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Carlo Altavilla
Luc Laeven
José-Luis Peydró

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Monetary and Macroprudential Policy Complementarities: Evidence from European Credit Registers*

Carlo Altavilla **Luc Laeven** **José-Luis Peydró**

Abstract

We show strong complementarities between monetary and macroprudential policies in influencing credit. We exploit credit register data – crucially from *multiple* (European) countries and for *both* corporate *and* household credit – in conjunction with monetary policy surprises and indicators of macroprudential policy actions. Expansive monetary policy boosts lending more in accommodative macroprudential environments. This complementary effect of monetary and macroprudential policy is stronger for: (i) expansionary (as opposed to contractionary) monetary policy; (ii) riskier borrowers; (iii) less capitalized banks (especially when lending to riskier borrowers); (iv) consumer and corporate loans (rather than mortgages); and (v) more (ex-ante) productive firms (especially for less capitalized banks).

JEL codes: G21, G28, G32, G51, E58.

Keywords: credit registers, household loans, corporate loans, monetary policy, macroprudential policy.

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* Carlo Altavilla (carlo.altavilla@ecb.europa.eu) and Luc Laeven (luc.laeven@ecb.europa.eu) are at the European Central Bank and are research fellows at CEPR. José-Luis Peydró (jose.peydro@gmail.com) is at Imperial College London, ICREA-Universitat Pompeu Fabra-CREI-Barcelona GSE and is a research fellow at CEPR. We would like to thank Viral Acharya, Ben Beckers, Konstantin Egorov, Mariassunta Giannetti, Adam Gorajek and Julien Idier, Peter Karadi, Angela Maddaloni, Alberto Martin, Caterina Mendicino, as well as seminar participants at the European Central Bank, the Central Bank of Russia, the New Economic School in Moscow, the Reserve Bank of Australia, the Banque de France, SciencePo and Norges Bank for comments. We are grateful to Bettina Farkas and Carl-Wolfram Horn for their excellent research assistance, to Carolina Villegas-Sanchez for sharing her code to compute firm-level productivity, and especially to Andrea Fabiani for his very useful comments and exceptional research assistance. The opinions in this paper are those of the authors and do not necessarily reflect the views of the European Central Bank or the Eurosystem.

1 Introduction

The global financial crisis of 2007-08 provided new evidence that disruptions in the flow of bank credit can have real effects (e.g. Loutskina and Strahan (2009); Ivashina and Scharfstein (2010); Jiménez, Ongena, Peydró and Saurina (2012); Chodorow-Reich (2014); Ramcharan, Verani, and Van den Heuvel (2016); Benmelech, Meisenzahl, and Ramcharan (2017); Amiti and Weinstein (2018)). This led to the development of a macroprudential approach to bank regulation, with special emphasis on credit (e.g., Hanson, Kashyap and Stein (2011); Kroszner and Strahan (2011); Freixas, Laeven and Peydró (2015); Cerutti, Claessens, and Laeven (2017); Jiménez, Ongena, Peydró and Saurina (2017); Akinci and Olmstead-Rumsey (2018)). The crisis also stimulated a rethink of the role of financial stability in monetary policy, including its interaction with macroprudential policy (e.g., Borio and Zhu (2008); Adrian and Shin (2010); Rajan (2010); Acharya and Naqvi (2012); Stein (2012); Brunnermeier and Sannikov (2014)).

These developments have spurred theoretical research on the optimal combination of monetary and macroprudential policies in managing the business cycle and safeguarding financial stability (e.g., Angelini, Neri and Panetta (2014); Farhi and Werning (2016); Brunnermeier and Sannikov (2016); Martinez-Miera and Repullo (2019); Adrian et al. (2020)). A key insight from this research is that macroprudential policy, by targeting financial risks, facilitates an effective transmission of monetary policy measures. Empirical research on the effects of macroprudential policy has lagged theoretical research because, at least in advanced economies, these policies are still in their infancy and micro-level data needed for identification is often lacking. An open empirical question is how macroprudential policy influences the transmission of monetary policy via credit. The amount of credit intermediated by banks plays a crucial role for monetary policy transmission (e.g., Bernanke and Gertler (1995); Diamond and Rajan (2006); Stein (2012); Brunnermeier and Sannikov (2014); Gertler and Karadi (2015)), but is also a key determinant behind the potential build-up of financial instability (e.g., Rajan (2005); Allen and Rogoff (2011); Adrian and Shin (2010)). There is also evidence that credit growth is a strong predictor of systemic financial crises (Schularick and Taylor (2012)), especially lending to households (Mian, Sufi and Verner (2017)).

In this paper, we contribute to this literature by studying whether the macroprudential environment influences the transmission of monetary policy to credit. We do so by using administrative loan-level data on *both* households and firms – corporate loans, consumer credit and mortgages – from a unique dataset comprising *multiple* credit registers from several European countries over the period 2012 to 2017. We merge this information with indicators of macroprudential and monetary policy actions, information on banks' balance sheet characteristics and information on borrower credit risk and the productivity of firms.

The combination of household and firm loans from a variety of countries greatly improves the external validity of the results compared to existing studies on other questions that typically rely on credit register data from a single country with a focus on corporate loans only. Moreover, we consider the inclusion of household loans to be particularly important given the significance of mortgage and consumer loans in propagating monetary shocks (e.g., Di Maggio, Kermani, Keys, Piskorski, Ramcharan, Seru, and Yao (2017); Beraja, Fuster, Hurst, and Vavra et al. (2019); Agarwal, Chomsisengphet, Mahoney, and Stroebel (2018)) and the fact that existing research has shown that mortgage lending can pose particularly large risks to financial stability (Jordà, Schularick, and Taylor (2015); Mian, Sufi and Verner (2017); Müller and Verner (2020)). Furthermore, several macroprudential instruments (e.g., loan-to-value and debt-to-income ratios) aims at primarily influencing household loans. Nevertheless, corporate loans are also crucial for risk-taking. Vulnerabilities in the corporate credit market, such as weakened credit quality of borrowers (e.g., International Monetary Fund (2020)) or credit misallocation toward low productive firms (e.g., Gopinath, Kalemli-Özcan, Karabarbounis, and Villegas-Sanchez, 2017), are crucial for macroeconomic and financial stability. In addition, focusing on Europe has the advantage of exploiting variation in macroprudential policies, which are set at the country level, while holding constant monetary policy, which is instead set at the euro area level.

We identify monetary policy shocks using high frequency surprises around central bank decisions (following Altavilla et al. (2019)).[1] The monetary policy shocks encompass both conventional and unconventional monetary policy, including large-scale asset purchases, negative policy rates and long-term refinancing operations. There is significant variation in monetary policy surprises in our sample (see Figure 5). We focus on euro area countries in order to have the same monetary policy shocks across countries, although the transmission of the single monetary policy might be heterogeneous across countries because of the different business cycle conditions (e.g., Taylor (1992)).

We analyze whether the impact of monetary policy surprises on credit varies with the ex-ante (lagged) macroprudential environment, which we measure using an index of macroprudential policy action constructed from the European Central Bank's (ECB) Macroprudential Database. This database considers a broad range of macroprudential policy measures, ranging from countercyclical capital buffers to loan-to-value ratios. As macroprudential policy reacts to the business and credit cycle, we control for GDP growth, inflation and credit growth developments, both in levels and in interactions with monetary policy surprises, and/or for various sets of (time) fixed effects.

In order to facilitate the identification of the effects of the two policies, we impose a clear timing assumption by lagging the macroprudential policy indicator with respect to the monetary policy surprises. This assumption effectively ensures that macroprudential policy does not react contemporaneously to monetary policy. At the same time, using high-frequency surprises

[1] The event-study literature concerning monetary policy effects on asset prices goes back to Cook and Hahn (1988) and has flourished since Kuttner (2001) showed how to use Federal fund rate futures contracts to measure market-perceived monetary policy surprises. Gürkaynak et al. (2005) have shown how to extract market-based measures of monetary policy communication using high-frequency data and factor rotations.

around monetary policy announcements avoids that monetary policy actions could be driven by macroprudential policies.

There is significant variation in macroprudential policies in our sample (see Figure 4). Moreover, there is also significant variation in terms of credit dynamics in our period across different countries and across household and corporate loans (see Figure 1, Panels A and B).

Our household-bank and firm-bank supervisory loan-level dataset offers several key advantages. First, we can capture heterogeneous effects across different types of lending (e.g. mortgage loans versus consumer loans versus corporate loans) and types of borrowers (e.g. riskier borrowers versus safer borrowers, or more productive firms versus unproductive firms). Second, the structure of the data allows for the inclusion of a rich set of fixed effects to control for unobservables, including country, time, borrower (household or firm) and lender (bank) fixed effects, and firm×time fixed effects. Moreover, saturating the model with high dimensional fixed effects allows us to meaningfully assess whether the estimated coefficients are stable despite substantial changes in explanatory power, and – based on tests developed by Oster (2019), following Altonji et al. (2005) – whether the results may be significantly biased by omitted variables and self-selection problems. Such robustness tests produce reassuring evidence on the validity of the results that we analyze throughout the paper.

We start with an analysis of whether and how the macroprudential regulatory environment affects the strength of the credit channel of monetary policy. The monetary policy stance can influence the amount of credit extended to firms and households, i.e., the "credit channel of monetary policy transmission" (Bernanke and Gertler (1989); Bernanke and Gertler (1995)). Similarly, the macroprudential regulatory environment can affect the availability of credit (Lorenzoni (2008); Bianchi (2011); Kashyap, Tsomocos and Vardoulakis (2014); Aikman, Nelson and Tanaka (2015); Farhi and Werning (2016); Bianchi and Mendoza (2018); Jeanne and Korinek (2019)).

We find strong complementarities between the two policies: the increase in bank lending that follows monetary policy easing is larger if the ex-ante macroprudential environment is more accommodative. This implies that the macroprudential policy environment reinforces the effects of monetary policy when the two policies push in the same direction. Effects are not only statistically significant but also economically strong. For loans to households, the estimated baseline marginal effect of a one standard deviation easing in monetary policy on lending, conditional on a one standard deviation softer macroprudential policy environment, is 1.3%. This effect is 42% larger than the average increase in lending due to softer monetary policy alone (reduced to around 20% after the inclusion of a richer set of fixed effects). For corporate loans, the marginal effect of a one standard deviation easing in monetary policy on lending, conditional on a one standard deviation softer macroprudential policy environment, is 11% larger than the increase in lending from softer monetary policy alone, and this estimated effect remains nearly identical with a richer set of fixed effects. These are all relatively large effects compared with the average loan growth throughout the sample (0.63% for household loans and -0.53% for corporate loans).

The empirical analysis also concentrates on whether this complementarity between monetary and macroprudential policy is affected by key margins based on theory, including the stance of monetary policy (easing versus tightening), borrower risk and firm productivity, bank capital and loan categories (corporate loans, consumer credit and mortgages). These heterogeneous effects shed light on the mechanism behind the complementarity policy mix. Importantly, we find that the complementary effect of monetary and macroprudential policy is asymmetric, being stronger for expansionary monetary shocks as opposed to contractionary monetary shocks. In particular, when the ex-ante macroprudential environment is more accommodative, an easing of monetary policy by one standard deviation increases household credit and corporate credit by 9.6% and 3.6%, respectively. The contractionary effects on household and corporate loans are instead more muted when monetary policy is being tightened in a less accommodative macroprudential environment (-2.6% and -0.7%, respectively).

We next consider the bank lending channel, which focuses on the financial frictions associated with the balance sheet strength of financial intermediaries (e.g. Bernanke and Blinder (1988 and 1992); Kashyap and Stein (2000)). Empirical studies generally show that the strength of monetary policy transmission is influenced by the balance sheet characteristics of financial intermediaries. Following monetary policy tightening, the transmission of monetary policy is stronger for small (Kashyap and Stein (1995)), illiquid (Stein (1998); Kashyap and Stein (2000); Jiménez et al. (2012)), and poorly capitalized banks (Peek and Rosengren (1995); Kishan and Opiela (2000); Van den Heuvel (2002); Jiménez et al. (2012)), and in environments with different competition for bank deposits (Drechsler, Savov and Schnabl (2017a); Wang, Whited, Wu, and Xiao (2020)). Similarly, bank lending channels may arise from changes in the macroprudential policy stance. For instance, a relaxation of countercyclical capital buffers may increase the lending capacity of banks, prompting an increase in loan supply to firms (see, for example, Jiménez et al. (2017)), or affecting mortgage loans due to risk-weighted capital requirements (see, for example, Benetton (2018)).

Regarding the bank lending channel, we find that the complementarity between monetary and macroprudential policies is stronger for less (ex-ante) capitalized banks. In other words, lower bank capital enhances the positive impact on lending of a more accommodative monetary policy stance in an environment of softer macroprudential policy. The effect is economically significant. For example, the marginal effect of a one standard deviation lower capital ratio on bank household (corporate) lending following a one standard deviation easing in monetary policy, and conditional on a one standard deviation softer macroprudential policy environment, is about 1.7% (1%).[2] Therefore, the complementarity between the two policies strongly influence the bank lending channel.

The analysis then focuses on how the macroprudential regulatory environment affects the risk-taking channel of monetary policy. In principle, monetary policy accommodation might encourage banks to take more risks on their loan books, thereby potentially influencing the overall banking sector resilience to shocks (Rajan (2005); Dell'Ariccia et al. (2014); Martinez-Miera and Repullo (2017)). Similarly, softer macroprudential policy may encourage banks to take more risks by lending to riskier borrowers (Kashyap, Tsomocos and Vardoulakis (2014); Aikman, Nelson and Tanaka (2015)). In addition, tighter macroprudential policy might be arbitraged leading to an increase in risk-taking due to an imperfect regulatory enforcement (e.g., Jiménez et al. (2017); Bengui and Bianchi (2018)).

In terms of the risk-taking channel of monetary policy, we find that monetary policy easing boosts lending to ex-ante riskier borrowers, especially in a softer macroprudential policy environment. Moreover, these effects are stronger for banks with ex-ante lower capital. We measure ex-ante borrower risk based on borrowers' past credit history; in practical terms, we label as having a high credit risk those borrowers (either firms or households) with at least one ex-ante non-performing loan.[3]

We find that, for households, the marginal effect on lending of a one standard deviation easing in monetary policy, conditional on a one standard deviation softer ex-ante macroprudential policy environment, is 1.8% larger for high credit risk borrowers than for low credit risk borrowers. A one standard deviation lower bank capital further enhances risk-taking by 0.8%. Interestingly, effects are stronger for consumer loans than for mortgages, which is

[2] Depending on the vector of fixed effects used for model estimation, the marginal effect of a one standard deviation lower capital ratio on bank lending following a softening of monetary policy in an environment with more accommodative macroprudential policy is reduced to about 0.7% and 0.5% for household and corporate loans respectively.
[3] Results for firms are similar (non-reported) if we measure firm risk by the z-score, which is an ex-ante measure of firm insolvency.

consistent with consumer loans being substantially riskier than mortgages, which are significantly more collateralized. For corporate loans, the increase in credit owing to a one standard deviation easing in monetary policy, following a one standard deviation softer ex-ante macroprudential policy environment, is 0.4% larger for high-risk firms than for low-risk firms. The additional contribution to risk-taking in corporate loans from a one standard deviation lower bank capital is large at 3.5%. In short, the impact of the macroprudential environment on the risk-taking channel of monetary policy is more pronounced for consumer and corporate loans than for mortgages.

