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ORIGINAL PAPER

Impact of macroprudential policy on economic growth in Indonesia: a growth-at-risk approach

Raluca Maran[1]

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Abstract
Macroprudential policy yields important benefits in terms of preventing and mitigating systemic risk, but it can also have an impact on economic growth, particularly on the left tail of the growth distribution. In this context, policymakers need to consider the effects of macroprudential policies on the entire growth distribution, and not only on average growth. The growth-at-risk (GaR) approach represents a useful framework for such an assessment. This paper describes the use of the GaR method and illustrates its implementation for assessing the impact of macroprudential policy on GaR in Indonesia. As a first step, I select 26 macrofinancial variables that are relevant for the Indonesian economy and build three partitions that capture financial conditions, macrofinancial vulnerabilities and other relevant factors. Results from quantile regressions have important policy implications, suggesting that an early tightening of macroprudential policy would reduce downside risks to Indonesia's gross domestic product (GDP) growth by increasing the resilience of the financial system. Results further show that a materialization of risk, stemming from either a loosening of financial conditions, an increase of macrofinancial vulnerabilities or a deterioration of the macroeconomic environment have important effects on Indonesia's GDP growth distribution and particularly on the left tail of the distribution, which represents the GaR. Under each of these scenarios, a tightening or loosening of the macroprudential stance, depending on the underlying vulnerabilities, yields high benefits in terms of improving Indonesia's GaR, which range from 0.06 and 0.14 percentage points.

Keywords Growth-at-risk · Growth distribution · Macrofinancial vulnerabilities · Macroprudential policy · Quantile regression

JEL Classification C21 · C22 · E27 · E58 · E61 · G18

✉ Raluca Maran
maran.raluca1@gmail.com

1 Paris, France

1 Introduction

Macroprudential policy has become an important policy area in the aftermath of the global financial crisis of 2007–08 (GFC). While the benefits of macroprudential policies in safeguarding financial stability have been extensively documented in the specialized literature, the impact of these policies on economic growth is more debatable. Policymakers therefore need to assess the costs and benefits associated with the implementation of macroprudential policy in a holistic manner. New empirical approaches have emerged in recent years to quantify the impact of macroprudential policy. Among these is the "growth-at-risk" (GaR) approach, developed by Adrian et al. (2019) as a tool for evaluating the impact of financial risks on economic growth, using a tail-risk approach known as GaR, which is equivalent to the value-at-risk (VaR) concept in finance. The interest of the GaR method lies in the fact that it can be easily augmented with a proxy for macroprudential policy (or any other type of policy) in order to capture its impact on the entire distribution of economic growth.

The GaR of an economy over a given horizon can be defined as a low quantile of the distribution of the projected gross domestic product (GDP) growth rate (i.e., 5% or 10%) over this horizon. This approach uses quantile regression methods to keep track of the distortion of the entire GDP growth distribution in response to developments in explanatory variables and therefore distinguishes itself from the standardized macroeconomic focus on the expected value of aggregate output growth. Put differently, quantile regressions capture the non-linear nature of the relation between variables. Additionally, the GaR focuses on the severity of potential adverse outcomes by looking at the low quantiles of the GDP growth distribution, in particular the 5th quantile.

My paper is motivated by the growing attention paid to the GaR approach in the assessment of macroprudential policies' impact on economic growth. Understanding the interlinkages between macroprudential policies and GDP growth can help the relevant authorities make informed decisions and fine-tune their policy frameworks accordingly. Second, Indonesia is an emerging market with a rapidly growing economy, being one of the largest economies in the Association of Southeast Asian Nations (ASEAN). As such, it is essential to investigate the specific factors that influence its GDP growth. Furthermore, Indonesia has experienced several financial crises in the past, with banking crises in 1992, 1994, 1997, 1998, 1999, 2000, 2001 and 2002 (Harvard Business School, 2023). This aspect makes it even more important to explore the role of macroprudential policy in mitigating such risks in Indonesia.

My paper makes several incremental contributions to the existing literature. First, the paper focuses specifically on the case of Indonesia, which is an important emerging market economy. Despite the growing popularity of the GaR method in assessing macroprudential policies, there are relatively few applications of it to emerging market economies, let alone to Indonesia. This paper attempts to fill this void by looking into the application of GaR to the Indonesian context. Second, the paper employs a comprehensive set of macrofinancial indicators relevant to the Indonesian economy (i.e., both internal and external factors) to explore the links between macroprudential policies and GaR. This adds to the existing literature by offering a rigorous and systematic framework for studying the effects of macroprudential policy on economic growth. Furthermore, the paper contributes to the literature by investigating the long-term effects of macroprudential policy on GaR. While previous studies have primarily focused on short-term effects, this research extends the analysis to consider the linkages between macroprudential policy measures and GaR over a longer time horizon. My paper therefore makes an important contribution to the macroprudential policy literature. Its findings can inform policymakers, researchers, and other stakeholders in their efforts to design and implement effective macroprudential policies that contribute to financial stability and economic growth.

Using 26 macrofinancial variables that are relevant for the Indonesian economy, I describe in detail the use of the GaR method and illustrate its use for assessing the impact of macroprudential policy on the entire GDP growth distribution in Indonesia. In the first step, I use factor analysis and group the 26 variables into three broad partitions of economic similarity, namely: financial conditions, macrofinancial vulnerabilities and other relevant factors. In the second step, I apply the quantile regressions to quarterly data spanning the second quarter of 2005 to the second quarter of 2022. I subsequently propose several applications to highlight the interest of the GaR approach, looking at how the implementation of macroprudential policy can alter the GDP growth distribution under different stress scenarios.

Results show that a materialization of risk, in the form of either an easing of financial conditions, an increase of macrofinancial vulnerabilities or a deterioration of the macroeconomic environment have important effects on the distribution of Indonesia's GDP growth. These effects are particularly acute on the left tail of the distribution, namely on the GaR. A substantial easing of financial conditions, a large increase of macrofinancial vulnerabilities, or a substantial deterioration in the macroeconomic environment all shift Indonesia's GDP growth distribution to the left. Under each of these scenarios, a tightening or loosening of the macroprudential stance, depending on the nature of the underlying vulnerabilities, yields high benefits in terms of improving GaR. Another important finding is that an early tightening of macroprudential policy would reduce downside risks to GDP growth by increasing the resilience of the financial system. Finally, I undertake a series of robustness exercises, firstly with an alternative definition of the macroprudential policy variable to account for potential endogeneity, secondly with a proxy for the dependent variable GDP growth, thirdly with additional control variables, and finally including lags of the dependent variable. All of these exercises underpin the validity of the baseline results presented in the paper.

The results carry several implications for policymakers in Indonesia, the comprehensive set of macrofinancial variables considered in the analysis allowing for a detailed assessment of risk sources. First, the results call for an early tightening of macroprudential policy when risks materialize to reduce the downside risks to GDP growth in the mid- to long-term. Moreover, I show how the macroprudential stance should respond to specific types of macrofinancial risks and interactions thereof. It is recommended that the macroprudential stance be tightened when financial conditions become very loose and the macroeconomic environment is strong. In addition, the results advocate for a tightening of the macroprudential stance when macrofinancial vulnerabilities become substantial amid an expansionary macroeconomic environment. Finally, I also conclude that a macroprudential policy tightening is beneficial when the macroeconomic environment improves considerably, because such an expansion could lead to the accumulation of macrofinancial vulnerabilities in the mid- to long-term.

The rest of the paper is organized according to the following structure. Section 2 provides a brief review of related literature. Section 3 presents the macrofinancial and macroeconomic data used for the construction of the partitions included in the GaR analysis, as well as the macroprudential policy index. It also outlines the empirical approach based on quantile regressions. Section 4 reports the quantile regression results and presents different simulations on the macroprudential policy impact on Indonesia's GDP growth distribution. Section 5 concludes the paper and discusses some implications for Indonesian policymakers.

2 Literature review

2.1 Interlinkages between macrofinancial imbalances and economic growth

In principle, macrofinancial imbalances may affect economic growth through different channels in any one direction. These vulnerabilities can arise from various factors such as excessive debt levels, asset price bubbles, or structural weaknesses in the financial system. There are five potential channels through which these imbalances can affect economic growth.

The first possible transmission mechanism is through the credit channel. An accumulation of macrofinancial imbalances, for instance through excessive borrowing or high debt levels, can lead to a tightening of lending standards. This means that banks and other financial institutions may become more risk-averse in their lending practices, which can restrict access to credit for households and firms (Del Giovane et al., 2011; Van der Veer & Hoeberichts, 2016; Gete, 2018). Private consumption and investment decline as a result, in turn leading to a slowdown in economic growth.

The second potential channel is the asset price one. Macrofinancial imbalances can result in the mispricing of assets, such as stocks or real estate. A speculative bubble in these markets can result in a sudden correction or crash, leading to a significant decline in asset values. This can have negative wealth effects, as households and firms see the value of their assets decline. As a result, consumer and business confidence may be eroded, thus reducing spending and investment, which in turn dampens economic growth (Blanchard, 1993; Carroll et al., 1994; Guo & He, 2020; Ozturk & Stokman, 2019).

The third is the balance sheet channel. There is a great deal of empirical evidence that macrofinancial imbalances can put strain on the balance sheets of households, firms, and financial institutions. For example, highly indebted households that have difficulties in repaying debt may need to cut back on spending, which can reduce aggregate demand and economic growth (Debelle, 2004; Dynan et al., 2012; Kukk, 2016). Similarly, firms that have excessive debt burdens may need to reduce investment or even face bankruptcy, leading to job losses and further economic contraction (Gebauer et al., 2018; Kalemli-Ozcan et al., 2022; Pal & Ferrando, 2010). Furthermore, a fragile and unstable banking sector can also severely disrupt economic growth. If banks are highly leveraged, face liquidity issues, or are confronted with an increase in non-performing assets, they may reduce lending to household and businesses, hampering consumption and investment, which in turn depresses economic growth (Fell et al., 2018; Kim & Sohn, 2017; Sanchez Serrano, 2021; Tolo & Viren, 2021).

The fourth channel is the fiscal policy one, as macrofinancial imbalances may also have a negative impact on fiscal sustainability. Excessive debt levels or financial instability can strain public finances, as the need for bailouts or stimulus measures may arise. This can result in increased political instability, higher public debt levels, increased borrowing costs, and lower fiscal space for productive investments, ultimately impeding economic growth (Dovis & Kirpalani, 2020; Prein & Scholl, 2021).

The fifth and last channel stems from cross-border spillover effects. Numerous studies have shown that a financial crisis or a sharp economic downturn in one country can have cross-border contagion effects, negatively impacting trade, investment, and financial flows with other countries. These shocks are mainly transmitted to other countries through banking sector networks (Castellacci & Choi, 2015; Glasserman & Young, 2015; Song & Zhang, 2021). This interconnectedness can amplify the adverse impact of macrofinancial imbalances on global economic growth.

Macroprudential policy plays a crucial role in addressing macrofinancial imbalances. One way in which macroprudential policy can tackle such imbalances is by imposing stricter regulations on financial institutions. These may include higher capital requirements or various restrictions on certain types of high-risk lending practices. Furthermore, macroprudential policy can enhance the resilience of the financial system by promoting market discipline and transparency. By implementing macroprudential policy measures, policymakers can take pre-emptive actions to address these issues before they escalate into larger imbalances with systemic implications (Akinci & Olmstead-Rumsey, 2018; Bruno et al., 2017; Cerutti et al., 2017; Meuleman & Vennet, 2020; Zhang & Zoli, 2016). Moreover, macroprudential measures may also be effective in dampening the effects of global financial shocks that could spill over to the domestic economy (Bergant et al., 2023).

