Macroprudential policies and links with monetary policy in the european union

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Politiques macroprudentielles et liens avec la politique monétaire dans l'Union Européenne

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Mots clés : réglementation bancaire, interactions, croissance du crédit, crise bancaire, transmission aux taux bancaires

Résumé : Après le début de la crise financière mondiale, les banques centrales ont commencé à utiliser des politiques monétaires non conventionnelles afin de restaurer le fonctionnement du système financier et de soutenir l'économie réelle. Dans la même période, les politiques macroprudentielles ont connu une accélération de leur utilisation afin de maintenir la stabilité financière. Par conséquent, comme ces politiques ont toutes deux des impacts potentiels sur la stabilité financière, il est essentiel d'étudier leurs interactions. Dans cette thèse, nous évaluons ces interactions dans l'Union Européenne (UE).
Premièrement, nous analysons les effets de ces interactions sur la croissance du crédit dans la zone euro, en développant un indicateur macroprudentiel et en utilisant des séries de surprises monétaires. Nos résultats suggèrent que ces deux politiques atténuent la croissance du crédit, et que bien que les effets de leurs interactions soient faibles, ils réduisent l'impact de chaque politique sur la croissance du crédit.
Deuxièmement, nous regardons si une augmentation des exigences de fonds propres diminue la probabilité des crises bancaires dans l'UE, en utilisant un modèle Probit. Nos résultats montrent que le ratio de capital bancaire sur les actifs totaux ainsi que le ratio de capital réglementaire sur actifs pondérés du risque sont efficaces pour réduire la probabilité de crises bancaires.
Finalement, nous testons la capacité des politiques monétaires et macroprudentielles à modifier les taux d'intérêt bancaires dans la zone euro, en utilisant l'estimateur fondé sur la moyenne de groupe. Nous trouvons que la politique monétaire augmente ces taux, tandis que les coussins de conservation des fonds propres ont un effet négatif uniquement sur les prêts aux entreprises non financières supérieurs à un million d'euros, et uniquement pour les pays de la périphérie.

Title: Macroprudential policies and links with monetary policy in the European Union

Keywords: banking regulation, interactions, credit growth, banking crisis, interest rate pass-through

Abstract: After the onset of the global financial crisis, central banks started to use unconventional monetary policies in order to restore the functioning of the financial system and to support the real economy. During the same period, macroprudential policy has known an acceleration of its use in order to maintain financial stability. Hence, as both policies have potential impacts on financial stability, it is essential to study their interactions. In this thesis, we analyze these interactions in the European Union (EU).
First, we assess the effects of these interactions on credit growth in the Euro Area, by developing a macroprudential index and by using monetary policy surprises series. Our results suggest that both policies mitigate credit growth, and that while the effects of their interactions are weak, they reduce the impact of both policies on credit growth.
Second, we assess if an increase in capital requirements reduce the occurrence of banking crises in the EU, by using a Probit model. Our results show that the bank capital to total assets ratio as well as the bank regulatory capital to risk-weighted assets are effective in reducing the occurrence of banking crises.
Finally, we test the ability of monetary and macroprudential policies in modifying banking interest rates in the Euro Area, by using the mean-group estimator. We find that monetary policy increases these rates, while capital conservation buffers have a negative effect only for loans to non-financial corporations over € 1 Million, and only for countries from the periphery.

The university of Franche-Comté neither approves or disapproves of the opinions expressed in this thesis. Any views expressed in the dissertation are those of the author.

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Initialisms

ABSPP Asset-Backed Securities Purchase Programme.
AIC Akaike Information Criterion.
APP Asset Purchases Programme.
AUC Area Under the Curve.
AUC-PR Area Under the Precision-Recall Curve.

BCBS Basel Committee on Banking Supervision.

CAMEL Capital adequacy, Asset quality, Management, Earnings, Liquidity, and Sensitivity.
CBPP Covered Bond Purchase Programme.
CEE Central and Eastern Europe.
CESEE Central, Eastern and South-Eastern Europe.
CPI Commodity Price Index/Consumer Price Index.
CRD Capital Requirements Directive.
CRD IV Capital Requirements Directive IV.
CRR Capital Requirements Regulation.
CSPP Corporate Sector Purchase Programme.

DSGE Dynamic Stochastic General Equilibrium.
DSTI Debt Service-To-Income.
DTI Debt-To-Income.

ECB European Central Bank.
ECM Error Correction Models.
ELB Effective Lower Bound.
EONIA Overnight Rate.
ESRB European Systemic Risk Board.
EU European Union.

FRAME Financial Regulation Assessment: Meta Exercise.
FSA Financial Services Authority.

GDP Gross Domestic Product.
GFDD World Bank Global Financial Development Database.

HCPI Harmonized Consumer Price Indices.

IFS International Financial Statistics.
iMaPP Integrated Macroprudential Policy.
IPI Industrial Production Index.

LCR Liquidity Coverage Ratio.
LTI Loan-to-Income.
LTV Loan-to-Value.

MaPPED Macroprudential Policies Evaluation Database.
MG Mean-Group.
MRO Main Refinancing Operations.

NFC Non-Financial Corporations.
NPISHs Non-Profit Institutions Serving Households.
NPLs Non-Performing Loans.
NSFR Net Stable Funding Ratio.

OMT Outright Monetary Transaction.
OIS Overnight Indexed Swaps.

PMG Pooled Mean-Group.
PSPP Public Sector Purchase Programme.

RoA Return On Assets.
RoE Return On Equity.
ROC Receiver Operator Characteristic (ROC).
RWA Risk-Weighted Assets.

SLTRO Supplementary Long-Term Refinancing Operations.
SMEs Small and Medium-sized Enterprises.
SMP Securities Market Programme.
SovCiss Composite Indicator of Systemic Sovereign Stress.
SRM Single Resolution Mechanism.
SSM Single Supervisory Mechanism.

TFEU Treaty on the Functioning of the European Union.

UK United Kingdom.
US United States.

VIX Volatility Index.
VLTRO Very-Long Term Refinancing Operations.

YoY Year-Over-Year.

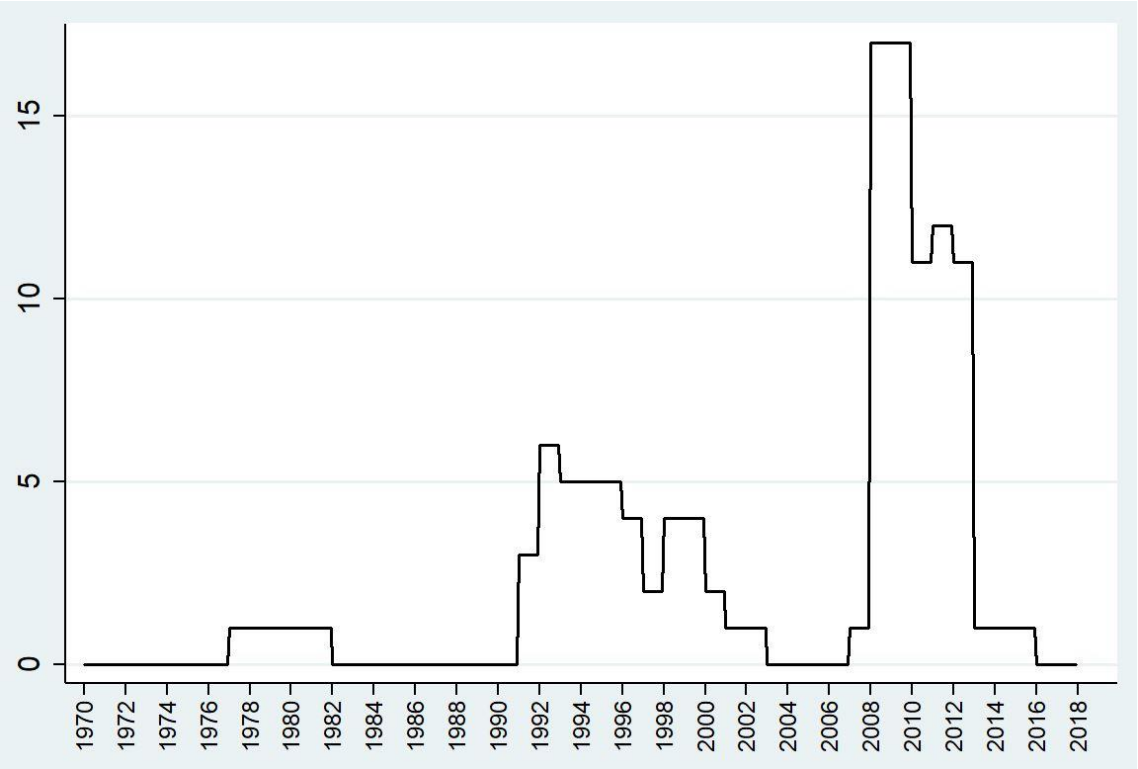
ZLB Zero Lower Bound.

General introduction

1. Motivation

The global financial crisis and the subsequent European debt crisis have seriously undermined the global financial stability. The number of European countries under banking crises episodes was very high between 1970 and 2017 as shown by Figure 1, which sums the number of systemic banking crises by year in 28 European Union (EU) member countries.[1] Although there were waves of banking crises during the 90s in Eastern Europe, the global financial crisis hit the majority of countries that were considered financially open, so mostly advanced economies. As a result, 17 of the 20 European economies considered in Figure 1 were hit by this crisis in 2008. As this crisis was triggered mainly by the actions of main players of the financial sector, the regulatory framework had to be profoundly modified. In addition, central banks decreased their interest rates and later launched a wide range of unconventional monetary policy measures in order to sustain economic growth as well as financial stability.

Figure 1. Number of systemic banking crises by year in 28 European countries between 1970 and 2017



Note: This figure displays the number of systemic banking crises by year in 28 current and past members of the EU between 1970 and 2017. Source: Laeven and Valencia (2020).

[1] Countries in the list included current and past members of the EU.

Macroprudential policy has known a considerable gain of interest since the global financial crisis of 2008, although the term "macroprudential" was mentioned in the late 1970s (Clement, 2010). Nowadays, this policy is widely used by macroprudential authorities around the world. While it was mainly used by emerging economies before the crisis of 2008 (Claessens et al., 2013) international agreements such as Basel III force advanced economies to implement further prudential measures. In fact, agreements such as Basel III were created due to the consequences of financial shocks, as monetary and microprudential policies have not been able to prevent them and to stop their transmission into the real economy. Since then, regulators and monetary authorities give considerable attention to a type of policy which aims to ensure financial stability, namely macroprudential policy.

In the case of microprudential policy, systemic risks are perceived as exogenous, implying that microprudential measures are not designed to mitigate them, while macroprudential regulation, on the other hand, consider them as endogenous (Galati and Moessner, 2018). These systemic risks are classified into two dimensions: cyclical and cross-sectional (Borio, 2010). First, the cyclical dimension refers to the procyclicality of the systemic risks, implying that macroprudential policy should smooth boom and bust cycles. In fact, booms may be linked to a rise in risk taking and in outstanding credit that fuels asset-price bubbles and that increases the occurrence of banking crises (Schularick and Taylor, 2012), while financial crises are extended by confidence crises within the financial system and within the borrower-lender relationship. During upturns, systemic risks decrease as well as microprudential requirements, while the latter are tightened during downturns and the subsequent increase in systemic risks. For example, Basel II solvency ratio limits the amount of loans provided by banks according to their weighted equity, which depends mostly on the credit risk. Therefore, during a recession, capital requirements increase due to the rise in credit risk, which leads to a credit crunch and exacerbates the recession. During a boom, the solvency ratio requires banks to hold less weighted equity due to the decrease in credit risk, implying that banks have the possibility to increase credit supply and therefore to fuel the boom. Consequently, microprudential policy exacerbates the procyclicality of the financial cycle. At the opposite, macroprudential policy attempts to mitigate the financial cycle through a countercyclical use, signifying that it may be tightened during booms and relaxed during busts. Second, the cross-sectional dimension refers to the resilience of the financial system as well as the interconnectedness amongst financial institutions and markets. During the onset of the crisis of 2008, the microprudential regulation already implemented was undersized, as

microprudential measures were adapted to each financial institution but didn't consider the interconnections amongst the financial institutions and the markets that composed the financial system, and their common exposures to financial risks (Bennani et al., 2017). The objective of macroprudential policy is to strengthen the resilience of the financial system by increasing macroprudential requirements (notably liquidity and capital ratios) and by reducing its exposure to risks.

As for monetary policy, before the onset of the crisis of 2008, it was believed that as long as it ensures price stability, financial stability was guaranteed. This principle, known as the Schwartz's hypothesis (Schwartz, 1995), states that financial instability comes from variations in aggregate price level. This vision was widely shared amongst academics and notably amongst central bankers, within what is called the Jackson Hole consensus. According to this consensus, monetary policy should intervene for mitigating financial instability only when it is threatening price stability. There is however a nuance between financial stability as a suitable goal for monetary policy and for central banks. Though opposed to the "leaning against the wind", a situation when monetary policy helps macroprudential policy in containing assets' prices by increasing its interest rates, Svensson (2018) argued that central banks already have a goal of financial stability because in case of financial turmoil, they will play the role of lenders of last resort and will provide liquidities to the financial system. Consequently, they have a role in crisis management, while macroprudential policy focus on crisis prevention. In any case, monetary policy wasn't able to prevent the crisis, nor to mitigate its effects. More precisely, while output was far below its pre-recession trend in the aftermath of the crisis in advanced economies, inflation has declined less than anticipated (Blanchard et al., 2015). Consequently, central banks started to decrease their interest rates at the floor rate, and therefore were forced to find new tools for loosening further monetary policy through the use of unconventional monetary measures. Partisans of the "leaning against the wind" argue that this overall loosening of monetary policy may impact financial stability positively (for example, long-term refinancing operations may reduce liquidity risks inside the financial system) during downturns, while a tightening prevent the formation of asset-price bubbles (see for instance Woodford, 2012, or Smets, 2014).

Therefore, there is no consensus amongst economists in using monetary policy for achieving financial stability, as there are several schools of thought. Yet, monetary policy may influence financial stability notably through its impact on credit growth, whose excessive development increase the occurrence of banking crises (Schularick and Taylor, 2012). In fact, a monetary

policy tightening will likely increase banking interest rates, which mitigates credit growth. However, financial stability is not the primary objective of monetary policy, which is price stability. Hence, in a context of excessive credit growth combined with a rise in inflation (see Beau et al., 2012), monetary and macroprudential policies will likely be tightened, which will, all else been equal, decrease credit growth. In this case, these two policies are set in the same direction, but it is possible that they may be set in opposite direction, notably if an excessive credit growth occurs during a period of deflation. In this case, monetary policy will be loosened while macroprudential policy will be tightened, which will provoke an ambiguous effect on credit growth and, therefore, on financial stability. In any case, more academic material is needed to understand and to assess the effects of monetary and macroprudential policies on financial stability, let alone the effects of their interactions. Do monetary and macroprudential policies interact? What are their influence on financial stability? The main objective of this dissertation is to bring some answers to these questions. By financial stability, we mean the resilience of the financial system to systemic risks and the ability to prevent the transmission of such shocks to the real economy. Hence, we encompass several aspects of financial stability throughout these three chapters. In the first chapter, we focus on the development of credit growth, then we investigate the occurrence of banking crises in the second chapter, and we finally scrutinize changes in banking interest rates offered by banks to their customers in the final chapter.

2. A recent history of the use of macroprudential policy in Europe

There is no single model for the governance of macroprudential policy (Nier et al., 2011). In the EU, the responsibility for this policy is shared between the European Central Bank (ECB) and national authorities through the principle of subsidiarity. This principle affirms that macroprudential actions should be taken at the European level only when they are supposed to be more efficient than isolated actions taken at the national level. Therefore, national authorities are better at evaluating the level of financial stability in their own country, which means that they are in charge of the implementation of national macroprudential measures. While they need to inform the ECB of the actions that they will take, the ECB has no power in influencing these decisions when they lead to a tightening of the macroprudential stance. However, since the 4th of November 2014 and the creation of the Banking Union, the ECB is in

charge of the Single Supervisory Mechanism (SSM). Under this mechanism, the ECB has the direct supervision of the largest banks of the participating members, which englobes all Euro Area (EA) members plus non-Eurozone EU member states that are willing to participate. This direct supervision allows the ECB to strengthen national macroprudential measures of the countries whose banks it supervises. However, the ECB can't soften macroprudential actions that were taken at the national level.

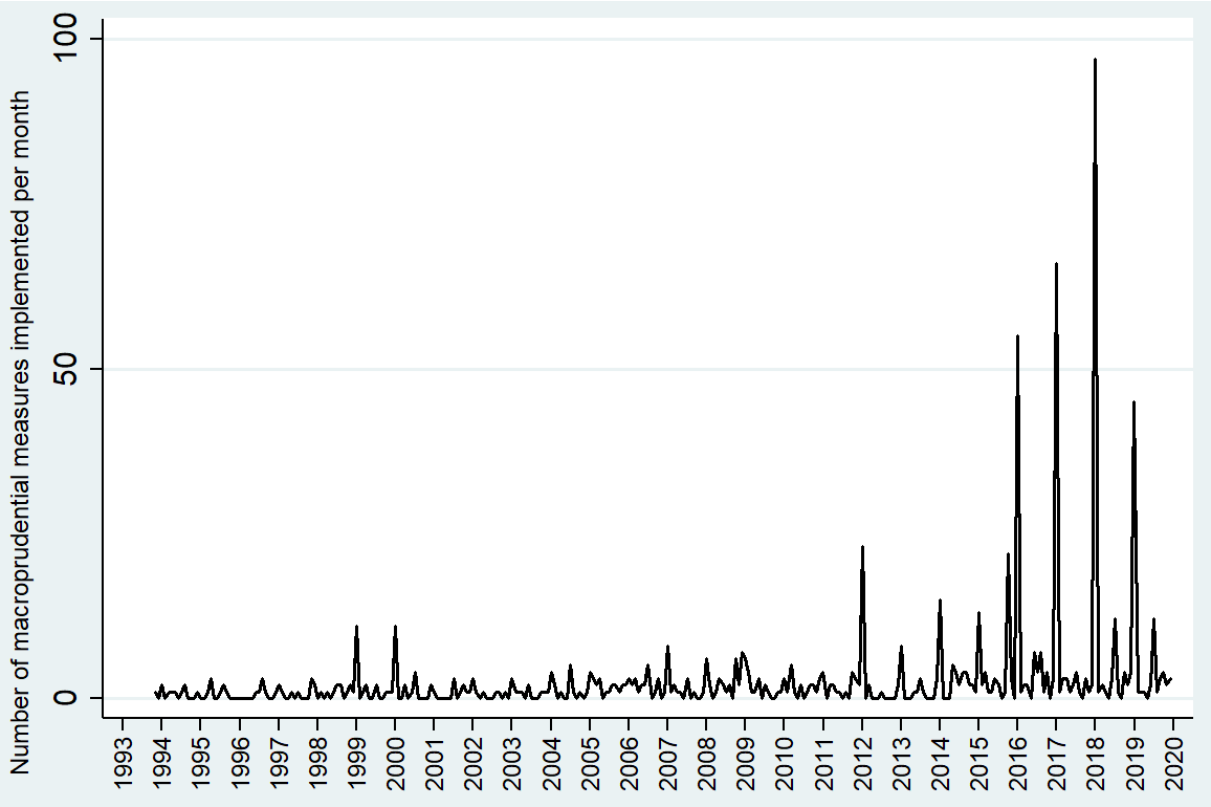
While the SSM constitutes the first pillar of the European banking union, the Single Resolution Mechanism (SRM) implemented in the 1st of January 2016 constitutes the second one. Its objective is to transfer the costs from the bail-out, a procedure in which the costs of resolution of failing banks are paid by national authorities, to the bail-in, a procedure in which the costs of resolutions are paid by creditors of the failing banks. The SRM was a necessary step because it mitigates the links between financial institutions and national authorities, as the latter are far less solicited to participate in the resolution process of failing banks. In general, this mechanism alleviates the problem of moral hazard of banks and notably risky behaviors—especially from systemic banks—in order to strengthen financial stability.

In addition to national authorities and the ECB, the European Systemic Risk Board (ESRB) was created in 2010 with the goal of supervising the European financial system and giving recommendations to prudential authorities.

2.1 Macroprudential measures translated in the European law

Although national authorities keep the primary responsibility of the macroprudential stance due the principle of subsidiarity, measures implemented through the European law represent a substantial part of the total of macroprudential measures implemented. Figure 2 displays the use of macroprudential policy over time in the 28 current or past EU members, since the creation of the EU until December 2019.

Figure 2. Use of macroprudential policy over time in the 28 EU members between November 1993 and December 2019



This figure displays the number of macroprudential measures implemented per month in 28 current and past members of the EU between November 1993 and December 2019. Source: Alam et al. (2019).

Globally, there is an acceleration of the use of macroprudential policies after the global financial crisis, especially since 2012. In general, in the EU, it appears that macroprudential measures started to be used more intensively since the crisis of 2008 and even more the following years. There is a clear acceleration around the 2010s due to the time lag between the occurrence of the crisis, the announcement of macroprudential measures and their implementation. As for the translation of Basel III in the European law, its importance is outstanding as there is clear spikes of macroprudential use around January in the 2010s, coinciding with its implementation schedule. It is especially visible between 2016 and 2019. In the EU, it has led to the adoption of the Capital Requirements Regulation (CRR) and the Capital Requirements Directive 4 (CRD IV), which are European rules that translate in the European law prudential measures related to Basel III.

2.2 A focus on national measures

Although that a significant part of the measures applied in recent years are related to the CRR and the CRD IV in the EU, the principle of subsidiarity remains. In fact, national macroprudential authorities have implemented a wide range of national macroprudential policies on the aftermath of the global financial crisis, and for some at the end of the 1990s according to Figure 2. Before 2008, countries from Central and Eastern Europe (CEE) were particularly active in using macroprudential policies compared to the other members. These measures were implemented in response to financial shocks due to the transition to free market economies (Budnik and Kleibl, 2018). After the global financial crisis, countries that used macroprudential tools the most are Cyprus, Hungary, Greece, Poland, Slovakia as well as Croatia according to the Budnik and Kleibl (2018) database. While Greece was particularly hit by the crisis of 2008 and the subsequent European sovereign debt crisis, CEE countries faced a fall in cross-border credit during this period (Nitoi et al., 2019). In addition, Cyprus has established macroprudential measures due to the weakening of its banking sector. Hungary and Croatia have both used macroprudential tools in order to mitigate excessive credit growth (Galac and Kraft, 2011, Kok et al., 2014).

At the opposite, some countries from Western Europe such as France, Germany, and Italy have relied much less on these tools (Arena et al., 2020). However, France and the United Kingdom have introduced taxes on financial institutions and activities due to the importance of their banking sector.

3. What do we know about the effects of monetary and macroprudential policies?

Before assessing the effects of the interaction between both policies, it is necessary to understand how both policies impact the objective of the other.

3.1 How macroprudential policy affects financial stability

3.1.1 Macroprudential tools

As the objective of macroprudential policy is to ensure financial stability, the ESRB (EU, 2013) identified five intermediate objectives of this policy.[2] In addition, the ESRB displays a list of macroprudential instruments that may be used for achieving each objective. The first objective is to mitigate excessive credit growth and leverage, as asset-price bubbles fueled by credit increase the occurrence of banking crises (Schularick and Taylor, 2012). Macroprudential instruments such as limits on credit, loan loss provisioning, capital requirements, leverage ratio as well as measures that target borrowers (Loan-to-Value (LTV) ratio, Loan-to-Income (LTI) ratio or Debt Service-To-Income (DSTI) ratio) can mitigate excessive credit growth and leverage. Limits on credit may be applied in volume or in growth in order to limit credit supply. Loan loss provisioning requires banks to increase their cash reserve to cover bad loans, which may prevent excessive credit expansion. Capital requirements constrain banks to have enough capital so they can meet their liabilities and be more solvent. Therefore, capital requirements reduce banks' leverage as well as credit growth. Capital requirements contain various tools: minimum capital requirements and capital conservation buffer as well as the leverage ratio, which are applied consistently to all banks, and other capital measures that are variable, the requirements of which depend on the financial cycle in the case of countercyclical capital requirements, depend on the size of banks in the case of the Global Systemically Important Banks (G-SIBs) or depend on the risks taken by banks in the case of risk weighting measures. Finally, lending standards restrictions limit the maximum amount of loans according to borrowers' characteristics (LTI and DSTI ratios) or to the value of the underlying collateral (LTV ratio).

The second intermediate objective is to restrict and prevent excessive maturity mismatch as well as market illiquidity. While maturity mismatch is an issue for banks because they finance long-term credit with short-term resources, liquidity problems create difficulties for banks in repaying their debts. The latter may lead to a liquidity crisis due to the interconnections between financial institutions notably in the interbank market, which may pose a threat to financial stability. Therefore, liquidity requirements are particularly appropriate for tackling this problem, by requiring banks to increase stock of liquid assets, which mitigate the occurrence of liquidity crises. These liquidity requirements are implemented through two

[2] One of these objectives, increasing the resilience of financial infrastructures, is not detailed here as its scope of application is still unclear (Revelo et al., 2018).

measures: the Liquidity Coverage Ratio (LCR) and the Net Stable Funding Ratio (NSFR). The LCR ratio, which is a short-term liquidity ratio, requires banks to hold more high-quality liquid assets (HQLA) in order to allow them to face a period of liquidity stress of 30 days. The NSFR ratio, which is a long-term liquidity ratio, requires banks to hold more stable funding than their required stable funding for a period of one year.

Moreover, during periods of recessions, deep interconnections between banks on various markets may lead to liquidity issues and potentially harm financial stability. In fact, bilateral exposures are common between banks and are very diverse: banks trade liquidities between themselves in the interbank market, and more generally, have liabilities and debts toward other banks. During downturns, banks may be reluctant to lend liquidities to those that are in difficulties, which may lead to crisis of confidence in the interbank market and thus to a liquidity dry-up. In this context, difficulties inside the banking system get worse: a liquidity crisis may appear, and the collapse of banks may be exacerbated by a domino effect, as banks that have gone bankrupt cannot meet their liabilities to other banks in order to mitigate the propagation of financial shocks inside the financial system, and prevent a series of bankruptcies. Thus, it is important to mitigate exposure concentrations inside the financial system, which constitute the third intermediate objective. The concentration of risks may appear among banks or between banks and certain types of sectors, borrowers or types of credit. Therefore, instruments such as exposures and concentration restrictions as well as taxes on specific and risky financial activities are appropriate for limiting concentration risks, because these instruments require banks to diversify their activities as well as their borrowers.

In addition, mitigating moral hazard risk[3] associated with systemically important financial institutions constitute the fourth intermediate objective, as it threatens financial stability. As the fall of one of these banks may lead to a financial shock, they have incentives to take risks as they are "too big to fail", meaning that they rely on potential bailouts in case of financial difficulties. Therefore, macroprudential authorities require systemic banks to increase their loss-absorbing capacity and to constitute additional capital surcharges, as well as using bail-in procedures rather than bail-out procedures in order to mitigate risky behaviors.

Taken together, all these measures should theoretically enhance financial stability. Empirically, few empirical studies assessed the impact of such tools on financial stability in

[3] Moral hazard refers to a situation where one party adopt a risky behavior knowing that it is protected against the bad consequences of this behavior, meaning that another party has to pay for it.

Europe due to the lack of data concerning the use of macroprudential tools. Most of these studies use broad indicators for measuring macroprudential policy, while the dependent variables studied are very diverse.

3.1.2 Empirical studies on the effect of macroprudential measures in ensuring financial stability

A significant part of this literature focus on multiple countries using panel data. Zhang and Tressel (2017) examine the effectiveness of macroprudential policies in reducing credit growth and price inflation inside mortgage markets in the Euro Area between 2003 and 2010. They find that macroprudential policies mitigate the credit cycle as well as the systemic risk, but do not have any effects on price stability. In the same vein, Poghosyan (2020) evaluate the changes in house prices and credit growth provoked by lending restriction measures in the EU between 1990 and 2018. Their results show that these prudential measures are successful in mitigating inflation in the housing sector as well as the credit cycle, and that they are more efficient when they are loosened than tightened, and for countries that are not EA members. Vandenbussche et al. (2015) argue that not all macroprudential instruments are efficient in reducing inflation in the housing sector in the Central, Eastern, and South-Eastern Europe (CESEE), while capital requirements are effective to do so. Contrary to Poghosyan (2020), they show that macroprudential measures have a larger impact on housing price inflation when they are tightened and when they are implemented during booms. On the other hand, Budnik (2020) find that few macroprudential measures are efficient in affecting the credit cycle in the EU, and that their impact is largely influenced by the business cycle as well as the monetary policy stance. Finally, some studies assess the efficiency of these tools in influencing macroeconomic outcomes or the occurrence as well as the severity of crises. In that respect, Fernandez-Gallardo and Paya (2020) analyze the effects of macroprudential policies in the EA, in terms of monetary and macroprudential policies target variables as well as macroeconomic outcomes. Their results suggest that both anticipated and unanticipated changes in terms of macroprudential policy changes strengthen financial stability. Finally, Fernandez-Gallardo (2023) assess the efficiency of macroprudential policies in reducing the risk and the severity of financial crises for 11 European countries. Their results suggest that macroprudential policies are effective in reducing credit risk, even during financial boom and periods of accommodative monetary policy stance. Second, they argue that these measures are able to reduce the severity of crises by mitigating output losses after a financial crisis and by accelerating recoveries.

