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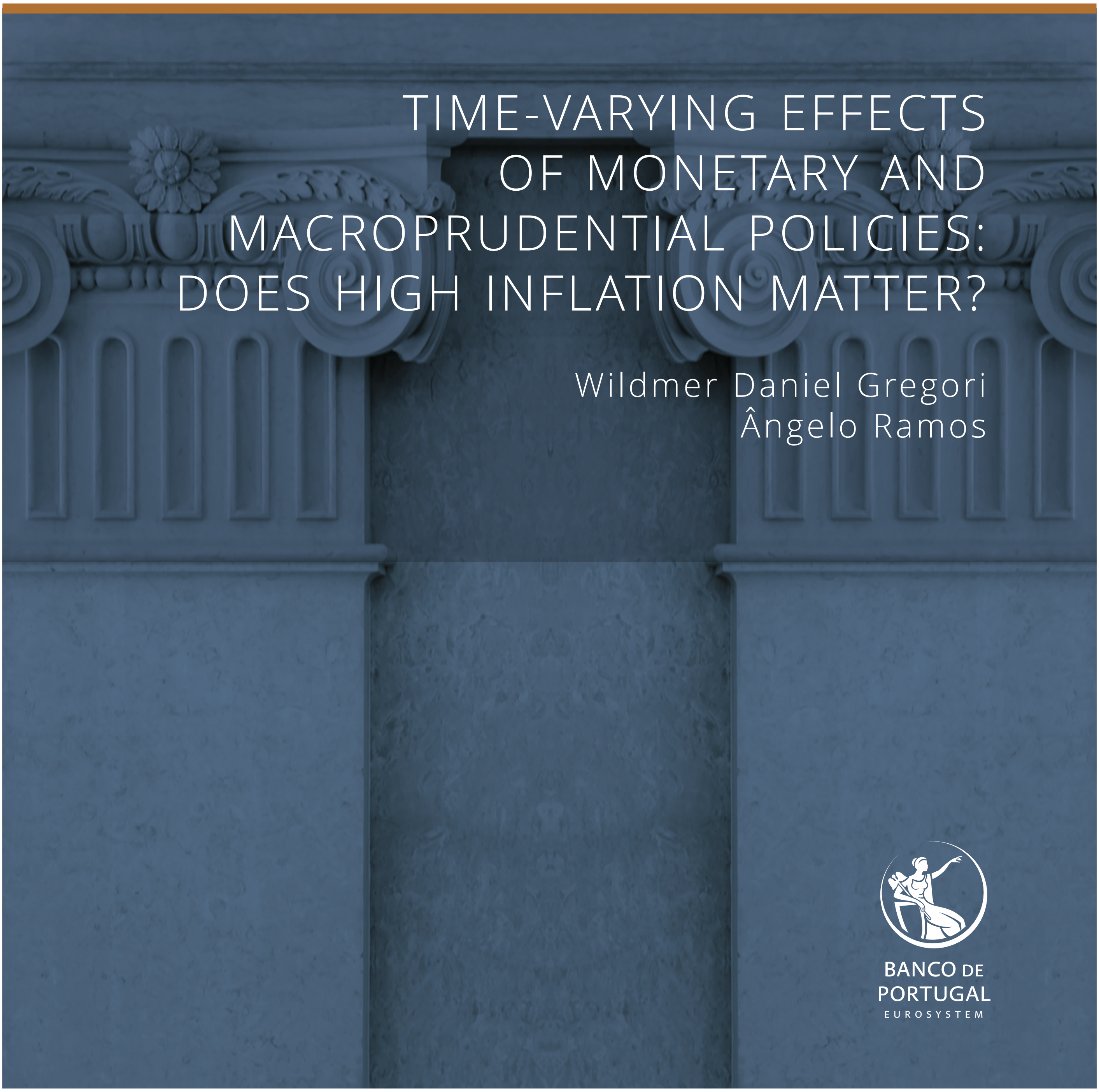

TIME-VARYING EFFECTS OF MONETARY AND MACROPRUDENTIAL POLICIES: DOES HIGH INFLATION MATTER?

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FEBRUARY 2024

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Time-varying effects of monetary and macroprudential policies: does high inflation matter?

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Abstract
This paper studies empirically the effects of monetary and macroprudential policy shocks on key policy-relevant macroeconomic variables, namely credit, consumer price, and economic growth. The analysis relies on a Bayesian TVP-SVAR model with monthly frequency data in the period 2010-2022 for Portugal. Macroprudential policy shocks are based on two micro-founded intensity indicators, for capital and borrower-based measures. Results show that a monetary policy tightening reduces credit growth, especially in periods of high inflation, suggesting a cross-policy effect. In addition, a macroprudential policy tightening does not lower macroeconomic aggregates, highlighting that the implemented measures did not disrupt credit or economic growth.

JEL: E58, E61.

Keywords: Financial Stability, Price Stability, Macroprudential Policy, Monetary Policy, High Inflation.

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1. Introduction

Do monetary policy (MP) and macroprudential policy (MaPP) affect key policy-relevant macroeconomic variables, namely credit, consumer price and economic growth? Are there cross-policy effects? Do high inflation periods have an impact on policy transmission channels? These are the key questions that our paper intends to address, in order to foster the policy discussion related to price and financial stability goals. Our time span ranges from 2010 to 2022, and starting from 2021 economies worldwide experienced high inflationary pressures attributable to different factors, such as the disruption of global supply chains, the materialisation of energy shocks, and the recovery in global demand (IMF (2023); Ari *et al.* (2023)). The European Central Bank (ECB) reacted by increasing its policy rates after a prolonged period of historically low levels. As shown in Figure 1 the deposit facility rate increased from 0% in June 2022 to 2.5% in December 2022,[1] highlighting the ECB goal of reducing the inflation rate to reach the 2% medium-term target.

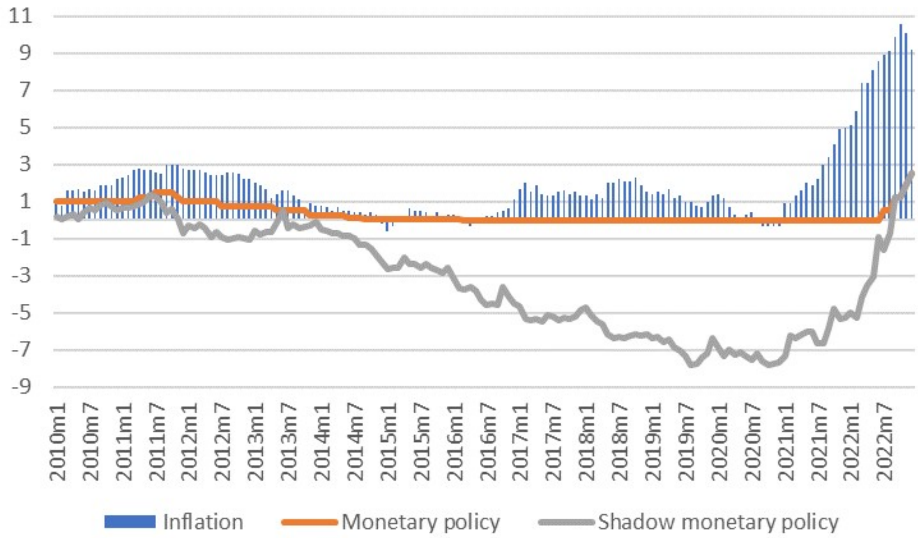
The maintenance of a lower-for-longer interest rate environment increased potential risks to financial stability through different channels. Economic agents have been subject to excessive risk-taking incentives to increase their yields, and the market to asset mispricing. Furthermore, a prolonged environment of low interest rates led to increased challenges in generating profitability in the traditional financial intermediation activity and commercial and residential real estate prices raised. The current MP tightening is expected to contribute to a decline in the search for yield. However, other risks could materialise, such as a fall in real estate prices resulting from changes in financing conditions.

To address inflationary pressures and foster financial stability, policymakers can resort to MP and MaPP. While the main goal of MP is price stability, the core objective of MaPP is to safeguard financial stability by mitigating systemic risks. However, MaPP may also affect aggregate demand (Teixeira and Venter (2023)), potentially impacting price and output levels. In the same vein, MP may go beyond price stability by influencing financial stability through credit effects (e.g., Tovar Mora *et al.* (2012); Claessens *et al.* (2013); Aiyar *et al.* (2014); Kuttner and Shim (2016); Bruno *et al.* (2017); Cerutti *et al.* (2017)). These policy tools could create challenges for policymakers especially during times when high (low) inflation coincides with low (buoyant) credit growth. Under such circumstances, contractionary (expansionary) MP would increase the disinflationary (inflationary) pressures, while accommodative (tightening) MaPP may increase (decrease) credit growth and inflationary (disinflationary) pressures, therefore pushing in the opposite

1. The key ECB interest rates refer to the interest rate on the main refinancing operations and the interest rates on the deposit and marginal lending facilities. In the text we focus on the deposit facility rate as it is the key rate. For further details, see: `https://www.ecb.europa.eu/stats/policy_and_exchange_rates/key_ecb_interest_rates/html/index.en.html`.

direction of MP. Private-sector agents would then be simultaneously encouraged to both decrease and increase borrowing, due to the contrasting policy incentives. Thus, a coordination between monetary and macroprudential policies may be required to better achieve both price and financial stability goals (Galati and Moessner (2013); Paoli and Paustian (2017); Agénor and Pereira da Silva (2022); Agénor and Jackson (2022)).