2.2 Quantifying the impact of macroprudential policy on GaR

Since the GFC, financial supervisors have doubled their efforts to identify systemic macrofinancial risks before their transmission to the real economy. The bulk of forecasting approaches aimed at quantifying the impact of financial risks on economic growth focused on expected mean or median growth without considering the entire growth distribution. These approaches have been increasingly criticized in recent years. As an alternative, Adrian et al. (2019) have developed a methodology known as GaR for measuring financial risks to economic growth in the United States (US). Related to the VaR approach in finance, GaR relies on a quantile regression of GDP growth on past financial conditions and past GDP, thus accounting for non-linearities between the variables of interest. An important finding of the study by Adrian et al. (2019) is indeed the non-linear nature of the relation between financial conditions and economic growth in the US. More precisely, the authors show that deteriorating financial conditions are associated with a decline in the conditional mean and an increase in the conditional volatility of GDP growth, whereby the lower quantiles of GDP growth vary with financial conditions and the upper quantiles are stable over time.

Numerous theoretical and empirical studies have shown that financial markets play a key role in the transmission and propagation of shocks to the real economy, while the channels of transmission are highly complex and present a strong degree of non-linearity. In a more recent paper, Adrian et al. (2022) conclude by applying the GaR method to a panel of 11 advanced economies that financial conditions have a larger effect on the lower 5th percentile of conditional growth than on the median. Additionally, the authors draw some conclusions as regards the term structure of GaR by arguing that downside risks are lower in the near-term but increase in later quarters when initial financial conditions are loose.

The GaR approach is also currently extensively used by central banks, as well as by the International Monetary Fund (IMF) in the context of Country Surveillance (see Prasad et al., 2019 for a discussion). Examples from central banks include Drenkovska and Volcjak (2022), who apply the GaR method to Slovenian macrofinancial data to study the impact of increased vulnerabilities and cyclical systemic risk on economic growth, or Krygier and Vasi (2022) who apply GaR to data from Sweden and show that high and increasing risks and vulnerabilities in the financial system exert a negative and significant impact on economic growth eight to 12 quarters ahead and in particular in the 5th quantile of the GDP growth distribution. Similarly, Chicana and Nivin (2022) apply the GaR approach to assess the impact of government policies to facilitate lending on macroeconomic and financial stability in Peru.

My paper is also closely related to a second strand of literature, namely the one exploring the impact of macroprudential policy on economic growth. Previous research mostly concludes to the benefits of macroprudential policy in different areas. For instance, macroprudential policy is largely associated with curbing credit and house price growth. In a recent paper, Poghosyan (2020) assesses 99 lending standard restrictions implemented across the member countries of the European Union (EU) over 1990–2018 and concludes that these measures are generally effective in curbing house prices and credit. Another benefit is associated with a reduced probability of systemic crises. In a very recent paper, Agenor and Bayraktar (2023) show for a panel of 107 countries that capital requirements can mitigate the risk of financial crises, potentially by encouraging a prudent lending behavior by banks. Finally, decreasing the probability of banks' default is another commonly cited benefit of macroprudential policy. Altunbas et al. (2017), for example, show for a panel of over 3100 banks in 61 countries that a macroprudential policy tightening on average reduces the probability of a bank's default by 0.35%.

On the other hand, the empirical studies on the impact of macroprudential policy on GDP growth typically document the negative effects of this type of policies on output. Kim and Mehrotra (2018) apply structural panel vector autoregression to a panel of Asia–Pacific economies and point to a negative impact of macroprudential policy on macroeconomic aggregates such as real GDP growth and inflation. In a similar vein, Richter et al. (2019) conclude for a panel of 56 advanced and emerging economies that a 10-percentage point tightening in the loan-to-value (LTV) ratio requirement leads to a 1.1% reduction in output over a four-year horizon. As regards other types of macroprudential policies, Darracq Paries et al. (2022) identify a negative impact of tightening bank capital requirements on output in the euro area. They obtain a negative impact on GDP that ranges from − 0.15 to − 0.35% in the short-term. Additionally, macroprudential policy is shown to increase wealth inequalities, particularly in advanced economies and when it takes the form of income-based prudential rules (Teixeira, 2023).

GaR methods are being increasingly used to quantify the impact of macroprudential policy on economic growth. In a closely related study, Galan and Rodriguez-Moreno (2020) use the GaR method to assess the impact of macroprudential policy in the EU member countries over the period running from the first quarter of 1970 to the fourth quarter of 2019. The authors use as explanatory variables in the quantile regression a macroprudential policy index, an indicator of cyclical systemic risk and an indicator of financial stress, as well as their interactions. The results show that cyclical risk and the materialization of financial stress have significant asymmetric effects on the EU member countries' GDP growth distribution. Macroprudential policy is shown to have beneficial effects in terms of improving GaR under various stress scenarios. Similarly, using data from Canada, Duprey and Ueberfeldt (2020) find that a tightening of macroprudential policy—captured by a composite index of policy actions—is successful in reducing GDP tail risk, but at the expense of lower mean growth. Specifically, they show that macroprudential policy can manage GDP tail risk by influencing household credit, the latter being identified as the main driver of tail risk in the medium term.

Another interesting approach is described in Fernandez-Gallardo et al. (2023). The authors augment the quantile regression framework with a narrative-identification strategy to study the causal effects of macroprudential policy on GaR in a sample of 12 advanced economies in Europe. The main result of this study is that a tightening of macroprudential policy yields benefits in terms of improving GaR, while restricting economic growth during boom periods (i.e., the upper tails of the GDP growth distribution). The paper also sheds light on the channels through which macroprudential policy impacts the GDP growth distribution in the sample countries. In particular, macroprudential policy shown to be effective in curbing credit growth, which in turn reduces risks to financial stability.

Suarez (2022) goes beyond the specific empirical assessment of the macroprudential policy impact on GaR by providing a conceptual framework in which the previous empirical studies can be incorporated. More precisely, the author develops a theoretical framework for designing and evaluating optimal macroprudential policies, defined as those that maximize social welfare criteria. Besides uncovering the properties of optimal macroprudential policies, the paper also considers cases with non-linearities in the impact of policy and risk variables on the outcomes of interest, with interactions between multiple policy tools, as well as cases with discrete policy variables.

Instead of using a composite index of macroprudential policy, other studies focus on specific types of tools, in particular bank capital requirements. Aikman et al. (2018), for the United Kingdom (UK), conclude that higher bank capitalization improves GaR at a horizon of 12 quarters without significantly reducing mean growth. Asset valuations are similarly found to have a positive impact on GDP growth at short horizons, across all quantiles. By contrast, the authors find at a horizon of one to four quarters ahead that private non-financial sector leverage exerts a negative impact on GDP growth at all quantiles, this impact being largest in the lower tail of the growth distribution.

Franta and Gambacorta (2020) similarly assess the differential impact of various macroprudential policy types on the GDP growth distribution, by using a panel of 56 countries as a basis for the analysis. The study documents a significant impact of macroprudential policy on GaR over the medium term. In addition, a tightening of borrower-based measures such as LTV ratios is shown to squeeze the entire GDP distribution. The positive effect of an LTV tightening on the left tail starts in the 12th quarter, while the negative effect on the right tail begins in the 10th quarter. On the other hand, and although the magnitude of the impact is greater than for LTV measures, a tightening of loan-loss provisioning rules applicable to housing loans only moves the left tail of the distribution upward.

3 Data and methodology

3.1 Macrofinancial variable selection and construction of partitions

The first step for conducting a GaR-based analysis is to select macrofinancial variables that are relevant for the Indonesian economy and group them into partitions. The selection of variables typically relies on a combination of local macroeconomic conditions, local macrofinancial conditions, and international macrofinancial conditions and it depends on the target country's risk profile, or its level of economic and financial development. There are potentially many variables that could be relevant for explaining the dynamics of GDP growth, but these variables may be highly correlated with one another partly because they reflect similar macrofinancial phenomena. The GaR approach uses partitions, which help extract common trends among similar variables, instead of relying on individual variables.

I will therefore build several broad partitions that characterize the economy of Indonesia. Although there is no single way to construct partitions, country applications of the GaR approach have benefitted from three broad partitions capturing: financial conditions; macrofinancial vulnerabilities; and other factors. Variables need to be grouped into partitions of economic similarity (Prasad et al., 2019).

In deciding whether a particular indicator warrants inclusion in the risk assessment framework, an important criterion is whether the respective indicator is likely to provide advance warning for policymakers of the build-up of systemic risk. In

Table 1 Factor loadings for the factors retained in the MINRES method: FINC partition

	Factor 1	Factor 2	Factor 3	Communality	Uniqueness
Term premium	− 0.11	− 0.47	0.47	0.46	0.54
Sovereign yield spread	0.75	0.33	0.47	0.89	0.11
Stock price return	− 0.90	0.39	− 0.15	0.99	0.01
Stock price return volatility	− 0.50	0.18	0.19	0.32	0.68
Sovereign yields	0.91	0.13	0.36	0.97	0.03
Mortgage rates	0.96	− 0.14	− 0.10	0.96	0.04
Interbank rate	0.93	0.19	− 0.28	0.97	0.03
Cost of USD funding	0.48	0.45	0.08	0.44	0.56
Exchange rate	− 0.59	0.68	0.14	0.83	0.17
Short-term interest rate	0.93	0.19	− 0.28	0.97	0.03
	Factor 1	Factor 2	Factor 3		
Proportion of variance	0.57	0.13	0.08		
Cumulative variance	0.57	0.70	0.78		
Proportion explained	0.73	0.16	0.11		
Cumulative proportion	0.73	0.89	1.00		

Source: Author's calculations based on data from: Bank Indonesia (2023b); BIS (2023a); FRED (2023); Investing (2023); OECD (2023a); and Yahoo Finance (2023)

order to build the partitions for Indonesia, I have sought to choose a broad, representative sample of indicators. In particular, I aimed to span different sources of vulnerability with my choice of indicators, capturing risks from tightening financial conditions, high levels of indebtedness in both the private and public sectors, rapid credit growth, as well as a deterioration of economic growth in Indonesia's main trading partners or a tightening of financial conditions in the US, which are all indicative of a deteriorating macrofinancial environment.

The definitions of the variables retained for the construction of the partitions are provided in Table 7 from Appendix A, which contains the list of indicators included, alongside the definition and transformations applied to each indicator (if any), as well as the data sources used.

