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Macroprudential Policy and Net Interest Margins in European banks

Małgorzata Olszak[1] · **Christophe Godlewski**[2] · **Iwona Kowalska**[1] · **Agnieszka Paciorek**[1]

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Abstract
In this study, we investigate the effects of macroprudential policies on banks' net interest margins (NIMs) using 3000 banks in 28 European Union countries from 1996 to 2019. Macroprudential tightening results in an immediate 2 basis point (bp) decrease in the NIMs, an increase in interest income (IIEA) of 7 bp, and an increase in interest expense (IEEA) of almost 10 bp. But the last two decline by 10.5 and 10.1 bp respectively 1–2 years later. The effect depends on the instrument type and varies based on the capital ratio and credit risk, but holds in high- and low-rate environments.

Keywords Net interest margin · Macroprudential policy instruments · Capital · Risk · Low-rate

JEL Classification E44 · E58 · G21 · G28

1 Introduction

The literature contends that banks' interest margin is a social cost of their intermediation role, with low costs representing greater social welfare. Simultaneously, net interest margins (NIMs) serve as key indicators of banks' profitability. A significant portion of the banking literature comprises of investigations into the determinants of NIMs. The factors influencing NIMs include bank-specific variables such as risk-taking, size, and managerial efficiency, as well as industry-level competition, market structure, macroeconomic conditions, and interest rates. While this literature delves into bank-level and cross-country determinants of interest margins a clear gap remains on the influence of macroprudential policy in driving NIMs.

✉ Małgorzata Olszak
molszak@wz.uw.edu.pl

[1] University of Warsaw, Faculty of Management, Warsaw, Poland

[2] Faculty of Law and Business & EM Strasbourg Business School, University of Strasbourg, Strasbourg, France

Macroprudential policy is designed to enhance financial stability by responding to or targeting the financial and credit cycles. It significantly influences bank lending that in turn, affects the interest income and funding costs of banks. Extensive empirical and theoretical research in banking predominantly concentrates on how macroprudential policy influences areas such as loan growth (Claessens et al. 2013; Gambacorta and Murcia 2020; Olszak and Kowalska 2022; González 2022; Jimenez et al. 2017; Gomez et al. 2020; Calem et al. 2020; Allen et al. 2020), risk-taking, financial stability (González 2022; Ely et al. 2021; Gaganis et al. 2020; Altunbas et al. 2018; Meuleman and Vennet 2020), and various aspects of efficiency and profitability (Davis et al. 2022; Gaganis et al. 2021; Chen et al. 2022; Ćehajić and Košak 2021). However, the specific effects of macroprudential policy on NIMs have not been a direct focus of this literature.

Therefore, several questions arise on how macroprudential policy influences bank managers' decisions regarding NIMs. First, we explore whether macroprudential policy tightening or loosening corresponds to a reduction or enhancement in NIMs. Second, we delve into the roles and relative significance of specific instruments employed by macroprudential policymakers in influencing NIMs, such as the standard restrictions on bank lending (borrower-targeted policies), taxes and levies on bank assets (fiscal measures), credit growth and volume limits, liquidity requirements, constraints on currency mismatches, and loan-loss provisioning rules. We are particularly interested in determining which instrument reduces the NIMs and therefore reduces the social cost of the intermediation role of banks that improves social welfare. Finally, we strive to uncover whether the effects of macroprudential policy on NIMs depend on the credit risk of banks.

We conduct a comprehensive analysis of NIMs across 3,000 banks from 28 European Union (EU) countries from 1996 to 2019. We use the narrative information available in the Macroprudential Policies Evaluation Database (MaPPED)[1] collected by experts at the European Central Bank (ECB) and national central banks (as in Richter et al. 2019; Meuleman and Vennet 2020; see Budnik and Kleibl 2021). This database contains information on almost 2000 policy actions taken in the 28 member states of the EU from 1995 to 2018. We focus on borrower-targeted and bank-oriented macroprudential policies that have not been subject to EU-level harmonization. We measure banks' NIMs as the difference between interest income and interest expense divided by interest earnings assets. We also consider the components of NIMs: the interest income to earning assets (IIEA) and interest expense to earning assets (IEEA). We consider the effects in the policy implementation year (denoted as immediately) and, separately, one to two years post policy implementation (denoted as the medium term). We use a traditional set of bank-specific, industry-specific, and macroeconomic factors which are important for the NIMs to ensure the accuracy of our analysis and to eliminate the risk of missing variable bias.

We find that, on average, tightening macroprudential policy immediately has a negative effect on the levels of NIMs, with increased funding costs (IEEA) being the basic channel of these reductions. In the medium term, we find statistically significant declines in IIEA of 10.5 basis points (bp) and IEEA of 10.1 bp two years after policy implementation. Both effects are economically substantial, implying negative changes of 3.3% and 17% for IIEA and IEEA, respectively. The policy also significantly and negatively affects medium term variations in NIMs, resulting mostly from lower IIEA. Lending standard restrictions emerge

[1] This database is available at: https://www.ecb.europa.eu/pub/research/working-papers/html/mapped.en.html.

as the primary driver of the immediate negative effect on NIM levels and are a result of higher IEEA. In the medium term, the taxes and levies imposed on financial institutions and liquidity requirements and limits on currency mismatches result in a reduction in NIMs. Sharp declines in IEEA are the basic channel for this effect. Conversely, limits on credit growth and volume increase NIM levels. This effect is attributed to the income channel of NIM, and the associated improvements in the IIEA. Furthermore, loan loss provisioning rules also have a notable positive effect, particularly on the variations in the NIMs.

Our results also underscore the role of bank capitalization and of credit risk (in terms of loan portfolio size, levels of LLPs and NPLs). In the short term, the tightening of policy results in increased IEEA in poorly capitalized banks. For better capitalized banks, NIMs are significantly affected in the medium term by limits on credit growth and liquidity requirements. We observe a decline in NIMs due to liquidity requirements and a positive effect for limits on credit growth. Banks with larger loan portfolios tend to experience an immediate decrease in NIMs due to lending standard restrictions. An opposite effect occurs for liquidity standards. In the medium term, lending-oriented banks have lower NIMs due to liquidity requirements and levies and taxes on financial institutions. We also find that levels of LLPs and of NPLs also matters (see the related concept of excessive risk-taking in Borio (2001), p.1). The findings hold especially in the medium term, whereby excessive risk-taking is associated with magnified reductions in NIMs due to liquidity standards, with the opposite effect occurring for limits on credit growth and volume. Our results are robust when subjected to the role of high- and low-rate environments, pre- and post-global financial crisis (GFC) periods, variations in the empirical specification, introduction of an additional control variable, and even after excluding the largest banking sector.

Our results are novel within the literature. We add to the literature on the determinants of NIMs and on the effects of macroprudential policy on bank profitability. In contrast to other studies, we show that macroprudential policy significantly affects both the levels and changes in the NIMs. Second, we add to recent studies that focus on the effects of macroprudential policies on efficiency, particularly on the returns on assets (ROA) and equity (ROE) (Davis et al. 2022), and the funding costs (Ćehajić and Košak 2021) of banks (Gaganis et al. 2021; Chen et al. 2022). However, these studies have omitted the NIMs (as well as IIEA and IEEA) as a profitability indicator. Diverging from the research, in our analysis we consider the time series changes in the macroprudential policy stance encompassing two distinct policy actions: tightening and loosening. We also show the dynamic effects of these policy changes in the short and medium terms. To the best of our knowledge, only González (2022) has used NIMs as an additional measure of competition and considered the dynamic effects of macroprudential changes. Our study stands apart through its distinct sample selection of EU banks, an extended time frame spanning from 1996 to 2019, and the utilization of a relatively uncommon narrative database regarding macroprudential policies (MaPPED). Additionally, the overall focus of our study is on NIMs (and IIEA and IEEA) as a profitability measure as well as an intermediation cost measure. Finally, our analysis also contributes to the literature concerning the role of prudential regulations in shaping banks' NIMs (Barth et al. 2004). The research has analyzed the role of microprudential regulations and omitted the impact of macroprudential policy changes.

The remainder of this study is structured as follows: In Sect. 2, we delve into the recent empirical evidence on the transmission mechanisms through which macroprudential policy influences NIMs to develop our research hypotheses. Section 3 has an outline of our data

sources, sample, variables, and method. In Sect. 4, we discuss the results and robustness checks. Section 5 presents our conclusions.

2 Literature Review and Hypotheses Development

The absence of empirical evidence exploring the impact of macroprudential policy on banks' NIMs is somewhat surprising, given the extensive literature assessing the effects of macroprudential policies on various aspects of banking, such as growth, stability, risk profiles, and profitability. Extant studies on NIMs tend to overlook the role of macroprudential policy. A particular background to our work is studies that highlight policy effectiveness via microeconomic bank-level data. We first provide an overview of prevailing research on the influence of macroprudential policies on banks' credit growth, risk, and profitability, with a specific focus on cross-country studies conducted at the bank level. We then formulate our hypotheses pertaining to the diverse categories of macroprudential instruments and their anticipated effects on NIMs.

2.1 Macroprudential Policy, and its Effects on Credit Growth, Risk, and Profitability

2.1.1 Effect on Credit Growth and Risk

As we aim to understand the influence of macroprudential policies on NIMs, the extensive research on credit growth acts as a foundation for our hypotheses. The potential influence of policy tools on credit expansion can indirectly impact banks' interest income, interest expenses, and, in turn, their NIMs. The extant literature focuses on the effectiveness of macroprudential policies in curbing credit growth and excessive procyclicality, which can be considered intermediate objectives. Only a few studies analyze the impact at the bank level. Cross-country studies provide evidence of reduced credit growth in countries applying macroprudential policy instruments (Claessens et al. 2013), with the effect depending on competition intensity (Olszak and Kowalska 2022) and the monetary policy stance (Gambacorta and Murcia 2020). Single-country investigations have shown that introducing new macroprudential instruments, such as dynamic provisions in Spain (Jimenez et al. 2017), the loan-to-value (LTV) ratio in Canada (Allen et al. 2020), and stress tests in the U.S. (Calem et al. 2020), was associated with reduced credit growth.

Macroprudential policy has a broader aim than limiting credit growth: tame bank risk. Recent studies have shown that macroprudential policy instruments affect risk heterogeneously. These findings inform our hypotheses regarding the impact of macroprudential policy on NIMs, as they are closely intertwined with bank risk considerations. González (2022) looks at the tightening of ten types of bank-oriented macroprudential policies and shows their positive significant effect on banks' Z scores. This effect holds for both capital-based and liquidity-oriented instruments in more than 2511 listed banks from 52 countries. Ely et al. (2021) analyze the effects of 12 macroprudential tools on the stability of individual banks. They show that the improvement of stability in more than 15000 banks from 45 emerging markets during 1995–2014 period is associated with the implementation of interbank limits, concentration limits, LTV ratios, systemically significant institutional tools, and dynamic provisions. They also show that the strength of the enhancement in stabil-

ity depends on the bank-level channel (liquidity and leverage). Liquidity-oriented foreign currency limits and reserve requirements are associated with declining stability and risk. Gaganis et al. (2020) use a sample of bank-level data on 356 banks from 50 countries over the 2002–2017 period and show that macroprudential policy matters for the influence of corporate governance on bank risk. The authors find that governance does not matter for risk-taking in countries which do not apply macroprudential policy instruments. Further, lending standard restrictions, covering borrower-targeted instruments (LTV, debt-to-income (DTI), do not matter for the effect of governance on risk-taking. The opposite is found for balance sheet-oriented tools. Altunbas et al. (2018) find that macroprudential policy tightening is associated with limited risk-taking by publicly traded banks in 61 countries. These effects are altered by bank-specific features (bank size, liquidity, leverage, and deposits). Meuleman and Vennet (2020) look at 113 European listed banks from 2000 to 2017, and show that liquidity tools and measures aimed at increasing bank resilience are especially effective in reducing systemic risk.

2.1.2 Influence on Bank Profitability and Efficiency

Davis et al. (2022) perform the one direct study assessing the effect of macroprudential policies on bank profitability, employing a comprehensive dataset covering over 7000 banks from 1990 to 2018. The authors proxy macroprudential policies using individual tools and aggregated measures, as found in the database of Alam et al. (2019). The results suggest a negative impact of these policies on bank ROA and ROE. Importantly, the impact of macroprudential policies is heterogeneous and, at times, ambiguous. This nuanced understanding is crucial when developing hypotheses about the effects of macroprudential policies on NIMs.

Additionally, Chen et al. (2022) and Gaganis et al. (2020) examine the effects of macroprudential policies on bank efficiency across various countries and emerging markets. Chen et al. (2022) observe increased efficiency under stringent macroprudential policies, whereas Gaganis et al. (2020) indicate a reduction in bank efficiency. These mixed findings emphasize the complexity of the relationship between macroprudential policies and bank performance.

Furthermore, Ćehajić and Košak (2021) consider the activation of macroprudential policies across European countries. Their findings show that such policies are associated with reduced bank funding costs, with a more pronounced effect in developed countries. Although not directly linked to NIMs, these results offer insights into the broader impact of macroprudential policies on bank profitability and operational costs.

2.2 Hypotheses

As established in prior studies (Claessens et al. 2013; Altunbas et al. 2018; Gaganis et al. 2020), macroprudential policies play a pivotal role in curbing excessive credit growth and mitigating procyclicality, which collectively enhance financial stability. However, these policies often result in more constrained lending and reduced risk-taking behaviors by banks. While these actions contribute to improved financial stability, they may also reduce NIMs, which form a substantial part of a bank's profitability (Dietrich and Wanzenried 2011). We

also expect that the components of NIMs– IIEA and IEEA, will be affected. The effects of this Drawing from these findings, we hypothesize the following:

H1: Macroprudential policy negatively affects banks' NIM, IIEA and IEEA.

Furthermore, the temporal dimension of the effects of macroprudential policies should be considered (González 2022). These policies are typically aimed at fostering long-term financial stability (Galán 2020). Consequently, their effects are likely to be observed not only initially in the implementation year but also in subsequent years. Extant research has considered different approaches to analyzing the dynamic effects of macroprudential policy changes. Davis et al. (2022) and Gaganis et al. (2020, 2021) consider the one-year lagged impact of macroprudential regulation, assuming that the effect is persistent in the long term. González (2022) looks separately at the immediate and medium-term impacts of macroprudential policy changes, and shows differing policy effects between the short and medium terms. We follow this approach and define *short-term* as an immediate effect of macroprudential policy (in the year of policy implementation). The *medium-term* effect refers to the one-year lagged and two-year lagged impact of policy change. Given this dynamic dimension, we propose the following hypothesis:

H2: Macroprudential policy changes differently affect the NIM, IIEA and IEEA in the short and medium terms.

Most studies on macroprudential policies (Altunbas et al. 2018; Ćehajić and Košak 2021; Davis et al. 2022; Chen et al. 2022) highlight the diversity of policy instruments and their differential impacts on specific aspects of bank activity. These instruments are usually divided into two broad groups: borrower-oriented measures and bank-oriented tools. Borrower-oriented policies cover many tools whose aim is to limit bank lending by mitigating access to credit on the demand side of the loan market. Bank-targeted instruments directly affect the supply side of credit markets and cover a wide range of tools, including limits on loan volume and growth, loan loss provisioning rules, and liquidity standards. The effects of these instruments on NIM, IIEA and IEEA are likely to be heterogeneous. Therefore, we posit an additional hypothesis:

H3. The effect of macroprudential policy on bank NIM, IIEA and on IEEA depends on the type of instrument.

2.2.1 Expected Effects of Macroprudential Policy Instrument Types on Net Interest Margin– The Role of Income and Expense Channels

Regulatory reports suggest various transmission mechanisms through which macroprudential policy instruments affect banks' credit activity (CGFS 2012; ESRB 2014). Our analysis focuses on the instrument types available in MaPPED (see Budnik and Kleibl 2021):[2]

[2] We omit capital adequacy standards (Basel II and III) because they have been intensively investigated in previous studies. Additionally, since they are implemented in the Single Market in a harmonized way, there is little heterogeneity in their changes across European Economic Area (EEA) banks. The full list of individual tools included in the instrument types is presented in Appendix.

Lending standards restrictions aim to limit credit quantity by imposing constraints on borrowing, such as LTV loan-to-income (LTI), or DTI caps. Research indicates that implementing such tools reduces credit growth (Cerutti et al. 2017; Carreras et al. 2018; Alam et al. 2019), and thus, interest income (and thus IIEA). Ćehajić and Košak (2021) show that these tools reduce debt funding costs (and thus IEEA). This may imply some downward pressures on interest income, which is a constituent part of the NIM. Therefore, lending standard restrictions can influence the NIM through the interaction between credit growth and interest income. Accordingly, we propose the following:

H3.1. Lending standard restrictions reduce the NIM.

The effects of *taxes and levies on financial activities* on NIMs remain less clear. These fiscal charges are recognized as tools to counteract procyclicality, and dampen the risk of contagion or shock propagation (Claessens et al. 2014; Cerutti et al. 2017). Cross-country studies show that they reduce loan growth and the levels of loan loss provisions (Cerutti et al. 2017; Carreras et al. 2018; Alam et al. 2019; Olszak and Kowalska 2022), which may influence NIMs. However, the overall impact may depend on funding costs (and thus IEEA), which are shown to increase (Ćehajić and Košak 2021) due to tightening of macroprudential policy. Taxes and levies can have a dual effect on the NIM through their impact on credit growth and funding costs. Accordingly, we propose the following:

H3.2. Levies and taxes on financial institutions and activities decrease the NIM.

Limits on credit growth and volume cover several tools that shape the size and composition of bank assets. They include reserve requirements on deposits (set by central banks) and asset-based limits (e.g., limits on loan growth and volume). They may reduce credit supply and interest income while potentially reducing interest expenses on deposits, which may balance the overall NIM. Reserve requirements result in increased loan growth (Olszak and Kowalska 2022) and increased debt-funding costs (Ćehajić and Košak 2021). However, they do not matter for overall profitability (Davis et al. 2022). Therefore, NIM may also increase. Next, limits on domestic currency loans reduce bank asset growth (Claessens et al. 2013, 2014) and growth in household credit (Alam et al. 2019), with no effect on loan growth (Olszak and Kowalska 2022). Limits on foreign currency loans reduce growth in real nonfinancial private domestic bank credit (Cerutti et al. 2017) and bank loan growth (Olszak and Kowalska 2022), and are associated with enhanced bank profitability (Davis et al. 2022) and a nonsignificant change in debt-funding costs (Ćehajić and Košak 2021). Thus, the reduction in credit growth may not directly correspond to a decrease in profitability. The complex interactions of these instrument types can lead to various outcomes for NIMs, with several studies implying enhanced efficiency. Considering these dynamics, we propose the following:

H3.3. The limits on credit growth and volume increase the NIM.