Figure 1: Inflation and monetary policy rates in the euro area.



Notes: Authors' elaboration on Eurostat and ECB data. Inflation refers to the Harmonised Index of Consumer Prices (HICP) taking into account that euro area (EA) members changed over time (i.e. EA11-1999, EA12-2001, EA13-2007, EA15-2008, EA16-2009, EA17-2011, EA18-2014, EA19-2015). Monetary policy refers to the ECB deposit facility rate, while Shadow monetary policy refers to the indicator elaborated by Wu and Xia (2016, 2017, 2020); see also: https://www.atlantafed.org/cqer/research/wu-xia-shadow-federal-funds-rate).

The euro area (EA) is characterised by countries sharing a single currency and MP, while facing a certain degree of coordination on fiscal policy, e.g. by the enforcement of the stability and growth pact. In addition, despite the high level of integration among EA countries, there can still be significant heterogeneity affecting financial stability risks, such as variations in the business and credit cycles (Maddaloni and Peydró (2013)). In this context, MaPP can play a central role (Buch *et al.* (2021)). In fact, in a monetary union where MP encompasses area-wide developments, country-level MaPPs gain importance to counteract possible adverse effects on financial stability of the "one-size-fits-all" MP, and MaPPs that complement MP by targeting national financial imbalances can deliver welfare benefits in terms of smaller business cycle fluctuations (Martin *et al.* (2021)). Different theoretical studies based on New Keynesian models have demonstrated the effectiveness and importance of country-specific targeted MaPPs in reducing imbalances and asymmetries among countries that share a common MP (Brzoza-Brzezina *et al.* (2015); Dehmej and Gambacorta (2019)). Furthermore, Houben *et al.* (2014) suggest that MaPP is particularly relevant in the EA compared to other regions, due to the fragmented nature of its financial sector along national lines and the absence of common macroeconomic instruments to address diverging financial cycles.

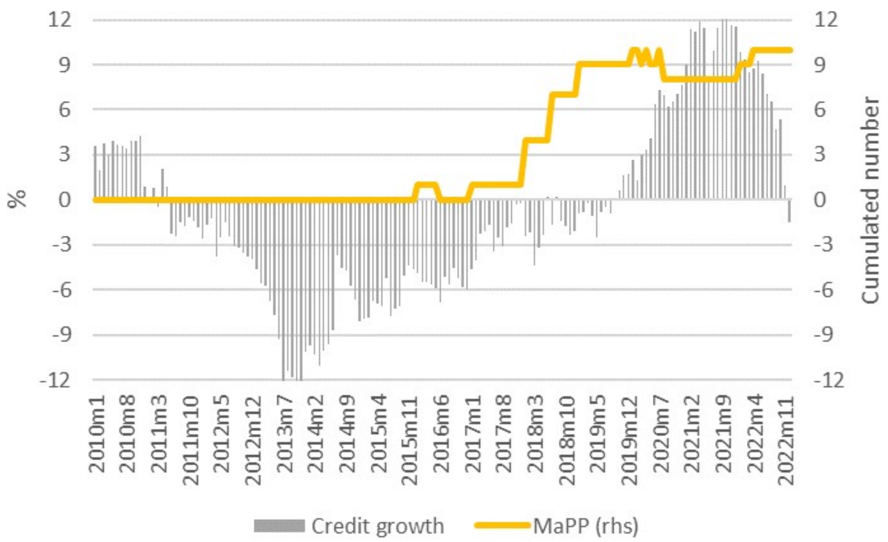
The role of MaPP may be considered especially relevant for small-open economies in a common monetary area, as the "one-size-fit-all" MP may be misaligned with the country financial or business cycle, and MaPP can better focus on country-specific factors. This study focuses on the Portuguese economy, as it represents a case study of interest to deepen monetary and macroprudential policy effects. Indeed, Portugal is a small-open economy characterised by a high share of real estate floating rate loans to households, with a ratio among the highest in the EA,[2] suggesting a stronger and quicker MP transmission channel linked to interest rate applied to loans compared to other EA countries. Furthermore, Portugal has been quite active in implementing MaPPs. For example, in 2018 borrower-based measures (BBM) have been introduced in the form of a Recommendation as a response to easing credit standards, high levels of indebtedness, and low saving rates of households. The Recommendation targets new loans to households, including mortgages as well as consumer credit, by setting limits to some of the criteria that are used by financial institutions when assessing the creditworthiness of borrowers. This measure aims to prevent credit institutions from taking on excessive risk when granting credit to households. Ultimately, this should lead to a more resilient financial sector as well as affordable access to finance for borrowers (Leal and Lima (2018)). Interestingly, Portugal was among the first countries to introduce a stressed DSTI ratio limit in BBM.[3] In addition, in the time span analysed Portugal is characterised by a dynamic credit cycle with both boom and bust periods. As shown in Figure 2, there has been a credit bust between 2011 and 2019, followed by a credit growth also during the COVID-19 period, which slowed down at the end of sample period.

2. In August 2023 floating rate loans accounted for 85% of housing loans in terms of stocks and 56% in terms of flows (source: Banco de Portugal). For further details, see: ESRB (2016, 2023).

3. The DSTI ratio for the purpose of the macroprudential Recommendation includes interest rate and income shocks. The numerator of the ratio considers the impact of an interest rate increase, depending on the loan's original maturity and the interest rate scheme. The denominator includes a reduction in borrowers' income by at least 20% if the borrower's age at the end of the loan contract is higher than 70 years old, given that a material income decrease is expected in the transition from working life into retirement. These shocks are in line with European Banking Authority's Guidelines on loan origination and monitoring. For more information, see EBA (2020) and Leal and Lima (2018).

Considering the potential existence of interlinkages between policies (Kim and Mehrotra (2018); Kim and Mehrotra (2022)), this paper focuses on the effects of monetary and macroprudential policy shocks on key policy-relevant macroeconomic variables in a unified framework. The MaPP shocks are based on two micro-founded intensity indicators, for capital and borrower-based measures. We implement a Bayesian Time-Varying Parameters Structural Vector Autoregressive model (TVP-SVAR), to capture the evolution of policy shocks' transmission channels through time. We focus on the period between 2010 and 2022 in Portugal with a monthly frequency to highlight potential short-term effects. Results show that MP tightening significantly reduces credit growth, especially in periods of high inflation[4], suggesting a cross-policy effect. By contrast, a tightening in MaPP does not lower credit growth, suggesting that the implemented measures did not disrupt credit dynamics.

Figure 2: Credit growth and extensity MaPP indicator in Portugal.



Notes: Gray bars refer to total credit growth (i.e. households and non-financial corporations), while the yellow line refers to the cumulative number of macroprudential policy measures implemented (i.e. extensity MaPP indicator), constructed using the Integrated Macroprudential Policy database (Alam *et al.* (2019)) considering both CBM and BBM. Data refer to Portugal.

The paper is structured as follows. The related literature is presented in section 2, and section 3 describes how the intensity macroprudential indicators have been

4. We consider periods of high inflation those where the Harmonised Index of Consumer Prices is above 4%.

constructed. The dataset and the empirical methodology are presented in section 4, while section 5 shows the results and robustness checks. Section 6 concludes.

2. Related literature

There is an increasing number of theoretical studies on the interactions between monetary and macroprudential policies (e.g., Angelini *et al.* (2014), Quint and Rabanal (2014); Smets (2014); Bailliu *et al.* (2015); Farhi and Werning (2016); Alpanda and Zubairy (2017); Martinez-Miera and Repullo (2019)). This paper serves as the empirical counterpart to those studies and contributes to different strands of the empirical literature.

We contribute to the literature on the analysis of the joint effects of monetary and MaPP shocks within a unified empirical framework (e.g., Kim and Mehrotra (2017); Kim and Mehrotra (2018); and Kim and Mehrotra (2022)). Our study is also related to the empirical research that explores the effects of MaPPs on credit (e.g., Tovar Mora *et al.* (2012); Claessens *et al.* (2013); Aiyar *et al.* (2014); Kuttner and Shim (2016); Bruno *et al.* (2017); Cerutti *et al.* (2017)), and on the linkages between monetary and macroprudential policies (e.g., Claessens (2013); Maddaloni and Peydró (2013)). The latter strand of research has highlighted the various links between MP and financial stability. These include examining the influence of MP on risk-taking behaviour in the private-sector (Borio and Zhu (2012)), developing a theoretical inflation targeting framework for MP that also takes into account financial stability concerns (Woodford (2012)) and analysing the associated costs (Svensson (2017)). Additional research focused on exploring the different impacts of monetary and macroprudential policies on financial conditions (Zdzienicka *et al.* (2015)), and investigating the historical role of MP in leading to booms in real estate lending and house prices' bubbles (Jordà *et al.* (2015)). Differently from these empirical studies, we analyse the effects of monetary and macroprudential policies on macroeconomic variables in a unified time-varying empirical framework, in order to take into account possible differences through time in both the magnitude of transmission channels, as policy effects could change through time (e.g. in a period of high inflation), and the intensity of the policy implemented (stochastic volatility). We implement a Bayesian TVP-SVAR, estimated with a monthly frequency dataset (instead of the commonly used quarterly approach for VAR models), which allows us to better detect policy shocks transmission to the economic variable of interest, especially in the short term. Furthermore, by focusing on a single country we can better examine the effects of country-level MaPPs, while panel studies average the effects of different heterogenous countries.

