of the macroprudential policy itself. By looking at the empirical databases mentioned in the previous section, one can see that MP tools are measured as binary indicators that give information on when a tool was announced, introduced and what direction of the tool was/is (i.e., is it a tightening or loosening measure). Besides collecting this information and summarizing it somehow (see the rest of this section), there is lack of agreement on what is actually MP stance. Part of the literature that talks about MP stance defines it as the value of the MP index (MPI henceforward) value that is collected from any of the available databases. E.g., Akinci and Olmstead-Rumsey (2015) state, "... *These cumulative variables sum the dummy variables (tightening net of easing) to get an idea of a country's "macroprudential policy stance" in a given quarter*..."; or Ćehajić and Košak (2019) state: "*we design our main macroprudential measures by summing all policy changes over time, both tightening and easing. This allows us to capture the overall macroprudential stance in a given country and time period*." Others use the MPI indicator in an empirical model and then talk about the MP stance when evaluating the effects on economic growth. I.e., stance needs to be contextualized within the GaR framework, via the effects on economic growth.

Surprisingly, some papers do not explicitly describe in which form the MPI indicator enters the analysis (net values, cumulative, etc.). MP tools are usually in a descriptive form. Thus, authors define simple binary variables, where the +1 value indicates a tightening measure that took place in a given quarter *t* and -1 is a loosening one:

$$mpi_t = \begin{cases} 1, & \text{if a measure is tightening} \\ 0, & \text{absence of measure (or absence)} \\ -1, & \text{if a measure is loosening} \end{cases} \quad (1)$$

Usually, ambiguous and absence of measures are given zero value. Formula (1) can be applied for any of the measures or can be disaggregated and looked only at a certain measure. E.g., one can focus only on LTV ratio as a tool. This means that formula (1) is applied only when this tool was activated or fine-tuned. More details can be found in Cerutti et al. (2017), Budnik and Kleibl (2018), Garcia Revelo et al. (2019), etc. Others do not take into account if the policy was tightening or loosening more times in a given quarter. This means that within the same quarter instead of taking value of $+N$ (where N is the number of tightening measures), we could opt to put +1. See Garcia Revelo et al. (2020) for more details.

To overcome lack of variability in the MPI type of indices, some authors try to overcome this by using a cumulative MPI index. It is a simple accumulation of values in (1), given as:

$$\text{MPI}_t = \sum_{t=1}^{T} mpi_t \,, \quad (2)$$

And then use this transformation in their analysis (see Akinci and Olmstead-Rumsey, 2015). However, Plagborg-Møller et al. (2020), and McCracken and Ng (2016) comment that it is better to utilize stationary variables if possible, and cumulated values of MPI are often not stationary for the case of countries that have a longer history of macroprudential policy. That is why more research is looking at year-on-year changes in the cumulative index:

$$\Delta\text{MPI}_t = \text{MPI}_t - \text{MPI}_{t\text{-}4} \,, \quad (3)$$

as found in Galán (2020 a, b), Vandenbussche et al. (2015), Cerutti et al. (2017), and Alam et al. (2019). Other possible transformations are found in a 20-quarter change of the cumulative MPI indicator in (2), as found in ESRB (2021).

Interpretation of the results thus depends on the definition of MPI. Another thing to bear in mind is that the transformations also need to have meaningful interpretation (besides the literal one as in interpreting the estimated coefficients): as we utilize the GaR approach to estimate the effects of MP on future economic growth, what does it mean to observe the effect of a 20-quarter change of MPI 16 quarters ahead? Although it takes some time for macroprudential policy measures to have effect, we need to consider what is also the duration of these effects.

Intensity of the measures. So far, the values discussed in previous sub-section did not tell us anything about the intensity of a measure or its relative importance. Majority of published papers still utilize the MPI as defined above. However, if we think about the consequences of this approach by just taking a simple example, it is understandable why this could impose issues in obtaining meaningful results. Let us compare two countries that introduce CCyB (countercyclical capital buffer) in the same quarter. Country A immediately introduces value of 2% and this remains constant in the next couple of quarters. Country B on the other hand, introduces value of 0.5% and in each subsequent quarter increases it by 0.5 pp until it reaches 2% as country A. In the current setting described in the subsection above, it would mean that country A gets +1 in the first quarter, and due to no changes afterwards, the value for this tool would be 0, with accumulated value of the original unit value. On the other side, country B gets +1 in each quarter four times, meaning that at the end its cumulative MPI result with value 4. This distribution could significantly affect the final result as the dynamics of the macroprudential variable is significantly different. We could say that in such setting, the MPI reflects the frequency of the measures, not the magnitudes.

Thus, it would be important to take into consideration the starting level of the policy, intensity of the change, type of the instrument that enters the toolkit, as well as the deactivation of the tool. There have been a couple of attempts to do so. Eller et al. (2020), Vandenbussche et al. (2015), and Richter et al. (2018 a, b, 2019) are some of the initial studies that have been working on this (see table 1.). Other approaches include Galán (2020b), who used the mean regulatory LTV to check robustness of the results of the original non adjusted MPI, and obtained results that are consistent to the main ones in the first part of the study. Chari et al. (2022) defined equally weighted index of the CCyB, LTV ratio and the FX (foreign exchange) macroprudential stance, another one being based on the principal component analysis on CCyB and LTV, and a comparison measure between the countries in the sample, such that the value of a country's implemented tool is compared to the average value of the sample.

Unfortunately, a consensus on how to solve this problem has not yet been found because research states that "*we assign a higher weight to policy actions we consider to be more important*", as in Meuleman and Vander Vennet (2020), a paper that Fernández-Gallardo and Paya (2020) follow. This is something future research needs to work on, trying to find an objective way to define such adjustments.

One way of dealing with this challenge would be defining a formal way to do so, as some methodological challenges were dealt with in the past through country-level coordination and working groups. One example is found at ESRB, where the

residential real estate vulnerabilities across countries are evaluated and compared based on a methodology that was developed via a working group of experts (see ESRB, 2019b). After such formal agreement would be made, research could apply the weighting scheme in order to obtain better comparability across countries and time, as well as for the purposes of robustness checking. Another thing that could be done is to analyse different weighting schemes of tightening versus loosening a tool, to evaluate the potential asymmetric differences. This is in line with studies that have introduced the financial cycle variable to take such effects into consideration (aforementioned study of Galán, 2020b).

Table 1: Approaches to intensity adjustments of MPI tools

Authors	Description
Vandenbussche et al. (2015)	Linear transformations of initial numbers. Regulation that has small number of parameters, take into consideration all parameters, complex rules: summarize the strength with fixed values. Minimum CAR: quarterly change in the minimum ratio, risk weights on mortgages: divide with 25 or 50 and take quarterly changes. For other details, see the appendix of the paper. Eller et al. (2020) follow this approach.
Richter et al. (2018a, b)	Focus on LTV as the main macroprudential tool. When max LTV ratio is lowered by 10 pp, LTV policy index takes value 10. When max LTV ratio is increased by 10 pp., index value is – 10. When one type of loan is prohibited, it is given zero max LTV ratio. When max LTV ratio changes more than once in a given quarter, sum up all changes and treat as one change. When nonstandard type of housing loans becomes subject to LTV change, give 10% weight to the loan type.
Fernández-Gallardo and Paya (2020); Meuleman and Vander Vennet (2020)	Activation of a tool: absolute value of 1 (positive if tightening, negative if loosening); change in the level of the tool: value 0.25 (again, depends on the nature of tightening or loosening), change in the scope of the tool: value of 0.1, maintaining the existing level and scope: value 0.05; deactivation of a tool: depends on the life cycle of the tool, cumulative value of the index goes to zero.

4.3. Endogeneity of the policy

4.3.1. Defining the problem

Endogeneity of macroprudential policy is probably one of the biggest issues in determining its causal effects on macro-financial variables in general. Question is how to identify the "true" policy shock in order to estimate its causal effects. It is well

known that regulators and policymakers take into consideration some typical variables such as credit growth, debt burden, etc., when making decisions about its instruments. As Akinci and Olmstead-Rumsey (2018) explain, those countries that experienced rapid credit growth have a greater probability of a tighter macroprudential policy; whereas Buch et al. (2018) explicitly state that macroprudential policy is endogenous: the policymaker reacts to expected economic environment, and in that form cannot be used to identify exogenous changes.

Endogeneity issue is not restricted only to macroprudential policy; monetary and fiscal policies have this problem as well, which has been tackled for many decades now. Some earlier approaches are reviewed in Christiano et al. (1999), whereas newer approaches are reviewed in a comprehensive chapter Ramey (2016), and include narrative identification, regime switching approach, and many others, both for monetary and fiscal policy specifications. That is why it is surprising why some of the related GaR research does not deal with this issue.

Richter et al. (2018a, 2019) define the following criteria in order to talk about causality: policy actions need to be exogenous with respect to the current and lagged variables; these actions have to be uncorrelated with other shocks, and the shocks have to be unexpected. If the problem is not addressed, the estimated coefficients of the MP effects are biased upwards (Vandenbussche et al., 2015). There are several approaches that tackle this, by using one approach or the other, as presented below. However, there are some researchers that state it is very difficult to move from correlations to causality, as Sekhon (2009:503) said: "*without an experiment, a natural experiment, a discontinuity, or some other strong design, no amount of econometric or statistical modelling can make the move from correlation to causation persuasive.*"

4.3.2. Reducing the endogeneity problem

We have found a couple of different approaches that address the endogeneity of the policy. We present each of them in the rest of this section, with the explanations on the rationale and the main outcomes. We focus on the following approaches:

- Obtaining non-systematic MP shocks, via regression, probit regression,
- Propensity score matching,
- Narrative approach,
- Lagging variables, and
- Multivariate approach.

Obtaining non-systematic policy shocks

Non-systematic policy shocks are defined as the portion of the policy that is not related to the state of the economy (McCallum, 1999). Non-systematic monetary policy shocks have been considered in empirical literature for a long time now, especially since the Lucas (1972) critique, who claimed that the non-systematic component of monetary policy is the part that is important for conducing the policy itself. In the context of measuring the effects of MP shocks on future GDP growth, this means that one cannot use the MPI values from the available databases, as introduction or fine tuning of a tool that makes MPI variable is conditional on what was previously observed in the economy and the financial system. Thus, the MPI variable needs to be somehow decomposed into the value that is conditional on macro-financial characteristics (*c_MPI*) of the economy - systematic, and the "true", non-systematic shock: *MPI* = *c_MPI* + *shock*. Then, the *shock* is utilized in further analysis (that can be other approaches besides the one that is in focus here).

A popular approach to obtain non-systematic shocks is to regress MPI on a set of variables that should affect macroprudential policy decision making: financial vulnerabilities, measured through credit-to-GDP gap, composite indicators of systemic risk, house price dynamics, and other variables found in early warning models literature (see Tölö et al., 2018, and Škrinjarić, 2022a, for an exhaustive list). Then, in the second step, the residuals from the first step are used in the second step that is GaR estimation. Rationale is simple: in the ordinary regression, if the model is specified correctly, the variation of the residuals is the variation of the dependent variable that is not explained with the selected regressors. That is why some authors employ this approach and call the residuals the non-systematic MPI shocks. Some caveats need to be mentioned though: the dependent variable in regression analysis should be a continuous numeric variable, however, MPI is not designed in that form (see section 4.2.). In some empirical studies, authors utilise the categorical definition of MPI and apply the regression regardless. This, however, should be avoided and other regression designs should be employed as shown below.

Ordered probit regression can be used in such cases, as the MPI variable defined in the form of number of tightening or loosening measures in a given period has such ordering from which we have an idea what it means. As MPI can take takes values {… , -2, -1, 0, 1, 2, …}, -2 could mean that in a given period, there were two loosening measures, compared to -1 which means that one loosening measure was introduced, or fine-tuned. However, it does not have to mean that two measures compared to one have double the effect, as one measure could be just introduced and have a greater effect compared to two that could be just smaller fine-tuning. That is why we can look

at MPI to have ordinal ordering and apply ordered probit regression. Afterwards, the residuals are collected and used in the main analysis.