A key, albeit empirically challenging, question concerning the risk-taking channel of monetary policy is whether policy-induced risk-taking can be considered excessive. Some argue that monetary policy influences not only risk-taking but also aggregate risk aversion and risk premia, and that an increase in risk-taking should not be necessarily interpreted as excessive (e.g., Brunnermeier and Sannikov (2014 and 2016); Drechsler, Savov and Schnabl (2017b)). Others argue that increases in risk-taking can become excessive when policy remains accommodative for an extended period (e.g., Dell'Ariccia, Laeven and Marquez (2014)). To investigate this question, we extend our analysis of firms and empirically assess whether a policy-induced change in the composition of credit is directed to fewer or more ex-ante productive firms. We match the firm-loan-level data to firms' balance sheet information and compute productivity using the same approach as in Gopinath et al. (2017). Based on the resulting measure, we label firms with productivity above the median (based on within-country and sector distribution) as highly productive. Moreover, we contrast this "good risk-taking" on borrowers with respect to higher ex-ante productivity versus (a potentially "worse" risk-taking based on) lending to borrowers with current defaulted loans or a recent bad credit history.

We find that a softer ex-ante macroprudential policy environment not only reinforces the positive effect of accommodative monetary policy on overall lending, but it also increases the volume of loans extended to firms with higher ex-ante productivity. A one standard deviation easing in monetary policy, conditional on a one standard deviation ex-ante more accommodative macroprudential policy environment, boosts lending to high ex-ante productive firms by 3.5% (relative to low ex-ante productive firms). Moreover, a one standard deviation lower bank capital further amplifies lending to productive firms by a 1.6%.

Comparing these results with the ones on lending to firms with high credit risk, it turns out that the overall increase in lending to productive firms dominates the higher lending for the high credit-risky companies (3.5% compared with 0.4% respectively). Moreover, the additional contribution of bank capital to the risk-taking is strong in both cases. However, the baseline findings would suggest, if anything, a larger "bad risk-taking" by low capitalized banks (a 3.5% relative increase for high credit risk companies versus 1.6% for highly productive firms), but the difference between the two channels is sensitive to the inclusion of fixed effects.[4] That is, the softer policy mix stimulates more lending to both ex-ante productive and high credit risk firms. In general, these effects are stronger for less capitalized banks and ex-ante productive firms.

Taking all the results together, we find strong complementarities between monetary and macroprudential policies in influencing credit: expansive monetary policy boosts lending more in an accommodative macroprudential environment. Moreover, this complementary effect of monetary and macroprudential policy is stronger for: (i) expansionary (as opposed to contractionary) monetary policy; (ii) riskier borrowers; (iii) less capitalized banks, especially when combined with lending to riskier borrowers; (iv) consumer and corporate loans (rather

[4] In general, results on corporate loans from models exploiting bank capital are statistically significant also when employing firm*time fixed effects, which control for time-varying unobserved firm fundamentals (proxying, for example, credit demand shocks), following Khwaja and Mian (2008). Furthermore, in terms of economic significance, the relative increase in credit supply operated by banks with lower capital towards highly productive firms (in reaction to softer monetary policy in an environment of more accommodative macroprudential policy) is more robust than the boost in credit supply by less capitalized banks towards (high) credit-risky companies.

than mortgages); and (v) more (ex-ante) productive firms as opposed to high credit risk firms, except for low capitalized banks.

Contribution to the literature. Our paper relates to the literature on the credit channel of monetary policy, including the bank lending channel (e.g., Kashyap and Stein 2000; Loutskina and Strahan 2009; Jiménez et al. 2012; Drechsler, Savov and Schnabl 2017a; Acharya et al. 2020; Gomez et al. 2020). We contribute to this literature by considering the influence of macroprudential policy. Moreover, this literature tends to provide evidence based on either more aggregate data from many countries or on loan-level data from a single country, limiting either identification or raising external validity concerns. We overcome these concerns by using loan-level data from multiple countries, with substantial variation in policy stance and in credit dynamics. Related to Chakraborty, Goldstein and MacKinlay (2020), we also find differential effects across mortgage and corporate loans. Further, unlike other studies drawing on credit register data, we exploit data on *both* household and firm loans and find different quantitative effects across loan types, notably consumer and corporate loans versus mortgages.

We also contribute to the literature on the risk-taking channel of monetary policy. This literature tends to find that monetary policy easing tends to increase bank risk-taking and that this channel is more pronounced for highly levered banks (e.g., Adrian and Shin (2010); Maddaloni and Peydró (2011); Jiménez et al. (2014); Dell'Ariccia et al. (2017); Martinez-Miera and Repullo (2017)). Similarly, there is evidence of reach for yield in other financial intermediaries (e.g., Becker and Ivashina (2015); Di Maggio and Kacperczyk (2017)). We contribute to this literature by considering how this risk-taking channel of monetary policy depends on the macroprudential policy environment. Moreover, we contribute to this literature by distinguishing between potentially "better versus worse risk-taking" by considering whether loans are extended to (a) more (versus less) ex-ante productive firms and (b) high (versus low) credit risky firms. Relatedly, we also analyze loans for household consumption and house purchases.

Our work is also related to an emerging literature on the effectiveness of macroprudential policy. This literature focuses mainly on the effectiveness of different macroprudential measures to influence credit dynamics and on the limitations of macroprudential policy (see, for example, Cerutti, Claessens and Laeven (2017)). We contribute to this literature by analyzing the interactions with monetary policy and by considering both household and firm loans. For instance, Jiménez et al. (2017) find that the adoption of dynamic loan loss provisioning in Spain effectively influences lending behavior of banks, with loans to firms being curtailed when provisioning requirements increase. Similarly, Gropp, Mosk, Ongena and Wix (2020) find that the imposition of higher capital requirements following supervisory stress tests in Europe resulted in a reduction in lending by affected banks, while Aiyar, Calomiris, and Wieladek (2014) find evidence of a substitution effect whereby the introduction of capital-based macroprudential regulation effectively curtails lending by regulated banks but stimulates it among unregulated entities. DeFusco, Johnson and Mondragon (2019) show that constraints on household leverage under the Dodd-Frank Act affect the cost and supply of US mortgages. Similarly, Benetton (2018) find that the pricing of mortgage loans in the United Kingdom is affected by risk-weighted capital requirements that vary depending on loan-to-value ratios, and Acharya, Bergant, Crosignani, Eisert and McCann (2019) show that borrower-based macroprudential measures affect the lending behavior of banks in Ireland. In a recent paper, Ahnert, Forbes, Friedrich, Reinhardt (2021) provide global evidence that macroprudential regulations targeting foreign currency exposures are effective in curtailing foreign currency borrowing by banks. Our paper differs from all these papers by considering the interactions with monetary policy. Moreover, our paper improves on external validity by analyzing a wide range of macroprudential measures, multiple countries, and both household and firm sectors.

Our paper is closely related to two recent studies. Using aggregate data on inflows of bank loans and bonds from 12 Asian-Pacific economies, Bruno, Shim and Shin (2017) argue that the effectiveness of macroprudential policies in limiting capital inflows increases when complemented with monetary tightening. Aiyar, Calomiris and Wieladek (2016) exploit the adoption of time-varying capital requirements in the UK and find that a tightening of either capital requirements or monetary policy curtails credit growth, but they do not find evidence of interaction between these two policies.

At the same time, our paper differs from these two papers along several dimensions. First, our study differs in the level of aggregation and coverage. Bruno, Shim and Shin (2017) use aggregate cross-country data and Aiyar, Calomiris and Wieladek (2016) use bank-level data from a single country. In our paper we use loan-level credit register data and multiple countries and reach at different conclusions. Moreover, contrary to these two studies, we exploit heterogeneity over borrowers and lenders and different types of loans, which generates a new set of evidence: (i) analyzing borrower and lender heterogeneity, as well as both household and corporate loans, we show that results crucially depend on these dimensions, with results being stronger for consumer and corporate loans and for weaker capitalized banks; (ii) we find that for firms, the increase in lending induced by a loose policy mix is stronger for (ex-ante) more productive firms than for firms with high ex-ante credit risk, except for banks with low capital.

The paper is structured as follows. Section 2 describes the data. Section 3 explains our empirical framework and presents the main results. Section 4 presents several extensions and robustness checks of our main analysis. Section 5 concludes.

2 Data and Descriptive Statistics

We match data from credit registries with lender and borrower information and combine this with information on macroprudential measures and monetary policy shocks to create the dataset for our analysis of the impact of policies on lending to households and firms.

2.1 Credit registries

Our analysis uses a unique, confidential dataset collected in the context of the preparatory phase of the AnaCredit project by the European System of Central Banks. The data are collected by the ECB from the credit registry of national central banks. To the best of our knowledge, it is the first time that a dataset based on *multiple* country credit registers with *both* household and corporate loans is employed in an empirical analysis. The dataset contains more than 140 million loan-level observations for households and more than 130 million loan-level observations for firms from many countries. The household data are provided on an anonymous basis to make sure that individuals cannot be identified. The frequency of the data is biannual, with the sample period running from June 2012 to December 2017.

Table A2.1 of Appendix 2 shows the number of total observations by country. The euro area countries included in the dataset are as follows: Belgium (BE), Germany (DE), Spain (ES), France (FR), Italy (IT), Latvia (LV), Lithuania (LT), Malta (MT), Austria (AT), Portugal (PT), Slovenia (SI) and Slovakia (SK).

The dataset is constructed at the loan level and includes information on key bank and borrower characteristics, such as credit volume, type of borrower (household or firm), payment history and the sector of activity of the borrowers. Figure 1 shows the evolution of the annual growth rate of total loans by country for households and non-financial firms. We see that there is substantial variation over time and across countries in the evolution of credit.

[Insert Figure 1]

In addition, we know for each loan the amount and type of loan. We use the information on payment history to identify risky borrowers, defined as borrowers who have at least one loan outstanding that is at least 90 days past due. Importantly, this measure is available for *each* firm *and* household.

We match the credit register database with a proprietary data set of balance-sheet items at bank level (Individual Balance-Sheet Items or IBSI), which is regularly updated by the ECB, to obtain key bank characteristics. We have information on bank size, bank capital (i.e. equity over total assets) and the ratio of a bank's non-performing loans to total loans.

We use the information on non-performing loans to construct a measure of borrower risk in our sample. Specifically, "NPE" is a dummy variable that indicates whether the borrower has experienced a non-performing exposure over the sample period. Figure 2 reports the average value of the non-performing exposure by country over time. We observe a significant variation across countries and over time in the share of non-performing loans on banks' balance sheets. In addition, there is also substantial variation across delinquent loans for households and firms.

[Insert Figure 2]

Importantly, the multiple credit registry dataset also allows us to track whether the individual units in our panel have single or multiple lending relationships. Table A2.2 of Appendix 2 shows that in all countries, a non-negligible share of household and firms have lending relationships with more than one lender. The share is substantially higher for firms and heterogeneous across jurisdictions. In Spain, France, Italy and Portugal, for example, the volume of lending originated to firms who have more than one bank is higher than 50%.

Overall, the rich cross-sectional and time variation of this unique dataset is crucial to assess the internal and external validity of the results obtained in the empirical analysis.

For firms, we can distinguish between "better" lending versus "worse" risk-taking using a measure of firm ex-ante productivity. We match the credit register database with the Amadeus database to obtain information on firms' financial statements. Using this data, we calculate firm-level productivity using the approach in Gopinath et al. (2017). Specifically, we first estimate the factor shares of labor and capital at the (2-digit NACE) sector level. To do so, we use the Wooldridge (2009) extension to the Levinsohn and Petrin (2003) method for the estimation of production functions. All relevant variables – wage bill, material costs, value added and capital – are deflated.[5]

We then calculate firm-level log total factor productivity (TFP) from the log Cobb-Douglas production function, using the estimated sector-level factor shares as follows:

$$log\left(TFP_f\right) = log\left(Value\ added_f\right) - \hat{\alpha}_s\, log\left(Wage\ bill_f\right) - \hat{\beta}_s\, log\left(Capital_f\right) \tag{1}$$

where $\widehat{\alpha}_s$ and $\widehat{\beta}_s$ are the estimated factor shares of (deflated) labor and capital, respectively, from the first step, computed for each sector s over our sample period from 2012 to 2017. We then classify a firm f as "high-productive" if its log TFP is above the median log TFP of firms within the same country, sector and year. $Productivity_f$ is a dummy variable that takes a value of 1 if the firm is classified as "high-productive", and zero otherwise.

[Insert Figure 3]

Figure 3 shows the distribution of firm productivity estimates for our sample of firms. The left-hand panel shows that the large firms tend, on average, to be more productive than the small firms in our sample. The right-hand panel shows that there is much cross-firm dispersion in firm productivity.

[5] The wage bill, material costs and value added variables are deflated with the industry-level price deflators for value added from EU Klems. The capital variable is deflated using a country-specific gross fixed capital formation deflator taken from the World Bank's World Development Indicators database.

2.2 Macroprudential regulations

Since the global financial crisis, many countries – including in Europe – have introduced a wide range of macroprudential measures. Within the European Union, macroprudential measures are taken at the country level.[6] Consequently, macroprudential policy across the euro area shows a pronounced country heterogeneity.

The new macroprudential policy toolkit includes a wide range of instruments that can be broadly classified into three types of measure: capital-based, liquidity-based and borrower-based. Capital-based measures include countercyclical capital buffers (CCyB), time-varying/dynamic provisioning and restrictions on profit distribution (e.g. restrictions on dividends). As regards liquidity-based measures, the EU legal framework currently includes the liquidity coverage ratio (LCR) as a short-term liquidity measure, and it is expected that the net stable funding ratio (NSFR), which addresses longer-term liquidity risks, will be added to the framework in the context of the ongoing revision of the Capital Requirements Regulation (CRR) and the Capital Requirements Directive (CRD IV). Moreover, there are restrictions on borrower leverage, such as measures that include caps on the loan-to-value (LTV) ratio, and caps on the debt-to-income (DTI) and debt service-to-income (DTSI) ratios. Most of the time, different macroprudential policies are introduced at the same time.

We obtain information on the time of adoption and implementation of country-specific macroprudential measures from the ECB's Macroprudential Database.[7] There are a broad range of prudential policies, including microprudential measures, that can be used for macroprudential purposes.

We create a simple index of macroprudential policy (MAP) intensity based on the number of measures that are put in place at a given point in time. We consider ten categories of measures: minimum capital requirements; capital buffers; risk weights; lending standard

[6] The European Systemic Risk Board can, in principle, ask countries for such measures to be topped up.
[7] See Budnik and Kleibl (2018).

restrictions; levy/tax on financial institutions and activities; limits on large exposures and concentration; liquidity requirements and limits on currency and maturity mismatch; leverage ratio; loan-loss provisioning; and limits on credit growth and volume. For each category, we add a value of 1 to the MAP index if a measure is adopted and subtract a value of 1 if a measure is removed. We construct this index for the period 1994-2017, which is the period during which the macroprudential data was collected. We do not change the value of the overall index if the policy action refers to a modification of an existing tool or maintains the existing scope of a policy tool. Further details on the construction of the index are in Appendix 1.