Liquidity requirements may induce banks to modify the profile of their assets and liabilities, directly affecting interest income and costs. By shifting funding toward long-term or secured funding, banks may suffer from increases funding costs (and the IEEA), thereby

reducing net interest income. Conversely, on the asset side, adjustments to the liquidity structure of assets may also decrease interest income, thus affecting the IIEA component of NIM. Studies on the effects of liquidity ratios on credit growth are scarce. Only two studies focus on the effects of liquidity ratios on individual bank profitability in a cross-country context. Davis et al. (2022) show that liquidity measures, covering liquidity coverage ratios, the net stable funding ratio (NSFR), and limits on loan-to-deposits (LTD) ratios, are associated with statistically insignificant reductions in ROA and increases in ROE. King (2013) estimates the NSFR in 15 countries in 2009, and shows that banks which need to meet the NSFR by increasing holdings of higher-rated assets and extending the maturity of wholesale funding experience reduced NIMs. Another study addresses the role of liquidity ratios in a single-country context. Nguyen et al. (2020) show that Vietnamese commercial banks with excess liquidity compress NIMs. Thus, we may also expect that liquidity requirements will decrease NIMs. Accordingly, we propose the following:

H3.4. Liquidity requirements and limits on currency mismatches reduce the NIM.

Loan-loss provisioning systems affect the procyclicality of banks (Claessens et al. 2013; Cerutti et al. 2017) and directly impact profit and loss accounts, affecting credit demand and potential adjustments by banks, such as increasing lending spreads or reducing credit supply. Tighter loan-loss provisioning systems may increase credit risk costs, and thus, NIMs as well to cover these costs. Banks may also reduce the supply of credit through the decline in asset holdings by rationing the overall quantity of credit. This may be achieved by shifting the composition of assets toward exposures that carry lower provisioning requirements (CGFS 2012; ESRB 2014). Research shows that more restrictive loan-loss provisioning systems may be associated with greater credit risk costs (Olszak and Kowalska 2023). Bank-level evidence shows that dynamic provisions are associated with increased individual bank loan growth (Olszak and Kowalska 2022) and insignificant reductions in the debt-funding costs of banks (Ćehajić and Košak 2021). Accordingly, we propose the following:

H3.5. Loan-loss provisioning systems increase the NIM.

2.2.2 Macroprudential Policy Effects and Credit Risk

Existing research also proves that the effects of macroprudential policy depend on a variety of factors, including bank capital ratios. Macroprudential policies reduce risk-taking in poorly capitalized banks that rely on wholesale funding (Altunbas et al. 2018). The effects of this policy on systemic risk reverse for highly leveraged banks (Ely et al. 2021). Poorly capitalized banks experience improved returns on assets and diminished returns on equity (Davis et al. 2022) under macroprudential policy changes. For instance, the growth of Colombian loan banks was more affected by macroprudential policies in banks with weaker capital and higher leverage (Gómez et al. 2020). A similar pattern on the role of the capital ratio on the effectiveness of macroprudential policy in taming credit growth is shown in a cross-country sample of publicly traded banks (Andrieş et al. 2022). Gambacorta and Murcia (2020) show that the capital ratio also matters for the effects of macroprudential policy on credit growth. Further, the NIM depends on the level of credit risk and costs associated with credit risk (Ho and Saunders 1981; Maudos and Fernández de Guevara 2004; López-

Espinosa et al. 2011). Macroprudential policy research shows that it affects bank risk, lending activity (and corresponding credit risk), and credit risk levels (Altunbas et al. 2018) and credit risk costs (i.e., loan-loss provision (LLP) levels; Olszak et al. 2025). Accordingly, we expect the following:

H4. The effects of macroprudential policy and its instrument types on the NIM depend on capital ratio and credit risk.

3 Data and Sample

We curated a distinctive dataset amalgamated from diverse sources, outlined comprehensively in Table 1. The foundation of our dataset comprises bank balance sheets and income statements from Bankscope and Orbis, both of which contribute annually. Given that Orbis only covers data from 2010 to 2019, we combined it with Bankscope, which provides a more extensive historical perspective from 1995 to 2015. The datasets were meticulously merged by hand due to distinct coding conventions between Bankscope and Orbis. Our focus was narrow: understanding the country-level effects of macroprudential policy on banks' NIM, IIEA and IEEA. Hence, we utilized unconsolidated banking data. This allows us to isolate the impact from nonbanking operations and other country effects (spillovers), which is particularly crucial for multinational banks reporting consolidated data. Further, it allows us to more closely examine the intermediary role of banks in lending and deposit markets. To ensure robust analysis, the continuous variables were winsorized at the 1 st and 99th percentiles, effectively mitigating the influence of outliers. The resultant sample includes 3,077 banks (22,134 observations) spanning 27 European countries over 1996–2019.

Our principal variable of interest is denoted as MPI, a proxy for macroprudential policy stance. To construct MPI, we leveraged qualitative data from the MaPPED (Budnik and Kleibl 2021), a comprehensive repository assembled by the ECB in collaboration with experts from national central banks and supervisory authorities of all EU member states. This database meticulously captures the "life cycle" of policy instruments, distinguishing between genuinely macroprudential and essentially micro-prudential measures with broad systemic implications. Since our bank-level dataset is annual, while MaPPED records actions within a year, we devised a strategy to construct the MPI. We assigned a value of 1 to tools that were effectively tightened, −1 to those that were loosely tightened, and 0 otherwise. For observations where both tightening and loosening occurred, indicating ambiguous effects, we set MPI to 0, assuming a cancellation of effects. MPI's construction can be summarized as follows:

$$MPI_{j,t} = \begin{cases} 1, & if \sum tightened\, tool_{j,t} > 0 \\ 0, & no\, policy\, action\, or\, actions\, cancel\, out \\ -1, & if \sum loosened\, tool_{j,t} > 0 \end{cases}$$

where j denotes the country and t denotes the year.

The choice of individual tools significantly influences the value of MPIs. We focused on five instrument groups—lending standards restrictions, credit growth limits, liquidity

Table 1 Variable names and definitions. This table defines each main and control variables applied in this study, shows expected effect of control variables on profitability and includes data sources. IMF- International Monetary Fund

Variable name	Variable definition	Expected effect on NIM	Source:
Main control variables			
MPI	Index measuring overall stance of macroprudential policy	-	Authors'design based on the MaPPED database
MPI Lend stand restrict	MPI measuring stance of lending standards restrictions	-	Authors'design based on the MaPPED database
MPI Levy/Tax on fin	MPI measuring stance of levy/Tax on financial institutions	+/-	Authors'design based on the MaPPED database
MPI Limits Credit Gr&Vol	MPI measuring stance of limits on credit growth and volume	+/-	Authors'design based on the MaPPED database
MPI Liquidity & lim on mismatches	MPI measuring stance of liquidity requirements and limits on currency mismatches	-	Authors'design based on the MaPPED database
MPI Loan-loss provisioning	MPI measuring stance of loan-loss provisioning standards	+/-	Authors'design based on the MaPPED database
Bank control and other variables			
NIM	Measures the difference between the interest income generated by banks and the amount of interest paid out to their lenders divided by the amount of their average earning assets	/	Bankscope & Orbis
ΔNIM_{t+1}	Annual change in the level of NIM, measured as a difference in NIM in year *(t+1)* and NIM in year *(t)*	/	Bankscope & Orbis
ΔNIM_{t+2}	Two-yearly change in the level of NIM, measured as a difference in NIM in year *(t+2)* and NIM in year *(t)*	/	Bankscope & Orbis
IIEA	Interest income generated by banks divided by the amount of their average earning assets	/	Bankscope & Orbis
$\Delta IIEA_{t+1}$	Annual change in the level of IIEA, measured as a difference in IIEA in year *(t+1)* and IIEA in year *(t)*	/	Bankscope & Orbis
$\Delta IIEA_{t+2}$	Two-yearly change in the level of IIEA, measured as a difference in IIEA in year *(t+2)* and IIEA in year *(t)*	/	Bankscope & Orbis
IEEA	Amount of interest paid out to their lenders divided by the amount of their average earning assets	/	Bankscope & Orbis
$\Delta IEEA_{t+1}$	Annual change in the level of IEEA, measured as a difference in IEEA in year *(t+1)* and IEEA in year *(t)*	/	Bankscope & Orbis
$\Delta IEEA_{t+2}$	Two-yearly change in the level of IEEA, measured as a difference in IEEA in year *(t+2)* and IEEA in year *(t)*	/	Bankscope & Orbis
CAP	Measure of capital adequacy counted as ratio of capital funds to total assets	+	Bankscope & Orbis
LtD	Loans to deposits ratio	+	Bankscope & Orbis
LLP	Loan loss provision deflated by loans of bank in year *(t −1)*	+/-	Bankscope & Orbis
Loans	The loans-to-assets ratio captures the proportion of loans relative to total assets, with a very high value indicating that the bank specializes in loan making	+/-	Bankscope & Orbis

Table 1 (continued)

Variable name	Variable definition	Expected effect on NIM	Source:
CIR	Cost to income ratio of bank. This variable is a proxy for the technical efficiency and quality of management	-	Bankscope & Orbis
Size	Natural logarithm of total assets of bank	-	Bankscope & Orbis
NPL	Ratio of nonperforming loans to total loans	-	GFDD World Bank
ir_ref	Reference rate of central bank	+	Eurostat
Unempl	Unemployment rate	+/-	IMF
GDPG	The annual real Gross Domestic Product growth rate	-	IMF
HHI	Herfindahl Hirschman index. This variable is a proxy for market structure	-	Eurostat

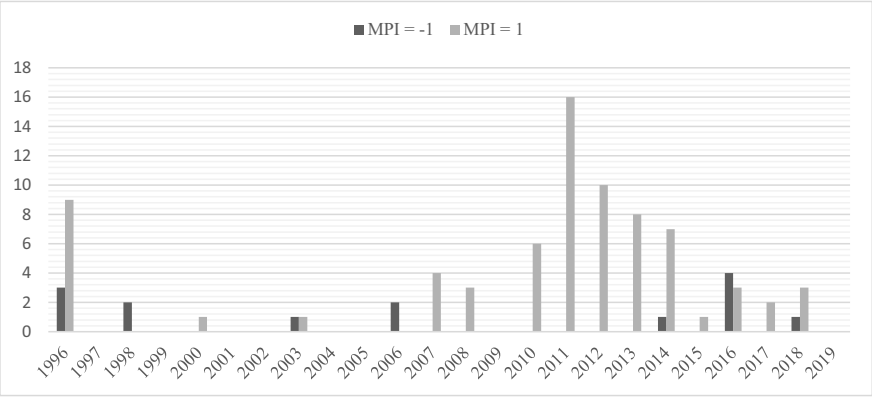

Fig. 1 Macroprudential policy index overall (MPI) levels in 1996–2019

requirements, limits on currency and maturity mismatch, provisioning systems, and taxes on financial activities—comprising 22 single tools.[3]

The distribution of MPI values varies across years and countries, as depicted in Figs. 1 and 2. Notably, in the majority of years and countries, policy was predominantly tightened, with an MPI equal to 1. The post-GFC period witnessed substantial policy modifications, with numerous instances of tightening observed in our sample. Examining EEA countries, Austria and the Netherlands have consistently applied tightened policies. Meanwhile, Germany, Italy, and Spain experienced only one year of net tightening. Greece and Slovakia stood out for at least four years of loosening, leading in this respect. Several countries, including Austria, Belgium, Germany, Hungary, Ireland, Luxembourg, Malta, the Netherlands, Romania, and Sweden, did not register negative MPI values in any of the years (see Fig. 1).

[3] In the ECB database, the overall number of these instruments is 23. However, as one of the tools (LTI ratio) was not subject to policy changes in the study period, we exclude it from the list of the tools covered in the MPI. The full list is included in Table 19 in the Appendix.

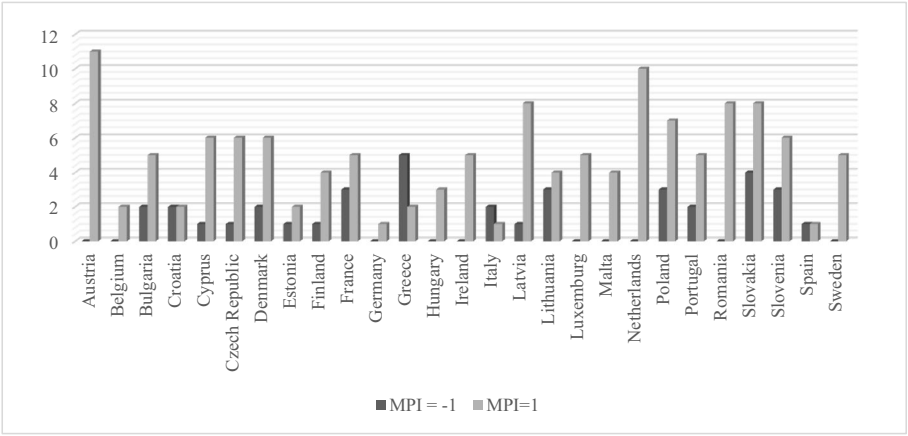

Fig. 2 MPI values across European countries

4 Methodology

4.1 Model and Variables Definitions

We begin with the following model specification:

$$Y_{i,j,t} = \alpha_0 + \alpha_1 \sum_{t=0}^{2} MPI_{j,t} + \beta\, BCOV_{i,j,t} + \epsilon_{i,j,t} \quad (1)$$

This equation outlines the general effects of macroprudential policy on the bank NIM, IIEA and IEEA $Y_{i,j,t}$ for bank *i* in country *j* in year *t*.

To explore the influence of macroprudential policy instrument types, we extend the model as follows:

$$Y_{i,j,t} = \alpha_0 + \alpha_m \sum_{m=1;t=0}^{5;2} MPI_{m,j,t} Instrument\ type + \beta\, BCOV_{i,j,t} + \epsilon_{i,j,t} \quad (2)$$

Here, *m* denotes the instrument type. We consider the cumulative effect of all instrument types in one equation to assess their relative importance. For bank i and year t in country j, the variables are as follows (refer to Table 1 for definitions).

$Y_{i,j,t}$ represents the bank net interest margin. Three proxies are examined: the NIM (NIM), annual change in NIM (ΔNIM_{t+1}= NIM_{t+1} - NIM_t), and two-year change in NIM (ΔNIM_{t+2} = NIM_{t+2} - NIM_t). Our definition of the NIM is in line with previous research (López-Espinosa et al. 2011; Lin et al. 2012; Chortareas et al. 2012; Entrop et al. 2015; Claessens et al. 2018; Yanikkaya et al. 2018; Nguyen et al. 2020; Kusi et al. 2020; Nguyen et al. 2022). We also explore the channels through which macroprudential policy changes affect the NIM by considering components of NIM: IIEA and IEEA.

To test the heterogeneous effects of changes in the macroprudential policy stance, we apply the immediate and lagged macroprudential policy indices in different, separate periods (see González 2022; Acharya and Subramanian 2009). First, we consider the immediate, and thus, *short-term impact* of macroprudential change on the NIM in the implementation year (t=0). Next, for the *medium-term effect*, we distinguish between effects on NIM levels

and changes in NIM. For the impact of macroprudential change on the NIM level, we consider the one- and two-year lagged impacts of the MPI. While analyzing the variations in NIM, we are interested in the effect of the macroprudential policy change in the first year of implementation on the annual variation in NIM (ΔNIM_{t+1}) and two-yearly variation in NIM (ΔNIM_{t+2}). The choice of the up to two-year window aligns with findings by Galán (2020), who suggests that the effects of the policy dilute over time (i.e., are visible in the three-year span encompassing the years 0, 1 and 2) (see also González 2022). Our strategy for the analysis of short- and medium-term effects is presented in Fig. 3.

BCOV is a vector of bank control and other variables. Bank-specific variables include the capital ratio (CAP), liquidity ratio (Loans to Deposits), LLP (LLP), loans to assets ratio (Loans to Assets), cost-to-income ratio (CIR), and bank size (Size). Capturing bank risk aversion, a higher capital adequacy ratio suggests that having a well-capitalized bank positively impacts NIM (Chortareas. et al. 2012; Claessens et al. 2018; Yanikkaya et al. 2018; Nguyen et al. 2020; Kusi et al. 2020; Nguyen et al. 2022). Reflecting reduced liquidity with higher values, banks with more liquid assets tend to exhibit increased NIM. This is in line with Ho and Saunders' (1981) findings. As a proxy for credit risk costs, a higher LLP is expected to positively influence the NIM (Drakos 2003; Kasman et al. 2010; López-Espinosa et al. 2011; Chortareas et al. 2012; and Nguyen et al. 2020). Reflecting bank orientation toward credit intermediation, higher values suggest greater lending intensity and more interest income. However, the relationship between Loans to Assets and NIM is nuanced (Maudos and Fernández de Guevara 2004; López-Espinosa et al. 2011; Chortareas et al. 2012; and Olszak and Kowalska 2023). A higher CIR tends to correspond to lower NIMs, indicating managerial efficiency. This is consistent with the findings of Dietrich and Wanzenried (2011; 2014) and Molyneux et al. (2019). The impact of bank size on NIM continues to be debated. While some studies suggest a negative relationship (Islam et al. 2016), others argue the opposite (Nguyen et al. 2020; López-Espinosa et al. 2011). Serving as a measure

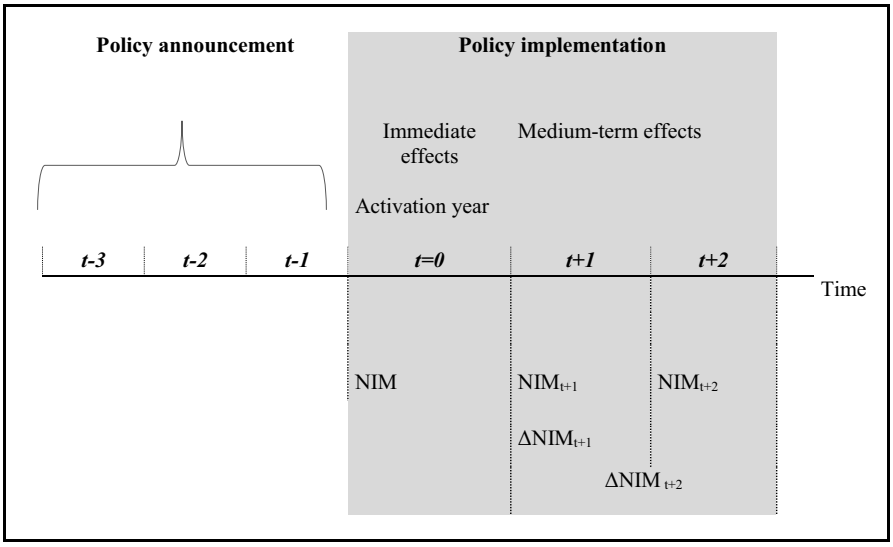

Fig. 3 The strategy for the analysis of the immediate and medium-term effects of macroprudential policy on net interest margin

of loan quality, a positive relationship between non-performing loans (NPL) and NIM is expected, following Kusi et al. (2020), Islam and Nishiyama (2016), and Nguyen et al. (2022). Banks might need to compensate for increased lending costs with greater income associated with loans.