Brandao-Marques et al. (2020) estimate an ordered probit regression where MPI is regressed on previous quarter credit-to-GDP gap, house price gap and previous year cumulative value of MPI itself are used as explanatory variables in the regression, and the estimated residuals are extracted and interpreted as true policy shocks. Ahnert et al. (2021) focus on FX macroprudential effects and by following work on fiscal (Auerbach and Gorodnichenko, 2013) and monetary (Furceri et al., 2016) policy, compute the first stage regression of FX regulation on a range of different variables that affect it. Similar approach was done in Gelos et al. (2022), where different policies were contrasted in how much they are effective in taming the capital inflows for selected countries, and macroprudential tools were found to be effective in mitigating risk of large inflows in the medium term. Škrinjarić (2023) also applies an ordered probit regression on MPI, with trying out different lag structure of the explanatory variables, and using information criteria to select the best lag structure with observing the estimated coefficients in order to have meaningful interpretations.

Some authors regress the MPI variable on other variables that will be used in the GaR setting: this is done in Galán (2020a), where an ordinary regression is applied over the MPI variable, alongside having the same quarter values of other variables in the analysis. This does impose questions on using the same quarter values, alongside utilizing regression approach on a variable that is basically categorical. Similar is found in Boar et al. (2017), who also apply panel regression[11] on MPI without lagging other explanatory variables (change of credit-to-GDP ratio, capital inflows and GDP growth).

Questions that remain open for future work include: which variables should be used in order to conduct the first stage analysis? As macroprudential policymaker tracks dozens of variables that affect the decisions on MPI tools over time, what would be the best combination of variables to select and use? This probably differs across countries, so how to reconcile this within a panel setting, or when a single-country analysis is done, how can we compare the results? If this last question is not important for a policymaker, he should focus on those variables that are commonly used in the

[11] Another question here is why utilize an OLS regression approach on a dependent categorical variable, such as in Biljanovska et al. (2023), and Chari et al. (2021, 2022). Biljanovska et al. (2023) regress MPI on credit to GDP gap, house price gap and VIX from the previous quarter, with a binary variable that captures period after GFC to account for potential regime change in adoption of MP, as many countries significantly increased MP activity after 2009. Chari et al. (2021, 2022) regressed the MPI variable on the crisis dummy, credit, growth, and some controls (such as inflation, openness, policy rate, REER growth, etc.) in the previous period.

decision-making process. Furthermore, it should be noted that MP tools and measures are introduced or fine-tuned after the policymaker observes important criteria over some time. There is also a lag in publishing many macroeconomic variables that he tracks, so using the same quarter values of explanatory variables to estimate pure MPI shocks could be questionable. Other issues include the non-validity of the Frisch-Waugh-Lovell theorem in quantile regression approach, and the coefficients suffer from omitted variable bias, as shown in Lloyd and Manuel (2023).

Propensity score matching

Another popular approach to deal with endogeneity is the propensity score matching (PSM, see Rosenbaum and Rubin, 1983; and Pearl, 2000). It is a quasi-experimental approach where an artificial control group is constructed such that a treated unit is matched with a non-treated one, and both have similar characteristics. It is used for causal inference (exactly what we want to obtain when measuring MP stance), in the case when the researcher cannot make real experiments. In economics and finance, research cannot make experiments as are done in medical sciences. However, by applying PSM, one can obtain the impact of an "intervention", or in case of estimating MP stance, impact of tightening or loosening MP tools. This approach uses observable variables that the policymaker tracks to estimate propensity scores that indicate the likelihood of policy action. These scores are applied over different countries that have similar characteristics in terms of those variable dynamics, but some of the countries did apply MP tools, whereas others have not. Their observations are matched, and the average differences are calculated to obtain the effects of MP.

General usage of PSM in macroeconomics is still relatively new (Alam et al., 2019). Some applications can be found in Jordà and Taylor (2016) for the case of fiscal policy, or Angrist et al. (2016) for monetary policy. Cizel et al. (2019), Alam et al. (2019), Richter et al. (2018 b) Duprey and Ueberfeld (2020) applied PSM to evaluate MP effects, with the last study being one within the GaR framework. Authors usually observe a panel of countries, where this unexpected part of the MP shock is estimated, such that the probability of facing an unexpected change of MPI is estimated and compared to the values that we actually observe (Duprey and Ueberfeld, 2020):

$$\mathrm{MAP}_t = (I\_\mathrm{MPI}_{t>0} - I\_\mathrm{MPI}_{t<0}) - (\Pr(\mathrm{MPI}_t > 0) - \Pr(\mathrm{MPI}_t < 0)), \qquad (4)$$

i.e. the unexpected change MAP is calculated as the actual change (first bracket) minus the change of probabilities of MPI values. Generally speaking, there are two steps in PSM. In the first step, the latter part of equation (4) is estimated, i.e. the likelihood of policy tightening/loosening is estimated. In the second step, the likelihoods of every

observation are matched to those that have almost identical likelihoods, but with no changes of macroprudential policy. The difference between the dependent variable between the two matching observations (countries) is calculated as in (4). This difference is later on used as an independent variable in the GaR model. More details on the PSM approach, specifically to evaluate prudential policy effects can be found in Hafemann (2021).

Here, similar questions on the variable and lag selection hold as for the previous approach. Since the probabilities are estimated with respect to macroeconomic variables, variable and lag selection remain one of the challenges. Based on the previous financial cycle and financial crises prediction literature, research could utilise those variables that were found to be best predictors for the majority of examined countries.

Narrative approach[12]

Narrative approach has the aim of identifying MP actions/instruments by studying contemporary primary sources, such as policymakers' statements about their intentions. In that way, actions that are exogenous with respect to the current and previous relevant macro-financial variables. In general, narrative policy framework (NPF) is a theoretical framework that studies policy narratives based on common assumptions, concepts and hypotheses (Shanahan et al., 2017). For an introduction, interested readers are referred to Jones and McBeth (2010). NFP requires the researcher to conduct detailed reading and understanding of the under motivations for MP measures and the information set of policy the policymaker. The main idea is to differentiate changes in a policy measure into those that were mainly motivated by current or projected fluctuations in important macro-financial variables, called endogenous changes, from those that were caused by other reasons, which are then the "true" exogeneous changes, used further in empirical modelling.

There are a couple of applications of this approach for MP effectiveness investigation. Ampudia et al. (2021) apply a narrative panel VAR (for 11 EU countries from 1998 to 2017). De Schryder and Opitz (2019, 2021) looked at MPI effects on credit dynamics for EU member countries (1995 to 2014). Richter et al. (2019) drop all policy actions that have been motivated by real economy objectives.

Fernández-Gallardo et al. (2023) is probably the only example within GaR approach, where authors construct MP indicator for each country in the study. Authors used the announcement date of the policy to assign a value to each policy action. In order to

[12] This approach is fairly popular in monetary policy applications, see Romer and Romer (1989, 2010).

fully utilize the narrative approach, authors excluded those actions and tools that had countercyclical design. Explanation for this is that such tools are aimed towards short to medium term stabilisation, whereas the remaining actions can be used to identify causal effects, as they were not affected by contemporaneous influences. Additionally, authors explored the sensitivity of these results by including forecasted GDP growth as an additional control. Main findings include the effects of tighter MP on boosting the left tail of future GDP growth, but also reducing the upside tail risk, with no effects on the centre of the distribution.

This approach asks for a detailed reading on the explanations of every MP tool that has been (de)activated and fine-tuned in a dataset, and the reader's knowledge on the nature of the measures. It is a time-consuming approach as every announcement needs to be investigated and reasons for its introduction or deactivation need to be examined. There is another drawback of this approach: it is difficult to distinguish between motivations driving the adoption of MP, and this method does not identify unanticipated measures (Biljanovska et al., 2023).

Lagging variables

Some authors decide to include lagged values of MPI indicator in the single-equation approach, i.e., in the GaR model specification, where the dependent variable is future GDP growth, MPI variable is introduced with several lags. This approach is attractive, as it does not require additional steps or other estimation procedures to do before utilising this one. Reasoning on why the independent variable is lagged in empirical research related to causality and endogeneity analysis is multiple-fold. One reason comes from theoretical considerations, as some theoretical models explain that effects of variable *x* on *y* are distributed over time. Another is statistical, as found in dynamic panel models, where such variables have statistical function. Final is identification reason, where lagged value of variable *x* affecting variable *y* is defined as *x* causing *y* (see Bellemare et al., 2017). Ossandon Busch et al. (2022) state that „*causality concerns can be addressed, for instance, by lagging the variable policy in order to separate the policy decisions from current macro trends*."; and Gelos et al. (2022) add one year of lagged MPI data in their model, without explaining on the reasoning.

However, others do the opposite: Cerutti et al. (2017) state that greater number of lags of other variables should be included in the model. This is something more common in other literature that tries to deal with endogeneity of a variable. If we assume that MPI is affected by previous values of, e.g. financial vulnerabilities in the system, it could be an obvious choice to include previous lags of the latter variable in a model. Some papers include lags of both the MPI and other variables, such as Eller et al.

(2020), who decide on the lags selection based on the BIC (Bayes information criterion).

Sánchez and Röhn (2016), although choose to lag policy variable by four quarters to mitigate endogeneity, state that results should not be interpreted in a causal way. This is supported by Bellemare et al. (2017), who explain that this approach does not mitigate endogeneity issue, nor does it identify causal effects, rather, this approach just moves the channel through which endogeneity affects the estimated parameters. To summarize, what could be done here is that lagged explanatory variables can be appropriate in the model is in the context of unobserved confounding (see Bellemare et al., 2017), and in the case of no unobserved confounding, there must not exist reverse causality (which is usually the case of MP stance analysis).

Multivariate approach

One very popular approach in macro-econometric modelling in general is to utilise multivariate models instead of single-equation ones. Vector autoregression models (VAR) and their variants have been extensively utilised to forecast economic and financial time series, as they are relatively simple, and useful for structural inference and policy analysis (see Stock and Watson, 2001). A structural VAR uses economic theory to sort contemporaneous links among the variables and thus require identifying assumptions that allow correlations to be interpreted as causality. As this is one of the most popular approaches in empirical analysis today, we touch upon some major points, and refer interested readers to the following references for more details: Budnik and Rünstler (2022), Kim and Mehrotra (2017), Tillmann (2015) or Morell et al. (2022).

Structural VAR applications within GaR modelling have been increasing in the last few years. Kim and Mehrotra (2017, 2018) utilize the Cholesky decomposition which asks for authors to determine the variable ordering, which is based on economic theory. The approach in the ECB papers on GaR modelling (see section 2.3.) and Beutel et al. (2022) also utilize this approach within QVAR (quantile). The authors identify three main results: exogenous tightening of financial conditions raises international GaR, unexpected tightening of monetary policy has stronger effects on GaR than the rest of the distribution, and country-specific characteristics (such as the exchange rate regime) matter for the results. However, this has some limitations, especially in the presence of foresight, as it is likely that changes in policy and other exogenous shocks are actually anticipated in advance (Ramey, 2016). Moreover, (S)VAR analysis asks for either theoretical justification of the causality or using Granger causality test, that is often criticised that it does not conceptually reflect the true meaning of causality, just

because a lagged value of one variable can explain the variability of another one (see Stokes and Purdon, 2017; or Maziars, 2015).

5: GENERAL GaR METHODLOGY CHALLENGES

Besides challenges regarding macroprudential policy definition, measurement and especially endogeneity one, there are other issues that research deals with when estimating MP stance by using Growth-at-Risk approach. They refer to dealing with shocks such as the COVID-19 pandemic, and other methodological questions. We comment on them in the rest of this section.

5.1. Covid-19 shock comments

Majority of empirical work has been done either right before the Covid-19 shock hit, or if it was done afterwards, authors cut of the data before this period. Reason being that it is difficult to model this type of shock, even ex post, and GaR model's purpose is not to capture such shocks. This was shown in several papers that comment on this challenge, as GaR approach is not suited to forecast pandemic shocks (Alessandri and Di Cesare, 2021; Krygier and Vasi, 2022; and Santis and Van der Veken, 2023).