We also contribute to the strand of literature related to macroprudential indicators, especially in the discussion of extensity vs intensity ones. The literature firstly constructed proxies of macroprudential measures building indicators based on the extensity of MaPPs, weighting each policy equally (e.g., Reinhardt and Sowerbutts (2015); Akinci and Olmstead-Rumsey (2018); Bruno *et al.* (2017); Cerutti *et al.* (2016, 2017); Kim and Mehrotra (2017); Kim and Mehrotra (2018); Ahnert *et al.* (2021)). This approach implies that an indicator is created starting from a value equal to zero and increasing by 1 unit when a policy tightening is introduced, while on the contrary decreasing by 1 unit for policy loosening. If in a certain period no action is taken, or there is a loosening and a tightening in the same period, the indicator does not change. Rather than policy changes, typically cumulative indicators are employed because macroprudential measures can affect the variables of interest not just in the implementation date, but also in the subsequent periods, as some of these policies may have delayed effects. Alternatively, some authors focused on the intensity of MaPPs, in order to assign different weight to dissimilar policies (e.g., Vandenbussche *et al.* (2015); Richter *et al.* (2019); Alam *et al.* (2019); Eller *et al.* (2020)). The intensity approach is challenged by difficulties in comparing and quantifying the effects of different measures. We contribute to the construction of intensity macroprudential indicators exploiting bank-level characteristics, also relying on a credit register with loan-level information.[5] We explore the effects of different MaPP tools, disentangling between capital and BBM, and constructing intensity capital and borrower-based indicators, used also aggregated to generate a single intensity MaPP indicator.

3. Macroprudential intensity indicators

The MaPP toolkit framework relies on the Basel III package, developed by the Basel Committee on Banking Supervision (BCBS) as a response to the 2007-2009 global financial crisis. The Basel III package comprises a global regulatory framework for the banking system, to enhance the robustness of banks' capital ratios and bank disclosures and improve risk management and governance. The introduction of MaPP is a key element of the Basel III regulatory framework. It contributes to the resilience of the banking system and to maintain the flow of credit to the real economy in the downturn of financial cycle. In the European framework, capital MaPP is regulated by the Capital Requirements Directive (CRD), while BBM are defined at the national level. Capital-based measures (CBM) aim to preserve financial stability by increasing the financial system's capacity to absorb unexpected losses mitigating procyclicality and allowing institutions to keep an adequate flow of funds to the economy throughout the different phases of the financial cycle. Their purpose is to increase the resilience of banks and to cushion the financial cycle, by encouraging them to build up capital that could be used during downturn periods. BBM directly target the borrowers, by tightening credit

5. The Banco de Portugal Central Credit Register is reported on a monthly basis to Banco de Portugal. It contains monthly loan-level information on all lending relationships between Portuguese credit institutions and Portuguese households.

conditions for riskier borrowers. These measures improve institutions' resilience indirectly and over the medium term by improving the risk level of new credit, which results in enhanced resilience of borrowers and banks (Gross and Población (2017); Neugebauer *et al.* (2021)).

Table 1 shows the different categories of macroprudential policies. Capital buffers include the capital conservation buffer (CCoB), the countercyclical capital buffer (CCyB), buffers for global and other systemically important institutions (G/O-SIIs), and the systemic risk buffer (SyRB). The combination of all these capital buffers constitutes the combined buffer requirement (CBR). Unlike CBM, BBM (e.g., limits on loan-to-value (LTV), debt-to-income (DTI) ratio, debt service-to-income (DSTI) ratios, amortizations requirements or maturity of the loans are not embedded in the European legislation.

Table 1. Categories of macroprudential policy measures.

Category	*Macroprudential policy measures*
Borrower-based measures	
	LTV ratio caps
	DSTI and LTI ratio caps
	Other loan restrictions (e.g., maturity caps)
Capital-based measures	
	Capital conservation buffer (CCoB)
	Countercyclical capital buffer (CCyB)
	Other systemically important institutions capital buffer (O-SII)
	Other capital-based measures (e.g., SyRB, risk-weights)
	Loan loss provision requirements
	Other measures (e.g., restrictions on profit distribution)

A common approach used in the literature is to construct a so-called "extensity indicators", imposing that all MaPPs have an equal weight. A different and more recent approach generates "intensity indicators", and it is based on the fact that MaPPs may have different effects, therefore the weight of each policy should be related to its intensity (Eller *et al.* (2020)). We contribute to latter approach, and in the next two subsections we analyse the CBM and BBM adopted in Portugal,[6] constructing the related intensity indicators. The advantage of having two different intensity indicators, one for CBM and another one for BBM, allows us to investigate separately the effects of CBM and BBM on macroeconomic aggregates.[7]

6. The list of adopted CBM and BBM is reported in Appendix, Table A1 and Table A2 respectively.

7. In the robustness checks, we also analyse the effects of combining the intensity of both CBM and BBM indicators in a unique intensity MaPP indicator.

In Portugal MaPP has been characterized by different phases. As show in Figure 2 (yellow line), the number of implemented macroprudential measures show three different dynamics. Up to September 2015, there were no macroprudential capital buffers nor BBM in place, also because a common European Union (EU) MaPP framework was still under development. The following period, between October 2015 and February 2020, is characterised by the increasingly use of macroprudential measures, such as the phase-in of three regulatory requirements: the CCoB, the capital buffers to O-SIIs, and a BBM, introduced in the form of a Recommendation. This last measure targeted new loans to households by setting LTV and DSTI ratio limits, maturity limits, as well as regular payments of interest and capital. CBM became increasingly used following the EU regulatory framework (CRD and CRR). The period between March 2020 up to the end of 2022 is characterized by less restrictive macroprudential measures following the uncertainty regarding the macro-financial outlook due to the COVID-19 pandemic. Loosened macroprudential measures in this period included the possibility for institutions to temporarily operate below the CBR. In addition, exemptions were introduced to some of the criteria in the BBM, and postponement of the phase-in period of the O-SII buffer was also applied. However, from 2020 more restrictive measures include the reduction of exemptions to the DSTI ratio limit, reduction of the maturity limits of personal credit, and dividend distribution restrictions. In 2022 the O-SII buffer was increased due to the yearly calibration exercise,[8] and new limits were introduced to the maximum maturity of new credit for house purchase based on the borrowers' age. Next subsections focus on how we have constructed the intensity indicators.

3.1. Intensity capital-based indicator

The capital-based intensity indicator focuses on macroprudential capital buffers. Capital buffers are funds that financial institutions are required to hold, in addition to the minimum capital, in the form of Common Equity Tier 1 (CET1) capital expressed in percentage of total risk exposure amount (TREA). While some capital buffers apply to all institutions, such as the capital conservation buffer and the countercyclical capital buffer, the O-SII buffer applies only to systemically important institutions, and the calibration of the buffer is institution specific. The systemic risk buffer can either be applied to all institutions and exposures, or to one or more subsets of those institutions and exposures (i.e. sectoral systemic risk buffer).

When determining the restrictiveness of the imposed capital buffers, it is important to take into consideration the importance of the institutions subject to

8. The O-SII buffer of: (i) Caixa Geral de Depósitos increased from 0.75% to 1%, (ii) Banco Comercial Português increased from 0.563% to 0.75%, (iii) LSF Nani Investments increased from 0.375% to 0.5%, (iv) Santander Totta from 0.375% to 0.5%, (v) Banco BPI from 0.375% to 0.5%, and (vi) Caixa Económica Montepio Geral from 0.188% to 0.25%.

each capital buffer requirement. Therefore, we use bank-level data to quantify each financial institution's market share, as an approximation of the relative importance, calculated as follows:

$$MarketShare_{i,t} = \frac{TotalLoans_{i,t}}{\sum_{i=1}^{I} TotalLoans_{i,t}} \tag{1}$$

where $MarketShare_{it}$ refers to the market share of bank i in month t, and I is the total number of banks. Since these data are quarterly (which differs from the remaining indicators set at monthly frequency), we assume that the monthly total loans of each bank is constant in each month of the same quarter. The market share-adjusted capital-based intensity indicator is computed as follows:

$$\begin{aligned} CBiM_{i,t} = CCoB_t + CCyB_t + SyRB_t + \sum_{s=1}^{S}(OSIIB_{s,t} * MarketShare_{s,t}) \\ + \sum_{g=1}^{G}(sSyRB_{g,t} * MarketShare_{g,t} * ExposureWeight_{g,t}) \end{aligned} \tag{2}$$

where S is the number of systemically important institutions and G is the number of institutions affected by a sectoral systemic risk buffer. Up until the end of 2022 the $CCyB$[9] and the $SyRB$ has not been introduced in Portugal, thus enter equal to zero. The CCoB is equal to 2.5% of TREA. The O-SII buffer ($OSIIB$) only applies to the systemically important institutions and the respective calibration is institution-specific, depending on the institutions' systemically importance, which may change over time. To take into consideration the importance of the institutions to which a O-SII buffer is applied to, we weigh the O-SII buffer of each institution by its market share. Since the $sSyRB$ may be applied to a subset of institutions and exposures , the buffer requirement is weighted by the market share of the institutions and by relevance of the targeted exposures (determined by dividing the exposure to which a sSyRB is applied to by total exposure of the institution).

