THÈSE

En vue de l'obtention du

DOCTORAT DE L'UNIVERSITÉ DE TOULOUSE

Délivré par l'Université Toulouse 1 Capitole

Présentée et soutenue par

Bruno DE MENNA

le 10 décembre 2020

Essays on the Risk-Taking Channel of Monetary Policy Transmission in the Euro Area

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École doctorale : **TESC – Temps, Espaces, Sociétés et Cultures**

Spécialité : **Sciences Économiques**

Unité de recherche : **LEREPS EA 4212**

Directeurs de thèse : **Olivier BROSSARD et Alexandre MINDA**

Jury

Rapporteurs Sophie Brana, Professor of Economics, Université de Bordeaux
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Suffragants Manthos Delis, Professor of Economics, Montpellier Business School
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« The views expressed in this thesis are those of the author

and do not necessarily reflect those of the university. »

"Withdrawing policy accommodation is not for today, tomorrow or even the day after tomorrow. The economy will require support for quite some time. Moreover, there is a natural concern that even talking about withdrawal could reduce the effectiveness of the policies in place by sapping confidence. But at some point, as soon as conditions allow, disengagement will be called for. Starting the debate now can get markets, and economic agents generally, ready."

Claudio Borio

Head of the BIS Monetary and Economic Department

Frankfurt, September 30, 2020

Acknowledgments

The present manuscript offers but a mere glimpse of my doctoral research that took place at Toulouse University between 2016 and 2020. Undoubtedly, this was an exhilarating experience extending far beyond the limits of this document, which appears to me still perfectible. However, I do experience a certain contentment regarding the product of the following pages, which I consider as a starting point of a hopefully long research series in economics. At the end of this journey, it is pleasant to look back at the progress and to thank those who, in many ways, contributed to its completion.

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Bruno De Menna

Toulouse, December 2020

Abstract

The thesis contributes to the recurrent debates in the macroeconomics of banking regarding the risk-taking channel of monetary policy transmission. As the unifying theme of the present essays, I tackle this issue from three different angles with a special focus on the euro area banking industry. I rely on available data–at both the bank-level and the country-level–and different identification strategies to deliver up-to-date empirical evidence contributing to a deeper understanding of the monetary policy impacts on credit risk.

In the first chapter of the thesis, I investigate how the risk-taking channel of monetary policy interacts with the degree of leverage in banks' balance sheets after the Global Financial Crisis of 2008 (GFC). Using dynamic panel techniques, I first find significant statistical evidence that credit risk is negatively associated with variations in interest rates, while competition in national banking industries tends to enhance this effect. I also suggest that this negative relationship is most pronounced for banks with relatively high levels of leverage, which is consistent with a "search for yield" effect. These results for the euro area are strikingly different from the U.S. banking industry, confirming that time, geographical circumstances, and local banking market conditions are key in understanding the impact of monetary policy on credit risk. Moreover, the results point to the importance of considering alternative channels of risk taking in addition to traditional portfolio rebalancing channels in theoretical studies.

The second chapter investigates the joint impact of bank capital and funding

liquidity on the monetary policy's risk-taking channel. Using data on the euro area from 1999 to 2018 and triple interactions between monetary policy, bank equity, and funding liquidity, I shed light on a "crowding-out of deposits" effect prior to the GFC, which supports the need for simultaneous capital and funding liquidity ratios to mitigate the monetary transmission to bank credit risk. Interestingly, the analysis also highlights a missing crowding-out of deposits effect among low-efficiency banks in the aftermath of the GFC. Consequently, a trade-off arises between financial stability and increased funding liquidity, requiring a special treatment for inefficient banks operating in a low interest rate environment. These results challenge the implementation of uniform funding liquidity requirements across the euro area as by the Basel III framework suggests.