First, the financial conditions (FINC) partition aims to reflect: the price of risks embedded in asset prices (captured by the term premium, sovereign yield spread, stock price returns, and volatility of stock price returns); the cost of funding (captured by sovereign yields, mortgage rates, interbank rates, and the cost of United States dollar (USD) funding); and the degree of financial stress (captured by the exchange rate and the short-term interest rate). Table 1 reports the results from factor analysis using the minimum residual (MINRES) method. This method determines that three factors are able to explain close to 100% of the original series' variability, and alternative statistical specifications (i.e., the weighted least squares factor analysis) yield very similar results. The first factor explains around 73% of the total variability. By looking at the factor loadings, it can be concluded that the first factor is mainly related to the cost of funding. The second factor explains around 16% of the total variability and is mostly driven by the exchange rate of the Indonesian rupiah

Table 2 Factor loadings for the factors retained in the MINRES method: MAF partition

	Factor 1	Factor 2	Factor 3	Communality	Uniqueness
Credit-to-GDP gap	0.96	– 0.18	– 0.06	0.97	0.03
Credit growth	– 0.18	– 0.81	0.56	1.00	0.00
House price growth	0.71	– 0.10	– 0.20	0.56	0.44
External debt	0.90	– 0.12	– 0.12	0.84	0.16
Current account balance	– 0.87	0.17	– 0.29	0.87	0.13
Debt service ratio	0.77	0.47	0.26	0.89	0.11
Total household credit	0.86	0.47	0.17	0.98	0.02
General government debt	– 0.55	0.75	0.34	0.98	0.02
	Factor 1	Factor 2	Factor 3		
Proportion of variance	0.59	0.22	0.08		
Cumulative variance	0.59	0.80	0.89		
Proportion explained	0.66	0.25	0.09		
Cumulative proportion	0.66	0.91	1.00		

Source: Author's calculations based on data from: AsianBondsOnline (2023); BIS (2023b); BIS (2023c); BIS (2023d); BIS (2023e); and OECD (2023b)

(IDR) to the USD. Finally, the third factor explains around 11% of the variability in the data and is driven mainly by the term premium and sovereign yield spreads.

Second, the macrofinancial vulnerabilities (MAF) partition is aimed at capturing macrofinancial imbalances and sectoral balance sheet weaknesses. In order to construct the MAF partition, I sought a representative sample of indicators across various sectors of the Indonesian economy. I gave particular prominence to the private sector represented by households and non-financial corporations because they represent a large share of total lending in the economy, through their purchases of residential and commercial real estate, and also because these economic agents provide a clear link to real activity. I also included measures of external sector vulnerability, such as external debt and current account balance, because these represent important sources of macrofinancial vulnerabilities in addition to credit boom-bust cycles. Table 2 reports the results from factor analysis for the retained variables in the MAF partition using the MINRES method. The first factor explains approximately 66% of the total variability in the data and is mainly related to the credit-to-GDP gap and external debt. The second factor explains around 25% of the total variability and is mostly driven by the growth rate of total credit and to a lesser extent by the ratio of government debt to GDP. Finally, the third factor explains 9% of the data variability and is mainly driven by credit growth.

Factors other than financial conditions and macrofinancial vulnerabilities are also likely to be relevant for explaining future growth dynamics in Indonesia. I include the following variables in the partition of other factors (OTH): measures of external demand (i.e., Indonesia's major trading partners' growth – China, the US and Japan), global commodity prices, as well as financial conditions in the US as a proxy for global financial conditions. Domestic factors such as consumer confidence, business sentiment, and

Table 3 Factor loadings for the factors retained in the MINRES method: OTH partition

	Factor 1	Factor 2	Factor 3	Communality	Uniqueness
China economic growth	0.04	– 0.47	0.42	0.40	0.60
US economic growth	0.80	– 0.34	– 0.22	0.80	0.20
Japan economic growth	0.87	– 0.42	0.00	0.94	0.06
Commodity prices	0.26	0.00	0.07	0.07	0.93
US financial conditions index	– 0.54	0.14	0.29	0.40	0.60
Consumer confidence	0.59	0.79	– 0.21	1.02	– 0.02
Business sentiment	0.67	0.41	0.63	1.00	0.00
Uncertainty index	0.08	– 0.10	0.05	0.02	0.98
	Factor 1	**Factor 2**	**Factor 3**		
Proportion of variance	0.32	0.17	0.09		
Cumulative variance	0.32	0.49	0.58		
Proportion explained	0.55	0.29	0.16		
Cumulative proportion	0.55	0.84	1.00		

Source: Author's calculations based on data from: Ahir et al. (2023); Bank Indonesia (2023c); Bank Indonesia (2023d); Federal Reserve Bank of Chicago (2023); IMF (2023); and OECD (2023c).

policy uncertainty also tend to significantly influence growth prospects and are included in the OTH partition. Table 3 reports the results from factor analysis using the MINRES method. The first factor explains around 55% of the total data variability. Loadings for the first factor suggest that it is mainly related to the economic growth of some of Indonesia's main trading partners—the US and Japan. The second factor explains approximately 29% of the total variability and is mostly driven by the confidence of Indonesian consumers. Finally, the third factor explains around 16% of the variability in the data and is mostly associated with developments in business sentiment.

To build the composite index for each partition, I compute a weighted sum of the three factors. For the partition of FINC, the weights given by the percentage of the overall data variability explained by each factor are 73%, 16% and 11%, respectively. As regards the MAF partition, the three factors will enter in the composite index with weights of 66%, 25% and, respectively, 9%. Finally, the calculation of the composite index for the OTH partition will weight the corresponding three factors by 55%, 29% and 16%, respectively.

Figure 1 illustrates the evolution of the composite indices for the FINC, MAF and OTH partitions. An increase (decrease) of the FINC index corresponds to a tightening (loosening) of financial conditions in Indonesia. Financial conditions tightened in the run-up and during the GFC and loosened between 2010 and 2013, and then again starting from the second quarter of 2016. The loosening was considerable in response to the COVID-19 crisis when Bank Indonesia and other central banks around the world loosened monetary policy to support the economy in the face of a double demand–supply shock. Second, an increase (decrease) of the MAF index corresponds to an increase (decrease) of macrofinancial vulnerabilities. The MAF index points to an increase in macrofinancial vulnerabilities in

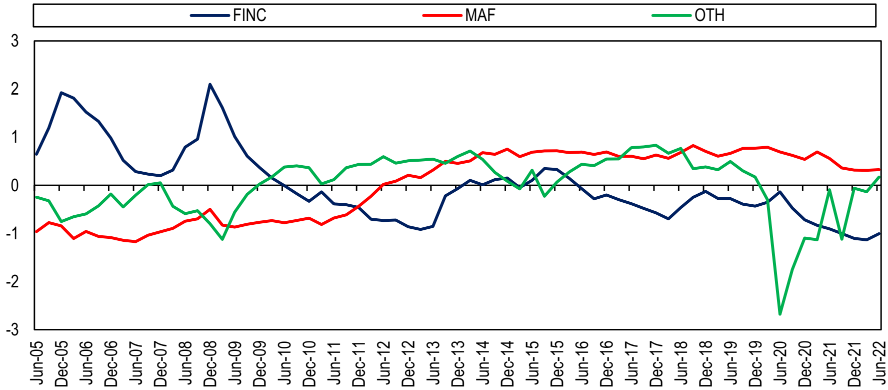

Fig. 1 Evolution of the composite indices for the FINC, MAF and OTH partitions. Source: Author's calculations

Indonesia, in particular starting from the second quarter of 2016. This is largely due to the rise in government and private sector indebtedness. Finally, an increase (decrease) of the OTH index corresponds to an improvement (deterioration) in Indonesia's internal and external macroeconomic environment. As anticipated, the OTH index decreased during the GFC and COVID-19 crises, when economic growth stalled in Indonesia's major trading partners, while at the domestic level consumer confidence and business sentiment faltered.

3.2 Macroprudential policy index

Based on the extensive information reported in the IMF's integrated Macroprudential Policy (iMaPP) Database originally constructed by Alam et al. (2019), I derive the macroprudential policy index (MAP) for Indonesia. To construct the MAP, I follow Galan and Rodriguez-Moreno (2020) and compute the sum of the scores obtained on 17 types of macroprudential tools for Indonesia. The type of tools included are the following: countercyclical capital buffer; capital conservation buffer; capital requirements for banks (i.e., risk weights, systemic risk buffer, and minimum capital requirements); limits on bank leverage; loan-loss provisioning requirements; limits on aggregate and/or sectoral credit growth; loan restrictions (i.e., loan limits and prohibitions, conditioned on loan characteristics); limits on foreign currency lending; limits to the LTV ratio; limits to the debt-service-to-income (DSTI) ratio and loan-to-income (LTI) ratio; taxes on specified transactions and balance sheet items; liquidity requirements; limits to the loan-to-deposit (LTD) ratio; limits on foreign currency exposures; reserve requirements applied for macroprudential purposes; capital and liquidity surcharges applicable to domestic systemically important financial institutions (SIFIs); and miscellaneous macroprudential measures not captured in any of the previous 16 categories.

As in Galan and Rodriguez-Moreno (2020), the MAP is calculated as follows:

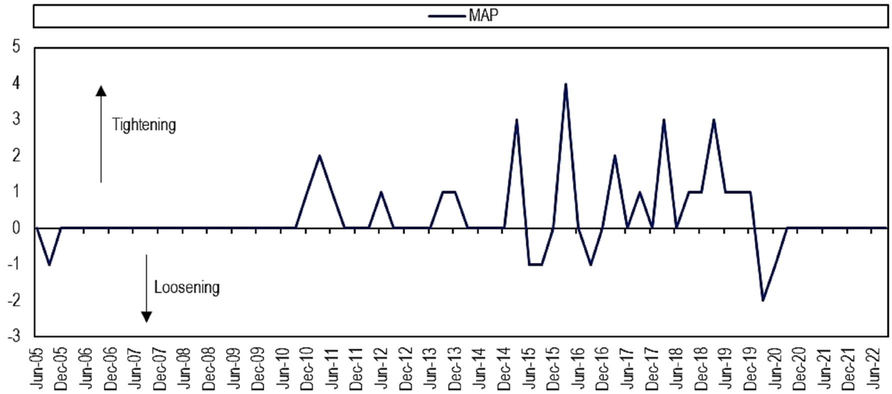

Fig. 2 Evolution of the MAP index in Indonesia, June 2005 to June 2022. Source: Author's calculations

$$MAP_t = \sum_{k=1}^{17} Score_{k,t} \tag{1}$$

$$Score_{k,t} = Score_{k,t-1} + \Delta Score_{k,t} \tag{2}$$

where MAP_t is the composite macroprudential policy index for Indonesia at quarter t, computed as the sum of the scores *Score* for each of the 17 categories of macroprudential tools k. For each category of tools, the score adds one when a macroprudential measure is either activated or tightened with respect to the previous quarter, and it subtracts one when a tool within the respective category is either loosened or deactivated compared to the previous quarter. The score adds zero if there were no changes within the respective category of macroprudential tools from the previous quarter.

Figure 2 illustrates the evolution of the MAP index in Indonesia. As an overall remark, the macroprudential policy stance was tightened multiple times in the aftermath of the GFC. There were several notable tightening episodes, namely: the tightening of reserve requirements and LTD ratio between October 2010 and June 2011, and the tightening of borrower-based requirements and other loan characteristics, as well as of the leverage and LTD requirements between September 2013 and January 2015. These were followed by the implementation of capital buffers (i.e., the capital conservation buffer) and capital surcharges applicable to SIFIs between January 2016 and January 2019, while liquidity and leverage requirements were also tightened several times during this period. It is also noteworthy to mention that the macroprudential stance was loosened in 2020 in response to the COVID-19 outbreak. Some of the liquidity and reserve ratio requirements were eased during this period, as were the loan-loss provisioning rules in order to help the Indonesian economy cope with the demand and supply shocks triggered by the pandemic.

3.3 Estimation of quantile regressions

The second step of the GaR analysis is represented by the estimation of quantile regressions. Quantile regressions are used to estimate the potentially non-linear relationship between quantiles of future GDP growth and selected explanatory variables. Conceptually, a quantile regression at the 5th percentile of the GDP growth distribution estimates a relation between these variables when growth is relatively weak, while a quantile regression at the 95th percentile would assess the relation when growth outcomes are relatively strong. The quantile regression must be applied to quarterly or monthly macroeconomic data spanning long periods (i.e., at least 10 years) in order to maximize the observations and obtain a proper identification (Ossandon Busch et al., 2022). For the purpose of this paper, I use quarterly data for 17 years, starting from the second quarter of 2005 to the second quarter of 2022.