The other control variables include macroeconomic measures that proxy the effects of monetary policy (ir_ref), the business cycle (GDPG), job market conditions (unempl), and market structure (HHI) on bank NIMs. Changes in monetary policy interest rates can affect lending conditions, and consequently, NIM. The direction of this effect varies across studies, with both positive and negative relationships reported (Ho and Saunders 1981; Entrop et al. 2015; Nguyen et al. 2022; Olszak and Kowalska 2023). The impact of GDP growth on NIM is twofold: it positively influences efficiency owing to greater loan demand but potentially reducing NIM as the loan supply declines. Diverse links between NIM and GDPG have been documented in the literature (Kasman et al. 2010; Islam et al. 2016; Entrop et al. 2015; Claessens et al. 2018; Yanikkaya et al. 2018; Molyneux et al. 2019; Kusi et al. 2020; Nguyen et al. 2022; Olszak and Kowalska 2023). A higher unemployment rate indicates a weakened borrower capability to repay debt, negatively affecting NIM, as shown by Molyneux et al. (2019) and Olszak and Kowalska 2023). Studies report both positive and negative links of the Hirschman–Herfindahl index with NIM (Chen and Liao 2011; Dietrich and Wanzenried 2011; Almeida and Divino 2015; Aydemir and Ovenc 2016; and Islam and Nishiyama 2016).

For hypothesis H4, we predict that the effects of macroprudential policy on the NIM differ depending on bank capitalization and credit risk. We test this hypothesis by running Eq. (2) in three subsamples of high-, medium-, and low-capital, and high-, medium-, and low-credit risk banks. We define highly, medium, and low capitalized banks as 30% of banks with the highest capital ratio (denoted as High CAP banks), capital ratios greater than 30% and less than 70% (denoted as Medium CAP banks), and 30% of banks with the lowest capital ratio (denoted as Low CAP banks), respectively. On credit risk, we consider (1) bank-specific risk, which is the overall credit risk level (as in Maudos and Fernández de Guevara 2004; López-Espinosa et al. 2011; Chortareas et al. 2012) proxied with the ratio of loans to total assets and credit risk costs (Ho and Saunders 1981) proxied with net LLPs divided by one-year lagged loans, and (2) the macroeconomic level of credit risk, proxied with a country-level nonperforming loans ratio. We divide banks into high-, medium- and low-credit risk groups by applying percentile values in the same way as for the capital ratio. To analyze our results on the role of credit risk, we refer to the literature on procyclicality in banking (Borio et al. 2001, p.1; Leaven and Majnoni, 2003; Olszak et al. 2017; Huizinga and Laeven 2019) and the related concept of excessive risk-taking. According to this concept, low and medium LLPs and NPL will denote periods of risk-build up (excessive risk-taking). In contrast, high LLPs and NPLs mark the risk materialization period (and reduced risk-taking).

4.2 Endogeneity and Estimation Modeling Methods

We apply several preventive measures to address endogeneity concerns. First, to eliminate the risk of omitted variable bias, we use the empirical specification of the model commonly applied in analyses of NIMs (Ho and Saunders 1981; Chen and Liao 2011; Dietrich and Wanzenried 2011; Chortareas. et al. 2012; Almeida and Divino 2015; Aydemir and Ovenc 2016; Bikker and Vervliet 2018; Claessens et al. 2018; Yanikkaya et al. 2018;

Molyneux et al. 2019; Nguyen et al. 2020; Nguyen et al. 2022; Olszak and Kowalska 2023), including an extended set of control variables that capture bank specific, industry-specific, and macroeconomic determinants. Second, we consider variable definitions (dependent and regressors) widely applied in the literature on NIMs and profitability (Bikker and Vervliet 2018; Claessens et al. 2018; Yanikkaya et al. 2018; Molyneux et al. 2019; Nguyen et al. 2020; Nguyen et al. 2022; Olszak and Kowalska 2023) with the goal of reducing the risk of measurement error bias. Third, in our analysis, we include all banks that are accessible in the Bankscope and Orbis databases and control for outliers by winsorizing our data at 1%, all with the aim of overcoming sample selection bias. We also apply sensitivity tests to check whether our conclusions hold in different subsamples (e.g., the EURO area) before the GFC in low- and high-rate environments. We also consider different sets of explanatory variables by including time dummies. Third, to eliminate simultaneity bias in the definitions of bank-specific variables (e.g., NIM, IIEA, IEEA, LLP, and CIR), we normalize the levels of income statement items with balance sheet items lagged by one year. Additionally, all bank-specific determinants included in the regressors are lagged by one year.

Our sample consists of unbalanced panel data that consider individual bank-level variables over a long period (up to 24 years). These variables are correlated with their previous values, causing endogeneity. To eliminate this, we apply robust standard errors clustered at the bank level. The bank-level dependent variables (NIM, IIEA and IEEA) are regressed on bank specific, industry specific, macroeconomic, and macroprudential explanatory variables. Considering the unbalanced panel data structure of our sample, we can apply fixed or random effects estimators. Mundlak (1978) argues that the random effects model assumes exogeneity of all regressors with random individual effects (Baltagi 2005). Meanwhile, the fixed effects model allows for endogeneity of all regressors with these individual effects. In our data, some variables (e.g., bank-specific variables) in a given period T may be endogenous with respect to the levels of NIM, IIEA and IEEA. However, other variables, including business cycle proxies and macroprudential policy, can be seen as exogenous. In summary, we consider several tests (Hausman test, Breusch and Pagan Lagrangian multiplier, and robust Hausman test), and opt for fixed effects with robust standard errors clustered at the bank level (Bell et al. 2018; Bell and Jones 2015; Wooldridge 2021). Several recent studies also consider the dynamic structure of bank net interest margins, applying a lagged dependent variable (refer to the discussion by Bikker and Vervliet 2018). However, the within estimators applied to datasets covering T dimensions below 30 (as is the case in our sample) are inadequate in dynamic settings, producing inconsistent estimates (Nickell 1981) because of the correlation between the lagged dependent variable and error term (Davis et al. 2022; Bikker and Vervliet 2018).

We start modeling our regression with random effects and fixed-effects estimators to conduct the Hausman specification test. The test reveals that the fixed-effect estimator is more suitable for our analysis because of the presence of a strong correlation between the regressors and error term. Therefore, in the results section, we present fixed-effects estimation models with robust standard errors. We apply robust standard errors that are bank clustered instead of country clustered because of the sample characteristics. When the cluster sizes are unbalanced (in our case, because of the enormous diversity of the number of banks and observations across countries) and their number is small (in our sample, the numbers of countries and years are small at below 50), inference via a cluster-robust estimator may be

incorrect (Nichols and Shaffer 2007, p.8–9; Cameron and Miller 2015). In effect, clustering by country (and year) is inappropriate in our study; hence, we cluster at the bank level.

4.3 Bank-level and Macroeconomic Data Description

We first examine the variables of interest. The mean NIM is 2.59%, with a standard deviation of 1.02% points (see Table 2). Both ΔNIM_{t+1} and ΔNIM_{t+2} exhibit negative average values of −0.07% and −0.16%, respectively. These variables are characterized by substantial diversity across banks, as indicated by standard deviations that significantly exceed their mean values.

Table 2 Descriptive statistics– overall. Variables definitions are included in Table 1. NIM - Net interest margin ratio; IIEA - interest income to earning assets; IEEA – interest expense to earning assets; CAP - Measure of capital adequacy counted as ratio of capital funds to total assets; LtD - Total loan to total deposit ratio; LLP - Loan loss provision; Loans- the loans-to-assets ratio; $CIR_{(t-1)}$ - Cost to income ratio; $Size_{(t-1)}$ - Natural logarithm of total assets of bank; $NPL_{(t-1)}$ - Ratio of nonperforming loans to total loans; ir_ref - Reference rate of central bank; unempl – Unemployment rate; GDPG – the real GDP growth rate; HHI - Herfindahl Hirschman index; MPI - Index measuring overall stance of macroprudential policy; MPI lend stand restrict - MPI measuring stance of lending standards restrictions; MPI Levy/Tax on fin - MPI measuring stance of levy/Tax on financial institutions; MPI Limits on credit Gr&Vol - MPI measuring stance of Limits on credit growth and volume; MPI liquidity & Lim on mismatch - MPI measuring stance of liquidity requirements and Limits on currency mismatches; MPI Loan-loss provisioning - MPI measuring stance of loan-loss provisioning standards

	#Observations	Mean	Std.Dev.	Min	Max
NIM	22,134	2.59	1.02	−0.59	12.44
ΔNIM_{t+1}	19,330	−0.07	0.38	−4.77	4.70
ΔNIM_{t+2}	16,659	−0.16	0.52	−7.19	6.27
IIEA	21,050	3.16	1.15	0.08	11.70
$\Delta IIEA_{t+1}$	18,095	−0.16	0.14	−9.15	9.93
$\Delta IIEA_{t+2}$	15,363	−0.32	0.28	−9.06	9.91
IEEA	21,017	0.61	0.80	−2.22	5.59
$\Delta IEEA_{t+1}$	18,044	−0.08	0.06	−4.36	4.93
$\Delta IEEA_{t+2}$	15,314	−0.15	0.15	−4.59	5.03
$CAP_{(t-1)}$	22,134	17.71	6.74	8.25	70.00
$LtD_{(t-1)}$	22,134	103.12	60.15	6.90	792.13
$LLP_{(t-1)}$	22,134	0.62	1.10	−3.05	11.24
$Loans_{(t-1)}$	22,134	59.34	15.74	0.99	95.28
$CIR_{(t-1)}$	22,134	69.50	15.30	7.88	173.44
$Size_{(t-1)}$	22,134	13.45	1.71	9.58	19.57
$NPL_{(t-1)}$	22,134	5.41	4.81	0.10	47.75
ir_ref	22,134	1.13	1.37	−1.25	17.00
unempl	22,134	7.23	2.87	2.00	27.50
GDPG	22,134	1.15	2.62	−14.80	25.30
HHI	22,134	0.05	0.04	0.01	0.41
MPI	22,134	0.10	0.40	−1	1
MPI Lend stand restrict	22,134	0.03	0.21	−1	1
MPI Levy/Tax on fin	22,134	0.08	0.28	−1	1
MPI Limits on Credit Gr&Vol	22,134	0.00	0.12	−1	1
MPI Liquidity & lim on mismatch	22,134	0.04	0.30	−1	1
MPI Loan-loss provisioning	22,134	0.01	0.13	−1	1

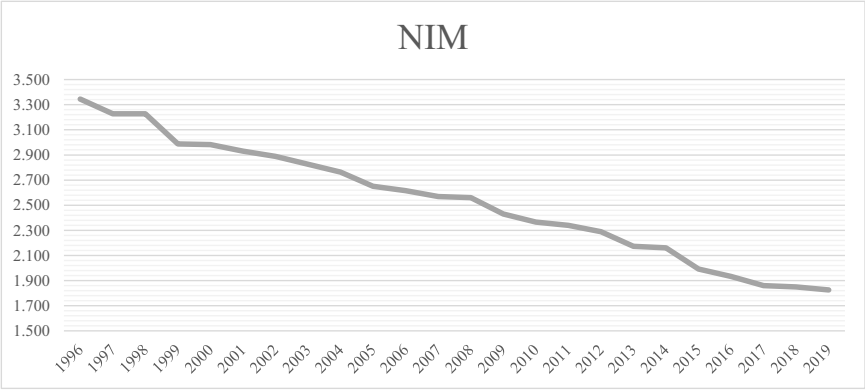

Fig. 4 NIM levels in 1996–2019

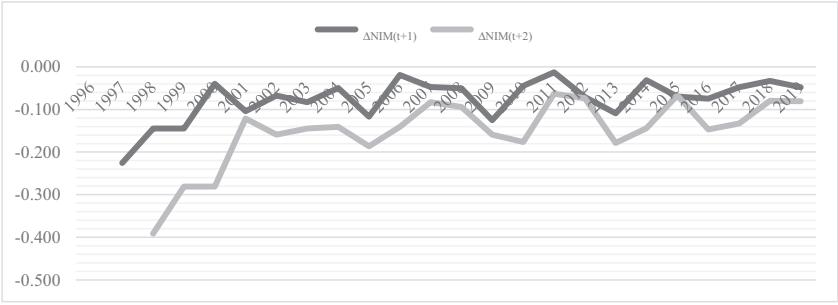

Fig. 5 Medium term changes in net interest margins: ΔNIM_{t+1} and ΔNIM_{t+2} in 1996–2019

Figures 4 and 5 visually depict the evolution of NIM, ΔNIM_{t+1}, and ΔNIM_{t+2}. Consistent with prior research, a declining trend in NIM was observed from 1996 to 2019. The most significant drops in bank net interest margins occurred prior to the GFC. Figures 6 and 7 underscore the diversity in mean net interest margins across EEA countries (see also Table 17 and Table 18 in the Annex). In most countries, the changes in the NIM level (ΔNIM_{t+1} and ΔNIM_{t+2}) were negative, with Bulgaria, Estonia, and Romania showing the greatest declines. Only Cyprus, Greece, Luxembourg, and Malta experienced slight increases in $\Delta NIMt+1$ and $\Delta NIMt+2$.

The correlation analysis presented in Panel A of Table 16. reveals statistically significant associations between NIM, ΔNIM_{t+1}, ΔNIM_{t+2}, and most explanatory variables. Notably, the correlation coefficient for MPI is negative for NIM (−0.105), indicating that an increase in MPI, representing policy tightening, is associated with a decline in NIM. The analysis of the correlations between explanatory and macroeconomic variables does not indicate at linear links that could result in collinearity. We find no strong linear links among the correlations between instrument types (Panel B of Table 16.).

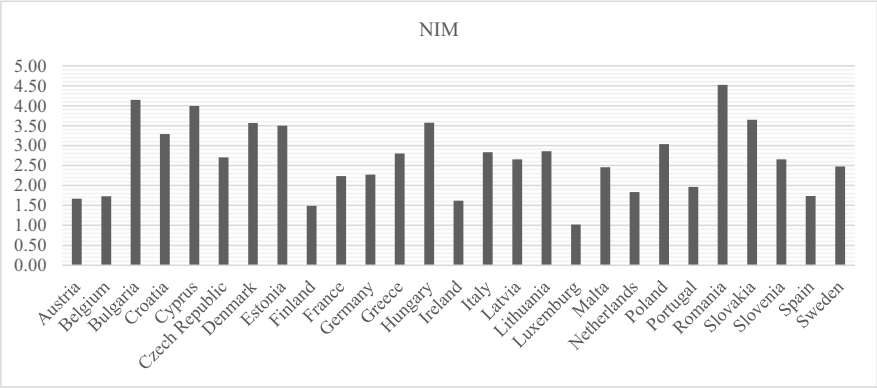

Fig. 6 Average NIM level across European countries

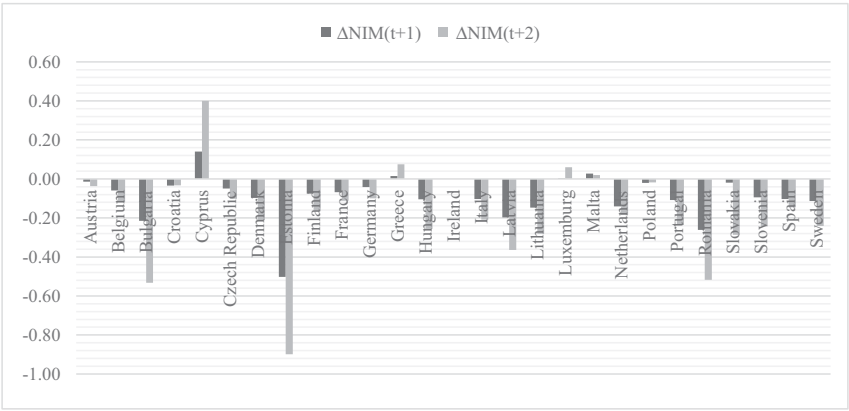

Fig. 7 Annual change in NIM (ΔNIM_{t+1}) and Two Yealy change in NIM (ΔNIM_{t+2}) in NIM across European countries

5 Results

5.1 Main Results

Table 3 presents the empirical results. The effects of the control variables on NIM are in line with those observed in previous studies.[4] Concerning Hypothesis H1, we find that macroprudential policy negatively affects the NIM level, with a significant effect observed in the policy implementation year. Specifically, the negative regression coefficient on the macroprudential index (MPI) is estimated at 0.019, indicating that a tightening of the policy correlates with a 0.019 decrease in NIM compared with its mean value. This translates to a 2 basis points (bp) reduction, constituting a 0.73% change relative to the average value.

[4] In Tables 3 and 4. we additionally include a diagnostic test, which supports the significance of all regression coefficients (F test) and that most of the model variability is due to the variability in the individual heterogeneity (Rho).