During the COVID-19 period macroprudential authorities across the EA acted to prevent the banking system from being an amplifying channel of the shock triggered by the outbreak of the pandemic, which changed the economic and financial conditions of economic agents.[10] As a consequence, CBM were released,

9. While the CCyB is also applied to a subset of exposures, i.e. to credit exposures to the domestic private non-financial sector, for the case of Portugal non-domestic credit exposures are negligible. Therefore, an extension of this indicator could also weight this buffer requirement by the share of domestic exposures and the market share of each institution.

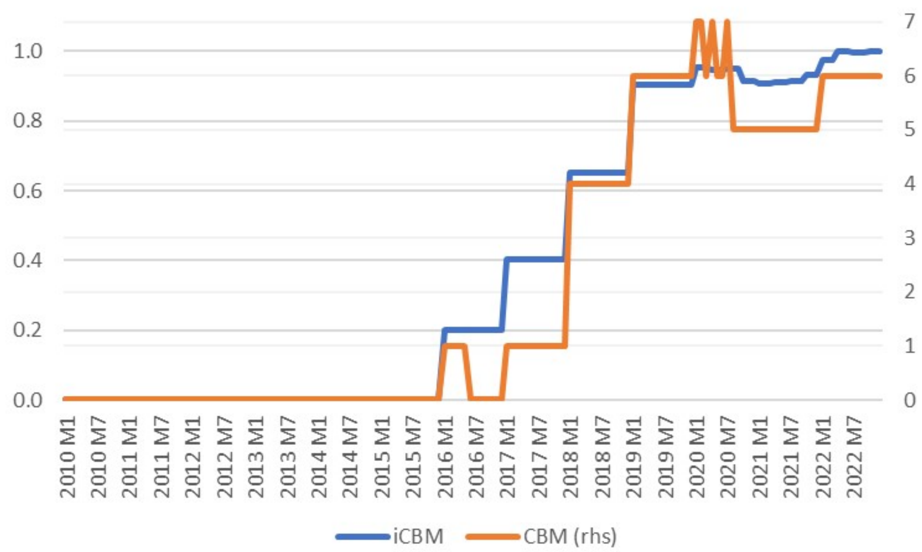
10. See the Banco de Portugal press release (May 8, 2020) on the decision to postpone the phase-in period of the capital buffer for "Other Systemically

and as mentioned before between March 2020 and the end of 2022 banks were able to operate below the combined buffer requirements (CBR). This measure was taken by macroprudential authorities to enable institutions to accommodate the expected impacts on capital stemming from the COVID-19 pandemic, and to free up resources to fund economic activity, thus preserving financial stability. However, in a period of deteriorating economic and financial conditions with a negative impact on the costs of capital, such as in the COVID-19 pandemic, banks may choose to maintain capital on top of macroprudential capital buffers due to an increase in the risk perceived by shareholders or debt holders. This can be achieved by reducing lending, reallocation of exposures to assets with lower risk weights, issue equity or reduce dividend pay-outs. In addition, authorities decided to recommend banks not to distribute dividends for the 2019 and 2020 exercises. There is evidence of the hampering effect of market discipline on the use of capital buffers, which may constrain banks from using their buffers during economic downturns (Avezum *et al.* (2023)). Due to different factors, such as potential market stigma, the fact that this measure was temporary, and that the COVID-19 pandemic did not significantly increase losses, capital to meet CBR was not significantly used. Considering these aspects, despite institutions have being allowed to operate temporarily below CBR in this period, we do not impose a CBM equal to zero as it would not reflect the actual intensity of this policy. Instead, in the months between March 2020 and December 2022, we decrease the capital-based intensity indicator by the percentage of capital effectively used to meet CBR.

The capital-based intensity indicator is normalized between zero and one. The normalization ensures that this indicator is comparable with the borrower-based intensity indicator, and zero and one represent the minimum and maximum level reached in the period under consideration. The higher this value (closer to one), the more restrictive the measure is. As shown in Figure 3, the intensity capital-based indicators reflect the dynamic showed by the extensity one, with a correlation coefficient equal to 0.978. However, the former is able to capture intensity differences in the policy implemented. For instance, the highest level for the intensity indicator is reached in the last months of 2022, while for the extensity indicator in 2020. In addition, the loosening implemented at the end of 2020 impacts less the intensity indicator vis-à-vis to the extensity one.

Important Institutions" available here: https://www.bportugal.pt/en/comunicado/press-release-banco-de-portugal-decision-postpone-phase-period-capital-buffer-other.

Figure 3: Intensity vs extensity capital-based indicators.



Notes: CBM refers to the extensity capital-based indicator, constructed using the Integrated Macroprudential Policy database (Alam *et al.* (2019)) while iCBM refers to intensity capital-base indicator. These indicators are based on CCoB, O-SII capital buffer, CCyB, and SyRB.

3.2. Intensity borrower-based indicator

The intensity borrower-based indicator captures the relative effectiveness of the imposed quantitative limits. It is calculated for each policy instrument separately, i.e., there are different intensity-adjusted indices for LTV, DSTI, and maturity limits. The characteristics used to compute these intensity-adjusted indices are the quantitative limits and the scope. The latter is measured by the importance of each loan segment to which the limit is applied to in the total household loans. The larger the scope, the broader the lending segment that is targeted and the higher the share of the economy that is potentially affected by the instrument. A larger scope contributes to a larger value for the index. Since there are different LTV and maturity limits depending on the loan category, we also calculate different indices for each of those loan categories. For each loan category and period, the relative effectiveness of the imposed borrower-based limits is computed by the deviation between each limit of the specific macroprudential measure, and the average (weighted by loan amount) of the related variable of interest (i.e. LTV, DSTI and maturity). By comparing the limit to the average, we get an indication of how effective each limit is over time, and not only when the measure is introduced or changed, as in the case of a dummy indicator.

Relating to the LTV ratio limits, we consider three limits: (i) 90% to new credits to residential immovable property for the purchase or construction of own and permanent residence, (ii) 80% to new credits to residential immovable property or credit secured by a mortgage or equivalent guarantee for other purposes than own and permanent residence, (iii) 100% to new credits to residential immovable property and credit secured by a mortgage or equivalent guarantee for purchasing immovable property held by the institutions and for property financial leasing agreements. We compute the difference between these limits to the average LTV ratio for these loan categories, and we weigh each loan category indicator by the respective loan amount to get an overall intensity LTV indicator.

The DSTI limit is 50%, with the following exceptions on the total amount of credit granted by each institution: (i) up to 10% with $DSTI{\leq}60\%$ and (ii) up to 5% without DSTI limit. Since 10% of new loans may be granted with an DSTI up to 60%, the DSTI limit is obtained as follows: $[(0.85*50)+(0.1*60)]/0.95=51.1$. We then compute the deviation from this DSTI limits of the actual DSTI.[11]

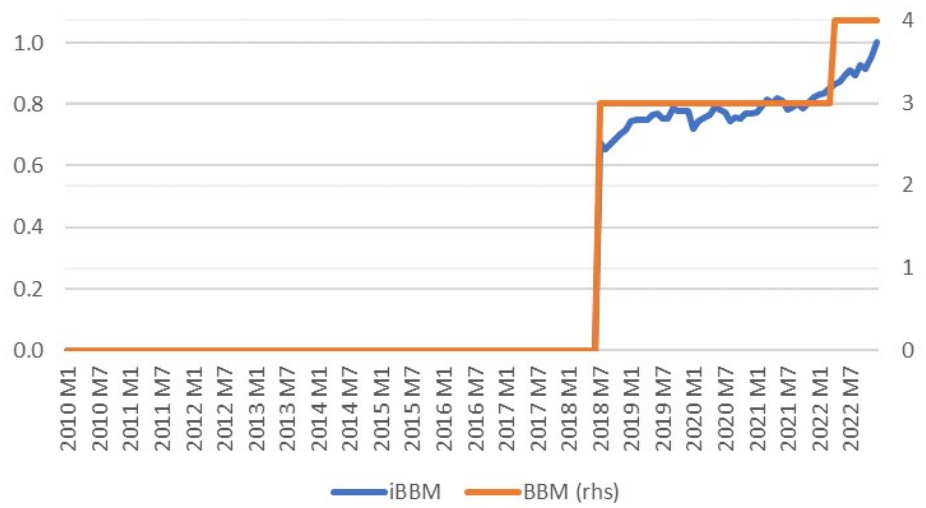
Regarding the maturity limits, we consider 40 years for credits relating to residential immovable property or credit secured by a mortgage or equivalent guarantee. For new consumer credit agreements, we consider a maturity limit of 10 years until December 2019, and from January 2020 until the end of 2022, we consider the following: (i) 7 years for new personal loans and 10 years for new car credit. BBM also determined that the average maturity of new credit agreements for house purchase, credit secured by a mortgage or equivalent guarantee should gradually converge (with a linear trend) to 30 years, from the time of entry into force of the Recommendation to the end of 2022. Then, from April 2022 onwards, Banco de Portugal set the maturity limits to the original maturity of new credit for house purchase depending on the borrower's age: 40 years for borrowers aged 30 or under, 37 years for borrowers aged over 30 and up to and including 35, and 35 years for borrowers aged over 35. As for the LTV indicator, we calculate the deviation between these limits and the average maturity of these loan categories, and each loan category indicator by the loan amount to get an overall intensity maturity indicator.