Contrary to monetary policy, macroprudential policy in our sample is country specific and therefore likely endogenous to a country's economic and credit developments. National competent authorities are likely to tighten policy during a boom cycle and release buffers during a downturn. In each regression, to purge our index of MAP from such country forces, we control for real GDP growth, inflation, and credit growth in the country, both in levels and in interactions with monetary policy surprises.[8]

[Insert Figure 4]

Figure 4 shows the evolution of the macroprudential policy index over time for each country in our sample. We show the main index and the index purged from economic and credit developments. We can see that over our sample period there is a general tightening of macroprudential policy, as many countries adopt new measures, but there is substantial variation in terms of both the timing and the intensity of these measures.

Some illustrative examples include: the adoption of a minimum liquidity coverage ratio in Austria in October 2015, the announcement of an increase in the capital surcharge for systemically important banks in Italy in March 2016 and the adoption of a countercyclical capital buffer in Latvia in January 2015. The interquartile range shows that some countries did

[8] Results are similar when we use credit gaps (relative to GDP) instead of credit growth.

not adopt macroprudential measures at all, while others were quite aggressive in the adoption of such measures over the sample period. There are also a few instances of a loosening of macroprudential policy, with countries relaxing or removing existing measures. Notable examples include Lithuania, which lowered its reserve requirements related to banks' liabilities in January 2015, and France, which lowered the rate of the systemic risk tax on banks' own funds requirements in January 2015. Interestingly, there is more variation in the index adjusted for economic and credit developments. As in all regressions we control for the local business and credit cycle either with observables (in levels and in key interactions) and/or related time fixed effects, we effectively have the variation of Panel B in Figure 4.

For easing the interpretation of our results, we estimate regressions using our macroprudential indicator $MAP_{c,t}$ with inverted sign, so that an increase in the resulting variable, which we label as $MAP_{c,t}^{soft}$, denotes a more accommodative macroprudential environment. To address endogeneity concerns with monetary shocks (surprises), we use the one period lag of this index of macroprudential policy, $MAP_{c,t-1}^{soft}$, in the regressions relatively to monetary policy surprises. This ensures that macroprudential policy does not react to monetary policy. Moreover, as we exploit monetary policy surprises from high-frequency data (see next subsection), and these are the unexpected component of monetary policy, we implicitly make sure that these surprises are not driven by macroprudential policies.

2.3 Monetary policy

Since the onset of the financial crisis, the ECB, as well as many other major central banks, has complemented its operating frameworks with a broad array of non-standard policy measures. These unprecedented policies include the fixed rate tender procedure with full allotment in the Eurosystem's euro credit operations, targeted and untargeted liquidity provision measures (such as the targeted longer-term refinancing operations), quantitative easing measures (such as the expanded asset purchase program) and negative interest rates policy (see Rostagno et al. (2021)).

Measuring the effects of monetary policy shocks in an environment where the central bank has announced and implemented both conventional and unconventional policies – affecting different segments of the yield curve – poses special challenges. Therefore, we capture the amount of monetary policy accommodation through high-frequency surprises, defined as the intraday changes of risk-free rates at various maturities around policy announcements (following Altavilla et al. (2019)). Importantly, the methodology can handle both conventional and unconventional monetary policy.

In greater detail, we construct a variable, MP_t, that measures the principal component of all monetary policy surprises from high-frequency intraday data on risk-free rates (overnight index swap rates) with different maturities, ranging from one month to ten years. Jointly analyzing a wide range of maturities is important as some policies (e.g. policy rate changes) may have a greater influence on the shorter segment of the yield curve, while others, e.g. quantitative easing policies, may have a greater influence on long-term rates. These surprises are calculated by measuring changes in risk-free rates in a narrow time window around official monetary policy communications. More precisely, for each Governing Council meeting, we first measure the realized policy surprise as the principal component of interest rate changes from 15 minutes before the press release to 15 minutes after the press conference, and then we cumulate them to match the frequency of the credit registers.

Figure 5 shows the estimated monetary policy surprises over our sample period. There were large negative (i.e. easing) monetary policy surprises in the first half of 2014, with the introduction of negative rates and the announcement of the liquidity provision program, and again in the first half of 2015, when the ECB launched its asset purchase program (APP) to counter a persistent decline in inflation expectations. Figure 5 also highlights the large positive (i.e. contractionary) surprises linked to the market disappointment following the Governing Council monetary policy meeting of December 2015, when financial markets had anticipated (and priced in) a lower policy rate and a larger increase in the volume of asset purchased under the APP. The recalibration of the non-standard measures in the first half of 2016 and the second half of 2017 also surprised markets.

[Insert Figure 5]

These monetary policy changes (surprises) are common across all euro area countries, as these countries have the same monetary policy. However, the stance of monetary policy can effectively vary across countries because of differences in (local) business cycles (Taylor (1992); Bernanke and Gertler (1995)).[9] This implies that there is a variation in the perceived stance of monetary policy for every monetary policy surprise, despite a single monetary policy shock in each period (Maddaloni and Peydró (2011); Jordà, Schularick and Taylor (2020)).

To facilitate the interpretations of the estimated coefficients, we run regressions using monetary policy shocks, MP_t, with inverted sign, so that an increase in the resulting variable, which we label MP_t^{soft}, corresponds to a softening in monetary policy.

2.3 Descriptive statistics

Table 1 presents the summary statistics of our main regression variables. The sample period covers the years from 2012 to 2017 and the data frequency is biannual. The average credit commitment of a loan to households is about €28,000, while the average credit commitment of a loan to non-financial firms is much larger at about €100,000.[10] For households, mortgage loans for houses tend to be much bigger than other types of household loans. The share of borrowers that are non-performing (i.e. with outstanding loans that are in default and/or more than 90 days past due) is, on average, 3% for households and 13% for firms. Moreover, the

[9] The results of the paper are similar if we control for GDP growth and inflation expectations at the country level, the level of unemployment and estimates of output gaps (also at the country level).
[10] Loan credit commitment in the database is expressed in thousands of euro.

average bank in our sample has a ratio of total equity to total assets of 8%, while the average TFP (in logs) of firms in our sample is 4.1 and the average z-score (in logs) is 3.0.

[Insert Table 1]

Our dataset covers a variety of loans. The vast majority of household loans are mortgage loans and other term loans that are mostly consumer loans, accounting for about 78% of loans for which the type of exposure is available (loan type information is missing for 29% of loans).

Multiple lending relationships are important for the identification of the bank lending channel. Table A2.2 of Appendix 2 shows the frequency of single and multiple lending relationships for loans to households and to firms by country. While the majority of households borrow from only one bank, about 20% of households have multiple banking relationships. For firms the number is much higher, with about 50% of firms having multiple banking relationships. Using model specifications that only focuses on multiple lending relationships would therefore potentially bias the comparison of the results between household and firms and at the same time still pose substantial concerns on the reduced representativeness of the sample. This is why in our main regressions we do not exploit multiple banks per borrower. Nevertheless, all our results on corporate loans are also analyzed (and robust to) exploiting observations with multiple banks per firm.

3 Results

Our empirical analysis focuses on the transmission channels of monetary and macroprudential policies to the lending behavior of euro area banks. Our analysis is divided into two parts. First, we study how the transmission of monetary policy on the volume of bank loans depends on the macroprudential environment. Second, we analyze heterogeneous effects: (i) We consider how monetary policy and macroprudential policy interact with the riskiness of borrowers and bank capital to influence the quantity of credit; (ii) We differentiate between "better" lending versus "worse" risk-taking by considering the link between policy-induced risk-taking and ex-ante firm productivity (in addition to lending to firms with current or past delinquent loans); (iii) We consider the implications of loan heterogeneity by assessing whether effects vary by loan type (consumer loans, mortgage loans, corporate loans); (iv) We analyze asymmetric effects of monetary policy on lending depending on the ex-ante macroprudential environment. Finally, we present several robustness checks. We conduct all analyses separately for households and firms (except for the productivity analysis which is by construction limited to firms).

For ease of explanation, we describe our estimation framework for households even though we apply the same framework subsequently also for firms. The terms household and firm – and therefore also the subscripts *h* and *f* in the equations that follow – can be used interchangeably for all practical purposes in the description of the estimation framework.

3.1 The credit channel of monetary and macroprudential policies

We start with an analysis of the transmission channels of monetary policy and macroprudential policy on the volume of lending of euro area banks.

Our first empirical exercise focuses on the existence of the broad credit channel and the effect of monetary policy shocks conditional on the ex-ante macroprudential policy environment. The regression model is as follows:

$$\begin{aligned} Loans_{b,h,t} = \alpha^{FE} + \beta_1 MP_t^{soft} + \beta_2 MAP_{c,t-1}^{soft} + \beta_3\left(MP_t^{soft} \times MAP_{c,t-1}^{soft}\right) \\ + \Gamma X_{c,t} + \epsilon_{b,h,t} \end{aligned} \tag{2}$$

The dependent variable ($Loans_{b,h,t}$) is the (log-)credit granted (both drawn and undrawn) by bank *b* to household *h* at time *t*. The variable MP_t^{soft} is the measure of monetary policy surprises lagged one period, while the variable $MAP_{c,t-1}^{soft}$ is the lagged measure of macroprudential policy changes (see the previous section). In both cases, higher values of either variable correspond to a softening of monetary policy and macroprudential policy respectively.

The vector $X_{c,t}$ includes country-specific observable controls of the business cycle and credit cycle in levels (lagged one period) and in interactions with monetary policy surprises. Specifically, the specifications include one-period lagged values of real GDP growth, inflation rate, and credit growth. The macroeconomic controls are lagged one period to mitigate endogeneity concerns, although results are unaltered when using contemporaneous variables.

We progressively saturate the model in equation (2) with different sets of fixed effects (α^{FE}), controlling for possible confounding factors. In particular, the most robust version of the model employs time and borrower fixed effects. Time fixed effects take care of all (observed and unobserved) shocks that are common across the euro area. Moreover, borrower fixed effects completely absorb the time-invariant borrower heterogeneity. In fact, as we show below, the inclusion of such dummies explains a large share of the variation in the data, suggesting that most borrower-level variation stems from time-invariant idiosyncratic characteristics.

We use the specification in equation (2) to study the credit channel mechanism of monetary policy and the potential complementarities between monetary policy and macroprudential policy. More specifically, the above model can be used to test whether, following monetary policy easing, banks increase their credit ($\beta_1 > 0$) and whether an ex-ante more accommodative macroprudential environment reinforces this effect ($\beta_3 > 0$). We also analyze the direct relationship of a more accommodative macroprudential environment on higher lending ($\beta_2 > 0$).

We conduct this analysis separately through separate but otherwise identical models for households and firms. The results are presented in Table 2.[11]

[**Insert Table 2**]

[11] Standard errors of these regressions and all subsequent regression tables are clustered at the borrower level. Clustering at lender and country-time level does not alter the significant results. Likewise, results are robust to clustering standard errors at the borrower and country-time level. The related tables are available upon request. See also Appendix A2.

We find strong evidence of the existence of credit channels of monetary policy and macroprudential policy across a wide range of fixed effects specifications of the model. Specifically, the positive coefficient estimates on the direct effects (β_1 and β_2) indicate that softer monetary policy and a softer macroprudential policy environment each contribute to an increase in lending.

Importantly, the positive coefficient on the interaction term (β_3) indicates that the two policies are complementary in the sense that softer monetary policy (surprises) boosts lending more when the ex-ante macroprudential policy environment is also softer. In other words, the two policies reinforce each other. We find qualitatively similar results for households (columns 1 to 3) and firms (columns 4 to 6).

The economic magnitude of our results is large. Based on the estimates in column (1) of Table 2 for household loans, we find that the marginal effect of a one standard deviation easing in monetary policy on lending, conditional on a one standard deviation softer macroprudential policy environment, is 1.3% (= 0.00514 × 4.16 × 0.60). This is 42% more than the average increase in lending due to softer monetary policy alone.[12] The additional effect from macroprudential policy drops to about 20% after the inclusion of a richer set of time and firm fixed effects in columns (2) and (3). This suggests that our estimates are robust (from both a statistical and economic perspective), as the inclusion of firm fixed effects implies a large increase in the R-squared, by roughly 60% (see Altonji, Elder and Taber (2005); and Oster (2019)). Formally speaking, the estimated coefficient in column (3) survives the Oster (2019) test for selection along unobservables, as indicated by the resulting lower-bound for our coefficient of interest, which is strictly positive.[13]

[12] A one standard deviation easing in monetary policy implies an increase in the volume of lending of 3.1% for households and 2.0% for corporate loans, while for softer macroprudential policies, these numbers are 9.8% and 2.3% respectively.

[13] We compute the Oster bound under the usual assumption of equal selection among observables and unobservables ($\delta = 1$). In practice, we compare estimates from models in column 1 and column 3 and fix the

For corporate loans, we find that a one standard deviation easing in monetary policy, conditional on a one standard deviation more accommodative ex-ante macroprudential policy environment, boosts lending by 0.22% (based on the estimates in column (4)). This is 11% more than the increase in lending from softer monetary policy alone, and this estimated effect remains nearly identical with a richer set of fixed effects (columns (5) and (6)). All these are large effects compared with an average loan growth during the period from December 2012 to December 2017 of 0.63% for household loans and -0.53% for corporate loans.

3.2 The bank lending channel of monetary and macroprudential policies

Having established the existence of a strong complementarity between monetary and macroprudential policy on the credit channel, we now focus on different heterogeneous effects. We start by analyzing the bank lending channel of monetary policy and the potential complementarities between monetary policy and macroprudential policy using the following specification:

$$\begin{aligned} Loans_{b,h,t} &= \alpha^{FE} + \gamma_1 MP_t^{soft} + \gamma_2 MAP_{c,t-1}^{soft} + \gamma_3 Equity_{b,t-1} + \Omega X_{b,h,t-1} \\ &\quad + \gamma_4\left(MP_t^{soft} \times Equity_{b,t-1}\right) + \gamma_5\left(MAP_{c,t-1}^{soft} \times Equity_{b,t-1}\right) \\ &\quad + \gamma_6\left(MP_t^{soft} \times MAP_{c,t-1}^{soft} \times Equity_{b,t-1}\right) + \epsilon_{b,h,t} \end{aligned} \qquad (3)$$

where $Equity_{b,t-1}$ is a measure of the bank's capital position obtained as the ratio of total equity to total assets, and $X_{b,h,t-1}$ includes all remaining double interactions.

The above model can be used to test whether, following monetary policy easing in an ex-ante more accommodative macroprudential environment, weaker capitalized banks increase their credit supply relatively more ($\gamma_6 < 0$).

Consistent with the previous model, the most saturated version of the model includes borrower and time fixed effects. Potentially, we could also include borrower*time fixed effects

maximum R-squared as the minimum between 1 and 1.3 times the R-squared obtained in the "robust" version of the model in column 3. We maintain these conventions throughout the paper.

to better control for time-varying unobserved firm fundamentals, including a proxy of firm credit demand shocks (Khwaja and Mian (2008)).[14] Nonetheless, this procedure would lead to a drop of most observations in the models for household credit, as most households just hold one loan at a time. The same is true for corporate loans for several countries in our sample. Hence, we present our baseline results with consistent models across firms and households, therefore employing at most borrower and time fixed effects. However, in Table A2.4 we show that findings on firms' credit are robust to controlling for time-varying firm fixed effects.