Table 3 Baseline results – effects of change in macroprudential policy on NIM. This table presents the robust fixed effect (FE) estimations of eq. 1 with bank clustered standard errors. This is the presentation of tests of hypotheses H1 and H2. Full variables definitions are in Table 1. NIM - Net interest margin ratio; MPI - Index measuring overall stance of macroprudential policy; CAP - Measure of capital adequacy counted as ratio of capital funds to total assets; LtD - Total loan to total deposit ratio; LLP - Loan loss provision; Loans - The loans-to-assets ratio; CIR - Cost to income ratio; Size - Natural logarithm of total assets of a bank; NPL- ratio of nonperforming loans to total loans; ir_ref - Reference rate of central bank; unempl– Unemployment rate; GDPG – the real GDP growth rate; HHI - Herfindahl Hirschman index; robust standard errors in brackets; F– denotes F statistics; Rho– denotes how much of the variability in the model is due to the variability in banks heterogeneity. # denotes the number of

	NIM	NIM_{t+1}	NIM_{t+2}	ΔNIM_{t+1}	ΔNIM_{t+2}
	Immediate	Medium-term			
	1	**2**	**3**	**4**	**5**
MPI	−0.019**	−0.013	−0.006	−0.079***	−0.081***
	(0.009)	(0.011)	(0.011)	(0.010)	(0.012)
$CAP_{(t-1)}$	−0.002	−0.002	−0.002	−0.002	−0.005**
	(0.003)	(0.003)	(0.003)	(0.001)	(0.002)
$LtD_{(t-1)}$	−0.002***	−0.002***	−0.002***	−0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$LLP_{(t-1)}$	0.018**	0.018**	0.018**	−0.001	−0.021**
	(0.008)	(0.008)	(0.008)	(0.006)	(0.009)
$Loans_{(t-1)}$	0.012***	0.012***	0.012***	−0.006***	−0.013***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
$CIR_{(t-1)}$	−0.007***	−0.007***	−0.007***	0.004***	0.005***
	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)
$Size_{(t-1)}$	−0.741***	−0.742***	−0.741***	0.161***	0.205***
	(0.059)	(0.059)	(0.059)	(0.017)	(0.028)
$NPL_{(t-1)}$	−0.018***	−0.019***	−0.019***	0.007**	−0.008*
	(0.005)	(0.005)	(0.005)	(0.003)	(0.005)
ir_ref	0.154***	0.154***	0.154***	0.016**	−0.058***
	(0.013)	(0.013)	(0.013)	(0.007)	(0.010)
unempl	0.019***	0.019***	0.019***	0.009***	0.033***
	(0.006)	(0.006)	(0.006)	(0.003)	(0.005)
GDPG	0.003	0.003	0.003	0.006***	0.008***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
HHI	3.425***	3.375***	3.351***	−2.660***	−7.281***
	(1.044)	(1.044)	(1.056)	(0.510)	(1.099)
Constant	12.123***	12.134***	12.127***	−2.083***	−2.213***
	(0.833)	(0.835)	(0.836)	(0.252)	(0.399)
#Observations	22,134	22,134	22,134	19,330	16,659
# Banks	3,077	3,077	3,077	2,971	2,805
R^2 within	0.449	0.449	0.449	0.044	0.077
R^2 between	0.209	0.208	0.208	0.006	0.011
R^2 overall	0.252	0.252	0.252	0.006	0.020
F	185.4	187.6	183.7	29.71	29.36
Rho	0.892	0.892	0.892	0.457	0.546
Bank fixed effects	yes	yes	yes	yes	yes

*,** and *** denote significance at 10%, 5% and 1% levels, respectively

Conversely, for loosening periods (i.e., MPI = −1), a positive effect is observed. Although the lagged effect of the MPI on the NIM level is negative, it is not statistically significant. Furthermore, our analysis supports Hypothesis H2, revealing a difference between short- and medium-term responses to MPI changes in the NIM, as proxied by lagged and annual (ΔNIM_{t+1}), and two-yearly (ΔNIM_{t+2}) variations. Specifically, policy tightening reduces ΔNIM_{t+1} (ΔNIM_{t+2}) by 0.079 (0.081). This effect holds economic significance, as indicated by the results in column 4, where a change in MPI from 0 to 1 (tightening) leads to a 110% (52%) change in ΔNIM_{t+1} (ΔNIM_{t+2}) from the mean. Conversely, loosening periods (MPI = −1) yield opposite effects.

In Table 4 we analyze the effects of macroprudential policy on the components of the net interest margin, that is the interest income (IIEA) and interest expense (IEEA). The immediate effect of macroprudential tightening is an increase in interest income by 7 bp and interest expense by almost 10 bp, with visibly strongest effect on the IEEA channel. Consequently, the net interest margin, as reported in Table 3 (column 1) decreases. We find a statistically significant declines in IIEA by 10.5 b.p, and IEEA by 10.1 bp two years after the implementation of policy change, that are economically strong and imply a negative change of 3.3% and 17% in comparison to the mean values, for IIEA and IEEA, respectively. Our results give further support to hypothesis H2, revealing a difference between short- and medium-term responses to MPI changes in the IIEA and IEEA, as proxied by lagged and annual ($\Delta IIEA_{t+1,}$ $\Delta IEEA_{t+1}$) and two-yearly ($\Delta IIEA_{t+2}$ and $\Delta IEEA_{t+2}$) variations. We also find that the drop is definitely stronger for the income component than for the funding cost component of the net interest margin, as is denoted by the over twice higher regression coefficient on $\Delta IIEA_{t+1}$ ($\Delta IIEA_{t+2}$) than on $\Delta IEEA_{t+1}$ ($\Delta IEEA_{t+2}$).

Table 5[5] presents the hypotheses testing results for hypothesis H3, along with hypotheses H3.1 to H3.5, for the NIM (Panel A) and its components, IIEA (Panel B) and IEEA (Panel C). Lending standard restrictions (*MPI lending restrictions*), which affect procyclicality through the composition of credit portfolios by including less risky borrowers, significantly reduce NIM (NIM) levels, with the most substantial decline observed in the activation year (refer to column 1) and a weaker effect found in the year after the policy implementation. However, these restrictions do not yield significant modifications in ΔNIM_{t+1} and ΔNIM_{t+2}. Analyzing the NIM components highlights that the direct consequence of the change in *MPI Lend stand restrict* is a significant increase in funding cost levels, expressed by IEEA, $IEEA_{t+1}$, and $IEEA_{t+2}$ (see columns 1–3 of Panel C, respectively). This increase in IEEA is not buffered by adjustments in IIEA levels (see columns 1–3 of Panel B, respectively), resulting in reductions in the NIM level (see columns 1–3 of Panel A, respectively). Yearly variations in IIEAs and IEEA are also affected (see column 4 of Panels B and C) and significantly decline if *the MPI Lend stand restrictions* are tightened.

Taxes and levies imposed on financial institutions have a significant positive effect on NIM levels in the activation year, resulting in a slight increase in NIM (see column 1 in Panel A). This increase is caused by positive adjustments in the income component (IIEA), which exceeds the upward change in funding costs (IEEAs) (see column 1 in Panels B and C). Looking at medium-term effects, we find a NIM increase two years after the change in *MPI Levy/tax on fin*, prompted mostly by an upward adjustment in the income component ($IIEA_{t+2}$).

[5] Beginning with Table 5, we omit inclusion of diagnostic tests presented in Tables 3 and 4, to increase the clarity of the message contained in our results. In this way, we also want to limit the range of pages occupied by one table (instead of two one page). All tables with full tests are accessible upon request from the authors.

Table 4 The effects of macroprudential policy change on IIEA and IEEA. These are the robust fixed effect (FE) estimations of eq. 1 with bank clustered standard errors. This is the presentation of tests of hypotheses H1 and H2. Full variables definitions in Table 1. IIEA - Interest income to earning assets; IEEA – Interest expense to earning assets; robust standard errors in brackets; MPI - Index measuring overall stance of macroprudential policy; F– denotes F statistics; Rho– denotes how much of the variability in the model is due to the variability in banks heterogeneity. # denotes the number of

	Interest income to earning assets					Interest expense to earning assets				
	IIEA	$IIEA_{t+1}$	$IIEA_{t+2}$	$\Delta IIEA_{t+1}$	$\Delta IIEA_{t+2}$	IEEA	$IEEA_{t+1}$	$IEEA_{t+2}$	$\Delta IEEA_{t+1}$	$\Delta IEEA_{t+2}$
	Immediate	Medium-term				Immediate	Medium-term			
	1	2	3	4	5	6	7	8	9	10
$MPI_{(t)}$	0.067***			−0.103***	−0.110***	0.095***			−0.036***	−0.052***
	(0.013)			(0.013)	(0.022)	(0.011)			(0.011)	(0.018)
$MPI_{(t-1)}$		−0.015					0.011			
		(0.013)					(0.011)			
$MPI_{(t-2)}$			−0.105***					−0.101***		
			(0.016)					(0.013)		
Control variables	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
#Observations	21,061	21,061	21,061	18,095	15,363	21,017	21,017	21,017	18,044	15,314
#Banks	2,998	2,998	2,998	2,890	2,712	2,997	2,997	2,997	2,888	2,707
R^2 within	0.547	0.546	0.549	0.103	0.142	0.321	0.318	0.322	0.092	0.103
R^2 between	0.195	0.197	0.195	0.017	0.000	0.280	0.277	0.273	0.028	0.000
R^2 overall	0.296	0.296	0.294	0.0317	0.0240	0.276	0.270	0.267	0.041	0.006
F	276.6	287.6	284.9	124.9	108.0	116.7	119.4	125.5	85.03	67.80
Rho	0.843	0.843	0.844	0.419	0.511	0.689	0.691	0.693	0.265	0.504
Bank fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

; *, ** and *** denote significance at 10%, 5% and 1% levels, respectively

These findings are consistent with the idea that banks experiencing decreased profitability due to taxes and levies (as found by Davis et al. 2022; for ROA and ROE) adjust their credit portfolio composition toward riskier loans. Nevertheless, our findings indicate that tightening *MPI taxes/Levy on fin* reduced the yearly and biannual changes in NIM, consistent with Hypothesis H3.2. These reductions are due to a decline in the annual variation in the income component ($\Delta IIEA_{t+1}$), which is accompanied by an insignificant increase in the funding cost component ($\Delta IEEA_{t+1}$). For two-yearly variations in NIM (ΔNIM_{t+2}), a strong increase in the funding cost component is not buffered by a proportionate change in the interest income component, resulting in a significant and strong decline in ΔNIM_{t+2} (see column 5 of Panels A, B, and C). In summary, our results provide some support for H3.2 because we find a decrease in NIM variations in the medium term. However, we find an upward adjustment in the NIM levels mostly due to an increase in the interest income component of the NIM.

Limits on credit growth and volume do not affect NIM in the year of the policy implementation. However, they have a significant negative effect on the income and funding costs components of the NIM, as denoted by the negative regression coefficients of −0.184 and −0.133 for the IIEA and IEEA, respectively. In the medium term, our results support the view that changes in the MPI Limits on Credit Gr&Vol increase the NIM. This significantly positive upward change in NIM is mostly due to the increase in the income component of NIM, which is not eaten by the funding costs component. Thus, Hypothesis H3.3 is supported in the medium term.

Liquidity requirements and limits on currency mismatches contribute to an increase in NIM levels during the activation year, which is due to a the higher interest income component that is not offset by the funding costs component of NIM. However, they exert opposite impacts in all medium terms (i.e., in the second and third years after activation). This negative and statistically significant effect holds across the NIM, ΔNIM_{t+1}, and ΔNIM_{t+2} models. Our results show that reductions in NIM in the medium-term result from the enormous decline in the income component (all coefficients on IIEA in columns 2–5 are significantly negative in Panel B), which is not buffered by the funding costs component of NIM (columns 2–5 in Panel C). Thus, our results align with H3.4 for the medium-term response to changes in liquidity requirements.

Changes in *loan-loss provisioning* rules reduce NIM in the implementation year. In the medium term, they do not significantly change NIM levels, but do have a strong negative effect on both the income and funding cost components of NIMs in the second year after the change in *MPI loan-loss provisioning*. In line with H3.5, yearly and two-yearly variations in NIM increase due to the tightening of *MPI loan-loss provisioning* (columns 4 and 5 in Panel A). This effect is not correlated with significant adjustments in the income and cost components of NIM (columns 4 and 5 in Panels B and C).

Regarding the relative importance of specific instrument types on the NIM, *lending standard restrictions* (i.e., borrower-based tools) and loan-loss provisioning rules reduce the NIM level, with the strongest effect which is statistically significant in the year of effective implementation found for *MPI loan-loss provisioning*. On the medium-term effect, *liquidity requirements and limits on currency mismatche*s most strongly reduce both the NIM level, and ΔNIM_{t+1} and ΔNIM_{t+2} in a significant way (at 1%). Their one-year lagged effect on the NIM level equals −0.159 and is definitely stronger than the effect of *lending standards restrictions* (equal to −0.041), implying a 6.2% change from the mean NIM level of NIM. Regarding the changes in NIM (ΔNIM_{t+1} and ΔNIM_{t+2}), *liquidity requirements and limits*

on currency mismatches exert stronger effects than *levies/taxes on financial institutions and instruments*. Specifically, for the yearly change in the NIM, changes in *liquidity instruments* result in a 154% change from the mean level of ΔNIM_{t+1}, compared with a 107% change caused by *levies/taxes on financial institutions and instruments. Limits on credit growth and volume* result in a medium-term increase in the NIM levels and changes in the NIM, with their effect being stronger than that of the *loan-loss provisioning rules.* Regarding the two-yearly change in NIM, a change in *limits on credit growth and volume* implies a 164% change from the mean ΔNIM_{t+2} (which equals −0.16), whereas changes in MPI *loan loss provisioning* coincide with a 104% adjustment of ΔNIM_{t+2}.

Analyzing the role of the level of capitalization on the links between macroprudential changes, and the NIM and its components, poorly capitalized banks have to pay more for obtaining access to deposits, as denoted by an increased funding cost component of the NIM in the policy implementation year (see Table 6). They also tend to increase the interest income, consistent with the expectation that riskier banks have more profitable loan portfolios. However, the overall immediate effect is no change in NIM. In the medium term, a change in MPI reduces NIM levels and its variations (ΔNIM_{t+1} and ΔNIM_{t+2}), which are not specifically driven by the capital ratio. However, among the NIM components, both interest income and funding costs decline more in poorly capitalized banks. Generally, our results once again support hypotheses H1 and H2, and validate hypothesis H4.

In Tables 7 and 8, we delve more into the role of the capital ratio in the effects of macroprudential instruments on NIM and its components, IIEA and IEEA. NIM levels and variations are more affected by changes in limits on credit growth and volume (*MPI Limits on Credit Gr& Vol*), and liquidity requirements (*MPI Liquidity & lim on mismatch*) in better capitalized banks (Table 7, columns 2–6) than in poorly capitalized ones and the full sample (see Table 5). Changes in taxes and levies result in slightly greater reductions in variations in NIM only in poorly capitalized banks. Loan loss provisioning changes result in magnified declines in NIM in the policy implementation year for well-capitalized banks. The effects of lending standard restrictions do not differ between well- and poorly capitalized banks. Regarding NIM components, the immediate effect of changes in lending standards restrictions is an increase in funding costs and a decline in interest income in banks with low and medium capital ratios (see Table 8). Facing changes in taxes and levies, poorly capitalized banks increase interest income more than well capitalized banks. However, better capitalized banks tend to increase funding costs more than low capital banks do; however, the difference is negligible (0.091 for high cap and 0.082 for low CAP banks). Changes in the *MPI Limits on Credit Gr&Vol* exert stronger negative effects on interest income and interest expenses in well-capitalized banks in the implementation year. Immediate effect of a change in liquidity requirements in enhanced (more positive in the full sample) poorly capitalized banks. In the medium term, in low CAP banks, a change in liquidity requirements results in magnified reductions in both interest income and the funding cost component, with the effect being especially intense for interest expenses (compare columns 2–5 and 12–15 in Panels A and B of Table 8). Facing changes in limits on credit growth and volume, poorly capitalized banks also exhibit a lower increase in interest income and pay relatively more for deposits than well capitalized banks. In summary, our results for the effects of instruments provide further support for H3.5 and H2, and validate hypothesis H4.

Next, we analyze the effects of policy changes on net interest margins on credit risk at the bank (loans-to-assets ratio and LLPs ratio in Table 9) and macroeconomic/country levels (nonperforming loans ratio in Table 10). The loan-to-asset ratio, LLPs and NPLs convey dif-

Table 5 Main effects of changes in macroprudential policy instruments on NIM, IIEA and IEEA. These are the robust fixed effect (FE) estimations of eq. 2 with bank clustered standard errors and bank fixed effects, testing the hypotheses H2, H3 and H3.1-5, regarding the impact of the change in macroprudential policy instrument types. We include full set of control variables and analyze diagnostic test as in Table 3, but not report them to save space. NIM - Net interest margin; IIEA - Interest income to earning assets; IEEA – Interest expense to earning assets; full variables definitions in Table 1; MPI lend stand restrict - MPI measuring stance of lending standards restrictions; MPI Levy/Tax on fin - MPI measuring stance of levy/Tax on financial institutions; MPI Limits on credit Gr&Vol - MPI measuring stance of Limits on credit growth and volume; MPI liquidity & Lim on mismatch - MPI measuring stance of liquidity requirements and Limits on currency mismatches; MPI Loan-loss provisioning - MPI measuring stance of loan-loss provisioning standards; robust standard errors in brackets; # denotes the number of

	Immediate	Medium-term			
	1	2	3	4	5
	PANEL A: Net interest margin				
	NIM	NIM_{t+1}	NIM_{t+2}	ΔNIM_{t+1}	ΔNIM_{t+2}
MPI Lend stand restrict	−0.088***	−0.041*	−0.014	−0.004	0.002
	(0.022)	(0.023)	(0.027)	(0.025)	(0.031)
MPI Levy/Tax on fin	0.036***	0.015	0.094***	−0.077***	−0.036***
	(0.011)	(0.011)	(0.011)	(0.010)	(0.013)
MPI Limits on Credit Gr&Vol	−0.091	0.168***	0.170***	0.205***	0.257***
	(0.072)	(0.059)	(0.064)	(0.050)	(0.088)
MPI Liquidity & lim on mismatch	0.033*	−0.159***	−0.096***	−0.111***	−0.235***
	(0.017)	(0.016)	(0.013)	(0.013)	(0.021)
MPI Loan-loss provisioning	−0.095*	−0.002	−0.015	0.139**	0.164**
	(0.051)	(0.054)	(0.036)	(0.064)	(0.068)
#Observations	22,134	22,134	22,134	19,330	16,659
#Banks	3,077	3,077	3,077	2,971	2,805
	PANEL B: Interest income to earning assets				
	IIEA	$IIEA_{t+1}$	$IIEA_{t+2}$	$\Delta IIEA_{t+1}$	$\Delta IIEA_{t+2}$
MPI Lend stand restrict	−0.014	−0.008	0.012	−0.055**	0.041
	(0.025)	(0.026)	(0.030)	(0.027)	(0.037)
MPI Levy/Tax on fin	0.119***	−0.011	0.073***	−0.067***	0.078***
	(0.014)	(0.015)	(0.015)	(0.013)	(0.017)
MPI Limits on Credit Gr&Vol	−0.184***	0.180**	0.204**	0.314***	0.475***
	(0.059)	(0.070)	(0.081)	(0.065)	(0.104)
MPI Liquidity & lim on mismatch	0.082***	−0.051***	−0.266***	−0.173***	−0.439***
	(0.020)	(0.018)	(0.017)	(0.019)	(0.030)
MPI Loan-loss provisioning	−0.071	−0.062	−0.107*	0.122	−0.019
	(0.069)	(0.059)	(0.064)	(0.076)	(0.104)
#Observations	21,061	21,061	21,061	18,095	15,363
#Banks	2,998	2,998	2,998	2,890	2,712
	PANEL C: Interest expense to earning assets				
	IEEA	$IEEA_{t+1}$	$IEEA_{t+2}$	$\Delta IEEA_{t+1}$	$\Delta IEEA_{t+2}$
MPI Lend stand restrict	0.099***	0.047*	0.058**	−0.061**	0.023
	(0.024)	(0.026)	(0.025)	(0.025)	(0.035)
MPI Levy/Tax on fin	0.089***	−0.013	−0.017	0.012	0.107***
	(0.014)	(0.015)	(0.014)	(0.012)	(0.017)
MPI Limits on Credit Gr&Vol	−0.133***	−0.005	−0.024	0.110**	0.181**
	(0.048)	(0.058)	(0.059)	(0.044)	(0.080)
MPI Liquidity & lim on mismatch	0.070***	0.120***	−0.164***	−0.099***	−0.232***
	(0.018)	(0.017)	(0.014)	(0.015)	(0.026)

Table 5 (continued)

	Immediate	Medium-term			
	1	2	3	4	5
MPI Loan-loss provisioning	−0.039	−0.048	−0.124**	0.036	−0.101
	(0.062)	(0.055)	(0.053)	(0.060)	(0.099)
#Observations	21,017	21,017	21,017	18,044	15,314
#Banks	2,997	2,997	2,997	2,888	2,707

*,** and *** denote significance at 10%, 5% and 1% levels, respectively

ferent messages about the level of risk. Loan ratios describe the overall level of credit risk associated with nonfinancial borrowers. A higher level of loans is usually associated with higher credit risk, even assuming loan portfolio diversification. Conversely, a lower level of loan ratios usually means relatively lower credit risk. Changes in the level of LLP and NPL also inform the modification of the risk level; however, the interpretation of their levels should consider their procyclicality, and the related concept of inappropriate risk measurement and inadequate response to risk. This is discussed next.