In addition to the empirical literature that use panel data, some studies focus on one country, due to the use of micro data. Thus, Galac and Kraft (2011) assess the effectiveness of macroprudential measures that were implemented in Croatia during the 2000s in mitigating credit growth and capital inflows, which were triggered by a period of booms. The macroprudential measures consisted of reserve requirements on increases in banks' loan portfolios and banks' foreign liabilities, of minimum foreign exchange liquidity requirements as well as risk weights on loans in foreign currency or linked to an exchange rate. Their results show that while banks were strengthened through an increase in both liquidity and capital resources due to the regulation, these measures were less effective in curbing credit and capital cycles. In the United Kingdom (UK), the impact of macroprudential measures on financial stability were notably assessed through three studies by Aiyar et al. (2014a, 2014b, 2016). Aiyar et al. (2014a) study if capital requirements were circumvented between 1998 and 2007. At that time, the Financial Services Authority (FSA) implemented minimum capital requirements through discretionary regulatory policy, which was based on banks' characteristics. During this period, capital requirements increased until the implementation of Basel II in 2006, after which they declined. Their results show that capital requirements provoked "leakages", a situation when credit activity shifts from regulated banks to institutions that are not subject to the same macroprudential regulation. In the same vein and for the same period, Aiyar et al. (2014b) find that these leakages work through foreign financial institutions that are not subject to banks capital requirements rather than through bond and stock markets. However, Aiyar et al. (2016) show that capital requirement regulation still has a dampening effect on the supply of lending in the UK. In Spain, Jiménez et al. (2017) study the effects of specific and general dynamic provisions implemented by the Spanish banking regulator in the third quarter of 2000, which were changed four times between their introduction and the second quarter of 2012. They focus on the impact of these dynamic provisions on the credit cycle as well as on the real economy. They provide evidence that these measures are effective in mitigating the procyclicality specific to the credit cycle. In Germany, Imbierowicz et al. (2021) study the impact of bank-specific capital requirements on banking interest rates and banking credit between 2008 and 2018, which were measures directly linked to Basel II and Basel III. Their results suggest that capital requirements decrease domestic and cross-border lending especially for banks that have lowers level of excess capital, but have no effects on banking interest rates. Hence, while results in the empirical literature are diverse, they tend to show that macroprudential tools are able to strengthen financial stability through their impact on intermediate objectives of macroprudential policy as defined by the ESRB.

3.2 How monetary policy affects financial stability

Due to the global financial crisis, the role played by central banks has evolved and is no longer limited to the control of the level of prices, of output or of the unemployment rate, but expands to other horizons such as financial stability. In fact, in addition to reducing their main interest rates and to assuming their role as lenders of last resort in reaction to the crisis of 2008, central banks started to use unconventional monetary policies such as forward guidance, quantitative easing as well as longer-term refinancing operations. Furthermore, central banks are now deeply involved in defining the prudential stance. Taken together, all these actions demonstrate central banks' willingness to ensure financial stability, whether through their impact on banks' funding conditions, banks' liquidity or on the capacity of borrowers in accessing credit. In recent years, macroprudential policy and monetary policy were widely used in order to ensure financial stability.

Theoretically, monetary policy may influence financial stability. First, through the balance sheet channel, a change in the monetary policy affects financial commercial banks as it impacts banking interest rates and credit supply. In addition, this modification impacts borrowers through the value of the collaterals and the repayment costs for variable-rate borrowings. Second, the risk-taking channel show that when monetary policy is accommodative for an extended period of time, banks have incentives to increase credit supply which may weaken financial stability (Adrian and Shin, 2010, Borio and Zhu, 2012), especially if they lend to risky borrowers. Third, banks funding such as deposits are short-term resources, while they provide long-terms loans. Hence, when monetary policy is tightened, it will affect deposit rates as well as variable-rate borrowings, leading banks to adopt risky behaviors in order to restore their intermediation rates. Fourth, the exchange rate channel implies that monetary policy affects capital flows, as a tightening (loosening) of the monetary stance provokes an inflow (outflow) of capital and then an appreciation (depreciation) of the domestic currency. This channel may be sources of imbalances in the trade balance and influences the indebtedness in foreign currencies. Finally, a low interest rate environment may amplify the financial cycle through the asset price channel (Bernanke and Gertler, 1989), as an accommodative monetary policy may increase the asset prices, which allows banks to boost their leverage.

Empirically, the effect of monetary policy on proxies of financial stability has been widely documented notably on credit growth and housing prices, but there is no consensus about the intensity of its effects. First, several studies do not find any significant impact of monetary policy on the credit cycle (e.g. Lim et al., 2011, Dell'Ariccia et al., 2012, Levin et al., 2016,

Morgan et al., 2015, Ayyagari et al., 2018, Morgan et al., 2019, Gómez et al., 2020, or Revelo et al., 2020), while other argue that it helps mitigating it (e.g. Wang and Sun, 2013, Barroso et al., 2017, Kim and Mehrotra, 2018, Altavilla et al., 2020, Yao and Lu, 2020, Wijayanti et al., 2020, Everett et al., 2021, Benchimol et al., 2022, or Kim and Mehrotra, 2022). Second, results are mixed concerning the impact of such policy on cross-border lending, as some studies find evidence of some impact (Bussière et al., 2021, Meunier and Pedrono, 2021) while other do not (Cizel et al., 2019, Takáts and Temesvary, 2021). Third, most of the empirical studies display evidence that an increase in the monetary policy rate leads to a house price depreciation (e.g. Craig and Hua, 2011, Mcdonald, 2015, Neagu et al., 2015, Zdzienicka et al., 2015, Zhang and Zoli, 2016, Akinci and Rumsey, 2018, or Poghosyan, 2020), although studies such as Crowe et al. (2013) or Vandenbussche et al. (2015) find little to no impact. Hence, while central banks use monetary policy in order to strengthen financial stability, notably through unconventional measures, the empirical literature displays mixed results about its efficiency to achieve this objective. Yet theoretical literature highlighted several channels through which monetary policy may influence financial stability.

3.3 Interactions between macroprudential and monetary policies and their implications

Since the use of unconventional monetary policies in order to support the financial system, the boundary between price stability and financial stability has become blurred. As monetary policy may affect the objective of macroprudential policy, it has led to questions about the possibility for monetary policy to deal with the objective of financial stability, and about which authorities should be in charge of macroprudential policy. In the EA, the ECB has been given the mandate to ensure both price stability and financial stability.[4] While this model of macroprudential management allows a large sharing of information as well as the possibility to coordinate easily these two policies, it has drawbacks (Bennani et al., 2017). For example, the ECB may be tempted not to tighten its monetary policy in a context of inflation if credit growth is considered insufficient. In this case, the ECB may be forced to choose between price stability and financial stability, and therefore, may face credibility issues. To mitigate these drawbacks, countries such as the UK use a second model, in which monetary and macroprudential authorities report directly to the central bank, but in two different bodies which possess their own goals and their own instruments. Finally, a third model, used for

[4] Article 127 of the Treaty on the Functioning of the European Union (TFEU).

example in Sweden, goes even further in terms of separation. This model prevents any credibility issues by giving the responsibility of each policy to two different institutions, which are the macroprudential authority and the central bank.

As a result, some debates about the inclusion of financial stability as an objective of monetary policy appeared, leading to the creation of new schools of thought. Several economists such as Caruana (2011), Woodford (2012) or Smets (2014) are considered as advocates of the "leaning against the wind". Hence, they argue that "cleaning after the burst", that is, monetary policy does not intervene until an asset bubble bursts, is costlier than mitigating assets' prices before the burst. Consequently, although macroprudential policy aims to ensure financial stability, it is not guaranteed that it will achieve this objective alone. In addition, as stated by Stein (2013), "monetary policy gets in all of the cracks", implying that it affects the whole economy and therefore, it is difficult to circumvent. However, as "monetary policy gets in all of the cracks", this instrument may be perceived as inadequate for targeting precise risks, and should be used with caution. At the opposite, macroprudential policy can be circumvented, whether through the shadow banking system or via leakages. Several economists go further and argue that financial stability should be considered as a main objective of the monetary authority in the same way as price stability. Therefore, they consider that these two objectives are inseparable.

Despite the crisis and the emergence of these new schools of thought, economists such as Cecchetti (2016) or Svensson (2018) argue that monetary policy must not take care of financial stability. First, this vision is in line with the Mundell's rule (1960) which states that each policy should be paired with the objective on which it is the most efficient, which is respectively price stability and financial stability for monetary and macroprudential policies. Second, it is consistent with Tinbergen's rule (1952), which stipulates that the number of policy instruments used must be equal or greater to the number of achievable policy goals. These two rules advocate for a separation between monetary and macroprudential policies (Bennani et al., 2017). In particular, Svensson (2018) shows that monetary policy should not help macroprudential policy in mitigating assets' prices, as it requires a significant rise in monetary policy rates, which could lead to a collapse of the economy. In fact, two costs occur when central banks increase their policy rate above what is recommended. First, it leads to a level of inflation that is too low, and a level of unemployment that is too high. Second, if a crisis occurs, the damage inflicted to the economy is higher the more the first cost is important. Furthermore, he argued that macroprudential policy is not design to control inflation and therefore should not consider price stability as a suitable goal, implying that monetary and macroprudential

policies must be conducted in a separate way. Cecchetti (2016) stated that these two policies should remain separated in most circumstances, as macroprudential policy must be stringent enough in order to minimize the occurrence of an intervention of monetary authorities. More generally, the defenders of the modified Jackson Hole consensus believe that monetary (macroprudential) policy may affect financial stability (price stability), but rather indirectly and not strongly. At best, they are conduct in a separate manner while taking into account the small influence that they may have on the objective of the other policy. In addition, this separation allows a more comprehensive assessment of these policies in a situation in which they are use simultaneously, because they have different goals as well as different instruments to achieve them.

Empirically, there is a growing literature that analyzes the interactions between macroprudential and monetary policies, notably through the use of Dynamic Stochastic General Equilibrium (DSGE) models. Studies such as Bruno et al. (2017) state that in a situation when one of this policy is tightened while the other is loosened, "*economic agents are being told simultaneously to borrow more and borrow less*", implying that these two policies should be coordinated. In addition, Altavilla et al. (2020) display evidence of complementarities between these two policies in curbing credit growth for a sample of 14 European countries, while Revelo et al. (2020) reach the same conclusion for 37 countries between 2000 and 2014. In addition, Budnik (2020) show, for 28 EU countries between 1995 and 2017, that the impact of monetary policy on credit growth may be attenuated or amplified depending on the macroprudential instruments used according to the monetary policy stance. In the same spirit, Everett et al. (2021) argue that in Ireland, domestic prudential policies alleviate the negative effects induced by a tightening of the monetary policy stance on mortgage lending, while this impact is not significant in the Netherlands.

At the opposite, Imbierowicz et al. (2021) show that in Germany, a period of loose monetary policy combined with a strengthening in capital requirements mitigate the impact of the former on banking interest rates. In addition, De Jonghe et al. (2020) find that a tightening in capital requirements during a period of accommodative monetary policy reduces credit supply compared to a period of restrictive monetary policy, meaning that there is a trade-off between these policies. Midway between these two types of results, Aguirre and Repetto (2017) test the presence of these interactions for banks credit to firms in Argentina between 2009 and 2014, with money market interest rates as a measure of monetary policy. They find that these effects are positive when macroprudential policy is proxied by a capital conservation

buffer, but negative with foreign currency position. These results suggest that there is synergy between monetary policy and foreign currency policy for taming credit growth, while capital buffers may be used counter-cyclically.

Moreover, a significant part of the literature finds no proof of interactions. Cerutti et al. (2017) find no interaction for 119 countries between 2000 and 2013, while Akinci and Rumsey (2018) display similar results for 57 economies between 2000 and 2013. Barroso et al. (2017) find weak effects of the interaction between reserve requirements and monetary policy on bank credit to firms between 2008 and 2015 in Brazil. In the same vein, Levin et al. (2016) find similar results for the impact of the interaction between monetary policy and provisioning rules on credit growth in Mexico, between 2004 and 2014. Finally, Morgan et al. (2015) as well as Morgan et al. (2019) find no effect of the interactions between the LTV ratio and monetary policy on mortgage credit for respectively 10 Asian economies and 46 countries. Hence, there is no consensus on the effects of these interactions on domestic credit amongst the empirical literature, which is still in its infancy.

A significant part of the empirical literature studies the effects of these interactions on the spillover effect provoked by monetary policy. Epure et al. (2018) study the impact of the interaction between macroprudential measures implemented in Romania and foreign monetary policy on local bank credit, for the period between 2004 and 2012. They find that macroprudential policy reduce the rise in foreign currency lending induced by an accommodative Eurozone monetary policy stance. In the same vein, Cao et al. (2021) study the effect on credit growth of the interaction between foreign monetary policy and domestic macroprudential policy, as well as between monetary policy and domestic macroprudential policy in Sweden and Norway. They find that in both countries, macroprudential policies have the power to influence spillovers provoked by changes in international monetary policies. Along the same lines, Coman and Lloyd (2022) find that emerging markets that implement tightening on prudential policies suffer less from spillovers that emerge from US (United States) monetary policy tightening shocks.

Finally, some studies such as Bussière et al. (2021), Meunier and Pedrono (2021), or Takáts and Temesvary (2021) assess the impact of this interaction on cross-border credit. Bussière et al. (2021), through the use of data for cross-border lending of banks between France in the UK, find that the spillover provoked by EA monetary policy through French banks' cross-border lending may be offset by prudential policies implemented by countries that benefit from the

spillover. In the same vein, using data from the French supervisor, Meunier and Pedrono (2021) find that countries that benefit from cross-border lending provoked by a tightening in other economies face a trade-off. By using prudential policies to reduce the volatility of banking flows, there is a risk of increasing cross border lending outflows. In addition, Takáts and Temesvary (2021) find for 27 countries between 2012 and 2014 that the evolution of cross-border lending is impacted by the interactions between both policies. They find that macroprudential policy easing amplify the impact of monetary policy, while tightening ones reduce it. Therefore, empirical studies show mixed results about the interactions between these two policies, which translate into divergent views amongst economists and between the different schools of thought on this subject.

4. Summary of chapters

In this dissertation, we use different database as well as different methodologies in order to assess the effectiveness of macroprudential policy in ensuring financial stability in all chapters, notably by studying its interaction with monetary policy in two of them. The three chapters of this dissertation consist of three research papers written independently.

In the first chapter, we assess if macroprudential and monetary policies are associated with changes in credit growth to households and non-financial corporations in the Euro Area by using the fixed effects estimator, and we study their interaction. For macroprudential policy, we compute an index based on the database from Budnik and Kleibl (2018) and the methodology from Meuleman and Vander Vennet (2020). As for monetary policy, we use the series measured by Altavilla et al. (2019). Finally, data for credit growth come from the ECB. In the second chapter, we use a Probit model for estimating the effectiveness of capital ratios in reducing the occurrence of banking crises in the European Union. In order to do so, we use a crisis dummy variable from Laeven and Valencia (2020) and data from the World Bank Global Financial Development Database (GFDD) for the dependent variables. In the third chapter, we study how macroprudential and monetary policies influence banking interest rates in the Euro Area when monetary policy reaches the effective lower bound, through the use of the mean-group estimator. Data for banking interest rates and macroprudential policy come from respectively the ECB MIR database and Alam et al. (2019), while data for monetary policy are extracted from Thomson Reuters Eikon and the ECB.

4.1 Chapter 1: Monetary and macroprudential policies and their transmission to credit growth: evidence from the Euro Area

Although the empirical literature on the effects of macroprudential policies in ensuring financial stability is growing, few studies have analyzed the impact of such policies in the Euro Area, as they are not intensively use in this area (Bennani et al., 2017). In this first chapter of this dissertation, our objective is to fill this gap by studying the correlation between macroprudential policies and credit growth in 12 Euro Area members between March 2003 and December 2017, as well as the impact of monetary policy. In addition to disentangling the effects of these policies on credit to households and non-financial corporations, we assess if macroprudential and monetary policies interact. In order to do so, we develop a macroprudential index and we use monetary policy surprises series measured by Altavilla et al. (2019). This macroprudential index consider the lifetime of every macroprudential instruments used in the Euro Area between 2003 and 2017, since their announcements until their deactivation. This procedure as well as the frequency of our data allow us to mitigate the reverse causality bias that arise between macroprudential policy and credit growth, as well as between monetary policy and credit growth.

Using the fixed effects estimator, we find that both policies are associated with a mitigation credit growth to both households and non-financial corporations. More specifically, our results suggest that borrowers-based measures as well as capital requirements are particularly inversely correlated with the credit cycle. Furthermore, we show that tightening measures are associated with bigger changes in credit growth than loosening measures, in line with most of the empirical literature. Finally, we find little but existing interactions effects between monetary and macroprudential policies, suggesting that there should be at least a sharing of information between the authorities responsible for these policies.

4.2 Chapter 2: Capital ratios and banking crises in the European Union

Although the first chapter of this dissertation focuses on credit growth, whose mitigation is one of the five intermediate objectives of macroprudential policy as defined by the ESRB (EU, 2013), it does not assess the effectiveness of macroprudential instruments in reducing the occurrence of banking crises. In this chapter, we assess if capital requirements reduce the occurrence of banking crises in the EU between 1998 and 2017. In order to do so, we use a

Probit model and focus on two capital ratios: the bank capital to total assets ratio and the bank regulatory capital to Risk-Weighted Assets (RWA). In the EU, the majority of the macroprudential measures implemented come from international regulatory framework and notably Basel III rather from national regulations. Hence, our study assesses the effectiveness of capital requirements measures from Basel III in ensuring financial stability. Consequently, the bank capital to total assets ratio can be considered as a proxy of the Basel III leverage ratio, while the bank regulatory capital to RWA is a proxy of the Basel III solvency ratio.

We find that both ratios are effective in reducing the probability of banking crises. However, our results show that the bank capital to total assets ratio does not have any influence on the occurrence of these crises under 11%. This finding suggests that the Basel III leverage ratio of 3% is clearly insufficient for ensuring financial stability. In contrast, the bank capital to total assets is more effective for this task as it has always an impact on the probability of banking crises, even if banks have the possibility to use internal rating models for determining regulatory capital.

4.3 Chapter 3: Macroprudential policies and retail banking interest rates in a low interest rate environment

Although the empirical literature assesses the impact of macroprudential policies on proxies of financial stability such as credit growth, few studies assess their effects on banking interest rates. In this last chapter of this dissertation, we complement the first two chapters by assessing if banking interest rates are affected by macroprudential and monetary policies. More specifically, we study the impact of this policy since the start of the effective lower bound. We focus on 11 Euro Area members from May 2009 to December 2019, as the main refinancing operations (MRO) rate reached a floor at 1% and as the ECB started to implement unconventional monetary policy measures in May 2009.

Using the mean-group estimator proposed by Pesaran and Smith (1995), we find that capital conservation buffers affect banking interest rates for loans to non-financial corporations. In particular, we find that conservation buffers have a positive impact on banking interest rates for loans to non-financial corporations over € 1 Million, while they have no effect on banking interest for loans below € 1 Million, for consumption loans and households' loans for house purchases. Hence, banks may be reluctant to increase their rates for large companies as the

latter have easier access to other sources of funding, such as nonbank credit and equity funding. In addition, the decrease in banking rates for loans to large corporations may be explained by the fact that capital requirements increase the resilience of banks, which may lead to a decrease of their funding costs. Finally, our results suggest that only countries from the periphery of the Eurozone are affected by this capital regulation.

5. Main contributions

This dissertation offers several innovations in comparison to the existing empirical literature.

In the first chapter, we present one of the few empirical study that evaluate the impact of macroprudential policy on credit growth in the Euro Area, as well as its interaction with monetary policy. In this chapter, we use a new methodology as well as original data. First, we compute an index that consider the lifetime of every macroprudential measure since their announcement until their deactivation. Second, we measure monetary policy changes through the use of monetary policy surprises series measured by Altavilla et al. (2019), which allow us to reduce the reverse causality bias between monetary policy and credit growth. Finally, as this endogeneity issue may occur between macroprudential policy and credit growth too, we mitigate this issue in our regressions by exploiting monthly data, a frequency that is rarely used in the literature.

In the second chapter, we provide the first empirical analysis of the effectiveness of capital ratios in increasing the resilience of the banking sector to shocks in the EU. We test this effectiveness through its impact on the occurrence of banking crises.

In the third chapter, we evaluate the impact of monetary and macroprudential policies on banking interest rates in the Eurozone, in a context of a low interest environment. We are not aware of other studies that consider the impact of both policies, including unconventional monetary policies, on such rates using panel data.

More generally, each chapter is different in terms of methodologies and data used. Concerning macroprudential policy, we first develop a macroprudential index that consider the lifetime of macroprudential measures as well as changes in those measures (in terms of level or scope), which give us the possibility to consider the intensity of the macroprudential policy to a certain

degree. Then, we measure the stance of macroprudential policy and more precisely, capital requirements, through the use of two capital ratios in the second chapter. Finally, we used an index developed by Alam et al. (2019) which aggregates 11 macroprudential instruments in the last chapter.

As for the interaction between monetary and macroprudential policies, we first consider it through the use of an interaction term between a macroprudential index and monetary surprises in chapter one. Second, in chapter three, we scrutinize this interaction through the effectiveness of macroprudential and monetary policies in affecting banking interest rates when monetary policy is at the effective lower bound, implying that it cannot be more loosened unless unconventional monetary policies are implemented.

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Chapter 1

Monetary and macroprudential policies and their transmission to credit growth: evidence from the Euro Area

1. Introduction

Since the wake of the financial crisis, a large part of the empirical literature assesses whether or not macroprudential policy is able to ensure financial stability and, notably, to mitigate credit cycle (e.g. Kuttner and Shim, 2016, Akinci and Olmstead-Rumsey, 2018, or Alam et al., 2019). The reason is that excessive credit growth is detrimental to financial stability as it increases the occurrence of banking crisis (Schularick and Taylor, 2012). Therefore, tightening on macroprudential measures such as lending standard restrictions are supposed to have a direct impact on credit demand, while a rise in liquidity and capital ratios may force banks to reduce credit supply in order to comply with these requirements. Besides, these requirements may increase banks' funding costs as well as banking interest rates if banks decide to transfer some of the costs to their borrowers, which decreases the volume of credit granted. At the opposite, when a bank accumulates capital, it is perceived as more resilient which reduce its funding costs, in line with Modigliani and Miller (1958) and could increase the volume of credit granted.

Assessing the effectiveness of macroprudential policy in mitigating credit growth is not without its challenges. In fact, the empirical literature struggles with the lack of data about macroprudential policies especially in advanced economies, hence the scarcity of studies in area such as the Eurozone. In addition, the empirical literature did not reach any consensus about the effectiveness of macroprudential policy in ensuring financial stability, let alone its interaction with monetary policy. Several reasons related to the data and the methodology use in this literature explain these mixed results (Alam et al., 2019, Poghosyan, 2020). First, macroprudential databases are different in terms of information provided. Hence, early studies such as Lim et al. (2011) and Claessens et al. (2013) use a dummy equal to one when at least one macroprudential measure of type j is active in a country i at time t, and zero otherwise. Other studies provide additional information about the intensity of macroprudential policy by counting the number of active measures over the same period (e.g. Cerutti et al., 2017a). In general, most papers consider the orientation of the measure (e.g. Reinhardt and Sowerbutts, 2015, Kuttner and Shim, 2016, Cerutti et al., 2017b), and some accounts for the life cycle of every measures (e.g. Bruno et al., 2017, Fendoğlu, 2017 or Akinci and Olmstead-Rumsey, 2018). Second, these databases are heterogeneous in terms of samples considered. Because of the relative recency in terms of usage of macroprudential measures, early studies analyze the impact of macroprudential tools in a large number of countries (see

for instance Akinci and Olmstead-Rumsey, 2018 or Cerutti et al., 2017a), which necessarily leads to a high degree of heterogeneity in results. For this reason, studies such as Aguirre and Repetto (2017), Minaya et al. (2017) or Jiménez et al. (2017) focus on one country, with the help of micro data. Third, another challenge that empirical literature is facing is the difficulty to isolate the impact of macroprudential policy from other policies, as they are often implemented simultaneously, and because of the reverse causality between macroprudential policy and proxies of financial stability such as credit growth. It is likely that credit growth reacts to an announcement of a macroprudential policy, but it is also likely that macroprudential policy reacts to change in the credit growth.

The first objective of this chapter is to study the correlation between monetary and macroprudential policies and credit growth in the Eurozone. Few studies focused on the Eurozone as macroprudential policy was not intensively used in this area (Bennani et al., 2017). In order to do so, we rely on a sample of 12 Euro Area (EA) members over the period March 2003 to December 2017. We use monthly data through the exploitation of the Macroprudential Policies Evaluation Database (MaPPED) constructed by Budnik and Kleibl (2018) and consider the announcement date of macroprudential measures in order to establish their lifetime, which mitigates the endogeneity issue due to reverse causality risks. Hence, exploiting monthly data as well as precise information about macroprudential measures makes easier the identification of macroprudential actions and allows us to dissociate between announcements and implementations of every macroprudential changes when they do not occur in the same month. In addition, a monthly frequency alleviates the reverse causality bias and provides us a high number of observations, which is needed as we focus on a relatively small sample of countries. Aside from the relation between credit growth and macroprudential policy, the reverse causality bias may occur between monetary and credit growth. Thus, we use a series of monetary surprises measured by Altavilla et al. (2019) in order to dampen the possible reverse causality bias that may occur between these two variables. Furthermore, our data allows us to focus on the Eurozone, which contains relatively homogeneous countries. Restricting the sample to 12 EA members makes easier and more precise the assessment of macroprudential and monetary policies.

The second objective of this chapter is to investigate if the impact of monetary policy on credit growth depends on the macroprudential stance. The reason is that theoretically, monetary and macroprudential policies have both an impact on credit growth notably through their effects on the banking sector (Imbierowicz et al., 2021). On one hand, macroprudential measures

affect credit growth directly notably through lending standard restrictions, and indirectly through their effects on credit costs with measures such as liquidity and capital requirements. On the other hand, monetary policy may affect credit growth. As an example, a tightening in the monetary policy stance increases banks funding costs, and banks may pass some of these costs to their borrowers notably through an increase in banking interest rates. Consequently, monetary policy has become more active in ensuring financial stability by tightening in the monetary policy stance in order to prevent assets bubbles fueled by credit ("Leaning against the wind"). In order to test the effects of potential interactions between monetary and macroprudential policies, we add an interaction term in our model between our monetary policy surprises series and our macroprudential index.

Our results show that tightening monetary measures, tightening macroprudential policies and especially tightening capital requirements – as well as measures that target borrowers –are associated with a mitigation of credit growth for households and non-financial corporations. At the opposite, our results suggest that loosening actions on the macroprudential stance and lending restrictions measures are not correlated with credit growth. In addition, our empirical analysis highlights a small but existing impact of the interaction between monetary and macroprudential policies on credit growth, with non-linear effects of monetary policy. Hence, our results show that the marginal effects of monetary policy conditioning on the macroprudential policy stance are larger for accommodative monetary policy shocks than for restrictive ones. Our results are robust to the use of alternative monetary and macroprudential policies measures.

Our study is related to the empirical literature that assess the impact of macroprudential policy on credit growth, notably in European countries. Zhang and Tressel (2017) find that macroprudential tools and notably the ones that impact the cost of capital are particularly adequate in mitigating mortgage credit growth, while Fernandez-Gallardo and Paya (2020) show that macroprudential policies reduce credit growth as well as its pro-cyclicality over the medium term. Otherwise, other studies use a wider sample of countries and consider the European Union (EU) rather than the EA for investigating the effects of macroprudential policy on credit growth. Poghosyan (2020) analyzes the impact of lending standard restrictions measures in house prices and credit, for the EU between 1990 and 2018. Through the use of local projections, his analysis suggests that lending restrictions measures are effective in mitigating credit growth in EU countries, and shows that lending restrictions measures are more suited for stimulating a weak credit growth than for reducing excessive credit growth.

Along the same lines, Budnik (2020) shows that several macroprudential tools are able to reduce credit to the non-financial sector in the EU, and that their efficiency is influenced by the business cycle and the monetary policy. In addition, as Central, Eastern and Southeastern Europe (CESEE) countries recorded a large number of macroprudential measures amongst EU countries in recent years, several studies focused on these particular group of countries (e.g. Galac and Kraft, 2011, Vandenbussche et al., 2015, or Eller et al., 2020). The closest paper to our work is De Schryder and Opitz (2021), which, using the life cycle of macroprudential measures, find that macroprudential policy is able to mitigate the credit cycle for 13 EU countries between 1999 and 2018. In addition, and contrary to Poghosyan (2020), they argue that this policy is more efficient during busts than downturns. However, contrary to our study, they consider monetary policy change through the use of shadow rates rather than monetary policy surprises, and they do not assess the impact of the interaction between monetary and macroprudential policies on credit growth. Finally, our study is linked to the literature that assess the asymmetric effects of monetary policy. Hence, Tenreyro and Thwaites (2016) and Angrist et al. (2018) find that monetary policy has a weaker impact on macroeconomic aggregates during recessions than during booms, while Blot et al. (2020) display similar results for stock price bubbles and that that its effects vary according to monetary, credit and business cycles.

The chapter is organized as follows: Section 2 provides the data description. Section 3 contains the empirical analysis. Section 4 presents the robustness checks. Our conclusion follows in the last section.

2. Dataset and variables description

In this section, we describe the data the that we use, starting with credit growth, then monetary and macroprudential policies, and finally the set of control variables.

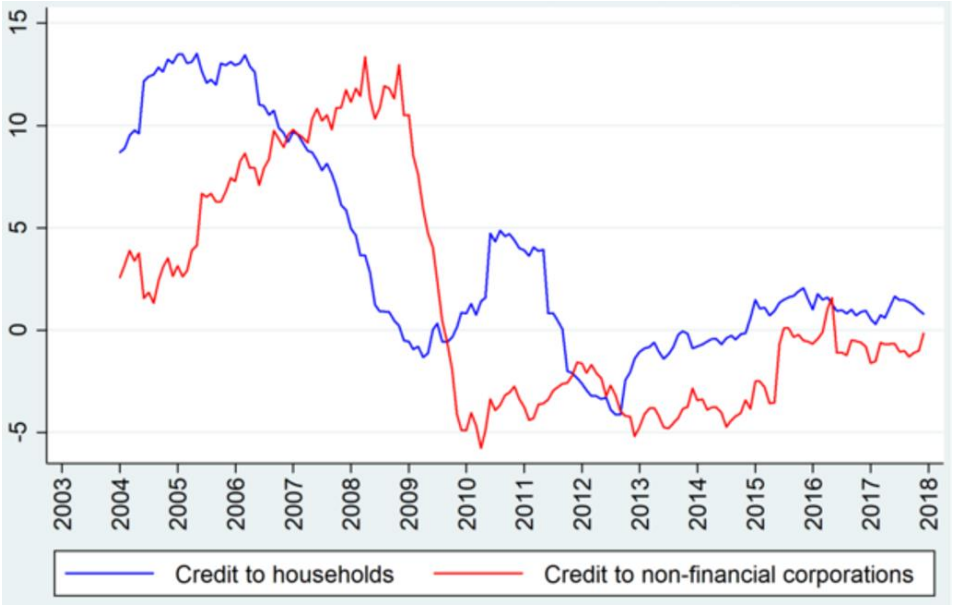
2.1 Credit growth

The dependent variables are two variables coming from the European Central Bank (ECB), which are credit to households and non-profit institutions serving households (NPISHs) and

credit to non-financial corporations (NFC). Monthly series are unavailable before 2003 for most countries, so we cut our sample before this date. We extract the volume series of credit which we deflate with the Consumer Price Index (CPI) from the International Financial Statistics (IFS). We consider year-over-year (YoY) growth. In our sample, the average credit growth for households and non-financial corporations is respectively 3.5% and 1.4%.