The GaR framework enables scenario analysis, given that it can be used to assess how the nature of tail risks changes in response to changes in explanatory variables. Furthermore, the GaR environment can be adapted for the purpose of assessing how macroprudential policies impact the GDP growth distribution. I therefore include a proxy for the macroprudential policy stance as an additional explanatory variable alongside the other macrofinancial variables in the quantile regressions. The macroprudential variable enters the GaR model as a standalone variable, allowing to explore changes in GaR driven by the tightening or loosening of macroprudential policy measures.

I utilize a set of parsimonious quantile regressions to forecast future GDP growth in Indonesia conditional on a FINC partition, a MAF partition, an OTH partition, and a proxy for macroprudential policy, while the contemporaneous GDP growth rate is included as a control variable. The quantile regressions are estimated across 20 different quantiles (including the 5th, 50th and 95th quantiles) and over several forecasting horizons. The quantile regression takes the following specification:

$$y^q_{t+h} = \alpha^q + \beta^q_1 X_{FINC,t} + \beta^q_2 X_{MAF,t} + \beta^q_3 X_{OTH,t} + \beta^q_4 X_{MAP,t} + \beta^q_5 X_{QGDP,t} + \varepsilon_{t+h} \quad (3)$$

where $X_{FINC,t}$, $X_{MAF,t}$, $X_{OTH,t}$, $X_{MAP,t}$ and $X_{QGDP,t}$ represent the partitions of FINC, MAF, OTH, the macroprudential policy variable, and the contemporaneous real GDP growth rate (as a control variable), respectively. $\widehat{\beta^q_1}$, $\widehat{\beta^q_2}$, $\widehat{\beta^q_3}$, $\widehat{\beta^q_4}$ and $\widehat{\beta^q_5}$ represent the estimated coefficients at different quantiles (denoted with q), and for different forecasting horizons ($h=4$, 8, 12 and 16).

y_{t+h} is the annualized GDP growth of Indonesia at $t+h$ quarters ahead and is computed as:

$$y_{t+h} = ln\left(\frac{GDP_{t+h}}{GDP_t}\right) / \frac{h}{4} \quad (4)$$

A more informative approach is to adapt the baseline GaR model to include interaction terms between macrofinancial variables and the proxy for the

Table 4 Descriptive statistics for the explanatory and control variables

Variable	Mean	Standard deviation	Minimum	Maximum	N
FINC	0.001	0.747	– 1.133	2.098	69
MAF	0.001	0.706	– 1.170	0.826	69
OTH	0.000	0.636	– 2.679	0.831	69
MAP	0.304	0.968	– 2.000	4.000	69

N represents the number of observations

Source: Author's calculations

macroprudential stance in the quantile regression. This approach allows exploring the non-linear effects of the macroprudential policy variable on Indonesia's GDP growth distribution. I therefore follow Galan and Rodriguez-Moreno (2020) and add interaction terms to Eq. (3). The augmented model can be written as follows:

$$\begin{aligned} y^q_{t+h} = \alpha^q + \beta^q_1 X_{FINC,t} + \beta^q_2 X_{MAF,t} + \beta^q_3 X_{OTH,t} + \beta^q_4 X_{MAP,t} + \beta^q_5 X_{QGDP,t} \\ + \beta^q_6 X_{FINC,t} * X_{MAP,t} + \beta^q_7 X_{MAF,t} * X_{MAP,t} + \beta^q_8 X_{OTH,t} * X_{MAP,t} + \varepsilon_{t+h} \end{aligned} \quad (5)$$

Section 4 reports the results and provides a detailed discussion of their implications for the conduct of macroprudential policy in Indonesia.

4 Impact of macroprudential policy on Indonesia's GDP growth

4.1 Empirical results from quantile regressions

Prior to running the quantile regressions, I will look at some descriptive statistics in order to identify any outliers in the data. Table 4 illustrates the mean, the standard deviation, and the minimum and maximum values for each of the explanatory variables (the control variable is excluded) in Eq. (3).

It is already obvious from Table 4 that some of the explanatory variables have extreme values that could alter the results. To reduce the influence of these outliers and give more clarity to the outcome of the quantile regressions, I drop the extreme values from each variable. An observation is considered to be an outlier if it lies below the first quartile or above the third quartile.[1] By applying this procedure, I identify one outlier for each of the FINC, OTH and MAP variables, and no outliers for MAF.

Table 5 reports the results from the quantile regression model described in Eq. (3). The variable of interest is the MAP index. I find that, at a horizon of up to four quarters ahead, MAP exerts a positive impact on GDP growth at the lower quantiles. This positive impact is largest in the lower tail of the growth distribution, namely at the 5th quantile (i.e., the GaR). This suggests that, when the

[1] This is done by assessing whether the respective observation is lower than (-1.5 * IQR) or higher than (1.5 * IQR); where IQR is the interquartile range and is defined as the difference between the third quartile and the first quartile.

Table 5 Regression coefficients for the effect of FINC, MAF, OTH and MAP on Indonesia's GDP growth across different quantiles and horizons

Percentile	5	10	25	50	75	90	95
Dependent variable: GDP growth rate quarters 0–4 ahead							
FINC	0.1310	0.1486	0.0594	0.0493	0.0313	– 0.0441	– 0.0862
MAF	– 0.0921	– 0.0796	0.0257	– 0.0191	– 0.0588	– 0.0808	– 0.0919
OTH	0.3035	0.3583	0.1110	0.0842	0.0415	– 0.0087	– 0.0267
MAP	0.0425	0.0289	0.0100	0.0059	– 0.0021	– 0.0140	– 0.0239
QGDP	0.0492	0.0422	0.0617	0.0440	– 0.0279	– 0.0098	– 0.0010
Pseudo-R^2	0.8295	0.8295	0.8295	0.8295	0.8295	0.8295	0.8295
Dependent variable: GDP growth rate quarters 0–8 ahead							
FINC	0.0043	– 0.0043	– 0.0057	– 0.0182	– 0.0533	– 0.1073	– 0.0983
MAF	0.0202	– 0.0101	– 0.0050	– 0.0299	– 0.0366	– 0.0735	– 0.0816
OTH	0.0025	0.0240	0.0036	– 0.0069	– 0.0507	– 0.1107	– 0.1145
MAP	0.0046	0.0108	0.0108	0.0043	0.0014	– 0.0062	– 0.0071
QGDP	0.0362	0.0192	0.0144	– 0.0093	– 0.0098	– 0.0415	– 0.0411
Pseudo-R^2	0.3619	0.3619	0.3619	0.3619	0.3619	0.3619	0.3619
Dependent variable: GDP growth rate quarters 0–12 ahead							
FINC	– 0.0019	– 0.0012	– 0.0033	– 0.0122	– 0.0373	– 0.0638	– 0.0679
MAF	– 0.0038	0.0015	– 0.0078	– 0.0302	– 0.0399	– 0.0409	– 0.0504
OTH	– 0.0040	– 0.0070	– 0.0017	0.0135	– 0.0171	– 0.0720	– 0.0680
MAP	0.0018	– 0.0005	0.0031	0.0028	– 0.0019	– 0.0077	– 0.0065
QGDP	0.0198	0.0208	0.0087	– 0.0107	– 0.0104	– 0.0285	– 0.0293
Pseudo-R^2	0.2325	0.2325	0.2325	0.2325	0.2325	0.2325	0.2325
Dependent variable: GDP growth rate quarters 0–16 ahead							
FINC	0.0015	– 0.0053	– 0.0214	– 0.0320	– 0.0529	– 0.0881	– 0.0614
MAF	– 0.0036	– 0.0046	– 0.0504	– 0.0623	– 0.0316	– 0.0627	– 0.0672
OTH	0.0018	– 0.0012	0.0435	– 0.0194	– 0.0837	– 0.1436	– 0.1469
MAP	0.0015	0.0025	0.0022	0.0071	– 0.0034	– 0.0136	– 0.0151
QGDP	0.0376	0.0366	– 0.0081	– 0.0087	– 0.0055	– 0.0446	– 0.0440
Pseudo-R^2	0.4796	0.4796	0.4796	0.4796	0.4796	0.4796	0.4796

Source: Author's calculations

macroprudential policy stance is tight, Indonesia's GDP growth distribution is likely to have a significant positive skew and be stronger over this horizon. When extending the horizon to up to eight quarters ahead, I find that the impact of MAP is almost negligible at all quantiles. For longer horizons, such as 12 and 16 quarters ahead, I similarly find that MAP exerts a positive impact on GaR. Moreover, the beneficial impact of macroprudential policy on GaR does not come at the expense of lower mean growth, as shown by the positive coefficients of the MAP variable at the 50th percentile. These findings are in line with Galan and Rodriguez-Moreno (2020) and Aikman et al. (2018). Overall, the magnitude of the positive impact of MAP on GaR is largest at the four-quarter horizon, as shown by its coefficient of 0.0425. These results carry important implications for policymakers in Indonesia, as they suggest that an early tightening of macroprudential policy would reduce downside risks to GDP growth by increasing the resilience of the financial system.

As regards the other explanatory variables in the regression model captured by Eq. (3), it can be seen from Table 5 that the short- and medium-term relationship between FINC and future growth differ considerably. For the four-quarters-ahead forecasting horizon, a tightening of FINC would represent a significant downside risk to growth when growth is very strong (i.e., the 90th and 95th quantiles). On the other hand, a tightening of FINC poses an upside risk when growth is weaker (i.e., the lower quantiles). The positive coefficient at the lower quantiles at the four-quarter horizon suggests that the impact of FINC on economic growth is not contemporaneous. For the eight- and 12-quarters-ahead horizons, a tightening of FINC is negatively correlated with economic growth at nearly all quantiles, except for the 5th quantile, which is the GaR. At the 16-quarter-ahead horizon, there is a negative correlation between FINC and economic growth at all quantiles. This may reflect that the tightening of financial conditions today will render credit more expensive in the medium- to long-term, thereby restraining future economic growth.

Turning to MAF, results from the quantile regressions reveal that a build-up of MAF constitutes a downside risk to GDP growth at almost all forecasting horizons and quantiles. An increase in MAF exerts a negative impact on GaR at all horizons except for the eight-quarters-ahead one. In terms of magnitude, the negative effect on GaR reaches its maximum impact in the short-term, at the four-quarter horizon, which confirms that the effect of MAF is more contemporaneous compared to the impact of FINC since the former implies a materialization of risk. The impact of MAF on mean GDP growth is also negative and its magnitude at the four-quarter horizon is nearly nine times lower than that on GaR, while for the longer horizons the impact is greater on mean growth.

Finally, the other relevant factors for the Indonesian economy, which represent a combination of international and domestic macroeconomic variables, also exert an asymmetric impact on the GDP growth distribution. An improvement of OTH exerts a positive impact on the lower quantiles of the distribution at nearly all horizons, while the impact is negative at the upper quantiles. An improvement in OTH is most beneficial for GaR in the short-term (i.e., at the four-quarter horizon), while the impact dilutes up to eight quarters ahead and it even turns negative at the one-year horizon. These results suggest that an improvement of the macroeconomic environment today is beneficial in the short-run, but this might lead to a build-up of vulnerabilities in the medium- to long-term. For instance, an improvement in consumer sentiment, which is one of the components of the OTH composite index, while beneficial in the short-term, may lead to an increase in consumer credit in the long-run and thus exacerbate macrofinancial vulnerabilities. These findings again suggest that an adjustment of the macroprudential policy stance early on when vulnerabilities start to emerge yields substantial growth benefits.

