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ORIGINAL ARTICLE

Tightening and Loosening of Macroprudential Policy, its Effects on Credit Growth and Implications for the COVID-19 Crisis

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Abstract

In this study, we analyze the effects of macroprudential measures on bank lending in the European Union. We develop several dedicated macroprudential policy indices reflecting different policy actions taken by the authorities in individual member countries, with the aim to affect credit activity in national banking sectors. In our empirical model, we measure responsiveness of gross loans in banks to selected macroprudential policy indices, taking into account a set of bank level and macroeconomic control variables. We use the Fitch Connect bank level dataset with financial statements for 3434 European banks with 18,616 observations and macroeconomic data provided by the World Bank and IMF statistics covering the period between 2000 and 2017. Information on the use of macroprudential instruments is taken from a new macroprudential policy database, MaPPED, gathered and published by European Central Bank, where we were able to extract the information on both timing and the direction of use of the macroprudential policy instruments. Our findings show that macroprudential instruments can be used effectively for regulatory modulation of credit activity in banks, with some fluctuations in the level of the effectiveness through the business cycles. Therefore, in loosening cycles, macroprudential measures are found to be strongly and positively associated with bank lending. On the other side, tightening actions are found to have a downward effect on bank lending, while these effects are less pronounced. These results are of great importance in the current crisis arising from the impact of COVID-19, as policymakers are trying to support the economy by easing macroprudential regulatory constraints to ensure lending to the real sector.

Keywords: Macroprudential policy, Bank lending, Credit growth, Financial stability, Credit cycles

JEL classification: E58, G21, G28

Introduction

Financial stability concerns have been the dominant theme of many research papers and regulatory discussions, particularly in the years following the 2008 global financial crisis. The focus has been on establishing systemic regulatory mechanisms to protect the entire financial sector from the risks arising from the interconnectedness of financial institutions and their procyclical behavior. The role of systemic surveillance and stability has been assigned to macroprudential policy. In the current period of the Covid-19 pandemic crisis, macroprudential policy is once again at the center of academic and institutional discussions regarding its effectiveness in mitigating the worsening effects of the pandemic-related crisis on investments and economic growth. The recent crisis has led to a significant decline in bank share prices, yet the crisis has not destabilized the financial sector. This could be a result of a shift in financial regulation, characterized by the introduction of stricter capital demands and various macroprudential tools following the 2008 financial crisis, (Borri & Giorgio, 2021).

In the period leading up to the 2008 financial crisis, it was believed that microprudential mea-

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sures were sufficient to ensure financial stability of the financial sector. Microprudential measures aim to ensure the safety of individual financial institutions and counter idiosyncratic risks, while macroprudential measures aim to protect the entire financial system by taking into account the interactions and interdependencies of individual financial institutions and systemic vulnerabilities, while limiting the collective exposure to system-wide risks (Aikman et al., 2015). The shift from the micro to the macro perspective called for a calibration of macroprudential instruments through two dimensions: cross-sectional and time dimension. The cross-sectional dimension of macroprudential policy requires a broader regulatory scope and the assessment of the system-wide importance of some institutions. On the other hand, the time dimension requires that macroprudential buffers be tightened in good times and relaxed in downturns, which represents the so-called "countercyclical" approach. This approach could increase the probability of survival of institutions as well as access to credit for the real economy, while reducing procyclical behavior in the financial system (Borio, 2003).

Macroprudential measures aim to address vulnerabilities in the financial sector that could trigger the development of systemic risk. As suggested by Yellen (2011), the risks manifest themselves in cyclical and structural forms, either through "too big to fail" concerns or through credit booms and soaring asset prices. Yellen (2011) also argues that some policies address certain risks that are present in all economic conditions, while cyclical risks should be addressed with countercyclical tools, with the goal of maintaining financial stability while ensuring that economic development can continue unimpeded. Countercyclical capital requirements imposed by the macroprudential regulator in good times can serve as an additional safety buffer in bad times. The dynamic nature of macroprudential instruments could contain banks' procyclicality more efficiently and reduce government spending in times of crisis (Jiménez et al., 2017).

Given the current crisis that has arisen as a result of the Covid-19 pandemic, the effectiveness of macroprudential policy is of momentous importance. The crisis should demonstrate the effectiveness of countercyclical design, as policymakers loosen built-up macroprudential buffers to allow credit to flow to the real economy (Araujo et al., 2020; Nakatani, 2020). This calls for further evidence on the effectiveness of macroprudential policy, in particular on its easing cycles and their impact on the availability of credit.

The aim of this paper is to investigate the impact of macroprudential policy on bank lending, using a sample of 3434 European banks spanning over 28 EU countries and covering the period between 2000 and 2017. This study contributes to the literature on financial regulation in several ways. First, to our knowledge, this is the first study to examine the effects of macroprudential policy on bank lending, using the recently collected and published MaPPED database covering all EU member countries.[1] This database is different with respect to the existing datasets provided by Cerutti et al. (2017), which captures only presence of the instrument, or Lim et al. (2011), which captures the direction of tools, but with limited number of macroprudential instruments covered. MaPPED contains the information on a larger number of tools by covering more than 50 policy instruments and recording their activation, tightening, loosening or deactivation, thus providing complete information on the life of the instrument. Second, we study these effects by using bank-level data that allow us to control for bank heterogeneity and the response of bank subsidiaries operating in different countries. By using bank-level data, we also reduce the sensitivity of our analysis to endogeneity biases associated with the introduction of macroprudential measures.[2] Third, we are also able to analyze tightening and loosening actions of macroprudential policy separately, as the macroprudential policy database provides this information in full. This allows us to observe the life cycle of macroprudential policy instruments, the effects of activation, tightening, easing, and deactivation of the instruments, and how the instruments work over the cycle. Fourth, given the information on the objective of macroprudential policies and the intention of their activation, we also examine the effectiveness of different groups of macroprudential instruments based on their respective objective.

Following Altunbas et al. (2018), we design our main macroprudential measures by summing all policy changes over time, both tightening and easing. This allows us to capture the overall macroprudential stance in a given country and time period. A higher value of the index indicates a tighter stance, while a lower value of the index indicates a looser macroprudential policy stance. To investigate whether there is an asymmetric effect of tightening and easing measures, we form additional

[1] Macroprudential Policies Evaluation Database, available at: https://www.ecb.europa.eu/pub/research/working-papers/html/mapped.en.html.
[2] See Morgan et al. (2018); Claessens et al. (2013).

indices that capture only tightening or only loosening actions. Furthermore, we measure the effectiveness of different types of macroprudential instruments based on their initial target and objective. This approach has also been followed by other studies in the literature (see Cerutti et al., 2017; Meuleman & Vander Vennet, 2020; Olszak et al., 2018). In our section on robustness checks, we additionally perform several tests by examining the effectiveness of groups of macroprudential instruments partitioned by their economic objective. To observe the relationship between macroprudential instruments and bank lending in different periods of the financial cycle, we run several estimations for the pre-crisis, crisis, and post-crisis periods. Finally, we also test whether macroprudential measures have stronger effects on a subsample of listed banks.

To account for endogeneity biases associated with the introduction of macroprudential policies, we conduct the empirical analysis using the Arellano-Bond generalized method of moments estimator corresponding to our small T and long N panel.[3] This estimator has become established in the literature as a standard tool for the analysis of macroprudential measures (see Altunbas et al., 2018; Cerutti et al., 2017; Morgan et al., 2018; Olszak et al., 2018; Zhang & Zoli, 2016).

Our results show that macroprudential measures are significantly associated with credit cycle movements. Macroprudential indices are significantly and negatively associated with bank lending when controlling for different bank and macroeconomic variables. This indicates that the macroprudential policy framework is successful in curbing credit growth and limiting excessive bank lending. When we test tightening and loosening actions separately, we find that macroprudential loosening actions have a stronger effect on bank behavior, i.e. when macroprudential measures are relaxed or deactivated, we can expect banks to increase their lending activity. Testing various indices of macroprudential policy, we find similar results, finding that credit-related macroprudential measures are most effective in curbing excessive lending. When we test macroprudential easing measures, we find that capital- and credit-related instruments are positively associated and have the strongest relationship with credit activity. The results suggest that relaxing macroprudential tools during downturns, such as the current one caused by the Covid-19 pandemic, can successfully improve market liquidity and support monetary policy efforts to stabilize credit supply in order to promote investment and economic growth. Nevertheless, various macroprudential measures still in place could alleviate concerns about deteriorating bank asset quality and keep bank capital from falling to dangerous levels.

The rest of the paper is structured as follows. The next part represents the overview of existing studies in the field. In section 2, we describe data, methodological approach in the paper and its findings. The section 3 represents extensions and additional robustness analysis, while the last, 4th, section concludes the paper.

1 Existing literature and hypotheses development

The literature on macroprudential policy can be divided into three distinct categories: cross-country macro studies and single-country studies, both of which cover most of the existing macroprudential literature, and, to a lesser extent, those studies that combine macro- and firm-level data.

Some of the most important contributions to the field have been macro-level studies, which have also provided the first datasets on macroprudential instruments in different countries. Such is the study by Lim et al. (2011), which uses a sample of 49 countries between 2000 and 2010 to show the effectiveness of macroprudential instruments in containing credit and debt financing and thus limiting the manifestation of systemic risks.

In a study by Cerutti et al. (2017), which employs the extensive macroprudential database for 119 countries during the period 2000–2013, the authors analyzed the effectiveness of macroprudential instruments in reducing credit growth and house prices. The paper shows that loan-to-value and debt-to-income limits, dynamic provisioning, and leverage ratio limits are most effective in curbing excessive lending. The effects were found to be stronger in upturns, while macroprudential tools were found to be less effective in downturns. As the authors pointed out, the impact of macroprudential measures depends on the level of economic development and capital openness of countries, and macroprudential measures were found to have a weaker relationship with credit growth in more open and financially developed economies than in developing countries.

[3] Countries might take macroprudential measures in response to excessive credit activity or systemic risk concerns. This may lead to reverse causality in our dependent variable. However, using bank-level data makes macroprudential policy studies less prone to this bias, as it is unlikely that regulators' decisions to apply macroprudential tools depend on the determinants of individual banks. It is more likely that these decisions depend on aggregate macroeconomic conditions (see Cerutti et al., 2017; Morgan et al., 2018).

Vandenbussche et al. (2013) found that reserve requirements associated with credit growth and restrictions on foreign-based financing have a strong impact on house price appreciation. Crowe et al. (2013) established that macroprudential tools such as loan-to-value limits or dynamic provisioning are effective in dampening house prices. A paper by Bruno et al. (2017), which investigates the effects of macroprudential instruments and capital flow management measures in 12 countries over the period 2004–2013, shows that capital flow management measures are associated with reductions in bank inflows, while also providing some evidence of increased effectiveness of macroprudential policy when implemented in a complementary manner to monetary policy measures. Dell' Ariccia et al. (2012) found that macroprudential policy could be effective in reducing the impact and containing credit booms, while the authors also caution against possible circumvention and avoidance of these policies and the need for coordination with other macroeconomic policies.

Some of the studies combining both macro and micro data have examined the impact of macroprudential measures on overall bank risk. For example, a study by Claessens et al. (2013) confirmed that macroprudential measures are effective in curbing bank leverage and asset and non-core liability growth during the upswings. In a study by Altunbas et al. (2018), it is shown that macroprudential measures are significantly associated with banks' risk exposure and that the effects of these measures strongly depend on banks' characteristics. The authors also suggest that a tightening of macroprudential measures has stronger effects on bank risk. Zhang and Zoli (2016) examine whether macroprudential measures have an impact on financial stability in 13 Asian economies. The results show that borrower-based macroprudential measures and tax measures are effective in stabilizing property prices, lending, and bank leverage.

Morgan et al. (2018) analyze the effects of a specific macroprudential measure, the loan-to-value ratio, introduced in many countries over the period 2000–2013, using a panel of 4000 banks. The results suggest that loan-to-value ratios strongly affect banks' mortgage lending, while the impact is less pronounced for larger banks and banks with a high share of non-performing loans. They also suggest that the introduction of LTV should be followed by other macroprudential measures that could enhance and complement its effects. Igan and Kang (2011) analyze whether loan-to-value and debt-to-income limits dampen house prices and stabilize the housing market. Their results show that after the activation of borrower-targeting macroprudential measures, a significant stabilization effect on prices is observed, while their activation, especially loan-to-value limits, also curbs expectations and speculative incentives.