In Table 9, we refer to bank-level credit risk, focusing on the effects of changes in instruments in banks that differ in the size of credit portfolios (Panel A of Table 9) and LLPs (Panel B). Beginning with the immediate impact on the NIM level, banks with larger loan portfolios experience decreased NIMs due to changes in lending standards restrictions, and increased NIM with changes in liquidity standards more than in the full sample (see Table 5) and low-risk banks (column 1 in Panel A of Table 8). NIMs of low loan banks are more affected by changes in levies and taxes, and loan loss provisioning standards in high loans banks, with positive effects found for taxes and a strong negative impact noted for provisioning rules. On the medium-term effect of policy changes on NIM levels, higher credit risk is associated with decreased (increased) NIM during a tightening (loosening) of lending standards restrictions and liquidity requirements (compare columns 2, 3, 7, and 8, and 12 and 13 of Panel A). High-risk banks also exhibit greater reductions in NIM variations (ΔNIM_{t+1} and ΔNIM_{t+2}) due to changes in levies/taxes and liquidity requirements (compare columns 4 and 5, and 14 and 15 in Panel A). Interestingly, high- and low-risk banks tended to decrease NIM more than did medium-risk banks because of changes in liquidity standards. The low-risk bank experience increased NIM due to a change in credit growth limits more than the high-risk banks and banks on average in the full sample (refer to Table 5). Restrictive loan loss provisioning standards are associated with enhanced NIM in high-risk banks.

The LLPs used here to analyze the impact of the MPI on net interest margins express the amount of the net cost of credit risk in period t (recorded in the profit and loss accounts) divided by loans in period t-1. Research shows that LLPs are procyclical, increasing during economic downturns and decreasing during favorable macroeconomic conditions (Huizinga and Laeven 2019; Olszak et al. 2017). Procyclicality in banks and LLPs is rooted in information asymmetries between borrowers and lenders, and inappropriate responses by financial market participants to changes in risk over time (Borio et al. 2001). These inappropriate responses are caused by risk measurement errors and socially suboptimal reactions of market participants to risk that is correctly assessed. In effect, risk is underestimated in booms and overestimated in recessions. In a boom, this contributes to excessively rapid credit growth, artificially low lending spreads (and depressed net interest margins to banks holding relatively little capital buffers), very tiny loans, loss provisions and improved quality of loan

Table 6 Effects of changes in macroprudential policy on NIM, IIEA and IEEA - the role of capital ratio. These are the robust fixed effect (FE) estimations of eq. 1 with bank clustered standard errors and bank fixed effects. We include full set of control variables and analyze diagnostic test as in Table 4, but not report them to save space. This is the presentation of tests of hypotheses H1 and H2. High CAP banks is a dummy=1; for up to 30% of banks with highest capital ratio; medium CAP banks is a dummy=1, for 40% of banks with capital ratio over 30% and below 70%; low CAP banks is a dummy=1; for 30% of banks with lowest capital ratio. Full variables definitions in Table 1. NIM - Net interest margin ratio; IIEA - Interest income to earning assets; IEEA – Interest expense to earning assets; robust standard errors in brackets; MPI - Index measuring overall stance of macroprudential policy; # denotes the number of

	High CAP banks					Medium CAP banks					Low CAP banks				
	Immediate	Medium-term				Immediate	Medium-term				Immediate	Medium-term			
	PANEL A: Net interest margin														
	NIM	NIM_{t+1}	NIM_{t+2}	ΔNIM_{t+1}	ΔNIM_{t+2}	NIM	NIM_{t+1}	NIM_{t+2}	ΔNIM_{t+1}	ΔNIM_{t+2}	NIM	NIM_{t+1}	NIM_{t+2}	ΔNIM_{t+1}	ΔNIM_{t+2}
$MPI_{(t)}$	−0.028			−0.088***	−0.164***	−0.029**			−0.085***	−0.055***	0.003			−0.070***	−0.067***
	(0.018)			(0.024)	(0.03)	(0.014)			(0.014)	(0.019)	(0.016)			(0.015)	(0.017)
$MPI_{(t-1)}$		−0.014			−0.037**					−0.025					
		(0.02)					(0.015)					(0.016)			
$MPI_{(t-2)}$			−0.044**					0.014					−0.046***		
			(0.022)					(0.015)					(0.015)		
#Observations	5,806	5,806	5,806	4,956	4,193	8,968	8,968	8,968	7,623	6,372	7,360	7,360	7,360	6,751	6,094
#Banks	1,368	1,368	1,368	1,245	1,110	2,197	2,197	2,197	2,032	1,819	1,662	1,662	1,662	1,612	1,546
	PANEL B: Interest income to earning assets														
IIEA	$IIEA_{t+1}$	$IIEA_{t+2}$	$\Delta IIEA_{t+1}$	$\Delta IIEA_{t+2}$	IIEA	IIEA	$IIEA_{t+1}$	$IIEA_{t+2}$	$\Delta IIEA_{t+1}$	$\Delta IIEA_{t+2}$	IIEA	$IIEA_{t+1}$	$IIEA_{t+2}$	$\Delta IIEA_{t+1}$	$\Delta IIEA_{t+2}$
$MPI_{(t)}$	0.034			−0.092***	−0.058	0.037*			−0.126***	−0.115***	0.116***			−0.102***	−0.158***
	(0.023)			(0.028)	(0.045)	(0.020)			(0.016)	(0.029)	(0.023)			(0.026)	(0.041)
$MPI_{(t-1)}$		−0.047**					−0.024					0.045*			
		(0.023)					(0.017)					(0.023)			
$MPI_{(t-2)}$			−0.102***					−0.059***					−0.197***		
			(0.024)					(0.019)					(0.033)		
Observations	5,613	5,613	5,613	4,716	3,928	8,629	8,629	8,629	7,252	5,984	6,819	6,819	6,819	6,127	5,451
#Banks	1,343	1,343	1,343	1,217	1,077	2,155	2,155	2,155	1,994	1,782	1,596	1,596	1,596	1,542	1,466
	PANEL C: Interest expense to earning assets														
IEEA	$IEEA_{t+1}$	$IEEA_{t+2}$	$\Delta IEEA_{t+1}$	$\Delta IEEA_{t+2}$	IEEA	IEEA	$IEEA_{t+1}$	$IEEA_{t+2}$	$\Delta IEEA_{t+1}$	$\Delta IEEA_{t+2}$	IEEA	$IEEA_{t+1}$	$IEEA_{t+2}$	$\Delta IEEA_{t+1}$	$\Delta IEEA_{t+2}$
$MPI_{(t)}$	0.069***			−0.022	0.054	0.077***			−0.047***	−0.070***	0.105***			−0.043**	−0.116***
	(0.019)			(0.022)	(0.034)	(0.017)			(0.016)	(0.024)	(0.021)			(0.019)	(0.034)
$MPI_{(t-1)}$		−0.023					0.020					0.071***			
		(0.021)					(0.016)					(0.018)			
$MPI_{(t-2)}$			−0.047**					−0.064***					−0.154***		

Table 6 (continued)

	High CAP banks					Medium CAP banks					Low CAP banks				
	Immediate	Medium-term				Immediate	Medium-term				Immediate	Medium-term			
			(0.019)					(0.015)					(0.028)		
Observations	5,598	5,598	5,598	4,703	3,918	8,618	8,618	8,618	7,240	5,968	6,801	6,801	6,801	6,101	5,428
#Banks	1,338	1,338	1,338	1,216	1,075	2,152	2,152	2,152	1,989	1,771	1,597	1,597	1,597	1,539	1,465

*,** and *** denote significance at 10%, 5% and 1% levels, respectively

Table 7 Effects of changes in macroprudential instruments on NIM and capital ratio. These are the robust fixed effect (FE) estimations of eq. 2 with bank clustered standard errors with bank fixed effects, testing the hypotheses H2, H3 and H3.1-5, regarding the impact of the change in macroprudential policy instrument types. This is also the presentation of tests of H4.We include full of control variables and analyze diagnostic test as in Table 3, but not report them to save space. High CAP banks is a dummy = 1; for 30% of banks with highest capital ratio; medium CAP banks is a dummy = 1, for 40% of banks with capital ratio over 30% and below 70%; low CAP banks30 is a dummy = 1; for 30% of banks with lowest capital ratio. Full variables definitions in Table 1. NIM - Net interest margin ratio; MPI measuring stance of lending standards restrictions; MPI Levy/Tax on fin - MPI measuring stance of levy/Tax on financial institutions; MPI Limits on credit Gr&Vol - MPI measuring stance of Limits on credit growth and volume; MPI liquidity & Lim on mismatch - MPI measuring stance of liquidity requirements and Limits on currency mismatches; MPI Loan-loss provisioning - MPI measuring stance of loan-loss provisioning standards; robust standard errors in brackets; # denotes the number of

	High CAP banks					Medium CAP banks					Low CAP banks				
	NIM	NIM_{t+1}	NIM_{t+2}	ΔNIM_{t+1}	ΔNIM_{t+2}	NIM	NIM_{t+1}	NIM_{t+2}	ΔNIM_{t+1}	ΔNIM_{t+2}	NIM	NIM_{t+1}	NIM_{t+2}	ΔNIM_{t+1}	ΔNIM_{t+2}
	Immediate	Medium-term				Immediate	Medium-term				Immediate	Medium-term			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
MPI Lend stand restrict	−0.060*	−0.057	−0.011	−0.009	−0.041	−0.107***	−0.056	−0.012	−0.028	0.043	−0.041	0.001	0.024	0.061	0.074
	(0.035)	(0.040)	(0.045)	(0.044)	(0.057)	(0.035)	(0.041)	(0.046)	(0.037)	(0.048)	(0.034)	(0.042)	(0.042)	(0.040)	(0.060)
MPI Levy/Tax on fin	0.018	0.015	0.101***	−0.060**	−0.017	0.012	−0.023	0.092***	−0.079***	−0.011	0.050***	−0.004	0.008	−0.089***	−0.079***
	(0.025)	(0.032)	(0.028)	(0.027)	(0.030)	(0.018)	(0.016)	(0.015)	(0.015)	(0.020)	(0.015)	(0.018)	(0.019)	(0.017)	(0.023)
MPILimits on Credit Gr&Vol	0.037	0.298*	0.322***	0.253	0.492**	−0.096	0.120	0.172**	0.244***	0.421***	−0.054	0.148**	0.107	0.196***	0.001
	(0.132)	(0.152)	(0.114)	(0.178)	(0.238)	(0.149)	(0.094)	(0.072)	(0.076)	(0.137)	(0.071)	(0.071)	(0.097)	(0.074)	(0.132)
MPI Liquidity & lim on mismatch	0.013	−0.123***	−0.211***	−0.132***	−0.361***	0.035	−0.143***	−0.106***	−0.137***	−0.264***	0.004	−0.165***	−0.092***	−0.082***	−0.193***
	(0.032)	(0.031)	(0.029)	(0.027)	(0.049)	(0.031)	(0.024)	(0.026)	(0.022)	(0.037)	(0.027)	(0.021)	(0.018)	(0.024)	(0.034)
MPI Loan-loss provisioning	−0.258**	0.053	0.024	0.391*	0.310	−0.130	−0.091	0.009	0.271**	0.254	0.018	0.034	−0.000	0.055	0.084
	(0.122)	(0.179)	(0.123)	(0.223)	(0.235)	(0.153)	(0.125)	(0.112)	(0.130)	(0.182)	(0.062)	(0.048)	(0.046)	(0.068)	(0.068)
#Observations	5,806	5,806	5,806	4,956	4,193	8,968	8,968	8,968	7,623	6,372	7,360	7,360	7,360	6,751	6,094
#Banks	1,368	1,368	1,368	1,245	1,110	2,197	2,197	2,197	2,032	1,819	1,662	1,662	1,662	1,612	1,546

*;** and *** denote significance at 10%, 5% and 1% levels, respectively

portfolios (denoted by low NPL). In recessionary periods, credit risk is assessed to be high, but the reverse tends to be the case (Borio et al. 2001, p. 1). Therefore, a decline in LLPs in boom periods denotes, in fact, a build-up in risk and contributes to excessive risk-taking, which will be materialized with magnified amounts of bad loans (heightened LLPs and NPLs) in recessions. With this background in mind, we look at our results regarding the role of LLPs (panel B, Table 9) and NPLs (Table 10) on the effects of macroprudential policy instrument changes on NIMs. Risk build-up and excessive risk taking (medium LLPs and low LLPs) are associated with magnified reductions in NIM in the medium term due to the tightening of liquidity standards. The opposite effect but also enhanced in comparison with the full sample results, is due to a change in limits on credit growth and volume. Regarding changes in lending standards restrictions, levies and taxes and loan-loss provisioning, we do not find any material difference between the risk build-up and risk materialization subsamples or in comparison to the full sample results. For the immediate effects, our results indicate magnified reductions in NIMs due to changes in *MPI loan-loss provisioning* in high-LLP banks (risk materialization) as well as due to changes in *MPI limits on credit GR&Vo*l in medium LLPs banks (risk build-up and excessive risk taking).

In Table 10, we report the analysis of the role of a country's NPLs. Our results regarding the NPL support our findings regarding the procyclical patterns in bank risk taking. Generally, we find that in the medium term, changes in liquidity standards and limits on credit growth and volume have a stronger effect on NIM in risk-build-up and excessive risk-taking subsamples (medium and low-NPL) (see columns 7–8 and 12–15) than in the full sample results (Table 5) and in the risk materialization sample (high-NPL, columns 2–5). The risk build-up samples denote different patterns of medium-term reactions of the NIM due to changes in lending standard restrictions and loan loss provisioning standards, such that the full sample results. We find that *MPI lending stand restrictions* are associated with statistically significant increased variations in NIM in the medium-NPL subsample and heightened NIM levels in the low-NPL subsample.

In conclusion, our analysis demonstrates that the influence of macroprudential policy instrument types on NIM is intricately tied to the credit risk level of a bank, especially when medium-term impacts are considered. Notably, LLPs and NPLs also play a substantial role, primarily by affecting NIM through the procyclicality channel and related concepts of biased risk measurement and a suboptimal response to risk by banks in economic upturns and downturns. However, this influence varies across specific instrument types. Therefore, our results substantiate hypothesis H4, emphasizing that the nuanced effects of macroprudential policy instrument types on the NIM are contingent upon the capital ratio, lending risk and associated procyclical costs of credit risk.

5.2 Robustness Checks

To ensure the robustness of our main findings, we subject them to scrutiny in various ways: the role of the interest rate environment (high- and low-rate environments), the role of the GFC (before the GFC, and during and after the GFC), the effects in the EURO area countries, including additional variables, including alternative estimation techniques, and altering sample composition.

In the study period, banking sectors worldwide experienced prolonged periods of ultimately low interest rates. These rates can affect bank profitability, risk taking (Andries et al. 2015; Bikker and Vervliet 2018; Borio et al. 2017; Campmas 2020; Claessens et al. 2018; Genay and Podjasek

Table 8 Effects of changes in macroprudential instruments on net interest margin components (IIEA and IEEA) and capital ratio. These are the robust fixed effect (FE) estimations of Eq. (1) with bank clustered standard errors and bank fixed effects. This is the presentation of tests of hypotheses H3, H3.1-5, and H4. High CAP banks is a dummy = 1; for 30% of banks with highest capital ratio; medium CAP banks is a dummy = 1, for 40% of banks with capital ratio over 30% and below 70%; low CAP banks30 is a dummy = 1; for 30% of banks with lowest capital ratio. Full variables definitions in Table 1. IIEA - Interest income to earning assets; IEEA – Interest expense to earning assets; MPI measuring stance of lending standards restrictions; MPI Levy/Tax on fin - MPI measuring stance of levy/Tax on financial institutions; MPI Limits on credit Gr&Vol - MPI measuring stance of Limits on credit growth and volume; MPI liquidity & Lim on mismatch - MPI measuring stance of liquidity requirements and Limits on currency mismatches; MPI Loan-loss provisioning - MPI measuring stance of loan-loss provisioning standards; robust standard errors in brackets; # denotes the number of