After computing the overall LTV and maturity, as well as the intensity DSTI-based indicators, we calculate the overall intensity borrower-based indicator, obtained from each individual indicator equally weighted. Similarly to the CBM, we normalize the overall LTV, DSTI and maturity limits to a number between zero and one to ensure that they are comparable, including with the intensity capital-based indicator. The higher this value (closer to one), the more effective the measure is

11. In case that the computation of the deviation considers the 50% DSTI limit, the intensity borrower-based indicator does not change significantly, and empirical results are confirmed.

considered. Figure 4 shows the extensity indicator (orange line), highlighting that BBM were firstly implemented in July 2018, and it highlights that the intensity borrower-based indicator (blue line) captures the dynamic of the extensity one, with a correlation coefficient equal to 0.996. Nevertheless, the former indicator is better able to capture the intensity through time of the related implemented measures.

Figure 4: Intensity vs extensity borrower-based indicators.



Notes: BBM refers to the extensity borrower-based indicator, constructed using the Integrated Macroprudential Policy database (Alam *et al.* (2019)), while iBBM refers to the intensity borrower-based indicator. These indicators are based on LTV and DSTI ratio limits, and maturity limits.

4. Data and Methodological framework

4.1. Data

The dataset covers the years 2010-2022 with a monthly frequency and it is constructed relying on different sources. MP is captured by the ECB shadow policy rate (R^s), to detect the effects of both conventional and non-conventional MP, following Wu and Xia (2017, 2020). MaPP consists of two intensity indicators, one for capital-based measures ($iCBM$) and the other for borrower-based measures ($iBBM$), constructed as detailed in the previous section. Considering that the ultimate goal of the MP is price stability, we include in the dataset the inflation rate through the consumer price index (CPI). As a key MaPP relevant macroeconomic variable we consider the stock of credit growth to the non-private sector (C), considering that excessive credit expansion may undermine financial stability (IMF-BIS-FSB (2011)), and the empirical evidence suggests that excessive credit growth typically precedes financial crises (e.g., Kaminsky and Reinhart (1999); Schularick and Taylor (2012)). Given that price and financial stability are intended to guarantee, as a prerequisite, a stable economic growth in the medium-long term, we include among the key policy-relevant variables also the level of economic activity, namely the coincidence indicator CI) as constructed by Rua (2015). It is a monthly composite indicator that captures underlying developments in the year-on-year rate of change in GDP. Furthermore, considering that different studies highlight that the United States MP may have impacts on macroeconomic variables of other countries (e.g., Rey (2015); McCauley *et al.* (2015); Chen *et al.* (2016)), the dataset also includes the shadow MP rate of the United States (R^s_{US}), as constructed by Wu and Xia (2016). Table 2 reports the description statistics of the dataset.

Table 2. Descriptive statistics

Variable	*Source*	*Obs*	*Mean*	*SD*	*Min*	*Max*
CI	BdP; Rua (2015)	156	0.76	3.27	-7.20	7.40
CPI	INE	156	1.62	2.29	-0.80	10.57
C	BdP	156	-0.86	6.01	-12.68	12.31
R^s	Wu-Xia	156	-3.13	2.93	-7.82	2.50
$iCBM$	Authors	156	0.38	0.41	0.00	1.00
$iBBM$	Authors	156	0.27	0.38	0.00	1.00
R^s_{US}	Wu-Xia	156	-0.18	1.62	-3.00	4.38

Notes: CI refers to Economic activity coincident indicator, CPI to Consumer price index rate (2012=100), C to Stock of banks' loans growth rate, R^s to Euro area shadow interest rate, $iCBM$ to Intensity capital-based measures indicator, $iBBM$ to Intensity borrower-based measures indicator, R^s_{US} to United States shadow fed interest rate. BdP stands for Banco de Portugal; INE stands for Statistics Portugal; Wu-Xia refers to the shadow indicator elaborated by Wu and Xia (2016, 2017, 2020); see also: `https://www.atlantafed.org/cqer/research/wu-xia-shadow-federal-funds-rate`.

4.2. Methodological framework

The aim of this study is to investigate the effects through time of monetary and MaPP shocks on key policy-relevant macroeconomic variables. An approach already implemented in the literature to study macroeconomic linkages relies on Bayesian Structural Vector Autoregressive models with time-constant parameters (e.g., Kim and Mehrotra (2018, 2022)). By contrast, we are also interested in detecting possible differences in policy effects through time, considering that macroeconomic variables could react differently to policy shocks, for instance in relation to the business cycle or in a period with high inflation, changing the magnitude of transmission channels. To capture this aspect, the parameters of the model should not be constant, but be allowed to change over time, and time-varying coefficient VAR models are well suited for this purpose. In addition, the intensity of the policy shocks may also change over time, such as in periods in which policymakers are more active (higher volatility) vis-à-vis periods in which they are less prone to undertake policy measures (lower volatility). To include this feature in the model, the error term shall be characterized by a time-varying volatility (i.e. stochastic volatility). As suggested by Cogley and Sargent (2005) and Primiceri (2005), these features can be included in SVAR models, leading to Time-Varying Parameters Vector Autoregressive models (TVP-SVAR). This approach allows to disentangle the evolution of macroeconomic relationships between those impacting coefficients' variations, and those related to volatile changes. There are studies where this approach has been applied to study macroeconomic dynamics (see, among others, Nakajima *et al.* (2011); Paul (2020); Balli *et al.* (2021)), but as far as we know the literature using this methodology involving MaPP indicators, especially intensity ones, is rather limited. Therefore, we study the effects of monetary and macroprudential policies in Portugal, considering both intensity capital and borrower-based macroprudential indicators, on a set of macroeconomic variables, namely inflation rate, credit and economic growth in a unified framework based on a Bayesian TVP-SVAR model. In addition to these endogenous variables, we also include an exogenous variable, reflecting US MP, considering that it may have impacts on macroeconomic variables of other countries (e.g., Rey (2015); McCauley *et al.* (2015); Chen *et al.* (2016)). Following Dieppe *et al.* (2016), the model is specified as follows:

$$y_t = c_t + A_{1,t}y_{t-1} + A_{2,t}y_{t-2} + ... + A_{p,t}y_{t-p} + D_t x_t + \varepsilon_t, \quad \varepsilon_t \sim N(0, \Sigma_t) \quad (3)$$

where y_t is a 6x1 vector of the observed endogenous variables at time t, c_t is a 6x1 vector of time-varying intercepts, $A_{1t}, \ldots, A_{pt}$ are 6x6 matrices of time-varying coefficients with number of lags p, x_t represents the exogenous variable, and D_t the related 6x1 time-varying coefficients, ε_t are heteroscedastic unobservable shocks with a time-varying covariance matrix Σ_t. This model allows time variation in both VAR coefficients and residual covariance matrix. We can rewrite equation (3) in the following compact form:

$$y_t = \bar{X}_t + \varepsilon_t \quad (4)$$

where $\bar{X}_t = I_t \otimes X_t$, with $X_t = (y'_{t-1}, y'_{t-2}, ..., y'_{t-p})$, and $\beta_t = vec(B_t)$, with $B_t = (A_{1,t}, A_{2,t}, ..., A_{p,t}, D_t)'$. The dynamic process for β_t is describe as follows:

$$\beta_t = \beta_{t-1} + \nu_t, \quad \nu_t \sim N(0, \Omega) \quad (5)$$

where the covariance matrix Ω is assumed to be a random variable endogenously determined by the model. The time-varying variance-covariance matrix Σ_t introduced in equation (3) can be decomposed, following Cogley and Sargent (2005), as follows:

$$\Sigma_t = F\Lambda_t + F' \tag{6}$$

$$F = \begin{bmatrix} 1 & 0 & \dots & 0 \\ f_{2,1} & 1 & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ f_{6,1} & \dots & f_{6,(6-1)} & 1 \end{bmatrix} \tag{7}$$

$$\Lambda_t = \begin{bmatrix} \bar{s_1}exp(\lambda_{1,t}) & 0 & \dots & 0 \\ 0 & \bar{s_1}exp(\lambda_{2,t}) & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ 0 & \dots & 0 & \bar{s_1}exp(\lambda_{6,t}) \end{bmatrix} \tag{8}$$

where F is a lower triangular matrix to measure contemporaneous relationships between structural shocks based on a recursive identification procedure, and Λ_t is a diagonal matrix representing the stochastic volatilities. $\lambda_{1,t}$, $\lambda_{2,t}$, .., $\lambda_{6,t}$ are dynamic processes able to introduce heteroscedasticity in the model, and they are assumed to be characterized by the following autoregressive process:

$$\lambda_{i,t} = \gamma_{i,t-1} + \upsilon_t, \quad \upsilon_t \sim N(0, \phi_i) \tag{9}$$

where λ is an autoregressive coefficient.[12]

In our model, the parameters to be estimated are the VAR coefficients β_t, the covariance matrix Ω, the elements in the matrix F, the latent values $\lambda_{i,t}$, and the heteroskedasticity parameters ϕ_i. Differently from VAR models with constant parameters, TVP-VAR models require the contemporaneous estimation of a relevant higher number of parameters, possibly leading to over-parametrization. Therefore, the estimation relies on the Bayesian approach using a Gibbs sampling algorithm, to prevent parameter instabilities and generate analytical solutions.[13]

The structural interpretation of the model is needed to quantify the dynamic interaction between policy and macroeconomic variables. It relies on the recursive

12. In this section we report only the key equations of the model. For a detailed explanation, refer to Dieppe *et al.* (2016).