Jiménez et al. (2017) examine the effects of macroprudential measures on the procyclicality of credit and the supply of credit to firms. Over the period 2000–2013, the authors study dynamic provisioning in Spain and find that this instrument constrains credit procyclicality and positively affects the credit supply of firms in bad times. The effects are weaker in good times and may also cause an increase in bank risk induced by the demand for higher profits. The paper shows the beneficial effects of increasing capital requirements in good times, which stabilizes credit supply in bad times.

In a study by Akinci and Olmstead-Rumsey (2018), covering 57 countries, macroprudential policies are found to be effective in mitigating excessive lending and house prices. The most effective tools are those that target borrowers, such as loan-to-value and debt-to-income limits. In a recent paper by Gambacorta and Murcia (2019), the authors use central bank lending data from five Latin American countries to examine the impact of macroprudential policies on bank lending and find that macroprudential policies are effective in mitigating the procyclicality of lending, while the impact is amplified when combined with tight monetary policy.

In summary, previous literature has shown that macroprudential measures are associated with restrained credit growth (Akinci & Olmstead-Rumsey, 2018; Cerutti et al., 2017; Gambacorta & Murcia, 2019; Lim et al., 2011; Morgan et al., 2018). To test whether macroprudential instruments have a mitigating effect on lending in the banking sector in European Union, we develop our first hypothesis using the macroprudential policy database (Budnik & Kleibl, 2018) with extensive information on over 50 policy instruments.

> **H1.** Macroprudential policy measures are significantly and negatively associated with bank lending volumes.

We test this hypothesis by examining the overall impact of macroprudential policy stance in a country on banking sector lending, as captured by the aggregate macroprudential indices.

Since the database captures all activations, tightenings and loosenings of all macroprudential instruments, we can test the effectiveness of these policy actions separately. Since macroprudential instruments were mostly introduced as tightening

measures during the period under consideration, requiring banks to either raise more capital, restrict lending to borrowers, or hold more liquid assets, we expect a negative relationship between the macroprudential policy index and lending. On the other hand, if macroprudential measures are loosened, we expect a positive relationship with credit growth, as in Poghosyan (2020). Accordingly, we develop the following hypotheses.

H2a. Tightening policy actions of macroprudential policy are negatively associated with bank lending.

H2b. Bank lending activity increases in response to macroprudential policy easing.

We test these hypotheses by studying the relationship between indices that capture only tightening actions or only loosening actions and bank lending. Following previous evidence (Cerutti et al., 2017; Morgan et al., 2018) and considering the goal of macroprudential tools to directly target the credit market and limit excessive lending and overheating in the mortgage market, we expect credit related instruments to be most effective in curbing credit growth. We thus develop the fourth hypothesis.

H3. Credit-related macroprudential measures have the strongest effects in curbing bank lending.

2 Data and methodology

To conduct our analysis, we combine bank-level and country-level data obtained from different databases. For macroprudential data, we use the recently published database, MaPPED, collected by ECB researchers and national authorities (Budnik & Kleibl, 2018). The database is based on a survey conducted with the help of national authorities in EU countries. MaPPED provides data on prudential and macroprudential measures covering 1700 actions and 53 prudential instruments grouped into 11 categories according to their objective. The database shows the life span of the instrument: its introduction, tightening or loosening actions, and deactivation of the instrument. The database also captures some policy measures that are ambiguous in nature, which we exclude from our analysis because we want to capture the accurate direction of the policy. We also exclude policies that were introduced as recommendations by the regulator, so that our analysis only captures binding measures for banks. We are able to construct different indices for prudential measures, either the overall direction of macroprudential policy in a country in a given period or indices based on the direction of the measures, i.e. whether the macroprudential measure was introduced as a tightening or easing tool.[4] In addition, the database offers the possibility to measure the effectiveness of macroprudential instruments based on their objective.

2.1 Macroprudential policy measurement design

The MaPPED database is based on a survey designed to capture the majority of regulatory actions over time. It was conducted with the help of the central banks of the participating countries and other regulatory and supervisory institutions. The policy instruments included in the database are macroprudential or have a macroprudential character, meaning that they affect the entire financial sector. MaPPED describes a complete life of a policy instrument, distinguishing three possible responses to the question on changes and policy actions: a) tightening, b) loosening, and c) other and with ambiguous effect. We capture these changes numerically by assigning 1 to tightening policy actions, −1 to loosening policy actions, and 0 to no change or actions with other and ambiguous effects (see Altunbas et al., 2018). This information is captured in the database on a monthly and quarterly basis, and since our bank-level data is available on an annual basis, we capture policy changes across quarters and then sum them to obtain annualized information. Using this approach, we obtain an annual policy stance with a positive or negative sign, while we can also obtain 0, if the summed measures cancel each other out or if there were no changes in the respective period.

Given the design and construction of the MaPPED database, we form six indices of macroprudential stance. First, we sum all annualized indicators of macroprudential policy actions across all countries in the sample consisting of all macroprudential measures and form the index *MPP*. We construct additional indices as an alternative measure of the macroprudential stance or a measure specifically designed to capture either periods of policy tightening or easing. Finally, we also construct various indices based on the target of these measures.

[4] To develop these indices, we follow several approaches from the literature (see Akinci & Olmstead-Rumsey, 2018; Altunbas et al., 2018; Garcia Revelo et al., 2020; Lim et al., 2011).

The *MPP* index represents the sum of all policy actions over macroprudential instruments recorded in the database. The index can take values from −4 to 9 within our sample and time coverage. The lower value of the index indicates a looser macroprudential policy stance, or simply put, more macroprudential policy easing actions were activated during this period. A higher value of the index indicates tighter macroprudential policy, with more tightening policy actions. The design of the index is given below:

$$MPP_{k,t} = \sum_j X_{j,k,t} \tag{1}$$

$X_{j,k,t}$ represents each policy action attached to the respective macroprudential instrument in country k and time t. As this index represents the sum of all policy actions: tightening and easing, higher value of this measurement represents macroprudential policy with a tightening stance. On the contrary, a lower or negative value indicates looser macroprudential policy stance within a given period.

In order to test the robustness of our results to alternative kind of measurement, we design our second index *MPP2* similarly as the former, but in this case the index is bounded and can take value of −1, 0 and 1 (for an application see Garcia Revelo et al., 2020). It is constructed based on the overall macroprudential stance and orientation of the policy in countries over different periods. The construction of the index is shown below:

$$MPP2_{k,t} = \begin{cases} 1 & if \quad \sum_j X_{j,k,t} > 0 \\ 0 & if \quad \sum_j X_{j,k,t} = 0 \\ -1 & if \quad \sum_j X_{j,k,t} < 0 \end{cases} \tag{2}$$

where $MPP2_{k,t} = \{-1,1\}$. It is equal to 1, if the stance of macroprudential policy in the respective country k and year t is of tightening nature, which means the $\sum_j X_{j,k,t}$ is higher than 0 and indicates restrictive macroprudential stance. From this, it follows that the number of tightenings exceeds the number of loosenings. Otherwise, when macroprudential stance in a country k and time t is of loosening nature and more relaxed, $\sum_j X_{j,k,t}$ is lower than 0, which means there have been more loosening macroprudential actions in the respective period.

Additionally, we construct several indices which serve as an additional measurement in order to provide accurateness and robustness of our results, while minimizing the limitations of our initial indices. The limitations of MPP and MPP2 are reflected in the fact that these measures take into account all policy actions, tightenings and loosenings of all instruments, while they do not distinguish the direction of the policies. Meanwhile, due to design of the indices, some of these policy actions, when summed up, cancel each other out, and their effect is neutralized. To account for separate effects of tightening and loosening actions of macroprudential policy is relevant and represents a major contribution of the paper.

With the next four indices, we aim to measure the effects of tightenings and loosenings of macroprudential policy separately and to distinguish between these two directions of policy actions. Our third macroprudential index, MPP3, takes into account the macroprudential stance, and is equal to 1, if the sum of all policy actions is higher than 0, which reflects a tightened macroprudential stance. The index design is as follows:

$$MPP3_{k,t} = \begin{cases} 1 & if \quad \sum_j X_{j,k,t} > 0 \\ 0 & if \quad \sum_j X_{j,k,t} \leq 0 \end{cases} \tag{3}$$

where $MPP3_{k,t} = \{0,1\}$. It is equal to 1, if the stance of macroprudential policy in the respective country k and year t is of tightening nature, which means the $\sum_j X_{j,k,t}$ is higher than 0 and indicates restrictive macroprudential stance. If $\sum_j X_{j,k,t}$ is equal to 0, or lower than 0, the index takes the value of 0.

Our next index, MPP4, takes into account loosening stance of macroprudential policy in the respective period.

$$MPP4_{k,t} = \begin{cases} 1 & if \quad \sum_j X_{j,k,t} < 0 \\ 0 & if \quad \sum_j X_{j,k,t} \geq 0 \end{cases} \tag{4}$$

where $MPP4_{k,t} = \{0,1\}$. It is equal to 1, if the stance of macroprudential policy in the respective country k and year t is of loosening nature, which means the $\sum_j X_{j,k,t}$ is lower than 0 and indicates loosened macroprudential stance. If $\sum_j X_{j,k,t}$ is equal to 0, or higher than 0, the index takes the value of 0.

However, the potential limitation of our previous indices, MPP3 and MPP4, whose values lie between 0 and 1, is that they do not weight the macroprudential stance by considering the number of tightening or loosening policy actions in a certain

period. One possibility to measure how restrictive macroprudential policy is during a given period in time is to take the sum of all tightening policy actions, leaving out 0 for all loosening policy actions and if there is no change. The index design is given below:

$$MPP5_{k,t} = \sum_{r} X_{r,k,t} \quad (5)$$

where $MPP5_{k,t}$ corresponds to the sum of all restrictive (tightening) policy actions in the respective country k and year t. The higher the value of this index, the more restrictive macroprudential stance. On the contrary, a lower value indicates less restrictive macroprudential policy stance within a certain period.

We do the same to measure loosening macroprudential policy stance, as we take into account only loosening policy actions with our last index, MPP6, whose design is as follows:

$$MPP6_{k,t} = \sum_{l} X_{l,k,t} \quad (6)$$

where $MPP6_{k,t}$ equals the sum of all loosenings in country k in year t. The higher the value of this index, the more relaxed macroprudential policy stance in a given period.[5]

To show the design and structure of our macroprudential measures, we review the exemplary country case studies of Cyprus and Lithuania for 2011 (see Table 1). The table shows the path of our indices design, from recording the policy actions over quarter, annualizing them, and finally, putting together macroprudential indices.

2.2 Bank and country level data

We collect bank-level data from the platform Fitch Connect. The sample includes data from 3434 banks, with balance sheet and income statement data over the period between 2000 and 2017. We cover data for all EU member states, including commercial, savings and cooperative banks and both inactive and active banks.[6] We exclude negative values for total assets and gross loans and winsorize all other variables at the 1% level at both ends of the distribution. The summary statistics of the bank variables can be found in Table 2. The database was checked for double counting and all duplicate observations were manually removed. All bank statements are annual and denominated in US dollars. In the unbalanced panel, we include all banks with available data on our dependent variable for two consecutive years, with the average bank observed for five periods. Since most macroprudential measures are introduced by national authorities, we analyze unconsolidated bank data to capture the impact on individual bank subsidiaries.

To control for macroeconomic differences across countries in the sample, we include several macroeconomic variables by drawing on IMF data platforms International Financial Statistics, World Bank and national central bank databases. Summary statistics for country variables can be found in Table 3.[7]

Table 1. Exemplary design of macroprudential indices based on country cases for Cyprus and Lithuania in 2011.

	Cyprus			Lithuania		
Macroprudential instruments	Tax on assets/ liabilities	Single client exposure limits	Sector and market segment exposure limits	Loan to value	Debt Service to Income	Maturity and amortization restrictions
Policy actions in quarters:	Q1:0	Q1:-1	Q1:1	Q1:0	Q1:0	Q1:0
Tightening: (+1)	Q2:1	Q2:0	Q2:0	Q2:0	Q2:0	Q2:0
Loosening: (−1)	Q3:0	Q3:0	Q3:0	Q3:0	Q3:0	Q3:0
	Q4:0	Q4:0	Q4:0	Q4:1	Q4:1	Q4:1
Policy actions annualized	1	−1	1	1	1	1
Number of tightening actions	2			3		
Number of loosening actions	1			0		
MPP	1			3		
MPP2	1			1		
MPP3	1			1		
MPP4	0			0		
MPP5	2			3		
MPP6	1			0		

Source: Budnik & Kleibl, 2018: Macroprudential policy Evaluation Database (MaPPED), based on authors' elaboration.