	High CAP banks					Medium CAP banks					Low CAP banks				
	Immediate	Medium-term				Immediate	Medium-term				Immediate	Medium-term			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	PANEL A: Interest income to earning assets														
	IIEA	$IIEA_{t+1}$	$IIEA_{t+2}$	$\Delta IIEA_{t+1}$	$\Delta IIEA_{t+2}$	IIEA	$IIEA_{t+1}$	$IIEA_{t+2}$	$\Delta IIEA_{t+1}$	$\Delta IIEA_{t+2}$	IIEA	$IIEA_{t+1}$	$IIEA_{t+2}$	$\Delta IIEA_{t+1}$	$\Delta IIEA_{t+2}$
MPI Lend stand restrict	0.004	−0.044	−0.024	−0.130***	−0.042	−0.104***	−0.055	−0.035	−0.108***	0.045	0.065	0.053	0.007	0.094	0.076
	(0.034)	(0.028)	(0.045)	(0.047)	(0.061)	(0.036)	(0.045)	(0.046)	(0.041)	(0.064)	(0.059)	(0.058)	(0.065)	(0.068)	(0.097)
MPI Levy/Tax on fin	0.115***	−0.065***	0.111***	−0.072**	0.166***	0.104***	−0.002	0.094***	−0.069***	0.065***	0.125***	−0.047*	−0.003	−0.101***	−0.019
	(0.033)	(0.025)	(0.029)	(0.029)	(0.051)	(0.022)	(0.023)	(0.017)	(0.019)	(0.023)	(0.018)	(0.025)	(0.031)	(0.019)	(0.027)
MPI Limits on Credit Gr&Vol	−0.328**	0.214	0.083	0.638***	0.841***	−0.210**	0.052	0.173**	0.218**	0.395***	−0.171**	0.250***	0.195	0.356***	0.369**
	(0.148)	(0.191)	(0.127)	(0.216)	(0.213)	(0.104)	(0.088)	(0.080)	(0.094)	(0.137)	(0.084)	(0.093)	(0.129)	(0.106)	(0.172)
MPI Liquidity & lim on mismatch	0.053	−0.039	−0.258***	−0.122***	−0.336***	0.114***	−0.060**	−0.262***	−0.179***	−0.457***	0.111***	−0.002	−0.369***	−0.218***	−0.595***
	(0.034)	(0.032)	(0.033)	(0.030)	(0.053)	(0.034)	(0.023)	(0.026)	(0.031)	(0.050)	(0.035)	(0.027)	(0.027)	(0.035)	(0.055)
MPI Loan-loss provisioning	−0.037	−0.189	−0.010	0.155	−0.071	0.109	−0.155	−0.148	−0.133	−0.541***	−0.176**	0.136*	−0.054	0.286***	0.329**
	(0.163)	(0.198)	(0.099)	(0.160)	(0.248)	(0.110)	(0.146)	(0.109)	(0.170)	(0.191)	(0.088)	(0.073)	(0.078)	(0.106)	(0.130)
#Observations	5,613	5,613	5,613	4,716	3,928	8,629	8,629	8,629	7,252	5,984	6,819	6,819	6,819	6,127	5,451
#Banks	1,343	1,343	1,343	1,217	1,077	2,155	2,155	2,155	1,994	1,782	1,596	1,596	1,596	1,542	1,466
	PANEL B: Interest expense to earning assets														
	IEEA	$IEEA_{t+1}$	$IEEA_{t+2}$	$\Delta IEEA_{t+1}$	$\Delta IEEA_{t+2}$	IEEA	$IEEA_{t+1}$	$IEEA_{t+2}$	$\Delta IEEA_{t+1}$	$\Delta IEEA_{t+2}$	IEEA	$IEEA_{t+1}$	$IEEA_{t+2}$	$\Delta IEEA_{t+1}$	$\Delta IEEA_{t+2}$
MPI Lend stand restrict	0.067**	0.013	−0.030	−0.125**	0.008	0.010	−0.008	0.053	−0.074**	0.021	0.133**	0.052	0.005	−0.007	−0.026
	(0.029)	(0.039)	(0.038)	(0.060)	(0.068)	(0.032)	(0.041)	(0.040)	(0.034)	(0.055)	(0.053)	(0.062)	(0.061)	(0.047)	(0.078)
MPI Levy/Tax on fin	0.091***	−0.065**	0.036	−0.001	0.184***	0.087***	0.021	0.006	0.014	0.077***	0.082***	−0.028	−0.015	−0.014	0.032

Table 8 (continued)

	High CAP banks					Medium CAP banks					Low CAP banks				
	Immediate	Medium-term				Immediate	Medium-term				Immediate	Medium-term			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	(0.035)	(0.028)	(0.028)	(0.032)	(0.049)	(0.021)	(0.022)	(0.016)	(0.021)	(0.026)	(0.018)	(0.025)	(0.030)	(0.019)	(0.024)
MPI Limits on Credit Gr&Vol	−0.214*	−0.073	−0.188**	0.333***	0.186	−0.262***	−0.178**	−0.043	0.056	0.115	−0.112*	0.116	0.023	0.179**	0.304***
	(0.118)	(0.093)	(0.093)	(0.111)	(0.186)	(0.099)	(0.072)	(0.073)	(0.081)	(0.129)	(0.064)	(0.096)	(0.110)	(0.076)	(0.109)
MPI Liquidity & lim on mismatch	0.051*	0.101***	−0.051**	−0.050**	−0.038	0.123***	0.104***	−0.157***	−0.105***	−0.243***	0.092***	0.154***	−0.269***	−0.162***	−0.403***
	(0.028)	(0.029)	(0.026)	(0.023)	(0.051)	(0.029)	(0.025)	(0.023)	(0.023)	(0.040)	(0.030)	(0.023)	(0.024)	(0.028)	(0.040)
MPI Loan-loss provisioning	0.082	−0.240*	−0.042	−0.081	−0.248	0.121	0.077	−0.243***	−0.319**	−0.544***	−0.206***	0.037	−0.045	0.243***	0.246**
	(0.121)	(0.133)	(0.130)	(0.171)	(0.334)	(0.109)	(0.153)	(0.091)	(0.135)	(0.181)	(0.079)	(0.057)	(0.069)	(0.067)	(0.110)
#Observations	5,598	5,598	5,598	4,703	3,918	8,618	8,618	8,618	7,240	5,968	6,801	6,801	6,801	6,101	5,428
#Banks	1,338	1,338	1,338	1,216	1,075	2,152	2,152	2,152	1,989	1,771	1,597	1,597	1,597	1,539	1,465

*;** and *** denote significance at 10%, 5% and 1% levels, respectively

Table 9 Effects of changes in macroprudential instruments on NIM and credit risk. These are the robust fixed effect (FE) estimations of Eq. (2) with bank clustered standard errors and bank fixed effects. This is the presentation of tests of hypotheses H3, H3.1-5, and H4. High loans banks is a dummy=1 for 30% of banks with highest loans to assets ratio; medium loans banks is a dummy=1 for 40% of banks with loans to assets ratio over 30% and below 70%; low loans banks is a dummy=1 for 30% of banks with lowest loans to assets ratio. High LLP is a dummy=1 for 30% of banks with highest LLP ratio; medium LLP is a dummy=1 for 40% of banks with LLP ratio over 30% and below 70%; low LLP is a dummy=1 for 30% of banks with lowest LLP ratio. Full variables definitions in Table 1. NIM - Net interest margin ratio; MPI measuring stance of lending standards restrictions; MPI Levy/Tax on fin - MPI measuring stance of levy/Tax on financial institutions; MPI Limits on credit Gr&Vol - MPI measuring stance of Limits on credit growth and volume; MPI liquidity & Lim on mismatch - MPI measuring stance of liquidity requirements and Limits on currency mismatches; MPI Loan-loss provisioning - MPI measuring stance of loan-loss provisioning standards; robust standard errors in brackets; # denotes the number of

	Credit risk −30% of highest ratios					Credit risk– 30%>ratios>70%					Credit risk– 30% with lowest ratios				
	NIM	NIM_{t+1}	NIM_{t+2}	ΔNIM_{t+1}	ΔNIM_{t+2}	NIM	NIM_{t+1}	NIM_{t+2}	ΔNIM_{t+1}	ΔNIM_{t+2}	NIM	NIM_{t+1}	NIM_{t+2}	ΔNIM_{t+1}	ΔNIM_{t+2}
	Immediate	Medium-term				Immediate	Medium-term				Immediate	Medium-term			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	High loans banks – High risk					**Medium loans banks - medium risk**					**Low loans banks – low risk**				
MPI Lend stand restrict	−0.108***	−0.117**	−0.059	0.035	0.103**	−0.102***	−0.067*	−0.022	−0.019	0.024	−0.050	0.046	−0.056	0.009	−0.033
	(0.040)	(0.047)	(0.051)	(0.029)	(0.043)	(0.030)	(0.034)	(0.039)	(0.041)	(0.054)	(0.045)	(0.040)	(0.037)	(0.036)	(0.055)
MPI Levy/Tax on fins	0.032	−0.005	0.038**	−0.094***	−0.086***	0.036***	−0.009	0.077***	−0.062***	−0.006	0.042**	0.012	0.081***	−0.055***	−0.050*
	(0.023)	(0.020)	(0.019)	(0.022)	(0.026)	(0.013)	(0.016)	(0.015)	(0.014)	(0.016)	(0.019)	(0.021)	(0.023)	(0.019)	(0.027)
MPI Limits on Credit Gr&Vol	−0.106	0.034	0.336*	0.137*	0.159	−0.119	0.238***	0.227***	0.176***	0.267**	0.127	0.400***	0.240*	0.286***	0.284
	(0.131)	(0.111)	(0.184)	(0.081)	(0.116)	(0.079)	(0.074)	(0.086)	(0.065)	(0.108)	(0.115)	(0.104)	(0.124)	(0.092)	(0.179)
MPI Liquidity & lim on mismatch	0.046*	−0.119***	−0.160***	−0.140***	−0.278***	0.011	−0.192***	−0.095***	−0.088***	−0.185***	−0.019	−0.170***	−0.119***	−0.103***	−0.270***
	(0.027)	(0.025)	(0.022)	(0.023)	(0.030)	(0.020)	(0.018)	(0.019)	(0.018)	(0.028)	(0.032)	(0.032)	(0.029)	(0.030)	(0.049)
MPI Loan-loss provisioning	−0.057	0.156	0.227***	0.214***	0.387***	−0.079	−0.093	−0.044	0.014	0.096	−0.247**	−0.094	−0.054	0.201	−0.014
	(0.056)	(0.114)	(0.073)	(0.077)	(0.093)	(0.100)	(0.062)	(0.060)	(0.085)	(0.094)	(0.111)	(0.097)	(0.082)	(0.152)	(0.168)
#Observations	6,559	6,559	6,559	5,803	5,088	9,498	9,498	9,498	8,232	7,010	6,077	6,077	6,077	5,295	4,561
#Banks	1,312	1,312	1,312	1,205	1,118	2,049	2,049	2,049	1,948	1,795	1,381	1,381	1,381	1,304	1,194
	High LLP– risk materialization					**Medium LLP - risk build up and excessive risk taking**					**Low LLP– risk build up and excessive risk taking**				
MPI Lend stand restrict	−0.052	−0.083*	0.055	−0.050	−0.076*	−0.061	0.058	0.010	−0.022	0.097	−0.090***	0.005	−0.038	0.061**	0.036
	(0.032)	(0.049)	(0.057)	(0.042)	(0.046)	(0.044)	(0.038)	(0.046)	(0.037)	(0.068)	(0.031)	(0.036)	(0.033)	(0.029)	(0.040)
MPI Levy/Tax on fins	0.028	−0.014	0.058	−0.081***	−0.054	0.046***	−0.021	0.077***	−0.088***	−0.024	0.041*	−0.014	0.066***	−0.050*	−0.014

Table 9 (continued)

	Credit risk − 30% of highest ratios					Credit risk– 30%>ratios > 70%					Credit risk– 30% with lowest ratios				
	NIM	NIM_{t+1}	NIM_{t+2}	ΔNIM_{t+1}	ΔNIM_{t+2}	NIM	NIM_{t+1}	NIM_{t+2}	ΔNIM_{t+1}	ΔNIM_{t+2}	NIM	NIM_{t+1}	NIM_{t+2}	ΔNIM_{t+1}	ΔNIM_{t+2}
	Immediate	Medium-term				Immediate	Medium-term				Immediate	Medium-term			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	(0.029)	(0.044)	(0.044)	(0.031)	(0.041)	(0.014)	(0.015)	(0.016)	(0.014)	(0.019)	(0.022)	(0.017)	(0.012)	(0.026)	(0.027)
MPI Limits on Credit Gr&Vol	−0.125	0.107	0.093	0.138**	0.218**	−0.355***	0.289**	0.429***	0.285**	0.321*	−0.010	0.081	0.193**	0.415***	0.281*
	(0.115)	(0.074)	(0.084)	(0.069)	(0.109)	(0.116)	(0.131)	(0.118)	(0.112)	(0.184)	(0.097)	(0.205)	(0.078)	(0.138)	(0.165)
MPI Liquidity & lim on mismatch	−0.002	−0.167***	−0.040	−0.029	−0.117**	0.034**	−0.176***	−0.143***	−0.136***	−0.316***	0.026	−0.105***	−0.096***	−0.148***	−0.273***
	(0.045)	(0.039)	(0.035)	(0.037)	(0.056)	(0.017)	(0.018)	(0.016)	(0.014)	(0.022)	(0.025)	(0.028)	(0.024)	(0.025)	(0.037)
MPI Loan-loss provisioning	−0.181**	0.014	0.081	0.125	0.257**	0.041	−0.023	0.117	0.171	−0.089	0.056	0.018	−0.120	0.037	−0.073
	(0.077)	(0.094)	(0.056)	(0.078)	(0.109)	(0.108)	(0.090)	(0.075)	(0.110)	(0.155)	(0.089)	(0.089)	(0.075)	(0.069)	(0.096)
#Observations	5,728	5,728	5,728	5,073	4,473	9,123	9,123	9,123	8,307	7,602	7,283	7,283	7,283	5,950	4,584
#Banks	1,880	1,880	1,880	1,800	1,649	2,493	2,493	2,493	2,350	2,213	2,383	2,383	2,383	2,191	1,800

*;** and *** denote significance at 10%, 5% and 1% levels, respectively

Table 10 Effects of changes in macroprudential instruments on NIM and non-performing loans (country level credit risk). These are the robust fixed effect (FE) estimations of Eq. (2) with bank clustered standard errors and bank fixed effects. This is the presentation of tests of hypotheses H3, H3.1-5, and H4. High NPL is a dummy=1 for 30% of countries with highest NPL; medium NPL is a dummy=1 for 40% of countries with NPL over 30% and below 70%; low NPL is a dummy=1 for 30% of countries with lowest NPL. Full variables definitions in Table 1. NIM - Net interest margin ratio; MPI measuring stance of lending standards restrictions; MPI Levy/Tax on fin - MPI measuring stance of levy/tax on financial institutions; MPI Limits on credit Gr&Vol - MPI measuring stance of Limits on credit growth and volume; MPI liquidity & Lim on mismatch - MPI measuring stance of liquidity requirements and Limits on currency mismatches; MPI Loan-loss provisioning - MPI measuring stance of loan-loss provisioning standards; robust standard errors in brackets; # denotes the number of

	High NPL - risk materialization					Medium NPL - risk build up and excessive risk taking					Low NPL - risk build up and excessive risk taking				
	NIM	NIM_{t+1}	NIM_{t+2}	ΔNIM_{t+1}	ΔNIM_{t+2}	NIM	NIM_{t+1}	NIM_{t+2}	ΔNIM_{t+1}	ΔNIM_{t+2}	NIM	NIM_{t+1}	NIM_{t+2}	ΔNIM_{t+1}	ΔNIM_{t+2}
	Immediate	Medium-term				Immediate	Medium-term				Immediate	Medium-term			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
MPI Lend stand restrict	−0.042	−0.086*	−0.018	0.007	−0.030	−0.109***	−0.040	−0.032	0.091**	0.104**	−0.043	0.064*	0.068*	0.017	0.026
	(0.033)	(0.050)	(0.049)	(0.056)	(0.064)	(0.037)	(0.034)	(0.034)	(0.041)	(0.049)	(0.031)	(0.033)	(0.037)	(0.040)	(0.059)
MPI Levy/Tax on fin	−0.020	−0.078	0.012	0.039	0.064	0.014	−0.047***	0.036**	−0.049***	−0.012	−0.005	0.063	0.085	0.177**	−0.029
	(0.082)	(0.080)	(0.077)	(0.070)	(0.116)	(0.012)	(0.013)	(0.017)	(0.012)	(0.013)	(0.081)	(0.071)	(0.088)	(0.086)	(0.089)
MPI Limits on Credit Gr&Vol	−0.001	−0.059	−0.035	0.121	−0.014	0.096	0.262***	0.138***	0.269***	0.309***	−0.386***	1.085***	0.971***	0.707***	0.874***
	(0.081)	(0.087)	(0.093)	(0.088)	(0.119)	(0.099)	(0.054)	(0.052)	(0.088)	(0.098)	(0.140)	(0.273)	(0.288)	(0.163)	(0.225)
MPI Liquidity & lim on mismatch	0.116***	0.104***	−0.091***	−0.031	−0.209***	0.006	−0.212***	0.042*	−0.389***	−0.426***	0.034	0.178***	−0.125***	−0.023	−0.264***
	(0.027)	(0.028)	(0.022)	(0.025)	(0.038)	(0.023)	(0.027)	(0.023)	(0.026)	(0.033)	(0.059)	(0.056)	(0.040)	(0.047)	(0.085)
MPI Loan-loss provisioning	−0.052	−0.091	0.163**	0.247**	0.240**	0.001	−0.018	−0.020	−0.033	0.031	0.049	0.330***	0.015	0.468***	0.068
	(0.098)	(0.105)	(0.070)	(0.104)	(0.098)	(0.055)	(0.063)	(0.072)	(0.082)	(0.077)	(0.115)	(0.084)	(0.067)	(0.152)	(0.265)
#Observations	7,302	7,302	7,302	6,541	5,809	11,378	11,378	11,378	10,007	8,616	3,454	3,454	3,454	2,782	2,234
#Banks	951	951	951	926	860	2,627	2,627	2,627	2,546	2,423	780	780	780	701	685

*;** and *** denote significance at 10%, 5% and 1% levels, respectively

2014; Lopez et al. 2020; López-Penabad et al. 2022), and lending (Jiménez et al. 2014). Generally, low rates only slightly affect NIM levels because reductions in interest income reduce funding costs (Lopez et al. 2020). However, Claessens et al. (2018) report that compared with a high-rate environment, a low-rate environment results in a greater reduction in NIM when short-term rates increase.[6] We find that NIMs are more affected by macroprudential policy changes in high-rate environments than in low-rate environments, with magnified reductions in NIM in the medium term (Panel A in Table 11. These reductions were due to deep declines in interest income (Panel B) accompanied by insufficiently depressed funding costs (Panel C). We also find that low rates are associated with immediate declines in NIM levels under macroprudential policy tightening, mostly resulting from an increased interest expense component of the NIM. In the medium term, NIM also tends to significantly decline only in the policy implementation year. Our results highlight that macroprudential policy is associated with an increase in NIM levels two years after the policy change (NIM(t+2) and the two-yearly variations in NIM (ΔNIM(t+2) under the low-rate environment. This is caused by an IIEA increase (column 8 in Panel B) and a highly depressed IEEA (column 10 in Panel C). On the effects of macroprudential instruments, NIM declines in the medium term are magnified under a high-rate environment when liquidity standards and taxes are changed (tightened). The effects of lending standard restrictions, and limits on credit growth and volume are muted in the high-rate subsample compared with the low-rate subsample and full sample results. Overall, the significant reductions in NIM found here cannot be exclusively attributed to low rates but rather to changes in macroprudential policy stances Table 12.

Our second check investigates whether the GFC matters for the effects of macroprudential policy. Generally, after the GFC and around this period, the use of macroprudential instruments intensified (Fig. 1), especially when tightening was more frequently implemented. Therefore, the effects of this policy may be enhanced in the post-GFC period. Indeed, as shown in Table 13, the effects of macroprudential policy change were stronger in the pre-GFC period for the NIM and its components. During and after the GFC, NIM, IIEA and IEEA also exhibited prominent declines. However, the effect was muted compared with the full sample results (Tables 3 and 4).