There are a couple of papers that try to explore what can be done and how the model performs in this setting. One approach was suggested by Kipriyanov (2022), who conducted recursive estimates as each new data point arrived during this crisis period. However, after the whole Covid-19 period was fed to the models, none successfully captured the great shock in GDP dynamics. Instead, the share of contact intense service industries was a better predictor of the severity of the Covid-19 crisis, as found by Furceri et al. (2021) and Glocker and Piribauer (2021). On the opposite side, Szendrei and Varga (2023) compare their results without and with Covid-19 period included in the analysis and did not find many differences. Thus, no final consensus is found on how to deal with the Covid-19 issue in the analysis.

GaR is not the only framework that is affected by Covid shock and the work on how to deal with empirical estimation is still ongoing. Questions that need to be answered in future work refer to assumptions about this shock changing the relationship between economic variables or not. E.g. if we assume that this shock did not change structural relationships between variables, some sort of binary variable introduction could take place. Otherwise, if the researcher assumes that the pandemic shock has permanently changed some economic behaviour, this will need to be tackled differently. It is not easy to "clean" the data up, as the pandemic shock is present in the growth variable at both sides of the equation. Many economic and financial analyses utilise dynamic models, and GaR is one of them, as we observe the effects of MPI shocks on future GDP growth at different time horizons. Thus, it becomes even more

challenging to tackle this problem. Some bias in the results is present due to pandemic dynamics being included in the analysis.

Some potential solutions could be the following ones. One can include adding binary variables regarding the pandemic period in the model to test if the effects were not permanent, another can include a geopolitical index as an additional explanatory variable as proposed by Engle and Campos-Martin (2020), as this measure was able to capture pandemic shock better and faster than other financial market variables. Third approach can include smoothing out some of the variables that have the pandemic shock in them, if the initial analysis shows that some variables have been extremely resilient to the same shock, whereas other did not.

5.2. Other challenges

A couple of other relevant challenges include examining different quantiles of tail risk within the GaR model, question on the term structure of the MPI effects and how to reconcile this for policy calibration, and challenges of measuring other relevant variables in the GaR framework.

Different quantiles for tail risks

Due to lack of data, some studies analyse higher quantile value of the left tail of the growth distribution, compared to others. E.g., usually in the single-country approach, authors examine the 10^{th} percentile GaR compared to the 5^{th} one in panel settings. This also hinders comparability between the results. The analysis should focus on a quantile that provides enough datapoints for the GaR value, but there is a trade-off between having enough data versus increasing the quantile of the distribution, as the idea of extreme values gets lost.

Term structure of the MP effects

One of the ideas of GaR framework modelling, besides evaluating the effectiveness and MP stance, to try to calibrate MP tools and measures based on the results. Current findings in literature show results that span for very different forecasting horizons, ranging from one quarter ahead to almost 9 years. This makes it hard to communicate and interpret the results. The choice of the forecasting horizon should reflect transmission lags of MP instruments. This could be based on some existing research that focuses on some transmission mechanisms from MP tool adjustment towards lending and other relevant variables of interest (see Behncke, 2020; or Davis et al.,

2022). Selection of "optimal" horizon could be based on statistical significance of MPI variable and previous experience of the policymaker.

Challenges of measuring other relevant variables

Besides different indicators of financial conditions, there are many other variables that authors include in the GaR modelling (see table A5 in the Appendix). Reasons are that the forecasts of the model are more accurate by including one specific variable or the other. A lot of reviewed papers introduce country-specific financial conditions or financial vulnerability indicators. Authors are motivated by some specific dynamics, characteristics, and/or problems of a single country, and to account for this, variables are modified to reflect this in the best possible way. This is probably the best approach for analysing a particular country, but disables a cross country comparisons.

Structual factors

Panel analyses often need to "correct" or change definitions of specific variables for come countries. E.g. O'Brien and Wosser (2021) in their panel GaR analysis use GNI for the case of Ireland instead of GDP for the growth forecast and the credit-to-GDP gap; and where financial conditions variable was also changed with respect to better forecasting performance for specific country. Plagborg-Møller et al. (2020) found great cross-country heterogeneity in the results of financial variables used in GaR prediction. After a battery of carried-out forecasts and estimations, the authors found a few significant mean growth predictors, less for the volatility of growth, alongside different signs of results, and great cross-country heterogeneity in the results, which prompt the authors to conclude that theoretical model building should be careful. As some specificities characterize individual countries and their experiences over time, such information could be lost in a panel setting.

Ampudia et al. (2021) list some drawbacks of panel settings as well, which include high diversity in macroprudential measures across countries is truncated into simple indicators. Budnik et al. (2021) comment that panel GaR estimation could be biased if time-invariant country characteristics are omitted from the model. Gächter et al. (2022) found that most relevant structural factors that affect the results are trade openness, financial sector size, public spending ratio, and government effectiveness. Based on a panel of 24 European countries (period 1999-2019), the findings suggest that these structural factors affect not only the different levels of GaRs between countries but also the reaction of GaR to changes in these variables. Such results are important for European countries, as macroprudential legislation is common, but many structural differences exist. As authors conclude, size of the financial sector affects the

magnitude of the effect of higher capital requirements, with limited effects on GaR risks for those countries with small financial sector.

6: WHAT DID WE LEARN FROM THIS SURVEY?

Although there are many empirical studies on forecasting GaR, there are only few that use this setting to evaluate macroprudential policy stance. Reasons could be found in a relatively short time series of the macroprudential policy indicator for many countries and problems defining and measuring this variable, MPI is difficult to define, as it consists of many macroprudential tools with different intensities, and endogeneity of the policy itself should be tackled in the best possible way.

Current findings on MP stance are still mixed. There are several reasons on why we still find this heterogeneity. Besides the obvious one - using MPI as simple aggregation of many different measures, there is the fact that for some countries both the MPI and its components are short time series. Thus, operationalization of a tool is not examined even through one financial cycle. Alessandri and Di Cesare (2022) warn about the empirical problems and conclude that MP instrument calibration based on such approach should be very cautious. Mixed empirical results we find in studies examined in this survey are in line with the comments of Reichlin et al. (2019), who agree that the relationship between financial and real variables is difficult to model. Single-country analyses often find insignificant results, whereas panel approaches find that some MP tools are more effective than others. BBM tools are found to be more effective than CBM ones, impact of MP is dependent on the position in the financial cycle, and time horizon of evaluating effects also shows different findings. However, we can generalize a bit: tightening MP during expansionary phase of the financial cycle has benefits in the mid-term, whereas loosening has a positive effect on downside risk. Galán (2020b) concludes that findings like that are actually important for the timing of MP. Less evidence is usually found for curbing the financial cycle. This could be an indication for the policymakers to focus more on those measures that increase the system's resilience, as it is much harder to reduce peaks and raise troughs of the financial cycle.

One thing to have in mind when using GaR framework of MP stance evaluation is that it is just a "bird's eye view". Channels of MP effectiveness, and its transmission cannot be seen in this approach. Thus, utilizing GaR approach to evaluate MP stance should be complemented with more granular data analyses. This could enable a more detailed analysis of the transmission channels. Micro-approach[13] of estimating the effects of macroprudential policy finds concrete and helpful results more often compared to the macro-approach. In the last couple of years, such studies have been emerging a bit more, as granular data has become more available within central banks to do such analyses.

[13] Individual bank or banks' counterparties approach and similar.

This survey did not examine theoretical papers on the MP stance evaluation. However, the number of these studies is growing in the last couple of years (see short info in Table A3 in the Appendix). It is to be expected that the number and richness of theoretical papers will also increase in future, as some ground has been established. There is a need to refine and reconcile different definitions of the MP stance in this stream of work, as there are still different ways of looking upon this concept, especially regarding the definition of the "optimal" stance. We expect that the number of theoretical studies will increase, as more stylized facts about MP emerge from empirical studies. Finally, we expect that future work will result in a formation of the policymaker's reaction function, when we get more understanding of the effects of different macroprudential tools.

We expect that both GaR and other methodological approaches on evaluating MP stance will continue to develop in future. Work on this has already started: Ferrara et al. (2022) combine high frequency data with the quarterly frequency that is typically used within GaR approach and utilize MIDAS-QR (mixed data sampling) approach. Some authors are starting to focus on DSGE (Dynamic stochastic general equilibrium) modelling approach (Buch et al., 2018). Other possible directions are the identification of SVARs from sparse narrative instruments, as in Budnik and Rünstler (2022), who are motivated by many issues regarding the MPI measurement. De Nicolò and Lucchetta (2017) compared the AR (autoregressive), factor-augmented VAR, and quantile regression (QR) approaches to see which one is the best for tail forecasting. The most accurate forecasts were found for the case of QR case by combining the predictors (more than 160) into factors. The authors comment that this approach could be utilized in the EWM (early warning models) framework, as good signalling properties of selected predictors were found for bad GDP realizations.

Other aspects that could be developed and incorporated in MP stance evaluation are issues with macroprudential policy leakages (see Poghosyan, 2019, or Araujo et al., 2022 on leakages and spillovers). It is also expected that the GaR framework will become more prevalent in climate change analysis. Bayoumi et al. (2021) and Kiley (2021) already provide an introduction. As climate disasters are becoming more frequent, it would not be surprising to see more and more applications to see the effects on financial stability.

References

1. Adams, P. A., Adrian, T., Boyarchenko, N., Giannone, D. (2020). Forecasting Macroeconomic Risks, FRBNY Staff Reports, No. 914, Federal Reserve Bank of New York.
2. Adrian, T., Boyarchenko, N., Giannone, D. (2016). Vulnerable growth, FRBNY Staff Report, No. 794, Federal Reserve Bank of New York.
3. Adrian, T., Boyarchenko, N., Giannone, D. (2019). Vulnerable growth, American Economic Review, 109(4), pp. 1263-1289.
4. Adrian, T., Grinberg, G., Liang, N., Malik, S., Yu, J. (2018). The Term Structure of Growth-at-Risk, IMF Working Paper, WP/18/180. International Monetary Fund.
5. Adrian, T., Grinberg, G., Liang, N., Malik, S., Yu, J. (2022). The Term Structure of Growth-at-Risk American Economic Journal: Macroeconomics, 14(3), pp. 283-323.
6. Adrian, T., Morsink, J., Schumacher, L. B. (2020). Stress testing at the IMF, Vol. 2020: issue 6, International Monetary Fund.
7. Ahnert, T., Forbes, K., Friedrich, C., Reinhardt, D. (2021). Macroprudential FX regulations: Shifting the snowbanks of FX vulnerability?. Journal of Financial Economics, 140(1), pp. 145-174.
8. Aikman, D., Bridges, J. Burgess, S., Galletly, R., Levina, I., O'Neill, C., Varadi, A. (2018). Measuring risks to UK financial stability, BoE Staff Working Paper No. 738, Bank of England.
9. Aikman, D., Bridges, J., Hoke, S. H., O'Neill, C., Raja, A. (2019a). Credit, capital and crisis: a GDP-at-risk approach, Staff Working Paper No. 824, Bank of England.
10. Aikman, D., Bridges, J., Hoke, S. H., O'Neill, C., Raja, A. (2019b). How do financial vulnerabilities and bank resilience affect medium term macroeconomic tail risk? https://www.bde.es/f/webbde/INF/MenuHorizontal/SobreElBanco/Conferencias/2019/How_do_financial_vulnerabilites.pdf.
11. Akinci, O., Olmstead-Rumsey, J. (2015). How Effective are Macroprudential Policies? An Empirical Investigation. International Finance Discussion Papers, No. 1136, Board of Governors of the Federal Reserve System.
12. Akinci, O., Olmstead-Rumsey, J. (2018). How effective are macroprudential policies? An empirical investigation. Journal of Financial Intermediation, 33, 33- 57.
13. Alam, Z., Alter, A., Eiseman, J., Gelos, G. Kang, H., Narita, M., Nier, E., Wang, N. (2019). Digging Deeper – Evidence on the Effects of Macroprudential Policies from a New Database, IMF working papers, No. 2019/066, International Monetary Fund.
14. Alessandri, P., Del Vecchio, L., Miglietta, A. (2019). Financial conditions and growth at risk in Italy, Working Papers, No. 1242, Banca D'Italia.
15. Alessandri, P., Di Cesare, A. (2021). Growth-at-risk in Italy during the Covid-19 pandemic, Notes on Financial Stability and Supervision, No. 24, Banca D'Italia.
16. Álvarez, N., Fernandois, A., Sagner, A. (2021). Economic Growth at Risk: An Application to Chile, Working Papers of the Central Bank of Chile, No. 905, Central Bank of Chile.
17. Ampudia, M., Lo Duca, M., Farkas, M., Pérez-Quirós, G., Pirovano, M., Rünstler, G., Tereanu, E. (2021). On the effectiveness of macroprudential policy, ECB Discussion Paper, No. 2559 / May 2021. European Central Bank.