13. A model with many state variables, as a TVP-VAR model, presents computationally difficulties, and the introduction of stochastic volatility increases the estimation complexity, considering that the likelihood function has no closed form. In this context, a Markov Chain Monte Carlo (MCMC) algorithm, such as Gibbs sampling, simplify the estimation process (Koop (2003); Primiceri (2005)).

identification procedure of the variance-covariance matrix Σ_t related to Cholesky factorization. This implies that the ordering of endogenous variables in the vector y_t should be placed in a decreasing order of exogeneity.[14] We assume that policy actions are implemented once the economic activity and main policy objectives are observed. In addition, considering that the MP is set centrally by the ECB for the EA countries, we assume that the MaPP is implemented after having observed the ECB behaviour. Therefore, the vector of endogenous variables (y_t) is defined as follows: $y_t = [CI_t, CPI_t, C_t, R_t^s, iCBM_t, iBBM_t]'$, where CI_t, CPI_t, C_t are the key policy-relevant macroeconomic variables of interest, namely Coincidence Indicators, Consumer Price Index, and Credit growth to private non-financial sector respectively, and t represents the time dimension on a monthly frequency. The policy variables are R_t^s,$iCBM_t$ and $iBBM_t$, referring to MP, intensity capital-based and borrower-based indicators respectively.

The Bayesian feature of the model requires to define in advance the hyperparameters' values. Specifically, the autoregressive coefficient on the residual's variance is set at $\lambda = 0.85$ as standard in the literature (Dieppe *et al.* (2016)), while the inverse Gamma shape and scale on the residual's variance are set at $\alpha_0 = 0.001$ and $\sigma_0 = 0.001$, in order to implement loose priors. To calculate the posterior distribution of parameters, the Gibbs sampling algorithm is iterated 3,000 times, discarding the initial 1,000 samples. The number of lags of the model detailed in equation (3) is equal to $p = 4$ and defined using the Akaike information criterion (AIC).[15]

5. Results

Results are based on impulse-response functions obtained from the estimated Bayesian TVP-SVAR.[16] The impulse responses allow us to examine the endogenous response of the macroeconomic variables to a one standard deviation shock in the policy variables (MaPP and MP shocks). Uncertainty on the results is based on 68% credibility intervals.[17]. A feature of our time-varying approach is that the estimated impulse responses show how the macroeconomic responses to policy shocks change through time, by allowing parameters of the model to change over

14. The importance of the decreasing order of exogeneity refers to t_0, considering that from t_1 onwards the endogenous variables affect each other contemporaneously.

15. This generates a large number of parameters to be estimated. Even if the Gibbs sampling simplify the estimation process, we also consider a model with a lower number of lags (i.e. p=4) and results are confirmed.

16. Computations are performed using the Bayesian Estimation, Analysis and Regression (BEAR) Toolbox available here: `https://www.ecb.europa.eu/pub/research/working-papers/html/bear-toolbox.en.html`.

17. We consider 68% credibility intervals as they correspond to the one standard deviation band under normality assumption (see Primiceri (2005); Nakajima *et al.* (2011)).

time. For simplification and illustration purposes, results focus on time-varying effects of policy shocks after two, six, and twelve months.[18] Solid lines indicate results confirmed by credibility intervals, while dashed lines results that are not statistically significant.

Figure 5 shows how credit growth reacts to policy shocks. MP shocks are found to negatively affect credit growth. The effect is statistically significant in all the reported impulse-response functions (after two, six, and twelve months) from January 2018 onwards. In terms of magnitude, the six-months impulse-response function has the strongest negative impact in July 2022, where the one standard deviation shock of MP generates a decrease of 23 basis points in credit growth. Rescaling this result from standard deviation to percentage shocks, 100 basis points of MP tightening result in a credit growth decrease of 48 basis points. Interesting, in Portugal the share of real estate floating rate loans to households is among the highest in the EA (in August 2023 floating rate loans accounted for 85% of housing loans in terms of stocks and 56% in terms of flows[19]), signalling that this transmission channel of the MP on credit dynamics may be particularly relevant. Regarding MaPP shocks, we find that they do not disrupt credit growth. CBM are positively related to credit growth, also during the COVID-19 period. This result could be attributable to a correlation effect, considering that the introduction of capital buffer requirements (such as CCoB and O-SII buffers) did not negatively affect banks in a significant way, since the period from 2016-20 was characterized by a credit growth (as shown in Figure 2). These capital buffers were introduced with relatively long phasing-in periods and with the intention of building up resilience and not to disrupt credit. BBM negatively affects credit growth in the short-term (after two months), has no significant effects after six months, and positively affects credit growth after twelve months, but all these effects are not statistically significant.[20] These results could be attributable to the fact that BBMs applied in Portugal only target new credit agreements to households and only significantly affect higher-risk loans (tail risk). In addition, BBM have been implemented to promote the adoption of prudent credit standards on loans and not to mitigate excessive credit growth (Leal and Lima (2018)). Furthermore, as already identified in the literature as an effect of the interaction between MP and MaPP (Alpanda and Zubairy (2017); Karadi and Nakov (2021)), the loosening of MP may lower the effectiveness of MaPP's tightening, highlighting the importance of policy coordination.

18. Results of the median impulse-response function for each period and up to 24-month ahead are reported in Appendix, Figure A1.

19. Source: Banco de Portugal. For further details, see: ESRB (2016, 2023).

20. Abreu and Passinhas (2021) focus on the effects of BBM on credit to households, suggesting that BBM contributed to the slowdown of new loans granted to households after 4 months, in line with our short-term findings.

Policy shocks' effects on inflation rate are shown in Figure 6. MP shocks generate different reaction on the consumer price index through time. In fact, focusing on the median response after 12 months (grey dashed line) we can observe that up to 2021 MP was not binding. In fact, these years were characterized by an ultra-accommodative MP, where also non-conventional tools have been implemented (such as the quantitative easing), and the economy experienced a long period of low inflation rate. At the end of 2021 the ECB announced that net purchases under the pandemic emergency purchase programme (PEPP) would end in March 2022. This period signalled the turning point from an accommodative MP to a normalisation process to address the higher level of inflation rate. These actions undertaken by the ECB seem to be captured by the model through the sharp decline in the 12-month ahead median response function, which moves from the positive to the negative area of the graph in the last period of the time span, especially those months characterised by high inflation. Nevertheless, credibility intervals suggest that the median evidence should be taken with caution, given that less than 68% of the response functions confirm this result. This could be due to the fact MP effects need time to materialise (Deb *et al.* (2023)), as well as that MP is less effective when inflation is driven by a supply shock. Concerning MaPP, both CBM and BBM do not seem to have a relevant impact on the inflation rate. Macroprudential policies aim to build resilience in the banking system to mitigate risks to financial stability rather than directly target inflation.

Finally, we analyse how policy shocks affect economic growth (Figure 7). MP shocks do not disrupt economic growth. Focusing on the most recent period of the time span considered in our study, the MP normalization has a negative median effect on economic growth, although not statistically significant. In the same vein, MaPP does not lower economic activity, which could be attributable by the fact that capital buffer requirements were introduced with relatively long phasing-in periods and BBM to promote the adoption of prudent credit standards on loans to consumers, only significantly affecting credit to higher-risk households.

5.1. Robustness checks

We perform a series of robustness checks to validate the results. First, the intensity capital and borrower-based indicators elaborated in section 3 are substituted with extensity cumulative indicators, which are created exploiting the Integrated MaPP database (Alam *et al.* (2019)), as shown in Figures 3 and 4, orange lines. Second, the iteration related to the Gibb sampling algorithm are doubled compared to the baseline, reaching 6,000 and discarding the initial 4,000 samples. Third, the calibration of hyperparameters is tested with different values. The autoregressive coefficient on residual variance is perturbated by 5 percentage points, testing both $\lambda = 0.80$ and $\lambda = 0.90$. The inverse Gamma shape and scale on residual variance is tested implementing less loose priors, imposing $\alpha_0 = 0.01$ and $\delta_0 = 0.01$. Fourth, we test the assumption related to the order of the endogenous variable.

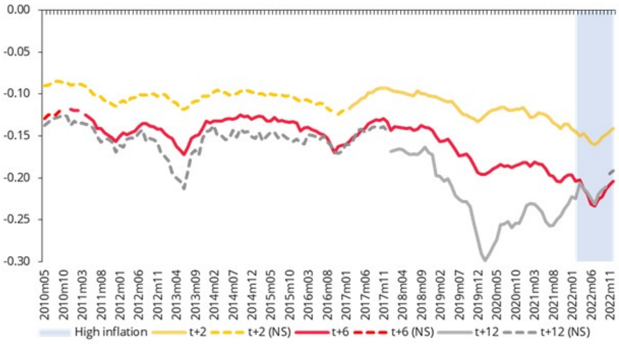
The baseline vector $y_t = [CI_t, CPI_t, C_t, R_t^s, iCBM_t, iBBM_t]'$ is substituted by a new vector $y_t' = [CI_t, CPI_t, C_t, iCBM_t, iBBM_t, R_t^s]'$ where MaPP decisions are taken before considering MP ones. Fifth, to limit the number of parameters to be estimated, we tested our results collapsing CBM and BBM in a single indicator of MaPP. The new intensity MaPP indicator, $iMaPP_t$, is constructed averaging the intensity capital-based and borrower-based indicators, resulting in a new indicator ranging from 0 to 1. The baseline vector y_t is substituted by the new vector $y_t'' = [CI_t, CPI_t, C_t, R_t^s, iMaPP_t]'$. Sixth, we check whether substituting the variable of overall credit growth C_t with either credit growth of non-financial corporation or households affect our results. Finally, we consider that the Economic and Financial Assistance Programme, which was agreed in the second quarter of 2011 with the IMF, the ECB and the European Commission, envisages stronger solvency and liquidity requirements for Portuguese banks, against a background of very tight access to financing in international markets and a widespread deterioration in the macroeconomic environment. Accordingly, Banco de Portugal has set a minimum Core Tier 1 ratio requirement of 9% by the end of 2011 and 10% by the end of 2012. To control for these requirements, we add a dummy variable equal to one for the years 2011 and 2012.[21] In all these robustness checks, main results are confirmed.[22]

21. On 22 July 2013 EBA issued a recommendation on the preservation of core Tier 1 capital during the transition to the CRD/CRR framework (EBA/REC/2013/03).