The third and last chapter extends the analysis to the special case of cooperative banks and relationship lending in the euro area. These financial intermediaries tell a different story between countries and therefore imply different responses to a common monetary policy. Accordingly, I find no evidence of the presence of a risk-taking channel of monetary policy for consolidated (i.e., less committed to relationship lending) cooperative banks, whereas the results indicate extensive evidence of a risk-taking channel in the euro area for non-cooperative banks (see also the previous chapters of the thesis). Therefore, consolidated cooperative banks seem not to raise their credit risk significantly when monetary policy is eased. Further, I highlight that the profitability of cooperative banks preserving their relationship lending model is more severely hit by a low interest rate environment compared to cooperative banks opting for consolidation. This finding raises issues on the mid-term durability of relationship lending as interest rates have been low for an extended period in the European banking industry. I ultimately find that both non-cooperative banks and relationship-based cooperative banks are concerned about the risk-taking channel of monetary policy transmission, which results in an increase in their credit risk under accommodating monetary conditions. Nevertheless, I suggest that such similarities do not exist for the same reasons, as relationship lending is associated with a fundamentally different lending process than transactions-based lending technologies, which devote significantly lower proportions of their assets to lending to small businesses.

Résumé

La thèse s'inscrit dans les débats florissants en macroéconomie bancaire dédiés au canal de prise de risque par transmission de la politique monétaire. Ainsi, nous abordons cette problématique sous trois angles différents au sein du secteur bancaire de la zone euro. Sur base de nombreuses données micro et macroéconomiques, nous utilisons toute une palette de stratégies d'évaluation pour fournir plusieurs preuves empiriques qui contribuent à une meilleure compréhension de l'impact de la politique monétaire sur le risque de crédit.

Dans le premier chapitre, nous étudions comment le canal de prise de risque de la politique monétaire interagit avec le niveau d'endettement des établissements bancaires après la crise financière mondiale de 2008. En utilisant des techniques de panel dynamiques, nous montrons que le risque de crédit est négativement associé aux variations de taux d'intérêt, bien que le degré de concurrence dans les industries bancaires nationales tende à renforcer cet effet. Nous suggérons également que cette relation négative est plus prononcée pour les banques ayant des niveaux d'endettement relativement plus élevés, ce qui correspond à un effet "de quête de rendement". Ces résultats pour la zone euro sont très différents de ceux observés dans le secteur bancaire américain, ce qui confirme que le temps, les circonstances géographiques ainsi que les conditions des marchés bancaires locaux doivent être pris en compte dans la compréhension de l'impact de la politique monétaire sur le risque de crédit. De plus, ce point souligne toute l'importance pour la littérature théorique d'envisager des canaux alternatifs de prise de risque, en plus des canaux

traditionnels de rééquilibrage de portefeuille.

Le deuxième chapitre examine quant à lui l'impact conjoint du capital bancaire et de la liquidité de financement sur le canal de prise de risque de la politique monétaire. En utilisant des données sur la zone euro de 1999 à 2018 et des interactions triples entre politique monétaire, fonds propres bancaires et liquidité de financement, nous mettons en lumière un effet "d'éviction des dépôts" avant la crise de 2008, justifiant la nécessité de mettre en place des ratios de capital et de liquidité de financement simultanés afin d'atténuer le mécanisme de transmission monétaire au risque de crédit. L'analyse met également en évidence l'absence d'un tel effet "d'éviction des dépôts" pour les banques peu efficaces après 2008. Ainsi, cela place les banques inefficaces opérant dans un environnement à taux bas face à un dilemme entre stabilité financière et liquidité de financement. En définitive, ces résultats nous invitent à questionner l'uniformisation des exigences de liquidité de financement au sein de la zone euro, comme le suggèrent les accords de Bâle III.