[5] Since we code loosening actions with −1 in the process of construction of MPP6 index, we multiply the index with −1 to have a comparable measurement similar to MPP5 index.

[6] We included all banks in the period covered, even if they withdrew from the market in a given year for various reasons such as merger and acquisition activity, or if the banks were liquidated or went bankrupt. This also means that our sample does not suffer from a survival bias (Košak et al., 2015).

[7] For a description of all variables used in the regression analysis and their sources, please see Appendix, Table A2.

Table 2. Summary statistics of bank variables.

Variable	Observations	Mean	Std. Dev.	Min	Max
Gross loans (USD, millions)	18,616	2, 830	9720	0.93	75,400
Gross loans (logs)	18,616	19.871	1.779	13.743	25.045
Size (total assets, logs)	18,616	20.431	1.721	15.115	25.746
Liquidity ratio (%)	16,186	15.081	20.151	0	94.52
Tier 1 ratio (%)	18,616	16.452	8.532	5.73	66.4
Loans to deposits (logs)	18,430	4.640	0.787	1.188	10.589
Loan loss provisioning (%)	18,207	0.666	1.464	−4.07	15.99
Market share (%)	18,616	0.761	3.848	0.0000142	81.985
Commercial (0–1)	18,616	0.237	0.425	0	1
Savings (0–1)	18,616	0.188	0.391	0	1
Cooperative (0–1)	18,616	0.575	0.494	0	1

Note: Summary statistics reflects the period 2000–2017. All variables, except the categorical ones, are winsorized 1% on both tails of the distribution.

2.3 Empirical model and findings

To examine the effects of macroprudential policies on bank loans, we specify the following model.

$$Y_{j,k,t} = \alpha Y_{j,k,\,t-1} + \beta MaPru_{k,t-1} + \gamma X_{j,k,t} + \delta Z_{k,t-1} + \lambda_j + \theta_t + \varepsilon_{j,k,t} \quad (7)$$

where $Y_{j,k,t}$ is the dependent variable, measured by logarithm of gross loans. $Y_{j,k,\,t-1}$ represents the lagged dependent variable included in the right-hand side to account for underlying autoregressive process. $MaPru_{k,t}$ represents the macroprudential index, our variable of interest, which is captured by different measurements. We expect that macroprudential measures are negatively associated to

Table 3. Summary statistics of country variables.

Variable	Observations	Mean	Std. Dev.	Min	Max
Macroeconomic variables					
Δ Policy rate	18,616	−0.182	0.608	−10.46	4.5
GDP growth (%)	18,616	0.741	2.167	−6.600	10
Credit to private sector (%)	18,554	89.959	28.038	26.280	191.189
Gross capital formation growth (%)	18,616	−0.125	6.887	−19.465	20.058
NPL gross (%)	15,020	6.348	5.013	0.379	18.064
Inflation rate (%)	18,616	1.707	1.253	−0.791	21.458
Macroprudential data					
Indices – all actions					
MPP	18,616	0.704	1.216	−4	9
MPP2	18,616	0.323	0.621	−1	1
MPP3	18,616	0.406	0.491	0	1
MPP4	18,616	0.084	0.277	0	1
MPP5	18,616	0.868	1.185	0	9
MPP6	18,616	0.164	0.458	0	6
Indices by target					
Credit	18,616	0.103	0.513	−4	4
Market liquidity	18,616	0.031	0.338	−1	5
Concentration	18,616	0.044	0.395	−3	3
Resilience	18,616	0.526	0.789	−2	4
Sub-indices by target					
Credit growth	18,616	0.002	0.140	−3	4
Lending caps	18,616	0.042	0.293	−3	4
Risk weights	18,616	0.059	0.400	−2	2
Liquidity measures	18,616	0.031	0.338	−1	5
Exposures	18,616	0.044	0.395	−3	3
MCR	18,616	0.336	0.695	−1	3
Capital buffers	18,616	0.089	0.348	−1	3
Taxes	18,616	0.027	0.173	−1	2
Provisioning	18,616	0.000	0.118	−2	2
Other requirements	18,616	0.072	0.271	−3	2
Leverage ratio	18,616	0.003	0.050	0	1

Note: Summary statistics is for the period 2000–2017. All variables are lagged for one period, except policy rate which was transformed with first difference. All variables apart from indicator variables are winsorized 1% on both tails of the distribution.

developments in lending activity (Akinci & Olmstead-Rumsey, 2018; Cerutti et al., 2017; Gambacorta & Murcia, 2019), although some studies have shown positive association of some macroprudential tools (Lim et al., 2011).

$X_{j,k,t}$ represents the vector of bank variables. In the main regressions, bank size, measured by the logarithm of total assets, and tier 1 capital ratio are included as bank controls. At various stages of the analysis, the liquidity ratio, measured by the ratio of liquid assets to total assets, and the loans to deposit ratio, which shows the funding position of the bank, are also included. As an important factor of the bank's credit activity and risk assessment, we additionally test for the relevance of loan loss provisions (LLP), measured by the ratio of loan loss provisions to gross loans. To control for the bank's market power, we include market share, measured by the size of the bank relative to the total assets of the entire banking sector in a country. Finally, we also test for the relevance of the bank's specialization by using dummies indicating whether it is a commercial, savings or cooperative bank. $Z_{k,t-1}$ is a vector of macroeconomic variables. All regressions include the change in the policy rate, while at different stages we include the real GDP growth rate, private sector credit as a percentage of GDP, gross capital formation growth, the gross NPL rate, the level of gross non-performing loans as a percentage of a country's GDP, and the inflation rate. λ_j and θ_t are bank and time fixed effects, while $\varepsilon_{j,k,t}$ is the error term.

The introduction of the lagged dependent variable on the right-hand side triggers endogeneity problems. According to Nickell (1981), the lagged dependent variable is correlated with the error term for small T-panel data and in the presence of fixed effects, leading to general biases associated with dynamic panel models. To control for endogeneity, the literature suggests the use of the dynamic generalized method of moments. The choice of this method is also confirmed by our small T and large N sample. Another endogeneity problem arises from the introduction of macroprudential measures in countries with elevated credit activity and systemic risk concerns. Namely, when countries experience an unsteady increase in overall credit activity that is accompanied by financial stability concerns, they are more likely to enforce macroprudential measures. Since we expect a negative association of the implementation of macroprudential measures with credit growth, especially since most macroprudential measures are introduced as tightening measures, we are concerned that this effect may arise as a result of reverse causality. The GMM estimation method should reduce such endogeneity concerns. Moreover, by using bank-level data, our estimates are less prone to endogeneity than macro-

Table 4. Comparison of different estimation methods of our initial model.

	(1)	(2)	(3)	(4)	(5)
	OLS	FE	GMM one-step	GMM two-step	GMM two-step
Dependent variable (lag)	0.847***	0.380***	0.730***	0.765***	0.765***
	(27.01)	(4.36)	(7.96)	(13.66)	(16.20)
Size (total assets, logs)	0.142***	0.648***	0.255***	0.226***	0.226***
	(4.45)	(4.70)	(2.82)	(4.03)	(4.75)
Tier 1 ratio	−0.00556***	−0.000537	−0.00803***	−0.00698***	−0.00699***
	(-4.36)	(-0.18)	(-3.67)	(-5.10)	(-5.57)
Δ Policy rate	−0.00908	0.00390	−0.0103	−0.00885	−0.00828
	(-1.23)	(0.60)	(-1.59)	(-1.55)	(-1.40)
MPP (lag)					**−0.00759****
					(-2.01)
Observations	18,616	18,616	18,616	18,616	18,616
Instruments			77	77	78
AR (1)			0.039	0.070	0.068
AR (2)			0.166	0.172	0.186
Hansen			0.260	0.260	0.226

Note: The dependent variable is gross loans in logs. OLS (column 1) stands for ordinary least squares, while FE (column 2) stands for panel fixed effects estimation method. Estimation method in columns 3–5 is dynamic one-step (3) or two-step (4–5) system generalized method of moments (GMM) estimator with robust standard errors and Windmeijer's correction. Lagged dependent variable is treated as endogenous, and all other variables as exogenous. All regressions include year fixed effects. T statistics is reported in the parentheses. All regressions include weights based on the number of observations of each country. Macroeconomic variables are lagged one period, while all variables, apart from indicators, are winsorized 1% on both tails of the distribution. The following are p-values which indicate the significance level of coefficients: *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.
Bold is used as to highlight our variable of interest.

Table 5. The impact of macroprudential policy on bank lending—bank controls.

	MPP						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent variable (lag)	0.735***	0.692***	0.783***	0.697***	0.688***	0.693***	0.689***
	(12.42)	(7.69)	(10.47)	(7.45)	(7.38)	(7.63)	(7.49)
MPP (lag)	**−0.00568**	**−0.00782****	**−0.00886****	**−0.00819****	**−0.00767****	**−0.00812****	**−0.00773****
	(-1.43)	**(-2.05)**	**(-2.23)**	**(-2.11)**	**(-2.03)**	**(-2.09)**	**(-2.05)**
Size (total assets, logs)	0.253***	0.286***	0.202***	0.268***	0.293***	0.287***	0.290***
	(4.37)	(3.32)	(2.80)	(3.10)	(3.23)	(3.28)	(3.27)
Tier 1 ratio	−0.00762***	−0.00827***	−0.00570***	−0.00802***	−0.00826***	−0.00821***	−0.00832***
	(-4.53)	(-4.43)	(-3.21)	(-4.05)	(-4.34)	(-4.39)	(-4.40)
Liquidity ratio	−0.00145**	−0.00111*	−0.000549	−0.00102*	−0.001000*	−0.00105*	−0.00110*
	(-2.00)	(-1.73)	(-0.74)	(-1.90)	(-1.66)	(-1.67)	(-1.75)
Δ Policy rate	−0.00700	−0.00837	−0.00665	−0.00485	−0.00905	−0.00829	−0.00866
	(-1.13)	(-1.41)	(-1.12)	(-0.74)	(-1.48)	(-1.38)	(-1.43)
Loans to deposits (logs)		0.109***	0.0687**	0.109***	0.110***	0.109***	0.109***
		(2.93)	(2.52)	(2.80)	(2.87)	(2.91)	(2.91)
LLP			−0.0119***				
			(-3.54)				
Market share				0.00472***			
				(3.16)			
Commercial					−0.0269		
					(-1.20)		
Savings						0.0347*	
						(1.78)	
Cooperative							0.00596
							(0.33)
Observations	16,186	16,065	15,771	16,065	16,065	16,065	16,065
Instruments	79	80	81	81	81	81	81
AR (1)	0.108	0.108	0.000201	0.106	0.108	0.108	0.108
AR (2)	0.344	0.465	0.247	0.484	0.461	0.465	0.463
Hansen	0.324	0.582	0.117	0.461	0.595	0.577	0.586

*Note: The dependent variable is gross loans in logs. Estimation method is dynamic twostep system generalized method of moments (GMM) estimator with robust standard errors and Windmeijer's correction. Lagged dependent variable is treated as endogenous, and all other variables as exogenous. All regressions include year fixed effects. T statistics is reported in parentheses. All regressions include weights based on the number of observations of each country. Macroeconomic variables are lagged one period, while all variables, apart from indicators variables, are winsorized 1% on both tails of the distribution. The following are p-values which indicate the significance level of coefficients: *p < 0.10, **p < 0.05, ***p < 0.01.*

(Continued on next page)

level studies, as the credit levels of individual banks are less relevant to policymakers when selecting regulatory instruments (see Claessens et al., 2013; Morgan et al., 2018). Finally, we lag our country variables by one period to further reduce endogeneity problems.