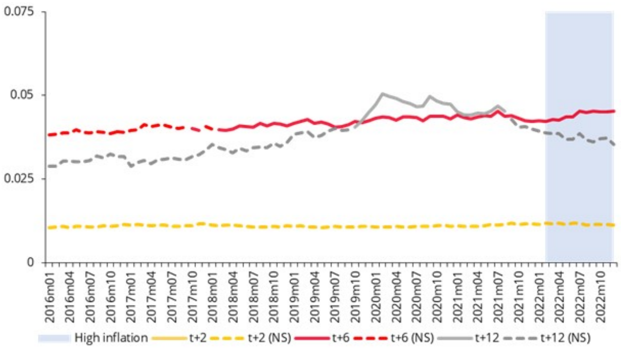
22. Results are available upon request to the authors.

Figure 5: Policy effects on Credit Growth

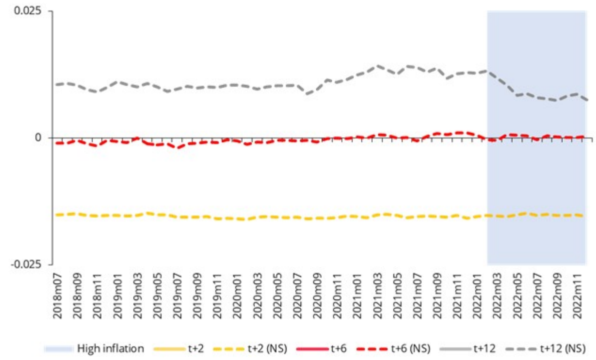
(a) Monetary policy



(b) CBM



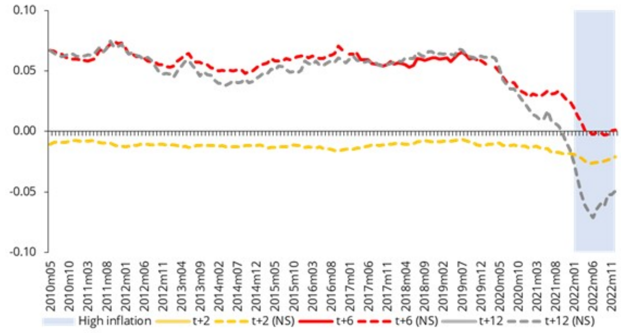
(c) BBM



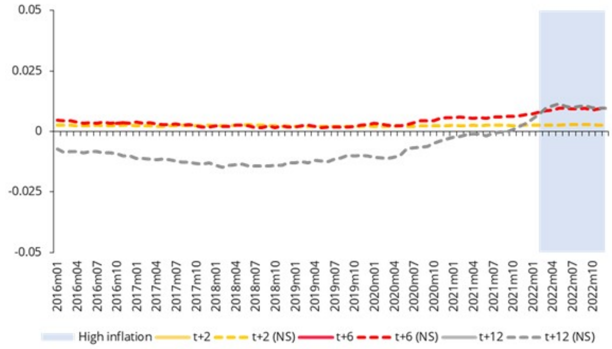
Notes: Figures show the IRFs after 2, 6 and 12 months of one standard deviation shock of policy variables, namely monetary policy (MP), capital-based measures (CBM) and borrower-based measures (BBM), on credit growth (in basis points). Solid lines represent results where 68% credibility intervals confirm the median outcome, while dashed lines represent results not significant (NS), meaning that they are not confirmed by 68% credibility intervals. The period of the analysis ranges from January 2010 to December 2022, but the first four observations are lost due to lags (Akaike criterion). The shaded area highlights the period of high inflation, where the Harmonised Index of Consumer Prices in Portugal is above 4%. For CBM and BBM, results are reported since the implementation of the first measures, January 2016 and July 2018 respectively.

Figure 6: Policy effects on Credit Growth

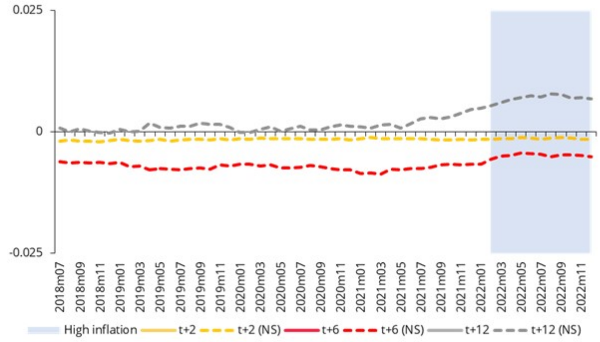
(a) Monetary policy



(b) CBM



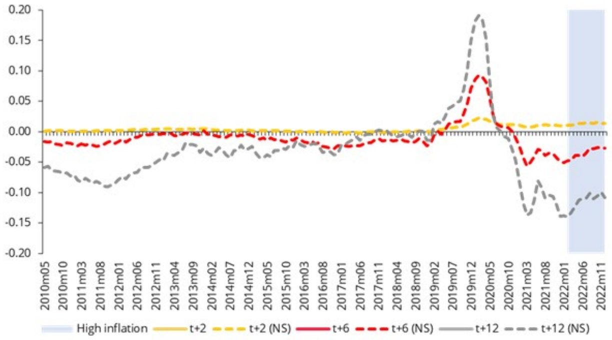
(c) BBM



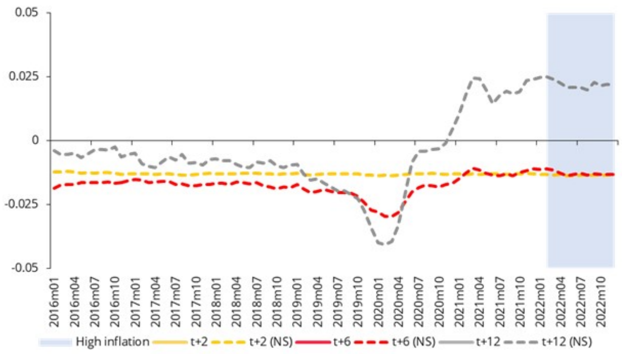
Notes: Figures show the IRFs after 2, 6 and 12 months of one standard deviation shock of policy variables, namely monetary policy (MP), capital-based measures (CBM) and borrower-based measures (BBM), on credit growth (in basis points). Solid lines represent results where 68% credibility intervals confirm the median outcome, while dashed lines represent results not significant (NS), meaning that they are not confirmed by 68% credibility intervals. The period of the analysis ranges from January 2010 to December 2022, but the first four observations are lost due to lags (Akaike criterion). The shaded area highlights the period of high inflation, where the Harmonised Index of Consumer Prices in Portugal is above 4%. For CBM and BBM, results are reported since the implementation of the first measures, January 2016 and July 2018 respectively.

Figure 7: Policy effects on Credit Growth

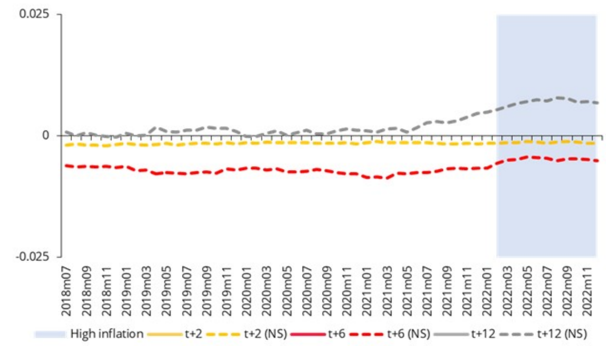
(a) Monetary policy



(b) CBM



(c) BBM



Notes: Figures show the IRFs after 2, 6 and 12 months of one standard deviation shock of policy variables, namely monetary policy (MP), capital-based measures (CBM) and borrower-based measures (BBM), on credit growth (in basis points). Solid lines represent results where 68% credibility intervals confirm the median outcome, while dashed lines represent results not significant (NS), meaning that they are not confirmed by 68% credibility intervals. The period of the analysis ranges from January 2010 to December 2022, but the first four observations are lost due to lags (Akaike criterion). The shaded area highlights the period of high inflation, where the Harmonised Index of Consumer Prices in Portugal is above 4%. For CBM and BBM, results are reported since the implementation of the first measures, January 2016 and July 2018 respectively.

