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Borrower- and lender-based macroprudential policies: What works best against bank systemic risk?☆

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ABSTRACT

This paper investigates the complementarity between the different macroprudential policies to contain bank systemic risk. We use a newly updated version of the IMF survey on Global Macroprudential Policy Instruments (GMPI). By disentangling the aggregate macroprudential policy index, we assess the complementarity between borrower-targeted and lender-targeted instruments in mitigating systemic risk arising from intra-financial system vulnerabilities. We investigate the effect of boom-bust cycle on such a relationship by analyzing the financial upturns and downturns and show the effectiveness of the macroprudential policies during calm period. We also show that their efficacy in mitigating instability is quite heterogeneous and may vary depending on the set of tools implemented, as well as bank' size, TBTF, leverage, liquidity and concentration. Our results bear critical policy implications for implementing optimal macroprudential tools and provide insights into the trade-off between financial *vis-à-vis* price stability.

1. Introduction

In the aftermath of the global financial crisis (GFC), regulators have shifted their attention from purely microprudential to the macroprudential frameworks for systemic risk to ensure financial stability. While microprudential policies aim to limit *idiosyncratic* bank risks and increase financial supervision, macroprudential policies aim to reduce *systemic* risk by focusing on the risk of correlated failures, contagion risks, and common exposures (e.g., Crockett, 2000, Borio, 2003; Caruana, 2010; Meuleman and Vennet, 2020). Microprudential regulatory regimes failed to provide early warning signs of an impending global financial crisis (e.g., Hanson et al., 2011; Claessens and Kodres, 2014). Therefore, both academicians and practitioners agree that macroprudential policies are designed

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to reinforce microprudential regulation of financial institutions and traditional macroeconomic tools. They aim to contain (the buildup of) risks to systemic stability by limiting spillovers arising from interconnectedness between banks, mitigating the excessive procyclicality, and thereby reducing the adverse consequences of financial volatility, in turn reducing the cost to the economy from a disruption in financial services that underpin the workings of financial markets (Gaganis et al., 2020).[1]

Against this background, macroprudential policy tools have gained more prominence and a greater appreciation for their potential value, notably in the aftermath of the financial crisis (Bank of England, 2009, 2011; Hanson et al., 2011; De Nicolò et al., 2012; Claessens et al., 2013; Meuleman and Vennet, 2020 for reviews). The number of macroprudential policy tools (buffer requirements for systemically important banks, countercyclical capital buffers, caps on loan to value, Pigouvian levies, etc.) aiming at reducing vulnerability and containing stability of the banking system has become more popular as a part of the policy paradigm in developed countries (Cerutti et al., 2017a).[2] However, despite the wide adoption of macroprudential regulatory policies for financial stability objectives (Claessens, 2015; Boar et al., 2017; Akinci and Olmstead-Rumsey, 2018), understanding of these ex-ante policies and their efficacy remains an open subject for new investigations.

There has been a fundamental lack of understanding of the effectiveness of macroprudential policies and their underlying components in achieving the ultimate regulatory goal of enhancing financial stability by reducing bank systemic risk and procyclicality. While several papers have already looked at the use and effectiveness of macro-prudential policies (Cerutti et al., 2017a; Altunbas et al., 2018) and the factors affecting different regulations enforcement (Altunbas et al., 2018; Gaganis et al., 2020; Apergis et al., 2021), very few contributions have explicitly analyzed how macro-prudential policies and their types like between borrower- and lender-based policies affect financial stability. Thus far, most studies on macroprudential policies argue the existence of mixed evidence on the effectiveness of these policies (Lim et al., 2011 Altunbas et al., 2018). Besides, they focus only on the intermediate targets of the policies like credit or asset price growth, bank lending, or at the subsector level, i.e., real estate prices, real estate credit, house asset prices (Aysan et al. 2015, Saurina, 2009; Igan and Kang, 2011; Aiyar et al., 2014; Zhang and Zoli, 2014; Aysan et al. 2014, Aysan et al. 2017; Akinci and Olmstead-Rumsey, 2018; Ezer, 2019, rather than their ultimate goal of the financial stability.

In the spirit of Cerutti et al. (2017a), this analysis uses a macroprudential index that reflects the tightening of the macroprudential stance. It also adjusts the index to changes in the scope or the level of two targeted tools. We do this by assessing the effectiveness of borrower- or lender-oriented tools. Using a sample of 662 banks from 27 countries, spanning the period 2001–2013, the results show that bank systemic risk is influenced by the presence of macroprudential policies, as well as that of different types of macroprudential instruments.

Our work aims to fill the missing link between lender- or borrower-targeted macroprudential tools in the literature; while focusing on the final target of the macroprudential policies, this paper differentiates Financial Institution-Targeted instruments and Borrower-Targeted instruments and analyze their joint and interactive effects on the financial stability. Even though Cerutti et al. (2017a) and Gaganis et al. (2020) cover these different types of macroprudential tools, they do not consider the interactive effects on these policies and, hence, do not discuss the substitutability of these two groups of macroprudential policies. Moreover, the focus of these two papers is different than ours. More specifically, Cerutti et al. (2017a) focus on the real credit growth, but not on the aggregate financial stability risk, as it was the main concern in the aftermath of the global financial crisis. In other words, their paper is limited to the country characteristics of the banking sector. In contrast, our work relies on the bank-level data set and draws more attention to the relatively overlooked riskiness of each bank and the resulting systemic risk. Thus, our paper, in this regard, is closer to Gaganis et al. (2020) who also use bank-level data to measure the systemic risk. However, their goal is to account for the effects of corporate governance characteristics in terms of systemic risk, while considering different types of macroprudential instruments. They find that bank risk is affected by the interaction of macroprudential policies with corporate governance. Hence, their interaction term is based on macroprudential policies and corporate governance variables, and they stress out the substitution between macroprudential policies and corporate governance characteristics. Even though this substitution between macroprudential policies and corporate governance characteristics is rather worth investigating providing some interesting results, the policy relevance of their findings is rather limited considering that changing the macroprudential instruments is at the authority of the policymakers and they can be swiftly implemented with a policy decision by the central banks. However, altering the corporate governance practices of each bank is not really a policy decision by the regulators and it requires longer-term devoted policy actions and reforms to improve them. Hence, their paper is important in the recognition of the issue, but less relevant for the immediate policy making, especially, during times when the financial stability concerns are elevated.

In contrast, our paper focuses on the potential trade-off between different types of macroprudential policies, namely, Financial Institution-Targeted Instruments (FITI) and Borrower-Targeted Instruments (BTI) and analyze their substitutability and complementarity issues. In our analysis, each of these two different types of macroprudential instruments is controlled by policymakers (often by central banks). Hence, our novel focus of attention has not been interestingly studied before and is much more policy relevant, highlighting the actual policy tradeoffs for policymakers in adopting and implementing certain macroprudential policies. In addition, our empirical analysis is more detailed and comprehensive in considering whether these different types of macroprudential policies are

[1] See Crockett (2000) and Borio (2003) for early discussions on 'macroprudential' policy, Altunbas et al. (2018) and Akinci and Olmstead-Rumsey (2018) for an early history of prudential regulations in the form of countercyclical financial regulatory practices, and Fendoğlu (2017), Claessens (2015), European Systemic Risk Board (2014), and Lim et al. (2011), for the taxonomy of macroprudential policies and the review of the literature.

[2] For valuable reviews of macroprudential tools, their objectives, and the related extensive theory (Cerutti et al., 2017a). For a summary of the macroprudential toolkit, see Claessens et al. (2013). FSB/IMF/BIS (2009) provides a general definition and a framework for macroprudential policies.

more effective, depending on business cycles, bank characteristics, and the regulatory and governance characteristics in relevance to banks. Finally, Gaganis et al. (2020) approach the systemic risk through the Z-score, the distance to default, and the probability of default. However, in addition to measuring the risk with these measures, our main dependent variable relies on more advanced systemic stability measures, which is another contribution of our paper.

This paper aims to add to this ongoing debate, both among policymakers and academics, on the effects of macroprudential policy (ex-ante) tools on bank stability. With the benefit of hindsight, the paper explicitly aims to investigate whether different types of macroprudential tools can foster bank stability over a pre-Basel III period using data for a large sample of OECD banks. As macroprudential policies are always designed and calibrated considering country characteristics and circumstances, macroprudential policies might affect banks' systemic risk in different ways across different countries. Accordingly, studying a more extensive set of the most developed countries contributes in threefold: *first*, most studies use mixed samples of emerging and advanced economies, with a focus on emerging countries as they have historically been using macroprudential policies more frequently, hence understanding these policies and their efficacy in a given institutional context tanned with systemically important banks is warranted, *second*, it allows the evaluation of these policies with a great deal of breadth and depth, and *third*, it explains some of the divergences obtained in some previous studies.

As an extension to this literature, the present study aims to fill the gap by empirically examining how effective different macroprudential policies are to reduce systemic risk and whether there is a complementarity between borrower- and financial-targeted policies in achieving financial stability. In terms of the contribution, this paper is, to the best of our knowledge, the first to explore the effects of macroprudential policies in a cross-panel data set for listed OECD banks during the pre-Basel III and the complementarity *versus* substitutability between the different macroprudential instruments: lender- or borrower-targeted tools. The distinction between the borrower- or lender-based macroprudential policies is not well-explored in the literature. However, this distinction is of great importance for policymakers. Lender-based macroprudential policies are more indirect policies while affecting incentive sets of the banks offered to the borrowers. However, lender-based macroprudential policies are faster to implement, considering the limited number of banks and already heavy regulations imposed on them. However, it could take lengthier and more challenging to enforce the borrower-based macroprudential policies given the lack of data on banks' customers. Besides, the governments may not prefer to impose financial restrictions on borrowers due to electoral concerns. Hence, it is a task to analyze the separate effectiveness of the borrower- or lender-based macroprudential policies and their complementarity effects on financial stability.

The main findings of the paper can be summarized as follows. In general, a tightening in macroprudential policies effectively reduces individual bank systemic risk, which is reflected in the market-based measures of systemic risk: *risk exposure*, *contagion risk*, and *systemic default risk*. This suggests that the introduction of macroprudential policies effectively mitigates the downward effects of bank systemic risk and thus increases financial stability. Our findings also indicate that macroprudential policies are more powerful than monetary policy mitigating instability. These results confirm the inclinations of the central banks to employ more macroprudential policies instead of just relying on interest rate policies in their policy formulations. In addition, the regulations that impose macroprudential policies, which relate to capital, lending, levy/tax, foreign exchange, and countercyclical reserve requirements on financial institutions, as well as the limit on household indebtedness and the loan to value ratio caps appear to have a mitigating role in bank systemic risk, and thus reduce externalities that contribute to adverse financial sector dynamics. Hence, we find that both Financial Institution-Targeted Instruments (FITI) and Borrower-Targeted Instruments (BTI) are effective in curbing bank systemic risk and thus increase financial stability.

Our results also show that a tightening in both FITI and/or BTI appears most effective over the upturn times. FITI are always effective in mitigating the systemic risk regardless of the downturns and upturns. However, BTI that regulations imposing limits on households' indebtedness and loan to value ratio caps do not appear to have a moderating role on bank systemic risk over the upturns and downturns periods, justifying why policymakers first prefer to apply financial institution-targeted instruments. However, we find that macroprudential policy might be ineffective during financials downturns, and thus might have counterproductive role by putting a drag on economic activity, which can in turn threaten financial stability. Lastly, we found that macroprudential policies have considerably heterogeneous effects depending on different bank's features: size, too-big-too- fail banks, leverage, liquidity and concentration. Our findings suggest that macroprudential policies are more effective, primarily through the leverage channel.

The following is a more detailed summary of our other findings: banks' systemic exposure risk is reduced as a result of overall macroprudential policy. Larger banks are found to be more systemically risky. Banks with larger market-to-book ratios are more vulnerable to systemic risk, implying that they have more growth options which raises systemic risk. The findings also point to a greater systemic risk for institutions that are less profitable. Banks that rely heavily on retail funding face a greater systemic risk. Systemic risks are lower in liquid banks that are more reliant on deposits and in banks with a higher proportion of loans in their total assets. The rate of GDP growth is positively connected with banks' systemic risk, implying that faster-growing economies take on more bank risks. In a similar vein, we discover that annual inflation is positively related to systemic risks. The results are also consistent across various measures od systemic risk, including MES (Marginal Expected Shortfall), SRISK (Systemic risk), expected capital shortfall, ΔCoVaR (ΔConditional Value-at-Risk of a bank), MZ-score (market-based z-score), and DtD (Merton's distance to default).

Overall, the aggregate macroprudential policy index, MPI, is statistically significant and inversely associated with systemic risk, but the monetary policy rate is statistically non-significant. These data show that macroprudential policies have been more effective than monetary policies when applied on average. As a result, three crucial cautions to this conclusion's interpretation are required: first, these findings support central banks' desire to use more macroprudential measures in their policy formulations, rather than depending just on short-term interest rate policies, second, monetary policy appears to have less of an impact on the stability in advanced economies, possibly because their financial systems are more complex and evolved, providing more alternatives to bank finance, and, third, monetary policy is designed to serve other central bank objectives, rather than directly resolving systemic risks (e.g., exchange

Table 1
Data description.

Panel A. Sample composition. The table shows the sample country composition. It presents the distribution of 622 listed banks in 25 OECD countries: Australia, Austria, Belgium, Canada, Czech, Finland, France, Germany, Hungary, Ireland, Italy, Japan, Mexico, Netherlands, Norway, Poland, Portugal, Slovakia, South Korea, Spain, Sweden, Switzerland, Turkey, UK, and US. The sample consists of 622 banks, among which 409 are from U.S., 71 are Japanese and 109 are European (from 18 different countries).

Country	Banks	N	Country	Banks	N
Australia	5	65	Netherlands	1	12
Austria	7	80	Norway	11	123
Belgium	2	24	Poland	10	119
Canada	8	99	Portugal	3	39
Czech	1	12	Slovakia	1	13
Finland	1	13	South Korea	4	39
France	16	185	Spain	6	63
Germany	6	64	Sweden	4	49
Hungary	1	13	Switzerland	17	205
Ireland	2	22	Turkey	14	125
Italy	15	176	United-Kingdom	5	57
Japan	71	890	United-States	409	4181
Mexico	2	24	Total	622	6692

Panel B. Sample distribution by calendar year. The table shows the sample distribution by calendar year. The sample spans 13 years, from 2001 to 2013. Bank-year observations vary between 346 and 589 observations.

Year	Freq.	Percent
2001	458	6.84
2002	480	7.17
2003	492	7.35
2004	520	7.77
2005	536	8.01
2006	575	8.59
2007	598	8.94
2008	597	8.92
2009	502	7.50
2010	540	8.07
2011	535	7.99
2012	513	7.67
2013	346	5.18
Total	6692	100

rate or inflation stability), making it less significant from the perspective of financial stability. When we adjust for central bank characteristics, the first thing we notice is that there are considerable correlations between central bank performance characteristics and individual bank systemic risks. The second point to note is that the characteristics of central banks tend to have varying effects on banks' systemic risk, but macroprudential regulations remain effective in moderating instability overall.

Our findings demonstrate that macroprudential measures focused on financial institutions, rather than on borrowers, are modestly effective in lowering banking (default) risks. Macroprudential policies (tightening) are more closely linked to the reduction in individual bank systemic risks, resulting in increased stability. The findings also reveal that a tightening of the FITI and/or BTI indexes appears to be quite effective in controlling bank systemic risks. The interaction term (FITI × BTI) is negative and statistically significant, implying that in the presence of both FITI and BTI instruments, the impact of macroprudential policies on bank systemic risks is larger. These findings suggest that a 'tightening' of both lender and borrower policies might be quite effective in reducing bank systemic risks, and that FITI and BTI can play a complementary role in moderating instability. Whereas the interaction FITI × BTI × Financial distress term is positive and statistically significant, implying that strengthening macroprudential regulation may have the opposite effect during financial downturns.

The rest of the paper is structured as follows. Section 2 explains the methodology and variable construction, sample in consideration, and data. Empirical specifications and various discussions on the model are also provided in Section 2. Section 3 presents the results in-depth, and Section 4 gives the results of robustness checks. Section 5 concludes with policy implications.

2. Methodology and variable construction

2.1. Sample and data

To conduct the analysis, we require financial market and accounting data for a sample of listed banks head-quartered in any OECD countries and analyze the 2001–2013 period.[3] We end the sample period in 2013 to avoid the confounding effect of implementing the Basel III Accords/Regulations that, among other things, introduced size caps and cross-border activity limits for complex international banks. Moeover, because of data availability on different macroprudential policies, we restrict our period to the Cerutti et al. (2017a) dataset covering the 2000–2013 period. We retrieve stock price information and other market data from Bloomberg. We obtained annual balance sheet and income statement data from Thomson-Reuters Advanced Analytics (TRAA) and Bloomberg. We collect macroeconomic data from the OECD Metadata stats.[4] We limit the sample to banks of which the TRAA industry specialization is bank holding company, commercial bank, cooperative bank, and saving bank. We exclude financial institutions not engaged in banking activity (e.g., insurance firms, wealth management firms, or online brokers). We also exclude small domestic banks' affiliates (e.g., regional branches of the French bank Crédit Agricole, community thrifts-regional US banks).[5] Because the systemic risk measures are primarily estimated daily, we further exclude banks with illiquid stocks; these are banks with infrequently traded stocks and low variability in stock prices. To achieve this, we require that the stocks' daily returns are non-zero over five consecutive rolling days, or at least 70 % of the daily returns are non-zero returns during the sample period. Subsequently, starting from the matched accounting and market data and the yearly averaged estimated systemic risk measures, we filter out bank-year observations by dropping the top and bottom 1 % levels to eliminate the adverse effects of outliers and misreported data.