18. Araujo, J., Patnam, M., Popescu, A., Valencia, F., Yao, W. (2020), Effects of Macroprudential Policy: Evidence from Over 6,000 estimates" WP/20/67, IMF, May 2020.
19. Arslan, Y., Upper, C. (2017). Macroprudential frameworks: implementation and effectiveness, BIS Papers, No. 94, Bank for International Settlements.
20. Auerbach, A., Gorodnichenko, Y. (2013). Measuring the output responses to fiscal policy, Am. Econ. J. Econ. Pol., 4 (2), pp. 1-27.
21. Banco de España (2021). How do central banks identify risks? A survey of indicators, Documentos Ocasionales, No. 2125, Banco de España.
22. Bank of Japan (2018). Financial Stability Review. Bank of Japan.
23. Banque centrale du Luxembourg (2022). Financial Stability Review, Banque centrale du Luxembourg.
24. Bayoumi, T., Quayyum, S., Das, S. (2021). Growth at Risk from Natural Disasters (September 1, 2021). IMF Working Paper No. 2021/234, Available at SSRN: https://ssrn.com/abstract=4026436 .
25. Behncke, S. (2020). Effects of Macroprudential Policies on Bank Lending and Credit Risks, SNB Working Papers 6/2020, Swiss National Bank.
26. Belkhir, M., Ben Naceur, S., Candelon, B., Wijnandts, J-C. (2020). Macroprudential Policies, Economic Growth, and Banking Crises, IMF Working Paper, WP/20/65, International Monetary Fund.
27. Belkhir, M., Ben Naceur, S., Candelon, B., Wijnandts, J-C. (2022). Macroprudential policies, economic growth and banking crises. Emerging Markets Review, 53.
28. Bellemare, M.F., Masaki, T., Pepinski, T.B. (2017). Lagged Explanatory Variables and the Estimation of Causal Effect, The Journal of Politics, 79(3).
29. Beutel, J., Metiu, N., Schüler, Y., Emter, L., Prieto, E. (2022). The global financial cycle and macroeconomic tail risks, Discussion Paper Deutsche Bundesbank, No 43/2022, Deutsche Bundesbank.
30. Biljanovska, N., Chen, S., Gelos, R. G., Igan, D. O., Martinez Peria, M. S., Nier, E., Valencia, F. (2023). Macroprudential Policy Effects Evidence and Open Questions, IMF Deparmental Papers, No. 2023/002, International Monetary Fund.
31. Boar, C., Gambacorta, L., Lombardo, G., Pereira da Silva, L. (2017). What are the effects of macroprudential policies on macroeconomic performance? BIS Quarterly Review, September 2017, pp. 71-88, Bank for International Settlements.
32. Botehlo, V., Foroni, C., Renzetti, A. (2023) Labour at risk, ECB Working Paper Series, No. 2840, European Central Bank.
33. Boucherie, L., Budnik, K., Panos, J. (2022). Looking at the evolution of macroprudential policy stance: a growth-at-risk experiment with a semi-structural model. ECB Occasional Paper Series, No. 301, European Central Bank.
34. Boyarchenko, N., Favara, G., Schularick, M. (2022a). Financial Stability Considerations for Monetary Policy: Empirical Evidence and Challenges, Finance and Economics Discussion Series 2022-006. Washington: Board of Governors of the Federal Reserve System.
35. Boyarchenko, N., Giannone, D., Kovner, A. (2022b). Bank Capital and Real GDP Growth, Federal Reserve Bank of New York Staff Reports, no. 950, FED.

36. Brandao-Marques, L., Gelos, G., Narita, M., Nier E. (2020). A Cost-Benefit Analysis for an Integrated Policy Framework, QAS IMF Working Paper, WP/20/123, International Monetary Fund.
37. Brownlees, C., Souza, A. B. M. (2021). Backtesting global Growth-at-Risk, Journal of Monetary Economics, 118, pp. 312-330.
38. Buch, C. M., Vogel, E., Weigert, B. (2018). Evaluating macroprudential policies, Working Paper Series, No 76, European Systemic Risk Board.
39. Budnik, K., Dimitrov, I., Giglio, C., Gross, J., Lampe, M., Sarychev, A., Tarbe, M., Vagliano, G. and Volk, M. (2021). The growth-at-risk perspective on the systemwide impact of Basel III finalisation in the euro area, ECB Occasional Paper Series, No 258, European Central Bank.
40. Budnik, K., Kleibl, J. (2018). Macroprudential regulation in the European Union in 1995-2014: ntroducing a new data set on policy actions of a macroprudential nature, ECB working paper series, No. 2123. European Central Bank.
41. Budnik, K., Rünstler, G. (2022). Identifying structural VARs from sparse narrative instruments: dynamic effects of U.S. macroprudential policies, ECB working paper series, No. 2353, European Central Bank.
42. Busetti, F., Caivano, M., Delle Monache, D., Pacella, C. (2020). The time-varying risk of Italian GDP, Working Papers, No. 1288, Banca D'Italia.
43. Bussière, M., Cao, J., de Haan, J., Hills, R., Lloyd, S., Meunier, B., Pedrono, J., Reindhardt, D., Sinha, S., Sowerbutts, R., Styrin, K. (2022). The interaction between macroprudential policy and monetary policy: overview, BoE Staff Working Papers, No. 886, Bank of England.
44. Carney, M. (2020). The Grand Unifying Theory (and practice) of Macroprudential Policy, Speech given by Mark Carney, Governor of the Bank of England. Available at: https://www.bankofengland.co.uk/-/media/boe/files/speech/2020/the-grand-unifying-theory-and-practice-of-macroprudential-policy-speech-by-mark-carney.pdf
45. Cecchetti, S., Suarez, J. (2021). On the stance of macroprudential policy, Reports of the Advisory Scientific Committee, ESRB: Advisory Scientific Committee Reports 2021/11. European Systemic Risk Board.
46. Ćehajić, A., Košak, M. (2021). Tightening and Loosening of Macroprudential Policy, Its Effects on Credit Growth and Implications for the Covid-19 Crisis, Economic and Business Review, 23(4), pp. 207-233.
47. Central Bank of Ireland (2022). Financial Stability Review. Central Bank of Ireland
48. Cerutti, E., Claessens, S., Laeven, L. (2017). The use and effectiveness of macroprudential policies: New evidence, Journal of Financial Stability, 28(c), pp. 203-224.
49. Chari, A., Dilts Stedman, K., Forbes, K. (2021). Spillovers at the Exremes: The Macroprudential policy stance and Vulnerability to the Global Financial Cycle, kcFED Research Working Papers, No. RWP 21.16, Federal Reserve Bank of Kansas City.
50. Chari, A., Dilts-Stedman, K., Forbes, K. (2022). Spillovers at the extremes: The macroprudential stance and vulnerability to the global financial cycle, Journal of International Economics, 136, 103582.

51. Chavleishvili, S., Engle, R. F., Fahr, S., Kremer, M., Manganelli, S., Schwaab, B. (2021b). The risk management approach to macroprudential policy, ECB Technical Paper, No. 2565, European Central Bank.
52. Chavleishvili, S., Fahr, S., Kremer, M., Manganelli, S., Schwaab, B. (2021a). A risk management perspective on macroprudential policy, ECB Discussion Paper No. 2556, European Central Bank.
53. Chavleishvili, S., Kremer, M. (2023). Measuring systemic financial stress and its risks for growth, ECB Working Paper Series, No. 2842, European Central Bank.
54. Chavleishvili, S., Manganelli, S. (2019/2020). Forecasting and stress testing with quantile vector autoregression, ECB Working Paper, No. 2330, European Central Bank, revised in 2020.
55. Chicana, D., Nivin, R. (2021). Evaluating Growth-at-Risk as a tool for monitoring macro-financial risks in the Peruvian economy, Graduate Institute of International and Development Studies Working Paper, No. HEIDWP07-2021, Graduate Institute of International and Development Studies, Geneva.
56. Christiano, L. J., Eichenbaum, M., Evans, C. L. (1999). Chapter 2 Monetary policy shocks: What have we learned and to what end?, Handbook of Macroeconomics Vol. 1, Part A, pp. 65-148.
57. Cizel, J., Frost, J., Houben, A., Wierts, P. (2019). Effective Macroprudential Policy: Cross-Sector Substitution from Price and Quantity Measures, Journal of Money, Credit and Banking, 51(5), pp. 1209-1235.
58. Collard, F., Delias, H., Diba, B., Loisel, O. (2017). Optimal Monetary and Prudential Policies." American Economic Journal: Macroeconomics 9 (1), pp. 40–87.
59. Couaillier, C., Lo Duca, M., Reghezza, A., Rodriguez D'Acri, C. (2024). Caution: Do Not Cross! Distance to Regulatory Capital Buffers and Corporate Lending in a Downturn, Journal of Money, Credit and Banking, Early View.
60. Cucic, D., Framorze Møller, N., Georgieva Yordanova, I., Gade Søndergaard, S. (2022). Evaluating the macroprudential policy stance in a growth-at-risk framework, Economic Memo, No. 14, Danmarks Nationalbanks.
61. Davino, C., Furno, M., Vistocco, D. (2013). Quantile regression: theory and applications. John Wiley & Sons.
62. Davis, E.P., Karim, D., Noel, D. (2022). The effects of macroprudential policy on banks' profitability, 80, 101989.
63. De Lorenzo Buratta, I., Feliciano, M., Maia, D. (2022). How bad can financial crises be? A GDP tail risk assessment for Portugal, Working Papers, No. 04/2022, Banco de Portugal.
64. De Nicolò, G., Lucchetta, M. (2017). Forecasting Tail Risks, Journal of Applied Econometrics, 32(1), pp. 159-170.
65. De Santis, R. A., Van der Veken, W. (2023). Forecasting macroeconomic risk in real time: Great and Covid-19 Recessions, ECB Working Paper Seires, No. 2436, European Central Bank.
66. De Schryder, S., Opitz, F. (2019). Macroprudential policy and its impact on the credit cycle, Ghent University, Department of Economics, Working Paper.
67. De Schryder, S., Opitz, F. (2021). Macroprudential policy and its impact on the credit cycle, Journal of Financial Stability, Vol. 53, 100818.