Next, we consider whether the effects of macroprudential change differ across EURO countries. This additional analysis indicates a magnified impact of a change in the macroprudential stance on NIM and its components (IIEA and IEEA) (see Table 14) compared with the full sample results (in Tables 3 and 4). An immediate effect of the macroprudential change is a slight NIM decrease. The overall effect is a decline in NIM, IIEA, and IEEA in the medium term. This finding further supports hypotheses H1 and H2. Additionally, we explore whether the effects of macroprudential policy differ in the EURO area depending on the high and low rates. This analysis provides results that are in line with the findings in Table 11, with effects magnified (muted) for high-rate (low-rate) environments.[7]

Next, we run three additional sensitivity tests that aim to confirm our findings regarding instrument types. In Panel A of Table 15, including time dummies does not undermine our results in Table 5. Panel B depicts the outcomes of a test which uses an alternate estimation method (robust random effects estimator) combined with the inclusion of commission and fees income (Nguyen 2012). This analysis does not undermine our main results, reaffirming the immediate and medium-

[6] Our analysis of full results in Tables 11 and 12 indicates that short term rate affects NIM levels more in low-rate than in high-rate environment. This similarity in the effects of short-term rates in our study and Claessens et al. (2018) implies that our empirical specification is adequate.

[7] These additional findings are not included here to save space. They can be accessed from the authors upon reasonable request.

Table 11 Sensitivity analysis – role of high and low rate for the overall effects of macroprudential changes on bank margins. These are the robust fixed effect (FE) estimations of Eq. (1) with bank clustered standard errors and bank fixed effects. This is the presentation of tests of hypotheses H1 and H2. Low rate is a dummy = 1 if ir_ref is at and below 1.13; high rate dummy = 1 if ir_ref above 1.13. Full variables definitions in Table 1. NIM - Net interest margin ratio; IIEA - interest income to earning assets; IEEA – interest expense to earning assets. MPI - Index measuring overall stance of macroprudential policy; standard errors in brackets; # denotes the number of

	High rate					Low rate				
	Immediate	Medium-term				Immediate	Medium-term			
	1	2	3	4	5	6	7	8	9	10
	PANEL A: Net interest margin									
	NIM	NIM_{t+1}	NIM_{t+2}	ΔNIM_{t+1}	ΔNIM_{t+2}	NIM	NIM_{t+1}	NIM_{t+2}	ΔNIM_{t+1}	ΔNIM_{t+2}
$MPI_{(t)}$	0.021			−0.186***	−0.311***	−0.064***			−0.045***	0.022**
	(0.023)			(0.027)	(0.035)	(0.009)			(0.009)	(0.011)
$MPI_{(t-1)}$		0.052					−0.069***			
		(0.044)					(0.009)			
$MPI_{(t-2)}$			−0.127***					0.056***		
			(0.034)					(0.007)		
#Observations	6,171	6,171	6,171	6,011	5,890	15,963	15,963	15,963	13,319	10,769
# Banks	1,422	1,422	1,422	1,405	1,378	2,877	2,877	2,877	2,777	2,616
	PANEL B: Interest income to earning assets									
	IIEA	$IIEA_{t+1}$	$IIEA_{t+2}$	$\Delta IIEA_{t+1}$	$\Delta IIEA_{t+2}$	$IIEA_{t+2}$	$IIEA_{t+1}$	$IIEA_{t+2}$	$\Delta IIEA_{t+1}$	$\Delta IIEA_{t+2}$
$MPI_{(t)}$	0.144***			−0.275***	−0.613***	−0.010			−0.084***	−0.067***
	(0.044)			(0.042)	(0.092)	(0.012)			(0.011)	(0.015)
$MPI_{(t-1)}$		0.233***					−0.053***			
		(0.052)					(0.013)			
$MPI_{(t-2)}$			−0.359***					0.064***		
			(0.048)					(0.011)		
#Observations	5,286	5,286	5,286	4,954	4,757	15,775	15,775	15,775	13,141	10,606
# Banks	1,359	1,359	1,359	1,330	1,294	2,827	2,827	2,827	2,730	2,567
	PANEL C: Interest expense to earning assets									
	IEEA	$IEEA_{t+1}$	$IEEA_{t+2}$	$\Delta IEEA_{t+1}$	$\Delta IEEA_{t+2}$	IEEA	$IEEA_{t+1}$	$IEEA_{t+2}$	$\Delta IEEA_{t+1}$	$\Delta IEEA_{t+2}$
$MPI_{(t)}$	0.123***			−0.108***	−0.345***	0.062***			−0.041***	−0.090***
	(0.036)			(0.036)	(0.068)	(0.011)			(0.010)	(0.013)

Table 11 (continued)

	High rate					Low rate				
	Immediate	Medium-term				Immediate	Medium-term			
	1	2	3	4	5	6	7	8	9	10
$MPI_{(t-1)}$		0.156***					0.017			
		(0.040)					(0.012)			
$MPI_{(t-2)}$			−0.259***					0.004		
			(0.034)					(0.009)		
#Observations	5,273	5,273	5,273	4,934	4,739	15,744	15,744	15,744	13,110	10,575
# Banks	1,360	1,360	1,360	1,327	1,294	2,822	2,822	2,822	2,727	2,557

*,** and *** denote significance at 10%, 5% and 1% levels, respectively

Table 12 Sensitivity analysis – the effects of macroprudential policy instruments on NIM in high- and low-rate environment. These are the robust fixed effect (FE) estimations of Eq. (2) with bank clustered standard errors and bank fixed effects. This is the presentation of tests of hypotheses H3, H3.1-5. Low rate is a dummy = 1 if ir_ref is at and below 1.13; high rate dummy = 1; if ir_ref above 1.13. Full variables definitions in Table 1. NIM - Net interest margin ratio MPI measuring stance of lending standards restrictions; MPI Levy/Tax on fin - MPI measuring stance of levy/Tax on financial institutions; MPI Limits on credit Gr&Vol - MPI measuring stance of Limits on credit growth and volume; MPI liquidity & Lim on mismatch - MPI measuring stance of liquidity requirements and Limits on currency mismatches; MPI Loan-loss provisioning - MPI measuring stance of loan-loss provisioning standards; robust standard errors in brackets; # denotes the number of

	High rate					Low rate				
	NIM	NIM_{t+1}	NIM_{t+2}	ΔNIM_{t+1}	ΔNIM_{t+2}	NIM	NIM_{t+1}	NIM_{t+2}	ΔNIM_{t+1}	ΔNIM_{t+2}
	Immediate	Medium-term				Immediate	Medium-term			
	1	2	3	4	5	6	7	8	9	10
MPI Lend stand restrict	−0.084	0.018	0.152***	−0.033	0.003	−0.073***	−0.090***	−0.084***	0.007	−0.007
	(0.065)	(0.060)	(0.057)	(0.063)	(0.081)	(0.016)	(0.018)	(0.023)	(0.020)	(0.030)
MPI Levy/Tax on fins	0.218	−0.099	−0.149	−0.135	−0.413*	−0.046***	−0.060***	0.097***	−0.080***	−0.005
	(0.142)	(0.206)	(0.181)	(0.181)	(0.237)	(0.009)	(0.010)	(0.009)	(0.011)	(0.012)
MPI Limits on Credit Gr&Vol	−0.083	0.229**	0.054	0.163*	0.013	−0.097	0.020	0.141**	0.153**	0.278**
	(0.102)	(0.094)	(0.116)	(0.090)	(0.141)	(0.084)	(0.083)	(0.063)	(0.064)	(0.109)
MPI Liquidity & lim on mismatch	0.040**	−0.047*	−0.233***	−0.125***	−0.319***	−0.033	−0.072**	−0.037*	−0.029	−0.032
	(0.018)	(0.024)	(0.019)	(0.016)	(0.023)	(0.037)	(0.034)	(0.020)	(0.034)	(0.056)
MPI Loan-loss provisioning	−0.112	−0.033	−0.044	0.090	−0.005	−0.135	0.063	0.050	0.068	0.259**
	(0.073)	(0.074)	(0.066)	(0.084)	(0.093)	(0.096)	(0.069)	(0.043)	(0.068)	(0.115)
#Observations	6,171	6,171	6,171	6,011	5,890	15,963	15,963	15,963	13,319	10,769
# Banks	1,422	1,422	1,422	1,405	1,378	2,877	2,877	2,877	2,777	2,616

*;** and *** denote significance at 10%, 5% and 1% levels, respectively

term effects of various instrument types on NIM levels. Finally, we assess the impact of limiting the sample size by excluding the largest banking sector—German banks—and examining the effects on instrument types. Panel C illustrates that this sample modification does not deviate from our main results regarding the effects of macroprudential policy instrument types on NIMs.

In summary, these sensitivity checks provide substantial support for the reliability and consistency of our main findings. The observed effects of macroprudential policy and instrument type on NIMs withstand variations in estimation techniques, the inclusion of additional variables, and alterations in sample composition, affirming the robustness of our empirical results.

6 Conclusion

We examine the intricate relationship between macroprudential policies and NIMs across 28 European Union countries from 1996 to 2019. Using an extensive dataset with over 22,000 observations from more than 3,000 commercial and cooperative banks, alongside pertinent control variables; our exploration addresses some key inquiries. We find a consistently negative effect of macroprudential policy on NIMs. Specifically, policy tightening leads to an immediate 2 bp reduction in NIM levels, signifying a 1.3% change from the mean. The pronounced medium-term effects further underscore the substantial effect, with one and two year changes reflecting 68% and 36% of the variations from the mean levels, respectively.

Further, the effect of macroprudential policy depends on the instrument type, with lending standard restrictions and loan-loss provisioning systems exerting strong immediate negative effects on NIMs with values of 9 and 10 bp, respectively. Other instrument types have a medium-term effect on NIMs, with liquidity requirements and limits on currency mismatches resulting in the strongest declines of 16 bp in the year after the change in this policy. Furthermore, the effect of these policy instruments varies by the capital ratio and credit risk.

Exploring the role of the level of capitalization on the links between macroprudential changes, and NIMs and their components (IIEA and IEEA) shows that poorly capitalized banks have to pay more for obtaining immediate access to deposits (in terms of increased IEEA) in the policy implementation year. In the medium term, NIMs are more affected by changes in limits on credit growth and liquidity standards in better capitalized banks. Facing changes in limits on credit growth and volume, poorly capitalized banks also have a lower increase in interest income and pay relatively more for deposits than well-capitalized banks.

Regarding loan portfolio size and the immediate policy effect, our results show a decline in NIMs due to lending standard restrictions and an increase in NIMs following changes in liquidity standards. In the medium term, higher credit risk is associated with decreased margins due to the restrictions in lending standards and the requirements for liquidity. Risk build-up and excessive risk-taking are associated with magnified reductions in the NIMs in the medium term due to the tightening of liquidity standards, with the opposite effect found for limits on credit growth and volume.

In summary, our results provide a deeper understanding of the multifaceted effects of macroprudential policies on NIMs. The differential effects of instrument types, coupled with modifications by the capital and credit risk levels of banks, underscore the complexity of the relationship. This study contributes valuable insights into the ongoing discourse on macroprudential policies by showing that NIMs are significantly affected by changes in macroprudential policy both immediately and in the medium term.

Table 13 Sensitivity analysis– the overall effects of macroprudential policy change on NIM, IIEA and IEEA before and after the GFC. These are the robust fixed effect (FE) estimations of Eq. (1) with bank clustered standard errors. This is the presentation of tests of hypotheses H1 and H2. Before GFC is a dummy = 1; in years before up to 2008; GFC and after is a dummy = 1 since 2009 onwards. Full variables definitions in Table 1. NIM - Net interest margin ratio; IIEA - Interest income to earning assets; IEEA– Interest expense to earning assets; robust standard errors in brackets; # denotes the number of

	Before GFC					During and after GFC				
	Immediate	Medium-term				Immediate	Medium-term			
	1	2	3	4	5	6	7	8	9	10
	PANEL A: Net interest margin									
	NIM	NIM_{t+1}	NIM_{t+2}	ΔNIM_{t+1}	ΔNIM_{t+2}	NIM	NIM_{t+1}	NIM_{t+2}	ΔNIM_{t+1}	ΔNIM_{t+2}
$MPI_{(t)}$	0.058**			−0.278***	−0.448***	−0.054***			−0.035***	0.035***
	(0.023)			(0.028)	(0.035)	(0.009)			(0.011)	(0.013)
$MPI_{(t-1)}$		−0.008					−0.052***			
		(0.043)					(0.011)			
$MPI_{(t-2)}$			−0.224***					0.050***		
			(0.034)					(0.008)		
#Observations	5,704	5,704	5,704	5,652	5,632	16,430	16,430	16,430	13,678	11,027
# Banks	1,332	1,332	1,332	1,320	1,318	2,978	2,978	2,978	2,874	2,696
	PANEL B: Interest income to earning assets									
	IIEA	$IIEA_{t+1}$	$IIEA_{t+2}$	$\Delta IIEA_{t+1}$	$\Delta IIEA_{t+2}$	IIEA	$IIEA_{t+1}$	$IIEA_{t+2}$	$\Delta IIEA_{t+1}$	$\Delta IIEA_{t+2}$
$MPI_{(t)}$	0.236***			−0.506***	−1.077***	−0.009			−0.064***	−0.013
	(0.040)			(0.056)	(0.103)	(0.013)			(0.012)	(0.020)
$MPI_{(t-1)}$		0.255***					−0.042***			
		(0.065)					(0.015)			
$MPI_{(t-2)}$			−0.520***					0.056***		
			(0.047)					(0.012)		
#Observations	4,848	4,848	4,848	4,624	4,529	16,213	16,213	16,213	13,471	10,834
# Banks	1,272	1,272	1,272	1,250	1,240	2,924	2,924	2,924	2,820	2,637
	PANEL C: Interest expense to earning assets									
	IEEA	$IEEA_{t+1}$	$IEEA_{t+2}$	$\Delta IEEA_{t+1}$	$\Delta IEEA_{t+2}$	IEEA	$IEEA_{t+1}$	$IEEA_{t+2}$	$\Delta IEEA_{t+1}$	$\Delta IEEA_{t+2}$
$MPI_{(t)}$	0.153***			−0.185***	−0.611***	0.053***			−0.033***	−0.054***
	(0.035)			(0.039)	(0.083)	(0.011)			(0.013)	(0.018)

Table 13 (continued)

	Before GFC					During and after GFC				
	Immediate	Medium-term				Immediate	Medium-term			
	1	2	3	4	5	6	7	8	9	10
$MPI_{(t-1)}$		0.187***					0.013			
		(0.052)					(0.012)			
$MPI_{(t-2)}$			−0.314***					−0.003		
			(0.037)					(0.010)		
#Observations	4,836	4,836	4,836	4,605	4,511	16,181	16,181	16,181	13,439	10,803
# Banks	1,273	1,273	1,273	1,247	1,240	2,920	2,920	2,920	2,817	2,627

*;** and *** denote significance at 10%, 5% and 1% levels, respectively

Table 14 Sensitivity analysis– role of EURO area countries. These are the robust fixed effect (FE) estimations of Eq. (1) with bank clustered standard errors and bank fixed effects. This is the presentation of tests of hypotheses H1 and H2 in the EURO area subsample. Full variables definitions in Table 1. NIM - Net interest margin ratio; IIEA - Interest income to earning assets; IEEA – Interest expense to earning assets. MPI - Index measuring overall stance of macroprudential policy; robust standard errors in brackets; # denotes the number of

	Net interest margin					Interest income to earning assets					Interest expense to earning assets				
	NIM	NIM_{t+1}	NIM_{t+2}	ΔNIM_{t+1}	ΔNIM_{t+2}	IIEA	$IIEA_{t+1}$	$IIEA_{t+2}$	$\Delta IIEA_{t+1}$	$\Delta IIEA_{t+2}$	IEEA	$IEEA_{t+1}$	$IEEA_{t+2}$	$\Delta IEEA_{t+1}$	$\Delta IEEA_{t+2}$
	Immediate	Medium-term				Immediate	Medium-term				Immediate	Medium-term			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
$MPI_{(t)}$	0.022***			−0.110***	−0.139***	0.130***			−0.140***	−0.199***	0.119***			−0.043***	−0.089***
	(0.008)			(0.010)	(0.013)	(0.013)			(0.015)	(0.025)	(0.013)			(0.012)	(0.021)
$MPI_{(t-1)}$		0.007					0.012					0.013			
		(0.011)					(0.013)					(0.011)			
$MPI_{(t-2)}$			0.006					−0.137***					−0.139***		
			(0.012)					(0.016)					(0.014)		
#Observations	19,387	19,387	19,387	16,882	14,486	18,759	18,759	18,759	16,093	13,644	18,715	18,715	18,715	16,041	13,593
# Banks	2,769	2,769	2,769	2,677	2,529	2,696	2,696	2,696	2,605	2,451	2,695	2,695	2,695	2,602	2,445

*,** and *** denote significance at 10%, 5% and 1% levels, respectively

Table 15 Sensitivity analysis– the effects of macroprudential policy instruments on NIM and the role of time dummies. These are the robust fixed effect (FE) (PANEL A)/random effects (RE) (PANEL B, PANEL C) estimations of Eq. (2) with bank clustered standard errors. This is the presentation of sensitivity tests of hypotheses H2, H3.1-5. Full variables definitions in Table 1. NIM - Net interest margin ratio. MPI measuring stance of lending standards restrictions; MPI Levy/Tax on fin - MPI measuring stance of levy/Tax on financial institutions; MPI Limits on credit Gr&Vol - MPI measuring stance of Limits on credit growth and volume; MPI liquidity & Lim on mismatch - MPI measuring stance of liquidity requirements and Limits on currency mismatches; MPI Loan-loss provisioning - MPI measuring stance of loan-loss provisioning standards; robust standard errors in brackets; # denotes the number of