The baseline results for household and firm loans are presented in Table 3 separately. Our results are consistent with the existence of a bank lending channel.[15] Monetary policy easing, in an environment of ex-ante more accommodative macroprudential policy, boosts lending especially for weakly capitalized banks. For instance, based on the estimates for households in column (1), we find that the marginal effect of a one standard deviation lower capital ratio on bank lending following a softening of monetary policy by one standard deviation, and in an ex-ante macroprudential policy environment that is one standard deviation softer, is 1.7% (= -0.173 × 4.16 × 0.60 × -0.04). The estimated effect drops to 0.7% following the inclusion of household fixed effects, which absorbs most of the variation and is robust in the Oster (2019) sense.

[Insert Table 3]

We obtain qualitatively similar results for firms. Specifically, lower bank capital enhances the positive impact on lending of a more accommodative monetary policy in an environment of

[14] Moreover, when we saturate the model with borrower*time fixed effects (i.e. in robustness checks for corporate credit exploiting bank-level time-varying heterogeneity), we can control for time-varying unobserved firm fundamentals (proxying for firm-level time-varying credit demand shocks à la Khwaja and Mian (2008)). We find that results are not qualitatively different from those retrieved from models employing firm fixed effects only; the sample, however, gets substantially reduced. Similarly, results are very similar when using industry*country*time fixed effects to control for demand.

[15] When considering the results of monetary policy and capital without an interaction of macroprudential policy, we find that , during the crisis and its aftermath, softer monetary policy – by providing more liquidity to banks – increases lending if banks have more ex-ante capital, , consistent with the findings in Peydró, Polo and Sette (forthcoming).

ex-ante more accommodative macroprudential policy. Moreover, effects for corporate loans are virtually unchanged (if anything, slightly magnified) after the inclusion of a richer set of fixed effects. For example, when we control for firm and time fixed effects in column (6), we find that the marginal effect of a one standard deviation lower capital ratio on bank lending to firms following a softening of each policy by one standard deviation is 1% (= -0.105 × 4.16 × 0.60 × -0.04).

3.3 The risk-taking channel of monetary and macroprudential policies

Next, we assess whether the macroprudential policy environment alters the risk-taking channel of monetary policy. The regression model to study the risk-taking channel of monetary policy and the potential complementarities between monetary policy and macroprudential policy takes the following form:

$$
\begin{aligned}
Loans_{b,h,t} = \alpha^{FE} &+ \lambda_1 MP_t^{soft} + \lambda_2 MAP_{c,t-1}^{soft} + \lambda_3 NPE_{h,t-1} + \Omega X_{b,h,t-1} \\
&+ \lambda_4 \left(MP_t^{soft} \times NPE_{h,t-1}\right) + \lambda_5 \left(MAP_{c,t-1}^{soft} \times NPE_{h,t-1}\right) \qquad (4) \\
&+ \lambda_6 \left(MP_t^{soft} \times MAP_{c,t-1}^{soft} \times NPE_{h,t-1}\right) + \epsilon_{b,h,t}
\end{aligned}
$$

where the variable $NPE_{h,t-1}$ is a dummy variable that equals 1 if one of the household's loans is non-performing, and zero otherwise, and $X_{b,h,t-1}$ includes all remaining double interactions. $NPE_{h,t-1}$ captures the ex-ante credit riskiness of the borrower based on the past (non-)performing loan status of the household.

The above model can be used to test whether, following an easing of monetary policy in an ex-ante more accommodative macroprudential policy environment, banks increase their lending to high credit risk borrowers ($\lambda_6 > 0$). Model estimation employs, at most, time and bank fixed effects. We avoid including borrower specific dummies, as this would imply the coefficient of main interest λ_6 being identified by within borrower heterogeneity across periods (characterized by performing and non-performing exposure respectively), whereas most of the variation in loan performing status occurs between borrowers.

The results are presented separately for households and firms in Table 4. We find evidence in support of the risk-taking channel of monetary policy being dependent on the ex-ante macroprudential policy environment. For both households and firms, we find that softer monetary policy boosts lending to riskier borrowers and that this effect is more pronounced in an ex-ante more accommodative macroprudential policy environment.

The economic effects are sizeable. For instance, based on the estimates in column (1) of Table 4 for households, we find that the marginal effect of a one standard deviation easing in monetary policy on lending, conditional on a one standard deviation softer macroprudential policy, is 1.8% more for non-performing borrowers than for performing borrowers. Including either time or bank fixed effects does not significantly alter the size of the coefficient. The comparable effect for firms is smaller at 0.4% (column (4)) and more sensitive to saturating the model with additional fixed effects, and just marginally robust according to the Oster (2019) test diagnostics, which places the lower-bound close to 0.

[Insert Table 4]

The nature and strength of the risk-taking channel may depend on the bank's capital (Dell'Ariccia, Laeven and Marquez (2014)). For instance, there is evidence that the risk-taking channel of monetary policy is more pronounced for weakly capitalized banks (e.g. Jiménez, Ongena, Peydró and Saurina (2014); Dell'Ariccia, Laeven and Suarez (2017)). To test for the differential effect of bank capital on the risk-taking channel of monetary policy and the role of macroprudential policy in this relationship, we estimate the following model:

$$
\begin{aligned}
Loans_{b,h,t} = \alpha^{FE} + \phi_1 MP_t^{soft} + \phi_2 MAP_{c,t-1}^{soft} + \Omega X_{b,h,t-1} \\
+ \phi_3 \left(MP_t^{soft} \times Equity_{b,t-1} \times NPE_{h,t-1} \right) \\
+ \phi_4 \left(MAP_{c,t-1}^{soft} \times Equity_{b,t-1} \times NPE_{h,t-1} \right) \\
+ \phi_5 \left(MP_t^{soft} \times MAP_{c,t-1}^{soft} \times Equity_{b,t-1} \times NPE_{h,t-1} \right) + \epsilon_{b,h,t}
\end{aligned} \tag{5}
$$

where $Equity_{b,t-1}$ is our proxy for bank capital (given by bank equity over total assets) and $X_{b,h,t-1}$ includes all remaining double and triple interaction terms. The above model can be used to test whether the risk-taking channel identified in model (4) (as captured by a positive coefficient λ_6) is more pronounced for ex-ante weakly capitalized banks ($\phi_5 < 0$), consistent with a risk-taking explanation of the risk-taking channel (Dell'Ariccia, Laeven and Marquez (2014)). Specifically, this would imply that, following monetary policy easing, there is an increase in the credit supply toward risky borrowers by weakly capitalized banks when the ex-ante macroprudential policy environment is also more accommodative.

The coefficient of interest ϕ_5 depends on interacted firm and bank heterogeneity. Hence, in line with the logic behind previous empirical models, we saturate the model with both bank and borrower specific fixed effects (and not with the interaction of the two, which would leave very little variation to identify ϕ_5).

The results are presented separately for households and firms in Table 5. Our results are consistent with a risk-taking effect of monetary policy being dependent on the ex-ante macroprudential policy environment. The estimated coefficient on ϕ_5 is negative throughout specifications, for both households and firms, across the different model specifications. This suggests that macroprudential policy reinforces the risk-taking effect of monetary policy: an easing of monetary policy will prompt especially weaker capitalized banks to lend to riskier borrowers and this effect is more pronounced in an ex-ante more accommodative macroprudential policy environment.

[Insert Table 5]

The results are also economically significant. Based on the baseline estimates for households in column (1) of Table 5, we find that the marginal effect of a one standard deviation lower capital ratio on lending to non-performing borrowers following a softening of monetary policy by one standard deviation, and conditional on an ex-ante macroprudential policy environment that is one standard deviation softer, is 0.8% (= -0.0798 × 4.16 × 0.60 × 1 × -0.04). The comparable effect for loans to firms is larger and close to 3.5% (= -0.349 × 4.16 × 0.60 × 1 × -0.04). Both coefficients are remarkably stable across progressively saturated versions of the model and are strictly lower than zero based on the Oster (2019) test.

3.4 Risk-taking and firm productivity

We have shown that looser monetary policy induces greater bank risk-taking especially in an ex-ante more accommodative macroprudential policy environment: banks respond to a loosening of the policies by lending more to riskier borrowers (in terms of ex-ante credit risk). This risk-taking channel is found to be more pronounced for weaker capitalized banks. An important question to ask is whether there is differential risk-taking in terms of better or worse firms. Thus far, a key shortcoming in the literature on the risk-taking channel of monetary policy is that this question has been left unanswered (see, for example, Dell'Ariccia, Laeven and Suarez (2017)).

To address this question, in this section we assess the extent to which induced lending by weaker capitalized banks flows to more productive or to less productive firms. We use firm productivity as a proxy for the "efficiency" of credit allocation to distinguish between "better" and "worse" risk-taking. We limit this analysis to firms because we have no comparable measure of productivity for households.

We start with an analysis of how monetary policy and firm productivity combine to influence bank lending, and to what extent this relationship depends on the macroprudential policy environment. Specifically, we first estimate the following model of the link between bank lending and firm productivity:

$$\begin{aligned} Loans_{b,f,t} = \alpha^{FE} + \phi_1 MP_t^{soft} + \phi_2 MAP_{c,t-1}^{soft} + \Omega X_{b,f,t-1} \\ + \phi_3\left(MP_t^{soft} \times Productivity_f\right) \\ + \phi_4\left(MAP_{c,t-1}^{soft} \times Productivity_f\right) \\ + \phi_5\left(MP_t^{soft} \times MAP_{c,t-1}^{soft} \times Productivity_f\right) + \epsilon_{b,h,t} \end{aligned} \tag{6}$$

where our coefficient of interest is ϕ_5 and $X_{b,f,t-1}$ includes all remaining double interactions. A positive coefficient for ϕ_5 would indicate that the induced lending by looser monetary in an ex-ante more accommodative macroprudential policy environment flows disproportionately to more ex-ante productive firms. In line with previous analysis, we saturate the model with bank and time fixed effects.

The results are presented in columns (1) to (3) of Table 6. We indeed estimate a positive and statistically significant estimate for ϕ_5. This suggests that the policy induced boost in lending flows disproportionately to (ex-ante) more productive firms.

[Insert Table 6]

The effect is economically meaningful. Based on the estimates in column (1) of Table 6, we find that the marginal effect of a softening of monetary policy by one standard deviation on bank lending, conditional on a macroprudential policy environment that is one standard deviation softer, is 3.5% (= 0.014 × 4.16 × 0.60 × 1) larger for productive firms than for non-productive firms.

Moreover, we also consider the role of bank capital in the link between bank lending and firm productivity by estimating the following model:

$$
\begin{aligned}
Loans_{b,f,t} = \alpha^{FE} + \phi_1 MP_t^{soft} + \phi_2 MAP_{c,t-1}^{soft} + \Omega X_{b,f,t-1} \\
+ \phi_3 \left(MP_t^{soft} \times Equity_{b,t-1} \right) + \phi_4 \left(MAP_{c,t-1}^{soft} \times Equity_{b,t-1} \right) \\
+ \phi_5 \left(MP_t^{soft} \times MAP_{c,t-1}^{soft} \times Equity_{b,t-1} \right) \\
+ \phi_6 \left(MP_t^{soft} \times Equity_{b,t-1} \times Productivity_f \right) \\
+ \phi_7 \left(MAP_{c,t-1}^{soft} \times Equity_{b,t-1} \times Productivity_f \right) \\
+ \phi_8 \left(MP_t^{soft} \times MAP_{c,t-1}^{soft} \times Equity_{b,t-1} \times Productivity_f \right) + \epsilon_{b,h,t}
\end{aligned} \tag{7}
$$

where our coefficient of interest is ϕ_8. A negative coefficient would indicate that the induced lending by weaker capitalized banks flows disproportionately to more productive firms. Consistent with our previous empirical strategy (for estimating the interaction of the bank-lending and the "bad" risk-taking channel based on firm credit risk), we saturate the model with country*time, firm and bank fixed effects.

The results are presented in columns (4) to (7) of Table 6. We find a negative and statistically significant estimate for ϕ_8. This suggests that macroprudential policy reinforces the bank lending channel of monetary policy and that such lending disproportionately flows to more productive firms, especially from more constrained banks in terms of ex-ante lower capital ratios.

This effect is economically large. Based on the estimates in column (4) of Table 6 we find that the marginal effect of a one standard deviation lower capital ratio on lending, following a softening of each policy by one standard deviation, is 1.6% (= -0.164 × 4.16 × 0.60 × -0.04 × 1) larger for more productive firms than for less productive firms.

Interestingly, taking stock of the analysis on corporate loans, the baseline results for firm productivity are, overall, stronger than those for high credit risk firms commented on in the previous sub-section, suggesting that the risk-taking induced by the complementary mix of monetary and macroprudential policies is more prominently directed towards highly productive firms than towards very credit-risky ones.

In addition, the interaction of the two channels (the “good” and “bad” risk-taking) with bank capital suggests that they are both significantly and largely strengthened by lower levels of bank capitalization. More specifically, the comparison of the coefficients stemming from this analysis would suggest that low-capital banks are relatively more responsive in increasing credit towards high credit-risky firms rather than towards highly productive ones (following a monetary loosening in a looser macroprudential policy environment). Nonetheless, the robustness exercises presented in the last section will highlight that such a difference is sensitive to applying higher-order fixed effects (see also Appendix A.2).

3.5 Mortgage loans versus consumer loans

Thus far, we have not conditioned the analysis on the type of household loan. For households, the main category of loan is the mortgage loan. Mortgage loans tend to be larger and have longer maturities than non-mortgage loans, such as consumer loans. Moreover, mortgage loans are also always highly collateralized, while consumer loans are substantially less well collateralized. The transmission channel of monetary policy and the influence on this channel of macroprudential policy are likely to depend on the type of loan. On the one hand, we might expect the risk-taking channel of monetary policy to be less pronounced for mortgage loans than for non-mortgage loans because mortgage loans have higher collateral. Mortgage lending behavior should therefore respond less to changes in the monetary policy stance. On the other hand, macroprudential policies that are borrower-based, such as LTV or DTI ratios, may be particularly binding for mortgage loans that tend to be larger in size than non-mortgage loans. Moreover, risk-taking may be greater with consumer loans, as this type of loan is substantially riskier.

[Insert Table 7]

To gauge the effect on different loan types, we re-estimate equation (5) separately for mortgage loans and non-mortgage loans. The results are presented in Table 7. In short, we find that the risk-taking channel is larger (and more robust) for non-mortgage household loans, which are basically consumer loans, than for mortgages. That is, overall, the complementarity between monetary policy and macroprudential policy is larger for consumer and corporate loans than for mortgages.