Le troisième et dernier chapitre étend l'analyse au cas particulier des banques coopératives et du prêt relationnel dans la zone euro. Avec des spécificités locales, régionales et nationales, ces organismes de crédit peuvent réagir de façon très différente à une même politique monétaire commune. Ainsi, nous ne trouvons pas de preuves empiriques quant à la présence d'un canal de prise de risque pour les banques coopératives dites consolidées (c'est-à-dire peu engagées dans le prêt relationnel), alors que ce canal a largement été mis en évidence pour les banques non-coopératives de la zone euro (voir également les chapitres précédents de la thèse). Par conséquent, les banques coopératives consolidées semblent ne pas augmenter leur risque de crédit face à un assouplissement de la politique monétaire. En outre, la rentabilité des banques coopératives qui préservent leur modèle de prêt relationnel est plus durement touchée par un environnement à taux bas que les banques coopératives ayant opté pour la consolidation de leurs activités. Cela soulève des interrogations quant à la viabilité du prêt relationnel lorsque les taux se maintiennent à des niveaux historiquement bas. Enfin, nous montrons que les banques non-coopératives et les banques coopératives relationnelles sont toutes deux touchées par le canal de prise de risque de la politique monétaire, ce qui se traduit donc par une augmentation de leur risque de crédit. Néanmoins, nous suggérons que de telles similitudes ne surviennent pas pour les mêmes raisons. En effet, le prêt relationnel est associé à un processus radicalement différent de celui des prêts dits *transactionnels* ; ces derniers consacrant des proportions beaucoup plus faibles de leurs actifs aux prêts aux petites entreprises ou aux entreprises ayant un ancrage territorial fort.

Contents

List of Acronyms

BIS	Bank for International Settlements
CTI	Cost To Income
ECB	European Central Bank
EONIA	Euro Overnight Index Average
EU	European Union
EURIBOR	Euro Interbank Offered Rate
GDP	Gross Domestic Product
GFC	Global Financial Crisis
GMM	General Method of Moments
HHI	Herfindahl-Hirschman Index
LLP	Loan Loss Provision
NFC	Non-Financial Corporations
NIM	Net Interest Margin
NPL	Non-Performing Loan
NSFR	Net Stable Funding Ratio
PTP	Pre-Tax Profit
ROAA	Return On Average Assets

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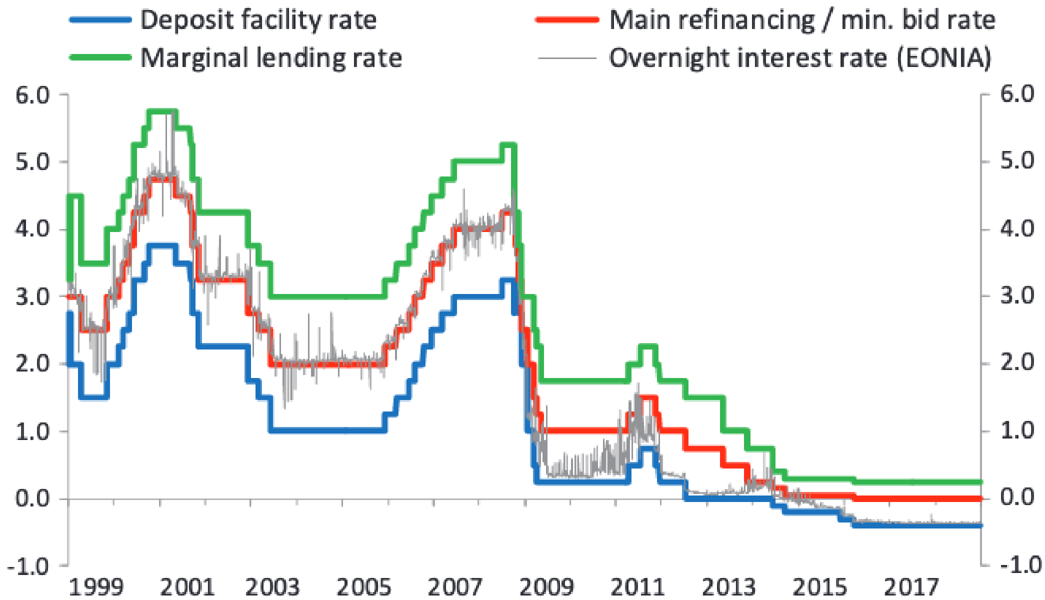
Chapter 1

General introduction

Most advanced economies, including the euro area, experienced a declining trend in market interest rates over the past few decades against a background of a declining equilibrium real interest rate, also referred to as the *natural interest rate*. In the aftermath of the Global Financial Crisis of 2008 (GFC), the European Central Bank (ECB) furthered its lender-of-last-resort function and intensified its market-making activities to stabilize the euro area economy. Thus, unconventional monetary policy measures addressing low inflation issues pushed interest rates to ultra-low levels, suppressed bond spreads, inflated asset prices, and distorted market signals in a way comparable to the application of financial repression tools after the 1930s (van Riet, 2019). Figure 1.1 shows the magnitude of the problem between 1999 and 2018 regarding the ECB's key interest rates and EONIA.