Figure 1 depicts the evolution the series of credit growth over time in our sample, measured in YoY growth rate. The growth in credit to households and non-financial corporations are correlated, as both series were severely affected by the great financial crisis.[1] However, the crisis has hit loans to non-financial corporations the hardest since the end of 2009, with an average growth rate that goes around -5% on multiple occasions. Since approximately 2016, both series in both panels seem to be rather stable, with a mean of 1.08% and -0.65% for respectively credit to households and credit non-financial corporations.

Figure 1. Evolution of credit growth for households and NFC (%, YoY)



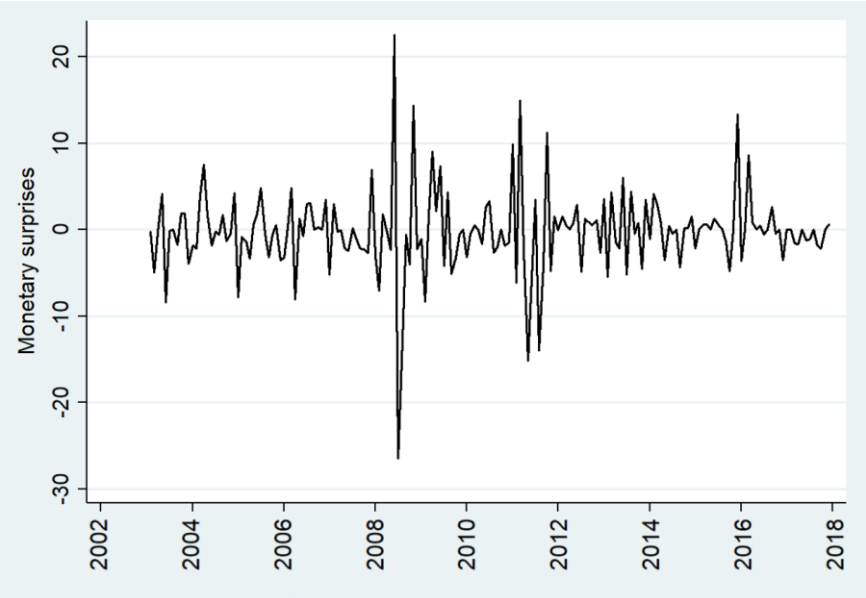
Source: ECB statistical data warehouse.

[1] The correlation coefficient between these two variables is 0.5307.

2.2 Monetary policy

We consider the monetary policy stance through a series of monetary surprises measured by Altavilla et al. (2019), as tightening and loosening of the monetary policy affects banks' funding conditions and, therefore, credit supply. In addition, credit demand may vary if banking interest rates are modified following changes in banks' funding conditions. Hence we used the German 2-year bond yields changes in the monetary event window in order to quantify surprises in the ECB monetary stance. This monetary event window is defined as the change in the median quote from the window 13:25-13:35 before the press release to the median quote in the window 15:40-15:50 after the press conference. This procedure allows us to capture both standard and non-standard monetary policy measures, as well as alleviate the reverse causality bias between this policy and credit growth. We used the German bonds because these bonds are particularly scrutinized by the investors as they represent the reference on the European bond market. These series identify the day of each surprise on these bonds as well as the intensity of these surprises. In these series, there are 3 cases where multiple surprises happen in the same month. Thus, we did the sum of these surprises by month. Figure 2 displays the monetary policy surprises series. The biggest surprises were observed at the beginning of the global financial crisis and after the subsequent European debt crisis.

Figure 2. Monetary policy surprises



Sources: Altavilla et al. (2019), author's calculation.

2.3 Macroprudential policy

Macroprudential data comes from the MaPPED database created by Budnik and Kleibl (2018), which collect data from a survey sent to economists working in national central banks and supervisory authorities. They classified 1925 macroprudential actions (or similar) for the EU into 11 categories of tools, which are themselves divided into 53 subcategories. We choose to keep information about the 11 categories of tools, as they may all have an impact on credit growth. These categories are: minimum capital requirements, capital buffers, risk weights, leverage ratio, loan-loss provisioning, lending standards restrictions, limits on credit growth and volume, levy and tax on financial institutions and activities, limits on large exposures and concentration, liquidity requirements and limits on currency mismatches, and other measures that are not considered in other categories.

This database is a large textual database which gives complete details about 1925 prudential measures, such as their announcement date, their date of implementation, their orientation, their description or even their objective. Based on our sample, we created an index called *MAPP* from 685 prudential actions. For each macroprudential action, *MAPP* takes into account its orientation as we differentiate between tightening and loosening actions. In addition, this database indicates for each action the previous one and the following one, if any. Thus, we are able to group different actions together in order to obtain the lifetime of each measure collected. As mentioned before, we consider the life cycle of every policy action, which means that for example, we attribute the same value every month for a given measure until there is a change in this measure.

This also raises the question of whether we choose the announcement date or the implementation date for coding macroprudential measures. In the literature, studies often consider the implementation as few databases provide information about the announcement date (e.g. Kuttner and Shim, 2016, Cerutti et al, 2017a, or Alam et al., 2019). In addition, most of the time, this question does not need to be addressed for studies using annual or quarterly frequency, because these two dates often fall in the same quarter/year. However, with monthly data, these two dates are more frequently separated. As a matter of fact, actions such as capital buffers from Basel III were announced years before their implementation because banks need time to constitute capital reserves. In this case, it is likely that this type of macroprudential measures has an impact on banks behaviors, right from its announcement. The MaPPED database created by Budnik and Kleibl (2018) displays the announcement date in addition to the implementation date, when available. Consequently, we choose to consider

the announcement date of these actions as financial institutions may start to comply to some measures before their implementation, as in Eller et al. (2020), Meuleman and Vander Vennet (2020) or De Jonghe et al. (2020).[2]

Likewise, we consider the intensity of macroprudential policy to some extent, as *MAPP* is based on a weighting scheme, which differentiates between the type of changes that occur for every instrument. More precisely, we use the weighting scheme created by Meuleman and Vander Vennet (2020) to differentiate between the various type of changes that occurred for many macroprudential actions. For example, we do not attribute the same value to the introduction of a new tool and the change in the scope of an existing tool. Table 1 describes the weighting scheme that we use.

Table 1. Weighting scheme of policy actions

Type of action	Weight	Orientation	Value attributed
Activation of a tool	1	Tightening	1
		Ambiguous	0
		Loosening	-1
Change in the level of an existing tool	0.25	Tightening	0.25
		Ambiguous	0
		Loosening	-0.25
Change in the scope of an existing tool	0.1	Tightening	0.1
		Ambiguous	0
		Loosening	-0.1
Maintening the existing level and scope of a tool	0.05	Tightening	0.05
		Ambiguous	0
		Loosening	-0.05
Deactivation of a tool			Dependent on the life cycle

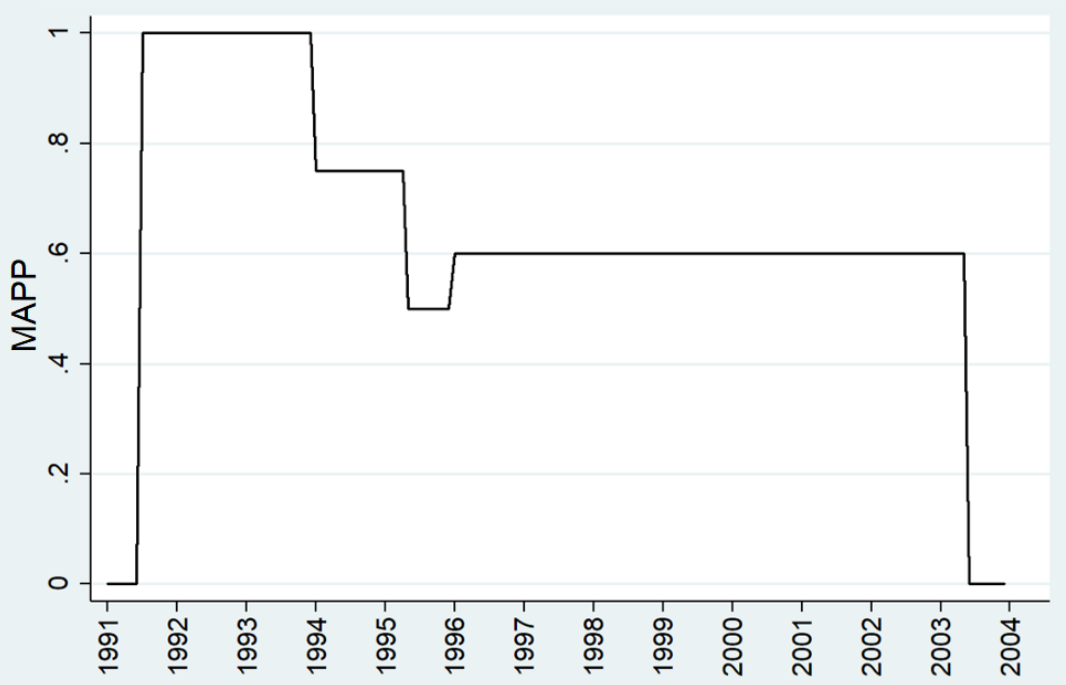
Source: Meuleman and Vander Vennet (2020).

[2] It should be noted that in the database, the announcement date is not always filled contrary to the implementation date. In that respect, 86 of the 685 actions contained in our sample do not have an announcement date. For these actions, we thus consider the implementation date.

MAPP is obtained through the sum of these measures by category of action and by country, meaning that we do not consider a different weighting scheme between the different categories of macroprudential policies.

As an example, Figure 3 displays the lifetime as well as the intensity of a measure that limits the volume of personal loans in Greece. The measure was announced in July 1991 as a lending standard restriction, so we compute a value of 1. Next, the level of the measure was loosened respectively in January 1994 and in May 1995, lowering the index to 0.75 and then to 0.5. In January 1996 the scope of this measure was enlarged, so the index increased to 0.6. Finally, it was deactivated in June 2003, so the index falls to 0.

Figure 3. Intensity across time of a measure that limits the volume of personal loans in Greece between July 1991 and June 2003

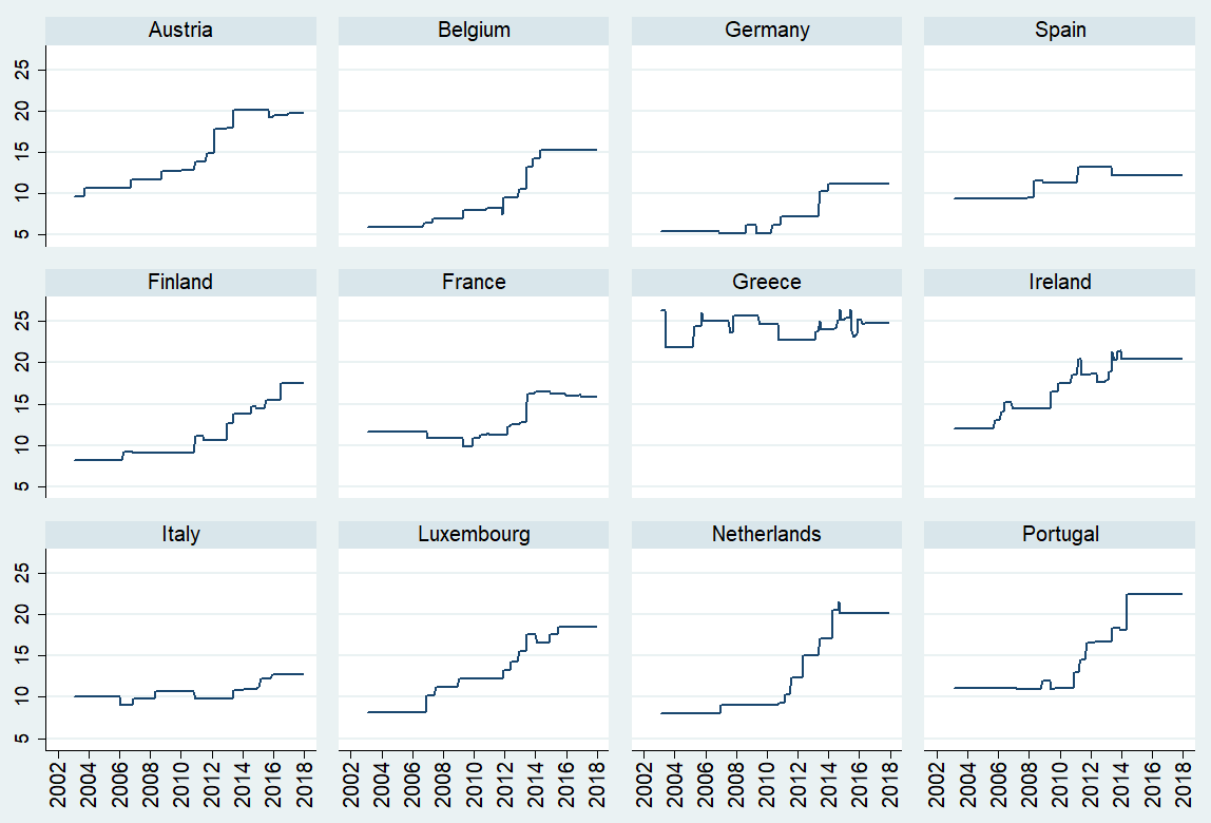


Sources: Budnik and Kleibl (2018), Meuleman and Vander Vennet (2020).

Figure 4 displays the evolution of the macroprudential index over time for all countries of our sample. Not only *MAPP* contains no negative values, meaning that tightening actions were used more intensively than loosening actions, but almost all countries experienced a tightening of their macroprudential policy over the years. Hence, *MAPP* equals 13.277 on average, indicating a strengthening of the macroprudential policy stance between March 2003

and December 2017, with minimal value of 5.1 and a maximum value of 26.450, as displayed in Table B. In addition, it seems that there is a brutal acceleration of tightening events for most countries around 2012, due to the implementation of the set of reforms related to the Basel 3 agreement.

Figure 4. Macroprudential indexes



Sources: Budnik and Kleibl (2018), Meuleman and Vander Vennet (2020), author's calculation.

2.4 Control variables

As control variables, we first use the unemployment rate, which comes from Eurostat. We used the unemployment rate as a proxy of the real Gross Domestic Product (GDP) growth, which is unavailable at a monthly frequency. Hence, we observe that there is a strong inverse correlation between unemployment and GDP, as depicted by Okun's law (1962). On average, the unemployment rate is close to 10% for the Eurozone between March 2003 and December 2017, with a value of 9.25%. The gap between its minimal and maximal values is significant with respectively 3.3% and 27.8%, which shows the differences between countries in terms of

economic performance and resilience to the global financial crisis. Second, we add an index proposed by Laeven and Valencia (2020), which is a dummy variable that takes the value of 1 when a crisis is under way in a given country. On average, this dummy has a value of 0.24 as shown in Table B, suggesting that the occurrence of crises represent roughly 25% of the observations in our sample.

3. Econometric approach and results

We use a fixed-effects estimator in order to estimate the impact of monetary policy on credit growth to households and to non-financial corporations as well as the correlation between macroprudential policy and these dependent variables, as in Kuttner and Shim (2016) and Meuleman and Vander Vennet (2020). We estimate this model using the following specification:

$$Y_{i,t} = \beta_1 DE2Y_{i,t-1} + \beta_2 MAPP_{i,t-1} + \beta_3 DE2Y_{i,t-1} * MAPP_{i,t-1} + \beta_4 Un_{i,t-1} + \beta_5 Crisis_{i,t-1} + \alpha_{i-1} + \varepsilon_{i,t} \quad (1)$$

Where $Y_{i,t}$ captures the credit growth to households or to non-financial corporations at time t in a country i. As for the variables of interest, $DE2Y_{i,t-1}$ stands for the monetary surprises variable based on the German bonds series from Altavilla et al. (2019). $MAPP_{i,t-1}$ represents the macroprudential index (*MAPP*). $Un_{i,t-1}$ refers to the unemployment rate which is a proxy for the economic cycle, as GDP growth is unavailable at a monthly frequency. Moreover, $Crisis_{i,t-1}$ stands for the crisis indicator which comes from Leaven and Valencia (2020). Using a crisis indicator allows us to control the effects related to reverse causality and the possibility that some countries announced macroprudential measures during periods of low credit growth related to low demand and supply constraints, as described in Cerutti et al. (2017a). Finally, we add country fixed-effects $\alpha_{i,t-1}$ to capture any country-specific unobserved heterogeneity. We expect that previous credit growth has a positive impact on current credit growth, as credit has a cyclical component. All independent variables are one period lagged. The coefficient β_1 associated with $DE2Y_{i,t-1}$ is expected to be negative as accommodative monetary surprise will likely increase, amongst other things, banks' funding costs, which will be reflected in credit costs. This makes credit less attractive, and so credit demand as well as credit supply will be weaker. Similarly, β_2 is expected to be negative as loosening (tightening)

of macroprudential actions should be positively correlated (inversely correlated) with credit growth, either directly or indirectly. Finally, we are agnostic about the expected sign of β_3, as there is no consensus in the empirical literature about the impact of this interaction on credit growth. Hence, some studies find that monetary and macroprudential policies reinforce each other (e.g. Morgan et al., 2019, Revelo et al., 2020), other show that they may come into conflict (De Jonghe et al., 2020), while some found no evidence of such interactions (e.g. Aiyar et al., 2016, Imbierowicz et al., 2021). As for the control variables, credit growth is expected to decline when the unemployment rate is high and during economic downturns.

Our objective is to estimate the potential influence of both policies on credit to households and non-financial corporations in the EA, as well as the difference of impact of monetary policy depending on the macroprudential stance. Consequently, our sample is composed of 12 members of the Eurozone, from March 2003 to December 2017.[3] It contains country level data at a monthly frequency, for around 2000 observations. This sample allows comparison between relatively homogeneous countries, both in terms of characteristics and in terms of use of monetary policy. Thus, there is less of a need for control variables that take into account heterogeneity between countries, such as an institutional quality or financial openness indicator. In addition, monthly data allow us to obtain a relatively high number of observations, which is needed when the N dimension is weak and to assess the effects of macroprudential actions, which were used intensively after the crisis of 2008. Furthermore, the frequency of the data mitigates the endogeneity issue due to reverse causality biases, as it is less likely that macroprudential policy reacts to change in credit growth within the same month, rather than in the same quarter (Meuleman and Vander Vennet, 2020). To make this happen, the macroprudential authority needs to notice the change in credit growth quickly, designs an appropriate macroprudential policy response, and then announces it in the same month, which is not a common occurrence. Second, while results could be biased due to the presence in the model of the lagged dependent variable, Nickell (1981) has demonstrated that this bias is negligible with large T samples, which is the case of the database that we use. Finally, the frequency of our data allow us to disentangle macroprudential announcements from macroprudential implementations when they do not occur in the same month. All

[3] Countries include are: Austria, Belgium, Germany, Spain, Finland, France, Greece, Ireland, Italy, Luxembourg, Netherlands and Portugal. In addition, Monthly credit growth series are not available before February 2003, and the crisis indicator from Laeven and Valencia (2020) is not available after 2017.

variables used in regressions are detailed in Table A, while descriptive statistics are presented in Table B.

3.1 Main regressions results

Table 2 presents the baseline estimates. In line with the empirical literature, we find the expected impact of monetary policy, for all specifications: it appears that a tightening in monetary policy has a negative impact on credit growth for households and non-financial corporations. An increase of one unit in monetary surprises, which reflects a tightening of the monetary policy stance, is associated with a decrease of 0.046 and 0.08 percentage point in respectively household loans and non-financial corporation loans. Concerning macroprudential policy, the correlation with credit growth is negative and significant for both household and non-financial corporation loans, in line with the empirical literature. More specifically, an increase of one unit in *MAPP*, so a tightening of the macroprudential stance, is associated with a decrease of 0.028 percentage point in household loans, and of 0.045 percentage points in non-financial corporation loans. Therefore, these results suggest that macroprudential policy mitigates excessive credit growth, which is one of its five intermediate objectives for ensuring financial stability according to the European Systemic Risk Board (ESRB). In addition, these findings are concordant with several studies that assess the effectiveness of capital requirements in reducing credit growth (e.g. Aiyar et al., 2016, or Imbierowicz et al., 2021), including the Basel III capital regulation (Roulet, 2018).

Then, we focus on the interactions between these two policies by looking at the coefficients and by calculating the marginal effects of changes in monetary policy conditioning on the macroprudential stance. Next, we find evidence of interactions between these two policies. Consequently, our results display that these interactions have a positive impact on credit growth. This suggests that while these two policies are negatively correlated with credit growth, these correlations are attenuated due to the simultaneous use of the two policies. Hence, due to these interactions, the negative correlation with credit growth is reduced by 0.004 and 0.005 percentage points in respectively household loans and non-financial corporation loans. In other words, the correlation of macroprudential policies with credit growth is attenuated when monetary policies are set in opposite directions, and the same reasoning applies to the effects of monetary policies. Hence, following the global financial crisis, monetary policy has been loosened notably through the lowering of key ECB interest

rates and the use of unconventional measures, while macroprudential policies have been rather tightened. Furthermore, Table 2 displays asymmetric effects of monetary policy on credit growth, as the effects of accommodative monetary policy shocks are significantly larger than the effects linked to the restrictive ones. For household loans, while the marginal effect of accommodative monetary policy conditioning on the macroprudential stance is equals to 0.099, the marginal effect of restrictive monetary policy is 0.007. Then, concerning credit to non-financial corporations, the marginal effects of accommodative and restricting monetary policies correspond to 0.146 and -0.014 respectively. However, these results should be interpreted with caution as the magnitude of the coefficients presented in both columns are small in size, probably due to the importance of the impact of the lagged dependent variable.

In addition, we find persistence in credit growth, reflecting the credit cycle. As for our control variables, unemployment rate as well as our crisis variable have the expected negative sign, meaning that countries that experience crisis and a rise in unemployment rate are likely to suffer from a decrease in credit growth.

Table 2. Baseline estimations

	(1) Household loans	(2) NFC loans
Household loans (lagged)	0.943***	
	(0.008)	
NFC loans (lagged)		0.935***
		(0.008)
Monetary surprises	-0.046**	-0.080**
	(0.023)	(0.032)
MAPP	-0.028*	-0.045**
	(0.015)	(0.019)
MAPP*Monetary surprises	0.004***	0.005**
	(0.002)	(0.002)
Crisis dummy	-0.438***	-0.589***
	(0.115)	(0.144)
Unemployment rate	-0.058***	-0.094***
	(0.016)	(0.021)
Constant	1.179***	1.710***
	(0.284)	(0.340)
N	2004	2004
R^2	0.941	0.924

Note: The Table presents the fixed-effects estimator where Household loans and NFC loans are monthly growth rates of the credit to households and to non-financial corporations. Monetary surprises is the monetary policy variable. MAPP refers to the macroprudential index. Crisis dummy is the crisis variable from Laeven and Valencia (2020). Standard errors in parentheses. * p<0.10, ** p<0.05, ***p<0.01.

3.2 Tightening and loosening macroprudential actions

In the next step, we wonder whether macroprudential policy has a greater correlation with credit growth across tightening and loosening actions, and if it affects the transmission of monetary policy to credit growth. The empirical literature provides evidence that the impact of this policy is different depending on its orientation. Thus, studies such as Cerutti et al. (2017a), Altunbas et al. (2018) or Richter et al. (2019) found that macroprudential policy has more sizeable effects when tightened rather than loosened, while Poghosyan (2020) has demonstrated the opposite. In order to test these asymmetrical correlations, we divide *MAPP* into two new variables. Hence, *MAPP tightening* contains the sum of the 11 categories of macroprudential tools when they are tightened (i.e. when the value exceeds 0), and a value of 0 when they are loosened. In the same way, *MAPP loosening* displays a value of 0 when macroprudential policy is tightened, but takes positive values when macroprudential policy is loosened. Hence, we expect that tightening macroprudential episodes are associated with a

reduction in credit growth and that loosening episodes have a positive correlation with credit growth. Table 3 presents the estimates.

Table 3. Tightening and loosening measures

	(1) Household loans	(2) NFC loans
Household loans (lagged)	0.942***	
	(0.008)	
NFC loans (lagged)		0.935***
		(0.008)
Monetary surprises	-0.046**	-0.082**
	(0.023)	(0.032)
MAPP tightening	-0.025*	-0.047**
	(0.015)	(0.020)
MAPP loosening	-0.159	0.117
	(0.183)	(0.253)
MAPP tightening*Monetary surprises	0.005***	0.005**
	(0.002)	(0.002)
MAPP loosening*Monetary surprises	-0.006	0.008
	(0.024)	(0.033)
Crisis dummy	-0.440***	-0.589***
	(0.116)	(0.144)
Unemployment rate	-0.054***	-0.096***
	(0.017)	(0.022)
Constant	1.141***	1.734***
	(0.286)	(0.350)
N	2004	2004
R^2	0.941	0.924

Note: The Table presents the fixed-effects estimator where Household loans and NFC loans are monthly growth rates of the credit to households and to non-financial corporations. Monetary surprises is the monetary policy variable. MAPP tightening refers to the macroprudential index that compute tightening events, while MAPP loosening accounts for loosening events. Crisis dummy is the crisis variable from Laeven and Valencia (2020). Standard errors in parentheses. * p<0.10, ** p<0.05, ***p<0.01.

We find that tightening events are inversely correlated with both households and non-financial corporation loans, as an increase of one unit in the *MAPP* index is associated with a reduction of credit growth to households and non-financial corporations of respectively 0.025 and 0.047 percentage point. More generally, our results concerning macroprudential tightening are close to those obtained in the baseline estimation and are significant for all specifications. By contrast, loosening events do not display any correlation with credit growth as the associated coefficients are never significant. Our results are in line with studies such as Kuttner and Shim (2016) or Altunbas et al. (2018) that argued that tightening measures have

larger effects than loosening measures. This may be due to the fact that loosening measures are mostly implemented during periods of economic downturns, while tightening measures are implemented during period of economic growth (McDonald, 2015). On one hand, tightening measures are supposed to be binding during economic booms. On the other hand, banks may suffer from low loan demand and from a weakening of their financial health during crisis, which hamper the possibility for macroprudential loosening to stimulate credit. Thus, macroprudential policies are generally not designed to mitigate downturns. In addition, measures such as Loan-to-Value (LTV) requirements and Debt Service-To-Income (DSTI) requirements ratios degrades mechanically during bad times as borrowers' net worth and income declines (Claessens et al., 2013).

However, it should be noted that these differences of significance amongst empirical studies are partially due to the characteristics of the data. Indeed, the larger impact of tightening events highlighted by most of empirical studies is partially due to the fact that the number of tightening changes recorded in databases is much higher that the number of loosening actions (Araujo et al., 2020). In addition, this difference of results may be due to the consideration of the announcement date rate than the implementation date. Hence, following an announcement of a tightening measure, banks may start to comply with the new requirement in order to keep pace with the new regulation. At the opposite, following an announcement of a loosening measure, banks will be probably interested in reducing their efforts, but they can't do it until the implementation of the new regulation.

As for the interactions terms, we find similar results to those obtain in the baseline estimates between monetary policy and macroprudential tightening, while we do not find evidence of such interactions between monetary policy and macroprudential loosening. In other words, the correlation of macroprudential tightening and monetary policy with the reduction in credit growth diminishes due to these interactions, by 0.005 for both categories of loans. Concerning the marginal effects of the monetary policy when the stance of macroprudential policy is tightening, they are equal to 0.022 and -0.014 for respectively households' loans and loans to non-financial corporations when the monetary policy is restrictive, and corresponds to 0.114 and 0.150 when it is accommodative. Again, these results are in line with the baseline estimates as they show that accommodative monetary policy shocks have a greater impact on credit growth than restrictive ones.

3.3 Borrowers-based and institutions-based measures

In this section, we investigate which macroprudential instruments have the greatest correlation with credit growth, and how they affect the transmission of monetary policy. In order to do so, we classify our macroprudential variable into two subcategories: *Lending standards*, which contains borrowers-based measures, and *MAPP lenders*, which accounts for institutions-based measures and contains all the others measures except those that do not fit into any one category (i.e. *Other measures*). Borrowers-based measures target financial positions, cover and leverage from borrowers, whereas financial institution-based measures focus on bank's balance sheet (Cizel et al., 2019). Hence borrowers-based measures may be more efficient for dampening credit than institutions-based measures, as they target non-bank credit in addition to bank credit (Kuttner and Shim, 2016, Cizel et al., 2019). As *Lending standards* contains subcategories of macroprudential measures targeting households rather than non-financial corporations, we investigate the correlation of such variable with household loans only.[4] Table 4 shows the results.

[4] The subcategories of instruments contained in this category are: loan-to-value limits, loan-to-income limits, debt-to-income limits, debt-service-to-income limits, limits on interest rates on loans, maturity and amortization restrictions, other income requirements for loan eligibility, limits on the volume of personal loans, other restrictions on lending standards.