3.6 Asymmetric effects of monetary policy

This subsection assesses whether monetary policy effects are asymmetric over the policy cycle. The asymmetry of the effects is captured by allowing the coefficient on monetary policy to differ over easing and tightening periods. Concretely, as we differentiate monetary surprises in terms of easing versus tightening according to whether the surprises are positive or negative. In particular, we estimate the following regression:

$$Loans_{b,h,t} = \alpha^{FE} + \varphi_1 MAP_{c,t-1}^{soft} + \varphi_2 \left(MP_t^{soft} \times MAP_{c,t-1}^{soft}\right) + \varphi_3 \left(MAP_{c,t-1}^{soft} \times D\left(MP_t^{soft} > 0\right)\right) + \varphi_4 \left(MP_t^{soft} \times MAP_{c,t-1}^{soft} \times D\left(MP_t^{soft} > 0\right)\right) + \Gamma X_{c,t} + \epsilon_{b,h,t} \quad (8)$$

Where $D\left(MP_t^{soft} > 0\right)$ is a dummy variable that takes value one over periods of expansionary monetary policy, i.e., when the monetary policy surprise variable MP_t^{soft} is positive. The other variables are the same as the ones used in equation (2). Note that the inclusion of time fixed effects (in α^{FE}) fully absorbs the monetary policy surprises: the overall size surprise (MP_t^{soft}), its sign ($D\left(MP_t^{soft} > 0\right)$), and the interaction of both variables ($MP_t^{soft} \times D\left(MP_t^{soft} > 0\right)$. Results are reported in Table 8.

[Insert Table 8]

The results indicate that the complementarity between monetary and macroprudential policy is stronger when there is easing of monetary policy (i.e. when financial markets are surprised by the central bank by injecting more accommodation than they had previously anticipated).[16] A one standard deviation softening of monetary policy in an accommodative macroprudential environment leads to an increase in household (corporate) credit by 9.6% (3.6%). Differently, the effects are more muted when conditioning on a tightening of both policies: the contraction in lending amounts to –2.6% and -0.7% for household and corporate credit, respectively.

When evaluating the estimated effects of monetary policy in our framework, a distinction should be made between the extensive margin of monetary policy, as captured by the sign of the surprise, and its intensive margin, as captured by the size of the monetary surprise. In terms of the extensive margin, we find that an easing of monetary policy in an ex-ante more accommodative macroprudential environment, stimulates household credit by 5.5%, as opposed to a reduction of 2.6% following a monetary tightening when the ex-ante macroprudential environment is also tighter.[17] In terms of the intensive margin, we find that the larger the easing of monetary policy in an ex-ante more accommodative macroprudential environment, the greater the credit expansion ($\varphi_4 > 0$), with an additional increase in household credit of 4.1%.[18] We find that similar dynamics apply to corporate debt, though they are more muted. A monetary easing in a more accommodative macroprudential environment expands corporate loans by 2% (whereas a monetary policy tightening in a tougher macroprudential environment cuts credit by 0.5%). Furthermore, a relatively larger monetary easing additionally expands corporate debt by 1.6%.

[16] Recall that we multiply the monetary policy surprises by -1, so higher values imply easing, i.e. lower rates than expected.

[17] The effect of a monetary policy softening (as captured by the sign of the dummy variable), conditional on a more accommodative macroprudential environment, is given by the sum of coefficients φ_2 and φ_4, multiplied by a one standard deviation of the softening of the macroprudential environment, that is: (0.0431 + 0.0488) x 0.6 = 5.5%. On the other hand, the effect of a monetary policy tightening, conditional on a more restrictive ex-ante macroprudential environment, is given by the multiplication of φ_2 by a one standard deviation macroprudential tightening, that is: 0.0431 x -0.6 = -2.6%.

[18] The effect of an additional one standard deviation monetary softening (as captured by the size of the surprise), conditional on a more accommodative macroprudential environment, is given by the sum of coefficients φ_3 and φ_5, multiplied by a one standard deviation macroprudential and monetary softening, that is: (0.0168 - 0.000205) x 4.16 x 0.6 = 4.1%. In this case, the mix of policy tightening implies a negative effect on credit, but its economic effect is close to zero.

3.7 Further robustness

We consider whether results are driven by loan size by re-estimating equation (4) using weighted least squares, with total credit commitment as a weight for each observation. Not only do these results serve as a robustness check, but they are also interesting from an aggregation perspective because, if results are largely driven by small loans that are quantitatively less important in the aggregate, then the aggregate effect will be quite different from the estimated effect at the loan level. The results are presented in Table A2.3 of Appendix 2. We find that results are insensitive to the weighting scheme, for both household loans and firm loans, or when we break down household loans by loan type. Moreover, results are also robust to the weighting scheme when augmented with a more conservative clustering at the borrower and country*time levels.

Finally, we check whether results on corporate loans exploiting bank heterogeneity are robust to employing firm*time fixed effects, which are commonly used in the literature to isolate credit supply shocks (Khwaja and Mian (2008)) and their interaction with monetary policy and macroprudential policy (Jiménez et al. (2012) and (2017)).[19] Results are presented in Table A2.4 of Appendix 2, where in each model we also include firm*bank fixed effects to further control for endogenous matching between firms and banks. All relevant findings go through, including the baseline bank-lending channel (column (1)) and its interactions with firm credit risk (columns (2)) and productivity (columns (4)). Moreover, in columns (3) and (5), we additionally include bank*time fixed effects, which help in identifying risk-taking as given by the interaction of bank capital and proxies of firms' riskiness (Jiménez et al. (2014)) and find that results are nearly unaffected. To conclude, a comparison with the baseline results in Tables 5 and 6 reveals that the magnitude of the effects is more robust to the inclusion of interacted

[19] We cannot apply the same robustness check to household loans, as applying household*time fixed effects would substantially drop the number of observations owing to a vast majority of euro area households being indebted to one bank only.

firm and time dummies in the case of "good risk-taking" based on firm productivity than in the case of "bad" risk-taking associated with firm ex-ante credit risk.

4 Conclusions

We have studied how the interaction between monetary policy and macroprudential policy influences bank lending behavior. Our main finding is that there is an amplification effect on lending when monetary policy becomes more accommodative in a loose macroprudential policy environment. We show these strong complementarities between monetary and macroprudential policies in influencing credit by exploiting credit register data from multiple (European) countries and for both corporate and household credit in conjunction with monetary policy surprises and indicators of macroprudential policy actions.

Our results also indicate that the complementary between monetary and macroprudential policy is stronger for: (i) expansionary – as opposed to contractionary – monetary policy; (ii) (credit) riskier borrowers; (iii) less capitalized banks, especially supplying credit to riskier borrowers; (iv) consumer and corporate loans rather than mortgages; and (v) more (ex-ante) productive firms (especially for less capitalized banks).

Overall, the empirical evidence provided in this paper suggest that the increase in lending origination following a monetary policy easing is reinforced by an accommodative macroprudential policy environment. These results suggest that a coordination of these two policies may enhance their overall effectiveness relative to a situation where each policy decision is taken in isolation.

Our findings also have a bearing on the mix of current policy responses to the COVID-19 crisis. Central banks and macroprudential authorities in many countries have responded to the escalating diffusion of this crisis with a combination of accommodative monetary policy and relaxation of macroprudential measures. Our results show that close coordination of monetary policy measures and prudential measures generates an amplification effect on lending, with more credit extended towards more productive firms. This additional effect on lending from a coordinated intervention can be sizeable: in a more accommodative macroprudential policy environment reinforced with accommodative monetary policy, the overall increase in lending may be as much as 40% larger.

Our study comes with a few caveats. First, we have focused on the role of banks. While banks continue to be the main source of funding for households and firms in the euro area, the increasing role of non-bank financing could limit the role played by macroprudential policy. Second, our reduced-form framework cannot determine whether bank risk-taking is excessive or whether past or present monetary policy is optimal, even though we attempt to address this issue by analyzing the link between bank lending and firm productivity. At the very least, our finding that risk-taking is also directed towards more productive firms does question the idea that an increase in risk-taking is necessarily bad (sub-optimal). Third, we have abstracted from the implications for the institutional set-up of a coordination of policies. This is particularly important for the euro area, where monetary policy is centralized and pursues a euro area-wide objective, while macroprudential policy is primarily conducted by national authorities and reflects country-specific credit dynamics. Our evidence of strong complementarities between monetary and macroprudential policies suggests that additional theoretical research is needed to consider the optimal degree of coordination between monetary policy and macroprudential policy.

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Tables

Table 1: Summary statistics

Variable	Observations	Mean	Std. Dev.	p25	p50	p75
Loan-level data						
ln(credit commitment to HHs)	99,475,542	3.34	1.90	2.61	3.95	4.61
ln(credit commitment to HHs for house purchases)	58,631,610	4.21	0.86	3.79	4.32	4.76
ln(credit commitment to HHs, other lending)	48,369,142	1.89	2.22	0.36	2.01	3.61
ln(credit commitment to NFCs)	90,415,238	4.59	1.72	3.64	4.60	5.63
Non-performing exposure to NFC - NPE(NFC)	90,415,238	0.13	0.39	0.00	0.00	0.00
Non-performing exposure to HH - NPE(HH)	99,475,542	0.03	0.16	0.00	0.00	0.00
Macroeconomic data						
Macroprudential index - MAP^{soft}	99,038,065	0.03	0.60	-0.61	-0.15	0.38
Monetary policy surprises - MP^{soft}	99,475,542	-0.24	4.16	-2.04	-0.27	4.33
Bank-level data						
Equity (total equity / total assets)	38,734,521	0.08	0.04	0.06	0.07	0.08
Firm-level data						
Productivity (dummy)	5,322,352	0.59	0.49	0.00	1.00	1.00
ln(TFP) -firm level measure of total factor productivity	5,322,352	4.09	1.37	3.00	4.00	5.00
median(lnTFP) by country-sector-date	5,322,352	3.95	1.25	3.00	4.00	5.00

Notes: The table reports the summary statistics of the variables used in the empirical analysis. **Loan-level data:** "ln(credit commitment to HHs)" is the overall credit amount provided by a bank to a household, expressed in logs. "ln(credit commitment to HHs for house purchases)" is the overall house-mortgage amount provided by a bank to a household, expressed in logs. "ln(credit commitment to HH, other)" is the amount of credit provided by a bank to a household for other purposes than house purchase (typically consumer loans), expressed in logs. "ln(credit commitment to NFCs)" is the overall credit amount provided by a bank to a firm, expressed in logs. The variables "Non-performing exposure to NFC" and "Non-performing exposure to HH" are dummies with a value of 1 if, respectively, the firm's or household's exposure is non-performing, and with a value of 0 otherwise. An exposure is defined as non-performing if it is in default and/or past due more than 90 days. **Macroeconomic data:** "MAP^{soft}" is a measure of macroprudential softening (with inverted sign) of a variable that for each country counts the implemented macroprudential policies. An increase in MAP^{soft} denotes a relaxation of macroprudential policy. "MP^{soft}" is the first principal component of the monetary policy surprises extracted from the high-frequency intraday yields at different maturities during all dates of policy announcements covered in the sample. We invert the sign of such principal component so that an increase in MP^{soft} corresponds to monetary policy softening. **Bank-level data:** "Equity" is a variable obtained as the ratio of bank total equity to total assets. **Firm-level data:** "Productivity" is a dummy variable with a value of 1 if a firm has TFP above the cross-sectional median of all firms within the same sector and country. TFP is measured at the firm level from the log Cobb-Douglas production function using the estimated sector-level factor shares. "ln(TFP)" is the resulting variable, expressed in logs.

Table 2: Monetary policy, macroprudential policy and the credit channel

	(1)	(2)	(3)	(4)	(5)	(6)
		Households			Firms	
MP^{soft}	0.00736***			0.00482***		
	(0.0000229)			(0.000198)		
MAP^{soft}	0.164***	0.0602***	0.00935***	0.00564***	0.00240***	0.0286***
	(0.000381)	(0.000721)	(0.000564)	(0.000626)	(0.000676)	(0.000504)
MP^{soft} x MAP^{soft}	0.00514***	0.00248***	0.00233***	0.000893***	0.000579***	0.000994***
	(0.0000377)	(0.0000719)	(0.0000469)	(0.0000485)	(0.0000469)	(0.0000362)
N	89,567,025	89,567,025	88,412,340	68,611,631	68,611,631	68,111,293
R^2	0.268	0.268	0.854	0.182	0.182	0.733
Country FE	Y	Y	-	Y	Y	-
Time FE		Y	Y		Y	Y
Borrower FE			Y			Y
Oster Beta-Bound (MP^{soft} x MAP^{soft})			0.00163			0.00103

Notes: The dependent variable is "(log-)credit granted (drawn and undrawn)" by bank "b" to households "h" (in columns 1 to 3) and to firms "f" (in columns 4 to 6) at time "t". "MP^{soft}" is the first principal component of the monetary policy surprises extracted from the high-frequency intraday yields at different maturities during all dates of policy announcements covered in the sample. We invert the sign of this principal component so that an increase in MP^{soft} corresponds to monetary policy softening. "MAP^{soft}" is a measure of macroprudential softening (with inverted sign) of a variable that for each country counts the implemented macroprudential policies. An increase in MAP^{soft} denotes a relaxation of macroprudential policy. The regressions control for country-specific macro conditions by including for each country the real GDP growth, the inflation rate and annual loan growth in levels and in interactions with monetary policy surprises. Data are semi-annual for the period from the first half of 2012 to the second half of 2017. "Y" indicates that the respective fixed effects are included. "-" indicates that a group of fixed effects is entirely absorbed by other vectors of fixed effects. The reported "Oster Beta-Bound" is computed for the coefficient of the MP^{soft} x MAP^{soft} interaction following Oster (2019), comparing results from models in columns 1 and 3 for households and columns 4 and 6 for firms. Standard errors are clustered at the borrower level in parentheses. *, ** and *** denote statistical significance levels at 10%, 5% and 1% respectively.

Table 3: Policy interactions and the bank lending channel

	(1)	(2)	(3)	(4)	(5)	(6)
		Households			Firms	
MP^{soft}	0.00306***			0.00659***		
	(0.0000640)			(0.000383)		
MAP^{soft}	0.0588***	0.0814***	0.0634***	0.0123***	0.0320***	0.0426***
	(0.000777)	(0.00130)	(0.000894)	(0.000857)	(0.000960)	(0.000696)
Equity	1.901***	1.993***	1.108***	1.004***	0.677***	1.819***
	(0.0352)	(0.0357)	(0.0441)	(0.0377)	(0.0388)	(0.0384)
MP^{soft} x MAP^{soft}	0.00789***	0.00414*	0.000389**	0.00173***	0.00360***	0.00139***
	(0.00128)	(0.00242)	(0.000153)	(0.000110)	(0.000107)	(0.0000639)
MP^{soft} x Equity	0.132***	0.140***	0.0392***	0.0899***	0.0972***	0.0123***
	(0.00239)	(0.00261)	(0.00145)	(0.00282)	(0.00286)	(0.00199)
MAP^{soft} x Equity	-0.612***	-0.465***	-0.181***	-0.683***	-1.014***	-0.753***
	(0.0175)	(0.0182)	(0.0121)	(0.0479)	(0.0484)	(0.0341)
MP^{soft} x MAP^{soft} x Equity	-0.173***	-0.175***	-0.0713***	-0.0527***	-0.0941***	-0.105***
	(0.00324)	(0.00336)	(0.00183)	(0.00679)	(0.00688)	(0.00423)
N	20,837,941	20,837,941	19,695,844	29,306,538	29,306,538	28,890,546
R^2	0.290	0.291	0.906	0.166	0.167	0.789
Country FE	Y	Y	-	Y	Y	-
Time FE		Y	Y		Y	Y
Borrower FE			Y			Y
Oster Beta-Bound (MP^{soft} x MAP^{soft} x Equity)			-0.05578			-0.12271

Notes: The dependent variable is "(log-)credit granted (drawn and undrawn)" by bank "b" to households "h" (in columns 1 to 3) and to firms "f" (in columns 4 to 6) at time "t". "MP^{soft}" is the first principal component of the monetary policy surprises extracted from the high-frequency intraday yields at different maturities during all dates of policy announcements covered in the sample. We invert the sign of this principal component so that an increase in MP^{soft} corresponds to monetary policy softening. "MAP^{soft}" is a measure of macroprudential softening (with inverted sign) of a variable that for each country counts the implemented macroprudential policies. An increase in MAP^{soft} denotes a relaxation of macroprudential policy. The variable "Equity" is obtained as the ratio of bank total equity to total assets. The regressions control for country-specific macro conditions by including for each country the real GDP growth, the inflation rate and annual loan growth in levels and in interactions with monetary policy surprises. Data are semi-annual for the period from the first half of 2012 to the second half of 2017. "Y" indicates that the respective fixed effects are included. "-" indicates that a group of fixed effects is entirely absorbed by other vectors of fixed effects. The reported "Oster Beta-Bound" is computed for the coefficient of the MP^{soft} x MAP^{soft} x Equity interaction following Oster (2019), comparing results from models in columns 1 and 3 for households and columns 4 and 6 for firms. Standard errors are clustered at the borrower level in parentheses. *, ** and *** denote statistical significance levels at 10%, 5% and 1% respectively.