More than ten years after the most acute phase of the GFC, growth remains sluggish and inflation below target in the euro area. In addition, the COVID-19 pandemic recently prompted renewed lender-of-last-resort interventions and asset

Figure 1.1: ECB key interest rates & EONIA (1999-2018)



Notes. Percent per annum from January 1, 1999 to December 31, 2018 (source: ECB).

purchases to ease financial constraints (Pfister and Sahuc, 2020). To help the euro area absorb the shock, a pandemic emergency purchase program was implemented by the ECB with an injection of 1,350 billion Euro aimed at reducing borrowing costs and boosting loan growth in the banking industry. Therefore, the way unconventional monetary policy frameworks impact bank behavior has been and will remain for some time on the agenda of euro area policymakers and scholars concerned with preserving financial stability. Drumetz et al. (2015) distinguish two important steps in the standard description of the monetary transmission to the economy. First, the ECB sets an interest rate that determines the short-term money market rates through arbitrage between operations with the central bank or in the interbank market. Second, the observed and anticipated short-term interest rates are deemed to feed through to the financial system and the economy. The present thesis aims to contribute to the current empirical debates related to this second step, with a focus on bank credit risk.

Setting policy rates at unprecedentedly low levels and adopting looser monetary policy overall results in flat yield curves. Eventually, "low-for-long" interest rates (Claessens et al., 2018) might be detrimental to the economy as they encourage "search for yield" strategies (with potential increases in non-performing loans), erode bank profitability (as low rates are typically associated with lower net interest margins), and reduce bank equity considerably (hence lowering the weight on loan supply).

A related issue is whether a prolonged period of low interest rates produces overconfidence in economic agents, with side effects on their risk tolerance. This mechanism is referred to in the literature as the *risk-taking channel of monetary policy transmission* (Fève et al., 2018; Borio and Zhu, 2012), and posits that the longer the yield curve remains flat, the higher the risk associated with low interest rates in the banking industry. In addition, an excessively long accommodative policy may encourage the build-up of leverage and fuel asset price bubbles.

From a theoretical perspective, it is noteworthy that the effects of monetary policy on bank risk taking are multifaceted. On the demand side, one might expect that looser monetary policy reduces the financial burden on borrowers, and therefore lowers the probability of overall default risk (Bernanke and Gertler, 1995). On the supply side, Smith (2002) suggests that the lower interest rates, the higher bank cash reserves (because such reserves depend mainly on bank opportunity cost), and the safer bank balance sheets.

Another strand of the literature provides evidence on the existence of a risk-taking channel of monetary policy that potentially hampers bank risk perception when they operate in a (persistently) low interest rate environment (Borio and Zhu, 2012). For instance, banks might loosen their credit terms (Dell'Ariccia et al., 2012) and lend to riskier borrowers. Bank profitability is also a matter of concern to several academics warning that lower profitability might eventually cause banks to take reckless investment decisions if they are willing to compensate for the losses incurred (Rajan, 2006). On the liability side, low interest rates also might be a source of cheaper funding costs for banks and therefore act as an incentive to increase their levels of leverage (Gertler and Karadi, 2011).

From an empirical perspective, the risk-taking channel of monetary policy is also extensively documented. Based on a threshold model, Djatche (2019) prove both the upsides and downsides of monetary policy in U.S. bank risk, where the latter vary with the deviation of interest rates from the Taylor rule-based rates. Chen et al. (2017) also suggests that in most emerging economies, lax monetary policy significantly increases bank risk. Additionally, most studies in advanced economies usually focus on the near-zero or negative interest rate setting (see, among others, Heider et al. (2019); Dell'Ariccia et al. (2014); Jiménez et al. (2014); Delis and Kouretas (2011); Maddaloni and Peydró (2011) or else Gaggl and Valderrama (2010)). Moreover, Brana et al. (2019) find that low interest rates and increasing central bank liquidity have a harmful effect on bank risk taking; this relation is non-linear as the effects of lasting unconventional monetary policies are stronger below a certain threshold.