Since the summary statistics presented in Table 2 show large variability and differences in our bank variables, such as the liquidity ratio and the loans to deposits ratio, which reveal different liquidity and funding strategies of banks within our sample, we are concerned about possible effects of outliers. To address concerns about outliers, all variables, except indicator variables, are winsorized by 1% at both tails of the distribution. Since our sample consists of 28 EU countries, with different numbers of banks and observations in the database, we also include weights that give each country equal importance in all our regression estimates. The weights are constructed as the inverse of the sum of each country's observations.

2.4 Baseline results

We start our analysis with the baseline model consisting of four variables on the right-hand side: the lagged dependent variable, the bank's gross loans transformed into the natural logarithm, and other variables at the bank level: size, measured by total assets and transformed into the natural logarithm, tier 1 capital ratio, and finally, the change in the policy rate as a country-level determinant. Bank size should show whether large banks lend more due to their size and access to many different forms of funding, while the tier 1 capital ratio shows the bank's overall capital position. The central bank

Table 5. (Continued).

	MPP2						
	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Dependent variable (lag)	0.736***	0.688***	0.768***	0.693***	0.685***	0.688***	0.685***
	(13.18)	(8.26)	(10.20)	(7.48)	(8.00)	(8.14)	(8.12)
MPP2 (lag)	**−0.0232****	**−0.0287*****	**−0.0226****	**−0.0298*****	**−0.0296*****	**−0.0299*****	**−0.0288*****
	(-2.23)	**(-2.80)**	**(-2.31)**	**(-2.87)**	**(-2.82)**	**(-2.79)**	**(-2.82)**
Size (total assets, logs)	0.251***	0.290***	0.217***	0.271***	0.296***	0.291***	0.293***
	(4.66)	(3.64)	(3.01)	(3.15)	(3.56)	(3.58)	(3.61)
Tier 1 ratio	−0.00737***	−0.00830***	−0.00596***	−0.00800***	−0.00832***	−0.00827***	−0.00836***
	(-4.19)	(-4.48)	(-3.42)	(-4.05)	(-4.32)	(-4.39)	(-4.46)
Liquidity ratio	−0.00149**	−0.00115*	−0.000682	−0.00103**	−0.00102*	−0.00109*	−0.00113*
	(-2.26)	(-1.87)	(-0.94)	(-1.99)	(-1.74)	(-1.80)	(-1.87)
Δ Policy rate	−0.00686	−0.00950	−0.00781	−0.00610	−0.0102*	−0.00941	−0.00981*
	(-1.07)	(-1.64)	(-1.33)	(-0.95)	(-1.70)	(-1.61)	(-1.67)
Loans to deposits (logs)		0.110***	0.0732**	0.109***	0.111***	0.110***	0.111***
		(3.15)	(2.54)	(2.94)	(3.09)	(3.11)	(3.14)
LLP			−0.0128***				
			(-3.62)				
Market share				0.00476***			
				(3.38)			
Commercial					−0.0282		
					(-1.39)		
Savings						0.0355*	
						(1.93)	
Cooperative							0.00730
							(0.43)
Observations	16,186	16,065	15,771	16,065	16,065	16,065	16,065
Instruments	79	80	81	81	81	81	81
AR (1)	0.104	0.102	0.000102	0.101	0.102	0.102	0.102
AR (2)	0.356	0.450	0.272	0.478	0.442	0.449	0.446
Hansen	0.334	0.589	0.0979	0.483	0.612	0.582	0.598

policy rate is an important indicator of credit market developments associated with monetary policy decisions.

The following dynamic panel data model is specified as:

$$Y_{j,k,t} = \alpha Y_{j,k,\,t-1} + \gamma X_{j,k,t} + \delta Z_{k,t-1} + \lambda_j + \theta_t + \varepsilon_{j,k,t} \qquad (8)$$

where the dependent variable is gross loans transformed in natural logarithm of bank j, in a country k and at a time t, $Y_{j,k,t}$, as a function of lagged dependent variable $Y_{j,k,\,t-1}$, and vector of bank (X) and lagged macroeconomic (Z) variables. λ_j and θ_t are bank and time fixed effects, while $\varepsilon_{j,k,t}$ is the disturbance term.

Although we have already chosen the system GMM as the primary estimation method, as in Morgan et al. (2018), we decide to also estimate this model using ordinary least squares (OLS) and a fixed effects panel estimator (FE) to compare the magnitude of the coefficients of the lagged dependent variable. When the coefficient of the lagged dependent variable is greater than zero, its OLS estimate is biased upward, while the fixed effects estimate is biased downward due to the correlation between the lagged dependent variable and the error term (Nickell, 1981). Since the system GMM estimator uses instruments in levels and first differences and reduces endogeneity bias, we would expect the GMM estimate of the lagged coefficient of the dependent variable to lie between the OLS and FE estimates. Table 4 presents the estimation results of equation (8). Looking at the coefficient of the lagged dependent variable, we can see that the OLS estimate (0.847) is biased upward, while the FE estimate (0.380) is biased downward. The GMM estimates are within the interval 0.380−0.847 with coefficients around 0.7, as expected. This reinforces our decision to choose the system GMM as the main estimator.

Since the GMM twostep estimator is applied together with the Windmeijer correction for small samples and robust standard errors (Windmeijer, 2005), we estimate all our subsequent regressions with this estimator. We use up to 5 lags of the

Table 6. The impact of macroprudential policy on gross loans—macroeconomic variables.

	MPP						MPP2				
	(1)	(2)	(3)	(4)	(5)		(6)	(7)	(8)	(9)	(10)
Dependent variable (lag)	0.697***	0.673***	0.684***	0.698***	0.685***	Dependent	0.693***	0.668***	0.674***	0.703***	0.682***
	(8.09)	(6.99)	(7.63)	(3.92)	(8.20)	variable (lag)	(8.24)	(7.67)	(7.66)	(3.64)	(8.58)
MPP (lag)	**−0.00991*** **	**−0.00734** **	**−0.00804** **	**−0.00669**	**−0.00871** **	**MPP2 (lag)**	**−0.0322*** **	**−0.0295*** **	**−0.0301*** **	**−0.0299** **	**−0.0309*** **
	(-2.85)	**(-1.97)**	**(-2.05)**	**(-1.61)**	**(-2.21)**		**(-3.51)**	**(-2.85)**	**(-2.98)**	**(-2.45)**	**(-2.91)**
Size (total assets, logs)	0.281***	0.304***	0.293***	0.284	0.294***	Size (total	0.285***	0.308***	0.302***	0.279	0.296***
	(3.41)	(3.33)	(3.42)	(1.64)	(3.69)	assets, logs)	(3.53)	(3.73)	(3.59)	(1.48)	(3.90)
Tier 1 ratio	−0.00802***	−0.00799***	−0.00836***	−0.00825*	−0.00859***	Tier 1 ratio	−0.00808***	−0.00801***	−0.00863***	−0.00803*	−0.00861***
	(-4.16)	(-4.10)	(-4.26)	(-1.95)	(-4.85)		(-4.12)	(-4.58)	(-4.31)	(-1.70)	(-4.90)
Liquidity ratio	−0.00121**	−0.00123**	−0.00134**	−0.00191	−0.00106*	Liquidity ratio	−0.00123**	−0.00131**	−0.00138**	−0.00182	−0.00107*
	(-1.96)	(-1.98)	(-2.11)	(-1.34)	(-1.65)		(-2.10)	(-2.13)	(-2.22)	(-1.20)	(-1.73)
Loans to deposits (logs)	0.108***	0.114***	0.109***	0.109	0.115***	Loans to	0.108***	0.117***	0.114***	0.106	0.115***
	(2.97)	(2.65)	(3.00)	(1.53)	(3.13)	deposits (logs)	(3.15)	(2.87)	(3.18)	(1.38)	(3.35)
Δ Policy rate	−0.00780	−0.00461	−0.00981	0.00337	−0.00601	Δ Policy rate	−0.00911	−0.00609	−0.0112*	−0.00148	−0.00704
	(-1.30)	(-0.81)	(-1.56)	(0.49)	(-0.98)		(-1.55)	(-1.21)	(-1.85)	(-0.21)	(-1.14)
GDP growth (lag)	0.00714*					GDP growth (lag)	0.00726*				
	(1.74)						(1.86)				
Private credit to GDP (lag)		−0.000252				Private credit to		−0.000301			
		(-1.41)				GDP (lag)		(-1.62)			
Gross capital formation growth (lag)			0.00243**			Gross capital formation			0.00259**		
			(2.06)			growth (lag)			(2.19)		
NPL gross (lag)				−0.00105		NPL gross (lag)				−0.00170	
				(-0.46)						(-0.75)	
Inflation rate (lag)					0.00859**	Inflation rate (lag)					0.00911***
					(2.54)						(2.70)
Observations	16,065	16,005	16,065	12,609	16,065	Observations	16,065	16,005	16,065	12,609	16,065
Instruments	81	81	81	69	81	Instruments	81	81	81	69	81
AR (1)	0.105	0.121	0.107	0.206	0.106	AR (1)	0.0992	0.115	0.101	0.204	0.0998
AR (2)	0.431	0.646	0.436	0.485	0.395	AR (2)	0.409	0.638	0.401	0.549	0.374
Hansen	0.589	0.644	0.494	0.471	0.641	Hansen	0.597	0.639	0.522	0.531	0.648

Note: The dependent variable is gross loans in logs. Estimation method is dynamic twostep system generalized method of moments (GMM) estimator with robust standard errors and Windmeijer's correction. Lagged dependent variable is treated as endogenous, and all other variables as exogenous. All regressions include year fixed effects. T statistics is reported in parentheses. All regressions include weights based on the number of observations of each country. Macroeconomic variables are lagged one period, while all variables, apart from indicator variables, are winsorized 1% on both tails of the distribution. The following are p-values which indicate the significance level of coefficients: *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

dependent variable as instruments to address the endogeneity problem, while instrumenting our exogenous variables with their lags in levels. The lagged dependent variable is treated as endogenous variable and all other variables as exogenous. In all regressions, we include year dummies to control for unobserved heterogeneity over time. To check whether our estimates are consistent, we need to confirm whether the chosen instruments are valid and whether the residuals show serial correlation. We check the choice of instruments with the Hansen test for overidentifying restrictions and the autocorrelation of the residuals with first and second order autocorrelation tests (see Arellano & Bond, 1991; Baum, 2013; Roodman, 2009). In the case of the first-order autocorrelation test, the error term is expected to be correlated, and in the case of the second-order serial correlation test, we should not reject the null hypothesis of the absence of second-order autocorrelation. When it comes to Hansen's test, we should not reject the null hypothesis that the over-identification restrictions are valid. Table 4 shows these tests, namely first, AR (1) and second order autocorrelation tests, AR (2) and overidentification test of the restrictions, Hansen's J-test, which confirms that our estimates are consistent.

In column 5, we introduce the MPP index, which measures the overall stance of macroprudential policy. The index is lagged by one period, and its coefficient, obtained using the GMM twostep system estimator, is statistically significant at the 5% level and has a negative sign, as expected. Consistent with previous findings on macroprudential policy, our empirical results show that tighter macroprudential policy is associated with a decrease in credit supply. For a one-unit increase in the MPP index indicating a tightening of policy, we find a negative effect of −0.76% on credit supply. The

Table 7. The impact of tightening and loosening stance of macroprudential policy on bank lending.

	(1)	(2)	(3)	(4)
	MPP3	MPP4	MPP5	MPP6
Dependent variable (lag)	0.698***	0.728***	0.704***	0.698***
	(7.36)	(7.60)	(6.98)	(6.94)
MPP3 (lag)	**−0.0196***			
	(-1.68)			
MPP4 (lag)		**0.0791*****		
		(4.14)		
MPP5 (lag)			**0.00423**	
			(1.12)	
MPP6 (lag)				**0.0254*****
				(4.24)
Size (total assets, logs)	0.266***	0.240***	0.261***	0.268***
	(3.02)	(2.70)	(2.81)	(2.88)
Liquidity ratio	−0.00116**	−0.000886*	−0.00112**	−0.00104**
	(-2.27)	(-1.86)	(-2.13)	(-2.08)
Tier 1 ratio	−0.00789***	−0.00716***	−0.00793***	−0.00787***
	(-3.72)	(-3.01)	(-3.39)	(-3.55)
Loans to deposits (logs)	0.108***	0.0994**	0.107***	0.112***
	(2.85)	(2.54)	(2.67)	(2.62)
Market share	0.00460***	0.00390**	0.00449***	0.00414***
	(2.95)	(2.57)	(2.61)	(2.67)
Δ Policy rate	−0.00579	−0.00415	−0.00464	0.00111
	(-0.92)	(-0.67)	(-0.74)	(0.17)
GDP growth (lag)	0.00401	0.00600	0.00321	0.00494
	(0.84)	(1.32)	(0.58)	(0.97)
Observations	16,065	16,065	16,065	16,065
Instruments	82	82	82	82
AR (1)	0.104	0.0980	0.108	0.104
AR (2)	0.475	0.446	0.484	0.468
Hansen	0.480	0.471	0.457	0.565

Note: The dependent variable is gross loans in logs. Estimation method is dynamic twostep system generalized method of moments (GMM) estimator with robust standard errors and Windmeijer's correction. Lagged dependent variable is treated as endogenous, and all other variables as exogenous. All regressions include year fixed effects. T statistics is reported in parentheses. All regressions include weights based on the number of observations of each country. Macroeconomic variables are lagged one period, while all variables, apart from indicator variables, are winsorized 1% on both tails of the distribution. The following are p-values which indicate the significance level of coefficients: *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

Table 8. Macroprudential indices and subindices based on the target of the measures.