Table 4. Borrowers-based measures and financial institutions-based measures

	(1) Household loans	(2) NFC loans
Household loans (lagged)	0.943***	
	(0.008)	
NFC loans (lagged)		0.935***
		(0.008)
Monetary surprises	-0.044	-0.079**
	(0.029)	(0.038)
MAPP lenders	-0.033*	-0.055**
	(0.018)	(0.024)
Lending standards	-0.006	
	(0.052)	
MAPP lenders*Monetary surprises	0.004*	0.005*
	(0.002)	(0.003)
Lending standards*Monetary surprises	0.008	
	(0.007)	
Crisis dummy	-0.440***	-0.591***
	(0.116)	(0.145)
Unemployment rate	-0.056***	-0.091***
	(0.016)	(0.021)
Constant	1.208***	1.756***
	(0.297)	(0.356)
N	2004	2004
R^2	0.941	0.924

Note: The Table presents the fixed-effects estimator where Household loans and NFC loans are monthly growth rates of the credit to households and to non-financial corporations. Monetary surprises is the monetary policy variable. MAPP lenders refers to financial institution-based measures. Crisis dummy is the crisis variable from Laeven and Valencia (2020). Standard errors in parentheses. * p<0.10, ** p<0.05, ***p<0.01.

We find that financial institutions-based measures seem to drive the results from the baseline, as the associated correlation is similar to those obtain in Table 2, with a decline of 0.033 and 0.055 percentage point for respectively household loans and non-financial corporation loans following a one-unit increase in the *MAPP* index. Our findings are divergent with Fendoğlu (2017) and Eller et al. (2020), who argue that measures that target borrowers are more suited in curbing credit than those that target lenders. In addition, we find no correlation of lending standards with household loans, while several studies find a negative impact (e.g. Kuttner and Shim, 2016, Cerutti et al., 2017a). These differences can be explained by the fact that we consider the announcement dates of macroprudential measures, while the majority of the empirical literature considers the implementation dates. On one hand, a tightening in lending standards dampens credit to households as it reduces the amount of money a lender can provide to households. On the other hand, this effect may be offset by the fact that banks have incentives to expand their lending as soon as a tightening is announced, due to the impossibility to do so when credit restrictions are implemented (De Schryder and Opitz, 2021).

As our data are subject to both effects, these may explain why we do not find any significant correlation between lending standards regulation and credit to households. Another reason is that there is significantly less lending standards measures recorded in our sample than institutions-based measures.

As a consequence, all these reasons may explain why our results display a positive and significant correlation only for the interaction between monetary policy and institutions-based measures, with coefficients similar to those reported in the baseline specification. Therefore, due to these interactions, the correlation of institutions-based measures with household and non-financial corporation loans is reduced by respectively 0.004 and 0.005 percentage point, while the impact of monetary policy decreases by 0.005 percentage point for non-financial corporation loans. In addition, the marginal effects of monetary policy in a context of a restrictive macroprudential measures targeting lenders correspond to 0.005 and -0.018 for respectively households loans and loans to non-financial corporations in case of negative monetary shocks, and to 0.093 and 0.140 for positive shocks. We found again the same asymmetric effects than in Table 2 and 3, with larger effects for accommodative monetary policy shocks.

3.4 A focus on capital requirements

Next, we take a closer look at the influence of capital requirements as well as its impact on the transmission of monetary policy on credit growth. In order to so, we created a new variable called *Capital*, which aggregates 4 instruments from the MaPPED database, namely *Minimum capital requirements, Capital buffers*, *Risk weights* and *Leverage ratio*. While their primary objective is to enhance the resilience of the banking system, a large number of studies display evidence that capital requirements affect credit growth whether negatively (e.g. Aiyar et al., 2014) or positively (Begenau, 2020), while some studies do not find any effect (Imbierowicz et al., 2021). On one hand, capital requirements may increase banks' funding costs notably because equity is riskier than debt (Almenberg et al., 2017). Hence, banks will reduce credit supply in order to comply with the regulation or transfer these costs to their borrowers through an increase in banking lending rates. On the other hand, capital requirements increase the stability of banks and thus may decrease their funding costs, allowing them to provide more credit (Fidrmuc and Lind, 2020). Table 5 displays the results.

Table 5. Capital requirements

	(1) Household loans	(2) NFC loans
Household loans (lagged)	0.943***	
	(0.007)	
NFC loans (lagged)		0.935***
		(0.008)
Monetary surprises	-0.014	-0.039*
	(0.014)	(0.020)
Capital	-0.045*	-0.079**
	(0.024)	(0.032)
Capital*Monetary surprises	0.009**	0.009
	(0.005)	(0.006)
Crisis dummy	-0.446***	-0.614***
	(0.117)	(0.146)
Unemployment rate	-0.053***	-0.086***
	(0.016)	(0.022)
Constant	0.902***	1.282***
	(0.196)	(0.230)
N	2004	2004
R^2	0.941	0.924

Note: The Table presents the fixed-effects estimator where Household loans and NFC loans are monthly growth rates of the credit to households and to non-financial corporations. Monetary surprises is the monetary policy variable. Capital refers to the capital requirements index. Crisis dummy is the crisis variable from Laeven and Valencia (2020). Standard errors in parentheses. * p<0.10, ** p<0.05, ***p<0.01.

In line with most of the empirical studies (e.g. Aiyar et al., 2016, Fraisse et al., 2020, or De Jongue et al., 2020), we find that capital requirements are associated with a reduction in credit growth in all our specifications, both for households and non-financial corporations. After a one-unit increase in the capital requirement index, household loans and non-financial corporation loans decrease by respectively 0.045 and 0.079 percentage point. Hence, in addition to increasing the resilience of the banking system, capital requirements may dampen the risk of future financial crisis as they are inversely correlated with excessive credit growth.

As for the interactions, it appears that they reduce the negative association between capital requirements and household loans by 0.009 percentage point. In this case, our results show the same asymmetric effects than those in previous sections: the marginal effect of accommodative monetary policy conditioning of the implementation of capital requirements is equals to 0.041, while the marginal effect of restrictive monetary policy is 0.013.

4. Robustness checks

As a first robustness check, we test our model with alternatives index for monetary policy. In order to do so, we replace our monetary policy surprises by the shadow rates from Krippner (2015) and Wu and Xia (2016), as a significant part of the empirical literature do not use surprises series for measuring the monetary policy stance (e.g. Aiyar et al., 2016, Budnik, 2020, or Imbierowicz et al., 2021). These shadow rates capture the stance of monetary policy as they account for both conventional and unconventional monetary instruments. Hence, contrary to the monetary policy interest rate, this type of index is not limited by the zero lower bound, as it can take negative values when the ECB use unconventional monetary policies. Table C and D displays the results.

In general, our results are in line with those obtained in the baseline estimate. Hence, our results concerning the negative correlation between macroprudential policy and credit growth seem robust to the use of alternative measures of monetary policy, suggesting that these actions may play an important role in ensuring financial stability. However, the negative correlation between macroprudential policies and household loans is now non-significant, although it was only significant at the 90% level in Table 2. As for monetary policy, its effect on credit growth disappears with the use of shadow rates for most specifications with the exception of column 2 in table 8, which suggests that it may even have a positive impact. These results are possibly related to a reverse causality bias between credit growth and monetary policy, something that doesn't exist when we consider monetary policy surprises. Finally, we do not find any evidence of interactions between monetary and macroprudential policies when using shadow rates. This finding are in line with our previous results, suggesting that the impact of the interactions between these two policies on credit growth are very small and even sometimes non-significant.

Then, we test if our results are robust by using an alternative index called *MAPP2*. The differences between *MAPP* and *MAPP2* are related to the life cycle of macroprudential measures. In the MaPPED database, an action may sometimes be replaced by another action instead of been followed by a new one. Hence, one can think that when an action is replaced by a new one, the new one may be considered as a new measure which is unrelated to the previous one. In consequence, the previous measure may be considered as deactivated, meaning that only the change in the new action is taken into account. *MAPP* follows this logic. However, it is possible that an action that replace the previous one may be considered as a

change rather than a replacement of the previous one. In this case, it is possible to take into account the value of the previous action when computing value of the whole measure. This is the approach behind the *MAPP2* index. For this index, we carefully read the description of the actions that have been replaced and the description of the action that replaced them, and made the correction manually. Results are reported in Table E in appendix, and are almost identical to those obtained in the baseline specification.

5. Conclusion

We study if macroprudential and monetary policies influence credit growth to households and non-financial corporations in the Eurozone, between March 2003 and December 2017. In order to do so, we compute a macroprudential index that accounts for the life cycle of every macroprudential measures since their date of announcements, which allows us to evaluate their effects as long as they are active.

We find that macroprudential policies are associated with a reduction in credit to both households and non-financial corporations. These results hold for capital requirements measures, suggesting that these tools may be used to dampen credit growth in addition to enhance the resilience of the banking sector. However, we do not find any significant correlation between borrowers-based measures and credit growth, while lender-based measures are associated with a reduction in both non-financial corporation loans and household loans. This can be explained by the fact that we consider the life cycle of every measures including lending standards regulation since their announcements, which could encourage banks to increase credit supply until the implementation date, and to reduce it afterwards. In addition, we show evidence of asymmetric correlation between loosening and tightening events as only the latter have a significant and negative association with credit growth to households and non-financial corporations. Our finding suggests that macroprudential policy and especially tightening on institutions-based measures may be efficient in reducing credit growth, implying that international agreements such as Basel III should significantly strengthen the financial system.

We find the excepted negative effect of monetary policy on credit growth, suggesting that monetary policy may have a key role to play in terms of financial stability, notably through

the so-called "leaning against the wind". Moreover, it appears that there are little but existing interaction between monetary and macroprudential policies on credit growth. Taken together, our findings show that both policies have an independent and negative association with credit growth, which is slightly reduced by these interactions. Hence, all of these results suggest that monetary and macroprudential authorities should at least be involved in a clear and efficient sharing of information upstream of the decision-making process, in order to mitigate the risk of a deteriorating efficiency of both policies in smoothing the credit cycle. Finally, we find evidence of asymmetric effects of monetary policy as accommodative monetary policy shocks conditioning on the macroprudential policy stance seem to have larger effects than restrictive ones.

Our work is subject to some caveats. First, while we employ methods for restricting the endogeneity issue, our results may still be affected by it. Second, the weighting scheme that we use contains a certain amount of subjectivity. Third, to create our macroprudential index, we consider the announcement date of a given measure as the beginning of its life-cycle. For some macroprudential tools, their effects appear as soon as they are announced, while other measures (typically lending standards) may have no effects before their implementation. Therefore, further research is necessary to establish a classification that indicates which date has to be considered regarding the type of macroprudential tool used.

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APPENDIXES

Table A. Variables definitions and sources

Variable	Description	Source
Households loans	Loans to non-financial corporations, seasonally adjusted and deflated by the CPI (growth, in %)	ECB
NFC loans	Loans to households and non-profit institutions serving households, seasonally adjusted and deflated by the CPI (growth, in %)	ECB
Monetary surprises	Monetary policy surprises, measured as the change in the German 2-year bond yields	Altavilla et al. (2019)
Shadow rate	Monetary policy series (in %)	Krippner (2015), Wu and Xia (2016)
MAPP	A macroprudential index that aggregates changes on 11 categories of instruments	Budnik and Kleibl (2018)
MAPP2	A macroprudential index that aggregates changes on 11 categories of instruments	Budnik and Kleibl (2018)
MAPP tightening	A macroprudential index that aggregates tightening on 11 categories of instruments	Budnik and Kleibl (2018)
MAPP loosening	A macroprudential index that aggregates loosening on 11 categories of instruments	Budnik and Kleibl (2018)
MAPP lenders	A macroprudential index that aggregates instruments targeting lenders	Budnik and Kleibl (2018)
Lending standards	A macroprudential index that aggregates instruments targeting borrowers	Budnik and Kleibl (2018)
Capital	A macroprudential index that aggregates capital requirements	Budnik and Kleibl (2018)
Crisis dummy	Dummy variable equals to 1 when a banking crisis occurs, and 0 otherwise	Laeven and Valencia (2020)
Unemployment rate	Unemployment rate (in %)	Eurostat

Table B. Descriptive statistics

	Observations	Mean	SD	Min	Max
Dependent variables					
Households credit growth (%, YoY)	2016	3.500	8.173	-29.419	35.155
Non-financial corporations credit growth (%, YoY)	2016	1.439	9.893	-38.775	48.986
Variables of interest					
Monetary surprises	2148	-0.267	4.905	-26.500	22.550
Shadow rate (%, Krippner, 2015)	2148	-0.120	3.061	-7.636	4.356
Shadow rate (%, Wu and Xia, 2016)	1920	0.030	2.700	-5.502	4.279
MAPP	2148	13.277	5.244	5.100	26.450
MAPP2	2148	13.647	5.636	5.100	26.450
MAPP tightening	2148	13.469	5.351	5.350	27.450
MAPP loosening	2148	0.192	0.391	0.000	1.550
MAPP lenders	2148	12.224	4.079	5.100	22.300
Lending standards	2148	0.655	1.522	-1.000	5.750
Capital	2148	3.038	2.328	0.000	9.200
Control variables					
Crisis dummy	2148	0.240	0.427	0.000	1.000
Unemployment rate (%)	2148	9.252	5.004	3.300	27.800

Table C. Baseline estimations with shadow rate from Krippner (2015)

	(1) Household loans	(2) NFC loans
Household loans (lagged)	0.942***	
	(0.008)	
NFC loans (lagged)		0.936***
		(0.008)
Shadow rate	0.411	-0.452
	(0.507)	(0.695)
MAPP	-0.026*	-0.045**
	(0.015)	(0.020)
MAPP*Shadow rate	-0.008	0.039
	(0.032)	(0.043)
Crisis dummy	-0.418***	-0.581***
	(0.117)	(0.147)
Unemployment rate	-0.056***	-0.091***
	(0.016)	(0.021)
Constant	1.155***	1.696***
	(0.284)	(0.343)
N	2004	2004
R^2	0.941	0.924

Note: The Table presents the fixed-effects estimator where Household loans and NFC loans are monthly growth rates of the credit to households and to non-financial corporations. MAPP to the macroprudential index. Shadow rate is the monetary policy variable from Krippner (2015). Crisis dummy is the crisis variable from Laeven and Valencia (2020). Standard errors in parentheses. * p<0.10, ** p<0.05, ***p<0.01.

Table D. Baseline estimations with shadow rate from Wu and Xia (2016)

	(1) Household loans	(2) NFC loans
Household loans (lagged)	0.938***	
	(0.008)	
NFC loans (lagged)		0.935***
		(0.008)
Shadow rate	0.600	1.157**
	(0.370)	(0.532)
MAPP	-0.013	-0.053**
	(0.015)	(0.021)
MAPP*Shadow rate	-0.034	-0.066*
	(0.025)	(0.036)
Crisis dummy	-0.353***	-0.582***
	(0.114)	(0.150)
Unemployment rate	-0.059***	-0.093***
	(0.016)	(0.022)
Constant	0.948***	1.837***
	(0.285)	(0.370)
N	1896	1896
R^2	0.941	0.924

Note: The Table presents the fixed-effects estimator where Household loans and NFC loans are monthly growth rates of the credit to households and to non-financial corporations. MAPP to the macroprudential index. Shadow rate is the monetary policy variable from Wu and Xia (2016). Crisis dummy is the crisis variable from Laeven and Valencia (2020). Standard errors in parentheses. * p<0.10, ** p<0.05, ***p<0.01.

Table E. Alternative macroprudential index

	(1) Household loans	(2) NFC loans
Household loans (lagged)	0.942***	
	(0.008)	
NFC loans (lagged)		0.934***
		(0.008)
Monetary surprises	-0.044*	-0.077**
	(0.023)	(0.031)
MAPP2	-0.027**	-0.044**
	(0.013)	(0.018)
MAPP2*Monetary surprises	0.004**	0.005**
	(0.002)	(0.002)
Crisis dummy	-0.450***	-0.599***
	(0.116)	(0.145)
Unemployment rate	-0.058***	-0.094***
	(0.016)	(0.021)
Constant	1.188***	1.721***
	(0.276)	(0.329)
N	2004	2004
R^2	0.941	0.924

Note: The Table presents the fixed-effects estimator where Household loans and NFC loans are monthly growth rates of the credit to households and to non-financial corporations. Monetary surprises is the monetary policy variable. MAPP2 refers to the macroprudential index. Crisis dummy is the crisis variable from Laeven and Valencia (2020). Standard errors in parentheses. * p<0.10, ** p<0.05, ***p<0.01.

Chapter 2

Capital ratios and banking crises in the European Union

Note: this chapter is based on an original paper, published in International Economics (Cardot-Martin, Labondance and Refait-Alexandre, 2021).

1. Introduction

Banking crises are a major concern for monetary, fiscal and regulatory authorities. They trigger huge economic costs (Reinhart and Reinhart, 2010; Taylor, 2015; Levieuge et al., 2018). It is also demonstrated that financial crises recessions are costlier than other recessions in terms of output losses (Jordà et al., 2013). During the last two decades, the European Union (EU) experienced two major episodes of banking crisis (the so-called Great Financial Crisis and the Sovereign Debt Crisis). Relying on the work of Laeven and Valencia (2020), output losses in the EU during recent banking crises are estimated around 40% of the Gross Domestic Product (GDP) and the public debt increased by more than 20% of GDP.[1]

Meanwhile, several modifications occurred in the regulatory environment. While the macro-finance literature points out that rapid credit growth increases the occurrence of banking crises (Schularick and Taylor, 2012), macroprudential regulators are extensively using capital ratios to prevent them. In particular, the successive implementation of Basel II and Basel III Agreements lead to tighter capital requirements. More specifically, Basel II enforced an accurate risk assessment of banks' assets, possibly through internal models. This risk-weighted asset (RWA) calculation allowed a more refined estimate of the capital required. Basel III enhances the quality of the regulatory capital (increasing the percentage of equity and reducing the percentage of subordinate debt), increases the level of capital by the creation of a conservation buffer and establishes a leverage ratio (independent from the level of banks' risk). Basel II was translated into the European laws through the CRD (Capital Requirements Directive) II in 2008 and CRD III in 2009. Basel III was adopted via CRD IV and the Capital Requirements Regulation (CRR) in June 2013. The EU also created in 2014 a banking union which gave the European Central Bank (ECB) a new task. The ECB is now in charge of the supervision of the larger banks in the EU and therefore responsible of banks' resilience. As a matter of fact, during the last two banking crises, non-performing loans rose sharply and deteriorated the health of the banking sector (see Table 1). As a consequence, monetary policy transmission channels were weakened so as the ability of central banks to fulfil their objectives. It is therefore crucial that the ECB promotes effective regulations to improve banking sector's resiliency. Although the use of capital ratios has been extensively investigated in the empirical literature, to our knowledge, there is no study focused on their impact on the resilience of the

[1] Table 1 summarizes the recent episodes of banking crisis in the European Union and their outcomes.

banking sector in the EU.[2] This chapter aims at examining the relationships between banks' level of capital and the probability of banking crises in the EU between 1998 and 2017.

From a theoretical view point, there is no consensus on the ability of capital ratios to prevent banking crises as several effects are at work. First of all, the implementation of a higher equity ratio mechanically leads to a stronger solvency since debts are lower in relation to the value of assets (Acosta-Smith et al., 2020). Second, an increase in the share of equity in total liabilities should lead shareholders to be more careful since they have more to lose. Actually, it is argued that if bankers have "more skin in the game", they would be more cautious not to engage their banks in highly risky activities and it would reduce the probability of crisis (Diamond and Rajan, 2000; Mehran and Thakor, 2011). Higher capital ratio requirements decrease the benefit that shareholders derive from limited liability (Kashyap et al. 2020). Furthermore, their risk aversion increases and their incentive to take risks is reduced (Agur, 2010; Martinez-Miera and Suarez, 2012). The implementation of a RWA ratio should particularly lead banks to be more cautious. A fall of their risk-taking – that reduces their RWA – makes possible either a decrease of the level of capital required, or simply an increase of the volume of business for a given level of capital (Martynova, 2015). In this line Repullo and Suarez (2013) show that Basel II made banks more prudent than Basel 1. Capital requirements may also reduce the occurrence of a bank run, leading banks to reduce the share of deposits in the total liabilities (Kashyap et al., 2020). However, capital requirements may not be sufficient to prevent banks to choose highly risky strategies and even may lead them to take riskier portfolios to achieve target rates of return (Rochet, 1992; Gale, 2010). As a lower leverage reduces the Return on Equity, shareholders may increase risk assets in order to restore financial rentability. Acosta-Smith et al. (2020) show that banks bounded by the capital requirements may increase their risk-taking. Another adverse effect exists: if the cost of equity is high, an increased requirement of capital raises the cost of capital, reducing the franchise value. As the loss in case of failure is lower, banks have an incentive to increase their risk (Hellman et al. 2000).

Empirical papers are then useful to assess how capital ratios may affect banking stability in any given context and ours contributes to this literature. A growing number of studies provide evidence that capital ratios actually reduce the probability of a banking crisis (Basel Committee on Banking Supervision (BCBS), 2010; Almenberg et al., 2017; Barth and Miller, 2018; Corbae and D'Erasmo, 2019). Acosta-Smith et al. (2020) show that while a leverage ratio leads banks

[2] Table A in the appendix presents the empirical literature on this topic.

to increase their risks if the cost of capital is high, the global effect improves bank sector resilience. Berger and Bouwman (2013) show that higher levels of capital always reduce small banks probability of default, while this benefice only occurs during banking crisis for medium and large banks. Boissay et al. (2019) find through a meta-analysis that on average, a 1 percentage point increase in capital ratios is associated with a 1 percentage point reduction of the crisis probability. In contrast, studies are more sceptical about the performance of these tools alone to mitigate banking risks (Barth et al., 2008; Čihák and Schaeck, 2010; Jordà et al., 2021). More broadly, this chapter contributes to the literature on the determinants of banking crises that has shown that rapid domestic credit expansion is a robust indicator of financial crises (Gourinchas and Obstfeld, 2012; Schularick and Taylor, 2012; Aikman et al., 2015). It is also argued that bank-specific characteristics can have a large impact on the functioning of this sector (Gambacorta and Marques-Ibanez, 2011; Jutasompakorn et al., 2014). Others point out that macroeconomic factors, such as slowdown of GDP, low interest rates or inflation are crucial determinants of banking crises (Demirgüç-Kunt and Detragiache, 1998; Von Hagen and Ho, 2007; Pedro et al., 2018).

In this chapter, we build on the aforementioned literature. We rely on the methodology used by Jordà et al. (2021). They use a Probit model and found that higher capital ratios are unlikely to prevent a financial crisis. Their study is based on a panel of 17 advanced countries between 1870 and 2015. We use this study as a benchmark to verify if their result is robust in the EU. We assess whether two variables of capital ratios – the bank capital to total assets ratio which can be considered as a proxy of the leverage ratio and the bank regulatory capital to RWA - reduce the occurrence of banking crises from 1998 to 2017 in the EU. Banking crises are identified by Laeven and Valencia (2020). We find that both ratios affect negatively this occurrence in the EU. This result is robust to the exclusion of outliers, to the inclusion of various control variables for banking, financial and macroeconomic risks. Finally, we show that while the bank regulatory capital to RWA has always a negative effect on the probability of crisis, the bank capital to total assets ratio is only significant above a threshold estimated between 10% and 12%. These results suggest that capital requirements under Basel III will likely strengthen financial stability through their negative impact on the likelihood of banking crises. While it exists more granular data than country level data, we believe that our approach is interesting for at least two reasons. First, microeconomic data are generally not exhaustive as all banks are not always providing their information. So here we gain in exhaustively what we lose in granularity. Second, as macroprudential policies are developing, more results at the

macroeconomic level are needed.[3] In this chapter, we document the link between aggregate capital ratios and banking crises and show that these tools can reduce the occurrence of banking crises.

The chapter is organized as follows. Section 2 describes the data and provides summary statistics. Section 3 presents the empirical model, our main results and discusses some robustness. Section 4 concludes.

2. Data

EU member states composed our sample, from 1998 to 2017. Our data are annual and country-level. They are extracted from the World Bank Global Financial Development Database (GFDD). We consider the 28 countries that were members of the EU in 2017. Our sample contains 560 observations. All variables used in this article are described in Table B in the Appendix and descriptive statistics are presented in Table C.

2.1 Banking Crisis

The dependent variable is the occurrence of a banking crisis. We use the binary variable built by Laeven and Valencia (2020) gathered in the GFDD. They consider that a banking crisis happens if two conditions are met. First, significant signs of financial distress appear in the banking system (for instance significant bank runs, losses in the banking system, or bank liquidations). Second, significant banking policy interventions are implemented in response to significant losses in the banking system. The variable equals one as long as the crisis continues and zero otherwise. The first year of the crisis is when both criteria are met. The end of a crisis is defined the year before real GDP growth and real credit growth are both positive for at least

[3] See for instance the impact study ran by the Basel Committee on Banking Supervision (2021) or the review of the macroeconomic level literature reported by Birn et al. (2020).

two consecutive years. Table 1 presents the banking crisis episodes in the EU and their outcomes.

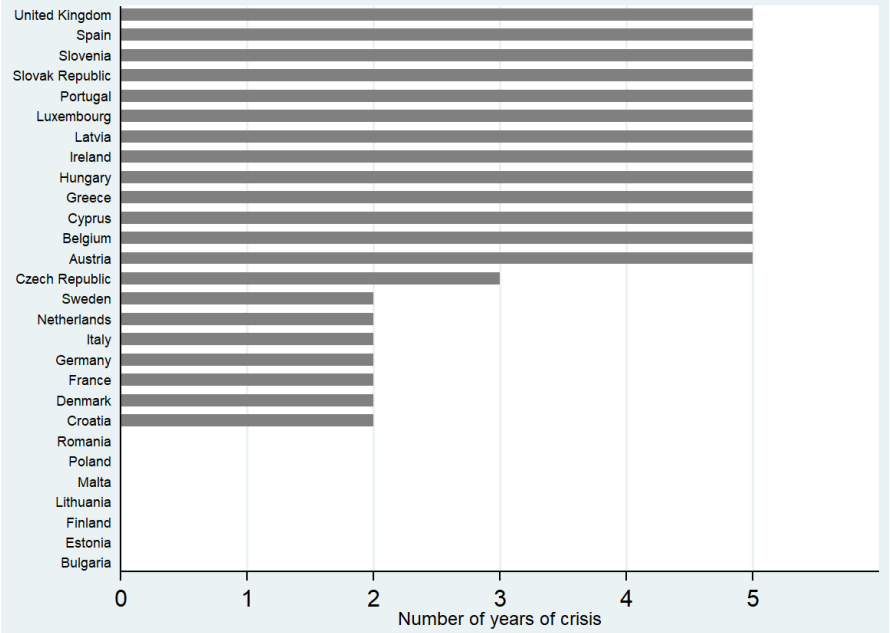
Table 1. Banking crises in the European Union and their outcomes

Country	Crisis dates		Output loss (% of GDP)	Fiscal Costs (% of GDP)	Non Performing loans (% loans)	Increase in public debt (% of GDP)
	Start	End				
Austria	2008	2012	19.2	5.2	4.1	19.8
Belgium	2008	2012	15.7	6.2	4.2	22.2
Croatia	1998	1999	...	6.9	10.5	14.1
Czech Republic	1996	2000	...	6.8	18.0	1.8
Cyprus	2011	2015	76.5	18.0	47.8	21.3
Denmark	2008	2009	35.0	5.9	5.95	32.8
France	2008	2009	23.3	1.3	4.5	15.9
Germany	2008	2009	12.3	2.7	3.7	16.2
Greece	2008	2012	64.9	28.7	37.1	43.9
Hungary	2008	2012	37.3	2.9	17.3	3.8
Ireland	2008	2012	107.7	37.6	25.7	76.5
Italy	2008	2009	32.2	0.7	18.0	8.6
Latvia	2008	2012	93.9	8.1	15.9	27.6
Luxembourg	2008	2012	43.3	7.2	1.7	12.7
Netherlands	2008	2009	26.1	14.3	3.2	24.9
Portugal	2008	2012	35.0	11.1	12.9	38.5
Slovak Republic	1998	2002	0.0	...	35.0	15.4
Slovenia	2008	2012	39.1	9.9	18.0	20.9
Spain	2008	2012	38.8	5.4	9.4	31.8
Sweden	2008	2009	25.5	0.2	2.0	12.8
United Kingdom	2007	2011	25.3	8.8	4.0	27.0
Mean			39.5	9.4	14.2	23.3

Note: Output losses are computed as the cumulative sum of the differences between actual and trend real GDP over the period [T, T+3], expressed in percent of trend real GDP, with T denoting the starting year of the crisis. The trend is computed by applying an HP filter (λ=100) to the GDP series over [T-20, T-1]. Fiscal costs refer to outlays directly related to the restructuring of the financial sector. For episodes starting in 2007 and later, the increase in public debt is measured as the change in debt projections, over [T-1, T+3], relative to the pre-crisis debt projections, where T is the starting year of the crisis. Source of the data: Laeven and Valencia (2020).

The occurrences of crisis represent 82 out of 560 observations (14.64%). According to this measure, 21 EU countries experienced a banking crisis over the period, and 13 of them suffered from a crisis which lasted 5 years (See Figure 1).

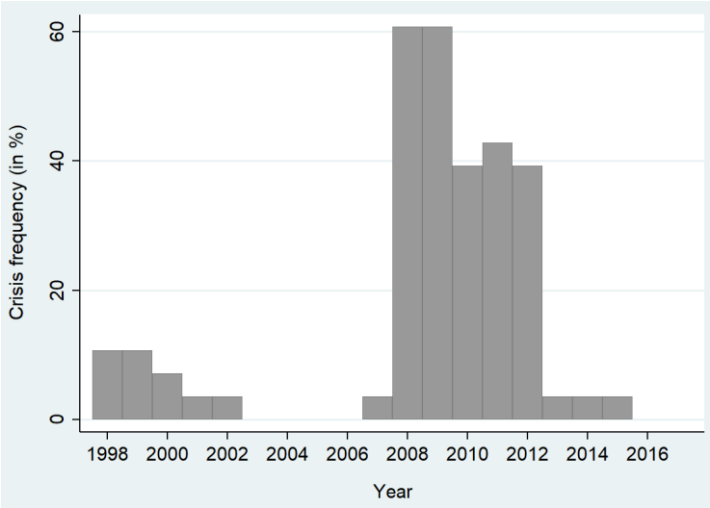
Figure 1. Occurrence of a banking crisis by country



Source: World Bank Global Financial Development Database.