Table 4: Policy interactions and risk-taking

	(1)	(2)	(3)	(4)	(5)	(6)
		Households			Firms	
MP^{soft}	0.00590***			0.00546***		
	(0.0000243)			(0.00209)		
MAP^{soft}	0.131***	0.0278***	0.0279***	0.0169***	0.0207***	0.0145***
	(0.000415)	(0.000733)	(0.000679)	(0.000704)	(0.000741)	(0.000727)
NPE	-0.0113***	-0.0107***	-0.173***	-0.211***	-0.210***	-0.212***
	(0.00159)	(0.00159)	(0.00140)	(0.00256)	(0.00257)	(0.00261)
MP^{soft} x MAP^{soft}	0.00446***	0.000906***	0.000987***	0.000680***	0.000487***	0.0000280
	(0.0000419)	(0.0000703)	(0.0000651)	(0.0000549)	(0.0000533)	(0.0000521)
MP^{soft} x NPE	0.000895***	0.000248***	0.00333***	0.00257***	0.00240***	0.00228***
	(0.0000725)	(0.0000724)	(0.0000689)	(0.0000599)	(0.0000599)	(0.0000582)
MAP^{soft} x NPE	0.0317***	0.0443***	0.0258***	0.0888***	0.0850***	0.0877***
	(0.00106)	(0.00106)	(0.000982)	(0.00157)	(0.00158)	(0.00152)
MP^{soft} x MAP^{soft} x NPE	0.00726***	0.00659***	0.00628***	0.00154***	0.000860***	0.000639***
	(0.000118)	(0.000117)	(0.000109)	(0.000120)	(0.000121)	(0.000117)
N	76,873,421	76,873,421	76,873,346	68,607,899	68,607,899	68,607,899
R^2	0.286	0.286	0.551	0.184	0.184	0.441
Country FE	Y	Y	-	Y	Y	-
Time FE		Y	Y		Y	Y
Bank FE			Y			Y
Oster Beta-Bound (MP^{soft} x MAP^{soft} x NPE)			0.00567			0.00018

Notes: The dependent variable is "(log-)credit granted (drawn and undrawn)" by bank "b" to households "h" (in columns 1 to 3) and to firms "f" (in columns 4 to 6) at time "t". "MP^{soft}" is the first principal component of the monetary policy surprises extracted from the high-frequency intraday yields at different maturities during all dates of policy announcements covered in the sample. We invert the sign of this principal component so that an increase in MP^{soft} corresponds to monetary policy softening. "MAP^{soft}" is a measure of macroprudential softening (with inverted sign) of a variable that for each country counts the implemented macroprudential policies. An increase in MAP^{soft} denotes a relaxation of macroprudential policy. The regressions control for country-specific macro conditions by including for each country the real GDP growth, the inflation rate and annual loan growth in levels and in interactions with monetary policy surprises. "NPE" is a dummy variable with a value of 1 if the borrower has experienced a non-performing exposure over the sample period, and zero otherwise. Data are semi-annual for the period from the first half of 2012to the second half of 2017. "Y" indicates that the respective fixed effects are included. "-" indicates that a group of fixed effects is entirely absorbed by other vectors of fixed effects. The reported "Oster Beta-Bound" is computed for the coefficient of the MP^{soft} x MAP^{soft} x NPE interaction following Oster (2019), comparing results from models in columns 1 and 3 for households and columns 4 and 6 for firms. Standard errors are clustered at the borrower level in parentheses. *, ** and *** denote statistical significance levels at 10%, 5% and 1% respectively.

Table 5: Policy interactions, bank capital and the risk-taking channel

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Households				Firms			
MP^{soft}	0.00740***				0.00484***			
	(0.0000684)				(0.000207)			
MAP^{soft}	0.0661***	0.0896***			0.0177***	0.0133***		
	(0.000915)	(0.00133)			(0.00385)	(0.00389)		
Equity	2.253***	2.372***	2.581***	0.375***	0.0197	0.214***	0.640***	0.373***
	(0.0400)	(0.0406)	(0.0416)	(0.0323)	(0.0421)	(0.0430)	(0.0279)	(0.0442)
NPE	-0.162***	-0.165***	-0.169***		-0.251***	-0.248***		-0.249***
	(0.00247)	(0.00247)	(0.00247)		(0.00293)	(0.00294)		(0.00294)
MP^{soft} x MAP^{soft}	0.0125***	0.0114***			0.0117***	0.0155***		
	(0.000295)	(0.000358)			(0.000544)	(0.000551)		
MP^{soft} x Equity	0.115***	0.104***	0.160***	0.00319*	0.0738***	0.0810***	0.0462***	0.0992***
	(0.00251)	(0.00270)	(0.00324)	(0.00167)	(0.00308)	(0.00311)	(0.00170)	(0.00351)
MP^{soft} x NPE	0.0112***	0.0109***	0.00960***	0.00173***	0.00415***	0.00333***	0.00215***	0.00304***
	(0.000168)	(0.000169)	(0.000170)	(0.000102)	(0.000502)	(0.000503)	(0.000243)	(0.000549)
MAP^{soft} x Equity	-1.170***	-1.150***	-0.969***	-0.0716***	-0.269***	-0.554***	-0.299***	-0.340***
	(0.0209)	(0.0220)	(0.0306)	(0.0155)	(0.0565)	(0.0571)	(0.0278)	(0.0585)
MAP^{soft} x NPE	0.0762***	0.0777***	0.0935***	0.0467***	0.170***	0.159***	0.0601***	0.200***
	(0.00197)	(0.00197)	(0.00199)	(0.00125)	(0.00746)	(0.00747)	(0.00380)	(0.00755)
Equity x NPE	-2.269***	-2.278***	-2.234***	-0.182*	-3.304***	-3.233***	-2.825***	-3.295***
	(0.0664)	(0.0664)	(0.0665)	(0.0938)	(0.0929)	(0.0930)	(0.0539)	(0.0934)
MP^{soft} x MAP^{soft} x Equity	-0.144***	-0.123***	-0.149***	-0.00748***	-0.163***	-0.197***	-0.0495***	-0.141***
	(0.00349)	(0.00360)	(0.00473)	(0.00222)	(0.00805)	(0.00817)	(0.00274)	(0.00851)
MP^{soft} x MAP^{soft} x NPE	0.0121***	0.0116***	0.00926***	0.00488***	0.0182***	0.0191***	0.00578***	0.0115***
	(0.000362)	(0.000363)	(0.000368)	(0.000180)	(0.00103)	(0.00103)	(0.000353)	(0.00105)
MAP^{soft} x Equity x NPE	2.237***	2.251***	2.127***	0.399***	-1.185***	-1.092***	-0.432***	-1.573***
	(0.0448)	(0.0448)	(0.0450)	(0.0289)	(0.112)	(0.112)	(0.0571)	(0.113)
MP^{soft} x Equity x NPE	-0.0834***	-0.0953***	-0.0776***	-0.0322***	0.109***	0.102***	0.0659***	0.0973***
	(0.00564)	(0.00562)	(0.00565)	(0.00354)	(0.00741)	(0.00742)	(0.00349)	(0.00793)
MP^{soft} x MAP^{soft} x Equity x NPE	-0.0798**	-0.118***	-0.0863**	-0.101***	-0.349***	-0.356***	-0.108***	-0.271***
	(0.0365)	(0.0366)	(0.0367)	(0.0159)	(0.0152)	(0.0152)	(0.00539)	(0.0153)
N	17,779,921	17,779,921	17,779,921	16,773,836	29,304,078	29,304,078	28,527,111	29,304,078
R^2	0.341	0.342	0.342	0.922	0.169	0.170	0.170	0.923
Country FE	Y	Y	-	-	Y	Y	-	-
Time FE		Y	-	-		Y	-	-
Country*Time FE			Y	Y			Y	Y
Borrower FE				Y				Y
Bank FE				Y				Y
Oster Beta-Bound (MP^{soft} x MAP^{soft} x Equity x NPE)				-0.10385				-0.26303

Notes: The dependent variable is "(log-)credit granted (drawn and undrawn)" by bank "b" to households "h" (in columns 1 to 4) and to firms "f" (in columns 5 to 8) at time "t". "MP^{soft}" is the first principal component of the monetary policy surprises extracted from the high-frequency intraday yields at different maturities during all dates of policy announcements covered in the sample. We invert the sign of this principal component so that an increase in MP^{soft} corresponds to monetary policy softening. "MAP^{soft}" is a measure of macroprudential softening (with inverted sign) of a variable that for each country counts the implemented macroprudential policies. An increase in MAP^{soft} denotes a relaxation of macroprudential policy. "NPE" is a dummy variable with a value 1 if the borrower has experienced a non-performing exposure over the sample period, and zero otherwise. The regressions control for country-specific macro conditions by including for each country the real GDP growth, the inflation rate and annual loan growth in levels and in interactions with monetary policy surprises. The variable "Equity" is obtained as the ratio of bank total equity to total assets. Data are semi-annual for the period from the first half of 2012 to the second half of 2017. "Y" indicates that the respective fixed effects are included. "-" indicates that a group of fixed effects is entirely absorbed by other vectors of fixed effects. The reported "Oster Beta-Bound" is computed for the coefficient of the MP^{soft} x MAP^{soft} x Equity x NPE interaction following Oster (2019), comparing results from models in columns 1 and 4 for households and columns 5 and 8 for firms. Standard errors are clustered at the borrower level in parentheses. *, ** and *** denote statistical significance levels at 10%, 5% and 1% respectively.

Table 6: Policy interactions and firm productivity

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
				Firms			
MP^{soft}	0.00170***			0.00151***			
	(0.000276)			(0.000353)			
MAP^{soft}	0.0845***	0.0693***	0.0500***	0.0587***	0.0355***		
	(0.00585)	(0.00608)	(0.00577)	(0.00733)	(0.00759)		
Equity				0.259	0.202	0.355	0.607***
				(0.238)	(0.241)	(0.244)	(0.147)
Productivity	0.681***	0.681***	0.640***	0.670***	0.670***	0.670***	0.00329
	(0.00591)	(0.00591)	(0.00564)	(0.00698)	(0.00699)	(0.00698)	(0.00327)
MP^{soft} x MAP^{soft}	0.0146***	0.0121***	0.0117***	0.00465***	0.00463***		
	(0.000622)	(0.000629)	(0.000599)	(0.000908)	(0.000900)		
MP^{soft} x Equity				0.0713***	0.0890***	0.0793***	0.0247**
				(0.0249)	(0.0252)	(0.0254)	(0.0116)
MP^{soft} x Productivity	0.00448***	0.00479***	0.00635***	0.000784*	0.000739	0.00104**	0.0000544
	(0.000368)	(0.000368)	(0.000352)	(0.000471)	(0.000470)	(0.000471)	(0.000211)
MAP^{soft} x Equity				-4.849***	-4.540***	-4.635***	-0.453**
				(0.374)	(0.375)	(0.378)	(0.183)
MAP^{soft} x Productivity	0.0494***	0.0518***	0.0599***	0.0582***	0.0626***	0.0607***	0.00231
	(0.00775)	(0.00774)	(0.00728)	(0.00981)	(0.00979)	(0.00978)	(0.00494)
Equity x Productivity				0.394	0.395	0.423	0.572***
				(0.298)	(0.298)	(0.298)	(0.154)
MP^{soft} x MAP^{soft} x Equity				-0.0347	-0.00106	-0.0352	-0.0531***
				(0.0488)	(0.0489)	(0.0495)	(0.0197)
MP^{soft} x MAP^{soft} x Productivity	0.0140***	0.0135***	0.0124***	0.00363***	0.00318***	0.00335***	0.00318***
	(0.000870)	(0.000871)	(0.000830)	(0.00123)	(0.00123)	(0.00123)	(0.000455)
MAP^{soft} x Equity x Productivity				-4.113***	-4.154***	-4.017***	-0.186
				(0.482)	(0.482)	(0.482)	(0.224)
MP^{soft} x Equity x Productivity				-0.0468	-0.0486	-0.0573*	-0.0330**
				(0.0328)	(0.0328)	(0.0329)	(0.0145)
MP^{soft} x MAP^{soft} x Equity x Productivity				-0.164**	-0.172***	-0.170**	-0.231***
				(0.0659)	(0.0660)	(0.0660)	(0.0256)
N	2,576,547	2,576,547	2,576,530	1413834	1413834	1413834	1304122
R^2	0.0731	0.0734	0.157	0.0723	0.0729	0.0736	0.902
Country FE	Y	Y	Y	Y	Y	-	-
Time FE		Y	Y		Y	-	-
Country*Time FE						Y	Y
Bank FE			Y				Y
Borrower FE							Y
Oster Beta-Bound (MP^{soft} x MAP^{soft} x Productivity)			0.0115				
Oster Beta-Bound (MP^{soft} x MAP^{soft} x Equity x Productivity)							-0.23891

Notes: The dependent variable is "(log-)credit granted (drawn and undrawn)" by bank "b" to firms "f" at time "t". "MP^{soft}" is the first principal component of the monetary policy surprises extracted from the high-frequency intraday yields at different maturities during all dates of policy announcements covered in the sample. We invert the sign of this principal component so that an increase in MP^{soft} corresponds to monetary policy softening. "MAP^{soft}" is a measure of macroprudential softening (with inverted sign) of a variable that for each country counts the implemented macroprudential policies. An increase in MAP^{soft} denotes a relaxation of macroprudential policy. The regressions control for country-specific macro conditions by including for each country the real GDP growth, the inflation rate and annual loan growth in levels and in interactions with monetary policy surprises. "Productivity" is a dummy variable with a value of 1 if a firm has TFP above the cross-sectional median of all firms within the same sector and country. "Equity" is a variable obtained as the ratio of bank total equity to total assets. Data are semi-annual for the period from the first half of 2012 to the second half of 2017. "Y" indicates that the respective fixed effects are included. "-" indicates that a group of fixed effects is entirely absorbed by other vectors of fixed effects. The reported "Oster Beta-Bound" for the coefficient of the MP^{soft} x MAP^{soft} x Productivity interaction compares results from models in columns 1 and 3 following Oster (2019). Applying the same methodology, the reported "Oster Beta-Bound" for the coefficient of the MP^{soft} x MAP^{soft} x Equity x Productivity interaction compares results from models in columns 4 and 7. Standard errors are clustered at the borrower level in parentheses. *, ** and *** denote statistical significance levels at 10%, 5% and 1% respectively.