Due to the delisting of many banks, mainly due to mergers and acquisitions, we end up with an unbalanced panel dataset of 622 banks from the 25 major advanced OECD economies. It consists of 407 U.S. banks and 213 non-U.S. banks, among which 109 are European (from 18 countries) and 71 are Japanese. Taken together, the publicly traded banks of our sample conveniently represent the U.S., Euro area, and Japanese banking sectors. They account for approximately 71 %, 50 %, and 31 % of the total assets of all U.S., European and Japanese banks recorded in BSI/Bloomberg statistics, respectively. For the rest of the OECD countries, the coverage varies between 9 % for Mexico to 29 % for Canada. Sample size varies across regression specifications because not all variables are available for all bank-year observations. Information on the sample composition by country and year can be found in panels A and B in Table 1.

The second step in the analysis is to build the database of macroprudential measures. We rely on the updated version of the Cerutti et al. (2017a) dataset, which uses national sources and the IMF survey called Global Macroprudential Policy Instruments (GMPI).[6] We also cross-check our database against cross-country databases used by Lim et al. (2011), Cerutti et al. (2017b), as well as the historical data available in the MacroPrudential Policies Evaluation Database (MaPPED) and the integrated Macroprudential Policy (iMaPP) database.[7] Time-varying country monetary policy conditions are retrieved from the OECD Metadata stats and the IMF's WDI.

2.2. Empirical specification

We estimate a panel regression model at the bank level with a yearly frequency to assess whether and how the macroprudential policies affect bank systemic risk. For the first part of our analysis, we use the following regression specification:

$$Risk_{ijt} = \alpha_0 + \beta_1 \bullet MPI_{jt-1} + \delta STInterest_{jt-1} + \varphi X_{ijt-1} + \gamma Country_{jt-1} + \omega_i + \lambda_t + \varepsilon_{ijt} \quad (1)$$

Based on the transmission mechanisms, the macroprudential instruments are commonly grouped using a two-way classification of measures aimed at: (i) financial institutions, and (ii) borrowers. Correspondingly, we detangle MPI into two sub-indexe: *FITI* and *BTI* by estimating the following equation:

$$Risk_{ijt} = \alpha_0 + \beta_1 \bullet FITI_{jt-1} + \beta_2 \bullet BTI_{jt-1} + \beta_3 \bullet FITI_{jt-1} \times BTI_{jt-1} + \delta STInterest_{jt-1} + \varphi \chi_{ijt-1} + \gamma Country_{jt-1} + \omega_i + \lambda_t + \varepsilon_{ijt} \quad (2)$$

To gain insight in the potential drivers of heterogeneity in β, we also evaluate how bank-individual features affect the effectiveness of the macroprudential instruments on containing bank systemic risk may change across banks and whether they exacerbate or mitigate the negative relationship between competition and systemic instability. In defense of justifying the inclusion of such bank-individual features, we can state that the literature has exemplified the interaction between bank-specific risks and

[3] We end the sample period in 2013 to avoid the confounding effect of implementing the Basel III Accords/Regulations that, among other things, introduced size caps and cross-border activity limits for complex international banks. Also, because of data availability on different macroprudential policies, we restrict our period to the Cerutti et al. (2017a) dataset covering the 2000–2013 period.

[4] All banks in our sample report annual financial statements, following an accounting period from January 1 to December 31. December 31 is the end of the fiscal year. We also consider local Generally Accepted Accounting Principles (GAAP) for all banks over the study period.

[5] Due to their core business activities, we exclude small community/cooperative banks with total assets less than $500 million, a ratio of net loans to total assets above 33%, and a percentage of customer deposits to total assets above 50%. See Bakkar et al. (2020).

[6] The 2011 IMF survey database on macroprudential measures is presented in Lim et al. (2011).

[7] The MaPPED database contains information on macroprudential actions taken in 28 member states of the European Union. It is publicly available and can be found here: https://www.ecb.europa.eu/pub/research/working-papers/html/mapped.en.html. The iMaPP database is updated annually using information from the IMF's annual survey; see IMF (2018) for a description of the survey.

macroprudential policies. More specifically, researchers have acknowledged the need to use policy instruments that target the soundness of the financial system (Hanson et al., 2011; De Nicolò et al., 2012). The financial sector is inherently procyclical, that is, it amplifies the business cycle through changes in the values of assets and leverage. In the presence of certain shocks, banks' balance sheet structures become more vulnerable to shocks, through rising leverage ratios and maturity mismatches, while the ratio of noncore-to-core funding also rises. As banks seek to expand their balance sheets, they generally turn to noncore funding since the more stable core (mainly deposits) liabilities are more sluggish (Hahm et al., 2012). Once the financial system as a whole becomes more leveraged, it becomes vulnerable to shocks, such as sudden withdrawals of funds, stops in capital inflows, or changes in asset prices. In that case, banks may be forced to deleverage, in turn creating systemwide declines in the supply of external financing. Alternatively, negative shocks that shake depositors' confidence can expose banks to the risk of runs, forcing them to hoard liquidity or sell assets at depressed market prices to meet withdrawals, if the systemwide maturity transformation or reliance on wholesale funds is high. Negative externalities related to fire sales can then occur because a generalized sell off of financial assets causes a decline in asset prices, which in turn, further impairs the balance sheets of intermediaries amplifying the contractionary phase of the cycle. Finally, in such cases banks may reduce new credit extension, ration credit via higher margins/haircuts, or raise interest rates to borrowers. Such deleveraging can have general effects because the economic slowdown adversely affects borrowers by lowering output and prices. This situation raises the probability of default for all other borrowers and can set off a cycle of adverse effects on the real economy, again further amplifying banking-sector losses. Additional systemic risks arise from the interconnectedness of financial institutions and markets. This interconnectedness can result in a specific shock to an institution or market at a point in time being amplified as it is propagated throughout the system (Allen and Gale, 2007; Bebchuk and Goldstein, 2011).

The analysis examines five bank-level features: absolute size, Too-big-Too-Fail (TBTF), liquidity ratio, leverage ratio and the Herfindahl-Hirschman loans concentration index. We run the following regression model:

$$\begin{aligned} Risk_{ijt} = \alpha_0 + \left(\beta_0 + \beta_1 \bullet FITI_{jt-1} + \beta_2 \bullet BTI_{jt-1} + \beta_3 \bullet FITI_{jt-1} \times BTI_{jt-1}\right) \\ \times \Lambda_{i,t-1} + \delta STInterest_{jt-1} + \varphi \chi_{ijt-1} + \gamma Country_{jt-1} + \omega_i + \lambda_t + \varepsilon_{ijt} \end{aligned} \quad (3)$$

In this setup, *i*, *j*, *t* stand respectively for bank, country and time. The dependent variable is bank *i*'s systemic risk in country *j* over year *t*, $Risk_{i,j,t}$ equals to the Marginal Expected Shortfall (MES). MPI_{jt-1} is the aggregated index of country-specific macroprudential policy (all tools included are equally weighted). Alternatively, we consider: Financial Institutions-Targeted Instruments ($FITI_{jt-1}$) and Borrower-Targeted Instruments (BTI_{jt-1}). In order to investigate complementarity between financial institutions-targeted and borrower-targeted instruments, we include an interaction term between the two policy instruments ($FITI_{jt-1} \times BTI_{jt-1}$). We lag the MPI and other macroprudential instruments by one year as we cannot expect immediate impact from the adoption of these policies. $\Lambda_{i,t-1}$ is a $N \times 1$ vector with the bank-level feature being interacted with, BTI_{jt-1}, $FITI_{jt-1}$ and $FITI_{jt-1} \times BTI_{jt-1}$: either size, TBTF, leverage, liquidity, or concentration, in order to assess how the effectiveness of the macroprudential policies changes according to these bank's features. $STInterest_{jt-1}$ denotes the monetary policy stance, gauged by the central bank short-term policy. β s are coefficients that state the relationship between macroprudential policies and systemic risk. We also control for the vector of lagged bank-specific variables, χ_{ijt-1}, which characterizes bank i's business model. $Country_{jt-1}$ is the vector of country-level control variables. Lagging the controls allows avoiding simultaneity problems, as the use of macroprudential policies affect banks' business model and real economic activity (Cerutti et al., 2017a).

In the regression, we address the potential endogeneity by exploiting the panel structure of the dataset, which allows us to include bank fixed effects ω_i (which subsume country fixed effects), that account for unobserved bank heterogeneity, such as the quality of management, risk preferences and the mix of markets in which the bank operates, and year fixed effects λ_t. ε_{ijt} is the error term. Explanatory variables are lagged by one period to address issues of simultaneity. Throughout the paper, the reported standard errors are heteroskedasticity robust and clustered at the bank-level to account for the serial correlation across the study period (Gaganis et. al., 2020). In the robustness, we also used four alternative specifications. *First*, we use country fixed effect regression to control for country heterogeneity while also controlling for year fixed effects. *Second*, we employ the panel structure of the database and control for fixed heterogeneity at the country-year level by interacting country and time fixed effects. *Third*, we perform the Weighted Least Squares (WLS) estimations in order to ensure that our results are not subject to sample bias affected by countries with a large number of banks. *Four*, we run a dynamic panel data regression model using the Generalized Method of Moments (GMM) method developed by Arellano and Bond (1991) to deal with the potential endogeneity problem of macroprudential policies.

2.3. Measures of systemic risk

The empirical methodology devotes special attention to market-based time-varying systemic risk measures. Although there is no common definition of systemic-wide risk, as suggested by Borio (2011) and Bisias et al. (2012), the study builds on a consistent framework for systemic risk analyses that have been applied in several recent studies (Acharya et al., 2012; Anginer et al., 2018; Bakkar et al., 2019).

The Marginal Expected Shortfall (MES) corresponds to the expected stock returns for a bank i, conditional on the system (market) when the latter is in a crisis, i.e., its return declines substantially (Bakkar et al., 2019). Alternatively, the MES for a bank i is defined as the first derivative of the Expected Shortfall (ES) of the system concerning the weight of the institution ($W_{i,t}$) in the system. Formally, Acharya et al. (2012) define the MES as the expected stock return for bank i, conditional on the system crash, as follows:

$$MES^{\alpha}_{i,t} \equiv \frac{\partial ES_{s,t}}{\partial W_{i,t}} = E\left(R_{i,t}|crisis\right) \tag{4}$$

where $R_{i,t}$ is one-day stock return for bank *i*, *crisis* stands for the Value-at-Risk of the system, which is a critical threshold value that measures the worst expected market loss over a specific time period at a given confidence level:

$$MES^{\alpha}_{i,t} = E\left(R_{i,t}|R_{s,t} \leq VaR^{1-\alpha}_{s,t}\right) \tag{5}$$

where $R_{i,t}$ is a one-day stock return of bank i, $R_{s,t}$ is one-day market (*system*) return,[8] and $VaR^{1-\alpha}_{s,t}$ stands for market Value-at-Risk, defined as the absolute value of the lowest daily market return observed in 100(1 $-\alpha$)% of trading days. The term $R_{s,t} \leq \mathrm{VaR}^{1-\alpha}_{s,t}$ reflects the set of days when the daily market return is at or below the 5th percentile of the distribution (*tail outcomes*) in that given period (250 days). Thus, under the nonparametric assumption, the MES is expressed as:

$$MES^{\alpha}_{i,t} = \frac{\sum R_{i,t} \times I\left(R_{s,t} < VaR^{1-\alpha}_{s,t}\right)}{\sum I\left(R_{s,t} < VaR^{1-\alpha}_{s,t}\right)} = \frac{1}{N}\sum_{R_{s,t} < VaR^{1-\alpha}_{s,t}} R_{i,t} \tag{6}$$

where I (.) is the indicator function defining the set of days where the market experienced q-percent worst days (crisis), and N is the number of days where the aggregate equity return of the market experienced its q-percent worst outcomes. We first estimate daily systemic risk measures. We then average these daily risk measures across all bank-year observations, for each calendar year, in order to match them with the yearly-based accounting data.

Following the discussion of Altunbas et al. (2018) and Meuleman and Vennet (2020), and given the nature of macroprudential policies, the interest could lay on how these policies may affect different dimensions of bank system risk. To this end, we suggest the use of four alternative measures of systemic risk: *systemic capital shortfall* (SRISK, Brownlees, and Engle, 2017), *systemic risk contagion* (ΔCoVaR, Adrian and Brunnermeier, 2016), *Merton's distance to default* (DtD, Campbell et al., 2008), and *market Z-score* (MZ-score, Bakkar et al. 2020). For the sake of space restrictions, more details about their construction are presented in Appendix A.

2.4. Macroprudential policy measures

The macro-prudential policies toolkit available is quite diverse, in part as it includes existing micro-prudential tools as well as new instruments. In this paper, we construct macroprudential policy stance indexes based on Cerutti et al. (2017a). Based on IMF's survey macroprudential policy actions (Global Macroprudential Policy Instruments-GMPI), Cerutti et al. (2017a) focuses on 12 different policy instruments to construct an annual dataset of macroprudential policies for 119 countries. This dataset indicates how many of the following instruments are in place, in each country-year, without capturing whether and when the instrument was adjusted: (i) caps on debt-to-income ratio (DTI), (ii) caps on loan-to-value (LTV), (iii) leverage ratio for banks (LEV), (iv) limits on foreign lending (FC), (v) limits on credit growth (CG), (vi) limits on interbank exposures (INTER), (vii) Levy/Tax on financial institutions (TAX), (viii) dynamic loan-loss provisioning (DP), (ix) reserve requirements (RR), (x) countercyclical provisioning and countercyclical capital buffers (CTC), (xi) capital surcharges on SIFIs (SIFI), and (xii) concentration limits (CONC). Cerutti et al. (2017a) attribute the value of one in each one of these twelve policies is in place, and the value of zero, otherwise. Then, they generate an aggregated macroprudential index (MPI) summing all the scores on all different twelve macroprudential policies. Higher values of MPI indicate a more stringent macroprudential framework.[9]

Based on the macroprudential policies transmission mechanism and following Cerutti et al. (2017a), we use the two-way classification of macroprudential policies and detangle them into: Borrower-Targeted Instruments index (BTI) and Financial Institution-Targeted Instruments (FITI). The former index aims at borrowers' leverage and financial positions and includes caps on the debt-to-income (DTI) ratio and the loan-to-value (LTV) ratio. These two instruments aimed at dampening the credit cycle and leverage. The latter index aims at financial institutions' assets, liabilities or building buffers, and includes limits on LTV, LEV, FC, CG, INTER, TAX, DP, RR, CTC, SIFI, and CONC. The main objective of this set of instruments is to enhance the financial sector's resilience.[10]

The GMPI database, as used in Cerutti et al. (2017a), has several advantages compared to existing databases such as: the IMF database used in Lim et al. (2011), the BIS database used in Kuttner and Shim (2016), the iMaPP database used in Alam et al. (2019), and the MaPPED database used in Meuleman and Vennet (2020). Four advantages over other databases need to be highlighted: *First*, it provides a comprehensive information coverage on the use of different macroprudential policies, the instruments, the countries, and the timing for a large set of countries around the world, in contrast to the MaPPED database that only contains information on the policy tools for European countries. These features ensure the comparability across measures and OECD countries, contrary to the

8 We refer to the broader stock market index, as market portfolio benchmark; so as to, catch bank's contribution to the economy stability.

9 The GMPI survey is detailed and covers 18 different instruments, of which Cerutti et al. (2017a) focus only on these 12 specific instruments, due to the lack of data. For an overview of the weights that are used to construct the life-cycle index for every tool separately, see Cerutti et al. (2017a) and Cerutti et al. (2017b).

10 Similar classifications can also be found in Gaganis et. al. (2020) and Kuttner and Shim (2016). For somwwhat similar classification, see also: Bank of England, 2011, Schoenmaker and Wierts, 2011, CGFS, 2010, European Systemic Risk Board, 2014, and IMF, 2011, 2018.

Table 2
Descriptive statistics and variables definition.