As expected, the events are concentrated during the Great Financial Crisis and the sovereign debt crisis, but some countries also experienced banking crises at the beginning of our sample (See Figure 2). From 2008 to 2010, 53% of the sample suffered from of a banking crisis, almost 40% during the period 2011-2012.

Figure 2. Occurrence of a banking crisis by year

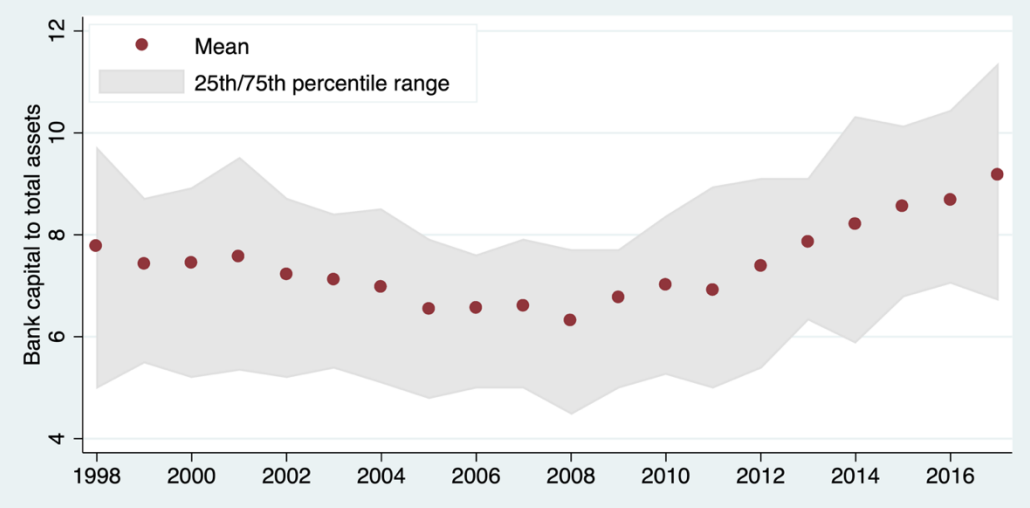


Source: World Bank Global Financial Development Database.

2.2 Capital ratio

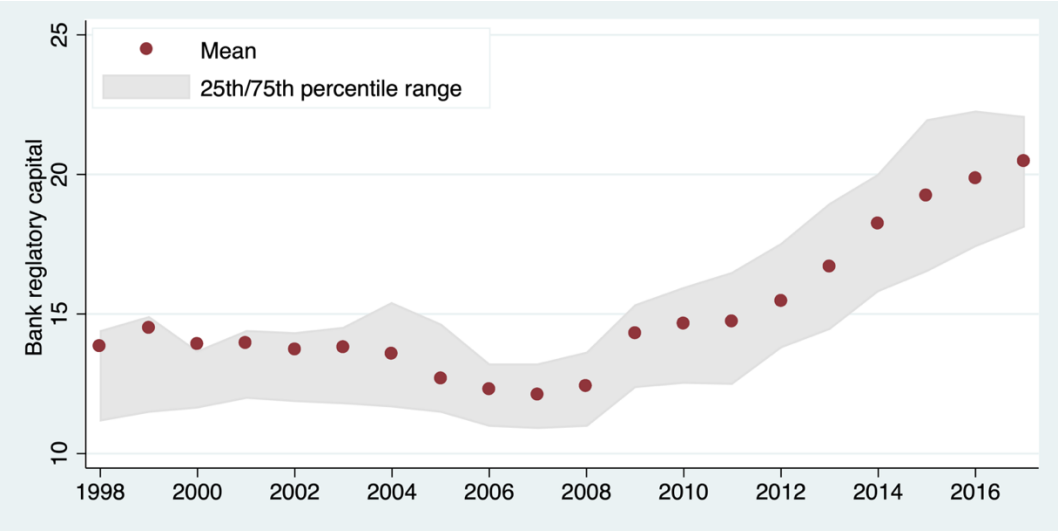
We consider two actual ratios of capital, reflecting the implementation of the two main regulatory capital ratios of Basel requirements: the leverage ratio and the minimum capital requirement. First, Bank capital to total assets is the ratio of banks' capital and reserves to their total assets. Capital consists in tier 1 capital and total regulatory capital, which includes several specified types of subordinated debt instruments (tier 2 and tier 3 capital). The average Bank capital to total assets is 7.37%. Bank capital to total assets is a proxy of the leverage ratio and we can see that its average level is above the 3% required by the regulatory leverage ratio implemented by the Basel III Agreements. We also consider Bank regulatory capital to RWA defines as the ratio of total regulatory capital of banks to their assets held, weighted according to those assets' risk. Its mean is 15.05%. This level complies with the 10.5% required by the Capital Adequacy Ratio under Basel III Agreements (Minimum total capital plus conservation buffer). However, at the beginning of the period, some countries presented low level of capital ratios. Actually, we can observe in Figures 3 and 4 that the average ratios slightly decreased from 2001 to 2008.

Figure 3. Bank capital to total assets in the European Union



Source: World Bank Global Financial Development Database.

Figure 4. Bank regulatory capital to RWA



Source: World Bank Global Financial Development Database.

The decrease is smaller for the Bank regulatory capital to RWA. During this period, banks implemented their internal valuation model, anticipating the Basel II Agreements. Internal models reduced the ratio RWA to Total Assets, leading to a decrease in the Bank capital to total assets ratio. On the contrary, both ratios increased from 2009 to 2017 and the rise is sharper for the Bank regulatory capital to RWA. These expansions may be explained by the necessity to fulfil the tighter level of capital requirements. The difference of dynamics can be justified by the fact that the gap between the actual ratio and the required level was higher for Bank regulatory capital to RWA.

2.3 Control variables

First, we include the credit to GDP ratio, as it widely used in the literature as a determinant of crises (Schularick and Taylor, 2012). More precisely, we use the 5-year average annual growth rate of the ratio of private credit to GDP. On average, the credit to GDP increased by 3%, with a range from -42% to 31%.

Second, we consider a set of variables in order to control for banks characteristics (Bank Controls thereafter). While assessing the effects of capital regulation on the probability of banking crises, we include in our model some control variables that are likely to explain crises. First, we include measures of banks default risk. Several default measurements are

traditionally used in literature: distance to default (following Merton option model, Merton, 1974, or KMV – Kealhofer, McQuown and Vasicek – model), Z-score, CAMEL or non-performing loans.[4] In order to consider variables that are both country-level and consistent across countries, we use the measures available in the World Bank GFDD: banks' default risk is assessed by the Z-score and by the non-performing loans ratio. On average, the Z-score equals to 11.84%, corresponding to a probability of default quite null. The minimal value (0.02%) corresponds to a probability of default almost equals to 50%, reflecting the difficulties of some countries during the period. The mean value of the non-performing loans ratio is 6.28%. As expected, the maximum value and the last decile are high, respectively 46.68% and 14.80%. We include several other bank control variables. Bank net interest margin (on average equals to 2.39% of the interest-bearing assets) and Bank noninterest income to total income (40.45% on average) report both the profitability and the business model of banks. During the last years of the period, the flat yield curve reduces the banks' net interest margin and may give them incentives to increase their risk taking. We also include return on assets (RoA) as a proxy for banks' profitability, its mean is 0.55%.[5] More than 10% of the observations are negative. Bank credit to bank deposits is the ratio between the financial resources provided to the private sector by domestic money banks as a share of total deposits. The business model of banks is also taken into account by the ratio Bank credit to bank deposits (118.88% on average). Berger and Bouwman (2013) underline the importance of access to financial markets in the relationships between capital ratio and risk level. We complete this measure by Liquid assets to deposits and short-term funding, quite near to the Basel III Liquidity Coverage Ratio (LCR). Liquid assets include for instance cash and due from banks, trading securities loans and advances to banks. Deposits are total customer deposits: current, savings and term. A low level of liquid assets to deposits and short-term funding undermines the banking sector and can lead to a banking crisis. The mean of this ratio is 37.41%, far from complying with the 100% required by the LCR rule and reflecting the liquidity crisis of the Great Financial Crisis. Liquid liabilities to GDP, the ratio between M3 aggregate and GDP, controls for global access to

[4] The distance to default estimates the probability that the value of the bank's assets (assumed to follow a stochastic process) will become less than the value of the debt. The Z-score considers that default occurs when losses exceed capital (See for instance Hannan and Hanweck, 1988); $Z-Score = \frac{Mean(RoA)+\frac{Capital}{Assets}}{StandardDeviation(RoA)}$. CAMEL is a rating system taking into account Capital adequacy, Asset quality, Management, Earnings, Liquidity, and Sensitivity. Importance of non-performing loans is often assessed as the ratio of defaulting loans (payments of interest and principal past due by 90 days or more) to total gross loans.

[5] Alternatively, the RoA is replaced by the return on equity (RoE). The results are not modified and are available from the authors upon request.

liquidity. Our sample shows a great heterogeneity: from 3.69% to 938.72%, with a mean of 99%. At last, the concentration of the banking sector may play a role. Goetz (2018) shows that a low concentration (a high level of competition) pushes banks to achieve efficiency gains, thus increasing profits and assets' quality and decreasing the likelihood of a banking crisis. Concentration is the share of the assets of the five largest banks in total commercial banking assets. European banking sector is concentrated as the mean value is 80.40%.

Third, we consider two variables in order to control for financial market characteristics (Financial Controls thereafter) as most of European banks cumulate credit activities and market activities. Stock market returns and Stock market volatility allow us to take into account the impact of financial turbulence on the banking sector. The volatility is quite high (21.6 on average) as shown in particular by the wide gap between the minimal stock return (-74.62%) and its maximal value (125.05%).

Fourth, we control for macroeconomic conditions (Macro Controls thereafter). We include the ratio of central bank assets to GDP. One can expect that a higher ratio is a sign that the central banks act as lenders of last resort. We also control for the macroeconomic environment by using the GDP growth and the Inflation.

3. Empirical strategy and results

How bank capital ratios affect the likelihood of banking crises in the EU? The GFDD dataset allows us to study this question in a panel setting with annual data from 1998 to 2017. More precisely, we follow the literature (Barth and Miller, 2018; Jordà et. al., 2021) and estimate Probit regressions that assume that the probability of a banking crisis is conditional on a set of explanatory variables and can be seen in terms of the normal cumulative distribution function:

$$\Pr\left[\text{Crisis}_{i,t} = 1 \,\middle|\, \alpha_i, X_{i,t-1}\right] = \Phi(\alpha_i + \beta\, X_{i,t-1}) \quad (1)$$

$\text{Crisis}_{i,t}$ stands for the indicator of banking crisis for all years t and countries i in our sample. We follow Jordà et al. (2021) and gauge the quality of classification against another one by focusing on the area under the curve (AUC) statistics (area under the receiver operator characteristic (ROC) curve). This statistic measures how a model accurately sorts the data

between banking crisis and non-banking crisis episodes. The AUC is close to 0.5 when a model does not classify correctly and higher when the classification is improved. As a benchmark, we estimate a model with only the country-fixed effects and obtain an AUC = 0.56. To complement the information provided by the AUC, we also propose in each Table the area under the precision-recall curve (AUC-PR) statistics**.** When the AUC-PR score is higher, the classification is better. In our benchmark, we obtain an AUC-PR = 0.16.

3.1 Baseline estimates

We begin by including in the vector $X_{i,t-1}$ of equation (1) the 5-year average annual growth rate of the ratio of credit to GDP (Δ_5Credit/GDP). The literature has extensively documented that increases in the quantity of credit proxied by Δ_5Credit/GDP are a major determinant of banking crisis (Schularick and Taylor, 2012; Jordà et al., 2013; Mian et al., 2017; Jordà et al., 2021).[6] We then introduce capital ratios variables and assess their additional explanatory power. A country fixed effect α_i is also used to control for the cross-country heterogeneity. All explanatory variables are lagged by one period. Table 2 presents our baseline estimates.

[6] Among others, Beck and Levine (2004) pointed out that using data averaged over five-years instead of annual or quarterly data help removing business-cycle influences and focusing on structural determinants.

Table 2. Baseline estimations

	(1)	(2)	(3)	(4)	(5)
Δ_5 Credit/GDP	2.77**	2.87**	11.77***	1.37	6.52***
	[1.22]	[1.39]	[2.67]	[1.40]	[2.50]
Bank capital to total assets		-0.19***			
		[0.05]			
Bank regulatory capital to RWA				-0.10***	
				[0.04]	
Δ_5 Bank capital to total assets			1.47		
			[2.20]		
Δ_5 Bank regulatory capital RWA					-0.88
					[3.00]
N	472	428	308	444	325
AUC	0.68	0.72	0.79	0.71	0.74
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
AUC-PR	0.24	0.27	0.51	0.26	0.36

Note: The Table presents Probit models where the dependent variable is the banking crisis and the regressors are lagged by one period. Country fixed effects are included. Clustered (by country) standard errors in brackets. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

First, the 5-year annual average credit growth rate (column 1) affects positively the probability of crisis as in Schularick and Taylor (2012) and Jordà et al. (2021). The AUC and the AUC-PR are respectively equal to 0.68 and 0.24, indicating that the rate of accurate classifications is significantly higher than in the benchmark (with country-fixed effects only). Second, we alternatively introduce our two variables of interest, the two bank capital ratios, in levels and their 5-year annual growth rate. The levels of Bank capital to total assets and bank regulatory capital to RWA (columns 2 and 4) are both associated with lower banking crisis risk. This is line with most results from the empirical literature (e.g. BCBS, 2010, Mikkelsen and Pedersen, 2017, or Boissay et al., 2019). We also estimate the marginal effects. They are computed from predictions of the model for each independent variable when all other covariates are set to their average values. They are smaller than the average effect. We find that an increase of one point of bank capital to totals assets reduces the probability of crisis of 0.04 point. The marginal effect is smaller for the weighted ratio: an increase of one point of bank regulatory capital to RWA reduces the probability of crisis of 0.02 point.[7] Turning to columns 3 and 5, the coefficients associated with the evolution of the banking capital ratios are not significant. These

[7] These marginal effects indicate that when the bank capital to total assets ratio is 1 point higher, the average probability of crisis is reduced by 0,27% and when the bank regulatory capital to RWA ratio is 1 point higher the average probability of crisis is reduced by 0,14%.

results suggest that what is important to enhance the resilience of the banking sector in the EU is the level of capital ratios rather than their variation. That implies that these macroprudential tools have perennial effects on banking stability, in line with the theoretical arguments that state that the impact of capital ratios on banks' risk taking is permanent.

3.2 Sensitivity analysis

We assess the robustness of these baseline estimates in several ways. First, we use of a Logit model instead of a Probit model. Second, we run our estimations on subsamples. We make sure that the results are not sensitive neither to the exclusion of outliers nor to the fact that our dataset is imbalanced between ones and zeros in the dependent variable. To test this latter point, our estimations are carried out on the sample 2008-2010. The proportion of 1 (banking crisis) over this period is 53%. Third, we check if our estimates are sensitive to the exclusion of the 5-year average annual growth rate of credit-to-GDP ratio. We also replace this traditional variable in the literature by the 1-year average annual growth rate of credit-to-GDP ratio and by its level. These robustness tests are presented in Table D in the appendix and confirm that bank capital ratios are associated with a lower banking crisis probability.[8]

Moreover, our baseline specification might suffer from an omitted variable(s) bias. Bank capital might capture the effects of alternative variables. We test this issue by adding controls in $X_{i,t-1}$ as defined in the previous section. We test bank controls, financial controls and macro controls. Results are presented in Table 3.

[8] The only coefficient that is not statistically significant is the one associated with the bank capital to total assets during the 2008-2010 subsample, but it is comparable to the baseline. Two explanations can be provided: first, this result is obtained on a smaller number of observations. Second, this variable is only significant above a certain threshold that has not been reached over this sample. We explore this point latter on.

Table 3. Controlling for bank characteristics, financial environment and macroeconomic dynamics

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Δ5 Credit/GDP	-0.46	-1.58	2.09	0.58	1.70	-0.19	-2.94	-5.00*
	[1.53]	[1.73]	[1.45]	[1.46]	[1.63]	[1.62]	[2.41]	[2.70]
Bank capital to total assets	-0.17**		-0.21***		-0.15***		-0.22***	
	[0.07]		[0.06]		[0.05]		[0.08]	
Bank regulatory capital to RWA		-0.13**		-0.11***		-0.15***		-0.20***
		[0.07]		[0.04]		[0.05]		[0.07]
Bank Controls								
Bank net interest margin (%)	-0.05	-0.01					0.32*	0.38**
	[0.15]	[0.13]					[0.18]	[0.15]
Bank noninterest income to total income (%)	-0.02	-0.02					-0.02	-0.02
	[0.01]	[0.02]					[0.01]	[0.01]
RoA	-0.17*	-0.27***					-0.16	-0.21**
	[0.10]	[0.09]					[0.11]	[0.10]
Z-score	-0.05*	-0.04					-0.06**	-0.06**
	[0.03]	[0.03]					[0.03]	[0.03]
Nonperforming loans	-0.04	-0.04					-0.02	-0.03
	[0.03]	[0.03]					[0.04]	[0.04]
Bank credit to bank deposits (%)	0.00**	0.00*					0.00*	0.00
	[0.00]	[0.00]					[0.00]	[0.00]
Liquid liabilities to GDP (%)	0.00**	0.00***					0.00**	0.01***
	[0.00]	[0.00]					[0.00]	[0.00]
Liquid assets to deposits and short term funding (%)	-0.02**	-0.01					-0.02**	-0.01
	[0.01]	[0.01]					[0.01]	[0.01]
Concentration	-0.03***	-0.03***					-0.04***	-0.03**
	[0.01]	[0.01]					[0.01]	[0.01]
Financial Controls								
Stock market return			-0.01***	-0.01***			-0.01**	-0.01*
			[0.00]	[0.00]			[0.00]	[0.00]
Stock price volatility			0.01	0.00			0.02	0.02
			[0.01]	[0.01]			[0.02]	[0.02]
Macro Controls								
Central Banks assets					-0.07*	-0.11**	-0.15**	-0.19**
					[0.04]	[0.04]	[0.07]	[0.08]
GDP Growth					-11.55***	-12.98***	-0.80	-3.10
					[2.89]	[2.67]	[4.52]	[4.29]
Inflation					-0.01	0.01	0.01	0.02
					[0.02]	[0.02]	[0.02]	[0.02]
N	371	386	403	417	410	426	336	349
AUC	0.84	0.84	0.75	0.75	0.78	0.80	0.87	0.88
se	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.02
AUC-PR	0.51	0.52	0.35	0.36	0.33	0.40	0.54	0.55

Note: The Table presents Probit models where the dependent variable is the banking crisis and the regressors are lagged by one period. Country fixed effects are included. Bank controls include bank interest margin, bank non-interest income, RoA, Z-score, bank non-performing loans, bank credit to bank deposits, liquid liabilities, liquid assets to deposits, banking concentration. Financial controls include stock market returns and stock market volatility and macro controls include central banks assets, GDP per capita growth rate and inflation. Clustered (by country) standard errors in brackets. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Control variables improve the rate of classification provided by the model (The AUC ranges from 0.75 to 0.88 and the AUC-PR ranges from 0.33 to 0.55). This is particularly true when we include additional banking variables. Among others, we can underline the fact that the concentration of the banking sector strengthens its resilience, in spite of Goetz (2018) (see columns 1, 2, 7 and 8). The short-term liquidity requirements (as the LCR) also seem to reduce the probability of a banking crisis (see columns 1 and 7). As expected, the banks' default risk

(assessed by the Z-score) increases the crisis probability. Furthermore, our results support the idea that lower net interest margins may lead banks to take risk in order to restore their profitability. Looking at the effects of bank capital ratios, the results are robust and quite the same than in the baseline.

3.3 Threshold estimations

We study more thoroughly the role played by the level of bank capital ratios in order to prevent banking crises. Theoretical literature shows that banks' behaviour may differ whether they are bounded by the requirements or not. We decompose our sample according to the distribution of bank capital ratios. More precisely, we estimate whether the results are affected if we only look at the bottom of the distribution of each ratio (below the median) or at the top (above the median).[9] Table 4 shows the results.

[9] We use linear regressions instead of non-linear ones to estimate these thresholds for sake of simplicity and transparency. Moreover, non-linear approaches such as panel smooth transition regression also have their drawbacks as they may converge slowly and are uncertain (Teräsvirta, 1994).

Table 4. Distribution of capital ratios

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Below median Bank capital to total assets		Above median Bank capital to total assets		Below median Bank regulatory capital to RWA		Above median Bank regulatory capital to RWA	
Δ_5 Credit/GDP	2.58	-1.99	2.09	-5.67*	0.49	-4.40	3.48	-31.76***
	[2.36]	[3.16]	[1.40]	[3.32]	[1.48]	[3.22]	[3.13]	[11.64]
Bank capital to total assets	-0.07	0.05	-0.21***	-0.68***				
	[0.10]	[0.16]	[0.06]	[0.14]				
Bank regulatory capital to RWA					-0.25***	-0.38***	-0.11***	-0.29***
					[0.06]	[0.15]	[0.04]	[0.10]
Bank controls	No	Yes	No	Yes	No	Yes	No	Yes
Financial Controls	No	Yes	No	Yes	No	Yes	No	Yes
Macro Controls	No	Yes	No	Yes	No	Yes	No	Yes
N	195	156	233	180	206	164	238	185
AUC	0.72	0.76	0.70	0.82	0.69	0.82	0.71	0.74
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.04)
AUC-PR	0.27	0.27	0.25	0.41	0.26	0.49	0.27	0.28

Note: The Table presents Probit models where the dependent variable is the banking crisis and the regressors are lagged by one period. Country fixed effects are included. Bank controls include bank interest margin, bank non-interest income, RoA, Z-score, bank non-performing loans, bank credit to bank deposits, liquid liabilities, liquid assets to deposits, banking concentration. Financial controls include stock market returns and stock market volatility and macro controls include central banks assets, GDP per capita growth rate and inflation. Clustered (by country) standard errors in brackets. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Bank regulatory capital to RWA has a negative effect on the probability of crisis whether we consider the values higher or lower than the median – columns (5) to (8). Interestingly, while the bank capital to total assets ratio is not significant if we only keep its values below its median – columns (1) and (2) – it is negative and significant above its median – columns (3) and (4) – whether we add controls or not.

This last result is explored by splitting the sample at different percentiles of the bank capital to total assets ratio to identify thresholds for which this effect is at work. Results are summarized in Table E in the appendix, in which we run the regressions with and without controls for each subsample. We do find a threshold effect for the capital to total assets ratio: this ratio has a significant negative effect on banking crises between the 85th and the 90th percentile following the specification. In other words, it seems that in the EU, the negative effect of capital to total assets ratio on banking crisis is at work for values above 10.11% (for an estimation without control) and 12.25% (for a specification with all controls). This threshold is far higher than the 3% recommended by the BCBS.

We therefore can consider that the required level of leverage ratio is not high enough. This is consistent with Barth and Miller (2018) who realized a cost-benefit analysis of a raise of the leverage ratio from 4 to 15 percent for nearly 4000 United States (US) banks between 1892 and 2014 and with Almenberg et al. (2017), who conclude that the optimal capital ratio should lie between 5% and 12%. At the opposite, our results suggest that the risk weighed capital requirement is sufficiently high, as this capital ratio always has a negative impact on the probability that a banking crisis occurs.

4. Conclusion

We study if the bank capital to total assets ratio and the bank regulatory capital to RWA affect the probability of banking crises in the EU between 1998 and 2017. We find that capital ratios are associated with lower probabilities of a banking crisis. Our results are robust to various specifications which include control variables related to banking, financial and macroeconomic risks. The bank capital to total assets ratio has a significant effect only for high levels, around 11%.

It could suggest that the leverage ratio implemented by Basel III at a 3% level may be insufficiently high to prevent a banking crisis. Our results also show that the ratio of bank capital to RWA is effective to reduce the probability of a banking crisis. This could mean that the discretionary use of internal models by banks does not conflict with the objective of improving resilience, despite the willingness of Basel Committee of reducing their usage in the finalised version of the Basel III agreement, in 2017. In sum, our results show that capital requirements under Basel III will likely strengthen financial stability through their negative impact on the likelihood of banking crises.

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APPENDIXES

Table A. Link between capital ratio and banking crisis.

Summary of results from the empirical literature

	Type of capital ratio	Dependent variable	Coverage	Period	Econometric model	Results
Almenberg et al. (2017)	Ratio Tier 1 capital to total assets	Probability of a banking crisis, which happens when at least one of the four large Swedish bank is defaulting	Major Swedish banks	NA	Standard structural and reduced probability of default models (Merton, 1974)	Increasing the ratio of capital decreases the probability of a crisis, and the appropriate capital Tier 1 ratio lies between 10 and 24%
Barth and Miller (2018)	Ratio Tier 1 capital to total assets	Probability of a banking crisis, using data from multiple studies	US banks	1892-2014	Probit, Logit	Increasing the ratio of Tier 1 capital from 4 to 15 percent decreases the probability of a crisis from 25% to around 7-8% for a given year. The optimal leverage ratio equals 19%
Berger and Bouwman (2013)	Ratio Core Tier 1 Capital to total assets	Banks'survival	U.S. banks	1984-2010	Logit	Increasing the ratio of Core tier 1 to gross total assets by on standard deviation increases banks' survival probabilities by about 50%
Basel Committee on Banking Supervision (2010)	Ratio Core Tier 1 Capital to RWA	Probability of a banking crisis, using data from Reinhart and Rogoff (2008) and Laeven and Valencia (2008)	BCBS members	1980-2008	Reduced-form models, calibrated portfolio models, calibrated stress test models	The optimal ratio lies between 10 and 15%. Increasing the capital ratio from 7 to 8% reduces the probability of a crisis by one third
Boissay et al. (2019)	Actual capital ratios and regulatory capital ratios	Probability of a crisis (definition varies between studies)	83 studies from the FRAME[10] (13 assess the impact of regulatory ratios on the probability of crisis/banks' default)	NA	Meta-analysis	A one percentage point increase in the capital ratio decreases crisis risk by 1.07 percentage points. Results are quite similar between studies
Brooke et al. (2015)	Ratio Core Tier 1 capital to total assets	Probability of a banking crisis, which happened when system-wide recapitalization costs exceed 3% of GDP, as in Laeven and Valencia (2012)	UK banks	NA	Bottom-up approach and top-down approach with a Logit	An increase in capital ratios decrease the probability of a crisis. The optimal Tier 1 capital ratio lies between 10% and 14% in United Kingdom
Dagher et al. (2016)	Capital to RWA	Nonperforming loans/total banks assets, using the indicator from Laeven and Valencia (2013)	Countries that experienced a banking crisis since 1970	1970-2011	Bottom-up approach	Banks' risk-weighted capital ratios between 15% and 23% would have been enough to absorb losses in advanced economies during 80% of the banking crises
Firestone et al. (2019)	Ratio Tier 1 capital to total assets	Probability of a crisis, using the indicator from Laeven and Valencia (2012)	US banks	1988-2014	Bottom-up approach and top-down approach with a Logit	The optimal capital ratio lies between 13% and 26% in the US. An increase in capital ratios decrease the probability of a crisis
Jordà et al. (2021)	Ratio Core Tier 1 capital to total assets	Probability of a banking crisis, using narrative identification	17 advanced economies	1870 -2015	Probit	A 2-percentage point rise in the capital ratio leads to a 0.34 percentage point increase in the likelihood of a banking crisis
Mikkelsen and Pedersen (2017)	Ratio Tier 1 capital to total assets	Probability of a financial crisis, using the indicator from Jordà et al. (2017)	OECD	1980-2013	Logit	A 1 percentage point rise in the capital ratio lead to a 1.2 percentage points decrease in the likelihood of a financial crisis
Miles et al. (2013)	Ratio Tier 1 capital to RWA	Probability of system banking crisis, which happens when asset values decrease by more than the level of bank equity	UK banks	Nearly 200 years	Bottom-up and top-down approaches	Higher capital requirements reduce the probability of systemic banking crises. The optimal capital ratio lies between 16% and 20%

[10] The Financial Regulation Assessment: Meta Exercise (FRAME) is an online repository which contains studies that focus on the economic impact of numerous types of financial regulations.

Table B. Data definitions and sources

Name	Description
Banking crisis	Dummy variable equal to 1 when banking crisis occurs,
Bank capital to total assets	Ratio of bank capital and reserves to total assets (%)
Bank regulatory capital to RWA	Total regulatory capital to RWA (%)
Δ5 Credit/GDP	5-year average annual growth rate of the ratio of private credit to GDP (%)
Bank net interest margin	Bank's net interest revenue to its interest-bearing assets (%)
Bank noninterest income to total income	Bank's income generated by noninterest related activities as a percentage of total income (%)
RoA	Return on Assets (%)
RoE	Return on Equity (%)
Z-score	(RoA+(equity/assets))/(Standard deviation of RoA)
Nonperforming loans	Ratio of defaulting loans to total gross loans (%)
Bank credit to bank deposits	Ratio of private credit provided by banks to their total deposits (%)
Liquid liabilities to GDP	Ratio of liquid liabilities (broad money or M3) to GDP (%)
Liquid assets to deposits and short-term funding	Ratio of banks' liquid assets to short-term funding plus total deposits (%)
Concentration	Ratio of assets of five largest banks to total commercial banking assets
Stock market return	Growth rate of annual average stock market index (%)
Stock price volatility	Average of the 360-day volatility of the national stock market index
Central bank assets	Ratio of central bank assets to GDP (%)
GDP Growth	Annual variation of GDP per capita
Inflation	Average Consumer Price Index (2010=100)

Note: The source of the data is the World Bank Global Financial Development Database.