Table 7: Policy interactions, bank capital and the risk-taking channel: household mortgages *vs.* consumer loans

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Mortgages				Consumer Loans			
MP^{soft}	0.00280***				0.00444***			
	(0.0000589)				(0.000228)			
MAP^{soft}	0.0313***	0.0623***			0.0779***	0.000811		
	(0.000760)	(0.00173)			(0.00234)	(0.00247)		
Equity	0.650***	0.713***	0.947***	0.281***	0.826***	0.868***	0.229***	0.823***
	(0.0380)	(0.0386)	(0.0397)	(0.0195)	(0.0363)	(0.0368)	(0.0306)	(0.0387)
NPE	-0.168***	-0.174***	-0.187***	-0.0990***	-0.591***	-0.589***	-0.238***	-0.588***
	(0.00958)	(0.00958)	(0.00957)	(0.00421)	(0.0157)	(0.0157)	(0.00943)	(0.0157)
MP^{soft} x MAP^{soft}	0.00164***	0.000191			0.0189***	0.0111***		
	(0.000115)	(0.000303)			(0.000389)	(0.000417)		
MP^{soft} x Equity	-0.124***	-0.114***	-0.169***	-0.0300***	-0.0720***	-0.108***	-0.0499***	-0.132***
	(0.00247)	(0.00273)	(0.00347)	(0.00167)	(0.00297)	(0.00324)	(0.00223)	(0.00401)
MP^{soft} x NPE	0.0248***	0.0248***	0.0246***	0.00267***	0.0281***	0.0303***	0.0173***	0.0314***
	(0.00118)	(0.00118)	(0.00118)	(0.000430)	(0.00196)	(0.00197)	(0.00120)	(0.00199)
MAP^{soft} x Equity	-0.528***	-0.419***	-0.426***	-0.0196**	-1.165***	-0.863***	-0.136***	-1.045***
	(0.0215)	(0.0227)	(0.0340)	(0.0041)	(0.0232)	(0.0242)	(0.0199)	(0.0354)
MAP^{soft} x NPE	0.0474***	0.0613***	0.0835***	0.0924***	0.0311*	0.0450***	0.600***	0.0539***
	(0.0110)	(0.0110)	(0.0110)	(0.00415)	(0.0162)	(0.0162)	(0.00986)	(0.0166)
Equity x NPE	5.035***	5.026***	5.009***	0.427***	-1.976***	-1.977***	-0.267***	-1.964***
	(0.232)	(0.232)	(0.232)	(0.137)	(0.111)	(0.111)	(0.0722)	(0.111)
MP^{soft} x MAP^{soft} x Equity	-0.146***	-0.145***	-0.417***	-0.0337***	-0.159***	-0.161***	-0.0274***	-0.198***
	(0.00340)	(0.00351)	(0.00559)	(0.00180)	(0.00407)	(0.00424)	(0.00304)	(0.00556)
MP^{soft} x MAP^{soft} x NPE	0.0333***	0.0333***	0.0293***	0.00206***	0.0368***	0.0354***	0.0272***	0.0367***
	(0.00225)	(0.00225)	(0.00226)	(0.000699)	(0.00308)	(0.00308)	(0.00183)	(0.00312)
MAP^{soft} x Equity x NPE	0.285	0.315	0.498**	1.111***	0.869***	0.831***	3.064***	0.746***
	(0.213)	(0.213)	(0.212)	(0.0910)	(0.124)	(0.124)	(0.0788)	(0.125)
MP^{soft} x Equity x NPE	0.0437	0.0376	0.0323	0.0528***	-0.303***	-0.314***	-0.0869***	-0.303***
	(0.0315)	(0.0315)	(0.0314)	(0.0123)	(0.0211)	(0.0211)	(0.0134)	(0.0212)
MP^{soft} x MAP^{soft} x Equity x NPE	-0.0465	-0.0367	-0.0510	-0.0113	-0.415***	-0.406***	-0.124***	-0.394***
	(0.0413)	(0.0413)	(0.0411)	(0.0148)	(0.0282)	(0.0283)	(0.0180)	(0.0284)
N	8638301	8638301	8638301	7897307	12448795	12448795	12448795	11858623
R^2	0.215	0.215	0.216	0.915	0.265	0.265	0.265	0.883
Country FE	Y	Y	-	-	Y	Y	-	-
Time FE		Y	-	-		Y	-	-
Country*Time FE			Y	Y			Y	Y
Borrower FE				Y				Y
Bank FE				Y				Y
Oster Beta-Bound (MP^{soft} x MAP^{soft} x Equity)				-0.02006				-0.20538
Oster Beta-Bound (MP^{soft} x MAP^{soft} x NPE)				-0.00173				0.03668
Oster Beta-Bound (MP^{soft} x MAP^{soft} x Equity x NPE)				-0.00703				-0.39002

Notes: The dependent variable is "(log-)credit granted (drawn and undrawn)" by bank "b" to households "h" at time "t", either in the form of mortgages (columns 1 to 4) or consumer loans (columns 5 to 8). "MP^{soft}" is the first principal component of the monetary policy surprises extracted from the high-frequency intraday yields at different maturities during all dates of policy announcements covered in the sample. We invert the sign of this principal component so that an increase in MP^{soft} corresponds to monetary policy softening. "MAP^{soft}" is a measure of macroprudential softening (with inverted sign) of a variable that for each country counts the implemented macroprudential policies. An increase in MAP^{soft} denotes a relaxation of macroprudential policy. The regressions control for country-specific macro conditions by including for each country the real GDP growth, the inflation rate and annual loan growth in levels and in interactions with monetary policy surprises. "NPE" is a dummy variable with a value of 1 if the borrower has experienced a non-performing exposure over the sample period, and zero otherwise. The variable "Equity" is obtained as the ratio of bank total equity to total assets. Data are semi-annual for the period from the first half of 2012 to the second half of 2017. "Y" indicates that the respective fixed effects are included. "-" indicates that a group of fixed effects is entirely absorbed by other vectors of fixed effects. All the reported "Oster Beta-Bound(s)" are computed comparing the relevant coefficient in models 1 and 4 for mortgages and 5 and 8 for consumer loans following Oster (2019). Standard errors are clustered at the borrower level in parentheses. *, ** and *** denote statistical significance levels at 10%, 5% and 1% respectively.

Table 8: Monetary policy, macroprudential policy and the credit channel: asymmetric effects

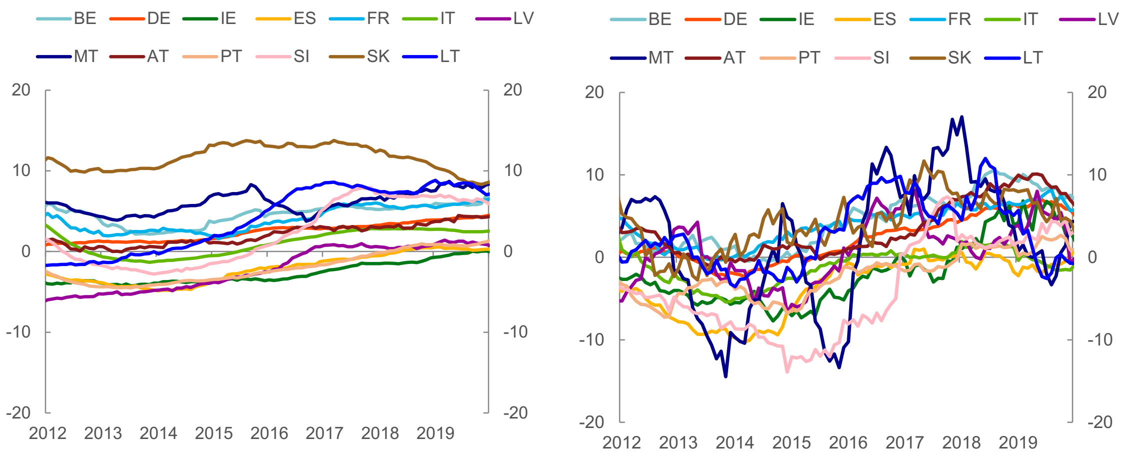
	(1)	(2)	(3)	(4)
	Households		Firms	
MAP^{soft}	0.0431***	0.0136***	0.00829***	0.0633***
	(0.000635)	(0.000433)	(0.000736)	(0.000464)
MP^{soft} x MAP^{soft}	-0.000205***	-0.00112***	-0.000749***	-0.00180***
	(0.0000467)	(0.0000264)	(0.0000597)	(0.0000349)
MP^{soft} x MAP^{soft} x (D(MP^{soft}>0))	0.0168***	0.00151***	0.00702***	0.00310***
	(0.000151)	(0.0000825)	(0.000141)	(0.0000787)
MAP^{soft} x (D(MP^{soft}>0))	0.0488***	0.0136***	0.0250***	0.00468***
	(0.000512)	(0.000282)	(0.000562)	(0.000313)
N	96935040	93044550	72934181	71397618
R^2	0.264	0.964	0.179	0.925
Country FE	Y	Y	Y	Y
Time FE	Y	Y	Y	Y
Bank*Borrower FE		Y		Y

Notes: The dependent variable is "(log-)credit granted (drawn and undrawn)" by bank "b" to households "h" (in columns 1 to 2) and to firms "f" (in columns 3 to 4) at time "t". "MP^{soft}" is the first principal component of the monetary policy surprises extracted from the high-frequency intraday yields at different maturities during all dates of policy announcements covered in the sample. We invert the sign of this principal component so that an increase in MP^{soft} corresponds to monetary policy softening. "MAP^{soft}" is a measure of macroprudential softening (with inverted sign) of a variable that for each country counts the implemented macroprudential policies. An increase in MAP^{soft} denotes a relaxation of macroprudential policy. D(MP^{soft}>0) is a dummy variable that takes value one over periods of expansionary monetary policy, i.e. when the variables MP^{soft} is positive. The regressions control for country-specific macro conditions by including for each country the real GDP growth, the inflation rate and annual loan growth in levels and in interactions with monetary policy surprises. Data are semi-annual for the period from the first half of 2012 to the second half of 2017. "Y" indicates that the respective fixed effects are included. "-" indicates that a group of fixed effects is entirely absorbed by other vectors of fixed effects. Standard errors are clustered at the borrower level in parentheses. *, ** and *** denote statistical significance levels at 10%, 5% and 1% respectively.

Figures

Figure 1: Evolution of the growth rate of total loans to households and non-financial corporations by country

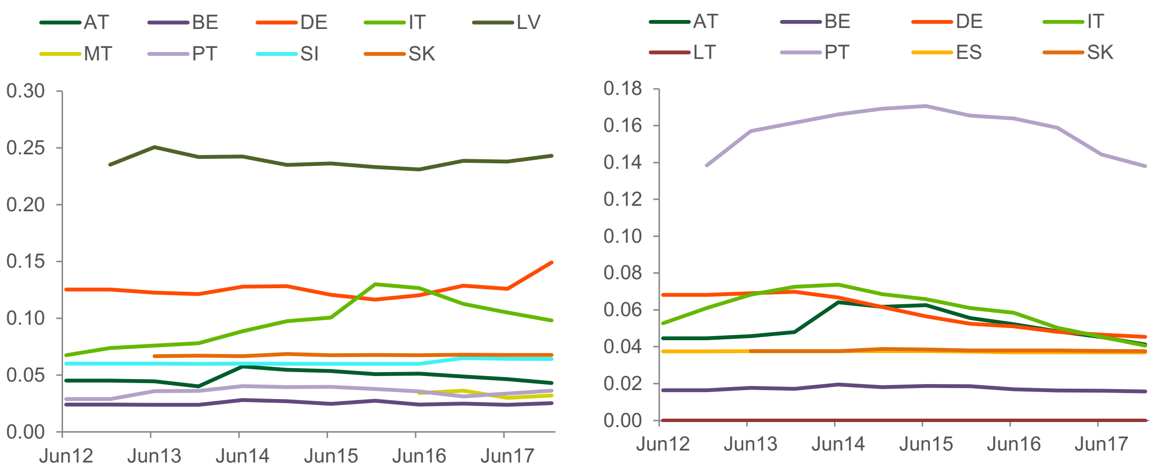
Panel A: Households | Panel B: Non-financial corporations



Note: The chart shows the time series of annual growth of loans to households (Panel A) and non-financial corporations (Panel B) across countries.

Figure 2: Non-performing exposures (NPE)

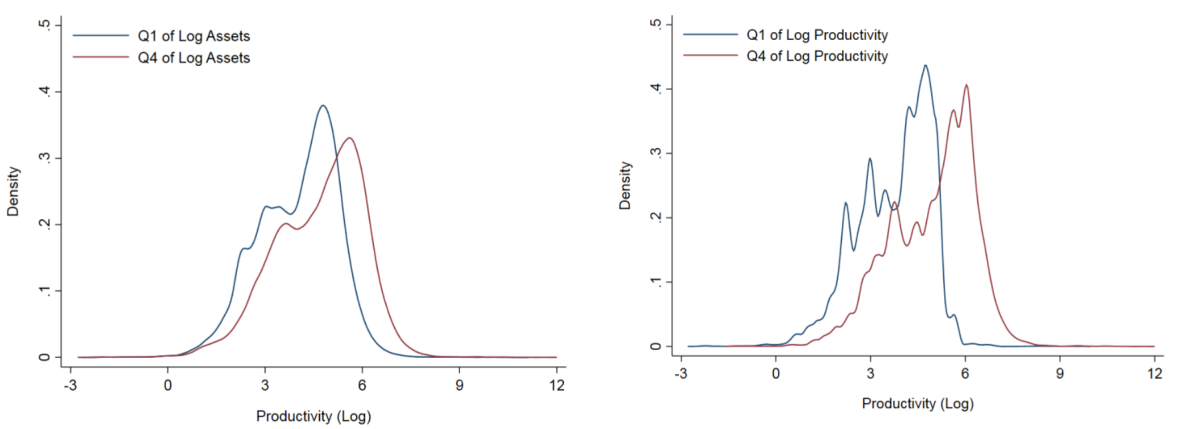
Panel A: Households | Panel B: Non-financial corporations



Note: The chart shows the time series of the average non-performing exposure, i.e. exposure in default and/or past due by more than 90 days, for households (Panel A) and non-financial corporations (Panel B) across countries.