	(1)	(2)	(3)
MPP	−0.00991***		
	(-2.85)		
Credit (lag)		−0.00497	
		(-0.75)	
Credit growth (lag)			0.0276**
			(2.55)
Lending caps (lag)			−0.0260**
			(-1.99)
Risk weights (lag)			−0.00919
			(-0.65)
Market liquidity (lag)		−0.00793	
		(-0.55)	
Liquidity measures			−0.00837
			(-0.59)
Concentration (lag)		−0.0196**	
		(-2.35)	
Exposures (lag)			−0.0198**
			(-2.36)
Resilience (lag)		−0.00594	
		(-1.12)	
MCR (lag)			0.00457
			(0.60)
Capital buffers (lag)			−0.0120
			(-1.61)
Taxes (lag)			−0.0114
			(-0.56)
Provisioning (lag)			−0.0218
			(-1.42)
Leverage ratio (lag)			0.103
			(1.21)
Other requirements (lag)			−0.00908
			(-0.64)

Note: The dependent variable is gross loans in logs. Estimation method is dynamic twostep system generalized method of moments (GMM) estimator with robust standard errors and Windmeijer's correction. Lagged dependent variable is treated as endogenous, and all other variables as exogenous. All regressions include year fixed effects. T statistics is reported in parentheses. All regressions include weights based on the number of observations of each country. Macroeconomic variables are lagged one period, while all variables, apart from indicator variables, are winsorized 1% on both tails of the distribution. The following are p-values which indicate the significance level of coefficients: $*p < 0.10$, $**p < 0.05$, $***p < 0.01$.

coefficient on bank size is statistically significant and positively associated with bank lending, while the tier 1 ratio is statistically significant and negatively associated with bank lending. The policy rate is not significantly associated with the dependent variable in this specification. This may indicate a lower effectiveness of monetary policy in dampening credit growth during the period under consideration, which is characterized by expansionary monetary policy and historically low interest rates (Borio & Gambacorta, 2017).

Table 5 shows the estimates of equation (7), with an extended set of variables designed to control for various bank characteristics. These results were obtained using two alternative macroprudential measures, the MPP index (right) and the MPP2 index (left). To allow for a better comparison of the results, we report the estimates in the same table. Banks' control variables were introduced at different stages of the regression analysis. In addition to bank size and tier 1 capital ratio, which were already introduced in our baseline model, we also include liquidity ratio to capture the quality of short-term asset management in an individual bank and the overall liquidity position. To control for the funding structure of banks, we enter the ratio of loans to deposits, transformed into logarithms. To control for asset quality and banks' assessment of credit risk based on estimated loan losses, we also introduce the ratio of loan loss provisions to gross loans (LLP). To control for the market power of banks, we include market share, a variable formed by the size of the bank's total assets standardized to the total size of the banking sector for a given country. Finally, we also include dummy variables indicating the bank's specialization: Commercial, Cooperative or Savings. These variables were chosen to take into account the overall performance and health of the bank.[8]

In six out of seven model specifications, the coefficient of the MPP index remains statistically significant and of negative sign, supporting our first hypothesis. For a one-unit increase in the MPP index, we find a negative impact of −0.5% to −0.8% on credit supply. The results obtained with our alternative measure, the MPP2 index, show similar results, with our second measure showing a stronger relationship with bank lending. A one-unit increase in the MPP2 index is associated with a decrease in credit supply from −2.26% to −2.99%. These results suggest the effectiveness of macroprudential policy in mitigating credit booms, while supporting the view that macroprudential policy should be given the primary mandate in promoting financial stability (see Martinez-Miera & Repullo, 2019). The results also warn of the importance of comparison of different measurements of the macroprudential stance in related studies reflected in the difference in the coefficients obtained.

Bank size is statistically significant at 1% level and shows positive association with credit supply in all estimations. On the other hand, tier 1 capital ratio remains statistically significant and with negative

[8] For a similar variables selection approach see Hasan et al. (2016), Demirgüç-Kunt and Huizinga (2010) and Garcia Revelo et al. (2020).

Table 9. Loosening cycles of different macroprudential indices and subindices based on the target of the measures.

	(1)	(2)	(3)
MPP4 (lag)	0.0791***		
	(4.14)		
MPP6 (lag)	0.0254***		
	(4.24)		
Credit (lag)		0.0370**	
		(2.53)	
Credit growth (lag)			−0.00114
			(-0.06)
Lending caps (lag)			0.104***
			(3.09)
Risk weights (lag)			0.0206
			(0.90)
Market liquidity (lag)		0.0294	
		(1.57)	
Liquidity measures			0.0295
			(1.56)
Concentration (lag)		0.0798***	
		(3.30)	
Exposures (lag)			0.0801***
			(3.32)
Resilience (lag)		0.0933***	
		(3.58)	
MCR (lag)			0.0113
			(0.26)
Capital buffers (lag)			0.107***
			(3.83)
Taxes (lag)			0.0712
			(1.58)
Provisioning (lag)			0.0717**
			(2.07)
Other requirements (lag)			0.0693*
			(1.89)

Note: The dependent variable is gross loans in logs. Estimation method is dynamic twostep system generalized method of moments (GMM) estimator with robust standard errors and Windmeijer's correction. Lagged dependent variable is treated as endogenous, and all other variables as exogenous. All regressions include year fixed effects. T statistics is reported in parentheses. All regressions include weights based on the number of observations of each country. Macroeconomic variables are lagged one period, while all variables, apart from indicator variables, are winsorized 1% on both tails of the distribution. The following are p-values which indicate the significance level of coefficients: $*p < 0.10$, $**p < 0.05$, $***p < 0.01$.

sign in all estimations. Liquidity ratio is statistically significant at 5% and 10% level and with negative coefficient in most specifications, indicating that an increase in liquid assets is associated with a decrease in credit activity. Loans to deposits ratio is positively associated with lending activity and statistically significant at 1% level. LLP, entered in columns 3 and 10, is statistically significant and negatively associated with lending. These estimates suggest that an increase in loan-loss provisioning hinders credit activity in banks. Policy rate is not significantly associated with bank lending in these specifications. To summarize, bank controls coefficients show that larger banks and better performing banks with stable sources of funding tend to lend more. The estimations also show that liquidity needs or capital demands can hinder bank lending activities. On the other side, increase in loan loss provisioning could indicate an increase in credit risk assessments, which can also prompt banks to reduce their loan supply. This can come as a result of procyclicality of loan loss provisioning, caused by a delay in provisioning during economic downturn (see Laeven & Majnoni, 2003). Our results show a negative relationship between loan loss provisioning and bank lending, in line with Pool et al. (2015) and Bouvatier and Lepetit (2013). We find market share is significantly and positively associated to bank lending. Numerous studies have shown that banks with higher market power have access to many alternative sources of financing, along with easier access to financial markets, thus they are able to lend more than banks with smaller market shares. These effects were found for normal times and for the period of economic downturns (see Cubillas & Suárez, 2018; Fungáčová et al., 2014). Of specialization dummies, only the coefficient received for savings banks is significantly associated to bank lending, but only at the 10 percent level. This may be the result of savings banks business models characteristics, which are to a large extent focused on lending business.

Table 6 shows estimations with different macroeconomic variables introduced in the model. The most relevant bank variables from previous analysis remain in the set of controls for these regressions. To complement our bank controls, we include additional macroeconomic variables in different stages of the analysis. First, we include GDP real growth rate, as our proxy for credit demand and economic development. We find that an increase in GDP growth is significantly associated with bank lending, but only at a 10% level. This association is expected, as higher credit demand and economic development stimulates heightened credit activity in banks. We also control for private credit growth as a percentage of GDP, as an additional measure of financial development (Morgan et al., 2018); gross capital formation growth, in order to account for the level of investments and the contribution to the economic activity in a country (Festić et al., 2011); NPL gross as a percentage of GDP, as a financial soundness indicator; and inflation rate, as an additional measure of credit demand. Domestic bank credit to private sector to GDP and country level NPL ratio are not significantly associated to individual bank lending in our specifications. As expected, gross capital formation growth is significantly and positively associated to bank lending, while the inflation rate is also

Table 10. Macroprudential indices vs. crisis.

	Pre-crisis			Crisis			Post-crisis		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Dependent variable (lag)	0.787***	0.789***	0.798***	0.697***	0.626***	0.642***	0.448	0.509***	0.533***
	(15.94)	(15.72)	(16.44)	(4.90)	(5.46)	(5.11)	(1.08)	(2.82)	(2.97)
MPP (lag)	**0.00120**			**−0.0123****			**−0.00283**		
	(0.08)			**(-1.99)**			**(-0.41)**		
MPP3 (lag)		**0.0112**			**−0.0508****			**0.00547**	
		(0.22)			**(-1.99)**			**(0.32)**	
MPP4 (lag)			**0.0708****			**0.0507***			**0.103****
			(2.35)			**(1.89)**			**(2.30)**
Size (total assets, logs)	0.173***	0.171***	0.164***	0.258**	0.321***	0.308***	0.173***	0.171***	0.164***
	(3.90)	(3.78)	(3.77)	(1.98)	(3.09)	(2.68)	(3.90)	(3.78)	(3.77)
Tier 1 ratio	−0.00570***	−0.00557***	−0.00556***	−0.0128**	−0.0158***	−0.0146***	−0.00570***	−0.00557***	−0.00556***
	(-3.63)	(-3.65)	(-3.60)	(-2.37)	(-3.30)	(-2.91)	(-3.63)	(-3.65)	(-3.60)
Liquidity ratio	0.000984*	0.000984*	0.00109**	−0.00177*	−0.00238**	−0.00203**	0.000984*	0.000984*	0.00109**
	(1.96)	(1.91)	(2.32)	(-1.88)	(-2.38)	(-2.04)	(1.96)	(1.91)	(2.32)
Loans to deposits (logs)	0.0715***	0.0729***	0.0695***	0.114*	0.137***	0.134***	0.0715***	0.0729***	0.0695***
	(2.70)	(2.71)	(2.69)	(1.92)	(2.81)	(3.02)	(2.70)	(2.71)	(2.69)
Market share	0.00124	0.00120	0.000961	0.00569***	0.00620***	0.00640***	0.00564	0.00546**	0.00467*
	(0.78)	(0.75)	(0.62)	(3.08)	(3.07)	(2.97)	(0.87)	(2.07)	(1.85)
Δ Policy rate	−0.0180**	−0.0182**	−0.0164**	0.00708	−0.0133*	−0.0141	−0.0180**	−0.0182**	−0.0164**
	(-2.38)	(-2.31)	(-2.13)	(0.78)	(-1.83)	(-1.50)	(-2.38)	(-2.31)	(-2.13)
GDP growth (lag)	0.0297***	0.0291***	0.0296***	0.00217	0.00533**	0.00374	0.0297***	0.0291***	0.0296***
	(4.26)	(3.85)	(4.36)	(0.49)	(1.99)	(1.16)	(4.26)	(3.85)	(4.36)
Observations	3889	3889	3889	4090	4090	4090	8086	8086	8086
Instruments	28	28	28	38	34	34	32	29	29
AR (1)	0.00126	0.00127	0.00141	0.0646	0.0726	0.0827	0.326	0.273	0.265
AR (2)	0.419	0.420	0.441	0.657	0.421	0.375	0.741	0.784	0.846
Hansen	0.156	0.151	0.124	0.390	0.030	0.004	0.253	0.000332	0.000167

Note: The dependent variable is gross loans in logs. Estimation method is dynamic twostep system generalized method of moments (GMM) estimator with robust standard errors and Windmeijer's correction. Lagged dependent variable is treated as endogenous, and all other variables as exogenous. All regressions include year fixed effects. T statistics is reported in parentheses. All regressions include weights based on the number of observations of each country. Macroeconomic variables are lagged one period, while all variables, apart from indicator variables, are winsorized 1% on both tails of the distribution. The following are p-values which indicate the significance level of coefficients: *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

significantly and positively associated to bank lending (Beutler et al., 2020).