Figure 3 plots the slope coefficients obtained from the quantile regression outlined in Eq. (3) versus those obtained using ordinary least squares (OLS). It can be seen that the slope coefficients obtained from quantile regressions are well below those from OLS at the lower quantiles, while they tend to exceed the OLS ones at the upper quantiles. Overall, these results lend support to the choice of the quantile

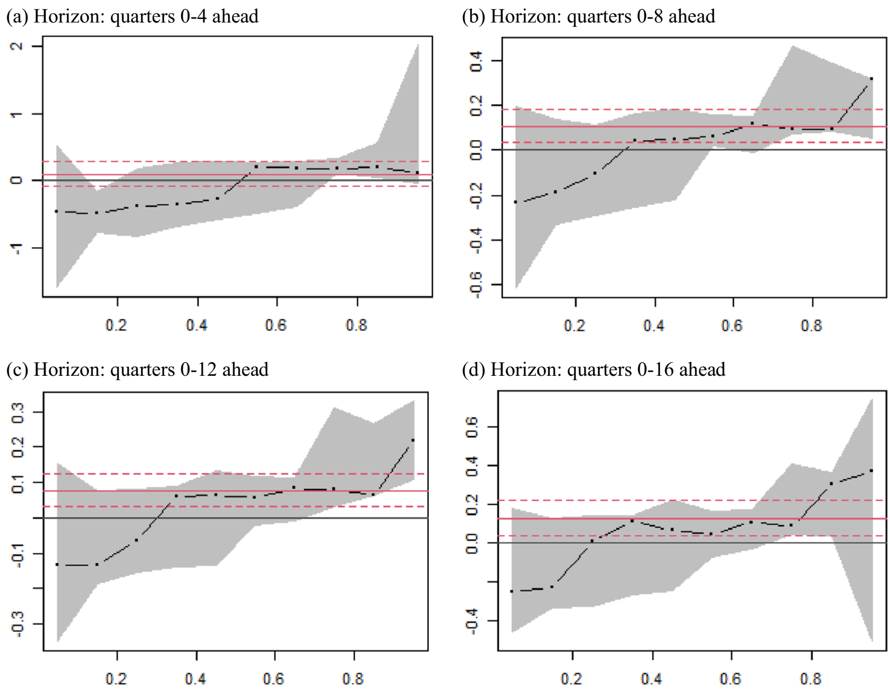

Fig. 3 Slope coefficients from quantile regressions versus OLS. Quantiles are indicated on the horizontal axis. Each dot represents the slope coefficient for the respective quantile. The solid red lines represent OLS estimates and the dotted red lines are their confidence intervals. Source: Author's calculations

regression method for assessing the impact of macroprudential policy on Indonesia's GDP growth.

Next, I propose an inference exercise based on the regression rank-scores, which were introduced by Gutenbrunner and Jureckova (1992) and Gutenbrunner et al. (1993) as dual variables to regression quantiles. The purpose of this exercise is to assess whether the baseline model specification is adequate. The rank-score inference method works by assigning a rank-score to each observation in the dataset. The rank-score represents the relative position of the observation within the data. The observation that falls below all other observations is assigned a rank-score of zero, while the observation that falls above all others is assigned a rank-score of one. The remaining observations are assigned rank-scores between zero and one based on their relative positions. The integration of the regression rank-score function for each observation over the interval [0, 1] results in a vector of Wilcoxon ranks.[2]

The null hypothesis in the rank-score test asserts that a model with fewer explanatory variables is more adequate compared to the baseline model with more variables specified in Eq. (3). Table 6 reports the results of the rank-score test at the four-quarter ahead horizon. The null hypothesis can be rejected at the 5% level, which

[2] Refer to Wilcoxon et al. (1963) for a discussion.

Table 6 Results of the rank-score test

Null hypothesis	*p*-value	Decision
A model with only MAP as explanatory variable is more adequate compared to the baseline model	**0.0101**	Reject
A model with only MAP and FINC as explanatory variables is more adequate compared to the baseline model	0.0537	Reject
A model with only MAP, FINC and MAF as explanatory variables is more adequate compared to the baseline model	**0.0231**	Reject
A model with only MAP, FINC, MAF and OTH as explanatory variables is more adequate compared to the baseline model	**0.0318**	Reject

The *p*-values in bold text denote statistical significance at the 5% level

Source: Author's calculations

allows me to conclude that the baseline specification is more adequate compared to alternative model specifications with fewer variables.

As a final step, I consider the interactions between explanatory variables, as the impact of macroprudential policy on Indonesia's GDP growth may depend on the level of the FINC, MAF and OTH partitions. In order to account for interactions between these variables, I estimate the model specification outlined in Eq. (5). Table 8 from Appendix B reports the results from this model. Figure 4 below illustrates the marginal effect of macroprudential policy tightening on GaR conditional on different levels of FINC, MAF and OTH at different horizons. Positive values of GaR can be interpreted as representing the benefits of tightening macroprudential policy, while negative values represent the cost of tightening macroprudential policies at given values of FINC, MAF and OTH. It can be observed from panel (a) of Fig. 4 that the positive impact of tightening macroprudential policy when FINC eases substantially (i.e., FINC − 2 standard deviations) is greater when the following two conditions are met simultaneously: MAF is low (i.e., it takes a value of around − 1); and the macroeconomic environment represented by the OTH partition is very strong (i.e., it takes a value of approximately 2). The positive impact is only evident at the four-quarter horizon. This entails that Indonesian policymakers should consider tightening macroprudential policies when financial conditions are very loose and the macroeconomic environment is strong, even if macrofinancial vulnerabilities have not yet started to build up. These results build on existing evidence that macroprudential measures lead to a tightening of financial conditions (Akinci & Olmstead-Rumsey, 2018; Claessens et al., 2013) through the credit channel, by effectively rendering bank credit more restrictive. Since the macroeconomic environment partition captures spillovers from other economies to Indonesia, the results also confirm the claims that macroprudential policy can be effective in addressing risks to the domestic economy stemming from financial integration (Malmierca, 2021), for instance by stabilizing capital flows (Bergant et al., 2023).

Under a severe increase of MAF (i.e., MAF + 1 standard deviation), as illustrated in panel (c) of Fig. 4, the benefits of tightening macroprudential policy on GaR are quite important in the short-term and larger under expansionary phases of OTH (i.e., when OTH takes a value of around 2). When these types of events occur, tightening macroprudential policy is beneficial, even if FINC are very tight. It would therefore be convenient for Indonesian policymakers to tighten the macroprudential policy stance as soon as macrofinancial vulnerabilities become substantial amid an expansionary macroeconomic environment, regardless of how restrictive/accommodative financial conditions are. These results confirm the views that domestic macrofinancial vulnerabilities can negatively impact economic growth through the credit, asset price and balance sheet channels and that a tightening of macroprudential policy is beneficial in these conditions (refer to the discussion in sub-Sects. 2.1 and 2.2).

Another interesting simulation considers a substantial expansion of the macroeconomic environment, captured by OTH (i.e., OTH + 2 standard deviations). This could be due, for instance, to an increase in economic growth in one of Indonesia's major trading partners such as China, Japan or the US, or to domestic factors like an improvement in consumer confidence or business sentiment. Such an expansion could lead to the accumulation of macrofinancial vulnerabilities and thus prompt authorities to tighten the

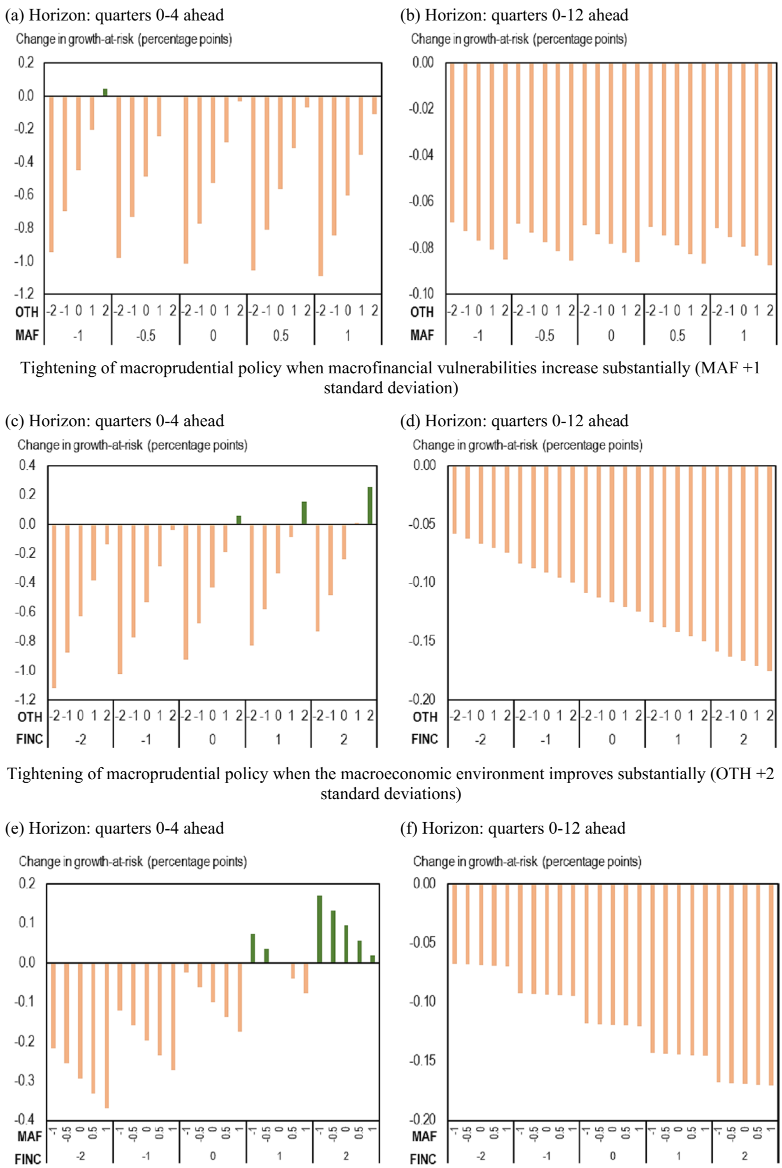

Fig. 4 Marginal effect of macroprudential policy tightening on GaR in Indonesia at 4 and 12 quarters ahead conditional on different levels of FINC, MAF and OTH. GaR refers to the 5th percentile of the GDP growth distribution. In each panel, the first line on the horizontal axis contains the different values of the first composite index (i.e., OTH in panels **a**, **b**, **b** and **d**, and MAF in panels **e** and **f**), and the second line illustrates the different values of the second composite index considered for the purpose of the simulations (i.e., MAF in panels **a** and **b**, and FINC in panels **b**, **d**, **e** and **f**) Source: Author's calculations

macroprudential stance. As shown in panel (e) of Fig. 4, tightening macroprudential policy is a convenient strategy when, in addition to the substantial expansion of OTH, the following two conditions are also met simultaneously: FINC is relatively tight (i.e., it takes values between 1 and 2); and MAF is low (i.e., it takes values between − 1 and − 0.5). These results suggest the importance of external factors for a small open economy such as Indonesia, which is also a net commodity exporter, and can be therefore assigned to the international channel of transmission from macrofinancial vulnerabilities to economic growth. They are underpinned by the theory that economies with more open capital accounts are more vulnerable to global financial shocks (Dabrowski et al., 2015), as well as by the hypothesis that macroprudential policies can effectively diminish the negative impacts from such shocks to the domestic economy (Bergant et al., 2023; Malmierca, 2021).