Table C. Descriptive Statistics

	Obs	Mean	Std. Dev.	Min	Max	1st decile	9th decile
Bank capital to total assets (%)	505	7.37	2.69	2.00	18.30	4.50	11.26
Bank regulatory capital to RWA	522	15.05	4.31	6.60	41.80	10.90	20.47
Δ_5 Credit/GDP	499	0.03	0.08	-0.42	0.31	-0.06	0.13
Bank net interest margin (%)	560	2.39	1.67	0.13	20.47	0.85	4.23
Bank noninterest income to total income (%)	559	40.45	11.30	14.64	81.25	26.80	55.62
RoA (%)	560	0.55	1.30	-10.47	4.24	-0.32	1.66
RoE (%)	560	7.42	14.81	-117.67	55.18	-4.74	18.80
Z-Score (%)	559	11.84	7.40	0.02	47.57	4.33	21.65
Nonperforming loans	507	6.28	7.30	0.10	48.68	0.70	14.80
Bank credit to bank deposits (%)	528	118.88	55.49	17.79	367.08	63.48	178.82
Liquid liabilities to GDP (%)	543	99.08	126.81	3.69	938.72	38.30	145.49
Liquid assets to deposits and short-term funding (%)	560	37.41	16.81	5.26	130.63	18.11	59.79
Concentration	549	81.40	13.72	41.40	100.00	66.23	98.14
Stock market return	511	7.29	26.87	-74.62	125.05	-25.27	37.48
Stock price volatility	508	21.60	9.07	6.34	61.33	12.00	33.20
Central banks assets	525	2.19	3.81	0.00	28.41	0.01	7.31
GDP Growth	560	0.02	0.04	-0.16	0.21	-0.01	0.06
Inflation	560	92.61	15.08	15.06	115.46	73.72	108.63

Source: World Bank Global Financial Development Database.

Table D. Sensitivity estimations

Panel A: Logit						
	(1)	(2)	(3)	(4)	(5)	
Δ_5 Credit/GDP	4.69**	4.87**	21.01***	2.21	10.99**	
	[2.16]	[2.45]	[5.14]	[2.41]	[4.54]	
Bank capital to total assets		-0.34***				
		[0.09]				
Bank regulatory capital to RWA				-0.19**		
				[0.08]		
Δ_5 Bank capital to total assets			2.66			
			[3.69]			
Δ_5 Bank regulatory capital RWA					-1.99	
					[5.37]	
N	472	428	308	444	325	
AUC	0.68	0.72	0.80	0.71	0.75	
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	
AUC-PR	0.25	0.27	0.52	0.26	0.38	
Panel B: Subsamples						
	Removing outliers				*2008-2010*	
	(1)	(2)	(3)	(4)	(5)	(6)
Δ_5 Credit/GDP	2.61*	2.49			4.81	3.27
	[1.36]	[1.53]			[3.87]	[3.98]
Bank capital to total assets			-0.20***		-0.20	
			[0.06]		[0.13]	
Bank regulatory capital to RWA				-0.09**		-0.24**
				[0.04]		[0.09]
Bank capital to total assets _rob	-0.18***					
	[0.07]					
Bank regulatory capital _rob		-0.09*				
		[0.04]				
Δ_5 Credit/GDP_rob			6.17***	3.82*		
			[2.16]	[2.21]		
N	392	398	392	406	75	76
AUC	0.70	0.69	0.75	0.72	0.72	0.71
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
AUC-PR	0.24	0.26	0.33	0.31	0.28	0.26
Panel C: Credit/GDP						
	(1)	(2)	(3)	(4)	(5)	(6)
Credit/GDP		0.01***			0.01***	
		[0.00]			[0.00]	
Δ_1 Credit/GDP			0.55			-0.95
			[0.75]			[0.94]
Bank capital to total assets	-0.10**	-0.11**	-0.11**			
	[0.04]	[0.05]	[0.05]			
Bank regulatory capital to RWA				-0.11***	-0.11***	-0.13***
				[0.03]	[0.04]	[0.04]
N	485	464	457	500	480	473
AUC	0.62	0.74	0.65	0.67	0.76	0.69
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
AUC-PR	0.20	0.35	0.23	0.27	0.46	0.24

Note: The Table presents Logit (Panel A) and Probit (Panel B and C) models where the dependent variable is the banking crisis and the regressors are lagged by one period. In panel B "_rob" is associated to variables for which we discard the outliers (bottom 5% and top 95%). In panel C, Credit/GDP stances for the level of credit to GDP and $\Delta 1$ Credit/GDP is one-year annual growth rate of credit to GDP ratio. Country fixed effects are included. Clustered (by country) standard errors in brackets. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table E. Threshold

	(1)	(2)	(3)	(4)	(5)	(6)
	Below 80th percentile		Below 85th percentile		Below 90th percentile	
Δ_5 Credit/GDP	2.44*	-2.75	2.54*	-2.99	2.60*	-3.32
	[1.44]	[2.61]	[1.44]	[2.62]	[1.42]	[2.51]
Bank capital to total assets	-0.10	-0.09	-0.13*	-0.11	-0.16***	-0.17**
	[0.08]	[0.08]	[0.07]	[0.08]	[0.06]	[0.08]
Bank controls	No	Yes	No	Yes	No	Yes
Financial Controls	No	Yes	No	Yes	No	Yes
Macro Controls	No	Yes	No	Yes	No	Yes
N	336	269	354	281	374	296
AUC	0.72	0.86	0.72	0.86	0.72	0.87
	(0.03)	(0.03)	(0.03)	(0.02)	(0.03)	(0.02)
AUC-PR	0.28	0.51	0.27	0.53	0.27	0.54

Note: The Table presents Probit models where the dependent variable is the banking crisis and the regressors are lagged by one period. Country fixed effects are included. Bank controls include bank interest margin, bank non-interest income, RoA, Z-score, bank non-performing loans, bank credit to bank deposits, liquid liabilities, liquid assets to deposits, banking concentration. Financial controls include stock market returns and stock market volatility and macro controls include central banks assets, GDP per capita growth rate and inflation. Clustered (by country) standard errors in brackets. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Chapter 3

Macroprudential policies and retail banking interest rates in a low interest rate environment

This chapter is co-authored with Christophe Blot, Fabien Labondance and Catherine Refait-Alexandre.

1. Introduction

Although monetary policy has a considerable influence on banking interest rates, the global financial crisis has reduced the efficiency of the interest rate pass-through (Ciccarelli et al., 2013). More precisely, central banks across the world started to decrease their main interest rates in the aftermath of the crisis, which poses a challenge when these rates reach the effective lower bound (ELB) as conventional monetary policy become inefficient. For the European Central Bank (ECB), the ELB was reached on May 2009 as no further cut in the main refinancing operations (MRO) rate was expected. This challenge pushes the ECB to innovate and to use unconventional monetary policies in order to restore the transmission of monetary policy. To achieve this goal, the ECB relied on a variety of unconventional instruments (such as forward guidance, liquidity provisions and asset purchase programmes) that have proven to be effective in influencing banking interest rates during the ELB period (Blot and Labondance, 2022).

On another note, during the mid-2010's, macroprudential authorities started to implement tightening measures such as capital and liquidity requirements in order to increase the resilience of financial institutions. Like monetary policy, macroprudential instruments may have effects on banks' lending rates too, as shown for instance by Imbierowicz et al. (2021) and Osborne et al. (2017). Macroprudential policies are expected to influence banking cost of credit. In return, a significant part of these costs may be passed on to their clients through a rise in banking interest rates.

In particular, capital requirements play a crucial role. As highlighted for instance by Motaze (2022), one of the determinants of the lending interest rate is the cost of resource. As capital requirements influence the capital structure of banks, it influences their weighted average cost of capital and, consequently, their costs of credit. Equity is riskier than debt, which leads investor to expect high return to compensate for their risk taking (Almenberg et al., 2017), therefore higher capital requirements may increase funding costs (See for instance Barth and Miller, 2018 or Gambacorta and Shin, 2018). In addition, according to Miller and Modigliani (1961) there are several frictions which make banks' funding costs between equity and debt different, such as difference in taxes, or asymmetric information. The role of states guarantee for depositors also makes debt financing cheaper. Hence, when capital requirements request

banks to increase their equity[1], their funding costs may increase. As a consequence, banks may transfer these costs to their borrowers through a rise in banking interest rates although the effect is generally small (e.g. Cosimano and Hakura, 2011, or Kisin and Manela, 2016), and even sometimes no significant (Imbierowicz et al., 2021).

By contrast, according to Modigliani and Miller (1958) framework, when banks accumulate equity, they become less risky as equity can absorb losses, which lead to a decrease of required return rates related to funding costs because equity becomes less volatile and debt safer. Moreover, banks may take several actions other than increasing their credit rates when they are required to accumulate equity, such as rising banking fees, decreasing deposit interest rates, reducing credit to bank borrowers that are highly dependent on bank credit (for example, medium-sized enterprises) and/or their operating expenditures (Basel Committee on Banking Supervision, 2010, Brooke et al., 2015). Furthermore, tighter capital requirements make the supply of deposits scarcer, which may encourage households to accept lower interest rates on deposits if they value liquidity provision by banks through deposits (Begenau, 2020). Thus, aside from increasing banks' monitoring incentives tighter capital requirements may cause a fall in banks' funding costs. (e.g. Toader, 2015, Santos and Wilson, 2013 or Boissay et al., 2018). Hence, some studies show that higher capital requirements lead to a reduction in banking cost of credit (e.g. Boissay et al., 2018 or Santos and Winton, 2013).

The objective of our study is to highlight the empirical effects of monetary and macroprudential policies on banking interest rates in the Eurozone. On one hand, during the last decade, monetary policy has been loosened in the Eurozone: the ECB has relaxed its key rates and has started to use unconventional monetary policies. On the other hand, the Eurozone has seen a significant increase in capital and liquidity requirements over the last decade, mainly due to the implementation of Basel 3 agreements. In particular, in 2013 the Capital Requirements Directive IV (CRD IV) establishes the legal basis of the countercyclical capital buffer of the capital conservation buffer and of the leverage ratio.

When measuring the macroprudential policy stance, the empirical literature often uses a value of +1 for a country that implement a tightening in a given instrument, a value of -1 when this country implements a loosening, and a value of 0 when no change occurred (see for instance the databases developed by Cerutti et al., 2017b, or Alam et al., 2019). Hence, the empirical

[1] As capital is a subcategory of equity, some capital measures require banks to raise equity. For example, Basel III standards increase the minimum Common Equity Tier 1 capital ratio for banks to 4.5% of their risk-weighted assets.

literature on macroprudential policy is confronted to an aggregation bias, as studies often use indicators which are based on the sum of policy action indicators of several macroprudential instruments. In order to avoid this bias, we consider separately 13 macroprudential instruments based on Alam et al. (2019), which provides information about the orientation of each instrument. Hence, these indexes indicate for a given country in a given month if a given macroprudential instrument is tightened, loosened or neutral. As for the sample, we focus on the post-crisis period and consider 11 Euro Area members from May 2009 to December 2019, as May 2009 represents the start of the ELB in the Eurozone.

As it is challenging to measure the transmission of monetary policy during the ELB, we follow the methodology used by Blot and Labondance (2022). We use Overnight Indexed Swaps (OIS) rates as these rates give information about the conduct of the monetary policy, even during the ELB. In addition to the OIS rates, as central banks have expanded their monetary arsenal since the start of the ELB, we add variables in our model that allow us to estimate the effects of several non-standard measures, such as liquidity provisions and ECB's asset purchase programmes. Furthermore, we consider the effects of macroprudential policies on banking interest rates by including the macroprudential indexes measured by Alam et al. (2019) for 13 instruments in our estimations. In our econometric analysis, we first test the cointegration between the OIS rate and the banking interest rates. Second, we rely on the mean-group (MG) estimator introduced by Pesaran and Smith (1995) for estimating panel Error Correction Models (ECM), as this estimator is suitable for nonstationary heterogeneous panels. Indeed, this model is more suited than fixed effects in our analysis as there is heterogeneity in our sample due to countries' differences.

First, we find that the OIS rate increases banking interest rates, while unconventional monetary policies reduce them. Second, we show that capital conservation buffers have an influence on banking interest rates for loans to non-financial corporations during the ELB period in the Eurozone. Tightening actions seem to reduce interest rates for loans over € 1 Million, while they have no impact on these rates for loans below € 1 Million. These results may be explained by the possibility for large corporations to use other sources of funding if credit banking becomes less advantageous, which may refrain banks to increase their rates. The results are robust to the use of the pooled mean-group (PMG) estimator, to the use of alternatives measures of conventional and unconventional monetary policies, to changes in control variables or to the consideration of different periods.

This paper also addresses the question of the influence of monetary policy banking interest rates during the ELB. Hence, this paper is related to the literature that assess the pass-through of monetary policy[2], whose early studies are Cottarelli and Kourelis (1994), Cechetti (2001), and Mojon (2000, 2001). Furthermore, this paper is closely linked to the literature that analyzes the changes in the monetary pass-through after the great financial crisis. Hence, studies such as Blot and Labondance (2013) and Aristei and Gallo (2014) find that during periods of financial distress, the transmission of ECB policy rate to bank lending rates is reduced. It is also related to studies that focus on the interest channel of the monetary policy during the ELB, and thus measure the monetary policy through the OIS rate (e.g. Abenassi and Linzert, 2012, Quint and Tristani, 2018). Finally, this paper is related to the literature that assess the impact of macroprudential measures on banking interest rates such as Osborne et al. (2017) and Imbierowicz et al. (2021). Osborne et al. (2017) find that Tier 1 capital ratio decreases banking interest rates for corporations in the United Kingdom (UK) lending market, while Imbierowicz et al. (2021) show that capital requirements have no effects on German banks' lending rates.

This paper is organized as follows. Section 2 provides a brief overview of both policies and how they are measured in our study in addition to the data description. Section 3 presents the empirical model and the results. Section 4 concludes.

2. Banking interest rates, monetary policy and macroprudential policies: Dataset and variables description

Our sample is composed of 11 members of the Eurozone[3], from May 2009 to December 2019. We obtained country level data with a monthly frequency, harmonized for the Euro Area. Our sample contains 1408 observations. Table A in appendix presents a description of our variables.

[2] For example, some studies focus on the impact of unconventional monetary measures on the interbank market (e.g. Szczerbowicz, 2015), on credit growth (e.g. Martins et al, 2019), or even on the economic activity (e.g. Gambacorta et al., 2014).

[3] Our sample is reduced to 11 countries due to data limitations. Countries included are: Germany, France, Italy, Spain, the Netherlands, Belgium, Ireland, Austria, Finland, Portugal and Greece.

2.1 Banking interest rates

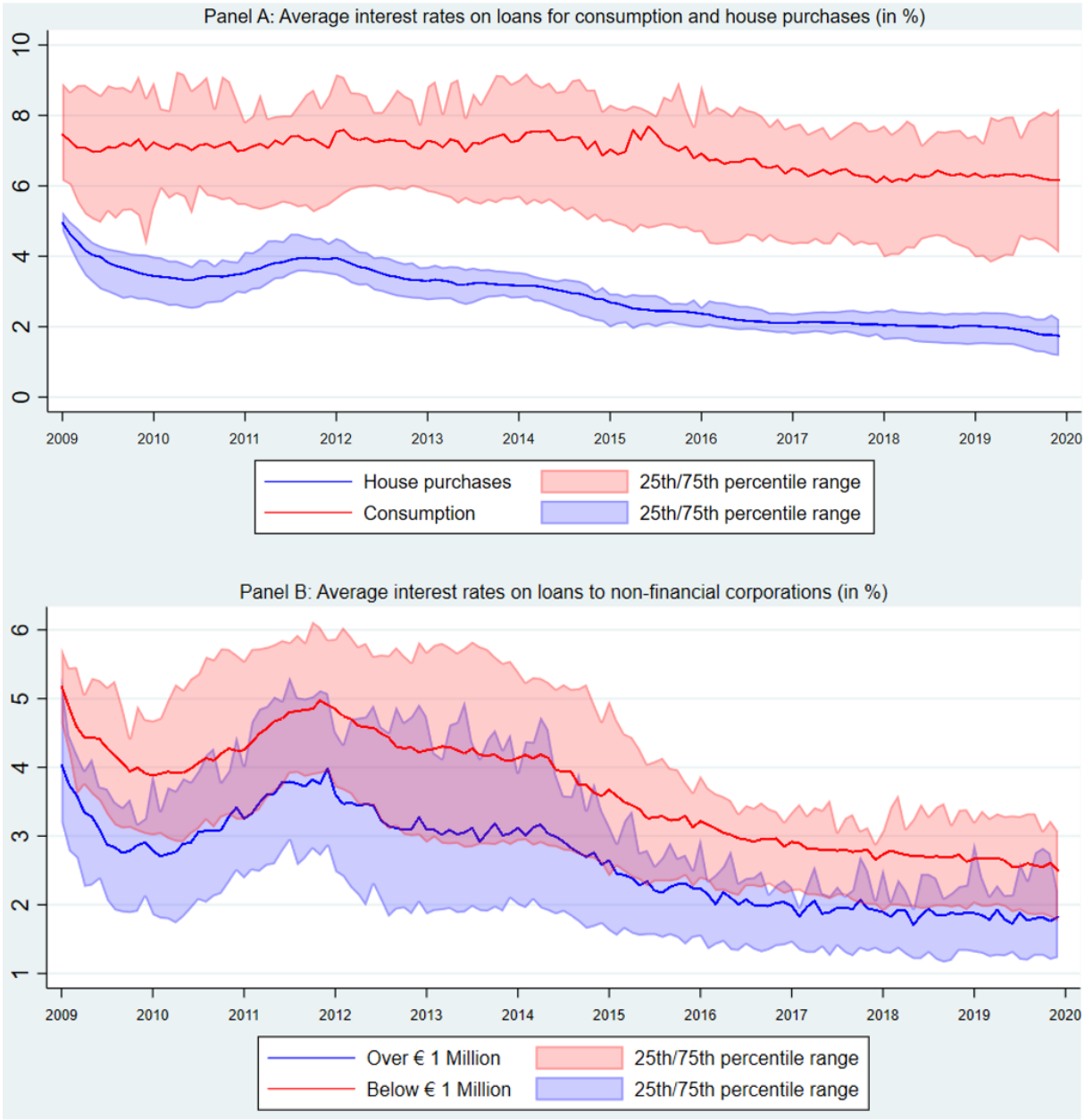
We analyse the impact of monetary policy and macroprudential policies on banking interest rates between May 2009 to December 2019, on four markets: loans to households for consumption, loans to households for house purchases, loans to non-financial corporations below € 1 Million and loans to non-financial corporations over € 1 Million. We use the series called "total maturity" available from the ECB MFI interest rate (MIR) database as well as data from national central banks when facing missing values.[4]

Figure 1 displays the evolution of the average interest rates for the four markets between 2009 and 2019. For all markets, the mean value decreased continuously during the whole period – despite a rebound around 2011 mainly due to the European debt crisis. Concerning households, the average value is lower for house purchases loans than for consumption loans, as the latter are riskier for banks (panel A). Moreover, the interest rates on loans to non-financial corporations are on average lower for loans over € 1 Million than for loans below € 1 Million, in particular because the latter are often contracted by smaller firms which have a greater risk of default (panel B).

Overall, the interquartile range indicates that the spread of interest rates between countries in our dataset increases. Actually, Euro Area members were hit differently by the global financial crisis. We consider this heterogeneity by using an error-correction model, as described in section 3.1.

[4] We partially use interest rates provided by national central banks: for Greece (loans to non-financial corporations below € 1 Million), Netherlands (loans for consumption), Italy (loans for consumption), and Belgium (loans to non-financial corporations over € 1 Million). Moreover, we use interest rates with an agreed maturity up to one year to deal with missing values for interest rates on loans to non-financial corporations below € 1 Million in Greece, as this series is highly correlated with the series « total maturities ».

Figure 1. Banking interest rates in the 11 Euro Area members between 2009 and 2019



Source: ECB monetary financial institutions interest rate database.

2.2 Monetary policy

In this chapter, we assess whether monetary and macroprudential policies have an influence on retail banking interest rates since the ELB period. In order to do so, we need to identify when the ELB period started. We consider that the ELB starts in May 2009 for two reasons. First, although the MRO and the overnight rate (EONIA) were set at 0% respectively in March 2016 and in July 2014, the MRO rate reached a floor at 1% in May 2009. At that date, ECB watchers did not expect any further cut in the MRO rate. Second, the ECB started to use

unconventional monetary measures on that date with the announcement of the Covered Bond Purchase Programme (CBPP) programme. This programme was supposed to ease funding conditions for banks as conventional monetary policy was now unable to influence banking interest rates, credit growth, inflation and banks' funding conditions.

Following the beginning of the global financial crisis, the ECB started several long-term refinancing operations, namely Supplementary Long-Term Refinancing Operations (SLTRO) with maturity of six months and one year, and very-long term refinancing operations (VLTRO). Their goals were to mitigate the illiquidity issue in Euro Area money markets by providing ample liquidity to the banking system at extended maturities (Fratzscher et al., 2016). Hence, six month SLTRO were introduced in March 2008, 12 month SLTRO were announced in May 2009, and VLTRO were announced in December 2011 namely due to the sovereign crisis.

At the same time, a second group of unconventional monetary measures were implemented, which took the form of assets purchase programmes. The first CBPP was announced in May 2009. It was considered as the first unconventional monetary policy action taken by the Eurosystem (Markmann and Zietz, 2017). Its objective was to ease funding conditions for banks. Afterwards, CBPP2 and CBPP3 were announced respectively in October 2011 and September 2014. The Securities Market Programme (SMP) was announced in May 2010 and the Outright Monetary Transaction (OMT) in August 2012. Their goal was to restore the transmission of monetary policy (Cœuré, 2013, Eser and Schwaab, 2016). Then, the ECB announced in January 2015 the asset purchase programme (APP) in order to increase inflation in a context of falling inflation across the whole Euro Area (Georgiadis and Gräb, 2016). This programme is itself divided into the CBPP3, the Asset-Backed Securities Purchase Programme (ABSPP), the Public Sector Purchase Programme (PSPP) and the Corporate Sector Purchase Programme (CSPP).

The literature has identified two main channels through which these unconventional monetary measures influence retail interest rates, namely the signaling and the portfolio balance channels (Bauer and Neely, 2014). First, when central banks communicate, for example through an announcement of an asset purchases programme, it sends a signal to investors that monetary path for future short-term rates will likely be lower, which leads to a decrease in long-term interest rates. Hence, this signalling channel is manifested through the diffusion of news on expected future policy interest rates, and has been identified not only for asset

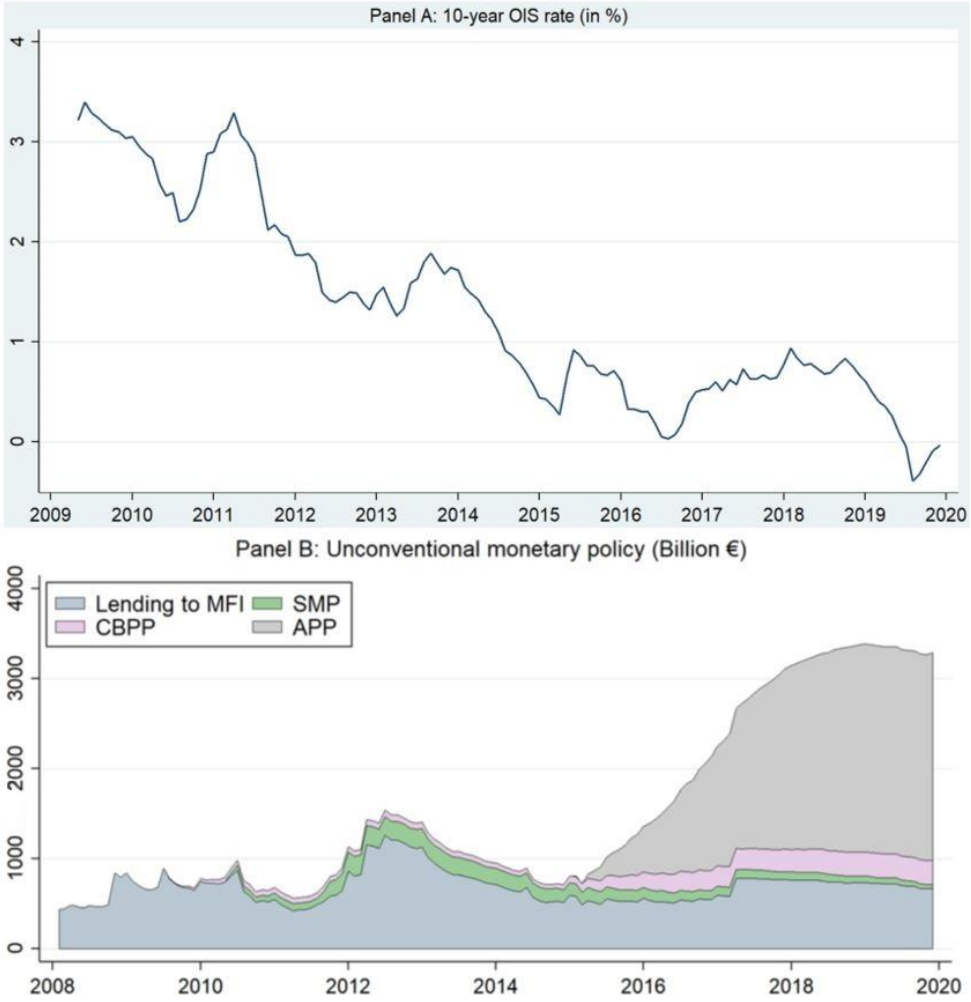
purchase programmes but also for forward guidance announcements (Hubert and Labondance, 2018) and liquidity provision, as all unconventional operations may contain information about future intentions of central banks (Falagiarda and Reitz, 2015). Second, assets purchase programmes increase the price of specific assets such as bonds and securities and decrease the term premia in long-term yields related to these assets, as well as their substitutes. Through the portfolio balance channel, this fall in term premia is transmitted to financial market conditions notably through a reduction of the default risks for sovereign debts. As a results, these two channels may reduce banking interest rates for households and non-financial corporations.

We measure the influence of monetary policy with the 10-year OIS rate, which is extracted from Thomson Reuters Eikon. The OIS rate takes into account both conventional and unconventional monetary policies, as this measure is based on the average market participants' expectations for the EONIA at this maturity. More precisely, these expectations are based on the average policy rate over the horizon related to the maturity of the swap (Bauer and Rudebush, 2014). Therefore, it still provides information about the monetary policy path at the ELB, as it captures the future monetary policy rate as expected by investors in addition to the current monetary policy rate.

In addition, we look at the impact of specific unconventional monetary measures introduced by the ECB through the variable *Balance sheet*, namely the CBPP, the SMP, the APP and the liquidity provisions programmes (Lending MFI hereafter). Hence, we account for the influence of unconventional monetary measures (liquidity provisions and assets purchases programmes) on banking interest rates through banking risk, sovereign risk as well as the term premium.[5] Data for unconventional monetary policy come from the consolidated weekly financial statement at the Eurosystem and are taken in logarithm of the amount provided in the Euro Area, in current euros.

[5] Studies such as Szczerbowicz (2015) and Blot et al. (2020) display evidence that assets purchase programmes decrease the default risks for sovereigns.

Figure 2. 10-years OIS rate, unconventional monetary policy in the Eurozone



Note: *Lending to MFI* refers to liquidity provisions measures, *CBPP*, *SMP*, and *APP* respectively, stand for covered bond purchase programme, securities market programme and asset purchase programme. Sources: Thomson Reuters Eikon, ECB.

Figure 2 displays the evolution over time of monetary policy since the global financial crisis. We observe the implementation of the APP in addition to the other asset purchases and liquidity provisions programmes (panel B). The latter is partially reflected in the decrease of the 10-year OIS rate (panel A). Monetary policy has been largely loosened as the OIS rate has fallen and as the ECB has implemented unconventional monetary policy decisions.

2.3 Macroprudential policies

To assess the impact of macroprudential policies on banking interest rates in a low interest rate environment, we need to quantify the implementation of these macroprudential tools.

There is no consensus about the way to compute the intensity of macroprudential measures: a large part of the empirical literature differentiates between tightening and loosening measures or only computes the number of measures implemented (e.g. Claessens et al., 2013, or Cerutti et al., 2017a), while studies such as Vandenbussche et al. (2015) and Richter et al. (2019) measure the intensity of macroprudential instruments. In this paper, we rely on data which comes from the Integrated Macroprudential Policy (iMaPP) database from Alam et al. (2019) in order to compute the macroprudential instruments indexes. The iMaPP database contains monthly data for numerous countries from January 1990 to December 2020 based on the implementation date, for 17 macroprudential instruments.[6] We focus on 13 of these instruments that were used at least once in our sample: *Countercyclical capital buffer*, *Capital conservation buffer*, *Capital requirements for banks*[7], *Loan loss provisions*, *Loan restrictions*, *Limits on foreign currency*, *Limits on the loan-to-the-value ratio*, *Limits on the debt-service-to-income ratio*, *Tax measures*, *Liquidity requirements*, *Reserve requirements*, *Measures targeting systemically important financial institutions*, and *Other types of macroprudential measures*. In the iMaPP database, tightening and loosening actions are recorded for each instrument. A tightening action is coded +1 whereas a loosening action is coded -1, and a value of 0 is coded when no change occurs in an instrument α during a month t in a country j. Our macroprudential indexes follows the same logic and is defined as follows:

$$IMAPP_{j,t} = \begin{cases} +1 \;\; if \sum_{\alpha} x_{\alpha,j,t} > 0 \\ 0 \;\; if \sum_{\alpha} x_{\alpha,j,t} = 0 \\ -1 \;\; if \sum_{\alpha} x_{\alpha,j,t} < 0 \end{cases} \quad (1)$$

[6] The 17 types of macroprudential instruments are the following: countercyclical capital buffer, capital conservation buffer, capital requirements for banks, leverage limits, loan loss provisions requirements, limits on credit growth, loan restrictions, foreign currency loans measures, taxes and levies, liquidity measures, reserve requirements, measures on systemic banks, limits to the loan-to-value ratio, limits to the debt-services-to-income ratio, limits to the loan-to-deposit ratio, limits on the foreign exchange positions, and other types of macroprudential measures.