Our macroprudential indices remain significantly and negatively associated to credit supply in most specifications. For a unit increase in MPP, bank lending exhibits a decrease from 0.7 to 1%. A unit increase in MPP2 index, is significantly associated with a decline in bank lending by around 3%.

2.5 Tightening and loosening of macroprudential policy

In order to analyze the existence of asymmetric effects in macroprudential response, we investigate the impact of tightening and loosening policy actions separately. The results of these estimations are given in Table 7. In these estimations, we include several important bank and macroeconomic determinants (see column 1 in Table 6), along with our four indices measuring the policy stance: 1) tightening: MPP3 and MPP5, and 2) loosening: MPP4 and MPP6. Tightening actions of macroprudential policy are significantly associated to bank lending at 10%, when measured with MPP3 index. These results are in line with Poghosyan (2020), where the author investigates the effectiveness of lending restrictions on credit supply and finds only weak association of tightening policy actions with lending activity in banks. On the other side, when we analyze loosenings of macroprudential policy, we find that these actions are strongly associated with the increase in lending activity of banks. We find statistically significant coefficient with positive signs for both, MPP4 and MPP6 indices, which are followed by an increase in bank lending by 8% (MPP4) and 2.5% (MPP6). The difference in the effects lies in the measurement design and suggest its importance when comparing and determining the effects of the policy. This analysis suggests that deactivation or loosening of macroprudential policy has stronger effects on bank lending and is associated with increase in credit activities. The asymmetry of results when analyzing tightenings and loosenings separately could come as a consequence of regulatory leakages due to

circumvention of regulatory measures (e.g. through window dressing). On the other hand, some borrowers might turn to non-bank institutions, while there is also a question on national jurisdiction for many macroprudential policies which could cause circumvention of the policies (see Aiyar et al., 2015; Poghosyan, 2020; Reinhardt & Sowerbutts, 2015).

3 Extensions and robustness tests

As we are interested in providing additional analysis which would extend and provide further insights into understanding the relationship between bank lending behavior and macroprudential policy, we perform additional tests which consider measurement, time period and sample of banks. First, we divide our main index to measures directed at certain regulatory targets. Second, we inspect the impact of time period and the state of the financial cycle by dividing the sample in respect to the 2008 financial crisis outbreak. Lastly, we measure the impact of macroprudential policy on a subsample of listed banks, as we are interested in examining if there is a stronger association between macroprudential instruments activation and institutions which are part of this subsample.

3.1 Different types of macroprudential instruments

Macroprudential data based on MaPPED consists of different macroprudential tools with numerous objectives. By following Meuleman and Vander Vennet (2020), we group macroprudential tools based on their target into four indices: 1) *Credit*, tools directed at curbing excessive lending; 2) *Market liquidity*, tools aimed to improve liquidity position of banks; 3) *Concentration*, policy tools aimed to decrease different bank exposures to certain types of loans or lenders and 4) *Resilience*, macroprudential measures directed at capital position of banks, as well as specific macroprudential measures aimed at banking sector resilience.

First column of Table 8 represents the baseline results for MPP index, for the purpose of comparability.[9] Column 2 shows results obtained with four groups of indices. We find statistically significant results only for *Concentration* index, which indicates that macroprudential measures targeted to limit bank exposures to different types of loans or lenders are effective in reducing bank lending for around 2%.

Additionally, we further examine the subdivision of the aforementioned indices, and we form different subgroups of these indices, to test macroprudential indices with more granular approach to their objectives. This is evident in column 3. Among the credit targeting macroprudential measures, we find lending caps to be most effective. Following the activation or tightening of existing lending caps, bank lending declines for 2.6%, a finding similar to Poghosyan (2020). This is expected as these tools specifically target excessive credit growth and overheating in credit market. These results are in line with Cerutti et al. (2017) and Morgan et al. (2018), whose paper specifically investigate loan to value measures, and other studies whose findings show that these measures are also effective in limiting bank risk (Altunbas et al., 2018; Claessens et al., 2013; Meuleman & Vander Vennet, 2020). Surprisingly, we receive significant and positive coefficient for credit growth tools, which are consisted of reserve requirements. Similar results were found by Akinci and Olmstead-Rumsey (2018), who suggest that this might be caused by the presence of euro area countries in the sample prone to the effects of ECB actions, which could have some countercyclical effects depending on country characteristics.

Due to the ever-growing interest in the loosening effects of macroprudential policies and in order to assess the beneficial effects of relaxation of some macroprudential measures to counter the effects of the current crisis and to support credit supply, we decide to examine in particular the loosening actions of different groups of macroprudential instruments. The results from Table 9 indicate that the strongest effects on bank lending have capital buffers and lending caps. After the relaxation of capital buffers, bank lending increases by about 10.7%, while the loosening of lending caps leads to a 10.4% increase in credit supply. The first column shows results received for MPP4 and MPP6 indices which we include for comparability of coefficients. We also obtain statistically significant and positive coefficients for provisioning and exposures related indices. These results confirm the effectiveness of macroprudential policies in easing cycles, which also underpins their use in the current Covid-19 crisis. However, we stress that the use of these policies should be accompanied by a cautious approach that should maintain the ultimate macroprudential objective of financial stability. This means that policymakers should still have other tools at their disposal to prevent deterioration in the quality of bank assets and the riskiness of the borrower base. We also stress the importance of coordinating different macroprudential policies at the national and supranational levels (e.g. in the

[9] The results in Tables 8 and 9 were minimized for brevity. Complete estimation results, with all variables coefficients, are available in Appendix (Tables A3–A6).

Table 11. The impact of macroprudential policy on listed banks.

	(1)	(2)	(3)	(4)	(5)	(6)
	MPP	MPP2	MPP3	MPP4	MPP5	MPP6
Dependent variable (lag)	0.604***	0.651***	0.667***	0.668***	0.649***	0.649***
	(5.65)	(6.15)	(6.28)	(6.85)	(6.25)	(5.46)
MPP (lag)	**−0.0186*** **					
	(-4.21)					
MPP2 (lag)		**−0.0369*** **				
		(-3.08)				
MPP3 (lag)			**−0.0509*** **			
			(-3.05)			
MPP4 (lag)				**0.0502***		
				(1.93)		
MPP5 (lag)					**−0.0116** **	
					(-2.20)	
MPP6 (lag)						**0.0218** **
						(2.48)
Size (total assets, logs)	0.370***	0.328***	0.313***	0.312***	0.327***	0.331***
	(3.76)	(3.43)	(3.29)	(3.54)	(3.42)	(3.02)
Tier 1 ratio	−0.00368	−0.00268	−0.00257	−0.00290	−0.00327	−0.00412
	(-1.16)	(-0.98)	(-0.90)	(-1.15)	(-1.12)	(-1.20)
Liquidity ratio	0.000889	0.000874	0.000775	0.000901	0.000746	0.000947
	(1.59)	(1.46)	(1.30)	(1.32)	(1.17)	(1.39)
Loans to deposits (logs)	0.294***	0.263***	0.251***	0.250***	0.258***	0.256***
	(3.29)	(2.88)	(2.66)	(2.87)	(3.10)	(2.63)
Market share	0.0000616	−0.000262	−0.000390	−0.000503	−0.00000114	−0.000815
	(0.05)	(-0.19)	(-0.28)	(-0.33)	(-0.00)	(-0.49)
Δ Policy rate	0.0114	0.00560	0.00470	0.00729	0.00676	0.0122
	(1.28)	(0.59)	(0.49)	(0.73)	(0.66)	(1.36)
GDP growth (lag)	0.00300	0.00221	0.00194	0.00130	0.000819	0.00312
	(0.88)	(0.63)	(0.52)	(0.36)	(0.22)	(0.78)
Observations	876	876	876	876	876	876
Instruments	82	82	82	82	82	82
AR (1)	0.096	0.081	0.088	0.071	0.094	0.075
AR (2)	0.375	0.575	0.784	0.388	0.586	0.283
Hansen	0.244	0.243	0.251	0.175	0.225	0.197

Note: The dependent variable is gross loans in logs. Estimation method is dynamic twostep system generalized method of moments (GMM) estimator with robust standard errors and Windmeijer's correction. Lagged dependent variable is treated as endogenous, and all other variables as exogenous. All regressions include year fixed effects. T statistics is reported in parentheses. All regressions include weights based on the number of observations of each country. Macroeconomic variables are lagged one period, while all variables, apart from indicator variables, are winsorized 1% on both tails of the distribution. The following are p-values which indicate the significance level of coefficients: $*p < 0.10$, $**p < 0.05$, $***p < 0.01$.

euro area) to maximize the positive effects of easing some instruments that may lead to an increase in credit supply and economic growth.[10]

3.2 Macroprudential policy over different periods

In order to test the effects of macroprudential instruments on bank lending in different periods reflecting the impact of the global financial crisis of 2008, we decide to split our sample over different time periods: pre-crisis, crisis and post-crisis period. We analyze the effects of MPP index, our base macroprudential index and initial two indices formulated to measure tightening and loosening policy actions separately, MPP3 and MPP4.

The analysis shows that macroprudential instruments are most effective in easing cycle in pre-crisis period, with the coefficient indicating when macroprudential measures are loosened, the credit supply increases by 7%. Other macroprudential indices are not significant in this setting. When we move on to the crisis period, we observe that macroprudential measures are effective in curbing credit growth during the economic downturn. For the one-unit increase in MPP and MPP3 index, bank lending declines by 1.2% and 5%. By looking at MPP4 index, the loosening effect of macroprudential policy is somewhat weaker indicating that if macroprudential measures are loosened, credit supply increases by 5%, with 10% level of significance. In the post-crisis

[10] The coefficient for the leverage ratio limit is not reported in Table 9 as the data do not report any loosenings of the leverage ratio limit within our sample and time coverage.

period, we find only MPP4 index to be significantly associated to bank lending. For a unit increase in MPP4 index, we find that bank lending increases by more than 10%. This relationship shows that loosening policy actions have stronger effect on bank lending, as in Poghosyan (2020). This finding is especially important in the current state of affairs when most countries are relaxing regulatory demands imposed on banks in order to combat the negative economic effects of the Covid-19 pandemic and further corroborate our previous analysis. Interestingly, we also find that the coefficient of the policy rate is strongly and negatively associated with bank lending in the pre-crisis and post-crisis periods, but the estimations restricted to the crisis period show that the coefficient of the policy rate is not statistically significant. This can be a sign of lower effectiveness of monetary policy on credit activity in the period of distress, however, this investigation goes beyond this paper (see Table 10).

3.3 Subsample of listed banks

To examine whether our results are robust to a limited set of institutions, we analyze the subsample of 112 listed banks available in the Fitch Connect database for EU countries. Majority of these banks are also the largest EU banks, and of systemic importance. This gives us an additional incentive to measure the impact of macroprudential measures on lending behavior of these institutions. As some of macroprudential tools are specifically aimed at systematically large banks, we expected to find significant relationship between macroprudential policy and lending behavior in this sample setting. We estimate the effects using all of our six macroprudential indices, as we want to account for both the overall macroprudential stance and the effects of tightening and easing cycles of policy. The results obtained show that, as in our previous analysis of the full sample of banks, the overall macroprudential policies and the MPP and MPP2 indices are significantly and negatively associated with bank lending at the 1% level, as expected. Tightening of macroprudential measures is followed by a decline in lending activity by 1.86% (MPP) and 3.7% (MPP2). When we analyze tightenings only, we see that tightening effects are even stronger for listed banks, with both indices significantly associated with bank credit at the 1% (MPP3) and 5% (MPP5) levels. A tightening of macroprudential instruments is followed by a reduction in bank credit of about 5% (MPP3) and 1.16% (MPP5). These estimates suggest that listed banks are more responsive to a tightening of macroprudential measures. Finally, we consider the results obtained for the MPP4 and MPP6 easing indices. The obtained statistically significant coefficients at 10% (MPP4) and 5% (MPP6) levels indicate that bank credit is elevated by 5% (MPP4) and 2.18% (MPP6) following a relaxation of macroprudential instruments (see Table 11).