68. Deghi, A., Katagiri. M., Shadid, S., Valckx, N. (2020). Predicting Downside Risks to House Prices and Macro-Financial Stability, IMF WP/20/11, International Monetary Fund.
69. Deutsche Bundesbank (2018). Financial Stability Review. Deutsche Bundesbank.
70. Deutsche Bundesbank (2021). Macroprudential policy and growth-at-risk. Monthly Report, July 2021, pp. 65-83.
71. Ding, X., Gross, M., Krznar, I., Lalitos, D., Lipinsky, F. Lukyantsau, P., Tressel, T. (2022). The Global Bank Stress Test, Departmental Papers (International Monetary Fund), DP/2022/009, International Monetary Fund.
72. Drenkovska, M., Volčjak, R. (2023). Growth-at-Risk and Financial Stability: Concept and Application for Slovenia, Discussion papers, No. 5, Banka Slovenije.
73. Duprey, T., Klaus, B., Peltonen. T. (2015). Dating systemic financial stress episodes in the EU countries, ECB Working Paper Series, No. 1873, European Central Bank.
74. Duprey, T., Ueberfeldt, A. (2018). How to Manage Macroeconomic and Financial Stability Risks: A New Framework. Staff Analytical Note, 2018-11, Bank of Canada.
75. Duprey, T., Ueberfeldt, A. (2020). Managing GDP tail risk. Bank of Canada working paper 2020–03, 1–63.
76. ECB (2014). Capturing the financial cycle in Euro Area countries, available at: Capturing the Financial Cycle in Euro Area Countries (europa.eu) .
77. ECB (2018). Database, available at: https://www.ecb.europa.eu/pub/research/working-papers/html/mapped.en.html
78. ECB (2018). MacroPrudential Policies Evaluation Database. Available at: https://www.ecb.europa.eu/pub/research/working-papers/html/mapped.en.html
79. ECB (2019). Financial Stability Report, European Central Bank.
80. ECB (2019). Financial Stability Review Issue 1. European Central Bank.
81. Eguren-Martin, F., O'Neill, C., Sokol, A., von dem Berge, L. (2021). Capital Flows-at-Risk: Push, Pull and the Role of Policy, ECB Working Paper, No. 2021/2538, European Central Bank.
82. Eller, M., Martin, R., Schuberth, H., Vashold, L. (2020). Macroprudential policies in CESEE – an intensity-adjusted approach, Focus on European Economic Integration, Oesterreichische Nationalbank (Austrian Central Bank), issue Q2/20, pp. 65-81.
83. Engle, R.F., Campos-Martins, S. (2020). Measuring and Hedging Geopolitical Risk, NIPE Working Papers 08/2020, NIPE - Universidade do Minho.
84. ESRB (2014). The ESRB Handbook on Operationalising Macro-prudential Policy in the Banking Sector, European Systemic Risk Board.
85. ESRB (2018). The ESRB Handbook on Operationalising Macro-prudential Policy in the Banking Sector, European Systemic Risk Board (newer version).
86. ESRB (2019a). Features of a macroprudential policy stance: initial considerations, European Systemic Risk Board.
87. ESRB (2019b). Methodologies for the assessment of real estate vulnerabilities and macroprudential policies: residential real estate, European Systemic Risk Board.
88. ESRB (2021). A framework for assessing macroprudential policy stance. Report of the Expert Group on Macroprudential policy stance – Phase II (implementation). European Systemic Risk Board.

89. Fernández-Gallardo, A. (2023). Preventing financial disasters: Macroprudential policy and financial crises, European Economic Review, 151, 104350.
90. Fernández-Gallardo, Á., Lloyd, S., Manuel, E. (2023). The transmission of macroprudential policy in the tails: evidence from a narrative approach, BoE Working Papers, No. 1027, Bank of England.
91. Fernández-Gallardo, A., Paya, I. (2020). Macroprudential Policy in the Euro Area. Working Papers 307121127, Lancaster University Management School, Economics Department.
92. Ferrara L., Mogliani M., Sahuc J.G. (2022). High-frequency monitoring of growth at risk. International Journal of Forecasting, 38(2), pp. 582-595.
93. Figueres, J. M., Jarocínski, M. (2020a). Vulnerable growth in the euro area: Measuring the financial conditions, ECB Working Paper, No. 2458, European Central Bank.
94. Figueres, J. M., Jarocínski, M. (2020b). Vulnerable growth in the euro area: Measuring the financial conditions, Economics Letters, No. 191, 109126.
95. Forbes, K. J., Klein, M. W. (2015). Pick your poison: the choices and consequences of policy responses to crises. IMF Economic Review 63(1), pp. 197–237.
96. Franta, M., Gambacorta, L. (2020). On the effects of macroprudential policies on Growth at Risk, Economics Letters, 196, 109501.
97. Furceri, D., Ganslmeier, M., Ostry, J. D., Yang, N. (2021). Initial Output Losses from the Covid-19 Pandemic: Robust Determinants. IMF Working Paper No. 2021/018, International Monetary Fund.
98. Furceri, D., Loungani, P., Zdzienicka, A., 2016. The effects of monetary policy shocks on inequality. Unpublished Working Paper WP/16/245. International Monetary Fund, Washington, DC.
99. Gächter, M., Geiger, M., Hasler, E. (2022). On the structural determinants of growth-at-risk, eeecon Working Papers in Economics and Statistics, No. 2022-06, University of Innsbruck.
100. Gai, P., Haworth, C. (2023). Macroprudential policymakers with cautious expectations, Economics Letters, 229, 111194.
101. Galán, J. E. (2020a). The benefits are at the tail: uncovering the impact of macroprudential policy on growth-at-risk, Documentos de Trabajo, No. 2007, Banco de España.
102. Galán, J. E. (2020b). The benefits are at the tail: uncovering the impact of macroprudential policy on growth-at-risk. Journal of Financial Stability, in press.
103. Galán, J. E., Rodríguez-Moreno, M. (2020). At-risk measures and financial stability, Revista de Estabilidad Financiera, 2020, No. 39, pp. 69-96, Banco de España.
104. Garcia Revelo, J. D. Lucotte, Y., Pradines-Jobet, F. (2020). Macroprudential and monetary policies: The need to dance the Tango in harmony, Journal of International Money and Finance, 108, pp. 102-156.
105. Gelos, G., Gornicka, L., Koepke, R., Sahay, R., Sgherri, S. (2022). Capital flows at risk: taming the ebbs and flows, Journal of International Economics, 134, 103555.
106. Gertler, M. (2020). Comment by Mark Gertler, comment on paper Plagborg-Møller, M., Reichlin, L. Ricco, G., Hasenzagl, T. (2020). When is Growth at Risk?, Brookings Papers on Economic Activity, 2020(1), pp. 167-229.

107. Giglio, S., Kelly, B., Pruitt, S. (2015). Systemic risk and the macroeconomy: An empirical evaluation. NBER working paper, No. 20963, National Bureau of Economic Research.
108. Giglio, S., Kelly, B., Pruitt, S. (2016). Systemic risk and the macroeconomy: An empirical evaluation. Journal of Financial Economics, 119(3), pp. 457– 471.
109. Glocker, C., Piribauer, P. (2021). The Determinants of Output Losses During the Covid-19 Pandemic, Economics Letters, 204, 109923.
110. Gondo, R. (2020). Vulnerabilidad financiera y escenarios de riesgo del PBI usando Growth at Risk (GaR), Serie de Documentos de Trabajo - Working Paper series, No. 2020-001, Banco Central de Reserva del Perú.
111. Górajski, M., Kuchta, Z. (2023). Coordination and non-coordination risks of monetary and macroprudential authorities: A robust welfare analysis, The North American Journal of Economics and Finance, Vol. 67, 101922.
112. Gurkov, M., Zohar, O. (2022). Growth at Risk: Forecast Distribution of GDP Growth in Israel, Discussion Paper 2022.08, Bank of Israel research department.
113. Hafemann, L. (2021). Prudential Policies in the Eurozone: A Propensity Score Matching Approach, MAGKS Papers on Economics 202109, Philipps-Universität Marburg, Faculty of Business Administration and Economics, Department of Economics (Volkswirtschaftliche Abteilung).
114. HNB (2023). Internal database of HIFS – Croatian index of financial stress.
115. HNB (2023). Online database Croatian National Bank, available at: www.hnb.hr
116. Hodula, M., Janků, J., Pfeifer, L. (2023). Macro-prudential Policies to Contain the Effect of Structural Risks on Financial Downturns, Journal of Policy Modelling, In Press.
117. IMF (2012). The interaction of monetary and macroprudential policies - background paper. Available at: The Interaction of Monetary and Macroprudential Policies--Background Paper; IMF Policy Papers; January 27, 2013.
118. IMF (2013). The Interaction of Monetary and Macroprudential Policies; IMF Policy Papers; January 29, 2013.
119. IMF (2017). Global Financial Stability Report. International Monetary Fund.
120. IMF (2022). Chapter 1 - Financial Stability in the New High-Inflation Environment, October 11, 2022, Global Financial Stability Report.
121. IMF (2022). Database, available at: https://www.elibrary-areaer.imf.org/Macroprudential/Pages/iMaPPDatabase.aspx.
122. IMF (2022). The Macroprudential Policy Survey. Available at: https://www.elibrary-areaer.imf.org/Macroprudential/Pages/Home.aspx.
123. Ivanova, A., Shmygel, A., Lubchuk, I. (2021). The Growth-at-Risk (GaR) Framework: Implication For Ukraine. IHEID Working Papers 10-2021, Economics Section, The Graduate Institute of International Studies.
124. Jones, M.D., McBeth, M.K. (2010). A Narrative Policy Framework: Clear Enough toBe Wrong?, The Policy Studies Journal, 28(2), pp. 329-353.
125. Jordà, Ò, Taylor, A. M. (2016). The Time for Austerity: Estimating the Average Treatment Effect of Fiscal Policy, The Economic Journal, 126(590), pp. 219–255.
126. Jordá, Ò., Schularick, M., Taylor, A. M. (2012). When Credit Bites Back: Leverage, Business Cycles, and Crises, San Francisco Fed, Working Paper No. 2011-27.

127. Jordá, Ò., Schularick, M., Taylor, A. M. (2013). When Credit Bites Back, Journal of Money, Credit and Banking, Supplement to Vol. 45, No. 2, pp. 3-28.
128. Kannan, P., Scott, A., Terrones, M. E. (2013). From Recession to Recovery: How Soon and How Strong, in: S. Claessens, M. A. Kose, L. Laeven, and F. Valencia, eds., Financial Crises, Consequences, and Policy Responses, Chapter 8, pp. 239-274.
129. Kiley, M.T. (2021). Growth at Risk from Climate Change (August, 2021). FEDS Working Paper No. 2021-54, Available at SSRN: https://ssrn.com/abstract=3907717.
130. Kim, S., Mehrotra, A. N. (2017a). Effects of Monetary and Macro-Prudential Policies – Evidence from Inflation Targeting Economies in the Asia-Pacific Region and Potential Implications for China. BOFIT Discussion Paper No. 4/2017.
131. Kim, S., Mehrotra, A. N. (2017b). Effects of Monetary and Macroprudential Policies—Evidence from Four Inflation Targeting Economies, Journal of Money, Credit and Banking, 50(5), pp. 967-992.
132. Kipriyanov, A. (2022). Comparison of Models for Growth-at-Risk Forecasting. Russian Journal of Money and Finance, 81(1), pp. 23–45.
133. Koenker, R. (2005). Quantile regression, Cambridge university Press.
134. Koenker, R. W., Bassett, G. (1978). Regression Quantiles. Econometrica, 46(1), pp. 33–50.
135. Koh, W. C., Ayhan Kose, M., Nagle, P. S., Ohnsorge, F. L., Sugawara, N. (2020). Debt and Financial Crisis, Policy Research Working Paper 9116, World Bank Group, Prospects Group.
136. Krygier, D., Vasi, T. (2021). Macrofinancial conditions, financial stability and economic growth in Sweden – evaluating the Growth-at-Risk framework, Staff Memo, Sveriges Riksbank.
137. Krygier, D., Vasi, T. (2022). Quantifying systemic risks with Growth-at-Risk, Staff Memo, Sveriges Riksbank.
138. Kupiec, P. (1995). Techniques for verifying the accuracy of risk measurement models, Journal of Derivatives, 2, pp. 173-184.
139. Kwark, N.-S., Lee, C. (2021). Asymmetric Effects of Financial Conditions on GDP Growth in Korea: A Quantile Regression Analysis, Economic Modelling, 94, pp. 351-369.
140. Laeven, L, A Maddaloni and C Mendicino (2022), "Monetary Policy, Macroprudential Policy and Financial Stability", ECB, Working Paper Series 2647.
141. Laeven, L., Valencia, F. (2012). Systemic Banking Crises Database: An Update. IMF Working Paper, No. WP/12/163, International Monetary Fund.
142. Landaberry, M. V., Lluberas, R. Vidal, M. (2021). Una aplicación de la metodología Growth at Risk a Uruguay, BCU Documento de Trabajo, No. 009-2021, Banco Central del Uruguay.
143. Lang, J. H., Forletta, M. (2019). Bank capital-at-risk: measuring the impact of cyclical systemic risk on future bank losses, ECB Macroprudential Bulletin 9, European Central Bank.
144. Lang, J. H., Forletta, M. (2020). Cyclical systemic risk and downside risks to bank profitability, ECB Working Paper Series, No. 2405, European Central Bank.
145. Lang, J. H., Rusnák, M., Greiwe, M. (2023). Medium-term growth-at-risk in the euro area, ECB Working Paper Series, No. 2808, European Central Bank.