[7] *Countercyclical capital buffer* contains all measures that require banks to accumulate capital when the systemic risk is increasing, in order to increase the resilience of banks during downturns. The legal bases for the buffer are contained notably in Articles 130, and 135 to 140 of the Directive 2013/36/EU, i.e. the CRD IV. *Capital conservation buffer* refers to a capital buffer of a certain percentage of bank's total exposures (2.5% of RWA in Basel III agreements). In period of stress, if the level of the buffer is beneath the regulatory level, banks are constrained in the distribution of earnings. Under Basel III, there were implemented by the Article 160(6) of the CRD IV. *Leverage limits* captures capital measures which are based on ratios of capital to bank's non-risk weighted exposures (as the leverage ratio implemented by Basel III). *Capital requirements for banks* refers to the other capital measures that are not include in *Capital conservation buffer* nor in *Countercyclical capital buffer*: mainly risk based capital ratios, systemic risk buffers and other minimum capital requirements.

In equation (1), *IMAPP* refers to the 13 types of macroprudential instruments, while j denotes countries, t time, and α instruments included in our index. Thus, $x_{\alpha,j,t}$ represents the orientation of an instrument α for a country j in a month t.

The use of the macroprudential policies in the Eurozone is detailed in Table 1. This table displays the number of times these instruments were used since the ELB in our sample. The majority of these instruments were tightened rather than loosened (amongst the 207 actions, there were 179 tightening actions compared to only 28 loosening actions). This can be explained by the fact that our period is characterized by the implementation of Basel 3 in the Europe Union. The countercyclical buffer requirement was applicable on January 2016 (European Union (EU) jurisdictions were free to implement them before). The requirement of leverage ratio has been applicable since January 2021 but the definition of the ratio was implemented in European law in 2015 and so was its voluntary respect (See Basel Committee for Banking Supervision, 2021). Capital Conservation Buffer and Minimum Common Equity start their mandatory increase by 2018 (see Basel Committee for Banking Supervision, 2017). Liquidity requirements we introduced through the Liquidity Coverage Ratio (LCR) in 2015 and through the Net Stable Funding Ratio (NSFR) in 2018.

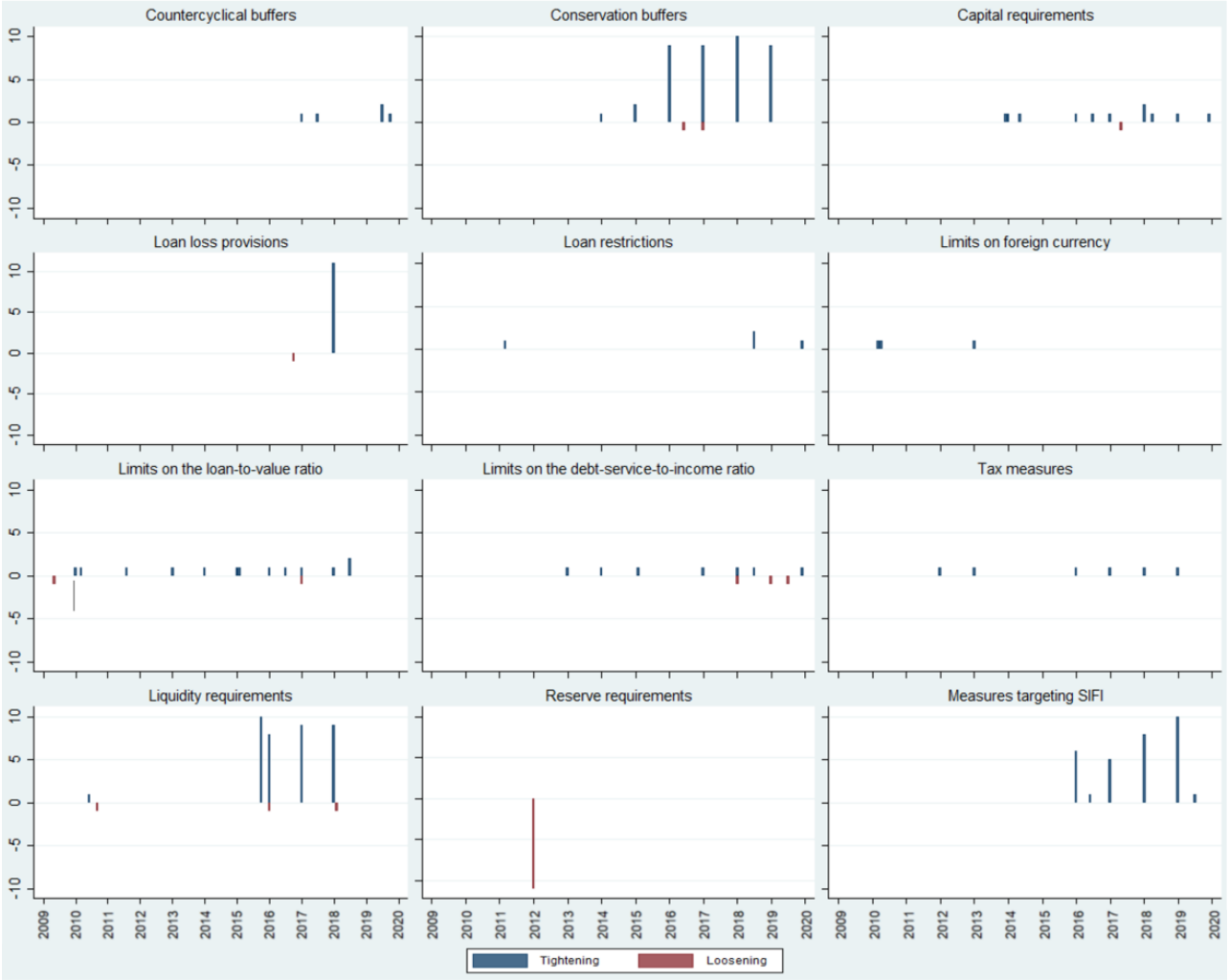
Table 1. Statistics on macroprudential actions in the Eurozone between May 2009 and Dec. 2019

Variable	-1	0	1	Total
Countercyclical capital buffer	0	1,403	5	1,408
Capital conservation buffer	2	1,366	40	1,408
Capital requirements for banks	1	1,396	11	1,408
Leverage limits	0	1,408	0	1,408
Loan loss provision requirements	1	1,396	11	1,408
Limits on credit growth	0	1,408	0	1,408
Loans restrictions	0	1,404	4	1,408
Foreign currency loans measures	0	1,405	3	1,408
Taxes and levies	0	1,402	6	1,408
Liquidity measures	3	1,368	37	1,408
Reserve requirements	11	1,397	0	1,408
Measures on systemic banks	0	1,377	31	1,408
Limits to the loan-to-value ratio	2	1,393	13	1,408
Limits to the debt-services-to-income ratio	3	1,398	7	1,408
Limits to the loan-to-deposit ratio	0	1,408	0	1,408
Limits on the foreign exchange positions	0	1,408	0	1,408
Other macroprudential measures	5	1,392	11	1,408
Total	28	23,729	179	23,936

Note: Column (-1) displays the number of loosening for all macroprudential instruments considered in Alam et al. (2019), while column (0) shows the number of times that no changes happened, and column (1) the number of tightening. Sources of the data: Alam et al. (2019), authors.

Figure 3 depicts the number of tightening and loosening measures over time in the Eurozone for all macroprudential instruments. We can observe an acceleration in the usage of these tools, consistent with the schedule of CRD IV. It appears that macroprudential measures were more intensively used in the sample, especially since 2016. This is due to a rise of tightening measures on the capital and liquidity requirements.

Figure 3. Number of loosening and tightening changes per macroprudential instrument



Note: This figure displays the number of tightening and loosening changes per month for the 13 macroprudential instruments included in our sample, for all countries. Sources Alam et al. (2019).

Although macroprudential policy has been evoked since the financial crisis of 2008, it seems that capital and liquidity requirements were widely used since the end of 2014 and in particular since 2016. Thus, macroprudential instruments are tightened in good times in order to strengthen the financial sector in case of a financial shocks while in bad times, macroprudential policy is loosened in order to assist economic recovery. In recent year (2016, 2017, 2018), it appears that conservation buffers and liquidity requirements were massively implemented in January across all countries, which correspond to the implementation of prudential measures in line with the Basel Committee's calendar. Hence, in January 2018, 10 of the 11 countries of our sample implemented a stronger tightening on conservation buffers at the exception of Finland, according to our index. Along the same lines, 10 of the 11 countries introduced liquidity requirements in 2015, apart from Belgium. This reflects the

implementation of the conservation capital buffers from the CRD IV (see above), as well as the introduction of the LCR.

3. The impact of macroprudential policies on retail banking interest rates: empirical strategy and results

3.1 Preliminary results using fixed effects panel estimations

First of all, we test a naïve model which allow us to justify what models we use in the following sections. In order to do so, we use a simple equation that contains the impact of the 10-year OIS ($OIS10Y_{t-l}$) and the *IMAPP* index ($IMAPP_{j,t-l}$) on banking interest rates ($rb_{j,t,k}$), using fixed effects panel estimations. This model is estimated for each country (j) at date (t) for all four markets (k):

$$\Delta rb_{j,t,k} = +\sum_{l=1}^{p2} \gamma_{j,k,l} \Delta OIS10Y_{t-l} + \varphi_{j,k} IMAPP_{j,t-l} + \varepsilon_{j,k,t} \quad (2)$$

Results based on equation (2) are presented in table 2.

Table 2. Fixed effects panel estimations

	Housing loans	Consumption loans	Loans <1 Million €	Loans > 1 Million €
Δ10-year OIS	0.039*	-0.207**	0.071	-0.024
	(0.021)	(0.082)	(0.047)	(0.032)
imapp	-0.010	0.042	0.059*	0.067***
	(0.010)	(0.050)	(0.031)	(0.013)
Constant	-0.015***	-0.017	-0.010	-0.017***
	(0.003)	(0.011)	(0.007)	(0.005)
N	1408	1408	1408	1408
Log-likelihood	1406.020	-651.412	-30.879	585.197

Note: The table presents fixed effects panel estimations based on equation (2). Changes in banking interest rates are estimated for four markets: loans to households for consumption, loans to households for house purchases, loans to non-financial corporations below € 1 Million and loans to non-financial corporations over € 1 Million. Δ10-year OIS refers to the 10-year OIS rate. imapp is the macroprudential index. All explanatory variables are lagged. Standard errors in parentheses. * p<0.10, ** p<0.05, *** p<0.01.

Concerning monetary policy, these results suggest that a tightening in monetary conditions increases banking interest rates for housing loans and decrease them for consumption loans. This is due to the fact that equation (2) suffers from several limits. Using only one measure of monetary policy does not allow us to differentiate between conventional and unconventional monetary policies. Hence, in the baseline estimates, we use a variable named *balance sheet* in addition to the 10-year OIS, which captures unconventional monetary policies on its own. As for our macroprudential index, it appears than a tightening on macroprudential policy increases banking interest rates for loans to non-financial corporations. More accurate results should be displayed as our index combine data from 13 macroprudential instruments that are very diverse. Therefore, we consider one variable per macroprudential instrument in the baseline estimates in order to minimize the aggregation bias. Finally, this model does not test for long-term relationship between the banking interest rates and the policy rate and, therefore, is not suited for cointegration. Thereafter, we test the presence of cointegration test with the Westerlund (2005) approach in our baseline estimates.

3.2 Assessing the interest rate pass-through in a lower interest rate context

During "normal" times, monetary policy influences retail bank interest rates mainly through the interest rate channel in the Euro Area (Angeloni et al., 2002). Hence, adjustments of these banking interest rates are provoked by changes in interbank money market rates such as the EONIA and the Euribor, which themselves react to modifications in central bank rates (Karagiannis et al., 2010). This transmission is partly dependent on the characteristics of the banking system such as the degree of competition (Leroy and Lucotte, 2015), the size of banks or their level of capitalization. All these factors may influence the mark-up that banks apply on loans.

The global financial crisis has harmed the transmission of monetary policy, which was the start of an atmosphere of distrust in the banking system as well as a period of liquidity crunch on the interbank market. In terms of banking interest rates, banks may have increased their risk premia following the rise in credit risk and insolvency of households, corporations and banks. In addition, some countries experienced an increase in the sovereign risk due to the sovereign debt crisis, which provoked a spike in banking interest rates around the end of 2011. Finally, the start of the ELB makes the transmission of conventional monetary policy impossible, thus forcing central banks to adopt new tools in order to restore this mechanism.

Hence, our goal is to assess whether ECB's monetary decisions and macroprudential policies have been transmitted to the retail banking interest rates. In order to do so, we follow Blot and Labondance (2022) and used panel data with a model that is suited for heterogeneities in the transmission of monetary and macroprudential policies during the ELB.

As our sample is composed of 11 countries for the period between May 2009 and December 2019, we use panel techniques in order to assess the impact of monetary and macroprudential policies on banking interest rates. However, our model is likely to suffer from heterogeneity due to differences between Euro Area members. More precisely, they were hit differently by the global financial crisis and the subsequent sovereign debt crisis depending on the characteristics of their national banking system, such as banks and borrowers' characteristics, the nature of bank-firm relationship and the capital structure of banks. In fact, Bouvatier and Delatte (2015) argue that the crisis of 2008 has led to a financial fragmentation amongst the Euro Area members. Thus, all these factors have an influence on the transmission of both policies to banking interest rates, which lead to heterogeneity in our data. Hence, it makes the use of the standard fixed-effect inadequate. Instead, we rather use the MG estimator introduced by Pesaran and Smith (1995) which performs better than the standards fixed-effect for nonstationary heterogeneous panels.

Equation (3) is estimated for the four markets: loans to households for consumption, loans to households for house purchases, loans to non-financial corporations below € 1 Million and loans to non-financial corporations over € 1 Million. In this error correction model, we explain the evolution of the retail banking interest rates by the change in monetary policy (current and future through the use of the 10-year OIS rate), specific unconventional monetary measures namely assets purchase programmes and liquidity provisions (*Balance sheet*), and by macroprudential policies (*MaPP*).

$$\Delta rb_{j,t,k} = \delta_{j,k} + \alpha_{j,k}\left(rb_{j,\,t-1,k} - \lambda_{j,k}.\,OIS10Y_{t-1} - Balance\ sheet_{t-1} - \phi_{j,k}SovCiss\right) + \sum_{l=1}^{p1}\rho_{j,k,l}\Delta rb_{j,k,t-l} + \sum_{l=1}^{p2}\gamma_{j,k,l}\Delta OIS10Y_{t-l} + \sum_{l=1}^{p3}\theta_{j,k,l}\Delta x_{j,t-l} + \varphi_{j,k}MaPP_{j,t-l} + \varepsilon_{j,k,t} \quad (3)$$

$rb_{j,t,k}$ stands for the retail-banking interest rate for country (j), at date (t) for each market (k), $OIS10Y_{t-1}$ refers to the 10-year OIS rate, $MaPP_{j,t-1}$ is a matrix that contains the 13 macroprudential instruments, and $x_{j,t-1}$ captures the control variables. These variables consider the influence of inflation through the harmonised consumer price indices (HCPI) which come from Eurostat, the volatility of the stock market through the Volatility Index (VIX) extracted from Thomson Reuters Eikon, and the sovereign stress through the Composite

Indicator of Systemic Sovereign Stress (SovCiss) taken from the ECB. It is expected that an increase in inflation and in global risk has a positive impact on banking interest rates related to loans, as well as an increase in inflation and in global risk. In these estimations, we are particularly interested by the coefficient $\varphi_{j,k}$ that assess the effect of macroprudential policies on banking interest rates.

As we assumed that there is a long-term relationship between the banking interest rates and the policy rate, we need to test for the presence of cointegration. We used the Westerlung (2005) test of cointegration, which performs well with heterogeneous panel data. We found that there is evidence of cointegration between the 10-year OIS rate and banking interest rates, for all markets and all countries. At the same time, we attribute a number of lags for the first-difference of the dependent variable and for the 10-year OIS rate based on the Akaike Information Criterion (AIC) and a number of lags equals to one for the control variables.[8] Hence, we can estimate our model with the MG estimator proposed by Pesaran and Smith (1995). We look at the average long-term pass-through of monetary policy decisions and at the average short-term impact of macroprudential policies. Table 3 presents preliminary results obtained using the MG estimator and the *IMAPP* index, which aggregates all macroprudential policy instruments.

[8] For sake of parsimony, we decided not to include any lags for the short-term pass-through of unconventional monetary policies. In addition, we do not show results for the VIX and the HCPI.

Table 3. Estimation with MG estimator and IMAPP

	Housing loans	Consumption loans	Loans <1 Million €	Loans > 1 Million €
10-year OIS	0.285***	-0.003	0.292***	0.243***
	(0.095)	(0.140)	(0.101)	(0.061)
Balance sheet	-0.567***	-0.395*	-0.427*	-0.197
	(0.182)	(0.230)	(0.241)	(0.222)
SovCiss	0.339***	0.243	0.469***	0.364*
	(0.066)	(0.154)	(0.168)	(0.187)
Error correction	-0.093***	-0.172***	-0.133***	-0.159***
IMAPP	0.007*	-0.025	0.036**	-0.019
N	1408	1408	1408	1408
Log-likelihood	2010.094	140.926	1384.577	608.381

Note: The Table presents estimations using the MG estimator proposed by Pesaran and Smith (1995), based on equation (3). Changes in banking interest rates are estimated for four markets: loans to households for consumption, loans to households for house purchases, loans to non-financial corporations below € 1 Million and loans to non-financial corporations over € 1 Million. Δ10-year OIS is the 10-year OIS rate. Balance sheet represents the CBPP, the SMP, the APP and the Lending MFI. SovCiss refers to the Composite Indicator of Systemic Sovereign Stress. IMAPP is the macroprudential index and is based on equation (1). All explanatory variables are lagged. For simplicity, we do not show the estimates for the VIX and the HCPI. Standard errors in parentheses. * p<0.10, ** p<0.05, *** p<0.01.

The error-correction term is significant and negative for all markets. We find that the 10-year OIS rate have a significant and positive impact on banking interest rates for nearly all specifications at the exception of consumption loans. These results suggest that banks transfer some costs related to monetary policy to their borrowers through change in retail interest rates.

Results for unconventional monetary policy measures have the expected negative coefficient for banking interest for all markets, except that it does not have an impact on loans over € 1 Million. These results suggest that unconventional monetary policies are effective in reducing banking interest rates.

Next, it appears that a tightening on the macroprudential stance increases banking interest rates on consumption loans and loans below € 1 Million to non-financial corporations. While these results give us a general idea of the impact of such measures on banking interest rates, our data allow us to assess the impact of each macroprudential instruments.

3.3 Baseline estimates

From now on, we disaggregate our *IMAPP* index into 13 macroprudential instruments. Table 4 presents the baseline estimates, which are based on the same methodology as in Table 3.

Table 4. Baseline models

	Housing loans	Consumption loans	Loans <1 Million €	Loans > 1 Million €
10-year OIS	0.273***	0.027	0.269**	0.239***
	(0.103)	(0.144)	(0.106)	(0.060)
Balance sheet	-0.557***	-0.244	-0.466*	-0.167
	(0.190)	(0.244)	(0.274)	(0.277)
SovCiss	0.369***	0.184	0.491***	0.392**
	(0.083)	(0.162)	(0.171)	(0.190)
Error correction	-0.092***	-0.177***	-0.128***	-0.159***
Countercyclical capital buffer	-0.001	-0.109	0.061	-0.010
	(0.005)	(0.119)	(0.049)	(0.020)
Capital conservation buffer	-0.017	-0.037	-0.035	**-0.130****
	(0.024)	(0.076)	(0.031)	(0.058)
Capital requirements for banks	0.015	0.131	0.026	0.025
	(0.013)	(0.140)	(0.026)	(0.037)
Loan loss provision requirements	-0.001	0.083	0.013	0.058
	(0.019)	(0.165)	(0.028)	(0.071)
Loan restrictions	0.009	-0.013	0.012	0.016
	(0.005)	(0.039)	(0.008)	(0.024)
Foreign currency loans measures	-0.001	-0.012	-0.004	-0.010
	(0.001)	(0.012)	(0.004)	(0.010)
Taxes and levies	-0.001	-0.002	-0.006	0.010
	(0.005)	(0.006)	(0.004)	(0.009)
Liquidity measures	**0.014***	0.036	0.091	0.029
	(0.008)	(0.099)	(0.079)	(0.033)
Reserve requirements	**0.056***	**-0.200****	**0.119*****	0.096
	(0.029)	(0.096)	(0.031)	(0.066)
Measures on systemic banks	-0.035	-0.118	0.033	**0.157***
	(0.031)	(0.114)	(0.037)	(0.081)
Limits to the loan-to value ratio	**0.008***	0.154	-0.016	-0.014
	(0.005)	(0.136)	(0.013)	(0.031)
Limits to the debt-services-to-income ratio and the loan-to-income ratio	-0.003	-0.134	0.021	-0.021
	(0.004)	(0.123)	(0.017)	(0.027)
Other macroprudential measures	0.009	**0.168***	0.035	0.081
	(0.014)	(0.101)	(0.030)	(0.050)
N	1408	1408	1408	1408
Log-likelihood	2042.785	187.196	1428.514	637.935

Note: The Table presents estimations using the MG estimator proposed by Pesaran and Smith (1995), based on equation (3). Changes in banking interest rates are estimated for four markets: loans to households for consumption, loans to households for house purchases, loans to non-financial corporations below € 1 Million and loans to non-financial corporations over € 1 Million. Δ10-year OIS is the 10-year OIS rate. Balance sheet represents the CBPP, the SMP, the APP and the Lending MFI. SovCiss refers to the Composite Indicator of Systemic Sovereign Stress. Results are presented for 13 macroprudential instruments. All explanatory variables are lagged. For simplicity, we do not show the estimates for the VIX and the HCPI. Standard errors in parentheses. * p<0.10, ** p<0.05, *** p<0.01.

As in Table 3, the baselines estimates suggest that banks increase their banking interest rates after a tightening in monetary policy as the error-correction term is significant and negative for all specifications. Our results show that the OIS rate have the expected negative and significant impact on all markets at the exception of consumption loans, for which there is no significant effect.

Results for unconventional monetary policy measures have the expected negative coefficient for banking interest rates related to housing loans and loans below € 1 Million to non-financial corporations. These results suggest unconventional monetary policies are efficient in reducing banking interest rates.

As for macroprudential policies, it appears that several instruments affect banking interest rates. Concerning loans to households, we find that liquidity measures, reserve requirements and limits to the loan-to-value-ratio increase banking interest rates related to housing loans, while reserve requirements reduce the interest rate linked to consumption loans. As for loans to companies, reserve requirements provoke a rise in banking interest rates related to loans below € 1 Million, while conservation buffers have a negative impact on rates for loans over € 1 Million and measures targeting systemic banks a positive one. In table B in appendix, we decompose the ECB balance sheet into three variables related to assets purchase programmes and one related to liquidity provisions programmes in order to avoid a potential aggregation bias, as these unconventional monetary policies have not evolved at the same pace. This table displays slightly different results. It suggests that only 2 of the 13 instruments have a statistically significant effect on at least one market, which are capital conservation buffers and reserve requirements. Capital conservation buffers were mainly introduced within the framework of Basel 3, with a general tightening amongst the countries in our sample in January 2016, 2017, 2018 and 2019.[9] As for reserve requirements, all countries have experienced a loosening in January 2012, as the ECB lowered the reserve requirement ratio from 2% to 1%.

Hence, we find that tightening on conservation buffers are associated with a decrease in banking interest rates for loans over € 1 Million to non-financial corporations. However, it appears that conservation buffers have no significant effect on banking interest rates for loans to households and for loans below € 1 Million to non-financial corporations.

The decrease of banking interest for loans over € 1 Million may be explained by the fact that an increase in capital requirements can reduce bank's funding costs (as in Begenau, 2020). Another explanation is the relationship between risk appetite and lending rates as suggested by Osborne et al. (2017). In their study, they found that an increase in the Tier 1 capital ratio has a negative impact on lending rates for corporations. They argue that it may be due to the fact that banks will likely decrease their risks during bad times, notably by changing the

[9] It was first introduced at 0.625% in 2016, then increased to 1.25%, 1.875% and 2.5% in respectively 2017, 2018, and 2019.

composition of lending from riskier loans with higher rates to safer loans with lower rates such as loans to non-financial corporations.

On the other side, the fact that capital requirements have no significant impact on several banking interest rates may be due to the fact that most banks often complied with these measures even before their implementation (Sutorova and Teplý, 2013). The main reason why there is such differences between loans below and over € 1 Million to non-financial corporations may be that banks are willing to decrease their interest rates on loans for large corporations, as the latter have easier access to financial markets or other financing options.[10] Notably, large firms may use other sources of funding such as equity funding or nonbank financial institutions actively engaged in the shadow banking system if the rise in banking interest rates is too high, which may disincentive banks to transfer costs related to tightening in macroprudential policy to this type of borrowers. In fact, macroprudential policies that focus on banks have less or no effects on "shadow institutions" (Forbes, 2019). Likewise, international corporations have easier access to cross-border bank credit provided by affiliated foreign branches owned by foreign-based banking groups. As these banks may be not involved in national or regional regulations contrary to domestically regulated banks (Aiyar et al., 2014), foreign branches may substitute for credit provided by domestically regulated banks if the latter increase their interest rates. In this line, Santos and Wilson (2013) find that the impact of capital requirements on lending rates is stronger for bank-dependant borrowers. So our results could be consistent both with studies finding that higher capital requirement lead to a decrease of lending rate (as Boissay et al., 2018, Begenau, 2020) and with studies putting forward the bank-dependency role.

The divergent findings over the different kind of loans may be explained by the possibility for banks to choose internal rating models in order to determine capital charges related to asset risk since Basel II, instead of the standard approach. On one hand, banks that adopted internal rating models are more likely to be larger banks due to the opportunity of benefiting from economies of scale, whereas smaller banks were more reluctant to adopt this approach because of its administrative costs (Behn et al., 2016, Benetton et al., 2021). On the other hand, small corporations borrow more from small banks, which usually use the traditional approach to capital regulation. Thus, large corporations may benefit from lower interest rates in their loans

[10] We assume that loans over € 1 Million are mostly contracted by large companies, whereas loans below this amount are mostly granted to small companies. For instance, in August 2021 in France, 527 trillions of euros were granted to 1,3 million small and medium-sized enterprises (SMEs) through banking credit (excluding loans below 25.000€), according to the French Banking Federation. Hence, the average size of the loans to SMEs is about 405.000 €.

because they borrow from large banks, whose internal rating models allow them to reduce capital charges (See Repullo and Suarez, 2004). At last, in a low interest rates environment, bank commissions represent a considerable part of the margins on bank lending. As these commissions are generally more important on loans to large corporations, banks could more easily decrease interest rates for these types of loans.

Furthermore, our baseline estimates show that reserve requirements decrease interest rates for consumption loans, and that they increase interest rates for loans below € 1 million to non-financial corporations.[11] However, these results should be interpreted with caution as the impact of reserve requirements is difficult to isolate from other policies (Ma et al., 2013). In fact, reserve requirements are often use in coordination with policy rates changes. Nonetheless, reserve requirements act as control in our model, and allow us to better isolate the impact of capital conservation buffers.

For robustness checks, we replace the 10-year OIS rate by the 5-year OIS rate, the 2-year OIS rate and the Euro Area sovereign interest rate. Then, we add the Industrial Production Index (IPI) in our model, and remove the control variables. In addition, we test our model for capital conservations buffers only, and we then replace the SovCISS by the sovereign rate of each country. Another test also considers using the PMG estimator proposed by Pesaran et al. (1999), which is based on the average of the short-term coefficients and on the pooling of the long run coefficients, and thus can be considered as a trade-off between the fixed-effect model and the MG estimator. At last, we test the robustness of our results for the whole period (since June 2005), then since the EONIA and the MRO were at the zero lower bound (ZLB) (respectively July 2014 and March 2016) and finally since the MRO was set at 0%. Table C in the appendix shows the results of our robustness checks which are mostly consistent with the baseline estimates for capital conservation buffers and reserve requirements.

3.4 Is the impact of macroprudential policies different between the core and the periphery of the Eurozone?

We investigate if our results are different between core countries of the Euro Area and peripheral countries. The reason behind this distinction is that peripheral countries have suffer more from financial stress and the sovereign debt crisis, two factors that may largely influence

[11] It appears that reserve requirements increase interest rates for housing loans, but it is only significant at the 10% level.

banking interest rates and their changes through the influence of monetary and macroprudential policies. Table 5 presents the impact of macroprudential policies on banking interest rates for core and peripheral countries. We did our subsamples based on the average of the sovereign spread relative to Germany, as German bonds are generally considered as the reference in the Euro Area, and even the EU. We considered a country as a core country if the mean spread was below 2 points. Thus, our core subsample contains Germany, Finland, the Netherlands, Austria, France, and Belgium, while the periphery subsample contains Spain, Greece, Ireland, Italy and Portugal.