Variable	N	Mean	Standard deviation	Min	P25	Median	P75	Max	Source	Definition
Panel 1. Bank-level variables										
Systemic risk measure										
MES (%)	6692	1.711	1.851	−1.681	0.309	1.376	2.600	9.633	Bloomberg	The Marginal Expected Shortfall
Alternative systemic risk measures										
SRISK	6624	2.981	16.301	−6.579	−0.055	0.001	0.453	77.562	Bloomberg	Systemic risk index, a proxy of systemic capital shortfall.
ΔCoVaR (%)	6572	1.564	1.688	−3.436	0.343	1.231	2.368	6.994	Bloomberg	Delta conditional VaR.
DtD	6607	3.621	1.608	0.125	2.535	3.470	4.472	10.916	Bloomberg	Merton's probability-of-default.
MZ-score	6352	54.534	22.783	12.212	38.768	52.156	67.017	139.938	Bloomberg	Market-based Z-score.
Bank characteristics										
Size	6692	8.404	2.205	4.362	6.510	7.795	9.730	14.210	Bloomberg, Thomsen-Reuters Advanced Analytic (TRAA)	Natural logarithm of bank total assets (in $billion).
Leverage	6692	0.090	0.046	0.177	0.062	0.086	0.111	0.532	Bloomberg, and TRAA	Capital ratio, total equity over total assets.
ROA	6692	0.007	0.009	-0.052	0.003	0.007	0.011	0.613	TRAA	Return on assets, ratio of net income to total assets.
Funding	6692	0.895	0.131	0.338	0.863	0.937	0.979	0.997	Bloomberg, and TRAA	Retail funding, total customer deposit divided by total funding (*st borrow* + *Tot.Cust. Dep*).
TobinQ	6692	1.053	0.145	0.720	0.984	1.021	1.068	2.701	Bloomberg, and TRAA	Charter value, proxy of market-to-book value.
Liquidity	6692	1.088	0 0.329	0.218	0.911	1.085	1.259	2.366	TRAA	Net loans over total deposit
Efficiency	6692	0.461	0.146	0.149	0.359	0.446	0.558	0.899	TRAA	Cost income ratio, non-interest expense over total income.
Loans	6692	0.694	0.144	0.146	0.611	0.700	0.788	0.996	TRAA	Loans to total assets, net loans over total assets.
Diversification	6692	0.203	0.112	0.001	0.124	0.188	0.271	0.898	TRAA	Income diversification, noninterest income over total income.
BIS capital adequacy	6004	0.116	0.033	0.041	0.090	0.108	0.133	0.221	Bloomberg, and TRAA	Bank of International Settlements' capital adequacy ratio bank i at year t.
TBTF	6692	0.498	0.459	0	0	1	1	1	Bloomberg, and TRAA	Too-Big-Too-Fail is a dummy that takes a value of one if bank's total assets is above US $20 billion, zero otherwise.
HHI	6692	0.405	0.212	0.131	0.221	0.412	0.587	0.789	Bloomberg, and TRAA	Herfindahl-Hirschman Index of concentration of total loans.
Panel 2. Country-level characteristics										
Macroprudential policy										
MPI	6692	2.425	1.014	0	2	3	3	5	An updated version of Cerutti et al. (2017a)	Aggregated macroprudential policies index. It contains all tools, equally weighted. It a summation of FITI index and BTI index.
FITI	6692	2.353	0.995	0	1	3	3	5	Updated version of Cerutti et al. (2017a)	Financial Institution-Targeted macroprudential instruments Index.

(*continued on next page*)

Table 2 (*continued*)

Variable	N	Mean	Standard deviation	Min	P25	Median	P75	Max	Source	Definition
BTI	6692	0.073	0.335	0	0	0	1	2	Updated version of Cerutti et al. (2017a)	Borrower-Targeted macroprudential instruments Index.
Monetary policy										
STInterest (%)	6692	2.520	3.750	0	0.32	1.560	3.690	60	OECD Metadata stats, and IMF WDI	Central bank short-term policy rate.
GovYield (%)	6692	2.031	2.396	−0.078	0.126	1.367	3.475	22.180	OECD Metadata stats, and IMF WDI	Government one-year bond yield.
InterbankRate (%)	6692	2.407	2.747	−0.043	0.430	1.623	3.565	50.205	OECD Metadata stats, and IMF WDI	Three-month interbank lending market interest rate.
Other controls										
GDP (%)	6692	1.847	2.133	−8.540	0.950	1.880	2.800	10.650	OECD stats Metadata, and IMF WEO	The annual real gross domestic product growth rate.
Inflation	6692	0.023	0.025	−0.045	0.015	0.025	0.032	0.549	OECD stats Metadata, and IMF WEO	The annual inflation rate.
Abs(Inflation)	6692	0.026	0.033	0	0.015	0.023	0.032	0.549	OECD stats Metadata, and IMF WEO	Absolute value of the annual inflation rate in each country j.
Financial distress	6692	0.543	0.498	0	0	1	1	1	Bloomberg, and TRAA	Dummy variable takes the value of one during distress years [2007–2013].
Monetary_Performance	6692	83.163	5.734	31.800	80.300	84.100	84.900	94.300	The Heritage Foundation	Monetary performance index measures the success of a country's monetary policy based on two components: the weighted average inflation rate over the most recent three years and the degree to which a country imposes price controls.
OutputGap	5143	1.000	0.942	−3.639	0.391	1.178	1.574	5.002	OECD stats Metadata, and IMF WEO	Output gap is the equally weighted, inflation and real growth (0.5*inflation variability + 0.5*real growth variability).
Capital stringency	6692	8.697	1,338	4	8	9	10	11	Barth et al. (2013)	The strength of capital regulation in a country.
Multiple supervisors	6692	0.891	0.312	0	1	1	1	1	Barth et al. (2013)	Dummy equal to one when there are multiple bank supervisors in a country.
External governance index	6692	15.655	2.049	11	15	15	18	18	Barth et al. (2013)	The strength of external auditors, financial statement transparancy, and the existence of an external rating in a country.

The table reports summary statistics for all variables: bank risks and explanatory variables, used in the regressions. Bank-level data consist of publicly traded OECD banks from 27 countries, spanning the period 2001–2013. The imbalanced sample explains why the number of observations is different. We report four basic summary statistics: number of observations, mean, standard deviation and median, for variables measured at time t. We also document data sources and the definitions of variables. Detailed information on the construction of these variables is provided in Section 4.

Table 3
Pairwise Correlation matrix.

	MES	SRISK	ΔCoVaR	MZ − score	DtD	MPI	FITI	BTI
Systemic risk measure								
SRISK	0.260***	1						
CoVaR	0.640***	0.135***	1					
MZ-score	−0.424***	−0.104***	−0.321***	1				
DtD	−0.406***	−0.112***	−0.305***	0.990***	1			
Macroprudential policies								
MPI	−0.0863***	−0.175***	−0.0767***	−0.0739***	0.00449	1		
FITI	−0.142***	−0.185***	−0.110***	−0.0505***	0.0250*	0.944***	1	
BTI	0.161***	0.0188	0.0948***	−0.0726***	−0.0567***	0.222***	−0.111***	1
Bank-level controls								
Size	0.460***	0.424***	0.335***	0.0793***	0.0544***	−0.476***	−0.558***	0.214***
Leverage	−0.0195	−0.168***	0.0496***	−0.0303*	0.0386**	0.375***	0.399***	−0.0474***
RoA	−0.0882***	−0.0835***	−0.0428***	0.234***	0.283***	0.144***	0.121***	0.0772***
Funding	−0.134***	−0.261***	−0.0524***	−0.117***	−0.124***	0.182***	0.219***	−0.100***
TobinQ	0.00782	−0.0460***	0.0774***	0.0354**	0.0650***	0.156***	0.170***	−0.0329**
Liquidity	−0.0379**	−0.0471***	0.0187	−0.113***	−0.0846***	0.154***	0.203***	−0.141***
Efficiency	0.0183	0.0206	0.0710***	−0.190***	−0.201***	−0.150***	−0.0948***	−0.176***
Loan	−0.122***	−0.275***	−0.0284*	0.00742	−0.0392**	−0.0197	−0.0228	0.00834
Diversification	0.242***	0.242***	0.175***	−0.00603	−0.00561	−0.261***	−0.278***	0.0365**
Country-level controls								
GDP	−0.228***	−0.0971***	−0.263***	0.303***	0.321***	0.0836***	0.0512***	0.101***
Inflation	0.101***	−0.0511***	0.0251*	−0.0105	0.0558***	0.251***	0.197***	0.174***
Financial distress	0.305***	0.110***	0.372***	−0.303***	−0.309***	0.121***	0.0724***	0.151***
Capital stringency	0.107***	−0.0275*	0.0125	0.00173	0.0217	0.0220	−0.0424***	0.192***
Multiple supervisors	−0.0928***	−0.152***	−0.121***	0.0322**	0.0370**	0.431***	0.429***	0.0319**
External governance index	0.0365**	−0.141***	0.0489***	−0.133***	−0.134***	0.256***	0.320***	−0.175***

	Size	Leverage	RoA	Funding	TobinQ	Liquidity	Efficiency	Loan	Diversification	GDP	Inflation	Financial distress	Capital stringency	Multiple supervisors
Bank-level controls														
Leverage	−0.366***	1												
RoA	−0.0331**	0.343***	1											
Funding	−0.370***	0.0934***	−0.0438***	1										
TobinQ	−0.138***	0.381***	0.215***	0.0597***	1									
Liquidy	−0.201***	0.0381**	−0.0240	0.550***	0.163***	1								
Efficiency	−0.00465	−0.0989***	−0.360***	0.337***	0.0159	0.438***	1							
Loan	−0.223***	0.167***	−0.0144	0.113***	0.335***	−0.480***	−0.0711***	1						
Diversification	0.515***	−0.138***	0.0560***	−0.213***	−0.0198	0.0165	0.394***	−0.232***	1					
Country-level controls														
GDP	−0.0542***	0.0804***	0.286***	−0.0203	0.131***	0.00870	−0.110***	−0.0255*	0.0128	1				
Inflation	−0.144***	0.223***	0.202***	−0.121***	0.168***	−0.111***	−0.339***	0.0351**	−0.141***	0.312***	1			
Financial distress	0.0799***	0.117***	−0.195***	0.0623***	0.0387**	0.00409	0.155***	0.136***	0.0364**	−0.338***	−0.0767***	1		
Capital stringency	0.0227	0.0356**	0.0919***	−0.0998***	−0.0218	−0.0970***	−0.219***	−0.0241	−0.0550***	0.135***	0.460***	−0.0647***	1	
Multiple supervisors	−0.363***	0.204***	0.106***	0.136***	0.0851***	0.103***	−0.0541***	0.0596***	−0.240***	0.193***	0.226***	−0.0623***	0.0591***	1
External governance index	−0.297***	0.167***	−0.000614	0.360***	0.0745***	0.404***	0.201***	−0.0745***	−0.178***	−0.0248*	0.0464***	0.0924***	−0.0272*	0.355***
N	6692													

This table reports the correlation matrix of the main regression variables for the sample of publicly listed OECD banks from 2001 to 2013, containing 6692 bank-year observations. All correlations are significant at the 1% level, unless otherwise noted., ***, **, and * indicate the significance of the pair-wise correlations respectively at the 1%, 5%, and 10% levels.

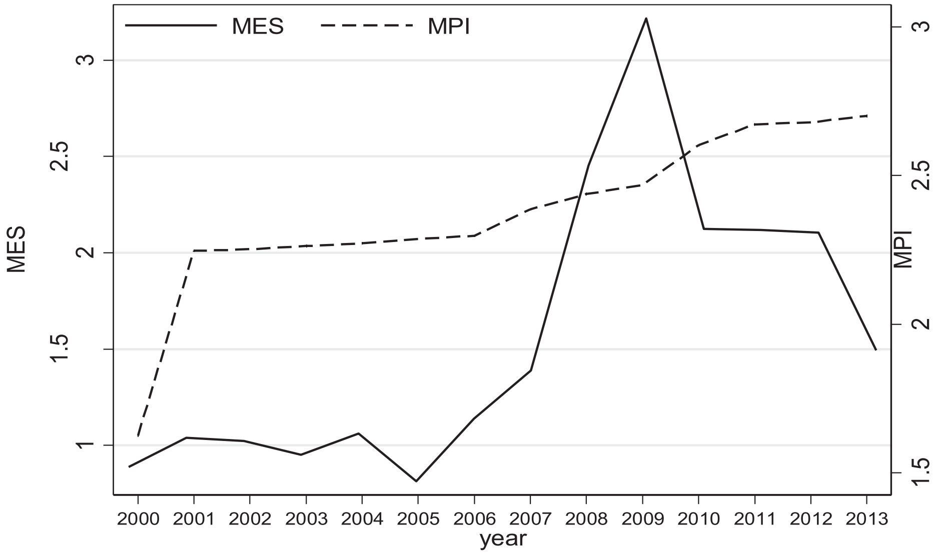

Fig. 1. Evolution over time of the MPI index and the MES. This graph contains information on the relationship between macroprudential policies and bank stability. The figure depicts the evolution between 2000 and 2013 of the two main variables of interest: macroprudential policies and bank stability. The macroprudential policies are proxied by the aggregated MPI index constructed by Cerutti et al. (2017a). Bank stability is captured by the MES. The former indicator is initially constructed at the country-year level, while the latter is calculated at the bank-year level. Both indicators are then averaged by country on an annual basis between 2000 and 2013. The plotted lines correspond with the annual averages of these cross-country averages. The evolution of the MPI index is shown on the right axis, whereas the evolution of the MES is shown on the left axis.

existing databases as used in (Budnik and Kleibl, 2018; Meuleman and Vennet, 2020). ***Second***, it combines detailed information from five existing databases, the recent survey of country authorities conducted by the IMF (the Annual Macroprudential Policy Survey), and various additional sources, such as authorities' official announcements and IMF country documents. *Third*, it tracks twelve macroprudential policies over time, so that many groupings are possible. Specifically, it contains information on the nature of the actions and provides a concise view of two main targeted policies. Each policy action is classified either as borrower-based or financial institutions-based policy action. *Fourth*, it is designed in such a way that respondents can choose from a closed list of policy tools, in an open-text questionnaire, which also ensures the comparability across measures and countries over time.[11]

Shortly after the financial crisis of 2007–2008, the Basel Committee on Banking Supervision launched Basel III. Despite earlier reforms, several banks were found to be overleveraged and undercapitalized during the crisis. Although the deadline for adopting the new rules was originally set for 2015, it has been continuously pushed back and is now set for January 1, 2023. Basel III aims to improve individual bank resilience to lessen the risk of systemic shocks and avoid future economic meltdowns.

The financial accounts of a bank include factors, like Tier 1 capital, equity, and declared reserves. Tier 2 denotes a bank's additional capital, such as secret reserves and unsecured subordinated debt instruments, whereas Tier 1 denotes the bank's main capital. By adding both layers, a bank's total capital is computed. Under Basel III, a bank's minimum overall capital ratio is 8 % of its risk-weighted assets (RWAs), with a Tier 1 capital ratio of 6 %. Under Basel III, banks must additionally retain additional reserves known as countercyclical capital buffers. Basel III also added new leverage and liquidity restrictions to protect banks from excessive and risky lending, while also ensuring that they have enough liquidity during times of financial stress. Certain countries have already implemented parts of the Basel III agreement.[12] The rest are scheduled to go into effect on January 1, 2023 and will be phased in over a five-year period. Certainly, a significant proportion of the 12 different macroprudential policy instruments considered in the paper are rather related in the current Basel III framework. Our empirical implicitly analysis accounts for changes designated in the Basel III, mainly through the capital ratios, leverage, and liquidity ratios and other bank-specific control variables. Since the countries have different levels and speeds of adoption of Basel III requirements, our control variables, like the capital ratios, leverage, and liquidity ratios, also reflect the changes in Basel III. Some of 12 different macroprudential policy instruments might be adopted due to Basel III requirements. Hence, the impact of Basel III is implicitly taken into account in our empirical analysis. Our results confirm the

[11] The macro-prudential policies toolkit is large, and hence, as it combines an array of different instruments. The purpose of the various policies could differ. Observers tend to classify policies by their effectiveness and intended targets. For instance, some policies are intended to increase directly the financial sector's resilience, while others focus on dampening the cycle as an intermediate target. Many classifications are proposed categorizes these measures, see Altunbas et al. (2018), Fendoğlu (2017), and Schoenmaker and Wierts (2011). Unlike Vandenbussche et al. (2015), we opt to quantify the policy tool over time rather than changes across policy types. More insights about how we construct the macro-prudential measures, see Fig. A1 in Appendix A.

[12] See for the list of countries and their progress at various report of Bank for International Settlement (BIS): "Progress Report on Adoption of the Basel Regulatory Framework: October 2021".

importance of these variables, as well as the implications of Basel III regulations in reducing banks' systemic risk. However, we are not mainly exploring the reasons of adoption of these macroprudential policies. Instead, we are focusing on the effects of their implementation on systemic stability.

2.5. Control variables

We use accounting and market data to construct a set of business model variables to capture asset, liability and income structure of the listed banks as in Anginer et al. (2014), Laeven et al. (2016), and Bakkar et al. (2020). We account for bank size *per se* by using the natural logarithm of total assets in U.S. dollars. We measure bank's asset structure by defining variables that capture the composition of earning assets (loan-to-value ratio, net loans to total assets), and bank liquidity proxy (net loans to total deposit). We account for banks' funding and capital structure by using retail funding (ratio of customer deposits, customer deposits to total funding) and unweighted capital ratio (leverage ratio, that is total equity to total assets). We capture banks' income structure by using diversification ratio (share of non-interest income in total income), and bank efficiency (cost-income ratio, defined as non-interest expenses to total income). Bank profitability is captured by the pre-tax income over total assets (return on assets ratio) and bank market power proxy is captured by the charter value (Tobin's q that is the proportion of the market value of assets in the book value of total assets). Besides, given country differences, we include various time-varying country controls in the regressions (Gaganis et al., 2020, Claessens et al., 2013). One set of variables consists of the short-term policy rate to control the monetary policy stance, which can be expected to affect the country's financial cycle, including the degree of risk-taking and the effectiveness of policies. Alternatively, we replace it by using the government one-year bond yield or the interbank interest rates in the market for each country. We include the real GDP growth rate to proxy for the country's business cycle state, as that will affect whether banks are more likely to expand or contract their balance sheets. We also control the country's inflation rate. Note that all variables have been winsorized at the top and bottom 1 % levels.

2.6. Descriptive statistics

Table 2 reports summary statistics, the sources and definitions on the bank-level and the country-level variables used in the analysis.