4 Conclusion

In this study, we investigate whether macroprudential measures are effective in curtailing bank lending on a sample of 28 EU countries and an over 17-year period horizon between 2000 and 2017. By employing the Arellano-Bond generalized method of moments, which enabled us to minimize endogeneity issues related with the introduction of these measures, we find that macroprudential measures are negatively associated with bank lending. We assess alternative measures of macroprudential policy. First, we analyze two macroprudential indices, which take into account all instruments available in the database and all policy actions: tightenings, and loosenings. We find that these measures are significantly and negatively associated to credit supply, when controlling for different bank and macroeconomic variables.

In an attempt to differentiate the effect of tightening and loosening measures, we construct four different indices capturing only tightening or loosening actions. We receive weak association of tightening indices and credit activity of banks. On the contrary, analysis shows that the effects on bank lending are stronger when macroprudential measures are loosened or deactivated. The coefficient for loosening actions is significantly and positively associated with bank lending when introducing different bank and macroeconomic variables which might have an effect on bank lending activity. These findings are particularly important in the current situation and economic consequences of the Covid-19 pandemic, as policymakers and governments relax prudential requirements to increase market liquidity and support investment and economic growth. The unloosing of macroprudential measures during economic downturns can also support monetary policy efforts to promote market liquidity without jeopardizing financial stability. In addition, the use of macroprudential measures in relation to specific sectors, such as SME borrowers or specific industries, may also take into account the special needs of the given country's sector. More efforts could also be made to better coordinate regulatory actions at both supranational and national levels (Guindos, 2021). As a robustness test, we further analyze which macroprudential measures have the strongest relationship with bank lending. We find, as expected, that lending

constraints are significantly and negatively associated with lending, while credit growth measures, such as reserve requirements on the liability and asset side of the bank balance sheet, show some procyclical effect, as we obtained a positive coefficient. Moreover, we find that capital buffers and lending measures have the strongest relationship with credit in macroprudential policy easing cycles.

To show whether there are differences in the effects of macroprudential indices in different periods of the financial cycle, we test the effects of three indices, the overall macroprudential stance, tightenings, and loosenings separately, in the pre-crisis, crisis, and post-crisis periods. We find that macroprudential measures are most efficient in controlling credit activity in the crisis period, while the effect of easing policy actions is somewhat limited. In the pre-crisis and post-crisis periods, the loosening cycle of macroprudential policy has a stronger impact on bank lending. In addition, we check our results with the subsample of listed banks. The results for listed banks are even stronger, as all of our macroprudential indices are statistically significant and exhibit the expected relationship. When analyzing policy instruments, policymakers should evaluate all measures introduced in a country in a given period: both macroprudential and microprudential instruments that could have some macroprudential effect, analyzing also their interaction with monetary policy. We also support the proposition that macroprudential policy should be a primary tool to curb credit booms and financial system vulnerabilities, as it effectively limits excessive bank lending. On the other hand, the effectiveness of macroprudential policy is significantly challenged by regulatory leakages and national responsibility for many macroprudential measures in the internationalized and interconnected European banking sector.

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Appendix

Table A1. Macroprudential instruments in MaPPED.

Instrument group	Instruments
Minimum capital requirements (MCR)	Capital adequacy ratio (CAR)
	Tier 1 capital ratio
	Common Equity Tier 1 capital ratio (CET 1)
	Core Tier 1 capital ratio
Capital buffers	Countercyclical capital buffer
	Capital conservation buffer
	Systemic risk buffer
	G-SII capital buffer
	O–SII capital buffer
	Other capital requirements targeting most important institutions
	Other capital surcharges and own funds requirements
	Profit distribution restrictions
Risk weights	Risk weights for loans backed by residential property
	Risk weights for loans backed by commercial property
	Other sectoral risk weights
Leverage ratio	Leverage ratio limit
Loan loss provisioning	Loan classification rules
	Minimum specific provisioning
	General provisioning
	Capital treatment of loan loss reserve
Lending standards restrictions	Loan-to-value (LTV) limits
	Loan-to-income (LTI) limits
	Debt-to-income (DTI) limits
	Debt-service-to-income (DSTI) limits incl. interest rate stress testing
	Limits on interest rates on loans
	Maturity and amortization restrictions
	Other income requirements for loan eligibility
	Limits on the volume of personal loans
	Other restrictions on lending standards

(*continued on next page*)

Table A1. (continued)

Instrument group	Instruments
Limits on credit growth and volume	Reserve requirements related to banks' liabilities
	Asset-based reserve requirements
Levies/taxes on financial institutions	Tax on assets/liabilities
	Tax on financial activities
Liquidity requirements and limits on currency and maturity mismatch	Loan to deposit (LTD) ratios
	Other stable funding req. incl. Net Stable Funding Requirement
	Short-term liquidity coverage ratios incl. Liquidity Coverage Ratio
	Liquidity ratios and deposit coverage ratios
	Limits on FX mismatches
	Other liquidity requirements
Limits on large exposures and concentration	Single client exposure limits
	Intragroup exposures limits
	Sector and market segment exposure limits
	Funding concentration limits
	Limits on qualified holdings outside financial sector
	Other exposure and concentration limits
Other measures	Structural measures
	Margin requirements
	Other regulatory restrictions on financial activities
	Limits on deposit rates
	Debt resolution policies
	Crisis management tools
	Changes in regulatory framework
	Other

Source: Budnik, K. & Kleibl, J. (2018). Macroprudential regulation in the European Union in 1995−2014: introducing a new data set on policy actions of a macroprudential nature. Macroprudential Policies Evaluation Database (MaPPED)

Table A2. Description of variables.

Variable	Description	Source
Bank specific variables		
Gross loans (logs)	The natural logarithm of gross loans.	Fitch Connect, Own calculations
Size (total assets, logs)	The natural logarithm of total assets.	Fitch Connect, Own calculations
Liquidity ratio (%)	Liquid assets/Total assets ratio.	Fitch Connect
Tier 1 ratio (%)	Tier 1 capital ratio/Total risk-weighted assets ratio.	Fitch Connect
Loans to deposits (logs)	Gross loans/Total customer deposits ratio.	Fitch Connect, Own calculations
Loan loss provisioning (%)	The ratio of loan-loss provisioning/Gross loans.	Fitch Connect
Market share (%)	Total assets of bank j in country k and year t over total assets of the banking sector in country k at year t.	Fitch Connect, Own calculations
Commercial (0−1)	Dummy variable equal to 1 if bank specialization is commercial, and 0 otherwise.	Fitch Connect, Own calculations
Savings (0−1)	Dummy variable equal to 1 if bank specialization is savings, and 0 otherwise.	Fitch Connect, Own calculations
Cooperative (0−1)	Dummy variable equal to 1 if bank specialization is cooperative, and 0 otherwise.	Fitch Connect, Own calculations
Macroeconomic variables		
Δ Policy rate	The yearly change in central bank policy rate, calculated by taking the first difference.	IMF, European Central Bank, own calculations
GDP growth (%)	Lag of annual real growth rate of GDP, lagged.	World Bank
Credit to private sector (%)	Domestic private credit as percentage of annual GDP growth rate, lagged.	World Bank
Gross capital formation growth (%)	Gross capital formation as percentage of GDP growth rate, lagged.	World Bank
NPL gross (%)	Bank non-performing loans to total gross loans, lagged.	World Bank
Inflation rate (%)	Inflation rate, based on CPI, lagged.	World Bank
Macroprudential data		
MPP	The sum of all macroprudential policy actions in the database over country k in a year t, lagged.	MaPPED, ECB, Own calculations
MPP2	The sum of all macroprudential policy actions in the database over country k in a year t bounded to interval −1 to 1, lagged.	MaPPED, ECB, Own calculations

(*continued on next page*)

Table A2. (continued)

Variable	Description	Source
MPP3	The sum of all macroprudential tightening policy actions in the database over country *k* in a year *t* bounded to interval 0 to 1, lagged.	MaPPED, ECB, Own calculations
MPP4	The sum of all macroprudential loosening policy actions in the database over country *k* in a year *t* bounded to interval 0 to 1, lagged.	MaPPED, ECB, Own calculations
MPP5	The sum of all macroprudential tightening policy actions in the database over country *k* in a year *t*, lagged.	MaPPED, ECB, Own calculations
MPP6	The sum of all macroprudential loosening policy actions in the database over country *k* in a year *t*, lagged.	MaPPED, ECB, Own calculations
Credit	The sum of all macroprudential credit related policy actions in the database over country *k* in a year *t*, lagged.	MaPPED, ECB, Own calculations
Market Liquidity	The sum of all macroprudential liquidity related policy actions in the database over country *k* in a year *t*, lagged.	MaPPED, ECB, Own calculations
Concentration	The sum of all macroprudential policy actions aiming to limit different bank exposures in the database over country *k* in a year *t*, lagged.	MaPPED, ECB, Own calculations
Resilience	The sum of all macroprudential policy actions aimed to strengthen the resilience of financial sector in the database over country *k* in a year *t*, lagged.	MaPPED, ECB, Own calculations
Credit growth	The sum of all macroprudential policy actions related with reserve requirements in the database over country *k* in a year *t*, lagged.	MaPPED, ECB, Own calculations
Lending caps	The sum of all macroprudential policy actions aimed to limit excessive lending in the database over country *k* in a year *t*, lagged.	MaPPED, ECB, Own calculations
Risk weights	The sum of all macroprudential policy actions related with risk weighing in banks in the database over country *k* in a year *t*, lagged.	MaPPED, ECB, Own calculations
Liquidity	The sum of all macroprudential policy actions aimed to strengthen the liquidity position of banks in the database over country *k* in a year *t*, lagged.	MaPPED, ECB, Own calculations
Exposures	The sum of all macroprudential policy actions aimed to limit different bank exposures in the database over country *k* in a year *t*, lagged.	MaPPED, ECB, Own calculations
MCR	The sum of all macroprudential policy actions aimed at capital position of banks in the database over country *k* in a year *t*, lagged.	MaPPED, ECB, Own calculations
Capital buffers	The sum of all countercyclical macroprudential policy actions aimed at capital positions of banks in the database over country *k* in a year *t*, lagged.	MaPPED, ECB, Own calculations
Taxes	The sum of all macroprudential policy actions related with taxation of bank assets/liabilities or other financial activities in the database over country *k* in a year *t*, lagged.	MaPPED, ECB, Own calculations
Provisioning	The sum of all macroprudential policy actions related with provisioning in the database over country *k* in a year *t*, lagged.	MaPPED, ECB, Own calculations
Leverage ratio	The leverage ratio policy actions in the database over country *k* in a year *t*, lagged.	MaPPED, ECB, Own calculations
Other requirements	The sum of all other macroprudential policy actions in the database over country *k* in a year *t*, lagged.	MaPPED, ECB, Own calculations

Table A3. Macroprudential indices based on the target of the measures.