Figure 3: Productivity

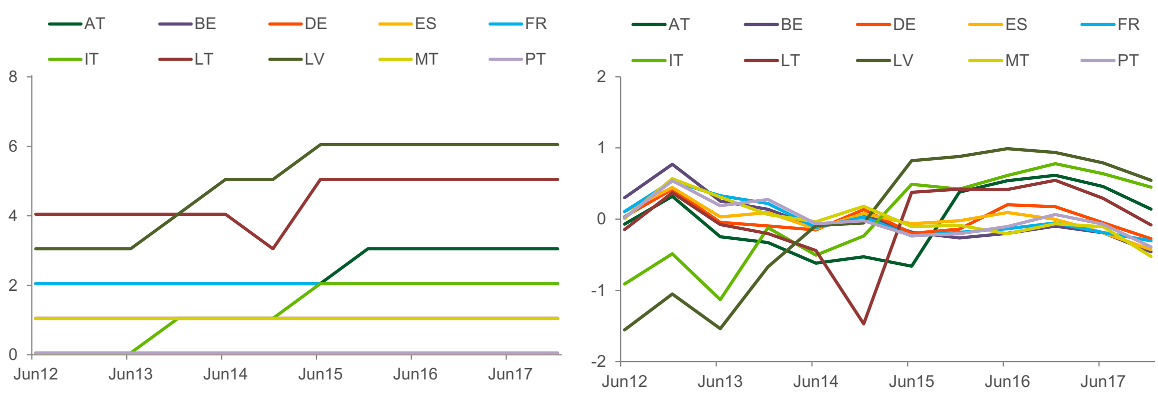
Panel A: Size Panel B: Quartiles of firm distribution



Note: The figure shows the first and fourth quartile of the distribution of firm size (Panel A) and firm productivity (Panel B) for the sample of firms used in the estimation.

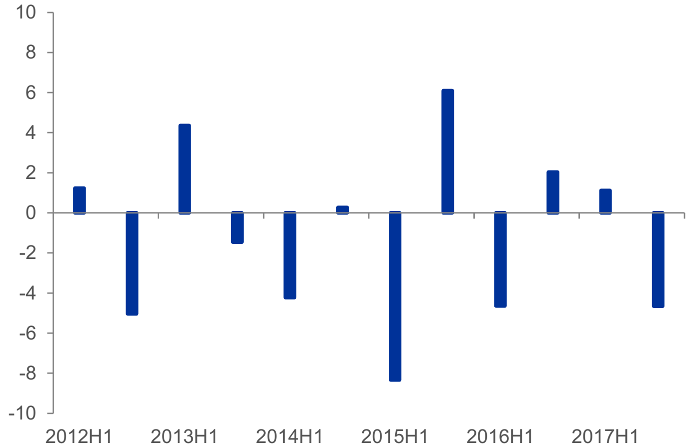
Figure 4: Macroprudential index

MAP index MAP index adjusted for economic developments



Notes: The left-hand panel reports the index of macroprudential policy (MAP) intensity based on the number of measures that are being put in place at a given point in time. The index adds (subtracts) 1 if a new measure that is implemented tightens (loosens) macroprudential policy. Further details on the construction of the index are reported in Appendix 1. The right-hand panel reports the MAP variable, obtained as the residuals of a regression of the MAP index against current GDP and credit growth. In contrast, in regression tables we use the overall MAP^{soft} intensity variable, which corresponds to the MAP variable depicted here on the left-hand panel but with inverted sign, so that an increase in MAP^{soft} corresponds to a relaxation of macroprudential policy. In the regressions we also control for interactions with monetary policy surprises and for GDP and credit growth, unless these variables are absorbed by fixed effects.

Figure 5: Monetary policy surprises



Notes: The figure reports the monetary policy surprise constructed as a principal component of all monetary surprises from high-frequency intraday data on risk-free (overnight index swap) rates with different maturities, ranging from one month to ten years. These surprises are calculated by measuring changes in risk free rates in a narrow time window around official monetary policy communications. In contrast, in regression tables we use the monetary policy surprise with inverted sign, labelled as MP^{soft}, so that an increase of MP^{soft} denotes monetary policy softening.

Appendix 1 – Construction of the Macroprudential Policy Index

The underlying data source for the construction of the Macroprudential Policy Index (MAP index) is Budnik and Kleibl (2018), who construct a comprehensive dataset on policies of a macroprudential nature in the banking sectors of the 28 EU Member States between 1995 and 2014. The database encompasses ten distinct categories of macroprudential policies:[20]

1. Minimum capital requirements
2. Capital buffers
3. Risk weights
4. Leverage ratios
5. Lending standard restrictions
6. Levy/tax on financial institutions and activities
7. Limits on large exposures and concentration
8. Liquidity requirements and limits on currency and maturity mismatches
9. Loan-loss provisioning
10. Limits on credit growth and volume

Following the literature on macroprudential policy instruments, we construct the MAP index encompassing all policy measures both borrower-based and lender-based, indicating the overall strength of macroprudential regulation in each country. The dataset by Budnik and Kleibl (2018) collects policy measures based on the date on which a specific policy measure has come into force. Since we are interested in the construction of an index spanning the same time period for each country, we fill in any missing time periods. We thus construct a bi-annual "balanced" panel dataset for the 28 EU countries running from the first half of 1994 to the second half of 2017.[21]

The index we build takes a value of between 1 and 10 and captures the extensive margin of macroprudential policy, i.e. whether at least one tool within each of the above categories has been in force. The index does not capture the intensity within each of these categories, because there is no clear mapping between intensity of policy and the number of distinct tools in place within each category.

More specifically, the index is constructed using the following steps:

- For each country, we count the number of policies in place within each category. To do so, we assign values {-1, 0, +1} for each category according to the following rules:[22]

[20] We focus on macroprudential measures exclusively and, hence, disregard the category "Other measures", which include other crisis management tools and structural measures.

[21] Note that we fill in the missing observations just to have consecutive dates. All missing policy variables are filled in and, hence, enter the calculation of the index values, with the default value of zero.

[22] Note that we set the default value to zero and replace the observations according to the criteria. In some cases a new policy leading to the deactivation or the change of an existing tool cannot be traced to a previous activation of the tool. In these instances, we assume the respective policy has been in place since the beginning of the sample period, i.e. the first half of 1994.

    - We assign a value of +1 for each new activation of a tool that led to policy tightening or that had an ambiguous impact depending on the state of the business cycle;
    - We assign a value of 0 for each policy measure that constituted a change in the level of an existing tool or maintained an existing level or scope of a policy tool;
    - We assign a value of -1 in the case of (i) the deactivation of an existing tool, and (ii) the activation of a new tool that led to policy loosening.
- We add up the values obtained in 1) for each half-year, category and country. This indicates the net addition of policy measures to the policy mix within each category relative to the preceding half-year.
- For each country, we calculate the cumulative sum over the sample period within each category. This indicates the evolution of the total number of measures (both previously and newly activated tools) in place within each category over time.
- As mentioned above, we focus on the *extensive margin* of macroprudential regulation. In this step, we hence assign a value of 1 if the number calculated in step 3) is positive for each country, category and half-year.
- We calculate the value of the MAP index in any half-year as the sum of the values obtained in step 5) across all ten categories. As indicated above, the index can thus take values of between zero and 10, where zero indicates that there were no measures active in any of the ten considered categories and 10 means that within each category at least one measure has been active.

Appendix 2 – Additional information on the dataset and further robustness

Table A2.1: Number of observations by country

	Households		Firms	
	Number of observations	Number of households	Number of observations	Number of firms
Country				
Austria	452,532	73,177	695,743	68,539
Belgium	4,681,811	460,860	8,205,390	537,834
Germany	689,330	122,618	5,384,682	560,334
Spain	-	-	23,629,274	1,096,536
France	6,110,020	535,653	29,599,290	2,193,441
Italy	97,742,566	9,538,577	48,954,134	1,505,793
Lithuania	-	-	378,435	24,885
Latvia	11,715,836	911,564	-	-
Malta	394	101	-	-
Portugal	101,669	8,952	8,543,131	373,673
Slovenia	226,297	89,516	-	-
Slovakia	351,116	41,348	729,465	66,614
Czech Republic	2,386,470	237,924	2,760,874	182,348
Romania	16,542,279	1,751,993	3,556,894	200,233
Total	141,000,320	13,772,283	132,437,312	6,810,230

Notes: The table reports the total number of observations and the number of unique cross-sectional units for firms and households in each country. Note that, in addition to euro area countries, the table also reports numbers for Romania and the Czech Republic. Although these two countries belong to the European Union, they have not yet joined the Economic and Monetary Union (EMU) and therefore maintain independent monetary and supervisory authorities.

Table A2.2: Single and multiple lending relationships by country

	Single	Multiple	Total	% multiple lending	
				number of multiple relationships	volume of multiple relationships
Panel A) Household					
Austria	393,403	59,129	452,532	13%	24%
Belgium	3,724,823	927,214	4,652,037	20%	25%
Germany	585,349	103,981	689,330	15%	30%
France	5,078,031	1,031,989	6,110,020	17%	19%
Italy	77,165,035	20,577,531	97,742,566	21%	22%
Latvia	6,035,247	5,680,589	11,715,836	48%	49%
Malta	386	8	394	2%	1%
Portugal	50,911	50,758	101,669	50%	52%
Slovenia	180,066	46,231	226,297	20%	47%
Slovakia	313,750	37,366	351,116	11%	17%
Czech Republic	1,764,193	291,688	2,055,881	14%	20%
Romania	14,540,163	2,002,116	16,542,279	12%	15%
Panel B) Firms					
Austria	376,594	319,149	695,743	46%	59%
Belgium	4,389,058	3,699,631	8,088,689	46%	62%
Germany	3,206,467	2,178,215	5,384,682	40%	58%
Spain	6,934,882	16,694,392	23,629,274	71%	76%
France	18,314,138	11,285,152	29,599,290	38%	66%
Italy	11,178,256	37,775,878	48,954,134	77%	87%
Lithuania	264,138	114,297	378,435	30%	41%
Portugal	2,045,832	6,497,299	8,543,131	76%	80%
Slovakia	531,426	198,039	729,465	27%	50%
Czech Republic	1,712,357	1,048,517	2,760,874	38%	52%
Romania	1,369,022	2,187,872	3,556,894	62%	66%

Notes: The table summarizes the number of single and multiple lending relationships for households (Panel A) and firms (Panel B) in each country. The last two columns show the percentage of multiple lending for firms in terms of number of relationships and volume of outstanding amount of lending. Note that, in addition to euro area countries, the table also reports numbers for Romania and the Czech Republic. Although these two countries belong to the European Union, they have not yet joined the Economic and Monetary Union (EMU) and therefore maintain independent monetary and supervisory authorities.

Table A2.3: Estimation using weighted least squares and different clustering

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
		Households			Consumer Credit			Mortgage			Firm	
	OLS	WLS	WLS clustered SE	OLS	WLS	WLS clustered SE	OLS	WLS	WLS clustered SE	OLS	WLS	WLS clustered SE
MP^{soft}	0.00736***	0.0115***	0.0115***	0.00693***	0.00708***	0.00708***	0.00357***	0.00323***	0.00323***	0.00482***	0.00514***	0.00514***
	(0.0000229)	(0.0000380)	(0.0000181)	(0.000153)	(0.000149)	(0.0000794)	(0.0000248)	(0.0000238)	(0.0000124)	(0.000198)	(0.0000441)	(0.0000284)
MAP^{soft}	0.164***	0.123***	0.123***	0.0270***	0.0276***	0.0276***	0.0230***	0.0249***	0.0249***	0.00564***	0.00571***	0.00571***
	(0.000381)	(0.000283)	(0.000364)	(0.000675)	(0.000676)	(0.000714)	(0.000191)	(0.000183)	(0.000231)	(0.000626)	(0.000426)	(0.000547)
MP^{soft} x MAP^{soft}	0.00514***	0.00607***	0.00607***	0.00747***	0.00947***	0.00947***	0.000595***	0.000680***	0.000680***	0.000893***	0.00687***	0.00687***
	(0.0000377)	(0.000700)	(0.000338)	(0.000171)	(0.000171)	(0.0000821)	(0.0000473)	(0.0000455)	(0.0000229)	(0.0000485)	(0.0000921)	(0.0000598)
N	89,567,025	89,567,025	89,567,025	44,322,141	44,322,141	44,322,141	58,631,610	58,631,610	58,631,610	68,611,631	68,611,631	68,611,631
R^2	0.268	0.131	0.131	0.0104	0.0129	0.0129	0.00614	0.00644	0.00644	0.182	0.122	0.122
Country FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Notes: The dependent variable is “total (log-)credit granted (drawn and undrawn)” by bank “b” to households “h” (in columns 1 to 3) - broken down into consumer loans (columns 4 to 6) and mortgages (columns 7 to 9) – and “total (log-)credit granted (drawn and undrawn)” by bank “b” to firms “f” (in columns 10 to 12). In columns 1, 4, 7 and 10, the table reports the results obtained with simple OLS and clustering at the borrower level. In columns 2, 5, 8 and 11, the table reports the results obtained with weighted least squares and clustering at the borrower level. The weighting scheme is built using the log of total credit commitment as a weight for each observation. In columns 3, 6, 9 and 12, the table reports the results obtained with weighted least squares and clustering at the borrower and country*time level. “MP^{soft}” is the first principal component of the monetary policy surprises extracted from the high-frequency intraday yields at different maturities during all dates of policy announcements covered in the sample. We invert the sign of the principal component so that an increase in MP^{soft} corresponds to monetary policy softening. “MAP^{soft}” is a measure of macroprudential softening obtained (with inverted sign) of a variable that for each country counts the implemented macroprudential policies. An increase of MAP^{soft} denotes a relaxation of macroprudential policy. *, ** and *** denote statistical significance levels at 10%, 5% and 1% respectively.

Table A2.4: Estimation for corporate loans using firm*time fixed effects

	(1)	(2)	(3)	(4)	(5)
			Firms		
Equity	0.461***				
	(0.0410)				
MP^{soft} x Equity	0.0259***				
	(0.00270)				
MAP^{soft} x Equity	-0.293***				
	(0.0423)				
MP^{soft} x MAP^{soft} x Equity	-0.0303***				
	(0.00421)				
MP^{soft} x MAP^{soft} x Equity x NPE		-0.0668***	-0.0458***		
		(0.00889)	(0.00890)		
MP^{soft} x MAP^{soft} x Equity x Productivity				-0.145***	-0.139***
				(0.0465)	(0.0162)
N	12,557,322	12,557,314	12,557,314	741,400	741,400
R^2	0.948	0.948	0.948	0.936	0.943
Bank*Firm FE	Y	Y	Y	Y	Y
Firm*Time FE	Y	Y	Y	Y	Y
Bank*Time FE			Y		Y

Notes: The dependent variable is "(log-)credit granted" by bank "b" to firms "f" at time "t". "MP^{soft}" is the first principal component of the monetary policy surprises extracted from the high-frequency intraday yields at different maturities during all dates of policy announcements covered in the sample. We invert the sign of this principal component so that an increase in MP^{soft} corresponds to monetary policy softening. "MAP^{soft}" is a measure of macroprudential softening (with inverted sign) of a variable that for each country counts the implemented macroprudential policies. An increase of MAP^{soft} denotes a relaxation of macroprudential policy. "NPE" is a dummy variable that takes a value of 1 if the firm has experienced a non-performing exposure over the sample period, and zero otherwise. "Productivity" is a dummy variable with a value of 1 if a firm has TFP above the cross-sectional median of all firms within the same sector and country. "Equity" is obtained as the ratio of bank total equity to total assets. Data are semi-annual for the period from the first half of 2012 to the second half of 2017. "Y" indicates that the respective fixed effects are included. "-" indicates that a group of fixed effects is entirely absorbed by other vectors of fixed effects. Standard errors are clustered at the borrower level in parentheses. *, ** and *** denote statistical significance levels at 10%, 5% and 1% respectively.