Panel A of Table 2 presents the bank-level systemic risk measures and the characteristics at the individual bank level over the sample period. The summary statistics reveal that banks vary in their systemic risk importance. An average bank in the sample has MES, SRISK and ΔCoVaR values of 1.71 %, 2.98, and 1.56 %, respectively, whereas systemic risk measures are dispersed regarding their standard deviations. We also provide descriptive statistics for the bank-level characteristics we use to control bank's systemic risk. The mean of the natural logarithm of total assets is 8.40 and the median is 7.80 (which corresponds to about $3 billion and $2 billion, respectively). Although we only consider publicly traded OECD banks, the sample still exhibits considerable heterogeneity across banks. This is clear from the standard deviation (2.21) and the range between the 5th and 95th (6.51 to 9.73). Overall, for the rest of bank characteristics across the sample, we observe that an average bank has a leverage ratio of 9 %, return on assets ratio of 0.7 %, retail funding ratio of 89.7 %, liquidity level as indicated by the ratio of net loans to total deposits of 109 %, cost-cost efficiency ratio of 46 %, profit-generating potential (Tobin's Q) of 1.05, and income diversification ratio of 20 %.[13]

Panel B of Table 2 provides summary statistics for the country-level characteristics. The average country in the sample has around three macroprudential policies in place at a given point in time; however, we observe values across almost the entire theoretical range of the MPI index, that is from zero (e.g., Netherlands in 2002) to five (e.g., Hungary in 2013). Turning to the monetary policy stance, the average country in the sample has a short-term policy rate (STInterest) of 2.52 %. As expected, there is heterogeneity across countries that is evident by the standard deviation of 3.75, and the range of the central bank policy rate value varies from 0 to 60 %. These numbers are comparable to those in previous studies in the literature (see, e.g., Gaganis et al., 2020; Cerutti et al., 2017a).

Table 3 presents the pairwise correlation coefficients among all variables. Consistent with our expectations, the correlation coefficients between MES and SRISK (ΔCoVaR) is 0.26 (0.64), and the three of them have a negative correlation with default measures (MZ-score and DtD). While MZ-score and DtD and MZ-score are positively correlated (0.79). The magnitude of these correlation coefficients indicates that the five indicators capture different aspects of bank systemic risk, as presented in Section 2.3. Among the rest of the variables, the test statistics reveal no major collinearity issues, enabling us to use the variables simultaneously in the regressions.

Fig. 1 illustrates the evolution of the average aggregated macroprudential policy index (MPI) and bank systemic risk (MES) over the 2000–2013 period. The MPI index is at the country level and then averaged yearly between 2000 and 2013. The MES is initially calculated at the bank-year level and then averaged by country yearly over the same period. The plotted lines correspond to the annual averages of these cross-country averages. Even though we only have the most developed OECD countries in our sample, the pattern of time-series changes in the MPI index is comparable to that in Cerutti et al. (2017a). The MPI index has sharply increased between 2000 and 2001 and keeps a steady increase until 2013. This suggests the existence of some macroprudential instruments even before the global financial crisis. Fig. 1 also shows the evolution of our measure of systemic risk (MES). Consistent with Anginer et al. (2018), we find an increase in systemic risk leading up to the global financial crisis peaked in 2009. Our figure also indicates a negative relation between macroprudential policies and systemic risk, which we will empirically examine in the following section.

[13] These variables are often used in similar studies, see e.g.: Meuleman and and Vennet (2020), Gaganis et al. (2020), Bakkar et al. (2020) or Bakkar and Pamen-Nyola (2021). Similarly, banks in our sample are on average larger, cost-effective, liquid, profitable, and have less retail funding, and a higher share of non-interest revenue.

Table 4
Macroprudential policies and systemic risk: baseline results.

	Panel A: the baseline measure		Panel B: Alternatives measures systemic risk			
	(1) MES	(2) MES	(3) SRISK	(4) ΔCoVaR	(5) MZ-score	(6) DtD
MPI	**−0.137***** **(−2.82)**	**−0.159***** **(−3.40)**	**−1.112**** **(−2.41)**	**−0.151***** **(−3.38)**	**2.629***** **(3.92)**	**0.189***** **(3.36)**
Size		0.592*** (5.41)	2.634** (2.43)	0.208** (2.28)	1.464 (1.30)	0.0866 (1.07)
Leverage		3.553*** (3.87)	−4.581 (−0.53)	4.012*** (4.46)	39.14*** (2.96)	3.966*** (4.03)
RoA		−21.71*** (−5.94)	22.66 (0.96)	−0.533 (−0.17)	406.0*** (10.99)	32.63*** (12.48)
Funding		0.672** (2.03)	11.51* (1.72)	0.589* (1.80)	−11.12*** (−2.81)	−0.620** (−2.21)
TobinQ		0.988*** (3.92)	14.36** (2.11)	−0.299 (−1.35)	−11.49*** (−3.59)	−0.570** (−2.37)
Liquidity		−1.033*** (−5.01)	−12.65** (−2.56)	−0.0422 (−0.24)	2.722 (0.88)	−0.0428 (−0.19)
Efficiency		−0.194 (−0.52)	10.49** (2.25)	−0.203 (−0.63)	−5.864 (−1.32)	−0.577* (−1.76)
Loan		−1.301*** (−2.92)	−39.09*** (−2.85)	0.933*** (2.62)	12.53** (2.16)	0.145 (0.34)
Diversification		−0.201 (−0.47)	−12.18** (−2.09)	0.519 (1.37)	−11.11** (−2.17)	−1.069*** (−2.86)
GDP		0.0475** (2.35)	0.0250 (0.10)	0.0416** (2.25)	0.0649 (0.29)	0.00550 (0.33)
Inflation		7.212*** (5.39)	34.88** (2.56)	3.394* (1.78)	10.14 (0.89)	1.629* (1.67)
Constant	1.957*** (14.86)	−2.078* (−1.78)	−1.276 (−0.09)	−0.386 (−0.37)	33.40*** (2.58)	2.599*** (2.84)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6692	6692	6624	6572	6607	6352
Banks	622	622	622	622	622	608
R–squared	0.330	0.361	0.100	0.345	0.508	0.536
Adjusted R–squared	0.159	0.358	0.096	0.343	0.506	0.534
Fischer test (p-value)	72.82***	51.19***	2.670***	79.31***	157.4***	168.9***

This table displays the regression results of the model in Equation (1), estimating the effect of macroprudential policies on bank systemic risks, including bank- and country-level controls. *Panel* A presents the results for the *MES* = Marginal Expected Shortfall, which is the marginal participation of a bank to the Expected Shortfall (ES) of the financial system, a measure of bank equity sensitivity to market crashes. *MPI* = denotes the aggregated macroprudential policies index (contains all tools, equally weighted). *Panel* B presents the results for: *SRISK* = Systemic risk, expected capital shortfall; Δ*CoVaR* = ΔConditional Value-at-Risk of a bank to an entire financial system or benchmark/reference market conditional on an extreme event leading to the fall of a bank's stock returns beyond their critical threshold level.; *MZ-score* = market-based z-score; and *DtD* = Merton's distance to default. Definitions of all variables are presented in Table 1 and Appendix A. Fischer test tests the absence of individual effects. Standard errors are reported in parentheses below their coefficient estimates adjusted for both heteroskedasticity and within correlation clustered at the bank level. ***, **, and * indicate significance of the p-value respectively at the 1 %, 5 %, and 10 % levels. We also ensure the absence of multicolinearity problems by computing the variance inflation factors (VIF test is not reported).

3. Empirical analysis and findings

3.1. Effectiveness of macroprudential policy on systemic stability: Baseline results

Table 4 presents the baseline results of the regression-based evidence on the relationship between the (lagged) aggregated macroprudential policies index, MPI (all tools), whereby all tools are equally weighted, and the individual bank systemic risk, the MES. Table 4 reports the coefficient estimates for the bank fixed effect regressions. *First*, since some of the control variables are correlated, in Column (1), we start by including only the MPI index as the explanatory variable for the individual bank stability. The baseline regression results highlight that the aggregated macroprudential index is negatively associated and statistically significant with the bank systemic risk. This suggests that macroprudential policies have substantial power to mitigate the effects of bank systemic risk and thus increase financial stability.

The effect of the MPI index on systemic risk is not only statistically significant but also economically important. For instance, a one standard deviation change in the MPI index reduces bank systemic risk (MES) by 0.16 % points on average across the sample period.

Table 5
Macroprudential policies, systemic risk, and monetary policy.

	Baseline	Alternative systemic risk measures			
	(1) MES	(2) SRISK	(3) ΔCoVaR	(4) MZ-score	(5) DtD
MPI	**−0.173***** (−3.84)	**−1.210**** (−2.18)	**−0.175***** (−3.77)	**2.634***** (3.79)	**0.179***** (2.91)
STInterest	−0.0172 (−1.17)	−0.112 (−0.59)	−0.0276** (−1.97)	0.00515 (0.03)	−0.00643 (−0.49)
Size	0.578*** (5.21)	2.545** (2.32)	0.187** (2.03)	1.468 (1.29)	0.0822 (1.01)
Leverage	3.545*** (3.85)	−4.646 (−0.53)	3.997*** (4.44)	39.15*** (2.96)	3.965*** (4.03)
RoA	−21.79*** (−5.95)	22.11 (0.92)	−0.629 (−0.20)	406.1*** (10.96)	32.58*** (12.43)
Funding	0.672** (2.03)	11.50* (1.72)	0.592* (1.81)	−11.12*** (−2.81)	−0.616** (−2.19)
TobinQ	0.953*** (3.75)	14.14** (2.16)	−0.352 (−1.57)	−11.48*** (−3.57)	−0.580** (−2.41)
Liquidity	−1.030*** (−4.98)	−12.62** (−2.57)	−0.0424 (−0.24)	2.721 (0.87)	−0.0469 (−0.21)
Efficiency	−0.243 (−0.65)	10.17** (2.23)	−0.275 (−0.86)	−5.849 (−1.31)	−0.596* (−1.79)
Loan	−1.322*** (−2.97)	−39.23*** (−2.83)	0.894** (2.47)	12.53** (2.16)	0.129 (0.30)
Diversification	−0.214 (−0.50)	−12.27** (−2.09)	0.497 (1.30)	−11.11** (−2.17)	−1.075*** (−2.87)
GDP	0.0473** (2.35)	0.0233 (0.09)	0.0415** (2.24)	0.0650 (0.28)	0.00512 (0.31)
Inflation	8.753*** (4.91)	44.91 (1.61)	6.067*** (3.22)	9.677 (0.66)	2.237** (1.97)
Constant	−2.800** (−2.26)	−2.294 (−0.16)	−0.904 (−0.82)	51.99*** (3.85)	4.007*** (4.15)
Year FE	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes
Observations	6692	6624	6572	6607	6352
Banks	622	622	622	622	608
R–squared	0.361	0.0993	0.346	0.508	0.536
Adjusted R–squared	0.358	0.0959	0.343	0.506	0.534
Fischer test (p-value)	49.66***	2.653***	75.60***	151.3***	161.9***

This table displays the regression results of the model presented in Equation (1), estimating the effect of macroprudential and monetary policies on bank systemic risks, including bank- and country-level controls. *MES* = Marginal Expected Shortfall, *SRISK* = Systemic risk, expected capital shortfall, *ΔCoVaR* = ΔConditional Value-at-Risk of a bank to an entire financial system or benchmark/reference market conditional on an extreme event leading to the fall of a bank's stock returns beyond their critical threshold level, *MZ-score* = market-based z-score, and *DtD* = Merton's distance to default. *MPI* = denotes the macroprudential policies index (contains all tools, equally weighted), and *STInterest* = is the short-term policy rate. Definitions of all variables are presented in Table 1 and Appendix A. Standard errors are reported in parentheses below their coefficient estimates and adjusted for both heteroskedasticity and within correlation clustered at the bank level. ***, **, and * indicate significance of the p-value respectively at the 1 %, 5 %, and 10 % levels. We also ensure the absence of multicolinearity problems by computing the variance inflation factors (VIF test is not reported).

This is associated with a 32 % standard deviation reduction in the individual bank's systemic risk exposure (MES).[14] In the second empirical setup, Column (2), we include the additional bank and country-level controls (as in Eq. (1)). We document that the MPI index and bank systemic risk relationship is both negative and statistically significant at 1 %. Similarly, the effect is not only and statistically significant but also economically important. Hence, a one standard deviation increase in the MPI index decreases the MES by 26 % of its standard deviation reduction during the entire period.

Overall, our results align with Meuleman and Vennet (2020), who find that the overall macroprudential policy has a downward effect on the systemic exposure risk of European banks. Still, all banks benefit from macroprudential tools for their individual risk. Indeed, unlike previous studies that have documented a moderating effect of macroprudential measures on curbing credit growth and housing prices, which can be considered as intermediate targets (see also Beck, 2015; Kuttner and Shim, 2016; Vandenbussche et al., 2015; Akinci and Olmstead-Rumsey, 2018; Ayyagari et al. 2017; Beck and Gambacorta 2019), we confirm that macroprudential policy is also effective in containing bank systemic risk as assessed by financial market information. This finding supports the view of the role of macro-prudential policies in safeguarding financial stability.

[14] For example, the effect of the MPI index on the MES is computed as follows: $\frac{\partial Risk}{\partial MPI}$= [1.01*–0.137] = –0.139. This is associated with a [0.139*1.851] = 0.256 standard deviation reduction in MES.

Table 6
Macroprudential policies, systemic risk, and other central bank features.

Dependent Variable: *MES*	(1) Monetary performance index	(2) Absolute value of annual inflation rate	(3) Output gap
MPI	−0.174***	−0.170***	−0.264***
	(−3.93)	(−3.76)	(−4.71)
STInterest	−0.0422***	−0.00250	0.0415***
	(−2.95)	(−0.18)	(3.17)
Size	0.535***	0.571***	0.374***
	(4.82)	(5.14)	(2.83)
Leverage	3.292***	3.566***	2.925***
	(3.59)	(3.87)	(2.66)
RoA	−21.64***	−21.79***	–22.69***
	(−5.89)	(−5.99)	(−4.47)
Funding	0.583*	0.695**	0.688*
	(1.76)	(2.09)	(1.81)
TobinQ	0.891***	0.974***	1.183***
	(3.53)	(3.84)	(4.11)
Liquidity	−1.094***	−1.018***	−1.382***
	(−5.24)	(−4.91)	(−5.62)
Efficiency	−0.486	−0.262	−0.756
	(−1.28)	(−0.69)	(−1.61)
Loan	−1.447***	−1.326***	−2.158***
	(−3.28)	(−2.96)	(−4.42)
Diversification	−0.281	−0.179	−0.345
	(−0.66)	(−0.42)	(−0.68)
GDP	0.0426**	0.0465**	
	(2.09)	(2.36)	
Inflation	8.327***		
	(4.78)		
Monetary_Performance	**−0.0347***		
	(−4.39)		
Abs(Inflation)		**6.187***	
		(3.30)	
OutputGap			**0.133***
			(4.01)
Constant	0.865	−2.763**	0.477
	(0.59)	(−2.22)	(0.32)
Year FE	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes
Observations	6692	6692	5143
Banks	622	622	622
R–squared	0.363	0.359	0.404
Adjusted R–squared	0.361	0.356	0.402
Fischer test (p-value)	47.76***	48.61***	52.44***

This table displays the regression results of the model presented in Equation (1), estimating the effect of macroprudential and monetary policies on bank systemic risks, including bank- and country-level controls. *MES* = Marginal Expected Shortfall. Additionally, we control separately for three different features of central banks: in *Column* (1) we control for Abs(Inflation) = absolute value of annual inflation rate in each country j, in *Column* (2) we control for Monetary performance index = that measures the success of a country's monetary policy, and in *Column* (3) we control OutputGap, assuming equal weights of both inflation and real growth, as a proxy for Taylor-type rule. Definitions of all variables are presented in Table 1 and Appendix A. Standard errors are reported in parentheses below their coefficient estimates and adjusted for both heteroskedasticity and within correlation clustered at the bank level. ***, **, and * indicate significance of the p-value respectively at the 1 %, 5 %, and 10 % levels. We also ensure the absence of multicolinearity problems by computing the variance inflation factors (VIF test is not reported).

In relevance to the control variables, most of them enter significantly and carry the expected sign as in previous studies. As expected, we find that larger banks are systemically riskier (higher MES). Banks with higher market-to-book ratios have higher systemic risk exposure, suggesting that the availability of growth options increases systemic risk. The results also indicate a high systemic risk for less profitable banks. Banks that are more reliant on retail funding exhibit higher systemic risks.

In contrast, liquid banks that are more reliant on deposits and banks with a higher share of loans in total assets exhibit less systemic risk (lower MES). In contrast, better-capitalized banks pose greater systemic risk. However, the variables accounting for cost efficiency and diversification are not generally significant. For country-level variables, the annual growth rate of GDP is positively correlated with bank systemic risk, indicating higher bank risks undertaken in these countries. Coherently, we find that the annual inflation rate is also positively associated with systemic risk. More importantly, the MPI index and bank systemic risk relationship remain negative and statistically significant.

For more evidence, we examine whether the results are robust across different alternative measures of systemic risk. The regression results are presented in Columns (3–6) of Table 5), with each column corresponding to a different risk measure. At this point, it should be reminded that similar to the MES, higher values of SRISK and ΔCoVaR indicate higher systemic risk (lower stability). In contrast, in the case of MZ-score and distance to default (DtD), this relationship is inversed, with higher values corresponding to higher stability

Table 7
Macroprudential policies and systemic risk: decomposition of the MPI index.