Table 5. Core and periphery

	Core				Periphery			
	Housing loans	Consumption loans	Loans <1 Million €	Loans > 1 Million €	Housing loans	Consumption loans	Loans <1 Million €	Loans > 1 Million €
10-year OIS	0.394***	0.245*	0.384***	0.311***	0.129	-0.235	0.132	0.152
	(0.141)	(0.137)	(0.088)	(0.067)	(0.138)	(0.233)	(0.205)	(0.097)
Balance sheet	-0.618***	-0.093	-0.487***	-0.405***	-0.483	-0.426	-0.443	0.118
	(0.153)	(0.370)	(0.184)	(0.073)	(0.401)	(0.327)	(0.602)	(0.615)
SovCiss	0.376***	0.123	0.095	0.007	0.361***	0.257	0.971***	0.853***
	(0.129)	(0.112)	(0.086)	(0.060)	(0.114)	(0.352)	(0.207)	(0.308)
Error correction	-0.070***	-0.173***	-0.120***	-0.139***	-0.118***	-0.183***	-0.136**	-0.182***
Countercyclical capital buffer	0.004	0.015	0.022	0.014	-0.008	-0.258	0.109	-0.039
	(0.005)	(0.024)	(0.019)	(0.015)	(0.008)	(0.258)	(0.109)	(0.039)
Capital conservation buffer	-0.030	-0.039	0.014	-0.017	-0.001	0.007	**-0.093***	**-0.260*****
	(0.036)	(0.115)	(0.025)	(0.038)	(0.032)	(0.100)	(0.054)	(0.094)
Capital requirements for banks	0.004	-0.014		-0.017	0.029	0.305	0.057	0.075
	(0.006)	(0.023)		(0.019)	(0.029)	(0.305)	(0.057)	(0.075)
Loan loss provision requirements	-0.015	-0.050	-0.019	0.061	0.016	0.243	0.051	0.055
	(0.014)	(0.077)	(0.037)	(0.039)	(0.039)	(0.360)	(0.041)	(0.159)
Loan restrictions	0.001	0.039	0.008	-0.009	0.018	-0.076	0.018	0.045
	(0.001)	(0.039)	(0.008)	(0.009)	(0.011)	(0.064)	(0.016)	(0.052)
Foreign currency loans measures	-0.002	-0.022	-0.008	-0.019	0.000	0.000	0.000	0.000
	(0.002)	(0.022)	(0.008)	(0.019)	(.)	(.)	(.)	(.)
Taxes and levies	-0.007	-0.009	-0.008	0.002	0.006	0.006	-0.003	0.020
	(0.007)	(0.009)	(0.008)	(0.002)	(0.006)	(0.006)	(0.003)	(0.020)
Liquidity measures	**0.016***	0.012	0.024	-0.017	0.012	0.066	0.170	0.085
	(0.008)	(0.022)	(0.017)	(0.023)	(0.016)	(0.230)	(0.176)	(0.062)
Reserve requirements	0.015	**-0.172*****	**0.140*****	0.022	**0.105***	-0.233	**0.100****	0.185
	(0.019)	(0.048)	(0.053)	(0.066)	(0.055)	(0.215)	(0.040)	(0.119)
Measures on systemic banks	**-0.014****	0.017	-0.022	0.003	-0.062	-0.322	**0.104***	**0.336****
	(0.005)	(0.070)	(0.041)	(0.021)	(0.069)	(0.219)	(0.054)	(0.146)
Limits to the loan-to value ratio	0.002	0.008	-0.006	-0.059	0.014	0.329	-0.027	0.039
	(0.002)	(0.014)	(0.019)	(0.038)	(0.010)	(0.295)	(0.018)	(0.044)
Limits to the debt-services-to-income ratio and the loan-to-income ratio	-0.007	-0.019	0.007	0.009	0.001	-0.272	0.037	-0.058
	(0.007)	(0.019)	(0.007)	(0.009)	(0.001)	(0.272)	(0.037)	(0.058)
Other macroprudential measures	0.002	0.056	-0.011	0.041	0.017	0.302	**0.089***	**0.130***
	(0.017)	(0.055)	(0.027)	(0.069)	(0.025)	(0.208)	(0.050)	(0.075)
N	768	768	768	768	640	640	640	640
Log-likelihood	1378.219	359.124	1016.708	609.627	664.566	-171.927	419.367	28.308

Note: The Table presents estimations using the MG estimator proposed by Pesaran and Smith (1995) for core countries of the EA and peripheral countries, based on equation (3). Changes in banking interest rates are estimated for four markets: loans to households for consumption, loans to households for house purchases, loans to non-financial corporations below € 1 Million and loans to non-financial corporations over € 1 Million. Δ10-year OIS is the 10-year OIS rate. Balance sheet represents the CBPP, the SMP, the APP and the Lending MFI. SovCiss refers to the Composite Indicator of Systemic Sovereign Stress. Results are presented for 13 macroprudential instruments. All explanatory variables are lagged. For simplicity, we do not show the estimates for the VIX and the HCPI. Standard errors in parentheses. * p<0.10, ** p<0.05, *** p<0.01.

Our results show that conservation buffers decrease banking interest rates for loans to non-financial corporations over € 1 Million in peripheral countries, while they have no effects on

banking interest rates in core countries. This could be related to the fact that banks in peripheral countries provide more variable-rate financing than banks in core countries (Eisenshmidt and Smets, 2019). Hence, it is easier for banks in peripheral countries to vary banking interest rates in response to capital requirements.

In addition, high shares of non-performing (NPLs) in peripheral countries lead to a decrease in income and capital for banks, forcing them to reduce credit supply and to accept higher risk premia on bank funding (Bijsterbosch and Falagiarda, 2015). In contrast, capital requirements may lower uncertainty for these banks, as well as their funding costs. Thus, well-capitalized banks may be able to reduce banking interest rates for non-financial corporations in peripheral countries.

Finally, banks in peripheral countries were under-capitalized in comparison to those from core countries (Chiesa and Mansilla-Fernández, 2021). This may explain why conservation capital buffers do not have an impact on banking interest rates in core countries, as a significant part of banks in these countries already comply with these requirements when they are implemented.

4. Conclusion

We study if macroprudential policies have an influence on banking interest rates in the Eurozone in a time of low interest rates. Using a panel of 11 countries between May 2009 and December 2019, we find that capital conservation buffers and reserve requirements are the only macroprudential policies that impact banking interest rates in all specifications. More specifically, capital conservation buffers reduce interest rates for loans to non-financial corporations over € 1 Million, while reserve requirements increase these rates for loans to non-financial corporations below € 1 Million and for loans to households for consumption. However, capital buffers do not affect rates related to loans to households for consumption, for house purchases and for loans below € 1 Million to non-financial corporations. This may be due to the fact that banks complied with these measures were implemented and that banks may be reluctant to increase their rates when firms have access to other sources of funding.

Furthermore, it appears that tightening measures even decrease interest rates for loans to non-financial corporations below € 1 Million. Several effects may be at work. First, large firms have

easier access to other sources of funding compared to small firms. So banks may take advantage of capital requirements regulation to attract non-dependent bank borrowers. Second, large companies borrow more from banks that use internal rating models compared to small companies. These could mean that these banks are likely to have less capital charges than smaller banks, which allow them to offer lower interest rates to their borrowers.

Finally, we provide evidence that capital conservation buffers decrease banking interest rates for loans to non-financial corporations in peripheral countries, while they have no effect on these rates in core countries.

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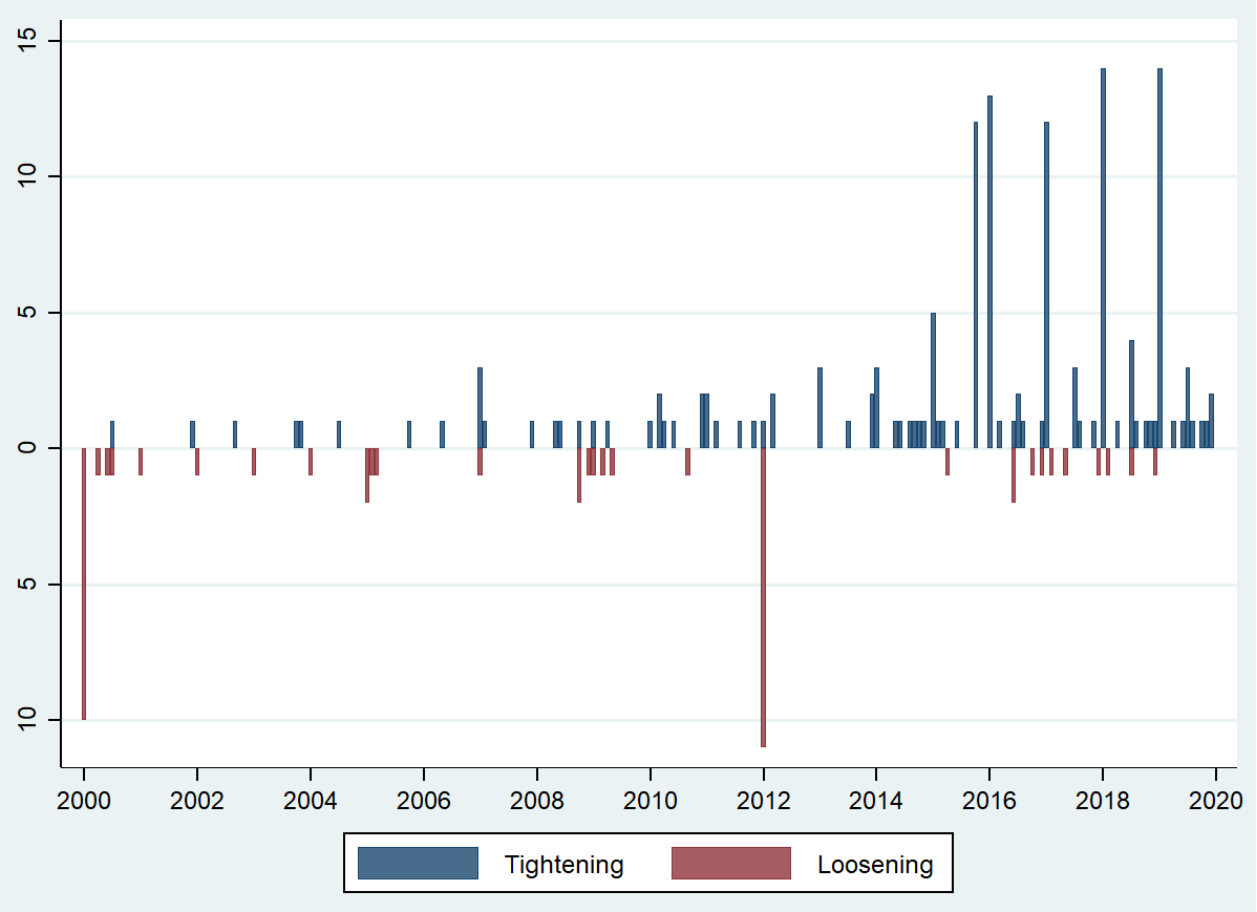
APPENDIXES

Table A. Variable Definitions and Sources

Variable	Description	Source
NFC Loans < 1 M, €	Loans to Non-financial corporations below one million euros	ECB
NFC Loans > 1 M, €	Loans to Non-financial corporations over one million euros	ECB
Housing loans	Loans to households for house purchases	ECB
Consumption loans	Loans to households for consumption purchases	ECB
Households' deposits	Deposits made with agreed maturity by households	ECB
NFC deposits	Deposits made with agreed maturity by Non-financial corporations	ECB
CCB	Countercyclical capital buffer	Alam et al. (2019)
Conservation	Capital conservation buffer	Alam et al. (2019)
Capital	Capital requirements for banks (countercyclical capital buffers and capital conservation buffers are not included)	Alam et al. (2019)
LLP	Loan loss provision requirements for macroprudential purposes	Alam et al. (2019)
LoanR	Loan restrictions	Alam et al. (2019)
LFC	Limits, rules and recommandations on foreign currency loans	Alam et al. (2019)
LTV	Limits to the loan-to-value ratio	Alam et al. (2019)
DSTI	Limits to the debt-services-to-income ratio and the loan-to-income ratio	Alam et al. (2019)
Tax	Taxes and levies	Alam et al. (2019)
Liquidity	Measures taken to mitigate systemic liquidity and funding risks	Alam et al. (2019)
RR	Reserve requirements	Alam et al. (2019)
SIFI	Measures taken to mitigate risks from systemically important financial institutions	Alam et al. (2019)
OT	Macroprudential measures that do not fall into any category	Alam et al. (2019)
10-year OIS rate	Overnight Indexed Swaps rates at 10 years	Thomson Reuters Eikon
CBPP	Covered Bond Purchase Programme	ECB
SMP	Securities Market Programme	ECB
APP	Asset Purchase Programme	ECB
Lending MFI	Lending to euro area credit institutions related to monetary policy operations	ECB
Balance sheet	Aggregate variable of CBPP, SMP, APP and Lending MFI	ECB
SovCISS	Composite Indicator of Sovereign Stress	ECB
VIX	Chicago Board Options Exchanges's Volatility Index	Thomson Reuters Eikon
HCPI	Harmonized Consumer Price Indices	Eurostat

Figure A. The use of macroprudential policies in our sample of 11 Euro Area members



Note: This figure displays the number of tightening and loosening changes per month for all countries and all types of macroprudential instruments. Source: Alam et al. (2019).

Table B. Baseline estimates with alternatives measures of unconventional monetary policies

	Housing loans	Consumption loans	Loans <1 Million €	Loans > 1 Million €
10-year OIS	0.721***	0.292**	0.712***	0.571***
	(0.117)	(0.138)	(0.166)	(0.096)
CBPP	0.180***	-0.056	0.253**	0.226**
	(0.056)	(0.161)	(0.110)	(0.104)
SMP	0.193***	0.149*	0.166***	0.199***
	(0.050)	(0.083)	(0.041)	(0.046)
APP	-0.045***	0.008	-0.040***	-0.059***
	(0.017)	(0.047)	(0.011)	(0.014)
Lending MFI	-0.435***	-0.146	-0.581***	-0.462***
	(0.110)	(0.121)	(0.198)	(0.137)
SovCiss	0.139***	0.139**	0.369***	0.148**
	(0.049)	(0.070)	(0.132)	(0.070)
Error correction	-0.135***	-0.303***	-0.234***	-0.394***
Countercyclical capital buffer	-0.004	-0.110	0.064	0.012
	(0.007)	(0.140)	(0.052)	(0.017)
Capital conservation buffer	-0.013	0.006	-0.037	**-0.111****
	(0.029)	(0.068)	(0.029)	(0.055)
Capital requirements for banks	0.003	0.113	0.004	0.018
	(0.004)	(0.125)	(0.006)	(0.024)
Loan loss provision requirements	-0.008	0.061	-0.002	0.046
	(0.012)	(0.168)	(0.024)	(0.076)
Loan restrictions	0.001	-0.025	0.007	0.003
	(0.002)	(0.040)	(0.006)	(0.022)
Foreign currency loans measures	0.003	-0.006	0.000	-0.002
	(0.003)	(0.006)	(0.000)	(0.002)
Taxes and levies	0.003	-0.001	-0.005	0.018
	(0.008)	(0.008)	(0.005)	(0.015)
Liquidity measures	0.013	0.024	0.098	0.041
	(0.015)	(0.116)	(0.082)	(0.043)
Reserve requirements	0.033	**-0.203****	**0.075***	0.064
	(0.025)	(0.084)	(0.040)	(0.066)
Measures on systemic banks	-0.037	-0.142	0.028	0.121
	(0.030)	(0.103)	(0.037)	(0.076)
Limits to the loan-to value ratio	0.012	0.201	-0.024	-0.025
	(0.008)	(0.153)	(0.017)	(0.029)
Limits to the debt-services-to-income ratio and the loan-to-income ratio	-0.006	-0.152	0.028	-0.019
	(0.005)	(0.143)	(0.026)	(0.024)
Other macroprudential measures	-0.004	0.134	0.020	0.065
	(0.017)	(0.084)	(0.025)	(0.054)
N	1408	1408	1408	1408
Log-likelihood	2155.658	241.264	1526.912	788.375

Note: The Table presents estimations using the MG estimator proposed by Pesaran and Smith (1995), based on equation (3). Changes in banking interest rates are estimated for four markets: loans to households for consumption, loans to households for house purchases, loans to non-financial corporations below € 1 Million and loans to non-financial corporations over € 1 Million. Δ10-year OIS is the 10-year OIS rate. CBPP, SMP and APP are assets purchases programmes, and Lending MFI means liquidity provisions programmes. SovCiss refers to the Composite Indicator of Systemic Sovereign Stress. Results are presented for 13 macroprudential instruments. All explanatory variables are lagged. For simplicity, we do not show the estimates for the VIX and the HCPI. Standard errors in parentheses. * p<0.10, ** p<0.05, *** p<0.01.

Table C. Robustness checks

	Housing loans	Consumption loans	Loans <1 Million €	Loans > 1 Million €
		5-year OIS rate		
Capital conservation buffer	-0.016	-0.021	-0.042	-0.137**
	(0.024)	(0.077)	(0.038)	(0.058)
Reserve requirements	0.055*	-0.211**	0.113***	0.103
	(0.031)	(0.093)	(0.032)	(0.067)
		2-year OIS rate		
Capital conservation buffer	-0.017	-0.018	-0.051	-0.144**
	(0.025)	(0.078)	(0.041)	(0.064)
Reserve requirements	0.057*	-0.228**	0.105***	0.087
	(0.033)	(0.092)	(0.031)	(0.068)
		Euro Area sovereign interest rate		
Capital conservation buffer	-0.023	-0.052	-0.047	-0.119*
	(0.024)	(0.086)	(0.042)	(0.061)
Reserve requirements	0.076**	-0.153	0.129***	0.144**
	(0.032)	(0.102)	(0.043)	(0.059)
		Industrial Production Index		
Capital conservation buffer	-0.019	-0.038	-0.041	-0.121**
	(0.023)	(0.068)	(0.034)	(0.057)
Reserve requirements	0.055*	-0.206**	0.119***	0.107
	(0.030)	(0.096)	(0.029)	(0.069)
		Removing control variables		
Capital conservation buffer	-0.021	-0.023	-0.026	-0.116**
	(0.023)	(0.072)	(0.028)	(0.048)
Reserve requirements	0.046	-0.195**	0.133***	0.109
	(0.030)	(0.096)	(0.029)	(0.072)
		Capital conservation buffers only		
Capital conservation buffer	-0.017	-0.140	-0.017	-0.070*
	(0.021)	(0.097)	(0.026)	(0.039)
		Sovereign interest rate for each country		
Capital conservation buffer	-0.005	0.009	-0.022	-0.117*
	(0.022)	(0.068)	(0.026)	(0.062)
Reserve requirements	0.053	-0.170**	0.118***	0.131*
	(0.039)	(0.085)	(0.028)	(0.069)
		Pooled mean group estimator		
Capital conservation buffer	-0.019	-0.053	-0.041	-0.133**
	(0.023)	(0.085)	(0.038)	(0.058)
Reserve requirements	0.072**	-0.166	0.152***	0.138**
	(0.031)	(0.119)	(0.026)	(0.059)
		Since June 2005		
Capital conservation buffer	-0.021	-0.028	-0.033	-0.126*
	(0.016)	(0.082)	(0.035)	(0.073)
Reserve requirements	0.044	-0.258**	0.100***	0.040
	(0.043)	(0.120)	(0.033)	(0.064)
		Since July 2014		
Capital conservation buffer	-0.022	-0.148	-0.020	-0.058
	(0.028)	(0.095)	(0.023)	(0.044)
Reserve requirements	0.000	0.000	0.000	0.000
	(.)	(.)	(.)	(.)
		Since March 2016		
Capital conservation buffer	-0.042	-0.073	0.030	-0.124
	(0.037)	(0.122)	(0.074)	(0.093)
Reserve requirements	0.000	0.000	0.000	0.000
	(.)	(.)	(.)	(.)

Standard errors in parentheses. * p<0.10, ** p<0.05, *** p<0.01.

General conclusion

The global financial crisis has cast doubt on the efficiency of microprudential and monetary policies in ensuring financial stability. In fact, microprudential policies were undersized to contain systemic shocks that have spread rapidly due to the interconnections amongst key players in the financial sector, and monetary policy did not ensure financial stability while the inflation was under control through the so-called Schwartz's hypothesis (Schwartz, 1995).

This led to a renewal of macroprudential policy, which, although used by several emerging markets when they faced financial crises in the 1990s (Lim et al., 2011), has exploded since the aftermath of the crisis, even in advanced economies. Since then, macroprudential policy has become an important tool for increasing the resilience of the financial system to shocks. However, as the global financial crisis happened in 2008, the subsequent worldwide used of macroprudential policy is fairly recent.

Hence, the academic work concerning macroprudential policy is still in its infancy. There are several debates about this policy in terms of its efficiency and, more recently, about its relation with monetary policy. Hence, as monetary policy affects financial stability, a significant part of the empirical literature focuses on the benefits and costs of synchronization between these two policies. Should these policies be coordinated or conducted in an independent manner? Are they complements or substitutes? While it appears that a consensus is taking shape amongst the theoretical literature about the necessity of coordinating them, the empirical literature has yet to come to such an agreement, notably because studies on the subject are scarce (Revelo et al., 2020).

As to whether if and which macroprudential tools are efficient in ensuring financial stability, the divergence of views is notably fueled by the lack of data about macroprudential measures. forcing researchers to use wide samples of heterogeneous countries when using macro-data. In addition, the multiple ways of measuring the macroprudential stance as well as the diverse econometrics methodologies used also make it difficult to obtain similar results amongst studies (see for instance Poghosyan, 2020). When considering the interaction between monetary and macroprudential policies, the different ways of considering monetary policy as well as the various procedures used for computing these interactions added to the reported heterogeneity between empirical studies.

In this thesis, we address the question of the impact of macroprudential policy and its interaction with monetary policy on financial stability, in order to fill the void that is left in the empirical literature. To achieve that, we consider the effect of both policies on credit growth,

on the occurrence of banking crises and on changes in banking interest rates. In addition, we consider different measures of macroprudential and monetary policies. For macroprudential policy, we compute an index that takes into account the announcement date of macroprudential measures as well as their lifetime, an index developed by Alam et al. (2019) that indicates the orientation of macroprudential policy, and two measures of capital requirements, which are part of the macroprudential toolkit. As for monetary policy, we consider it through various indexes such as monetary policy surprises series measured by Altavilla et al. (2019), shadow rates computed by Krippner (2015) or Wu and Xia (2016), overnight indexed swap rates as well as assets purchase and liquidity provisions programmes. Furthermore, we use a wide range of econometrics methods to answer our research questions, such as fixed-effects models, Probit models and the mean-group estimator introduced by Pesaran and Smith (1995).

We focus our work on the European Union and notably on the Eurozone, for several reasons. First, few empirical studies assess the impact of macroprudential policy in these areas, let alone its interaction with monetary policy. Second, it allows comparison between countries that are relatively homogeneous. Third, in the case of the Euro Area, it makes it easier to assess the impact of monetary policy as well as how it interacts with macroprudential policy, as monetary policy is under the sole responsibility of the European Central Bank.

This thesis opens with an investigation of how macroprudential and monetary policies affect credit growth in the Euro Area, notably through the use of an interaction term. The originality of this chapter is multiple. First, few empirical studies restrict their sample to the Eurozone especially when using macro data, due to a lack of implementation of macroprudential measures in this area in recent years. Second, we rely on the database constructed by Budnik and Kleibl (2018) and consider an index that takes into account the lifetime and the intensity of macroprudential measures as well as the announcement date of such measures. At the opposite, the majority of the empirical studies uses the implementation date and records only the general orientation of the macroprudential stance (i.e. tightening or loosening), but not the type of changes that occurs in macroprudential tools. Third, monthly data combined with monetary policy surprises mitigate the reverse causality bias that may arise between the dependent variable and the variables of interest, while most of the literature uses at best quarterly data and rarely relies on monetary policy surprises series.

Therefore, in line with the empirical literature, our results show that monetary and macroprudential policies stances affect credit growth, as tightening hinder credit dynamics.

Concerning macroprudential policy, our findings suggest that tightening measures have a bigger impact than loosening ones, and that borrowers-based measures as well as capital requirements are suitable for mitigating credit dynamics. Finally, we do confirm the theoretical findings that highlight channels through which monetary policy and macroprudential policy interact, albeit the interactions effects that we find are relatively small. As a consequence, our results show that both policies have mostly an independent and negative impact on credit growth, but the presence of small interaction effects indicates that the marginal effects of monetary policy on credit growth, conditioning on the macroprudential policy stance, is stronger for accommodative monetary policy shocks. Consequently, our finding advocate for a coordination between these two policies or at least a sharing of information between the competent authorities.

However, it should be noted that no macroprudential index is better than another in measuring the macroprudential stance, and our macroprudential index is no exception. First, while we consider a weighting scheme created by Meuleman and Vander Vennet (2020) that allow us to measure the intensity of macroprudential actions according to the type of changes announced by macroprudential authorities (e.g. activation of a tool, change in the scope or the level of an existing tool, etc.), such weighting scheme contains a certain amount of subjectivity. Second, we consider the announcement date of macroprudential tools rather than the implementation date, as we assume that banks comply with such measures before their entry into force. However, it is possible that some tools such as lending standard restrictions or limits on credit growth and volume are effective only when they are implemented. It is even possible that banks increase credit supply between the announcement date and the implementation date because they will not be able to do it due to future tightening in the macroprudential stance (De Schryder and Opitz, 2021). Hence, there is no rule about which date to consider in the empirical literature, implying that studies must choose between the two. This chapter suffers from the same flaws. For now, the empirical literature lacks of a classification that indicates whether tools are supposed to have significant effects as soon as there are announced or implemented.

In the second chapter of this thesis, we look at the probability of banking crises as a proxy of financial stability, in the European Union over the period 1998-2017. In addition, as in one of the subsections of the first chapter, we look at the effectiveness of capital requirements in reducing the occurrence of such crises, which are part of the macroprudential toolkit. The motivation of this chapter relies on Jordà et al. (2021), who find no proofs that capital ratios

decrease the probability of crises. Interestingly, such results are not widely share in the empirical literature, as demonstrated by Boissay et al. (2019). Their meta-analysis shows that, on average, a tightening of one percentage point in capital ratios diminishes the probability of a crisis of about one percentage point. Therefore, we test if two capital ratios, namely the bank capital to total assets ratio and the bank regulatory capital to risk-weighted assets (RWA), are associated with a decrease in crisis probability measured by a dummy variable built by Laeven and Valencia (2020). Consequently, we exploit a Probit model in our empirical strategy.

We find that these two ratios effectively reduce the occurrence of a crisis, implying that capital requirements implemented under Basel III will likely have a positive and significant effect on the resilience of the financial system. Nevertheless, we find evidence that the bank capital to total assets ratio starts having significant effects above around 11%, in line with Almenberg et al. (2017). This finding suggests that the leverage ratio under Basel III, which is currently set at 3%, should be significantly raised in order to increase the resilience of the banking system. Finally, while the internal valuation model used mostly by large banks for determining their capital charges accordingly to their level of risk-weighted assets is subject to criticism, we find that it significantly reduces the risk of emergence of a banking crisis, whatever its level.

An extension of this chapter would be to use more granular data in order to obtain more precise results (see Araujo et al., 2020 for a meta-analysis on the impact of macroprudential policy that compares the statistical and identification power between micro and macro studies). However, it should be noted that microeconomic data are generally no exhaustive as all banks are not always providing their information. Therefore, with macro data, this chapter gains in exhaustivity what it loses in granularity. In addition, while we use linear regressions to estimate thresholds effects, another possibility would be to use non-linear approaches such as the panel smooth transition regression model. Nonetheless, linear regressions have the merit of simplicity and transparency.

After focusing on credit growth and on the occurrence of crises in the first two chapters, we investigate in the last chapter of this thesis if the interaction between monetary and macroprudential policies affects banking interest rates. In fact, the literature has highlighted several channels through which macroprudential policy affects banks' funding conditions as well as banks' performance and therefore, the cost of credit (see for instance Blundell-Wignall and Atkinson, 2010, Cosimano and Hakura, 2011, or Santos and Wilson, 2013). More precisely, we look at the effects of both policies on four markets in the Eurozone, namely housing loans, consumption loans, and loans to non-financial corporations below and over € 1 Million. We

look at these effects in a low interest rate environment induced by the fact that monetary policy reaches the effective lower bound, which may change the transmission of these policies to banking interest rates (e.g. Borio and Zhu, 2012, Gambacorta and Shin, 2018, Döttling, 2020, or Blot and Labondance, 2022). Thus, another objective of this chapter is to assess if monetary policy still has some effects on banking interest rates during periods of effective lower bound, notably through the use of the unconventional monetary measures toolkit. The originality of this chapter is to combine an evaluation of macroprudential and monetary policies on banking interest rates in a low interest rate environment, while using panel data. We estimate our results with the mean-group estimator developed by Pesaran and Smith (1995), which is suitable for dealing with nonstationary heterogeneous panels.

First, in line with the literature, our results show that monetary tightening increase banking interest rates, while the implementation of unconventional monetary measures decreases them. Second, we find that capital conservation buffers affect banking interest rates, but that these effects are limited to banking interest rates related to loans provided to non-financial corporations over € 1 Million, and only in countries from the periphery of the Eurozone. Furthermore, these capital requirements have a negative impact, implying that tightening actions reduce banking interest rates for large companies. Consequently, our results suggest that larger companies benefit from smaller banking interest rates comparing to smaller ones, which may be due to the fact that the latter have less alternative to bank credit. In fact, large companies have easier access to financial markets and have the possibility to seek loans from institutions engaged in the shadow banking system, which may explain why banks are reluctant in increasing their rates for such companies. Furthermore, large companies are perceived as less risky, and borrow more from large banks that benefit from lower funding costs, which allow them to offer attractive rates.

An extension of this chapter would be to expand the analysis to the credit cycle, in order to obtain results that investigate both price and quantity effects of macroprudential and monetary policies. Hence, it is important to mention that while our results show that capital requirements and, more generally, macroprudential policy, only affect banking interest in one of the fourth markets that we study, our results tell nothing about the effectiveness of these measures in mitigating the credit cycle.

As a whole, this thesis provides evidence of the effects of monetary and macroprudential policies on financial stability. Taken together, our results suggest that in addition to macroprudential policy, monetary policy has some influence on banking interest rates and on

credit growth, and thus on financial stability. Moreover, our results display little but existing interactions between both policies on credit growth, which advocate for at least a sharing of information between monetary and macroprudential authorities. Moreover, we find that while the ratio of bank capital to RWA implemented by Basel III reduces the occurrence of banking crises, the actual level of the leverage ratio, which is 3%, may not be enough to have such effects. According to our findings, this ratio starts having the desired impact at around 11%, and therefore should be increased.

However, we should be cautious about the recommendations in terms of policies that are emerging out of these three chapters. In fact, while we mainly focus on these interactions between the two policies, wo do not take into account other policies such as microprudential policies and fiscal policy. Yet, microprudential policy shares several tools with macroprudential policy and the boundary between these two policies are sometimes blurred, implying that the former has an impact on financial stability (see for instance Angelini et al., 2013, or Osinski et al., 2013). Furthermore, fiscal policy influences financial stability because taxes affects leverage, asset prices as well as house prices (Claessens, 2015). Hence, in order to make recommendations in the conduct of such policies, we should therefore consider all types of interactions. These could be particularly relevant because studies that investigate the interactions between macroprudential and monetary policies, despite the differences of opinion, highly recommend that there is a certain degree of cooperation between the responsible authorities in terms of transparency and accountability, notably during bursts (Svensson, 2018).

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