146. Lang, J-H., Izzo, C., Fahr, S., Ruzicka, J. (2019). Anticipating the bust: a new cyclical systemic risk indicator to assess the likelihood and severity of financial crises. Occasional Paper Series, No 219. European Central Bank.
147. Lloyd, S., Manuel, E. (2023). Controls, Not Shocks: Estimating Dynamic Causal Effects in the Face of Confounding Factors. Mimeo: splloyd-econ.github.io/ID_LM_SWP.pdf.
148. Lloyd, S., Manuel, E., Panchev, K. (2022). Foreign vulnerabilities, domestic risks: the global drivers of GDP-at-Risk, BoE Staff Working Paper No. 940, Bank of England.
149. Lloyd, S., Manuel, E., Panchev, K. (2023). Foreign Vulnerabilities, Domestic Risks: The Global Drivers of GDP-at-Risk. IMF Econ Rev, International Monetary Fund.
150. López-Salido, D., Loria F. (2021). Inflation at Risk, FEDS Working Paper No. 2020-013, Finance and Economics Discussion Series, The Federal Reserve.
151. Lucas, R.E. (1972). Expectations and the Neutrality of Money. Journal of Economic Theory 4(1), pp. 103-124.
152. Martin, A., Mendicino, C., Van der Ghote, K. (2021). On the interaction between monetary and macroprudential policies, ECB working paper, No. 2527, European Central Bank.
153. Mathur, A., Naylor, M., Rajan, A. (2023). Creditable capital: macroprudential regulation and bank lending in stress. BoE Staff Working Paper, No. 1011, Bank of England.McCallum, B.T. (1999). Analysis of the Monetary Transmission Mechanism: Methodological Issues NBER Working Paper 7395.
154. Maziars, M. (2015). A review of the Granger-causality fallacy, The Journal of Philosophical Economics: Reflections on Economic and Social Issues, VIII(2), pp. 86-105.
155. McCracken, M. W., Ng, S. (2016). FRED-MD: A Monthly Database for Macroeconomic Research. Journal of Business and Economic Statistic, 34(4), pp. 574– 589.
156. Meuleman, E., Vander Vennet, R. (2020). Macroprudential policy and bank systemic risk, Working Papers of Faculty of Economics and Business Administration, No. 19-971, Ghent University, Belgium.
157. Morell, J., Rice, J., Shaw, F. (2022). A Framework for Macroprudential Stress Testing, vol. 2022, no. 7, Research technical paper, Central bank of Ireland.
158. Nier, Erlend W. and Kang, Heedon, Monetary and Macroprudential Policies – Exploring Interactions (September 2016). BIS Paper No. 86e
159. O'Brien, M., Wosser, M. (2021). Growth at Risk & Financial Stability, Financial stability notes, Vol. 2021, No. 2, Central Bank of Ireland.
160. O'Brien, M., Wosser, M. (2022). Assessing Structure-Related Systemic Risk in Advanced Economies, Research Technical Paper, Vol. 2022, No. 3, Central Bank of Ireland.
161. Oman, W. (2019). The Synchronization of Business Cycles and Financial Cycles in the Euro Area. International Journal of Central Banking, 15(1), pp. 327-362.
162. Ossandon Busch, M., Sánchez-Marínes, J. M., Rodríguez-Martínez, R., Martínez-Jaramillo, S. (2022). Growth at risk: Methodology and applications in an open-source platform, Latin American Journal of Central Banking, 3, 100068.
163. Papell, D. H., Prudan, R. (2011). The Statistical Behavior of GDP after Financial Crises and Severe Recessions, Paper prepared for the Federal Reserve Bank of Boston conference on "Long-Term Effects of the Great Recession," October 18-19.
164. Pearl, J. (2000). Causality: Models, Reasoning, and Inference. New York: Cambridge University Press.

165. Plagborg-Møller, M., Reichlin, L. Ricco, G., Hasenzagl, T. (2020). When is Growth at Risk?, Brookings Papers on Economic Activity, 2020(1), pp. 167-229.
166. Poghosyan, T. (2020). How effective is macroprudential policy? Evidence from lending restriction measures in EU countries, Journal of Housing Economics, Vol. 49, 101694.
167. Prasad, A., Elekdag, S., Jeasakul, P., Lafarguette, R., Alter, A., Xiaochen Feng, A., Wang, C. (2019). Growth at Risk: Concept and Application in IMF Country Surveillance. IMF Working Paper 36, International Monetary Fund.
168. Ramey, V.A. (2016). Chapter 2 - Macroeconomic Shocks and Their Propagation, Vol. 2, pp. 71-162.
169. Reichlin, L., Ricco, G., Hasenzagl, T. (2020). Financial variables as predictors of real growth vulnerability, Discussion Papers 05/2020, Deutsche Bundesbank.
170. Reinhart, C. M., Rogoff, K. S. (2009). This Time is Different: Eight Centuries of Financial Folly, Princeton Press.
171. Revelo, Levieuge (2022). When could Macroprudential and Monetary Policies be in Conflict? , Journal of Banking and Finance, 139, 106484.
172. Richter, B., Schularick, M., Shim, I. (2018 b). The macroeconomic effects of macroprudential policy, BIS working papers, No. 740, Bank for International Settlements.
173. Richter, B., Schularik, M., Shim, I. (2018a). The costs of macroprudential policy, NBER Working paper series, No. 24989, National Bureau of Economic Research.
174. Richter, B., Schularik, M., Shim, I. (2019). The costs of macroprudential policy, Journal of International Economics, 118, pp. 263-282.
175. Romer, C. D. and Romer, D. H. (2010) The macroeconomic effects of tax changes: estimates based on a new measure of fiscal shocks, American Economic Review, 100, pp. 763–801.
176. Romer, C., Romer, D. (1989). Does Monetary Policy Matter? A New Test in the Spirit of Friedman and Schwartz. NBER Macroeconomics Annual, 4, pp. 121–184.
177. Rosenbaum, P. R., Rubin, D.B. (1983). The Central Role of the Propensity Score in Observational Studies for Causal Effects. Biometrika. 70 (1), pp. 41–55.
178. Samarina, A., Zhang, L. Bezemer, D. (2017). Credit cycle coherence in the eurozone: Was there a euro effect?, Journal of International Money and Finance, Elsevier, vol. 77(C), pp. 77-98.
179. Sánchez, A. C., Röhn, O. (2016). How do Policies Influence GDP Tail Risks? OECD Economics Department Working Papers, No. 1339. Organisation for Economic Co-operation and Development.
180. Schüler, Y. (2020). The impact of uncertainty and certainty shocks. Bundesbank Discussion Paper, No. 2020/14, Deutsche Bundesbank.
181. Sekhon, J.S. (2009). Opiates for the Matches: Matching Methods for Causal Inference.Annual Review of Political Science 12, pp. 487-508.
182. Shanahan, E. A., Jones, M.D., McBeth, M.K., Radaelli, C.M. (2017). The narrative policy framework. In Theories of the policy process, ed. Christopher M. Weible, Paul A. Sabatier, 173–214. New York: Westview Press.
183. Signorini, L. F. (2022). An EU Legal Framework for Macroprudential Supervision through Borrower-Based Measures, Welcome address, Banca d'Italia, available at:

https://www.bancaditalia.it/pubblicazioni/interventi-direttorio/int-dir-2022/Signorini-23092022.pdf.
184. Škrinjarić, T. (2022). Introduction of the composite indicator of cyclical systemic risk in Croatia: possibilities and limitations, CNB Working Papers, No. W-68, Croatian National Bank.
185. Škrinjarić, T. (2023a). Introducing a composite indicator of cyclical systemic risk in Croatia: possibilities and limitations, Public sector economics, 47(1), pp. 1-39.
186. Škrinjarić, T. (2023b). Macroprudential stance assessment: problems of measurement, literature review and some comments for the case of Croatia, Croatian National Bank, forthcoming.
187. Škrinjarić, T., Bukovšak, M. (2022). New Indicators of Credit Gap in Croatia: Improving the Calibration of the Countercyclical Capital Buffer, CNB Working Papers, No. W-69, Croatian National Bank.
188. Škrinjarić, T., Sabol, M. (2023). Easier said than done: Predicting downside risks to house prices in Croatia, CNB working paper series, No. W-73, Croatian National Bank.
189. Škrinjarić, T., Sabol, M. (2024). Easier said than done: Predicting downside risks to house prices in Croatia, Czech journal of economics and finance, forthcoming.
190. Stein, J.C. (2013). Overheating in Credit Markets: Origins, Measurement, and Policy Responses. Speech at the Restoring Household Financial Stability after the Great Recession: Why Household Balance Sheets Matter research symposium sponsored by the Federal Reserve Bank of St. Louis, St. Louis, Missouri, February 17, 2013. https://www.federalre-serve.gov/newsevents/speech/stein20130207a.htm.
191. Stock, J.H., Watson, M.W. (2001). Vector Autoregressions, Journal of Economic Perspectives, 15(4), pp. 101–115.
192. Stokes, P.A., Purdon, P. L. (2017). A study of problems encountered in Granger causality analysis from a neuroscience perspective, Proceedings of the National Academy of Sciences of the United States of America, 114(34), pp. E7063-E7072.
193. Suarez, J. (2020). Growth-at-risk and macroprudential policy design, CEMFI and ESRB-ASC working paper, Center for Monetary and Financial Studies, European Systemic Risk Board Advisory Scientific Committee.
194. Suarez, J. (2021). Growth-at-risk and macroprudential policy design. ESRB Occasional Paper Series, No. 19. European Systemic Risk Board.
195. Suarez, J. (2022). Growth-at-risk and macroprudential policy design, Journal of Financial Stability, Elsevier, vol. 60(C).
196. Szabo, M. (2020). Growth-at-Risk: Bayesian Approach, Working Paper No. 3/2020, Czech National Bank.
197. Szendrei, T., Varga, K. (2023). Revisiting vulnerable growth in the Euro Area: Identifying the role of financial conditions in the distribution, Economics Letters 223, 110990.
198. Tillmann, P. (2015). Estimating the effects of macroprudential policy shocks: A Qual VAR approach, Economics Letters, 135, pp. 1-4.
199. Tölö, E., Laakkonen, H., Kalatie, S. (2018). Evaluating Indicators for Use in Setting the Countercyclical Capital Buffer. International Journal of Central Banking, 14(2), pp. 51-111.

200. Vandenbussche, J., Vogel, U., 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(S1):343–377.
201. Villar, A. (2017). Macroprudential frameworks: objectives, decisions and policy interactions, BIS Papers, No. 94, Bank for International Settlements.
202. Wang, Y., Yao, Y. (2001). Measuring Economic Downside Risk and Severity: Growth at Risk. Policy Research Working Paper, No. 2674. World Bank.
203. White, H., Kim, T-H., Manganelli, S. (2015a). VAR for VaR: measuring tail dependence using multivariate regression quantiles, ECB Working Paper Series, No. 1814, European Central Bank.
204. White, H., Kim, T-H., Manganelli, S. (2015b). VAR for VaR: Measuring tail dependence using multivariate regression quantiles, Journal of Econometrics, 187, pp. 169-188.