Panel A: Lender-targeted and borrower-targeted macroprudential policies and systemic risk

	(1) MES	(2) MES	(3) MES	(4) MES
FITI	**−0.137*** **		**−0.145*** **	
	(−2.68)		**(−2.82)**	
BTI		**−0.174***		**−0.228** **
		(−1.80)		**(−2.51)**
Size			0.581***	0.585***
			(5.31)	(5.37)
Leverage			3.541***	3.653***
			(3.84)	(3.97)
RoA			−21.81***	−22.00***
			(−5.96)	(−6.05)
Funding			0.632*	0.665**
			(1.92)	(2.01)
TobinQ			0.965***	0.987***
			(3.84)	(3.91)
Liquidity			−0.992***	−1.025***
			(−4.84)	(−4.95)
Efficiency			−0.159	−0.228
			(−0.43)	(−0.61)
Loan			−1.207***	−1.276***
			(−2.73)	(−2.85)
Diversification			−0.152	−0.193
			(−0.35)	(−0.45)
GDP			0.0496**	0.0396*
			(2.41)	(1.92)
Inflation			7.582***	7.237***
			(5.69)	(5.41)
Constant	1.298***	1.025***	−2.094*	−2.434**
	(15.06)	(24.62)	(−1.79)	(−2.08)
Year FE	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes
Observations	6692	6692	6692	6692
Banks	622	622	622	622
R–squared	0.330	0.329	0.360	0.360
Adjusted R–squared	0.163	0.140	0.357	0.357
Fischer test (p-value)	72.89***	72.38***	51.18***	50.59***

Panel B: Lender-targeted and borrower-targeted macroprudential policies and systemic risk: alternatives measures of systemic risk

	(1) SRISK	(2) ΔCoVaR	(3) MZ-score	(4) DtD	(5) SRISK	(6) ΔCoVaR	(7) MZ-score	(8) DtD
FITI	**−1.029** **	−0.0774	**2.479*** **	**0.190** **				
	(−1.97)	(−1.44)	**(2.80)**	**(1.97)**				
BTI					**−1.561** **	**−0.384*** **	**3.598*** **	**0.238*** **
					(−2.11)	**(−4.54)**	**(3.27)**	**(3.06)**
Size	2.561**	0.193**	1.642	0.0992	2.586**	0.213**	1.558	0.0919
	(2.38)	(2.11)	(1.44)	(1.22)	(2.40)	(2.37)	(1.38)	(1.14)
Leverage	−4.627	4.039***	39.41***	3.985***	−3.838	4.130***	37.39***	3.925***
	(−0.53)	(4.46)	(2.98)	(4.04)	(−0.45)	(4.59)	(2.84)	(3.98)
RoA	22.07	−0.744	407.7***	32.72***	20.66	−0.719	410.0***	32.49***
	(0.93)	(−0.23)	(11.01)	(12.48)	(0.87)	(−0.22)	(11.07)	(12.45)
Funding	11.22*	0.541*	−10.44***	−0.570**	11.44*	0.625*	−10.99***	−0.613**
	(1.69)	(1.66)	(−2.64)	(−2.03)	(1.71)	(1.92)	(−2.78)	(−2.20)
TobinQ	14.20**	−0.325	−11.12***	−0.541**	14.35**	−0.277	−11.45***	−0.571**
	(2.10)	(−1.45)	(−3.46)	(−2.23)	(2.10)	(−1.26)	(−3.58)	(−2.38)
Liquidity	−12.37**	0.00546	2.038	−0.0914	−12.57**	−0.0770	2.536	−0.0737
	(−2.54)	(0.03)	(0.66)	(−0.40)	(−2.54)	(−0.43)	(0.82)	(−0.32)
Efficiency	10.76**	−0.176	−6.453	−0.622*	10.26**	−0.272	−5.394	−0.559*
	(2.29)	(−0.55)	(−1.46)	(−1.90)	(2.22)	(−0.85)	(−1.22)	(−1.71)
Loan	−38.43***	1.047***	10.96*	0.0258	−38.88***	0.859**	12.11**	0.121
	(−2.83)	(2.95)	(1.88)	(0.06)	(−2.83)	(2.41)	(2.06)	(0.28)
Diversification	−11.85**	0.573	−11.94**	−1.117***	−12.14**	0.481	−11.25**	−1.095***
	(−2.04)	(1.49)	(−2.32)	(−2.97)	(−2.05)	(1.27)	(−2.20)	(−2.93)
GDP	0.0403	0.0409**	0.0271	0.00211	−0.0305	0.0314*	0.189	0.00772
	(0.17)	(2.22)	(0.12)	(0.13)	(−0.12)	(1.67)	(0.85)	(0.48)
Inflation	37.50***	3.869**	4.088	1.192	35.14**	3.076	9.066	1.358
	(2.67)	(2.05)	(0.35)	(1.17)	(2.56)	(1.61)	(0.84)	(1.44)

(*continued on next page*)

Table 7 (*continued*)

Panel B: Lender-targeted and borrower-targeted macroprudential policies and systemic risk: alternatives measures of systemic risk

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	SRISK	ΔCoVaR	MZ-score	DtD	SRISK	ΔCoVaR	MZ-score	DtD
Constant	−1.398	−0.532	33.54***	2.580***	−3.766	−0.737	39.45***	3.053***
	(−0.10)	(−0.51)	(2.58)	(2.80)	(−0.28)	(−0.72)	(3.07)	(3.33)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6624	6572	6607	6352	6624	6572	6607	6352
Banks	622	622	622	608	622	622	622	608
R–squared	0.098	0.344	0.507	0.535	0.0980	0.346	0.506	0.535
Adjusted R–squared	0.095	0.342	0.505	0.533	0.0947	0.344	0.504	0.533
Fischer test (p-value)	2.620***	78.32***	158.6***	170.4***	2.680***	76.10***	158.0***	167.3***

This table displays the regression results of model presented in Equation (2), based on the macroprudential policies transmission mechanism. Results present the effect of the borrower-targeted *or* lender-targeted macroprudential tools on bank systemic risks, including bank- and country-level controls. *Panel* A presents the results for the *MES* = Marginal Expected Shortfall. *FITI* = denotes the financial institution-targeted macroprudential instruments Index, and *BTI* = borrower-targeted macroprudential instruments index. *Panel* B presents the results for: *SRISK* = Systemic risk, expected capital shortfall, Δ*CoVaR* = ΔConditional Value-at-Risk of a bank to an entire financial system or benchmark/reference market conditional on an extreme event leading to the fall of a bank's stock returns beyond their critical threshold level, *MZ-score* = market-based z-score, and *DtD* = Merton's distance to default. Definitions of all variables are presented in Table 1 and Appendix A. Standard errors are reported in parentheses below their coefficient estimates and adjusted for both heteroskedasticity and within correlation clustered at the bank level. ***, **, and * indicate significance of the p-value respectively at the 1 %, 5 %, and 10 % levels. We also ensure the absence of multicolinearity problems by computing the variance inflation factors (VIF test is not reported).

(lower risk).

Column (3) Table 4 reports the regression results of SRISK on the MPI index and the control variables. We find a negative relationship between the MPI and SRISK, suggesting that macroprudential policies significantly mitigate systemic risk exposure and thus reduce bank capital shortfalls. In Column (4), we use ΔCoVaR as the measure of systemic risk contribution. We find a negative relationship between the MPI index and ΔCoVaR, suggesting that the employment of macroprudential policies reduces contagion risks. In Column (5), we use the market-based z-score to measure bank default risk. The results suggest that the MPI index also decreases bank default (insolvency) risks (higher MZ-score). Column (6) uses the bank Merton's distance to default as a proxy of default risk. Similar to our results using the MZ-score, we find that the MPI index is positively associated with the market z-score, which implies that the usage of macroprudential policies increases the bank distance to default and, thus, reduces the probability of bank failure (higher DtD). The results suggest that these findings are robust to different risk measures and that the use of these alternative systemic risk measures in studying the effectiveness of macroprudential policies on bank systemic risk can be beneficial, as these risk measures are calculated using different methods. Overall, the evidence in Table 4 suggests that the regulations that impose macroprudential policies enhance stability.

3.2. *Estimation results with additional central bank features*

Besides the direct effect of macroprudential tools on bank stability, monetary policy also has an impact on risk-taking and financial stability (Altunbas et al., 2018; and Borio and Zhu, 2014). Borio and Zhu (2014) and Altunbas et al. (2018) argue that low policy rates could affect bank risk-taking policies in two different channels. The first channel is through the search-for-yield incentive, as argued by Rajan (2006) and Dell'Ariccia et al. (2010). Therefore, low interest rates may increase incentives for managers to take on more risks for contractual, behavioural or institutional reasons.[15] The second channel is through their impact on valuations, incomes and cash flows. Lower policy rates could boost asset and collateral values, which in turn can reduce risk perceptions and/or increase risk tolerance (Borio and Zhu, 2014).

Against this background, Table 5 reports the estimated effect of the aggregated macroprudential policy index (all tools) on systemic risk, while controlling the effect of monetary policy stance, gauged by the central bank short-term policy rate. In the aftermath of the Global Financial Crisis, there was a widespread perception that new regulations were needed to ensure the stability of the financial system, which fostered the design and adoption of macroprudential policies (Cerutti et al., 2017). This raised important questions for monetary policy. According to Martin et al. (2021), macroprudential policies apply to interventions that attempt to correct any excessive risk coming from the systemic risk part of the banking sector and raised by certain factors, such as monetary policy. At the same time, given that macroprudential policies are generally incomplete, this raises the significance of the necessary optimal adjustments to monetary policy to deal not just with its traditional business regarding nominal rigidities, but also with the distortions coming from systemic risk and that cannot be appropriately addressed by macroprudential policy. Overall, the literature has identified the complementary role monetary and macroprudential policies can play (Arujo et al., 2020; Gadea et al., 2021) and this is really what

[15] Dell'Ariccia et al. (2011) show in their theoretical model that monetary easing leads to a reduction in the interest rate on bank loans and bank's return. This reduces the bank's incentive to monitor its loans, and hence increases their risky assets.

Table 8
The joint stance of lender-related and borrower-related macroprudential policies and systemic risk.

Dependent Variable: MES	(1)	(2)	(3)	(4)	(5)
	Joint stance: complementary vs substitutability		Effect of financial distress	Microprudential regulation	
FITI	**−0.150*****	**−0.121****	**−0.164*****	0.0076	0.0251
	(−3.10)	(−2.57)	(−2.91)	(0.10)	(0.32)
BTI	**−0.237*****	0.192	0.380	−0.0331	−0.293**
	(−2.79)	(1.33)	(0.94)	(−0.50)	(−2.30)
BTI × FITI		**−0.214*****	**−0.763*****		**−0.156*****
		(−3.09)	(−3.33)		(−2.69)
FITI × Financial distress			0.0950*		
			(1.79)		
BTI × Financial distress			−0.0901		
			(−0.22)		
FITI × BTI × Financial distress			**0.508****		
			(2.23)		
BIS capital adequacy				**−0.250*****	**−0.250*****
				(−16.39)	**(−16.39)**
STInterest	−0.0181	−0.0241*	−0.0302**	−0.0279	−0.0354*
	(−1.24)	(−1.69)	(−1.97)	(−1.53)	(−1.86)
Financial distress			1.257***		
			(7.03)		
Size	0.580***	0.574***	0.550***	0.276***	0.274***
	(5.23)	(5.17)	(4.93)	(2.74)	(2.72)
Leverage	3.567***	3.601***	3.507***	13.16***	13.12***
	(3.86)	(3.90)	(3.77)	(10.44)	(10.44)
RoA	−21.82***	–22.04***	−21.41***	−17.73***	−17.70***
	(−5.96)	(−6.04)	(−5.76)	(−4.59)	(−4.59)
Funding	0.683**	0.639*	0.609*	0.433	0.389
	(2.06)	(1.94)	(1.80)	(1.15)	(1.03)
TobinQ	0.958***	0.918***	0.963***	0.965***	0.926***
	(3.77)	(3.63)	(3.78)	(3.05)	(2.91)
Liquidity	−1.041***	−1.029***	−1.066***	−1.023***	−1.000***
	(−5.00)	(−4.93)	(−5.10)	(−4.04)	(−3.93)
Efficiency	−0.263	−0.281	−0.355	−0.0344	−0.0443
	(−0.70)	(−0.75)	(−0.94)	(−0.09)	(−0.11)
Loan	−1.348***	−1.297***	−1.484***	−0.962*	−0.895
	(−3.01)	(−2.91)	(−3.32)	(−1.67)	(−1.55)
Diversification	−0.229	−0.222	−0.243	−0.863**	−0.877**
	(−0.54)	(−0.52)	(−0.57)	(−1.98)	(−2.01)
GDP	0.0452**	0.0524**	0.0660***	0.0455**	0.0509**
	(2.19)	(2.45)	(2.67)	(2.08)	(2.27)
Inflation	8.725***	9.173***	9.865***	12.51***	12.92***
	(4.88)	(5.25)	(5.25)	(3.82)	(3.81)
Constant	−2.828**	−2.825**	−2.653**	−0.0434	−0.0584
	(−2.29)	(−2.28)	(−2.25)	(−0.04)	(−0.05)
Year FE	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes
Observations	6692	6692	6692	6004	6004
Banks	622	622	622	603	603
R–squared	0.361	0.362	0.364	0.402	0.403
Adjusted R–squared	0.358	0.360	0.361	0.399	0.400
Fischer test (p-value)	48.07***	47.58***	51.13***	63.74***	62.51***

This table displays the regression results of the model presented in Equation (2), estimating the effect of the borrower-targeted and lender-targeted macroprudential tools and monetary policy on bank systemic risks, including bank- and country-level controls. *Columns* (1) and (2) present results of joint effect of both FITI and BTI on banks systemic risk (stability), to assess the possible complementarity (or *substitutability*) between the components of the macroprudential policy. *Column* (3) show the role of economic pressures (*boom bust cycle*) in the efficacy of the joint stance of FTI and BTI in mitigating instability. *Columns* (4) and (5) we control for the microprudential policies using BIS capital adequacy ratio. *MES* = Marginal Expected Shortfall. *FITI* = denotes the financial Institution-targeted macroprudential instruments Index, and *BTI* = borrower-targeted macroprudential instruments index. *Financial distress* = dummy variable takes the value of one during distress years [2007–2013], and zero otherwise. *BIS capital adequacy* = Bank of International Settlements' capital adequacy ratio for each bank i at year t. *STInterest* = is the short-term policy rate. Definitions of all variables are presented in Table 1. Standard errors are reported in parentheses below their coefficient estimates and adjusted for both heteroskedasticity and within correlation clustered at the bank level. ***, **, and * indicate significance of the p-value respectively at the 1 %, 5 %, and 10 % levels. We also ensure the absence of multicolinearity problems by computing the variance inflation factors (VIF test is not reported).

motivated us to explicitly introduce the stance of monetary policy into our regressions. For further discussions on the interaction between monetary policy and macroprudential regulations the literature offers the studies by Leduc and Natal (2016), De Paoli and Paustian (2017) and Gersbach el al. (2018), among others.

The coefficients on the MPI index, as well as those on the control variables, do not change much when the monetary policy index is

Table 9
Macroprudential policies, systemic stability and bank features interactions.