	(1)	(2)	(3)	(4)
	Credit	Liquidity measures	Concentration	Resilience
Dependent variable (lag)	0.723***	0.720***	0.727***	0.723***
	(6.81)	(7.51)	(7.03)	(7.04)
Index (lag)	**−0.00497**	**−0.00793**	**−0.0196****	**−0.00594**
	(-0.75)	**(-0.55)**	**(-2.35)**	**(-1.12)**
Size (total assets, logs)	0.246**	0.247***	0.243**	0.246***
	(2.52)	(2.82)	(2.54)	(2.61)
Liquidity ratio	−0.00106**	−0.00111**	−0.00112**	−0.00104*
	(-1.96)	(-2.07)	(-2.19)	(-1.92)
Tier 1 ratio	−0.00778***	−0.00787***	−0.00768***	−0.00772***
	(-2.87)	(-3.29)	(-2.88)	(-3.00)
Loans to deposits (logs)	0.106**	0.107**	0.105**	0.105**
	(2.31)	(2.57)	(2.35)	(2.40)
Market share	0.00343*	0.00372**	0.00339**	0.00344**
	(1.96)	(2.20)	(2.01)	(1.97)
Δ Policy rate	−0.0360**	−0.0369**	−0.0283*	−0.0348**
	(-2.09)	(-2.27)	(-1.72)	(-2.14)
GDP growth (lag)	0.00612	0.00593	0.00660	0.00596
	(1.34)	(1.41)	(1.53)	(1.34)
Observations	16,065	16,065	16,065	16,065
Instruments	82	82	82	82
AR (1)	0.109	0.105	0.107	0.107
AR (2)	0.378	0.357	0.385	0.394
Hansen	0.644	0.656	0.604	0.678

Note: The dependent variable is gross loans in logs. Estimation method is dynamic twostep system generalized method of moments (GMM) estimator with robust standard errors and Windmeijer's correction. Lagged dependent variable is treated as endogenous, and all other variables as exogenous. All regressions include year fixed effects. T statistics is reported in parentheses. All regressions include weights based on the number of observations of each country. Macroeconomic variables are lagged one period, while all variables, apart from indicator variables, are winsorized 1% on both tails of the distribution. The following are p-values which indicate the significance level of coefficients: *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

Table A4. Macroprudential subindices based on the target of the measures.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	Credit growth	Lending caps	Risk weights	Liquidity measures	Concentration	MCR	Capital buffers	Taxes	Provisioning	LEV	Other requirements
Dependent variable (lag)	0.727*** (7.11)	0.730*** (6.61)	0.712*** (5.44)	0.718*** (7.41)	0.724*** (6.80)	0.719*** (6.75)	0.717*** (6.88)	0.722*** (6.82)	0.720*** (6.79)	0.721*** (6.89)	0.722*** (7.34)
Index (lag)	**0.0276** (2.55)**	**−0.0260** (-1.99)**	**−0.00919 (-0.65)**	**−0.00837 (-0.59)**	**−0.0198** (-2.36)**	**0.00457 (0.60)**	**−0.0120 (-1.61)**	**−0.0114 (-0.56)**	**−0.0218 (-1.42)**	**0.103 (1.21)**	**−0.00908 (-0.64)**
Size (total assets, logs)	0.240** (2.55)	0.239** (2.34)	0.256** (2.15)	0.248*** (2.79)	0.244** (2.47)	0.248** (2.53)	0.250*** (2.59)	0.245** (2.51)	0.247** (2.53)	0.247** (2.55)	0.245*** (2.70)
Liquidity ratio	−0.00105** (-1.98)	−0.000984* (-1.87)	−0.00104* (-1.76)	−0.00113** (-2.15)	−0.00114** (-2.25)	−0.00109** (-2.07)	−0.00110** (-2.08)	−0.00108** (-2.04)	−0.00102* (-1.88)	−0.00109** (-2.05)	−0.00109** (-2.05)
Tier 1 ratio	−0.00768*** 0.240**	−0.00774*** (-2.76)	−0.00828** (-2.34)	−0.00791*** (-3.25)	−0.00772*** (-2.78)	−0.00788*** (-2.91)	−0.00788*** (-3.01)	−0.00772*** (-2.94)	−0.00769*** (-2.97)	−0.00784*** (-3.00)	−0.00779*** (-3.14)
Loans to deposits (logs)	0.105** (2.41)	0.103** (2.18)	0.108* (1.94)	0.108** (2.56)	0.106** (2.30)	0.107** (2.33)	0.107** (2.38)	0.106** (2.34)	0.107** (2.35)	0.107** (2.37)	0.106** (2.51)
Market share	0.00401** (2.55)	0.00380** (2.44)	0.00367* (1.79)	0.00424*** (2.80)	0.00389** (2.53)	0.00402*** (2.58)	0.00408*** (2.63)	0.00398** (2.52)	0.00397** (2.57)	0.00401*** (2.59)	0.00406*** (2.62)
Δ Policy rate	−0.0358** (-2.01)	−0.0380** (-2.10)	−0.0365* (-1.74)	−0.0366** (-2.22)	−0.0279* (-1.65)	−0.0375** (-2.10)	−0.0357** (-2.06)	−0.0359** (-2.08)	−0.0386** (-2.39)	−0.0366** (-2.11)	−0.0357** (-2.20)
GDP growth (lag)	0.00440 (0.87)	0.00597 (1.29)	0.00562 (1.08)	0.00563 (1.35)	0.00632 (1.46)	0.00508 (1.07)	0.00533 (1.17)	0.00545 (1.21)	0.00530 (1.17)	0.00523 (1.16)	0.00545 (1.23)
Observations	16,065	16,065	16,065	16,065	16,065	16,065	16,065	16,065	16,065	16,065	16,065
Instruments	82	82	82	82	82	82	82	82	82	82	82
AR (1)	0.109	0.112	0.112	0.105	0.108	0.108	0.108	0.108	0.106	0.108	0.107
AR (2)	0.354	0.320	0.383	0.359	0.389	0.380	0.385	0.386	0.417	0.375	0.379
Hansen	0.497	0.637	0.589	0.660	0.604	0.618	0.604	0.643	0.727	0.650	0.682

Note: The dependent variable is gross loans in logs. Estimation method is dynamic twostep system generalized method of moments (GMM) estimator with robust standard errors and Windmeijer's correction. Lagged dependent variable is treated as endogenous, and all other variables as exogenous. All regressions include year fixed effects. T statistics is reported in parentheses. All regressions include weights based on the number of observations of each country. Macroeconomic variables are lagged one period, while all variables, apart from indicator variables, are winsorized 1% on both tails of the distribution. The following are p-values which indicate the significance level of coefficients: $*p < 0.10$, $**p < 0.05$, $***p < 0.01$.

Table A5. Loosening cycles of different macroprudential indices based on the target of the measures.

	(1)	(2)	(3)	(4)
	Credit	Liquidity measures	Concentration	Resilience
Dependent variable (lag)	0.731***	0.726***	0.718***	0.732***
	(7.34)	(7.39)	(6.61)	(8.25)
Index (lag)	**0.0370****	**0.0294**	**0.0798*****	**0.0933*****
	(2.53)	**(1.57)**	**(3.30)**	**(3.58)**
Size (total assets, logs)	0.251***	0.254***	0.262**	0.249***
	(2.65)	(2.74)	(2.56)	(2.97)
Liquidity ratio	−0.00102*	−0.00106*	−0.00115*	−0.00100*
	(-1.66)	(-1.71)	(-1.80)	(-1.81)
Tier 1 ratio	−0.00749***	−0.00772***	−0.00784***	−0.00753***
	(-2.99)	(-3.12)	(-2.78)	(-3.47)
Loans to deposits (logs)	0.100**	0.102**	0.107**	0.0981***
	(2.46)	(2.54)	(2.34)	(2.72)
Market share	−0.000249	−0.000118	−0.0000429	−0.000210
	(-0.49)	(-0.24)	(-0.08)	(-0.47)
Δ Policy rate	−0.0372**	−0.0392**	−0.0316*	−0.0336**
	(-2.04)	(-2.27)	(-1.68)	(-1.98)
GDP growth (lag)	0.00800**	0.00693	0.00726	0.00839**
	(2.01)	(1.59)	(1.63)	(2.39)
Observations	16,065	16,065	16,065	16,065
Instruments	82	82	82	82
AR (1)	0.105	0.107	0.109	0.101
AR (2)	0.331	0.355	0.390	0.352
Hansen	0.622	0.653	0.745	0.788

Note: The dependent variable is gross loans in logs. Estimation method is dynamic twostep system generalized method of moments (GMM) estimator with robust standard errors and Windmeijer's correction. Lagged dependent variable is treated as endogenous, and all other variables as exogenous. All regressions include year fixed effects. T statistics is reported in parentheses. All regressions include weights based on the number of observations of each country. Macroeconomic variables are lagged one period, while all variables, apart from indicator variables, are winsorized 1% on both tails of the distribution. The following are p-values which indicate the significance level of coefficients: *p < 0.10, **p < 0.05, ***p < 0.01.

Table A6. Loosening cycles of different macroprudential subindices based on the target of the measures.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(11)
	Credit growth	Lending caps	Risk weights	Liquidity measures	Concentration	MCR	Capital buffers	Taxes	Provisioning	Other requirements
Dependent variable (lag)	0.727***	0.720***	0.723***	0.723***	0.715***	0.727***	0.720***	0.727***	0.726***	0.740***
	(7.20)	(7.07)	(7.38)	(7.24)	(6.48)	(7.75)	(7.70)	(7.26)	(7.06)	(8.58)
Index (lag)	**−0.00114**	**0.104*** **	**0.0206**	**0.0295**	**0.0801*** **	**0.0113**	**0.107*** **	**0.0712**	**0.0717** **	**0.0693***
	(-0.06)	**(3.09)**	**(0.90)**	**(1.56)**	**(3.32)**	**(0.26)**	**(3.83)**	**(1.58)**	**(2.07)**	**(1.89)**
Size (total assets, logs)	0.253***	0.260***	0.257***	0.256***	0.264**	0.254***	0.259***	0.253***	0.254***	0.240***
	(2.64)	(2.69)	(2.76)	(2.70)	(2.52)	(2.85)	(2.92)	(2.66)	(2.61)	(2.95)
Liquidity ratio	−0.00107*	−0.00112*	−0.00113*	−0.00107*	−0.00116*	−0.00109*	−0.00110*	−0.00109*	−0.000937	−0.00100*
	(-1.72)	(-1.74)	(-1.74)	(-1.72)	(-1.82)	(-1.79)	(-1.83)	(-1.75)	(-1.51)	(-1.74)
Tier 1 ratio	−0.00771***	−0.00786***	−0.00786***	−0.00780***	−0.00791***	−0.00773***	−0.00784***	−0.00770***	−0.00766***	−0.00738***
	(-3.05)	(-3.25)	(-3.14)	(-3.09)	(-2.75)	(-3.35)	(-3.39)	(-3.08)	(-3.00)	(-3.47)
Loans to deposits (logs)	0.102**	0.108**	0.106**	0.103**	0.108**	0.102***	0.104***	0.102**	0.102**	0.0978***
	(2.48)	(2.40)	(2.55)	(2.53)	(2.33)	(2.60)	(2.64)	(2.49)	(2.46)	(2.73)
Market share	−0.0000289	−0.0000109	−0.000105	−0.0000495	0.0000446	−0.0000328	0.0000555	−0.0000380	−0.0000609	−0.0000644
	(-0.07)	(-0.02)	(-0.23)	(-0.11)	(0.10)	(-0.08)	(0.12)	(-0.09)	(-0.14)	(-0.16)
Δ Policy rate	−0.0391**	−0.0459***	−0.0383**	−0.0392**	−0.0316*	−0.0356*	−0.0308*	−0.0398**	−0.0398**	−0.0402**
	(-2.16)	(-2.63)	(-2.14)	(-2.23)	(-1.65)	(-1.89)	(-1.84)	(-2.20)	(-2.13)	(-2.45)
GDP growth (lag)	0.00683	0.00641	0.00748*	0.00673	0.00710	0.00686	0.00795**	0.00712*	0.00624	0.00821**
	(1.59)	(1.50)	(1.76)	(1.53)	(1.58)	(1.64)	(2.01)	(1.71)	(1.42)	(2.26)
Observations	16,065	16,065	16,065	16,065	16,065	16,065	16,065	16,065	16,065	16,065
Instruments	82	82	82	82	82	82	82	82	82	82
AR (1)	0.108	0.105	0.107	0.107	0.109	0.108	0.108	0.106	0.108	0.104
AR (2)	0.349	0.297	0.357	0.355	0.390	0.352	0.353	0.360	0.333	0.320
Hansen	0.666	0.659	0.553	0.666	0.757	0.630	0.750	0.673	0.760	0.675

Note: The dependent variable is gross loans in logs. Estimation method is dynamic twostep system generalized method of moments (GMM) estimator with robust standard errors and Windmeijer's correction. Lagged dependent variable is treated as endogenous, and all other variables as exogenous. All regressions include year fixed effects. T statistics is reported in parentheses. All regressions include weights based on the number of observations of each country. Macroeconomic variables are lagged one period, while all variables, apart from indicator variables, are winsorized 1% on both tails of the distribution. The following are p-values which indicate the significance level of coefficients: *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.