Table A1: Summary of empirical research on Growth-at-Risk

Authors	Country, timeframe	Variables	Methodology	MPI included?	MPI definition/ transformation	Additional info	Conclusion
Giglio et al. (2015, 2016)	USA and advanced economies, 1946(78,94)-2011	Financial stress indicators (a couple of dozen)	q-reg partial q-reg	No	-	Comparison of predictability of financial stress measures.	Financial sector stress predicts better future GaR, compared to other measures.
Sánchez and Röhn (2016)	OECD, 1970-2014 (differing over variables)	Several dozens of indicators for categories: financial market indicators, institutional quality, macroprudential indicators, labour market, external policies	panel q-reg	Yes	As in Cerutti et al. (2015): sum of individual measures in a quarter, ranging from 0 to 12	Endogeneity tackled with policy variable lags	Macroprudential policy lowers average growth, but decreases lower-tail risks, but newer data needs to confirm this.
De Nicolo and Lucchetta (2017)	US, 1972-2014	160 different variables tested	AR, factor augmented VAR, q-reg	No	-	-	This approach could be utilized in the EWM (early warning models) framework, as good signalling properties of selected predictors were found for bad GDP realizations.
Aikman et al. (2018)	UK, 1987-2018	Financial vulnerabilities indicators	q-reg, BVAR	No	-	Indicators are grouped into three meaningful groups, the idea is to have alternative approach to EWM.	Authors propose such approach for macroprudential policy decision making, and communication with public.
Prasad et al. (2018)	Peru 1997-2017 Portugal Singapore 1992-2017	Financial conditions, macro-financial vulnerabilities	q-reg	No	-	Paper presents GaR methodology, reasoning to use it, advantages	-

Authors	Country, timeframe	Variables	Methodology	MPI included?	MPI definition/ transformation	Additional info	Conclusion
Duprey and Ueberfeldt (2018)	Canada, 1992-2020	Alongside the usual ones, inflation, overnight policy rate	q-reg and VAR	Yes	Number of measures in given quarter	Both monetary and macroprudential policies considered.	Macroprudential policy lowers tail risk.
Aikman et al. (2019a,b)	16 AE, 1908-2017	Different specifications of credit growth information, house price growth, current account imbalances	panel q-reg	No, but banking sector leverage included	-	Leverage included, to see how capital requirements affects bank capital, thus, a quasi MPI included.	Greater capitalisation would reduce downside risks, especially before GFC.
Alessandri et al. (2019)	Italy, 1970-2018	IIP and Itacoin alongside usual GDP, different financial conditions variables tested	q-reg	No	-	Forward looking recession probability, and uncertainty indicator defined, useful for future work on this topic.	OOS forecasting is not stable over time, and risk assessment framework could use GaR just as one aspect
Chavleishvili & Manganelli (2019/2020)	EA, 1999-2018	CISS and IIP	QVAR	No	-	Developed structural QVAR model, shown how to perform basic stress test scenarios	Different results over different quantiles and horizons.
Plagborg-Møller et al. (2020)	13 AE, 1975(80) - 2019, focus on USA	A couple of dozens of individual variables that are grouped into categories via factor estimation	panel q-reg	No	-	Many forecasting and nowcasting exercises with a lot of predictor variables	Higher moments of the forecasted distribution are imprecise, no stable stylized facts are found in variable selection procedure, cross-country heterogeneity of results.
Duprey and Ueberfeldt (2020)	Canada, 1982-2018	As in Duprey and Ueberfeldt (2018), and credit dynamics	q-reg and VAR	Yes	Number of measures in given quarter	Both monetary and macroprudential policies considered. Theoretical analysis alongside empirical. Endogeneity solved with propensity score method for MPI.	Macroprudential policy lowers tail risk.

Authors	Country, timeframe	Variables	Methodology	MPI included?	MPI definition/ transformation	Additional info	Conclusion
Galán and Rodríguez-Moreno (2020)	27 EU, 1970-2019	Usual ones	panel q-reg	Yes	Cumulative over time	Robustness checked via replacing MPI with banks' solvency ratio (CET1 capital over RWA). HaR examined as well. Endogeneity issues not solved.	MPI increases GaR, decreases medium growth, i.e. trade-offs found.
Busetti et al. (2020)	Italy, 1970-2018	Besides the usual ones, EPU and PMI included	Expectile regression	No	-	Authors propose a decomposition of expected shortfall, for more insights about drivers of risk.	Financial conditions are useful for prediction, but deterioration of predictive power found at longer horizons.
Galán (2020a)	28 EU, 1970-2018	Instead of SRI, C2GDP 2y change, HPI 2y growth, CAB (%GDP)	panel q-reg	Yes	Cumulative over time	Endogeneity tackled with extracting non-systematic MPI by regressing it on other variables in the model. Problem here that the same period is used (MPI cannot react in the same period to these variables). Both financial cycle upswings and downswings included in the analysis. BBM and CBM measures observed separately.	Position of the financial cycle is important for MPI effectiveness.
Galán (2020b)	28 EU, 1970-2018	Instead of SRI, C2GDP 2y change, HPI 2y growth	panel q-reg	Yes	4-quarter net sum	Both financial cycle upswings and downswings included in the analysis. BBM and CBM measures observed separately. Robustness checking by dividing the sample to AE and EE). Endogeneity issue not solved.	Similar conclusions to Galán (2020a)
Franta and Gambacorta (2020)	56 countries, 1980-2012	Inflation, monetary policy interest rate	panel q-reg	Yes	No transformation, values take from -2 to 2	No financial stress and vulnerabilities included in the study.	LTV limits narrow the whole growth distribution.

Authors	Country, timeframe	Variables	Methodology	MPI included?	MPI definition/ transformation	Additional info	Conclusion
Brandao-Marques et al. (2020)	37 countries, 1990-2016	Besides FCI, inflation and credit growth, exchange rates, capital flows	panel q-reg	Yes	Range from -2 to 2	Macroprudential policy endogeneity issue tackled with ordered probit regression residuals extraction. Proposition of estimation of loss-functions of different policies.	Estimated trade-offs are in favour of using macroprudential policy, whereas monetary policy alone is unfavourable.
Figueres and Jarocínski (2020a,b)	Euro area, 1986-2018	Different specifications of financial conditions	q-reg	No	-	-	Financial conditions predict shifts of the lower tail of future growth distribution
Adams et al. (2020)	USA, 1971-2018	Unemployment, FCI, inflation	q-reg	No	-	Besides growth, inflation and unemployment are forecasted	Financial conditions predict growth and unemployment better than inflation
Gondo (2020)	Peru, 1997-2018	Financial risk measures: leverage, asset prices, VIX	q-reg	No	-	Including such variables improves growth's lower tail forecasting, especially in the case of GFC. Such results are already stylized facts in literature	
Szabo (2020)	Czech 2004-2018	Financial conditions, financial cycle indicator, banking prudence indicator, GEPU	q-reg, Bayes q-reg	No	-	Focus on forecasting capabilities of models	Bayes model outperforms others
Landaberry et al. (2021)	Uruguay 1999-2019	FII	q-reg	No	-	-	Good forecasting capability of FII
Kwark & Lee (2021)	Korea, 1996-2018	FCI	q-reg	No	-	-	FCI have good forecasting properties
Álvarez et al. (2021)	Chile, 1994-2020	FCI	q-reg	No	-	-	FCI have good forecasting properties

Authors	Country, timeframe	Variables	Methodology	MPI included?	MPI definition/ transformation	Additional info	Conclusion
Chicana & Nivin (2021)	Peru, 2005-2020	A couple of dozen variables from credit and financial markets, external financial conditions, financial strength	q-reg, VAR-X	No	-	Several variations of empirical distribution fitting, and forecasting capability testing	Kernel density estimation and mixture of normal probability density functions best ones in forecasting. VAR-X for counterfactual analysis
O'Brien & Wosser (2021)	27 OECD countries, 1990-2020	CLIFS, ISCR for Ireland; C2GDP gap	panel q-reg	No	-	GNI instead of GDP for Ireland (see main text); 5th percentile	Good for forecasting, advising to use for HaR and other applications
Ivanova et al. (2021)	Ukraine, 1996-2020	23 financial variables, grouped via PCA for forecasting purposes in the next step; GEPU	q-reg	No	-	Included variables that were good predictors of crises via EWM approach in previous literature	Results as previous literature on better growth predictability.
Alessandri & Di Cesare (2021)	Italy, 1970-2020	Same as Alessandri et al. (2019)	q-reg	No	-	Continuation of Alessandri et al. (2019), to see performance over Covid-19 period	Historical descriptions are fine, but forecasts need to be scrutinized.
Deutsche Bundesbank (2021)	Panel (44 countries), and Germany, 1970-2019(21)	Besides usual variables, US excess bond premium, inflation, interest rate	QVAR, panel q-reg	No	-	-	Publication finds it difficult to make real-time estimates of GaR with a longer lead time.
Brownlees & Souza (2021)	24 OECD countries, 1961Q1 to 2019Q1	National financial conditions index, credit to GDP gap, growth, term spread, housing prices, world uncertainty index, stock variance, credit spread, geopolitical risk index	q-reg and GARCH	No	-	Backtesting both approaches shows that quantile regression and GARCH forecasts have a similar performance, with GARCH(1,1) having more accurate results.	-

Authors	Country, timeframe	Variables	Methodology	MPI included?	MPI definition/ transformation	Additional info	Conclusion
Krygier & Vasi (2021, 2022)	Sweden, 1995-2021	SRI, FCI (Swedish version)	q-reg	No	-	-	Results as previous literature on better growth predictability. Authors warn about problems of Covid-19 period predictability.
Drenkovska & Volčjak (2022)	Slovenia, 2003-2020	Usual variables, with external macroeconomic conditions	q-reg	Yes	Cumulative over time	Authors warn about shortfalls of using such defined MPI. Own version of financial conditions variable. Endogeneity issues not solved.	Usual conclusion about effects of financial conditions and vulnerabilities. MPI not significant.
De Lorenzo Buratta et al. (2022)	Portugal, 1991-2019	Usual variables	q-reg	No	-	In and oos forecasts, expected shortfall estimated, expected longrise, entropy, probability of entering recession	Proposed measures could be useful for forecasting, and complementary to GaR.
O'Brien & Wosser (2022)	27 OECD, 1090-2020	Structural: degree of trade, financial openness, FDI flows, and bank concentration	panel q-reg	No	-	Systemic banking crisis likelihood estimated as well.	Smaller, open economies with greater FDI flows are more vulnerable.
Ossandon Busch et al. (2022)	5 Latin American countries, 1990-2020	Financial conditions, VIX	panel q-reg	No	-	Paper popularizes the online platform developed for GaR estimation, and gives introduction to this topic.	-
Cucic et al. (2022)	Denmark, 1982-2022	SRI, BBM MPI and CBM MPI	q-reg	Yes	Not specified	Financial conditions are not included in the analysis.	BBM measures shift the whole future distribution right, whereas CBM measures increase GaR, and lower median growth. However, nothing is stated about endogeneity of MPI variables.

Authors	Country, timeframe	Variables	Methodology	MPI included?	MPI definition/ transformation	Additional info	Conclusion
Gächter et al. (2022)	24 European countries 1999-2019	Structural factors	Panel q-reg	No	-	-	Trade openness, financial sector size, public spending ratio and government effectiveness most important structural factors that determine differences between GaR levels and reactions to shocks in these variables.
Kipriyanov (2022)	USA, 1971-2020	Macro and financial variables: FCI, term spreads, stock returns, credit gap, inflation, etc.	q-reg, GARCH, quantile forest	No	-	Different model specifications contrasted to find best forecasting ones. Covid-19 period tested in recursive forecasts	Quantile regression found best, in sample and in out of sample forecasts of Covid-19 period.
Lloyd et al. (2022, 2023)	AE, 1981-2018	Domestic and foreign FCI and financial vulnerabilities	Panel q-reg	No, but capital ratio included	-	Capital ratio as a resilience variable included	Foreign factors have greater predictive power to domestic ones.
Gurkov & Zohar (2022)	Israel, 1990Q1-2019Q4.	17 macro financial variables	q-reg	No	-	Contrast to other previous findings, the future GDP growth distribution here is found to be symmetric	Forecast uncertainty rises when median forecast decline
Fernández-Gallardo et al. (2023)	12 advanced economies, 1990Q1 to 2017Q4	YoY credit growth, CPI inflation, US VIX	Panel q-reg	Yes	Number of measures in a given quarter, intensity adjustment	Macropru has near-zero effects on the median growth, but also brings benefits by reducing the variance of future GDP growth, significantly and robustly boosting the left tail while simultaneously reducing the right.	Intensity adjustment to MPI done.