Dependent Variable: MES	(1) Size	(2) Too-Big-Too-Fail	(3) Leverage	(4) Liquidity	(5) Concentration
FITI	−0.466**	−0.0538	−0.0424	−0.0592	−0.0451
	(−2.21)	(−0.93)	(−0.54)	(−0.54)	(−0.35)
BTI	2.202***	0.378**	−0.343	0.889	0.557
	(3.19)	(2.08)	(−0.90)	(1.37)	(1.56)
FITI × BTI	**−1.436***	**−0.293***	**−0.241***	**−1.113***	**−0.479***
	(−3.13)	(−3.39)	(−1.95)	(−3.55)	(−3.16)
FITI×Λ_{t-1}	0.0389*	−0.0919*	−0.594	−0.0200	0.0175
	(1.66)	(−1.76)	(−0.80)	(−0.17)	(0.10)
BTI×Λ_{t-1}	−0.193***	−0.478	6.585	−0.703	−1.048*
	(−2.97)	(−1.61)	(1.29)	(−0.83)	(−1.81)
FITI × BTI×Λ_{t-1}	**0.112***	**0.229**	**−5.991***	**0.837**	**0.903***
	(2.94)	(2.24)	(−2.95)	(2.45)	(2.87)
STInterest	−0.0334**	−0.0260*	−0.0414***	−0.0373***	−0.0313**
	(−2.36)	(−1.85)	(−2.63)	(−2.64)	(−2.08)
Size	0.483***	0.581***	0.564***	0.569***	0.586***
	(4.23)	(5.27)	(5.05)	(5.09)	(5.27)
Leverage	3.547***	3.585***	5.300**	3.669***	3.586***
	(3.83)	(3.87)	(2.54)	(3.96)	(3.91)
RoA	−22.28***	−21.72***	−22.60***	−22.70***	−21.65***
	(−6.07)	(−6.04)	(−6.20)	(−6.21)	(−5.93)
Funding	0.638*	0.594*	0.619*	0.561*	0.612*
	(1.92)	(1.82)	(1.86)	(1.69)	(1.86)
TobinQ	0.939***	0.928***	0.846***	0.868***	0.928***
	(3.71)	(3.70)	(3.29)	(3.41)	(3.69)
Liquidity	−1.050***	−1.025***	−1.027***	−0.997***	−0.994***
	(−5.02)	(−4.97)	(−4.94)	(−2.76)	(−4.85)
Efficiency	−0.332	−0.307	−0.373	−0.377	−0.219
	(−0.88)	(−0.82)	(−0.97)	(−1.00)	(−0.58)
Loan	−1.346***	−1.300***	−1.244***	−1.272***	−1.239***
	(−3.02)	(−2.96)	(−2.77)	(−2.83)	(−2.81)
Diversification	−0.291	−0.252	−0.281	−0.293	−0.263
	(−0.69)	(−0.60)	(−0.64)	(−0.69)	(−0.61)
TBTF		0.348***			
		(2.82)			
HHI					1.085**
					(2.17)
GDP	0.0550**	0.0608***	0.0527**	0.0498**	0.0605***
	(2.56)	(2.99)	(2.42)	(2.24)	(2.86)
Inflation	9.650***	9.328***	9.871***	9.670***	9.384***
	(5.62)	(5.41)	(5.58)	(5.65)	(5.03)
Constant	−1.876	−3.056**	−2.802**	−2.693**	−3.443***
	(−1.50)	(−2.50)	(−2.23)	(−2.08)	(−2.64)
Year FE	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes
Observations	6692	6692	6692	6692	6692
Banks	622	622	622	622	622
R–squared	0.364	0.365	0.364	0.365	0.364
Adjusted R–squared	0.362	0.362	0.361	0.362	0.361
Fischer test (p-value)	44.07***	42.93***	44.02***	45.31***	43.95***

This table displays the regression results of the model presented in Equation (3), estimating the heterogeneity of macroprudential instruments effect on systemic stability depending on several bank features and market structures. *MES* = Marginal Expected Shortfall. *FITI* = denotes the financial Institution-targeted macroprudential instruments Index, and *BTI* = borrower-targeted macroprudential instruments index. Λ represents vector of the variables to be interacted with FITI and BTI: Size, TBTF dummy, leverage ratio, liquidity ratio, and HHI loans concentration index. *STInterest* = is the short-term policy rate. Definitions of all variables are presented in Table 1. Standard errors are reported in parentheses below their coefficient estimates and adjusted for both heteroskedasticity and within correlation clustered at the bank level. Lags have been determined through the Akaike criterion. ***, **, and * indicate significance of the p-value respectively at the 1 %, 5 %, and 10 % levels. We also ensure the absence of multicolinearity problems by computing the variance inflation factors (VIF test is not reported).

added. We present the new regression results in Table 5. Overall, the results in Column 1 show that the aggregate macroprudential policy index, MPI, is negatively and statistically significantly associated with systemic risk, whereas the monetary policy rate enters as statistically non-significant. These findings suggest that macroprudential policies, as implemented on average, have been more effective compared to monetary policies. This suggests that macroprudential policies, as implemented on average, have been relatively more instrumental than conventional monetary policy (Cerutti et al., 2017a). Monetary policy rate appears globally less important in

Table 10
Macroprudential policies and systemic risk: alternative estimation methods and endogeneity correction.

Dependent Variable: MES	(1) Country FE	(2) Country*Year FE	(3) WLS	(4) GMM
Lagged MES	—	—	—	0.426***
				(18.94)
MPI	**−0.0906***	**−1.055*****	**−0.205****	**−0.0694****
	(−1.94)	(−20.40)	(−2.52)	(−2.29)
STInterest	−0.0103	**0.208*****	**0.107*****	**−0.0268****
	(−0.77)	(8.58)	(4.16)	(−1.99)
Leverage	2.071***	2.171***	3.600	0.154
	(2.91)	(3.02)	(1.34)	(0.29)
Size	0.570***	0.573***	0.513***	0.327***
	(17.51)	(16.92)	(7.62)	(13.69)
RoA	−17.53***	−15.80***	14.85	−5.999
	(−4.57)	(−3.97)	(0.69)	(−1.58)
Funding	0.819**	0.717*	−0.347	0.140
	(2.21)	(1.80)	(−0.47)	(0.52)
TobinQ	1.014***	1.469***	1.898**	0.992***
	(3.66)	(4.64)	(2.13)	(5.07)
Liquidity	−0.291	−0.146	0.389	−0.387***
	(−1.51)	(−0.69)	(0.78)	(−2.93)
Efficiency	−0.213	−0.0341	1.888*	−0.0256
	(−0.60)	(−0.09)	(1.85)	(−0.10)
Loan	−0.374	0.0300	0.0535	−0.478*
	(−0.87)	(0.06)	(0.05)	(−1.69)
Diversification	0.303	0.337	−1.063	−0.316
	(0.84)	(0.94)	(−0.88)	(−1.16)
GDP	0.0363*	0.119***	−0.0682	0.146***
	(1.71)	(2.91)	(−1.40)	(7.38)
Inflation	8.130***	−8.756***	5.215	10.10***
	(4.64)	(−3.14)	(1.43)	(5.58)
Constant	−4.655***	−7.320***	−4.782***	−3.496***
	(−6.82)	(−11.39)	(−2.60)	(−7.53)
Year FE	Yes	Yes	Yes	Yes
Country FE	Yes	No	No	No
Country × Year FE	No	Yes	No	No
Country relative weights	No	No	Yes	No
GMM	No	No	No	Yes
Bank FE	No	No	No	No
Observations	6692	6692	6692	6500
Banks	622	622	622	622
R–squared	0.515	0.586	0.528	—
Adjusted R–squared	0.511	0.565	0.526	—
Fischer test (p-value)	—	—	63.41***	—
AR2 test: *p-value*	—	—	—	0.117
Hansen test: *p-value*	—	—	—	0.206

This table shows the results of over the entire period using alternative estimation methods associated with the model presented in Equation (1), estimating the effect of macroprudential and monetary policies on bank systemic risks, including bank- and country-level controls. *MES* = Marginal Expected Shortfall. *MPI* = denotes the macroprudential policies index (contains all tools, equally weighted), and *STInterest* = is the short-term policy rate. Definitions of all variables are presented in Table 1. *Column* (1) reports the results for country fixed effects regressions. *Column* (2) presents country-year fixed effects regression results. *Column* (3) reports WLS regression results. For WLS, we take the inverse of the number of country observations for each country as the weight for each bank. *Column* (4) reports the coefficient estimates from a Arellano–Bond (GMM) panel regression (with two-step covariance estimates) that addresses the Nickell bias and uses the lagged macroprudential policies and all the explanatory variables as instrumental variables for the dependent variable. Hansen test's null hypothesis of over-identifying restrictions (i.e., the instruments as a group are exogenous) is not rejected (Hansen test's p-value = 0.206). Testing the null hypothesis of no first-order autocorrelation in levels (AR(2)) is not rejected. Robust standard errors are reported in parentheses below their coefficient estimates and adjusted for both heteroskedasticity and within correlation. Fischer test checks the absence of individual effects. The VIF test (not shown in the table) asserts the absence of muticollinearity problems. ***, **, and * indicate significance of the p-value respectively at the 1 %, 5 %, and 10 % levels. We also ensure the absence of multicolinearity problems by computing the variance inflation factors (VIF test is not reported).

affecting financial stability for OECD countries. This is in line with the literature that suggests that macroprudential policies are most effective in the long run and during periods of tightened monetary policy (see e.g., Yener et al., 2018; Ailian et al., 2020). This result also explains why more central banks across the globe start resorting more on macroprudential policies, especially when global interest rates decline. Correspondingly, three important caveats to the interpretation of this result are in order. *First*, these results confirm the inclinations of the central banks to employ more macroprudential policies instead of just relying on short-term interest rate policies in their policy formulations. *Second*, monetary policy seems to have less impact on stability in advanced economies, perhaps due to their more sophisticated and advanced financial systems that offer more alternatives to bank finance, which indeed increase banks' incentive to take on liquidity risk (Cerutti et al., 2017a). *Third*, monetary policy mainly serves for other objectives of the central banks rather than directly overcoming systemic risks (e.g., exchange rate or inflation stability), making monetary policy less relevant by design from the financial stability dimension (Borio and Zhu, 2014).[16]

The regression results using the alternative risk measures are reported in Columns (2–5) in Table 5. The new results show that the aggregate macroprudential policy index, as measured by the MPI index, significantly reduces bank systemic risk; however, we find no significant relationship between the monetary policy rate and systemic risk. Further investigations of alternative measures of the monetary policy stance, namely yield of government bonds (GovYield) and three-month interbank lending market interest (InterbankRate), corroborate our main findings. The results are reported in Table B1 in Appendix B.

Price stability is seen as one of the primary goals of monetary policy pursued by central banks. Although a price-level target rather than an inflation target has been pursued in the past by central banks (for the Swedish experience see Berg and Jonung, 1999), many central banks in the OECD countries have opted for controlling inflation and aim for low and stable inflation. Hence, following Hasan and Mester (2008), we consider the following two inflation performance measures in the baseline model in Equation (1): (i) *Abs (Inflation)*: absolute value of annual inflation rate in each country j in year t, which acknowledges that countries can miss hitting their price stability target via deflation as well as inflation and (ii) *Monetary performance index*: index that measures the success of a country's monetary policy based on two components: the weighted average inflation rate over the most recent three years and the degree to which a country imposes price controls.[17]

Since there can be short-run trade-offs between price and output stabilization, we also control a third feature of central bank, that is a kind of Taylor rule that relates the policy instrument to target for inflation and output gap or the unemployment rate (i.e.*, it relates the instrument to macroeconomic variables*). For simplicity, we follow Hasan and Mester (2008) and control for the Output Gap, assuming equal weights such as:

$$OutputGap = 0.5 \times Inflationvariability + 0.5 \times Realgrowthvariability \tag{7}$$

Table 6 presents the coefficient estimates for bank fixed effects regressions with the central banks' features included as additional explanatory variables. The first thing to notice is the presence of significant associations between performance characteristics of central banks and individual bank systemic risk. The second thing to notice is that the central banks' features do appear to have different effects on banks' systemic risk, and overall the macroprudential policies remain effective in mitigating instability. Column (1) shows that the success of a country's monetary policy leads to higher stability. This in line with the previous literature that suggests that an aggressive monetary policy, coupled with strict macroprudential policies leads to a more stable economic and financial system (see e.g., Rubio and Carrasco-Gallego, 2016). Whereas results presented in Columns (2) and (3) are not too surprising, given that in the presence of adverse economic conditions, such as inflationary pressures or unfavorable economic conditions, banks become riskier and more vulnerable to systemic shocks (see e.g., Bakkar et al. 2020).

3.3. *Macroprudential policy index disaggregation*

In this subsection, we try to shed light on the moderating role of the macroprudential policy index (MPI). To this end, we estimate the specification presented in the Eq. (2), while disaggregating the aggregate index into two major components: FITI index and BTI index, as presented in Gaganis et al. (2020) and Cerutti et al. (2017a). The latter index considers the first two policies of the MPI index (i.e., DTI and LTV), while the former index considers the remaining ten policies.

Panel A of Table 7 presents the results for the exposure to common shocks (namely the MES). Similar to the findings reported in Section 5.2, the new results show that both the FITI and the BTI measures have the same sign and significance as the aggregated MPI index. Hence, the regulations that impose, macroprudential policies, which relate to capital, lending, levy/tax, foreign exchange, and countercyclical reserve requirements on financial institutions, as well as the limit on household indebtedness and the loan to value ratio caps have a mitigating role in bank systemic risk, and thus reduce externalities that contribute to adverse financial sector dynamics.

We also consider alternative measures of the bank systemic risk and bank default risks. The results are presented in Panel B of Table 7. Columns (1 and 5) in Panel B report the regression results of SRISK on FITI index and BTI index, respectively, and the control variables. We find a negative relationship between both macroprudential policies measures and SRISK, suggesting that both policies toolkit reduce the systemic capital exposure, and thus enhance stability. In Columns (2 and 6), we use ΔCoVaR as our measure of risk contagion. The results suggest that only BTI index that aims at borrowers reduces bank systemic risk contagion and thus increases

[16] The policy rate can also be an imperfect proxy for the monetary policy stance. It is not the only or necessarily best measure of the monetary policy stance in a country. Recently in a number of developed countries, unconventional policy measures have provided important monetary stimulus. However, our ability to capture monetary policy measures in a comparable way across a large set of countries and long-time span is limited by data availability. Alternatively, we consider the one-year yield government bonds and the three-month interbank lending rate (in the domestic interbank lending market) as other proxies for the monetary policy stance and obtain similar results. Insights about these proxies are presented in Table 2. Importantly, time-invariant monetary policy characteristics, such as whether the country pursues inflation targeting, are already controlled for using bank fixed effects (which subsume country fixed effects), and country fixed effects (see, results of our robustness checks).

[17] The index varies from 0 to 100, with lower inflation and lack of price controls yielding higher scores. A country with inflation of 10 percent and no price controls would have a score of 80, while a country with inflation of 2 percent would have a score of 91 (for more insight see: Hasan and Mester (2008), and the 2013 Index of Economic Freedom, the Heritage Foundation).

Table 11
Macroprudential policies and systemic risk: a*dditional country-level controls*.

Dependent Variable: MES	(1) Capital stringency	(2) Multiple supervisors	(3) External governance index	(4) All three indicators
MPI	**−0.174***** (−3.79)	**−0.0835*** (−1.75)	**−0.222***** (−4.23)	**−0.163***** (−2.76)
STInterest	−0.0171 (−1.16)	−0.00234 (−0.17)	0.00728 (0.50)	0.0165 (1.14)
Size	0.578*** (5.21)	0.537*** (4.90)	0.359*** (3.01)	0.327*** (2.76)
Leverage	3.544*** (3.84)	3.702*** (3.98)	2.543*** (2.74)	2.734*** (2.91)
RoA	−21.79*** (−5.95)	−22.56*** (−6.12)	−16.47*** (−4.46)	−17.32*** (−4.67)
Funding	0.673** (2.02)	0.582* (1.80)	0.503 (1.50)	0.357 (1.09)
TobinQ	0.953*** (3.73)	1.006*** (4.02)	0.856*** (3.23)	0.850*** (3.26)
Liquidity	−1.030*** (−4.96)	−0.993*** (−4.96)	−1.262*** (−5.73)	−1.180*** (−5.60)
Efficiency	−0.243 (−0.65)	−0.208 (−0.56)	−0.689* (−1.66)	−0.587 (−1.43)
Loan	−1.323*** (−2.94)	−1.291*** (−2.97)	−2.347*** (−4.90)	−2.149*** (−4.69)
Diversification	−0.213 (−0.50)	−0.0334 (−0.08)	−0.0176 (−0.04)	0.0994 (0.22)
GDP	0.0472** (2.30)	0.0345* (1.75)	−0.00805 (−0.37)	−0.0231 (−1.04)
Inflation	8.754*** (4.91)	7.298*** (4.08)	6.909*** (3.88)	5.756*** (3.17)
Capital stringency	−0.00086 (−0.93)			−0.0202* (−1.58)
Multiple supervisors		−0.601*** (−4.85)		−0.583*** (4.24)
External governance index			0.0466 (0.79)	−0.0164 (−0.29)
Constant	−2.807** (−2.24)	−3.286*** (−2.66)	0.103 (0.06)	0.788 (0.46)
Year FE	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes
Observations	6692	6692	6692	6692
Banks	622	622	622	622
R–squared	0.361	0.368	0.391	0.397
Adjusted R–squared	0.358	0.366	0.388	0.395
Fischer test (p-value)	47.83***	50.89***	43.30***	43.33***

This table displays the regression results of the augmented model presented in Equation (2), while controlling for microprudential regulations and corporate governance. *MES* = Marginal Expected Shortfall. *MPI* = denotes the macroprudential policies index (contains all tools, equally weighted), and *STInterest* = is the short-term policy rate. *Capital stringency* = gauges the strength of capital regulation in a country. *Multiple supervisors* = is a dummy that equals one if there are multiple bank supervisors in a country. *External governance index* = denotes the degree of external corporate governance strength in a country. Definitions of all variables are presented in Table 1. Standard errors are reported in parentheses below their coefficient estimates and adjusted for both heteroskedasticity and within correlation clustered at the bank level. ***, **, and * indicate significance of the p-value respectively at the 1 %, 5 %, and 10 % levels. We also ensure the absence of multicolinearity problems by computing the variance inflation factors (VIF test is not reported).

stability. In Columns (3 and 7), we use the MZ-score to measure bank total risks, where the MZ-score is calculated as the average of bank returns on assets plus the bank equity to assets ratio, scaled by the standard deviation of returns on assets. We find that both financial institution- and borrower-targeted instruments are positively related to MZ-score, which implies that both macro-prudential policies mitigate bank default risks. In Columns (4 and 8), we use bank Merton's distance to default (DtD). Similarly, the results endorse that both macroprudential policies reduce bank distance to default and thus decrease bank total risk.[18]

Overall, these results partly align with Gaganis et al. (2020), who find that macroprudential policies aimed at financial institutions are moderately effective in reducing banking (default) risks, rather than policies aimed at borrowers, but do not display clear, conclusive positive or negative behavior in terms of systemic risk (stability). This finding is consistent with the general finding reported earlier that, all-in-all, macroprudential policies (tightening) are more associated with a decrease in the individual bank systemic risk and hence leading to more stability.