6. Final remarks

This paper studies empirically the effects of monetary and macroprudential policy shocks on key policy-relevant macroeconomic variables, namely credit, consumer price and economic growth. The analysis focuses on Portugal during the period 2010-2022 with monthly frequency data, to better capture short-term effects, relying on a Bayesian TVP-SVAR model. Macroprudential policy shocks are based on two micro-founded intensity indicators, for capital and borrower-based measures. Results show that a monetary policy tightening reduces credit growth, especially in periods of high inflation, suggesting a cross-policy effect. In addition, a macroprudential policy tightening does not lower macroeconomic aggregates, suggesting that the implemented measures did not disrupt credit or economic growth.

The main policy implication of the evidence provided by this study relies on the role of monetary policy in addressing financial stability concerns. In fact, in a period where there is a monetary policy tightening, the extent to which macroprudential policy should also be tightened shall be carefully examined, to balance financial stability needs and adverse effects on economic growth.

This analysis has a series of limitations, such as it does not consider the banking system's capital level. In addition, the interaction of macroprudential policy with other policies, such as fiscal policies, may provide additional evidence useful to foster the policy debate, therefore additional research could focus on these dynamics.

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Appendix

Appendix 1: Adopted policies related to capital-based measures.

Date	*MPP*	*Effect*	*Description*
2016M1	CCoB	+1	The capital conservation buffer was at at 0.625%
2016M6	CCoB	-1	The decision to bring forward the implementation was revoked and the phase-in would follow Article 160.º of CRD
2017M1	CCoB	+1	The capital conservation buffer was increased to 1.25% from 0.625%
2018M1	CCoB	+1	The capital conservation buffer was increased to 1.875% from 1.25%
2018M1	LPP	+1	International Financial Reporting Standard 9 (IFRS 9) was implemented, which introduced a forward-looking approach to loan loss provisions
2018M1	SIFI	+1	Other systemically important institution (O-SII) buffers for six O-SIIs, ranging from 0.063% to 0.25%, became effective
2019M1	CCoB	+1	The capital conservation buffer was increased 2.5% from 1.875%
2019M1	SIFI	+1	Other systemically important institution (O-SII) buffers for six O-SIIs, ranging from 0.125% to 0.5%, became effective
2020M1	SIFI	+1	Other systemically important institution (O-SII) buffers for six O-SIIs, ranging from 0.188% to 0.75%, became effective
2020M3	Capital	-1	Systemically and less significant important institutions in Portugal can operate temporarily below the level of capital defined by the Pillar 2 Guidance
2020M3	CCoB	-1	Systemically and less significant important institutions in Portugal can operate temporarily below the level of capital defined by the combined buffer requirement (CBR)
2020M3	OT	+1	Systemically important institutions in Portugal are recommended to refrain from dividend payouts distributions and performing share buy-backs aimed at remunerating shareholders during the period of the COVID-19 related economic shock, at least until October 1, 2020
2020M4	OT	+1	Non-systemically important institutions in Portugal are recommended to refrain from dividend payouts distributions and performing share buy-backs aimed at remunerating shareholders during the period of the COVID-19 related economic shock, at least until October 1, 2020
2020M5	SIFI	-1	Postponement by one year the phase-in period of the O-SII buffer (till 2022 from 2021)
2020M7	OT	+1	The guidance on dividend payouts has been extended until at least January 1, 2021
2020M8	Capital	-1	The guidance on the Pillar 2 buffers for Portuguese banks was extended until end-2022
2020M8	CCoB	-1	The guidance on the combined buffer requirement and capital conservation buffer for Portuguese banks was extended until end-2022
2021M1	SIFI	+1	O-SII buffer increased ranging from 0.25 to 1.00

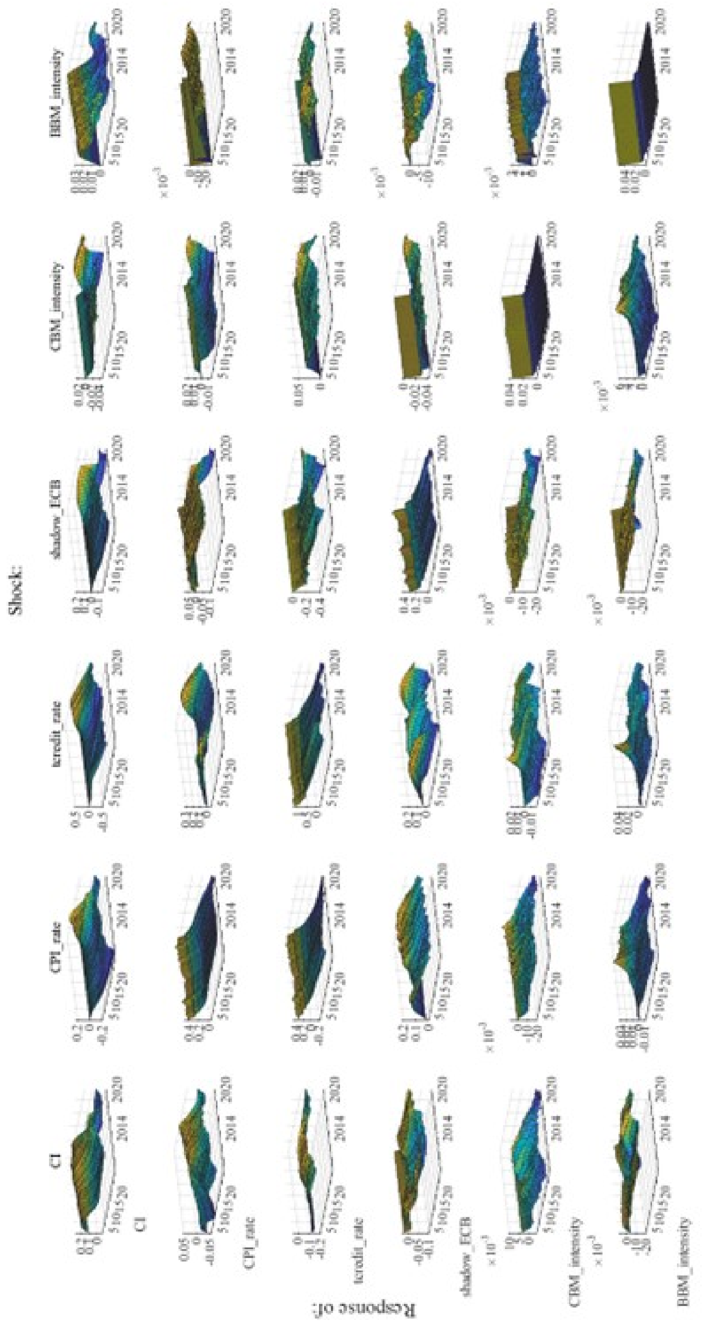
Notes: The list of policies derives from the Integrated Macroprudential Policy database (Alam *et al.* (2019)). CCyB refers to countercyclical capital buffer; CCoB refers to conservation capital buffer; SIFI refers to other systemically important institution (O-SII) buffer; Capital refers to capital measures other than CCyB, CCoB, and O-SII buffer; OT refers to macroprudential measures not captured in the other categories (e.g., stress testing, restrictions on profit distribution) and structural measures (e.g., limits on exposures between financial institutions); LPP refers to loan loss provision requirements for macroprudential purposes, which include dynamic provisioning and sectoral provisions (e.g. housing loans).

Appendix 2: Adopted policies related to borrower-based measures.

Date	*MPP*	*Effect*	*Description*
2018M7	DSTI	$+1$	A DSTI ratio limit of 50% (on a comply or explain basis) became effective
2018M7	LoanR	$+1$	Maturity limits (on a comply or explain basis) for loans secured by a mortgage (40 years) and for new consumer loans (10 years) became effective
2018M7	LTV	$+1$	LTV limits (on a comply or explain basis) became effective
2020M4	DSTI	-1	New personal credit granted from April 1 until September 30, 2020, of up to two-year maturity does not have to comply with the DSTI ratio limit
2020M4	DSTI	$+1$	The share of new loans granted to borrowers with a DSTI above 50% but below 60% was lowered to 10% (from 20%) of new credit
2020M4	LoanR	$+1$	The recommendation limiting maturity of personal credit to seven years became effective
2020M4	LoanR	-1	Personal credit with maturities of up to two years and duly identified as intended to mitigate households' temporary liquidity shortage situations will be exempted from observing the Recommendation of regular principal and interest payments
2022M4	LTV	$+1$	New limits to the maximum maturity of new credit for house purchase on the basis of the age of borrowers

Notes: The list of police derives from the Integrated Macroprudential Policy database (Alam *et al.* (2019)). DSTI refers to Limits to the debt-service-to-income ratio and the loan-to-income ratio, which restrict the size of debt service payments or the size of a loan relative to income (e.g., household income, net operating income of the company); LoanR refers to loan restrictions. They include loan limits and prohibitions, which may be conditioned on loan characteristics (e.g., the maturity, the size, the LTV ratio and the type of interest rate of loans), lender characteristics (e.g., mortgage banks), and other factors; LTV refers to limits to the loan-to-value ratio.

Appendix 3: 3-D matrix of results for the baseline model.



Notes: Figures show the matrix IRFs up to 24 months, between 2010 and 2020 on a monthly frequency of one standard deviation shock. Each column represents the response of all endogenous variables (constructed as described in section 4) to one standard deviation shock of the Coincidence indicator (CI), inflation rate (CPI_{rate}), stock of banks' loans growth rate ($tcredit_{rate}$), EA shadow interest rate ($shadow_{ECB}$), CBM intensity indicator ($CBM_{intensity}$), and BBM intensity indicator ($BBM_{intensity}$).

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