4.2 Robustness tests

Besides assessing the validity of the findings at different horizons (i.e., 4, 8, 12 and 16 quarters ahead), I perform a series of additional robustness exercises to ensure the robustness of the main results. Appendix C presents the outcomes of these exercises.

In the first robustness exercise I address the issue of endogeneity. An important issue stemming from the inclusion of macroprudential policy in the quantile regression models pertains to the potential endogeneity of this variable to future GDP growth. That is, macroprudential authorities in Indonesia may implement macroprudential policies depending on their expectations on future economic activity. To offset the bias induced by the potential endogeneity issue, I define an alternative MAP index for Indonesia. More precisely, I follow Galan (2020) and build the MAP on strictly exogenous measures, keeping only the macroprudential measures reported in the iMaPP database that constitute transpositions of international regulations into Indonesian law.[3] Measures with strictly national character are excluded. The results of the quantile regressions are presented in Table 9, whereby the previous MAP index is replaced by a new version that contains only exogenous macroprudential measures. The quantile regression results are very similar at all horizons to those presented in Table 5, namely the impact of a macroprudential policy tightening on GaR is positive. Overall, these results lead me to conclude that the previous findings are robust to the use of a more restrictive MAP index.

Second, I try to answer the question whether the main results are robust to alternative measures of economic activity. Specifically, I use a proxy for the dependent variable GDP growth rate, such as the growth rate of industrial production (as in Mitchell et al., 2005). The industrial production data are obtained from Statistics Indonesia (2023). The results are presented in Table 10, and they remain qualitatively the same when the dependent variable is replaced with a proxy.

[3] These include the following types of measures: countercyclical capital buffer; capital conservation buffer; capital requirements for banks (i.e., risk weights, systemic risk buffer, and minimum capital requirements); limits on bank leverage; liquidity requirements; and capital and liquidity surcharges applicable to domestic systemically important financial institutions (SIFIs).

Third, I expand the set of control variables to assess the robustness of my findings to alternative specifications. When assessing the impact of macroprudential policy on GDP growth, it is important to consider the interlinkages between this policy domain and other types of policies, such as monetary policy. Loria et al. (2022), for instance, conclude that monetary policy also has heterogenous effects on the distribution of GDP growth. To control for potential interlinkages between macroprudential and monetary policies, I augment the model specification in Eq. (3) to include a proxy for the monetary policy stance. Since data on Indonesia's monetary policy rate only go as far back as 2016 and are therefore unsuitable for the analysis, I use instead the inflation rate as a proxy for monetary policy and rerun the quantile regressions. The inflation data are sourced from Bank Indonesia (2023a). Table 11 reports the results from this exercise. The inclusion of the inflation variable as an additional control does not alter in any way the results obtained without it.

Finally, I expand the baseline specification including two lags of the dependent variable. Formally, I estimate Eq. (3) but augment the set of control variables with the first lag, and then with both the first and second lags of the annualized GDP growth rate. Table 12 contains the results. Across all specifications, I find that the impact of a macroprudential policy tightening on GaR is positive at all horizons, which allows me to conclude that the baseline results are also robust to this exercise.

4.3 Conditional GDP growth distributions for Indonesia

After running the quantile regressions outlined in Eqs. (3) and (5), the third step of the GaR analysis entails the generation of the future GDP growth distributions for Indonesia. More specifically, I derive the conditional distribution of future GDP growth by fitting a skew *t*-distribution[4] to the predicted values of the estimated conditional quantiles. The distribution of future GDP growth conditional on the state of the financial and business environment enables an assessment of the likelihood of future economic activity for any combination of FINC, MAF, OTH and MAP. Starting from a baseline normal times scenario (i.e., FINC, MAF and OTH at average values), in Fig. 5 I show that both the location and the shape of the GDP growth distribution change after a shock in either FINC, MAF or OTH, and that the parameters of the distribution further change when the macroprudential policy stance is either tightened or loosened in response to these shocks.

It can be seen from panel (a) of Fig. 5 that a substantial easing of FINC (i.e., FINC -2 standard deviations), leads to an asymmetric change in the location of the four-quarter ahead GDP growth distribution in Indonesia (blue line). The GDP distribution shifts to the left. In this case, mean growth drops by around 0.06 percentage points (pps), whereas GaR declines by 0.47 pps. Under a scenario characterized by a substantial easing of FINC, tightening macroprudential policy shifts the growth distribution to the right (red line), improving GaR by around 0.07 pps. These results are very intuitive, since loose financial conditions typically lead to an increase of systemic risk and thus to lower economic growth. Barajas et al. (2021), for example,

[4] Refer to Azzalini and Capitanio (2003) for a detailed description of the skew *t*-distribution.

show for a sample of 29 advanced and emerging market economies that a loosening of financial conditions is associated with a stronger build-up of household and non-financial corporate leverage, and that looser financial conditions are also associated with an increase in downside risk to economic activity particularly in the medium-term.

The impact of a substantial increase in MAF (i.e., MAF + 1 standard deviation for the Indonesian case) is presented in panel (b) of Fig. 5. The four-quarter ahead GDP growth distribution shifts to the left under this scenario (blue line), with a decrease of 0.38 pps in GaR, while mean growth drops by 0.09 pps. A tightening of the macroprudential policy stance in the scenario characterized by a substantial increase in macrofinancial vulnerabilities shifts the growth distribution to the right (red line), improving GaR by around 0.06 pps. The effect on mean growth is less pronounced (+ 0.01 pps). These results are not surprising, given the extensive literature documenting the negative impact of macrofinancial vulnerabilities on economic growth and the benefits of macroprudential policy in correcting these vulnerabilities. A relevant example in this regard is the single-country study by Gomez et al. (2017), who show for Columbia that the aggregate macroprudential policy stance has been effective in stabilizing credit cycles and in moderating banks' risk-taking behavior in this country.

Finally, panel (c) of Fig. 5 shows how Indonesia's GDP growth distribution changes after a deterioration of the macroeconomic environment similar to what occurred during the COVID-19 crisis (i.e., lower economic growth of Indonesia's main trading partners, declining consumer confidence and business sentiment, rising commodity prices), and the impact of loosening macroprudential policy under such a scenario. I map the quantile estimates of GDP growth four quarters ahead. I observe that a substantial deterioration of the OTH partition (i.e., OTH -2 standard deviations), moves the location of the distribution to the left. Notably, GaR declines by around 0.69 pps. Loosening macroprudential policy under this scenario yields benefits, improving GaR and mean growth by around 0.14 and 0.02 pps, respectively. These results corroborate the findings of Bergant and Forbes (2021), who show that countries that eased their macroprudential stance more during the COVID-19 crisis have experienced less financial and economic stress compared to those having implemented a less accommodative stance. This underlines the importance of implementing countercyclical macroprudential policy measures in response to negative economic shocks such as those triggered by the recent pandemic.

5 Conclusions

The main objective of macroprudential policy is to prevent and mitigate systemic risk. While the benefits of macroprudential policy in improving financial stability have been extensively documented in the literature, there is also evidence on the negative impact macroprudential policy may have on economic growth, particularly in the left tail of the growth distribution. In this context, policymakers

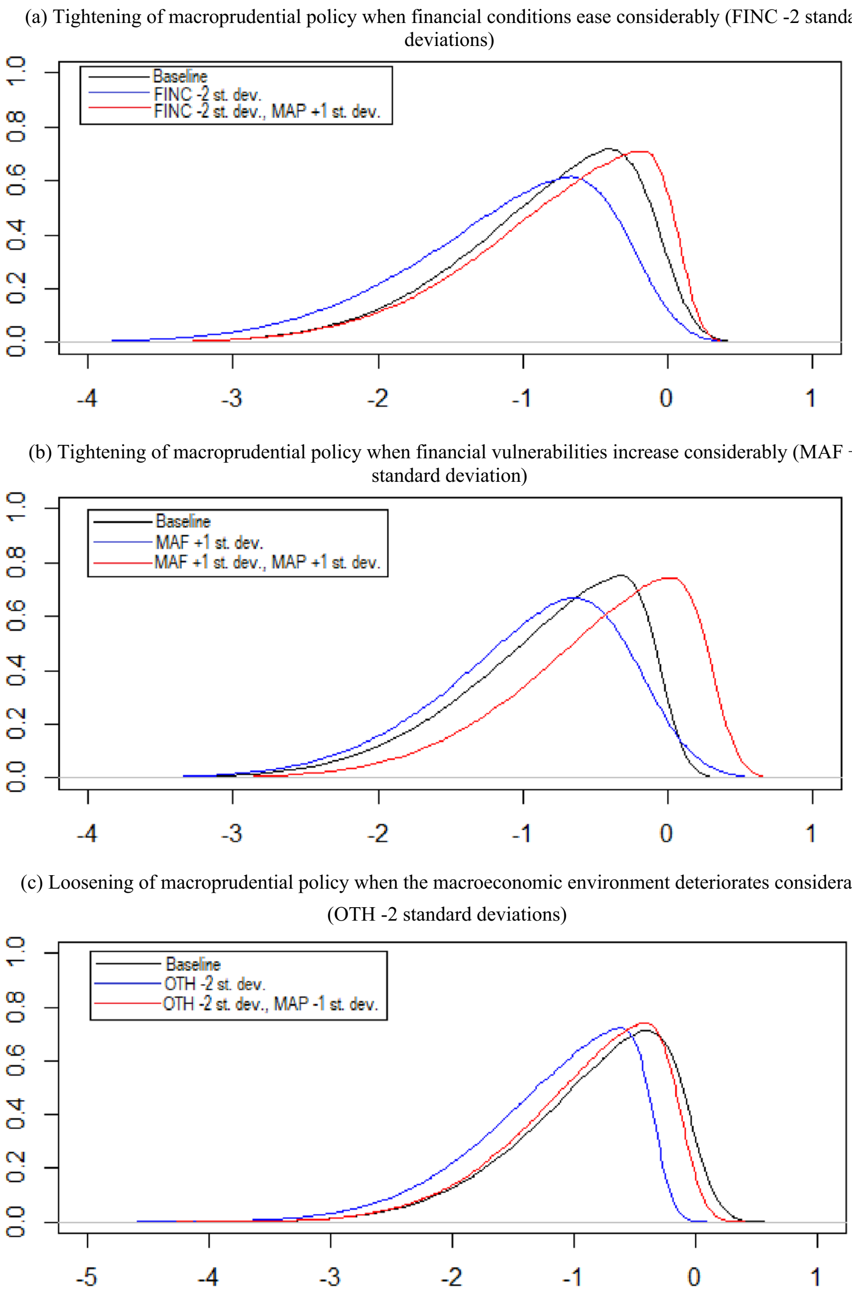

Fig. 5 Conditional GDP growth distribution quarters 0–4 ahead under different scenarios. Fitted density distribution of annualized GDP growth four quarters ahead. Annualized GDP growth rate in per cent Source: Author's calculations

need to assess the effects of financial risk and macroprudential policies on the entire GDP growth distribution, rather than only on the central tendency. The GaR methods, developed in 2019 by Adrian et al. (2019) and increasingly popular among academics and policymakers, provide a useful framework for the assessment of the macroprudential policy impact on economic growth by acknowledging the existence of non-linear effects. Quantile regressions are successfully used for this purpose.