[18] Furthermore, we consider yield of government bonds (GovYield) and interbank lending market interest (InterbankRate) as alternative measure of the monetary policy stance. Results are presented in Table B2 in Appendix B. The results are qualitatively and statistically similar.

Table 12
Macroprudential policies and systemic risk: over different sample selection criteria and time period.

Dependent Variable: MES	(1) US Excluded	(2) Japan Excluded	(3) Europe Excluded	(4) Countries with fewer than seven banks Excluded	(5) Year '2013' Excluded
MPI	**−0.254*****	**−0.245*****	**−0.168*****	**−0.188*****	**−0.187*****
	(−4.38)	(−5.27)	(−3.98)	(−4.42)	(−3.97)
STInterest	−0.00494	0.00589	**−0.0257***	−0.0182	−0.0201
	(−0.25)	(0.38)	(−1.86)	(−1.29)	(−1.39)
Size	0.665***	0.435***	0.560***	0.677***	0.632***
	(4.21)	(3.50)	(4.85)	(5.81)	(5.39)
Leverage	6.113***	2.635***	3.716***	3.511***	4.183***
	(3.02)	(2.86)	(3.86)	(3.62)	(4.44)
RoA	−31.31***	−16.70***	−20.88***	−20.57***	–22.04***
	(−3.62)	(−4.44)	(−5.76)	(−5.75)	(−5.75)
Funding	0.707*	0.604*	0.932**	0.945***	0.865***
	(1.66)	(1.86)	(2.36)	(2.69)	(2.61)
TobinQ	1.243***	0.891***	1.017***	0.921***	0.863***
	(2.92)	(3.41)	(4.00)	(3.32)	(3.27)
Liquidity	−0.887**	−1.309***	−0.640***	−0.995***	−1.046***
	(−2.24)	(−6.13)	(−3.18)	(−4.59)	(−4.82)
Efficiency	0.364	−0.478	−0.245	−0.101	−0.156
	(0.65)	(−1.05)	(−0.66)	(−0.27)	(−0.41)
Loan	−1.064	−2.253***	−0.742*	−1.217**	−1.274***
	(−1.27)	(−4.99)	(−1.70)	(−2.46)	(−2.76)
Diversification	−0.714	−0.128	−0.114	−0.205	−0.391
	(−1.09)	(−0.27)	(−0.26)	(−0.46)	(−0.87)
GDP	0.0733***	−0.0102	0.0925***	0.0961***	0.0664***
	(3.16)	(−0.47)	(5.76)	(5.51)	(3.12)
Inflation	8.109***	6.663***	9.200***	9.485***	8.952***
	(3.89)	(3.56)	(5.63)	(5.74)	(5.09)
Constant	−5.564***	0.844	−2.692**	−4.121***	−3.791***
	(−2.70)	(0.63)	(−2.15)	(−3.24)	(−3.19)
Year FE	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes
Observations	2511	5802	5422	6335	6346
Banks	213	551	513	592	622
R–squared	0.393	0.403	0.345	0.359	0.371
Adjusted R–squared	0.387	0.400	0.342	0.356	0.369
Fischer test (p-value)	42.71***	41.23***	43.94***	48.09***	52.40***

The table reports the results of the estimations using alternative sample selection criteria. Model in *Column* (1) removes US banks. Model in *Column* (2) excludes Japanese banks. Model in *Column* (3) removes European banks. Model in *Column* (4) drops countries with fewer than seven banks. Model in *Column* (5) does not consider the year 2013. Definitions of all variables are presented in Table 1. Robust standard errors are reported in parentheses below their coefficient estimates and adjusted for both heteroskedasticity and within correlation. Fischer test tests the absence of individual effects. The VIF test (not shown in the table) asserts the absence of muticollinearity problems. ***, **, and * indicate significance of the p-value respectively at the 1%, 5%, and 10% levels. We also ensure the absence of multicolinearity problems by computing the variance inflation factors (VIF test is not reported).

3.4. Complementarity between financial institution- and borrower-targeted macroprudential policies and financial distress effect

We also assess the possible complementarity (or *substitutability*) between the components of the macroprudential policy stance (as presented in Section 2.4.) and its tightening on banks' systemic risk. For that, we involve in this section four steps. *First*, we gauge the effect of the FITI index (macroprudential tools aimed at increasing the financial industry's resilience), the BTI index (macroprudential tools aimed at dampening the cycle) and the monetary policy stance. *Second*, we investigate the joint effect of both FITI and BTI. Addressing this issue is paramount to design effective macroprudential policy instruments in systemically reducing risks in the banking sector. *Third*, according to Cerutti et al. (2017a), the main sources of banking risk that justify the implementation of macroprudential policies are externalities that exist in the financial sector and market failures, that can be associated with the vulnerabilities that may arise due to boom-bust cycle. Hence, we examine the role of economic conditions (financial distress) in determining the joint effects of FTI and BTI indexes on financial stability. *Fourth*, we gauge the stability of the efficacy of macroprudential regulations in mitigating systemic risk, while considering the traditional microprudential policies, that is the BIS capital adequacy ratio. Table 8 summarizes the results of these investigations using the model displayed in Eq. (2) (see Table 9).

In Column 1 of Table 8, we consider both the influence of FITI and BTI indexes. The results show that a tightening (easing) in the FITI index and/or the BTI index appears to be significantly helpful in containing (increasing) bank systemic risk and hence instability (stability). The monetary policy stance is insignificant in containing systemic risk. This confirms the previously documented evidence with the specification that uses the index based on all tools.

In Column 2, we include the interaction term of FITI and BTI indexes. There, the FITI index is negative and statistically significant at the 5 % level, while the BTI index enters insignificant. As it concerns policy rate, the coefficient is negative and statistically significant, at the 10 % level only. Overall, these findings indicate that our findings in Section 3.2 are driven by the FITI that has the same sign and significance that MPI, rather than by BTI which is insignificant. Suggesting that macroprudential policies aimed at financial institutions (tools addressing asset side, liability side and bank buffers) are particularly important to curb systemic risk.

In addition, macroprudential policies are designed to dampen the expansionary phase of the boom-bust business and financial cycles and reinforce the resilience of the financial sector to the adverse phases of the cycles. Therefore, to reduce the buildup of imbalances and financial instability risks, and curb '*excessive'* cycles and economic pressures, many countries have increasingly utilized macroprudential policy tools during financial downturns (Igan and Kang, 2011; Claessens et al., 2013; Aiyar et al., 2014).[19] In that respect, the effects of specific macroprudential tools on bank systemic risk can be different. To test for this, we divide our time span in a boom period on the one hand, and financial bust period on the other hand. Based on the economic conditions, we disentangle the effect of the normal years (2001–2006) from the financial pressure years (2007–2013). Specifically, we introduce dummy variable '*Financial distress*' in our model (Eq. (2)) to distinguish the two period.[20]

In Column 3 of Table 8, we include interaction terms with *Financial distress* variable to investigate the joint stance of the FITI and BTI indexes on bank systemic risk according to the state and soundness of the economy. There, the **FITI** × **BTI** term is negative and statistically significant at the 1 % level, with a higher magnitude, in reducing systemic risk during the economic upturns. Hence, the results documented in Columns 2 pertain. Whereas the interaction **FITI** × **BTI** × **Financial distress** term enters positive and statistically significant at 5 % level. This finding clearly highlights that although macroprudential policies can have a positive effect on financial stability, there exists a negative impact on credit supply and investment during stressful conditions, thus, depressing economic growth (Sanchez and Rohn, 2016; Richter et al., 2019), which in turn can trigger financial instability. Specifically, a slowdown in economic activity typically increases the amount of non-performing loans and causes losses to the banking sector, which in the presence of stressful conditions (excessive leverage, low liquidity buffers) can evolve into a full-blown crisis. Moreover, in case of negative shocks that hit the economy, the market price of assets falls, which can worsen the creditworthiness of the nonfinancial sector, while the financial sector gets less willing to grant loans, leading to a supply-side credit crunch. Risk premia can rise abruptly on account of growing risk aversion in the financial sector, which would exacerbate a downturn in the real economy. If financial frictions, due to tight macroprudential policies, become binding, they can be amplified by market liquidity frictions. The latter limit the ability to exchange investments and other assets for liquid financial assets during periods of stress. The financial frictions lead to investors increasingly and simultaneously wishing to sell assets in times of crisis in order to remain solvent. This has a negative impact on the value of asset prices. Existing market liquidity frictions can result in market illiquidity, with even stronger drops in asset prices. The latter exerts added pressure on equity, amplifying financial frictions which put more pressure on asset prices. Frictions which affect market liquidity can therefore trigger additional nonlinear dynamics, leading to further financial instability. Overall, macroprudential policies whose aim is to ensure financial stability can thus end up being counterproductive by putting a drag on economic activity, which can in turn threaten financial stability.

However, BTI index (caps on LTV and DTI ratios) loses its significance. This suggest that overall tightening in macroprudential policy stance might work perversely during the financial downturns. This result is in fact rather expected, due to the nature of the financial distress period, especially, for our sample of countries. After the global crisis, the major concern was not to constrain the banks in lending especially in the case of the OECD countries. The main motivation was to boost the economy and thereby to provide more confidence to the aggregate economy. This increasing confidence into the economy is expected to positively affect banks' stock returns and mitigate financial risks. Hence, we may read this result as after the global crisis, the countries have not eased their macroprudential policies, especially Financial Institution-Targeted Instruments, on time to mitigate financial stability concerns. This sluggishness in easing macroprudential policies may stem from the heightening attention on the banks and the resulting regulatory pressure on the banking system.

The BTI is individually insignificant during upturns and downturns, contrarily to the FITI. This result is also vital. BTI is significant in taming the systemic risk. But its effect may be experienced in the longer horizon, considering that regulators are expected to be even slower in introducing BTI and even more sluggish to modify them, depending on the macroeconomic conditions. Since BTI is mainly targeting the borrowers, while FITI is directly targeting the banks, for the shorter-term objective of enhancing the financial stability, policymakers could be more active in revising their stance on the FITI. In this sense, this finding also points out the possible policy errors during the post-GFC, at least among the OECD countries.[21]

Columns (4) and (5) present the coefficient estimates for bank fixed effects regression (Equation (2)) with the traditional microprudential policies included as additional explanatory variables. We consider the Bank of International Settlements (BIS) capital

[19] In the aftermath of the Lehman Brothers bankruptcy in September 2008, regulators have introduced stringent changes to banking regulations and macroprudential policies along with the implementation of generalized rescue programs, new resolution plans and unconventional monetary policies.

[20] This dummy variable takes the value of one during distress years [2007–2013]. Distress period includes the severe crisis years of the financial crisis (2007–2008), the European sovereign debt crisis (2009–2013). The acute financial crisis period started from July 2007 to March 2009, as well as the European debt crisis that started to affect some of European countries (namely the GIPS countries including Greece, Ireland, Portugal and Spain) from late 2009 and reached its peak in 2012.

[21] We evaluate how the boom-bust cycle might have modified the effect of the macroprudential policies on systemic risk, using a sub-sampling analysis. For that, we investigate the effectiveness of the macroprudential policies on mitigating instability over the pre-GFC period [2000–2006] vs the financial distress period [2007–2013], rather than using interaction terms as in model in Equation (2). Our main results and conclusion globally remain unchanged, see results in Table B3 in Appendix B.

adequacy ratio, which is the main index to secure the banks' capital adequacy, i.e., banks must hold at least 8 % of RWA as core core capital in their reserves. Consistent with our previous findings, these results support the complementary effects of both macroprudential policies (the coefficient for FITI × BTI is negative and statistically significant at the 1 % level), and suggest that the microprudential policy is effective in containing systemic risks (negative and statistically significant at the 1 % level), while monetary policy stands ineffective. This finding is also in line with the existing literature suggesting that strict capital regulations, a macroprudential approach, may lead to a more stable economic and financial system (Rubio and Carrasco-Gallego, 2016). This is also in line with the Basel III approach in strengthening the capital requirement to alleviate systemic risk.

3.5. Macroprudential policies, bank features, and systemic stability

Table 6 presents the coefficient estimates for five different specifications of bank fixed effects regressions with the banks' features interactions. In Columns (1) to (5), we present the results for Equation (3), where we interact the FITI and BTI indexes with the size of banks, TBTB dummy, the liquidity ratio, the leverage ratio, and the HHI loans concentration index. Consistent with our previous findings, the new results document that both macroprudential policies (FITI × BTI) are complementary and more effective. Whereas, when we check for the heterogeneous effects of these policies $\left(\boldsymbol{FITI} \times \boldsymbol{BTI} \times \boldsymbol{\Lambda}_{i,t-1}\right)$, we find that both macroprudential policies are less effective for larger banks, TBTF banks, banks with more liquidity and more concentrated markets (Columns (1, 2, 4, 5)), which is supported by the literature since large banks are more likely to benefit from regulatory forbearance and this might create incentives to invest in risky activities (Brown and Dinc, 2009), weakening the effectiveness of macroprudential policies. Although large banks actively build-up capital that exceeds the regulatory minimum requirements (Berger et al., 2008), they are also better-capitalized associated with a lower contribution to systemic risk, but they might engage in risky operations (Perotti et al., 2011), which leads to lower financial stability. Both macroprudential policies are more effective for less leveraged banks (Column (3)), which has received empirical support from the literature (Gauthies et al., 2012; Brunnermeier et al., 2012). Overall, the evidence in Table 6 suggests that lower leverage (more equity) undermines financial stability.

These results have some similarities with the findings of Ely et al. (2021), who argue that macroprudential regulation is substantially effective through the leverage channel in most cases in which macroprudential instruments are effective in reducing risk-taking.

4. Extensions and robustness checks

In this section, we perform several tests to check for the robustness and the validity of the main results. We summarize the results of these additional regressions and further robustness checks to **(i)** the other remaining concerns regarding whether the results are truly driven by the empirical specification, **(ii)** the presence of possible heterogeneity in the effectiveness of macroprudential policies across countries; **(iii)** controlling for microprudential regulations; and **(iv)** possible limits in different sample selection criteria and time period.

4.1. Alternative specifications and endogeneity correction

In Table 10, we consider four alternative regression specifications. *First*, we follow Cerutti et al. (2017a) and use country fixed effects regression to control for country heterogeneity, while also controlling for year fixed effects. The regression results are presented in Column (1). The relationship between the aggregated macroprudential policy (MPI) index and bank systemic risk (MES) is still negative and statistically significant, while the short-term policy rate is statistically insignificant. *Second*, we follow Beck et al. (2013), Altunbas et al. (2018) and Demirgüç-Kunt et al. (2020) and use a time-varying country fixed effect framework to capture time-varying country-specific regulations or business cycle effects on bank systemic risk. The coefficient estimates of this specification are presented in Column (2). Similarly, the results show a statistically significant negative relationship between the MPI index and systemic risk. *Third*, we use a weighted least squares (WLS) estimation to control for country representation in the sample's total observations while also controlling for year-fixed effects. To this end, we take the inverse of the number of country observations as the weight for each bank. The coefficient estimates in Column (3) display the results and show a statistically significant negative effect of MPI index on the individual bank systemic risk.

Finally, we follow Fendoğlu (2017) and Akinci and Olmstead-Rumsey (2018) and run a Generalized Method of Moments (GMM) panel regression to mitigate the potential endogeneity of macroprudential policy actions. It also considers the heterogeneity of the data caused by unobservable factors affecting individual banks. Endogeneity problems may taint the inclusion of bank-fixed effects in the baseline empirical evidence. As our study treats the behavior of respective banks, the GMM estimation may have the advantage to correct, to some extent, for the biases introduced by endogeneity problems (i.e., macroprudential policy may be set in response to concerns about systemic instability, captured in a major part by the dependent variables).[22] Accordingly, we employ a dynamic panel data regression model using the GMM method developed by Blundell and Bond (1998). The instruments are used as defined by Blundell and Bond (1998). The exogenous variables are instrumented by themselves, while the endogenous regressor is instrumented by its lags in levels. Both exogenous and endogenous variables are transformed in first differences, whereas all bank-specific

[22] For more insight, see also Claessens et al. (2013), Cerutti et al. (2017a) and Meuleman and Vennet (2020).

characteristics are considered at $t - 1$.[23] To assess the validity of the GMM instruments, we perform two specification tests: (i) the Arellano and Bond test for the second-order serial autocorrelation in the residuals (AR2 test), and (ii) the Hansen J-test for the homogeneity of the joint validity of all instruments as a group.[24] The coefficient estimates of the regression are presented in Column (4) in Table 10. The results confirm the presence of a negative and statistically significant relationship between the MPI index and bank systemic risk, while the short-term policy rate enters negative and statistically significant. We conclude that macroprudential policies and systemic risk results are robust to these alternative regression specifications.

4.2. Additional country-level control variables

Differences may influence our results in the intensity of banking regulation and supervision, unrelated to macroprudential policies, which could impact the amount of risk undertaken and systemic risk (Laeven et al., 2016; Bakkar et al., 2019). Previous cross-country studies argue that bank-risk-taking policies can be explained by differences in institutional settings, and regulatory and supervisory frameworks across countries (Anginer et al., 2018; Altunbas et al., 2018; Gaganis et al., 2020; Apergis et al., 2021).