The starting point of the empirical analysis consists of assessing how the risk-taking channel of monetary policy takes the floor in the euro area, the latter displaying a great deal of heterogeneity in bank-specific characteristics, business models, and macroeconomic conditions. Interestingly, investigating this path might have important implications for policymakers to adjust banking supervision and regulation. From this pivotal issue, this thesis covers three lines of research and conducts empirical investigations in the following chapters.

In Chapter 2, I first analyze the amplitude of the risk-taking channel of monetary policy in 16 euro-area countries over the period 2009-2017. The final sample consists of 3,898 banks and 27,072 observations. I first evidence the presence of a "portfolio reallocation" effect whereby, in a low interest rate environment, banks are influenced to shift their investments away from safe assets towards assets with higher expected returns (Albertazzi et al., 2018). I also suggest that competition in the banking industry interacts with this portfolio reallocation channel: the higher the competition, the greater the extent that monetary policy changes are passed on to bank credit risk. As high competition lowers the opportunity for banks to enjoy high market power, herding behaviors are likely to arise, intensifying the negative impact of monetary policy on risk taking.

I also make the case that bank leverage influences the relation between credit risk and interest rates through a search for yield effect: highly levered euro area banks are prone to higher risk taking when monetary policy is eased. This finding stands in stark contrast to the U.S. banking industry, where the negative link between risk taking and interest rates is steeper for highly capitalized banks (Dell'Ariccia et al., 2017). This might be due to the presence of a "skin-in-the-game" effect (De Nicolò et al., 2010) in the European banking industry: the more a bank has to lose in case of failure (i.e., having high levels of capitalization), the less severe the moral hazard problem. Similarly, a bank with a high franchise value has much to lose and little incentive to take excessive risk, whereas a zombie bank is prone to greater risk taking to gamble for resurrection. An important implication of this result is that a macroprudential tool such as the leverage ratio is actually effective in influencing the transmission mechanism of monetary policy (Angelini et al., 2014) and in modifying credit risk.

Further, I identify nonlinearities in the search for yield effect depending on the level of bank capitalization. Search for yield strategies intensify as bank capital is depleted and limited liability is more likely to be binding. Such an outcome suggests that banks complying with the Basel III capital requirements are better prepared to face the side effects of low-for-long interest rates. Eventually, Chapter 2 highlights the importance of considering bank heterogeneity and geographical circumstances (including within the euro area) to gauge the relative significance of monetary policy's risk-taking channel.

In turn, Chapter 3 is devoted to the joint impact of bank capital and funding liquidity on the risk-taking channel of monetary policy. I believe that analyzing monetary policy's risk-taking channel from this perspective is key, as banks, in addition to being subject to a low interest rate environment, are required to comply with *simultaneous* capital and funding liquidity standards within the Basel III regulatory framework. Accordingly, the coordination of capital and funding liquidity ratios with monetary policy is a crucial issue.

Using an extensive dataset of 58,280 bank-year observations on the euro area between 1999 and 2018, I provide empirical evidence that before the GFC, banks concerned with a crowding-out of deposits effect (Gorton and Winton, 2017) (i.e., having low levels of deposits when equity capital is high) are more sensitive to the risk-taking channel of monetary policy. However, in the aftermath of the GFC, only efficient banks continue to display such an effect. Under low interest rates, inefficient banks become more sensitive to the risk-taking channel of monetary policy if they must comply with capital and funding liquidity standards *simultaneously*. In this scenario, concomitant capital ratios and the net stable funding ratio (NSFR) might be counterproductive in taming risk-taking behaviors.