In this paper, I describe the GaR method and illustrate its use for assessing the impact of macroprudential policy on the GDP growth distribution in Indonesia. Indonesia is one of the largest economies in Southeast Asia and globally, thus being of particular interest for such an analysis. Furthermore, there is limited empirical evidence on the impact of macroprudential policy on economic growth in Indonesia, while the GaR approach has not been so far applied to the Indonesian case. My paper therefore makes two important contributions to the macroprudential policy literature.

In order to conduct the GaR analysis, I select 26 macrofinancial variables that are relevant for the Indonesian economy and group them into three broad partitions that capture financial conditions, macrofinancial vulnerabilities, and other relevant factors besides the first two categories. Results show that a materialization of risk, stemming from either an easing of financial conditions, an increase of macrofinancial vulnerabilities or a deterioration of the macroeconomic environment have important effects on Indonesia's GDP growth distribution. These effects are particularly acute on the left tail of the distribution, which represents the GaR. A substantial easing of financial conditions, a large increase of macrofinancial vulnerabilities, or a substantial deterioration in the macroeconomic environment all shift Indonesia's GDP growth distribution to the left. Under each of these scenarios, a tightening or loosening of the macroprudential stance, depending on the scenario, yields high benefits in terms of improving GaR that range from 0.06 to 0.14 percentage points.

To the best of the author's knowledge at the time of writing, there is no other paper on this topic targeting the case of Indonesia. The results obtained in this paper provide policymakers in Indonesia with very useful insights, as it uncovers the benefits of macroprudential policy on GaR that may offset the downside risks posed by the accumulation of macrofinancial vulnerabilities. In addition, the analytical framework outlined in this study could help macroprudential authorities in Indonesia to optimize the timing of their macroprudential policy decisions.

Furthermore, the analysis could be extended to compare the benefits of macroprudential policy on GaR with the costs associated to reductions in mean or median growth. This would allow policymakers in Indonesia to perform a cost–benefit analysis of macroprudential policy. An additional application of the analysis presented in this paper is to disentangle between different types of macroprudential policies (i.e., policies targeting bank capital, liquidity, foreign-currency exposures, borrower-based measures, etc.). This constitutes another direction for future research.

Appendix A

See Table 7.

Appendix B

See Table 8.

Table 7 Description of partitions, variables, and data sources

Partition	Variable	Description	Data source
Financial conditions	Term premium	Difference between yields on Indonesian 10-year and 3-year sovereign bonds (basis points). Quarterly average of daily observations	Investing (2023) and own calculations
	Sovereign yield spread	Difference between yields on Indonesian 10-year sovereign bonds and yields on US 10-year Treasuries (basis points). Quarterly average of daily observations	Investing (2023) and own calculations
	Stock price return	Price return of the Jakarta Stock Exchange Index (JKSE) based on closing prices. Quarterly average of daily observations	Yahoo Finance (2023) and own calculations
	Stock price return volatility	Standard deviation of daily stock return on a rolling five-day window. Quarterly average of daily observations	Yahoo Finance (2023) and own calculations
	Sovereign yields	Yield on Indonesian 10-year sovereign bonds. Quarterly average of daily observations	Investing (2023) and own calculations
	Mortgage rates	Interest rate on mortgage loans denominated in IDR	Bank Indonesia (2023b)
	Interbank rate	3-month interbank rate for Indonesia	FRED (2023)
	Cost of USD funding	Interest rate on investment loans denominated in USD	Bank Indonesia (2023b)
	Exchange rate	IDR to USD exchange rate. Quarterly average of daily observations	BIS (2023a) and own calculations

Table 7 (continued)

Partition	Variable	Description	Data source
	Short-term interest rate	The rate at which short-term borrowings are realized between financial institutions, or the rate at which short-term government paper is issued or traded in the secondary market in Indonesia	OECD (2023a)
Macrofinancial vulnerabilities	Credit-to-GDP gap	Credit-to-GDP gap (actual trend); total credit to the private non-financial sector in Indonesia	BIS (2023b)
	Credit growth	Year-on-year change of quarterly values of total credit to the private non-financial sector in Indonesia (in per cent); credit denominated in IDR	BIS (2023c) and own calculations
	House price growth	Year-on-year change of quarterly real property prices in Indonesia (in per cent)	BIS (2023d)
	External debt	Amount of Indonesian local-currency government bonds held by foreign investors as a percentage of the total amount of Indonesian local-currency government bonds outstanding	AsianBondsOnline (2023)
	Current account balance	Current account balance as a percentage of GDP	OECD (2023b)
	Debt service ratio	Debt service ratio of the private non-financial sector in Indonesia (in per cent)	BIS (2023e)
	Total household credit	Total credit to households and non-profit organizations serving households as a percentage of GDP	BIS (2023c)
	General government debt	Gross general government debt as a percentage of GDP	BIS (2023c)

Table 7 (continued)

Partition	Variable	Description	Data source
Other factors	China economic growth	Year-on-year growth rate of GDP for China; growth rate based on seasonally adjusted volume data	OECD (2023c)
	US economic growth	Year-on-year growth rate of GDP for the US; growth rate based on seasonally adjusted volume data	OECD (2023c)
	Japan economic growth	Year-on-year growth rate of GDP for Japan; growth rate based on seasonally adjusted volume data	OECD (2023c)
	Commodity prices	All commodity price index, 2016 = 100. Includes both fuel and non-fuel price indices	IMF (2023)
	US financial conditions index	Weighted average of 105 indicators of financial activity in the US	Federal Reserve Bank of Chicago (2023) and own calculations
	Consumer confidence	Consumer Confidence Index, average of Present situation and Expectations indices. Quarterly average of monthly observations	Bank Indonesia (2023c) and own calculations
	Business sentiment	Indicator of financial conditions over the past three months. Average of liquidity (net balance: percentage of good minus percentage of bad) and Rentability (net balance: percentage of good minus percentage of bad) indices	Bank Indonesia (2023d) and own calculations
	Uncertainty index	World Uncertainty Index for Indonesia. Tracks uncertainty in Indonesia by text mining the country reports produced by the Economist Intelligence Unit	Ahir et al. (2023)

Source: Author's elaboration

Appendix C

See Tables 9, 10, 11 and 12.

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Data availability The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Table 8 Regression coefficients for the effect of FINC, MAF, OTH, MAP and their interaction on Indonesia's GDP growth across different quantiles and horizons

Percentile	5	10	25	50	75	90	95
Dependent variable: GDP growth rate quarters 0–4 ahead							
FINC	0.1180	0.1504	0.0616	0.0516	0.0272	– 0.0432	– 0.0862
MAF	– 0.1144	– 0.0725	0.0253	– 0.0003	– 0.0640	– 0.0910	– 0.0919
OTH	0.3137	0.3712	0.1048	0.0955	0.0438	0.0098	– 0.0267
MAP	0.0620	0.0571	0.0156	0.0038	– 0.0154	– 0.0372	– 0.0540
QGDP	0.0473	0.0406	0.0719	0.0324	– 0.0283	– 0.0146	– 0.0010
FINC*MAP	– 0.0211	– 0.0654	0.0321	– 0.0270	– 0.0059	– 0.0319	– 0.0321
MAF*MAP	0.0393	0.0261	0.0112	0.0096	0.0156	0.0467	0.0595
OTH*MAP	– 0.0678	– 0.1277	– 0.0033	– 0.0295	0.0065	– 0.0409	– 0.0456
Pseudo-R^2	0.8157	0.8157	0.8157	0.8157	0.8157	0.8157	0.8157
Dependent variable: GDP growth rate quarters 0–8 ahead							
FINC	0.0019	– 0.0131	– 0.0043	– 0.0181	– 0.0381	– 0.1098	– 0.1202
MAF	0.0228	0.0060	– 0.0142	– 0.0314	– 0.0300	– 0.0617	– 0.0807
OTH	– 0.0006	0.0071	0.0073	– 0.0057	– 0.0351	– 0.1097	– 0.0939
MAP	– 0.0033	– 0.0081	0.0229	0.0176	0.0096	– 0.0095	– 0.0161
QGDP	0.0342	0.0137	0.0109	– 0.0098	– 0.0141	– 0.0415	– 0.0441
FINC*MAP	– 0.0120	– 0.0478	– 0.0415	– 0.0400	– 0.0679	– 0.0539	– 0.0295
MAF*MAP	0.0133	0.0138	– 0.0238	– 0.0158	– 0.0061	– 0.0197	0.0018
OTH*MAP	0.0014	– 0.0342	– 0.0416	– 0.0438	– 0.0571	– 0.0005	0.0078
Pseudo-R^2	0.3440	0.3440	0.3440	0.3440	0.3440	0.3440	0.3440
Dependent variable: GDP growth rate quarters 0–12 ahead							
FINC	– 0.0054	– 0.0046	– 0.0025	– 0.0124	– 0.0368	– 0.0633	– 0.0740
MAF	– 0.0032	– 0.0027	– 0.0069	– 0.0309	– 0.0474	– 0.0390	– 0.0571
OTH	– 0.0043	– 0.0015	– 0.0023	0.0139	– 0.0082	– 0.0763	– 0.0652
MAP	– 0.0011	– 0.0004	0.0023	– 0.0037	– 0.0066	– 0.0303	– 0.0311
QGDP	0.0174	0.0157	0.0101	– 0.0109	– 0.0127	– 0.0279	– 0.0298
FINC*MAP	– 0.0322	– 0.0230	– 0.0226	– 0.0182	0.0012	– 0.0252	0.0002
MAF*MAP	– 0.0001	– 0.0005	0.0035	0.0140	0.0214	0.0064	0.0131
OTH*MAP	– 0.0107	– 0.0031	– 0.0123	– 0.0209	– 0.0086	0.0454	0.0485
Pseudo-R^2	0.2213	0.2213	0.2213	0.2213	0.2213	0.2213	0.2213
Dependent variable: GDP growth rate quarters 0–16 ahead							
FINC	– 0.0138	– 0.0156	– 0.0209	– 0.0321	– 0.0503	– 0.1285	– 0.0614
MAF	– 0.0068	– 0.0131	– 0.0509	– 0.0645	– 0.0442	– 0.0905	– 0.0672
OTH	– 0.0146	– 0.0038	0.0241	– 0.0158	– 0.0663	– 0.1376	– 0.1469
MAP	– 0.0058	– 0.0119	– 0.0207	– 0.0091	– 0.0270	– 0.0486	– 0.0568
QGDP	0.0377	0.0335	0.0065	– 0.0096	– 0.0099	– 0.0463	– 0.0440
FINC*MAP	– 0.0075	– 0.0147	– 0.0287	– 0.0325	– 0.1750	– 0.1595	– 0.0812
MAF*MAP	0.0157	0.0222	0.0459	0.0362	0.0493	0.0546	0.0401
OTH*MAP	0.0172	0.0075	– 0.0148	– 0.0212	– 0.1258	0.0138	– 0.0247
Pseudo-R^2	0.4205	0.4205	0.4205	0.4205	0.4205	0.4205	0.4205

Source: Author's calculations

Table 9 Robustness exercise #1: regression coefficients for the effect of FINC, MAF, OTH, MAP on Indonesia's GDP growth across different quantiles and horizons with an exogenous MAP index