To control for such institutional and regulatory settings, we employ data from the four waves (2001, 2005, 2008, and 2012) of the Bank Regulation and Supervision database compiled by the World Bank and use three indicators. The *first* is the overall *Capital stringency* index that indicates explicit requirements regarding the amount and source of capital that a bank should have. A higher index indicates greater stringency. Capital Stringency ranges from 4 to 11, with an average of 8.70. The *second* is related to the initial banking supervision system, *Multiple supervisors*. It indicates whether there are multiple bank supervisors in the institutional structure of supervision. Hence, having numerous supervisors may lead to different supervisory approaches, which can generate valuable information which would otherwise be neglected (Beck et al., 2013). However, it might also lead to regulatory arbitrage, exacerbating the effect of macroprudential policies on stability. 89 % of our sample observations (country-years) have multiple bank supervisors. The *third* is the *External governance index***.** It relates to the effectiveness of external corporate governance, the transparency of financial reports, the evaluations by rating agencies, and the monitoring by creditors. This variable thus serves as a proxy for the influence of external governance and monitoring mechanism. External governance ranges from 11 to 18, with an average of 15.66. In the three cases, higher values of these indicators correspond to stringent regulation and supervision.[25]

In Table 11, we present alternative specifications of the baseline regression shown in Table 5. In Columns (1, 2, and 3), we introduce one indicator at a time, while Column (4) we all the three indicators simultaneously. The evidence in Table 11 suggests that macroprudential policy enhances stability, as the MPI index still has a negative and significant effect on bank systemic risk (MES). Our main results remain very similar to the main findings. Interestingly, these results show that stringent regulation and supervision have, in general, a positive impact on stability. Specifically, in presence of high capital stringency requirements and multiple supervisors (Columns 1, 2 and 4), results suggest that the benefit in reducing systemic risk is greater. All other coefficients remain practically unchanged. Overall, these results remain consistent under these specifications.

4.3. Evidence across different sample selection and period

As discussed earlier (Section 2.1.), our sample of OECD banks is dominated by three world regions: Europe, Japan, and the U.S. Hence, our results may be induced by the sample selection and regional differences. For that, we gauge the robustness of our findings to different sample sections and periods. Hence, we conduct a battery of robustness checks using other sample selection criteria, such as excluding banks in the U.S., Japan and Europe. Besides, we drop countries with fewer than seven banks and limit the analysis to the pre-Basel III period by excluding bank-year observations in 2013 (viewed as a moderate crisis year). Columns (4) and (5) in Table 12 presents these alternative results for the baseline regressions. In all the cases, the results hold. Hence, we show strong evidence that regardless of the different sample selection criteria and period, the effect on systemic risk depends on the extent of macroprudential policies in force.

5. Conclusion and policy implications

In this paper, we have used a panel data model to assess the complementarity of the macroprudential policies and their effectiveness in containing bank systemic risk in the most developed countries. To do so, we developed a novel set of indexes using the newly updated Cerutti et al. (2017a)'s database. We use the aggregate macroprudential policy index and disentangle between the ten financial institution-targeted macroprudential tools (FITI index) the two borrower-targeted instruments (BTI index). We first assess the complementarity between financial institutions-targeted and borrower-targeted tools in reducing systemic risk arising from intra-financial system vulnerabilities. We also investigate the effect of boom-bust cycles on such a relationship by analyzing upturns and

[23] For more evidence, see Cerutti et al. (2017a) and Altunbas et al. (2018).

[24] The consistency of the GMM estimator depends on the validity of the assumption that the error terms do not exhibit serial correlation, as well as on the validity of the instruments used. We use two specification tests suggested by Blundell and Bond (1998) to address these issues. The first test examines the hypothesis that the error term is not serially correlated. The second is a Hansen test of over-identifying restrictions, which tests the overall validity of the instruments by analyzing the sample analog of the moment conditions used in the estimation process.

[25] The four regulatory measures we use are pre-constructed indexes. More insights are presented in Table 2. Information for the construction of these indexes is described in detail in Barth et al. (2013).

downturns periods.

Our results show that there is a statistically significant complementarity between the financial institution-targeted and borrower-targeted macroprudential instruments in shaping systemic stability. That is, implementing both set of instruments appear to have negative effect on bank systemic risk, and hence more effective in enhancing stability especially during financial upturns. However, macroprudential policies do not appear to be effective during financials downturns, it can indeed be counterproductive by putting a drag on economic activity, which can in turn threaten financial stability. We also found that the effectiveness of the macroprudential policies have considerably heterogeneous effects, depending on bank features and market structures. Specifically, banks' size, TBTF statute, leverage, liquidity, and concentration are essential to explain how macroprudential instruments may affect systemic stability. Our findings also suggest that macroprudential policies are more effective, primarily through the leverage channel. Our results bring critical policy implications for the implementation of optimal macroprudential tools. They also provide insights into the trade-off between financial stability and price stability. To the best of our knowledge, this paper is the first to explore the effects of macroprudential policies in a cross-panel data set for listed OECD banks during the pre-Basel III and the complementarity between the different macroprudential instruments: borrower- or lender-oriented tools.

Overall, the findings suggest that macroprudential policies have been more powerful than monetary policies. This explains why policymakers and central banks have resorted to macroprudential policy instruments even more after the global crisis when conventional monetary policy channels hit their limits. Expectedly, similar macroprudential policies have been implemented with the Covid19 pandemic. We find that financial institution- and borrower-oriented macroprudential instruments reduce bank systemic risk. Hence, policymakers and central banks are likely to expand their policy space by resorting to financial institution-targeted instruments (FITI) and borrower-targeted instruments (BTI). Both instruments are effective in containing the systemic risk in the overall sample. However, the results change when we consider the business cycles of the economy' upturns and downturns.

We show that macroprudential policies effectively enhance banking stability over financial upturns, whereas they can work perversely during financial downturns, especially when if they are not adjusted on time. However, we conjecture that that some macroprudential policies aimed at borrowers (imposing limits on households' indebtedness and caps on loan-to-value) do not independently moderate role on bank's systemic risk over both the upturn and downturns. This result justifies why policymakers first chose to apply financial institution targeted instruments after the global financial crisis. This could be related with the adoption of policy changes. Financial institution-targeted instruments are easier to introduce considering the long-term relations between regulators and banks. However, borrower-targeted instruments may require more consent from the politicians. Hence, central banks may resort to BTI to reach their desired outcome of fostering financial stability during the downturns. We may expect a similar policy move by the central banks in the post-Covid19 period. Future research could investigate the effects of development and democracy levels of countries in adopting different types of macroprudential instruments.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. The paper has received financial support for Open Access Service from the Qatar National Library.

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Appendix A. . Estimating the alternative systemic risk measures and construction of macroprudential measures

A1. SRISK

For macroprudential regulations, SRISK measures the extent of bank *i*'s capital shortfall to systemic-wide distress when the market performs poorly (Acharya et al., 2012; Engle et al., 2015; Laeven et al., 2016). Formally, Brownlees and Engle (2017) define SRISK as:

$$SRISK_{i,t} = E_t(CapitalShortfall_i|Crisis) = \left(kD_{i,t}\right) - \left(VE_{i,t} \times (1-k) \times \left(1 - LRMES_{i,t}\right)\right) \quad \text{(A1)}$$

where *k* is the minimum prudential capital ratio each bank has to hold (we set *k* equal to the equity-to-total *unweighted* asset ratio of 8

Agg. index	Index by target		Instrument	Description
Macroprudential policies Index: **MPI** (LTV + DTI+ CTC+ DP + SIFI+ LEV+INTER+CONC+CG + FC + RR + TAX) **(0–12)**	**Borrower-Targeted Index BTI** (LTV + DTI) **(0–2)**		LTV	Loan-to-value limit (0–1)
			DTI	Debt-to-income limit (0–1)
	Financial Institution-Targeted Index: **FITI** (CTC+ DP + SIFI+ LEV+INTER+CONC+CG + FC + RR + TAX) **(0–10)**	Capital (CTC + DP + LEV+SIFI) **(0–4)**	CTC	Countercyclical capital buffer (0–1)
			DP	Dynamic loan-loss provisioning (0–1)
			LEV	Leverage ratio limit (0–1)
			SIFI	Capital requirement for SIFI (0–1)
		Structural (INTER+CONC) **(0–2)**	INTER	Limits on interbank exposures (0–1)
			CONC	Caps on concentration exposures (0–1)
		Institution (CG + FC + RR + TAX) **(0–4)**	CG	Limits on domestic currency loans (0–1)
			FC	Limits on foreign currency loans (0–1)
			RR	Countercyclical Reserve Requirements (0–1)
			TAX	Tax on financial institutions (0–1)

Fig. A1. Construction of macroprudential measures based on Cerutti et al. (2017).

percent), $VE_{i,t}$ is the market value of its equity and $D_{i,t}$ is the book value of its debts (proxied by total liabilities). Following Acharya et al. (2012), we use an approximation to compute long-run MES ($LRMES_{i,t}$) based on one-day MES loss expected if market returns are less than –2%: $LRMES_{i,t} = (1 - k)exp^{(-18MES_{i,t})}$.

A2. ΔCoVaR

The CoVaR introduced by Adrian and Brunnermeier (2016) is based on the VaR of one-day market return $R_{M,t}$ conditional on a tail event observed for bank i (Anginer et al., 2018; Bakkar et al., 2020; Bakkar and Pamen-Nyola, 2021). $CoVaR^{q}_{R_{M|i,t}}$ is the q-percent quantile of a conditional probability distribution which is defined as follows:

$$Prob_{t-1}\left(R_{M,t} \le CoVaR^{q}_{M|i,t} | R_{i,t} = VaR^{q}_{i,t}\right) = q \tag{A2}$$

where $VaR^{q}_{i,t}$ corresponds to the critical threshold equal to the p-percent quantile of the bank return $R_{i,t}$ distribution. Adrian and Brunnermeier (2016) define bank's ΔCoVaR as the difference between the VaR of the financial market conditional on bank i being in distress and the VaR of the system conditional on the bank i being in its median value. Setting q at 1-percent, ΔCoVaR of bank i is expressed as:

$$\Delta CoVaR^{q=1\%}_{i,t} = CoVaR^{q=1\%}_{M|i,t} - CoVaR^{q=50\%}_{M|i,t} \tag{A3}$$

A3. Default risk measures

Furthermore, we use two other proxies of systemic default risk measures. We follow Merton (1974) contingent claim framework to measure the Merton's probability-of-default (MPoD), by quantitatively analyzing the Merton's distance-to-default (dtd) and other covariates that cover market-based and accounting-based firm-specific attributes as proposed by Anginer et al. (2014), Anginer et al. (2018), Kreis and Leisen (2018), Bakkar et al. (2020), and Bakkar and Pamen-Nyola, 2021. The estimations are based on the normal transformation of the dtd, computed as: $PD_{i,t} = F(-dtd_{i,t})$, where F is a cumulative distribution function of a standard normal distribution, and dtd is the Merton (1974)'s volatility adjusted leverage measure for each bank i based on Campbell et al. (2008), that accounts for differences in the banks' capital structures. The dtd is then estimated as: $dtd_{i,t} = \left(\log\left(\frac{VA_{i,t}}{D_{i,t}}\right) + \left(r_f - 0.5 \times \left(\sigma^{A}_{i,t}\right)^2\right) \times T\right) \Big/ \sigma^{A}_{i,t}\sqrt{T}$. The larger the $dtd_{i,t}$, the greater is the distance of bank i from the default point and the lower is the $PD_{i,t}$.

Besides, we use the market Z-score to measure bank total risks (defaults). The MZ-score is calculated as the average of bank returns on assets (net income divided by total assets) plus the bank equity to assets ratio, scaled by the standard deviation of returns on assets over a 3-year rolling window. Formally, it is presented as follows: MZ-Score $= \left(\overline{R_{i,t}} + 1\right) / \sigma_{R_{i,t}}$, where $\overline{R_{i,t}}$ is the mean and $\sigma_{R_{i,t}}$ the standard deviation of the monthly returns for a given year. The MZ-score is widely used in the banking literature and shows the number of standard deviations below the mean by which profits must fall to eliminate equity. A higher value of MZScore indicates a lower probability of failure (Lepetit et al., 2008; Bakkar et al., 2020) (Fig. A1).

Appendix B

Alternative regression results. See Table B1-B3.

Table B1
Macroprudential policy index and systemic risk: *alternative measure of the monetary policy stance.*

	(1) MES	(2) MES
MPI	**−0.133***** (−2.85)	**−0.159***** (−3.52)
GovYield	0.0122 (0.52)	
InterbankRate		−0.0240 (−1.53)
Size	0.593*** (5.24)	0.578*** (5.19)
Leverage	3.533*** (3.76)	3.566*** (3.87)
RoA	−21.45*** (−5.82)	−21.96*** (−5.95)
Funding	0.614* (1.81)	0.669** (2.00)
TobinQ	1.019*** (4.00)	0.945*** (3.73)
Liquidity	−0.983*** (−4.66)	−1.026*** (−4.96)
Efficiency	−0.200 (−0.53)	−0.246 (−0.66)
Loan	−1.214*** (−2.67)	−1.330*** (−2.97)
Diversification	−0.328 (−0.75)	−0.285 (−0.67)
GDP	0.0371* (1.76)	0.0405* (1.94)
Inflation	1.948 (0.59)	9.958*** (4.11)
Constant	−2.269* (−1.84)	−1.847 (−1.54)
Observations	6644	6679
Banks	622	622
R–squared	0.361	0.361
Adjusted R–squared	0.358	0.358
Fischer test (p-value)	48.37***	49.52***

Definitions of all variables are presented in Table 1. Standard errors are reported in parentheses below their coefficient estimates and adjusted for both heteroskedasticity and within correlation clustered at the bank level. ***, **, and * indicate significance of the p-value respectively at the 1%, 5%, and 10% levels. We also ensure the absence of multicolinearity problems by computing the variance inflation factors (VIF test is not reported).

Table B2
Decomposition of macroprudential policy index and systemic risk: *alternative measure of the monetary policy stance.*

	(1) MES	(2) MES
BTI	**−0.171****	**−0.206****
	(−2.20)	(−2.52)
FITI	**−0.119****	**−0.142*****
	(−2.35)	(−2.90)
GovYield	0.0113	
	(0.50)	
InterbankRate		−0.0246
		(−1.58)
Size	0.594***	0.579***
	(5.25)	(5.20)
Leverage	3.543***	3.580***
	(3.76)	(3.87)
RoA	−21.48***	−21.98***
	(−5.83)	(−5.96)
Funding	0.622*	0.678**
	(1.83)	(2.03)
TobinQ	1.022***	0.949***
	(4.00)	(3.75)
Liquidity	−0.990***	−1.035***
	(−4.66)	(−4.96)
Efficiency	−0.213	−0.260
	(−0.56)	(−0.69)
Loan	−1.231***	−1.349***
	(−2.70)	(−3.00)
Diversification	−0.336	−0.294
	(−0.77)	(−0.69)
GDP	0.0358*	0.0390*
	(1.67)	(1.82)
Inflation	1.975	9.945***
	(0.60)	(4.10)
Constant	−2.291*	−1.882
	(−1.86)	(−1.57)
Observations	6644	6679
Banks	622	622
R–squared	0.361	0.361
Adjusted R–squared	0.358	0.358
Fischer test (p-value)	47.19***	48.24***

Definitions of all variables are presented in Table 1. Standard errors are reported in parentheses below their coefficient estimates and adjusted for both heteroskedasticity and within correlation clustered at the bank level. ***, **, and * indicate significance of the p-value respectively at the 1%, 5%, and 10% levels. We also ensure the absence of multicolinearity problems by computing the variance inflation factors (VIF test is not reported).

Table B3
The join stance of lender-related and borrower-related macroprudential policies and systemic risk: subsampling analysis.

Dependent Variable: MES	(1) Pre-GFC period [2000–2006]	(2) Financial distress period [2007–2013]
FITI	−0.077	−0.178**
	(−0.77)	(−2.43)
BTI	−0.220**	0.251
	(−2.39)	(1.39)
FITI × BTI	−0.350***	0.240**
	(−2.79)	(2.39)
STInterest	−0.0685***	−0.0343
	(−2.89)	(−1.24)
Size	−0.116	−0.0527
	(−0.88)	(−0.31)
Leverage	1.942*	−1.748
	(1.66)	(−1.37)
RoA	4.686	−18.58***
	(1.15)	(−4.44)
Funding	−0.709*	−0.755
	(−1.95)	(−1.17)
TobinQ	3.318***	1.079***
	(3.82)	(3.28)
Liquidity	−0.217	−1.212***
	(−0.70)	(−3.94)
Efficiency	−0.326	−1.393***
	(−0.73)	(−2.66)
Loan	−0.503	−1.549***
	(−0.83)	(−2.66)
Diversification	−0.539	−0.694
	(−1.09)	(−1.06)
GDP	0.101***	0.0557*
	(3.98)	(1.95)
Inflation	11.94***	12.74***
	(7.31)	(2.68)
Constant	−0.226	5.460***
	(−0.13)	(2.97)
Year FE	Yes	Yes
Bank FE	Yes	Yes
N	3061	3631
Banks	582	620
R–squared	0.105	0.263
Adjusted R–squared	0.0995	0.258
Fischer test (p-value)	15.07***	30.48***

Definitions of all variables are presented in Table 1. Standard errors are reported in parentheses below their coefficient estimates and adjusted for both heteroskedasticity and within correlation clustered at the bank level. ***, **, and * indicate significance of the p-value respectively at the 1%, 5%, and 10% levels. We also ensure the absence of multicolinearity problems by computing the variance inflation factors (VIF test is not reported).

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