These findings argue for special treatment for banks unable to recover in terms of efficiency after the GFC, as it might be harmful for them to require funding liquidity standards along with the existing capital ratios. The growing share of inefficient banks in most euro-area countries between 2011 and 2018 also suggests that inefficiency is a major concern when regulators strengthen capital and funding liquidity standards *simultaneously* in a low interest rate environment.

Risk persistence due to strong regulation (Delis and Kouretas, 2011) might explain this scenario. In particular, capital requirements and liquidity guarantees might broaden moral hazard, leading to inefficient and risky investments or portfolio rebalancing toward trading activities over a considerable period. Whereas prolonged low interest rates erode banks' income and franchise value, only the financial institutions able to fix moral hazard eventually mitigate the risk-taking channel of monetary policy. In line with Distinguin et al. (2013), my results also question the implementation of uniform funding liquidity requirements when less efficient banks seem to manage their credit risk differently under an accommodative monetary policy.

Finally, Chapter 4 analyzes the effects of monetary easing on bank credit risk and profitability in 10 euro-area countries between 2010 and 2019 (with a sample of 30,467 observations). I investigate how such effects depend on bank ownership structures and, for cooperative banks, how they interact with relationship lending practices. Building on previous studies indicating that credit risk and profitability are jointly determined, I consider a simultaneous equations system to examine how relationship lending by cooperative banks influences their performance in a low interest rate environment.

I find no evidence of the presence of a risk-taking channel of monetary policy for consolidated (i.e., less involved in relationship lending) cooperative banks and extensive evidence for this channel in the euro area for non-cooperative banks (see also the previous chapters of the present thesis). Second, the profitability of cooperative banks preserving their relationship lending model is more severely hit by a low interest rate environment compared to cooperative banks opting for consolidation. This raises issues on the mid-term durability of relationship lending, as interest rates having been low for an extended period in the European banking industry. Further, both non-cooperative banks and relationship-based cooperative banks are concerned about the risk-taking channel of monetary policy transmission, but not for the same reasons. As relationship lending is associated with a fundamentally different lending process than transactions-based lending technologies, these latter banks devote significantly lower proportions of their assets to lending to small businesses and high-risk firms (Berger and Udell, 2002).

Therefore, under low-for-long interest rates, non-cooperative banks accord higher priority to maintaining their profitability at the expense of higher credit risk (Kuc and Teply, 2019), whereas relationship-based cooperative banks increase their capital buffers (on average, the capitalization of relationship-based cooperative banks is significantly higher than the capitalization of consolidated cooperative banks) to ensure access to credit, including for risky local businesses. As a close bank-customer relationship produces informational rents to the cooperative banks involved, they exercise some degree of market power and are better prepared to finance riskier borrowers and projects. While one might be concerned about the durability of relationship lending when interest rates are close to the zero lower bound, this insight points to the crucial impact of the bank-customer relationship on the development of regional and local economies.

Accordingly, the greater the relationship lending strategy of a cooperative bank, the greater its willingness to undertake credit risk, which is particularly valuable to high-risk firms and small businesses. Such borrowers are often being informationally opaque and have far fewer alternatives to access external finance than large companies. The conclusions raised in this last chapter suggest that further research on the impact of the risk-taking channel of monetary policy on relationship-based cooperative banks may yield new insights into alternative transmission mechanisms, which would differ from the traditional channels already identified in the previous literature on commercial (i.e., non-cooperative) banking.

Ultimately, this thesis is in direct line with the relatively recent and abundant literature that aims to refine the understanding of the risk-taking channel of monetary policy transmission while accounting for the inherent diversity of bank-level characteristics, business models, and macroeconomic conditions in the European banking industry. Hopefully, the substantive issues addressed throughout the manuscript are avenues to explore to improve the regulatory framework that governs banking activities in the euro area.

Chapter 2

Monetary policy's risk-taking channel & leverage in bank-based financial systems

2.1 Introduction

The 2008 Global Financial Crisis (GFC) has drastically impacted risk assessment standards in banking regulation. As a result, a growing consensus has emerged among policymakers on the need to better understand the role of credit institutions in linking financial markets to the real economy. Besides a lively debate about the extent to which monetary policy should include financial stability considerations (Woodford, 2012), an important line of research also suggests that a monetary policy of "low–for–long" interest rates in the aftermath of the GFC has fueled an asset price boom, leading banks to increase leverage and engage in excessive risk–taking behaviors (Adrian and Shin, 2010).