	NIM	NIM(t+1)	NIM(t+2)	NIM(t+1)	ΔNIM(t+2)
	Immediate	Medium-term			
	1	2	3	4	5
	PANEL A: time fixed effects included				
MPI Lend stand restrict	−0.047**	−0.011	−0.000	0.008	−0.004
	(0.021)	(0.023)	(0.026)	(0.025)	(0.031)
MPI Levy/Tax on fin	0.052**	−0.062**	0.074***	−0.139***	0.020
	(0.022)	(0.024)	(0.025)	(0.022)	(0.024)
MPI Limits on Credit Gr&Vol	−0.047	0.190***	0.150**	0.133***	0.177**
	(0.073)	(0.060)	(0.066)	(0.051)	(0.088)
MPI Liquidity & lim on mismatch	−0.064**	−0.231***	−0.109***	−0.074***	−0.069**
	(0.025)	(0.025)	(0.020)	(0.023)	(0.034)
MPI Loan-loss provisioning	−0.101**	0.002	−0.020	0.116**	0.183***
	(0.049)	(0.052)	(0.036)	(0.056)	(0.063)
#Observations	22,134	22,134	22,134	19,330	16,659
# Banks	3,077	3,077	3,077	2,971	2,805
	PANEL B: commission and fees added and robust RE				
MPI Lend stand restrict	−0.141***	−0.091***	−0.050*	0.015	0.037
	(0.020)	(0.023)	(0.027)	(0.024)	(0.030)
MPI Levy/Tax on fin	0.009	0.007	0.116***	−0.053***	−0.030**
	(0.010)	(0.011)	(0.011)	(0.010)	(0.013)
MPI Limits on Credit Gr&Vol	−0.073	0.155**	0.188***	0.189***	0.283***
	(0.070)	(0.061)	(0.063)	(0.045)	(0.088)
MPI Liquidity & lim on mismatch	0.072***	−0.140***	−0.075***	−0.086***	−0.181***
	(0.017)	(0.015)	(0.012)	(0.012)	(0.019)
MPI Loan-loss provisioning	−0.048	0.022	0.041	0.072	0.152**
	(0.048)	(0.052)	(0.036)	(0.048)	(0.065)
#Observations	22,082	22,082	22,082	19,286	16,620
# Banks	3,072	3,072	3,072	2,967	2,804
	PANEL C: largest banking sector excluded and robust RE				
MPI Lend stand restrict	−0.116***	−0.078***	−0.031	−0.019	−0.009
	(0.021)	(0.023)	(0.027)	(0.024)	(0.029)
MPI Levy/Tax on fin	−0.006	0.030	0.048	0.039	−0.029
	(0.033)	(0.040)	(0.041)	(0.032)	(0.045)
MPI Limits on Credit Gr&Vol	−0.089	0.140**	0.196***	0.146***	0.238***
	(0.074)	(0.061)	(0.065)	(0.046)	(0.087)
MPI Liquidity & lim on mismatch	0.113***	0.047**	−0.146***	−0.096***	−0.217***
	(0.017)	(0.019)	(0.016)	(0.012)	(0.020)
MPI Loan-loss provisioning	−0.060	0.021	0.046	0.082*	0.165***
	(0.049)	(0.054)	(0.037)	(0.048)	(0.061)
#Observations	12,034	12,034	12,034	10,802	9,662
#Banks	1,388	1,388	1,388	1,332	1,257

*;** and *** denote significance at 10%, 5% and 1% levels, respectively

Appendix

Table 16. Correlation matrix. Variables definitions in Table 1. NIM - Net interest margin ratio; MPI - Index measuring overall stance of macroprudential policy CAP - Measure of capital adequacy counted as ratio of capital funds to total assets; LtD - Total loan to total deposit ratio; LLP - Loan loss provision; Loans- The loans-to-assets ratio; CIR(t-1) - Cost to income ratio; Size(t-1) - Natural logarithm of total assets of bank; NPL(t-1) - Ratio of nonperforming loans to total loans; ir_ref - Reference rate of central bank; unempl – Unemployment rate; GDPG – The real GDP growth rate; HHI - Herfindahl Hirschman index; MPI - Index measuring overall stance of macroprudential policy; MPI Lend stand restrict - MPI measuring stance of lending standards restrictions; MPI Levy/Tax on fin - MPI measuring stance of levy/Tax on financial institutions; MPI Limits on Credit Gr&Vol - MPI measuring stance of limits on credit growth and volume; MPI Liquidity & lim on mismatch - MPI measuring stance of liquidity requirements and limits on currency mismatches; MPI Loan-loss provisioning - MPI measuring stance of loan-loss provisioning standards

PANEL A: Correlation matrix of the main variables

	NIM	$DNIM_{t+1}$	$DNIM_{t+2}$	$CAP_{(t-1)}$	$LtD_{(t-1)}$	$LLP_{(t-1)}$	$Loans_{(t-1)}$	$CIR_{(t-1)}$	$Size_{(t-1)}$	$NPL_{(t-1)}$	ir_ref	unempl	GDPG	HHI
NIM	1													
$DNIM_{t+1}$	-0.298***	1												
$DNIM_{t+2}$	-0.387***	0.685***	1											
$CAP_{(t-1)}$	0.013**	-0.025***	-0.013*	1										
$LtD_{(t-1)}$	-0.077***	0.004	-0.011**	-0.156***	1									
$LLP_{(t-1)}$	0.254***	-0.042***	-0.063***	-0.017***	0.014***	1								
$Loans_{(t-1)}$	0.16***	-0.023***	-0.033***	-0.336***	0.346***	-0.12***	1							
$CIR_{(t-1)}$	0.007*	0.04***	0.047***	-0.032***	-0.17***	-0.112***	-0.087***	1						
$Size_{(t-1)}$	-0.352***	0.039***	0.069***	-0.22***	0.201***	-0.067***	0.017***	-0.206***	1					
$NPL_{(t-1)}$	0.132***	-0.018***	-0.039***	0.045***	0.069***	0.288***	-0.06***	0.011***	-0.053***	1				
ir_ref	0.274***	-0.035***	-0.083***	-0.009	0.027***	0.126***	-0.038***	-0.039***	-0.076***	0.01***	1			
unempl	0.13***	-0.039***	-0.067***	0.036***	0.04***	0.266***	-0.072***	-0.021***	-0.015***	0.553***	0.064***	1		
GDPG	0.038***	0.003	-0.006	0.014**	-0.05***	-0.006	-0.064***	-0.054***	-0.01***	0.011***	0.244***	-0.05***	1	
HHI	-0.021***	-0.011***	-0.021***	0.081***	0.03***	0.069***	-0.059***	-0.123***	0.109***	0.052***	-0.012***	0.07***	0.053***	1
MPI	-0.105***	0.006	0.003	-0.006	0.021***	0.039***	-0.009**	-0.045***	0.038***	-0.031***	-0.076***	-0.105***	0.071***	0.098***

PANEL B: Correlation matrix of instrument types

	MPI Lend stand restrict	MPI Levy/Tax on fin	MPI Limits on Credit Gr&Vol	MPI Liquidity & lim on mismatch	MPI loan-loss provisioning
MPI Lend stand restrict	1				
MPI Levy/Tax on fin	0.038***	1			
MPI Limits on Credit Gr&Vol	-0.004	0.019***	1		
MPI Liquidity & lim on mismatch	0.03***	0.013***	-0.014***	1	
MPI Loan-loss provisioning	-0.023***	-0.008***	0.052***	-0.034***	1

*,** and *** denote significance at 10%, 5% and 1% levels, respectively;

Table 17 Country level sample description– NIM, IIEA and IEEA. Variables definitions are in table 1; # denotes the number of

	#Banks	#Observation	NIM	ΔNIM_{t+1}	ΔNIM_{t+2}	IIEA	$\Delta IIEA_{t+1}$	$\Delta IIEA_{t+2}$	IEEA	$\Delta IEEA_{t+1}$	$\Delta IEEA_{t+2}$
Austria	115	493	1.67	−0.01	−0.04	2.12	−0.12	−0.25	0.59	−0.12	−0.25
Belgium	15	91	1.73	−0.06	−0.12	3.17	−0.21	−0.45	0.95	−0.10	−0.26
Bulgaria	18	142	4.14	−0.21	−0.53	5.06	−0.27	−0.57	0.93	−0.09	−0.15
Croatia	29	128	3.29	−0.03	−0.03	4.36	−0.34	−0.70	1.08	−0.29	−0.66
Cyprus	29	118	3.99	0.14	0.40	6.11	0.17	0.40	1.84	−0.01	−0.03
Czech Republic	20	166	2.70	−0.05	−0.10	3.18	−0.06	−0.15	0.75	−0.01	−0.05
Denmark	70	1005	3.57	−0.10	−0.21	3.70	−0.21	−0.37	0.26	−0.14	−0.23
Estonia	2	19	3.50	−0.50	−0.90	5.13	−0.65	−1.20	1.23	−0.10	−0.14
Finland	32	124	1.49	−0.08	−0.16	1.73	−0.07	−0.16	0.26	−0.03	−0.05
France	76	280	2.24	−0.07	−0.11	3.79	−0.14	−0.28	1.21	−0.08	−0.15
Germany	1689	10,100	2.28	−0.04	−0.10	2.99	−0.21	−0.41	0.68	−0.17	−0.31
Greece	8	81	2.80	0.01	0.08	3.74	−0.10	−0.15	1.14	−0.09	−0.19
Hungary	14	63	3.58	−0.10	−0.26	4.20	−0.39	−0.70	0.70	−0.14	−0.03
Ireland	2	15	1.62			1.77	−0.13	−0.31	0.56	−0.05	−0.11
Italy	525	6443	2.84	−0.10	−0.21	3.35	−0.12	−0.24	0.47	0.00	−0.01
Latvia	20	194	2.65	−0.20	−0.36	3.32	−0.24	−0.47	0.67	−0.04	−0.09
Lithuania	8	106	2.86	−0.15	−0.28	3.42	−0.13	−0.29	1.07	−0.07	−0.20
Luxemburg	27	104	1.02	0.00	0.06	1.94	−0.03	0.00	0.99	−0.03	−0.06
Malta	7	55	2.46	0.03	0.02	3.26	−0.03	−0.13	0.66	−0.09	−0.18
Netherlands	12	62	1.83	−0.14	−0.19	3.12	−0.03	0.06	1.34	−0.01	0.01
Poland	78	372	3.04	−0.02	−0.02	3.96	−0.11	−0.19	0.96	−0.08	−0.18
Portugal	110	647	1.96	−0.11	−0.24	2.44	−0.15	−0.43	0.38	−0.03	−0.17
Romania	22	162	4.52	−0.26	−0.52	5.26	−0.22	−0.50	1.00	−0.02	−0.11
Slovakia	5	19	3.65	−0.02	−0.29	3.53	−0.06	−0.17	−0.25	−0.11	0.20
Slovenia	18	187	2.65	−0.09	−0.24	3.53	−0.23	−0.50	1.05	−0.14	−0.27
Spain	40	121	1.74	−0.10	−0.15	2.30	−0.22	−0.42	0.45	−0.15	−0.33
Sweden	86	837	2.48	−0.11	−0.24	2.78	−0.11	−0.26	0.36	−0.01	−0.03

Table 18 Country level sample description– bank-control and macroeconomic variables

	CAP	LtD	LLP	Loans	CIR	Size	NPL	ir_ref	unempl	gdpg	HHI
Austria	16.78	135.13	0.60	59.02	68.18	15.39	2.66	0.77	5.11	1.51	0.04
Belgium	16.80	87.00	0.32	49.61	67.58	16.43	3.03	1.13	7.60	1.65	0.14
Bulgaria	18.15	98.53	1.87	59.97	58.39	14.21	10.47	0.76	8.42	2.74	0.09
Croatia	18.59	85.51	1.58	59.33	71.84	13.66	13.91	0.00	15.26	1.66	0.14
Cyprus	16.96	88.35	1.86	56.42	63.98	13.83	28.33	0.22	10.61	2.55	0.17
Czech Republic	15.81	82.16	0.96	53.18	51.72	15.54	5.56	1.16	5.47	2.51	0.10
Denmark	17.44	93.16	1.20	55.70	67.24	13.55	2.39	1.38	5.79	1.48	0.11
Estonia	20.65	101.92	1.41	61.43	63.68	13.90	1.46	1.30	8.81	3.66	0.31
Finland	23.07	130.73	0.17	66.98	66.97	14.03	0.99	0.66	8.31	1.12	0.30
France	15.11	169.90	0.54	59.49	68.11	15.81	4.28	1.75	9.21	1.74	0.06
Germany	16.84	89.50	0.30	58.25	72.61	13.69	2.75	0.66	5.62	1.21	0.03
Greece	14.91	108.69	2.14	62.09	63.35	16.85	18.29	1.41	15.90	−0.18	0.16
Hungary	14.74	105.88	1.56	55.04	70.68	15.36	7.84	5.23	6.96	2.79	0.08
Ireland	14.53	161.42	1.32	61.37	62.62	17.57	10.20	1.20	8.86	5.13	0.06
Italy	17.79	132.24	0.86	61.71	67.62	13.31	9.37	1.83	9.06	0.13	0.03
Latvia	16.86	91.36	2.09	47.21	62.01	13.56	5.83	1.37	11.39	3.07	0.11
Lithuania	16.14	117.29	1.21	63.11	67.03	13.79	8.68	1.58	10.76	3.90	0.19
Luxemburg	24.47	124.21	0.12	39.87	59.30	15.90	0.63	0.05	6.03	3.30	0.03
Malta	15.08	65.07	0.53	51.59	52.84	14.44	6.78	1.06	5.63	4.65	0.14
Netherlands	17.89	129.89	0.62	57.45	63.44	15.81	2.46	1.36	5.21	1.67	0.20
Poland	15.71	103.11	0.99	58.94	65.13	14.47	5.18	2.57	7.55	4.00	0.06
Portugal	19.87	95.89	0.76	51.32	71.33	13.47	10.83	0.48	10.51	1.40	0.12
Romania	18.48	124.19	2.28	58.36	70.52	14.65	9.90	5.05	6.14	3.53	0.09
Slovakia	17.53	56.30	1.01	40.57	64.78	14.59	8.71	5.71	15.36	5.86	0.12
Slovenia	14.25	118.05	1.53	63.50	62.97	14.38	7.06	1.42	7.06	2.14	0.12
Spain	15.37	110.16	0.77	57.65	60.00	16.32	4.90	0.95	18.20	1.51	0.08
Sweden	20.24	110.48	0.34	67.90	59.52	13.96	1.03	0.34	7.01	2.64	0.08

Table 19 List of macroprudential tools covered in the types of instruments with description of the tools. This information has been prepared using the mapped database and the report of ECB experts (Budnik and kleibl 2021). These tools are covered in the definition of MPI and MPI instrument type

Instrument type and tools covered	Type of macroprudential measures	Description of specific aspects of the tool
Lending standards restrictions include:	**Borrower– oriented measures**	
Loan-to-value (LTV) limits;	Cyclical	
Loan-to-income (LTI) limits;	Cyclical	
Debt-to-income (DTI) limits;	Cyclical	
Debt-service-to-income (DSTI) limits;	Cyclical	Also includes interest rate stress testing
Limits on interest rates on loans;	Cyclical	caps or additional restrictions on interest rate setting for private sector borrowers
Maturity and amortisation restrictions;	Cyclical	Maximum maturity restrictions (e.g. maximum maturity of mortgages set to 30 years) or regulations concerning loan amortisation periods
Other income requirements for loan eligibility;		Income based criteria of creditworthiness such as minimum disposable income, permanent source of income in the currency of a loan
Limits on the volume of personal loans;		
Other restrictions on lending standards;		
Levy/Tax on financial institutions and activities:	**Fiscal measures**	
Tax on assets/liabilities;	Diversified purposes, also fiscal needs, may enhance resilience	
Tax on financial activities;		
Limits on credit growth and volume include:	**Bank-oriented measures**	
Reserve requirements related to banks' liabilities;	Cyclical	Reserve requirements are the amount of funds that a depository institution must hold in reserve against specified deposit liabilities. These required reserves are normally in the form of deposits made with a central bank, or cash stored physically in the bank vault (vault cash
Asset-based reserve requirements;	Cyclical	Requirements for banks whose credit growth exceeds a certain limit per annum (or per quarter) to invest in low-yield central bank bills; obligations to set up custody accounts for non-resident portfolio investors; or compulsory purchases by banks of central bank bills when the growth or volume of loans exceeds a specified threshold, e.g. marginal reserve requirements
Liquidity requirements and limits on currency mismatches cover:	**Bank-oriented measures**	
Loan-to-deposit (LTD) limits;	Resilience enhancing	
Other stable funding requirements incl. Net Stable Funding Requirement (NSFR);	Resilience enhancing	

Table 19 (continued)

Instrument type and tools covered	Type of macroprudential measures	Description of specific aspects of the tool
Short-term liquidity coverage ratios incl. Liquidity Coverage Ratio (LCR);	Resilience enhancing	
Liquidity ratios and deposit coverage ratios;	Resilience enhancing	
Limits on FX mismatches;	Resilience enhancing	
Other		Introduction of qualitative requirements for the management of liquidity or FX risks; additional reporting requirements of banks' liquidity or FX positions
Loan-loss provisioning cover:	**Bank-oriented measures**	
Loan classification rules;	Resilience enhancing, cyclical	
Minimum specific provisioning;	Resilience enhancing, cyclical	
General provisioning;	Capital based, cyclical	
Capital treatment of loan loss reserve.	Capital based, cyclical	

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Author Contributions Małgorzata Olszak: Conceptualization: Ideas; formulation or evolution of overarching research goals and aims, Methodology: Development or design of methodology; creation of models, Validation: Verification, whether as a part of the activity or separate, of the overall replication/ reproducibility of results/experiments and other research outputs, Investigation: Conducting a research and investigation process, specifically performing the experiments, or data/evidence collection, Resources: Provision of study materials, instrumentation, computing resources, or other analysis tools, Data Curation: Management activities to annotate (produce metadata), scrub data and maintain research data (including software code, where it is necessary for interpreting the data itself) for initial use and later reuse, Writing - Original Draft: Preparation, creation and/or presentation of the published work, specifically writing the initial draft (including substantive translation), Writing - Review & Editing: Preparation, creation and/or presentation of the published work by those from the original research group, specifically critical review, commentary or revision– including pre-or post-publication stages, Visualization: Preparation, creation and/or presentation of the published work, specifically visualization/ data presentation, Supervision: Oversight and leadership responsibility for the research activity planning and execution, including mentorship external to the core team, Project administration: Management and coordination responsibility for the research activity planning and execution. Iwona Kowalska: Software: Programming, software development; designing computer programs; implementation of the computer code and supporting algorithms; testing of existing code components, Validation: Verification, whether as a part of the activity or separate, of the overall replication/ reproducibility of results/experiments and other research outputs, Formal analysis: Application of statistical, mathematical, computational, or other formal techniques to analyze or synthesize study data, Investigation: Conducting a research and investigation process, specifically performing the experiments, or data/evidence

collection, Data Curation: Management activities to annotate (produce metadata), scrub data and maintain research data (including software code, where it is necessary for interpreting the data itself) for initial use and later reuse, Writing - Review & Editing: Preparation, creation and/or presentation of the published work by those from the original research group, specifically critical review, commentary or revision– including pre-or post-publication stages. Christophe Godlewski: Writing - Original Draft: Preparation, creation and/or presentation of the published work, specifically writing the initial draft (including substantive translation), Writing - Review & Editing: Preparation, creation and/or presentation of the published work by those from the original research group, specifically critical review, commentary or revision– including pre-or post-publication stages, Visualization: Preparation, creation and/or presentation of the published work, specifically visualization/ data presentation. Agnieszka Paciorek: Writing - Original Draft: Preparation, creation and/or presentation of the published work, specifically writing the initial draft (including substantive translation), Visualization: Preparation, creation and/or presentation of the published work, specifically visualization/ data presentation.

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