Authors	Country, timeframe	Variables	Methodology	MPI included?	MPI definition/ transformation	Additional info	Conclusion
Lang et al. (2023)	19 euro area countries, 1970Q1 - 2020	CLIFS, DSR, CISS, bank credit to GDP gap, d-SRI, total credit to GDP gap, ESI	Panel q-reg	No	-	Contrasting several measures of financial stress and vulnerabilities to see which ones perform the best.	Typical results as found in other related papers.
Škrinjarić (2023b)	Croatia, mid 1990s to 2022Q2	CLIFS, HISS, different financial vulnerability measures	q-reg	Yes	Number of measures in a given quarter	Additional cleaning of the MPI variable, testing different variable specifications	Results depend on the definition of variables. Warns about data sources.
Szendrei & Varga (2023)	EA, 2003Q1 to 2019Q3	HY bond spread, Bank bond spread, Loan growth, TED spread, Term spread, Soverign spread, VSTOXX CISS	q-reg, AdaLASSO	No	-	Authors suggest that when modelling Euro Area Growth-at-Risk, one should opt for a selection of bank variables, rather than solely relying on the CISS	-
Chavleishvili & Kremer (2023)	EA, US	PMI, financial stress	Q-VAR	No	-	Good short term forecasting properties of financial stress indicator	-

Note: real GDP growth is not stated as a variable, as it is the main dependent variable in studies. CLIFS – country level index of financial stress, ISCI – index of systemic cyclical risk, C2GDP – credit to GDP, GNI – gross national income, AE – advanced economies, EWM – early warning model, GEPU – geopolitical economic policy uncertainty, OECD – Organisation for Economic Cooperation and Development, MPI – macroprudential policy indicator, GFC – global financial crisis, SRI – systemic risk indicator, FCI – financial conditions index, IIP – index of industrial production, OOS – out of sample, EPU – economic policy uncertainty, PMI – purchasing managers index, CET – capital equity tier, RWA – risk weighted assets, CAB – current account balance, BBM – borrower based measures, CBM – capital based measures, HPI – house price index, EU – European Union, EE- emerging economies, QVAR – quantile vector autoregression, FDI – foreign direct investment, LTV – loan to value, VIX – volatility index, BVAR – Bayesian VAR, FII – financial instability index, CISS – composite indicator of systemic stress, GARCH – generalized autoregressive conditional heteroscedasticity, DSR – debt service ratio, ESI – Economic Sector Indicator, HISS – Croatian index of financial stress.

Table A2: Summary of research with important findings related to Growth-at-Risk

Authors	Country, timeframe	Variables	Methodology	MPI included?	MPI definition/ transformation	Additional info	Conclusion
Boar et al. (2017)	64 countries (AE and EE), 1990-2014	Financial development, openness, independence of supervisory authority	Dynamic panel	Yes	Log of 5y sum of number of changes of MPI measures in a given country.	GDP per capita growth it on a 5y non-overlapping basis. Interaction between some variables included. Endogeneity of MPI tackled with first-step regression of this variable (but no lags in the model).	The greater the macroprudential activity, the higher and less volatile GDP per capita growth is.
Kim & Mehrotra (2017, 2018)	4 Asia Pacific 2000-2012	GDP, interest rates, consumer prices, stock of credit	Panel VAR	Yes	Cumulative MPI, as all other variables are in levels	-	Both policies (monetary and macroprudential) have negative effects on growth, inflation and credit dynamics
Richter et al. (2018a, 2019)	56 countries, 1990-2012	Inflation and policy rate changes. No financial conditions and vulnerabilities	Panel regression, local projections	Yes	LTV limits observed as MPI actions; no cumulation of values	Endogeneity of policy tackled by excluding those measures that had real activity as goals in announcements. Intensity adjusted MPI values as well. However, this could be subjective.	Tightening of LTV has greater effects on real activity, compared to loosening.
Belkhir et al. (2020, 2022)	100 countries, 2000-2017	Financial development index, GDP growth, debt-to-GDP, capital account openness, trade-to-GDP	Discrete dynamic panel regression, panel regression	Yes	Values of MPI from 0 to 12, based on Cerutti et al. (2017)	When data divided based on AE and EE, greater results obtained for EE.	Benefits of macroprudential policy outweighs costs. BBM measures more effective than financial-based tools.
Chari et al. (2021)	66 countries (AE and EE)	Many variables, such as inflation, openness, policy rate, REER growth	Panel regression, panel q-reg	Yes	Different transformations based on type of policy	Endogeneity of policy tackled by regressing MPI on other variables in the model, with one period lag	Different policies have different impacts over the financial cycle.
Ampudia et al. (2021)	11 EU countries, 1998-2017	GDP growth, inflation capital requirements, LTV ratios, other BBM measures	Panel VAR	Yes	MPI included in form of +1/-1	MPI not directly included in VAR, rather, policy shocks obtained from the proxy VAR approach	BBM measures more effective than CBM ones, longer lags for policy to have effect.

Authors	Country, timeframe	Variables	Methodology	MPI included?	MPI definition/ transformation	Additional info	Conclusion
Beutel et al. (2022)	44 counties, 1980-2018	US financial conditions and interest rates	QVAR	No	-	Additional analysis on QIRFs based on country-specific characteristics to see what affects transmission of US shocks to other countries' GaRs.	Both US financial conditions and monetary policy shocks are important in GaR forecasting of other countries in the study.

Note: Note: real GDP growth is not stated as a variable, as it is the main dependent variable in studies. CLIFS – country level index of financial stress, ISCI – index of systemic cyclical risk, C2GDP – credit to GDP, GNI – gross national income, AE – advanced economies, EWM – early warning model, GEPU – geopolitical economic policy uncertainty, OECD – Organisation for Economic Cooperation and Development, MPI – macroprudential policy indicator, GFC – global financial crisis, SRI – systemic risk indicator, FCI – financial conditions index, IIP – index of industrial production, OOS – out of sample, EPU – economic policy uncertainty, PMI – purchasing managers index, CET – capital equity tier, RWA – risk weighted assets, CAB – current account balance, BBM – borrower based measures, CBM – capital based measures, HPI – house price index, EU – European Union, EE- emerging economies, QVAR – quantile vector autoregression, FDI – foreign direct investment, LTV – loan to value, VIX – volatility index, BVAR – Bayesian VAR, FII – financial instability index, CISS – composite indicator of systemic stress, GARCH – generalized autoregressive conditional heteroscedasticity.

Table A3: Summary of theoretical work on macroprudential policy stance definition

Authors	Basis	Conclusion
Suarez (2020, 2021, 2022)	Social welfare: $W = \bar{y} - 0{,}5w(\bar{y} - y_c)^2$, where w>0 is the aversion for financial instability, $\bar{y}$ is the average or median growth, and y_c is the relevant quantile (GaR) of growth; and W is maximised with respect to risk level x, median and GaR growth depending on x, and a macroprudential policy variable z (which is assumed to be exogenous	The solution to the optimisation problem yields an optimal policy that keeps the gap between the median and the GaR constant at a certain target level, which depends on w and the relative impact of the policy z on the GaR compared to the median growth. Comparative statics shows that the higher the risk aversion, the smaller the optimal distance between median and GaR growth values is.
Cecchetti and Suarez (2021)	Continuation of work of Suarez (2020, 2021, 2022). define MP stance as the difference between the observed distance between median and GaR growth $(\bar{y} - y_c)_o$, and the optimal distance $(\bar{y} - y_c)$*: $MP\_stance = (\bar{y} - y_c)_o - (\bar{y} - y_c)$*	As the optimal distance is derived from the optimization process, it depends on three factors: benchmark probability of stress, risk aversion, and the relative impact of policy on GaR compared to median growth. One can see that even if we solve all of the empirical problems of measuring the observed difference between median and GaR growth, there still exists a challenge in how to estimate the optimal difference, as it depends on the risk aversion of the policymaker.
Duprey and Ueberfeldt (2020)	Building upon Suarez (2020, 2021, 2022) and Cecchetti and Suarez (2021).	Policymaker that balances between monetary and macroprudential policy. Derived indifference curves indicate that there exists a substitution effect between policies. When monetary policy rates are high (low), capital adequacy ratios need to be relaxed (tightened).
Chavleishvili et al. (2021a)	Dynamic utility optimization problem. Prudential policy maker has the following objective function: $\sum_{h=1}^{H}(\beta^h(E_t(y_{t+h}) + \lambda GS^{\tau}_{t,t+h}))$, where $\lambda > 0$ is the risk aversion parameter, $0 < \beta < 1$ is the intertemporal discount factor, τ is the selected quantile, and (4) observes the sum of discounted future expected growth and penalisation of downside risks (GS – growth shortfall).	If the policymaker would estimate the utility he obtains from an active MP and compares it to a passive policy (i.e. case when he does not act accordingly), then the MP stance would be defined as: $MP\_stance = U^*_{active} - U^*_{passive}$.
Gai and Haworth (2023)	Introduce cautious[14] expectations of a policymaker, which means that newly obtained information (signal) biases expectations based on historical dependence but reduces forecast volatility.	Resulted MP efficiency trade-off between median and GaR growth is reduced, and in the end, the policymaker pursues looser policy stance. For more related work, see Górajski and Kuchta (2023).

[14] Definition of a cautious expectation is as follows (Gai and Haworth, 2023): An agent exhibits caution to signal j iff the weight on the jth signal X_{jt} in the expectation $f_t Y_{t+k} = X'_t\hat{\beta}$ satisfies $E[\hat{\beta} \mid X_t] = m_j(X_t)\beta_j$ when $\beta_j \neq 0$, where $m_j \in [0, 1)$, where hats indicate cautious estimation.

Table A4: MPI data sources and comparisons

Name	Source	Coverage	Information
The integrated Macroprudential Policy (iMaPP)	Link ; IMF	184 economies	Updated annually
The Macroprudential Policies Evaluation Database (MaPPED)	Link; ECB	EU countries	Updates ended in 2018
Macroprudential measures	Link: ESRB	EEA countries	Updated based on national authorities' submissions
Cerutti et al. (2015) database	Link	64 countries	Updates ended in 2021

Note: other databases and more details can be found in Alam et al. (2019), see table 4 in Appendix I.

Table A5: List of some of the variables used in empirical modelling

Financial conditions or stress	Financial vulnerabilities	Structural and other factors
VIX	External debt	World growth
Bank lending standards	Credit to GDP gap	Growth of bigger economies
Term premiums	Credit growth	Energy prices
Interest rates	House price growth	Stock indexes
Financial conditions index	House prices relative to	exchange rates,
Bond returns	fundamentals	Supply Management indexes
Bond yield spreads	Current account deficit	Employment
CDS spreads	Corporate leverage	Unemployment
Equity returns	Household debt to GDP	Monetary aggregates
CLIFS	Solvency and leverage of credit	Industrial production
HY bond spread	institutions	CPI
Bank bond spread	Composite indicators of	Producer price index
Loan growth	variables above	Housing permits
TED spread	Debt service ratio	Personal consumption
Term spread		Real personal income
Sovereign spread		Economic Sentiment Indicator
VSTOXX		Size of the economy
CISS		Degree of trade
Eonia		Financial openness
FED rate		FDI (foreign direct investment) flows
		Bank concentration
		Government revenues as a share of GDP
		Financial reform index
		Development in the security markets
		Privatisation of the banking sector
		Government effectiveness
		Control of corruption
		Rule of law
		Exports, imports

Source: author's compilation based on the literature review