Percentile	5	10	25	50	75	90	95
Dependent variable: GDP growth rate quarters 0–4 ahead							
FINC	0.1180	0.1369	0.0549	0.0568	0.0324	0.0001	– 0.0862
MAF	– 0.1144	– 0.0915	0.0166	0.0137	– 0.0604	– 0.0859	– 0.0919
OTH	0.3137	0.3441	0.0956	0.0818	0.0428	0.0314	– 0.0267
Alt MAP	0.0535	0.0422	0.0182	0.0097	0.0040	– 0.0005	– 0.0039
QGDP	0.0473	0.0438	0.0716	0.0434	– 0.0286	– 0.0222	– 0.0010
Pseudo-R^2	0.8025	0.8025	0.8025	0.8025	0.8025	0.8025	0.8025
Dependent variable: GDP growth rate quarters 0–8 ahead							
FINC	0.0019	– 0.0013	– 0.0024	– 0.0193	– 0.0554	– 0.1140	– 0.0899
MAF	0.0228	0.0181	– 0.0043	– 0.0312	– 0.0323	– 0.0779	– 0.0737
OTH	– 0.0006	– 0.0031	– 0.0039	– 0.0152	– 0.0583	– 0.1077	– 0.1183
Alt MAP	0.0135	0.0127	0.0157	0.0104	– 0.0025	– 0.0021	– 0.0078
QGDP	0.0342	0.0325	0.0211	– 0.0082	– 0.0077	– 0.0421	– 0.0404
Pseudo-R^2	0.3672	0.3672	0.3672	0.3672	0.3672	0.3672	0.3672
Dependent variable: GDP growth rate quarters 0–12 ahead							
FINC	– 0.0056	– 0.0016	– 0.0019	– 0.0141	– 0.0371	– 0.0638	– 0.0642
MAF	– 0.0028	0.0013	– 0.0077	– 0.0323	– 0.0430	– 0.0409	– 0.0463
OTH	– 0.0032	– 0.0064	– 0.0028	0.0039	– 0.0144	– 0.0720	– 0.0698
Alt MAP	0.0064	0.0075	0.0127	0.0087	– 0.0015	– 0.0077	– 0.0085
QGDP	0.0171	0.0199	0.0110	– 0.0094	– 0.0113	– 0.0285	– 0.0289
Pseudo-R^2	0.2322	0.2322	0.2322	0.2322	0.2322	0.2322	0.2322
Dependent variable: GDP growth rate quarters 0–16 ahead							
FINC	– 0.0147	– 0.0214	– 0.0097	– 0.0305	– 0.0529	– 0.0922	– 0.0614
MAF	– 0.0139	– 0.0186	– 0.0490	– 0.0637	– 0.0316	– 0.0657	– 0.0672
OTH	0.0080	0.0140	0.0250	– 0.0140	– 0.0837	– 0.1449	– 0.1469
Alt MAP	0.0094	0.0142	0.0139	0.0068	– 0.0051	– 0.0138	– 0.0151
QGDP	0.0261	0.0210	0.0041	– 0.0101	– 0.0055	– 0.0445	– 0.0440
Pseudo-R^2	0.4927	0.4927	0.4927	0.4927	0.4927	0.4927	0.4927

The *Alt MAP* index is built on solely exogenous macroprudential policy measures to address the endogeneity issue

Source: Author's calculations

Table 10 Robustness exercise #2: regression coefficients for the effect of FINC, MAF, OTH, MAP on Indonesia's industrial production growth rate across different quantiles

Percentile	5	10	25	50	75	90	95
Dependent variable: growth rate of industrial production							
FINC	0.0997	0.0021	– 0.0091	– 0.0236	– 0.0350	– 0.0449	– 0.0573
MAF	0.1786	0.1822	0.0614	0.0344	0.0234	0.0264	0.0155
OTH	– 0.0465	– 0.1459	– 0.0535	– 0.0282	– 0.0396	– 0.0510	– 0.0644
MAP	0.0194	0.0039	0.0027	0.0001	– 0.0049	– 0.0039	– 0.0057
QGDP	0.0196	0.0502	0.0322	0.0280	0.0302	0.0346	0.0388
Pseudo-R^2	0.3592	0.3592	0.3592	0.3592	0.3592	0.3592	0.3592

In this exercise, the growth rate of industrial production is a proxy for the GDP growth rate

Source: Author's calculations

Table 11 Robustness exercise #3: regression coefficients for the effect of FINC, MAF, OTH, MAP on Indonesia's GDP growth across different quantiles and horizons with inflation as an additional control variable

Percentile	5	10	25	50	75	90	95
Dependent variable: GDP growth rate quarters 0–4 ahead							
FINC	0.2283	0.1888	0.0861	0.0741	0.0433	0.0090	– 0.0833
MAF	– 0.0677	– 0.0866	0.0184	– 0.0176	– 0.0659	– 0.1024	– 0.0898
OTH	0.3107	0.3495	0.1046	0.0973	0.0295	– 0.0078	– 0.0917
MAP	0.0599	0.0423	0.0077	0.0019	0.0025	– 0.0050	– 0.0177
QGDP	0.0606	0.0437	0.0665	0.0395	– 0.0207	– 0.0101	0.0143
INFL	– 1.2728	– 0.8667	– 0.7626	– 0.9666	– 1.0522	– 0.9754	– 0.4260
Pseudo-R^2	0.7884	0.7884	0.7884	0.7884	0.7884	0.7884	0.7884
Dependent variable: GDP growth rate quarters 0–8 ahead							
FINC	0.0091	0.0065	– 0.0051	– 0.0061	– 0.0339	– 0.1027	– 0.0914
MAF	0.0237	0.0017	– 0.0112	– 0.0296	– 0.0521	– 0.0791	– 0.0928
OTH	0.0025	0.0208	0.0081	– 0.0103	– 0.0346	– 0.1043	– 0.1036
MAP	0.0059	0.0098	0.0102	0.0047	0.0008	– 0.0072	– 0.0093
QGDP	0.0380	0.0257	0.0113	– 0.0085	– 0.0133	– 0.0424	– 0.0427
INFL	– 0.1162	– 0.2309	– 0.0546	– 0.1923	– 0.3510	– 0.3070	– 0.4470
Pseudo-R^2	0.3593	0.3593	0.3593	0.3593	0.3593	0.3593	0.3593
Dependent variable: GDP growth rate quarters 0–12 ahead							
FINC	– 0.0060	– 0.0009	– 0.0036	– 0.0006	– 0.0206	– 0.0626	– 0.0657
MAF	– 0.0070	0.0010	– 0.0063	– 0.0330	– 0.0447	– 0.0474	– 0.0496
OTH	– 0.0062	– 0.0054	– 0.0033	0.0092	– 0.0086	– 0.0719	– 0.0679
MAP	0.0021	– 0.0004	0.0035	0.0019	– 0.0003	– 0.0062	– 0.0073
QGDP	0.0181	0.0204	0.0104	– 0.0091	– 0.0127	– 0.0286	– 0.0292
INFL	0.0867	0.0198	0.0372	– 0.3403	– 0.2292	– 0.1009	– 0.0629
Pseudo-R^2	0.2311	0.2311	0.2311	0.2311	0.2311	0.2311	0.2311
Dependent variable: GDP growth rate quarters 0–16 ahead							
FINC	– 0.0021	– 0.0212	– 0.0216	– 0.0339	– 0.0700	– 0.0844	– 0.0647
MAF	– 0.0075	– 0.0097	– 0.0505	– 0.0615	– 0.0368	– 0.0741	– 0.0965
OTH	0.0041	– 0.0057	0.0434	– 0.0142	– 0.0833	– 0.1298	– 0.1326
MAP	0.0012	0.0010	0.0021	0.0064	– 0.0009	– 0.0156	– 0.0160
QGDP	0.0342	0.0294	– 0.0082	– 0.0102	– 0.0058	– 0.0466	– 0.0464
INFL	0.1065	0.2421	0.0029	0.1091	0.2488	– 0.4955	– 0.6726
Pseudo-R^2	0.4767	0.4767	0.4767	0.4767	0.4767	0.4767	0.4767

INFL is the annual rate of inflation and is a proxy for the monetary policy stance in Indonesia

Source: Author's calculations

Table 12 Robustness exercise #4: regression coefficients for the effect of FINC, MAF, OTH, MAP on Indonesia's GDP growth across different quantiles and horizons with lags of the dependent variable

Percentile	5	50	95	5	50	95
Dependent variable: GDP growth rate quarters 0–4 ahead						
FINC	0.2780	− 0.0056	− 0.1034	0.2739	− 0.0066	− 0.0191
MAF	− 0.0473	0.0065	− 0.0772	0.2300	0.0054	− 0.0799
OTH	0.4468	0.0083	− 0.1009	0.1546	0.0047	0.0254
MAP	0.0818	0.0003	− 0.0201	0.0403	0.0004	− 0.0125
QGDP	0.0106	0.0073	0.0159	0.1299	0.0047	− 0.0156
Dep(− 1)	1.1116	0.3215	0.0954	1.4437	0.3250	0.3009
Dep(− 2)				0.1777	0.0374	− 0.1610
Pseudo-R^2	0.7359	0.7359	0.7359			
				0.7256	0.7256	0.7256
Dependent variable: GDP growth rate quarters 0–8 ahead						
FINC	0.0377	− 0.0028	− 0.0757	0.0018	− 0.0039	− 0.0679
MAF	− 0.0350	− 0.0297	− 0.0370	− 0.0145	− 0.0238	− 0.0478
OTH	0.0924	0.0202	− 0.0747	0.0420	0.0166	− 0.0423
MAP	0.0198	0.0033	− 0.0110	0.0150	0.0037	− 0.0094
QGDP	− 0.0276	− 0.0172	− 0.0229	0.0027	− 0.0132	− 0.0373
Dep(− 1)	0.5448	0.6468	0.9242	0.4943	0.8361	0.7561
Dep(− 2)				− 0.5170	− 0.2206	0.1702
Pseudo-R^2	0.2900	0.2900	0.2900			
				0.2767	0.2767	0.2767
Dependent variable: GDP growth rate quarters 0–12 ahead						
FINC	− 0.0005	− 0.0010	− 0.0001	− 0.0020	− 0.0043	− 0.0095
MAF	− 0.0132	− 0.0203	− 0.0003	− 0.0157	− 0.0199	− 0.0334
OTH	0.0219	0.0127	− 0.0002	0.0262	0.0120	− 0.0223
MAP	0.0067	0.0009	0.0000	0.0079	0.0007	− 0.0008
QGDP	0.0067	− 0.0115	− 0.0002	0.0041	− 0.0088	− 0.0276
Dep(− 1)	0.2305	0.8773	0.0107	0.2297	1.0481	1.1319
Dep(− 2)				0.0546	− 0.2776	− 0.2473
Pseudo-R^2	0.1758	0.1758	0.1758			
				0.1602	0.1602	0.1602
Dependent variable: GDP growth rate quarters 0–16 ahead						
FINC	0.0031	− 0.0224	− 0.0072	0.0031	− 0.0344	− 0.0279
MAF	− 0.0129	− 0.0374	− 0.0298	− 0.0144	− 0.0334	− 0.0549
OTH	0.0170	0.0037	− 0.0414	0.0198	− 0.0008	− 0.0120
MAP	0.0092	0.0006	− 0.0028	0.0105	− 0.0004	− 0.0061
QGDP	0.0217	− 0.0139	− 0.0276	0.0194	− 0.0108	− 0.0446
Dep(− 1)	0.1976	0.6454	1.4349	0.1950	0.6557	1.2949
Dep(− 2)				0.0385	− 0.1000	− 0.1934
Pseudo-R^2	0.3446	0.3446	0.3446			
				0.3058	0.3058	0.3058

Dep(− 1) is the first lag of the dependent variable GDP growth rate, and Dep(− 2) represents its second lag

Source: Author's calculations

Declarations

Conflict of interest The author has no relevant financial or non-financial interests to disclose.

Ethical approval Not applicable.

Consent to participate Not applicable.

Consent to publish Not applicable.

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