While Borio and Zhu (2012) introduced the concept of "risk-taking channel of monetary policy transmission" to show that interest rates affect the quality — and not just the quantity — of bank credit, literature offers ambiguous predictions on how the relationship between interest rates and risk–taking interacts with bank leverage.

On the asset side of banks' balance sheets, traditional portfolio allocation models predict that increased interest rates reduce risk–taking through a reallocation from riskier securities towards safe assets. In this case, monetary policy tightening raises the hurdle rate for investment, leading agents to cut low return and/or high risk projects with an uncertain impact on the investment pool risk.

Still on the asset side, a "search for yield" effect might also arise amongst financial intermediaries experiencing negative maturity mismatches. This results in a larger share of risky assets when monetary policy easing compresses their margins. Therefore, a negative relationship between interest rate and risk–taking is predicted in this case. As returns on short–term assets are undermined compared to those on long–term liabilities, the "search for yield" effect might be more pronounced for highly levered banks.

In turn, on the liability side of balance sheets, a "risk–shifting" effect appears when higher interest rates that banks pay on deposits worsen the agency problem associated with limited liability and result in greater bank risk. A positive relationship between interest rate and risk–taking is predicted here. Moreover, as highly levered banks are more prone to agency issues, they are expected to be more sensitive to monetary policy changes, and to further exacerbate the agency problem when interest rates are higher and intermediation margins are compressed. Dell'Ariccia et al. (2014) also show that the effect of interest rates changes on risk–taking depends on the extent to which banks pass such monetary shift onto lending rates, and how they optimally adjust their capital structure.

Accordingly, the net effect of monetary policy changes on bank risk–taking and its interaction with leverage still raise important empirical questions. While a more negative impact for slightly–levered banks would be consistent with the classical "risk–shifting" effect, a more negative impact for highly–levered financial intermediaries would be consistent with a "search for yield" channel of monetary policy. Therefore, literature on bank leverage and monetary policy requires to consider alternative channels of risk-taking in addition to traditional portfolio rebalancing channels.

Consistent with the "risk–shifting" channel, Dell'Ariccia et al. (2017) provide evidence that the negative effect of interest rates on risk–taking in the U.S. industry is less pronounced for poorly capitalized banks (i.e. with higher levels of leverage). Conversely, Jiménez et al. (2014) yield insights on a "search for yield" channel for the Spanish banking industry where highly levered banks react most to changes in interest rates, taking less risk when monetary policy is tightened and more risk when it is eased. While the link between interest rates, leverage, and bank credit risk is likely to depend on geographic circumstances, there is still a lack of studies to date analyzing the post–GFC euro area as a whole to determine whether it is concerned either by a "risk–shifting" channel — similarly to the U.S. banking industry —

or, conversely, by a "search for yield" channel. However, the euro area is one of the biggest bank–based financial systems worldwide, contrary to the U.S. where the industry is rather market–based (Bats and Houben, 2020). It is also of great interest as it displays a large diversity in domestic banking systems with different levels of competition led by a common monetary policy. This empirical paper is an attempt to fill in this gap.

In the present analysis, we study the link between interest rates at different maturities, bank leverage and bank credit risk using yearly data based on a panel of 3,898 euro area banks over the period 2009–2017. We find that bank credit risk — gauged ex–ante by the loan loss provision ratio and ex–post by the non–performing loans ratio — is negatively associated with monetary policy. Confirming Ioannidou et al. (2015) insights, our results also suggest that a high level of competition in nationwide banking industries is an important vehicle for transmitting the negative impact of interest rates on bank credit risk. Further, consistent with the "search for yield" channel (Rajan, 2006), we also show that this negative relationship is more pronounced for highly levered banks operating in the post–GFC euro area.

One may be concerned that our results are confounded by an endogenous relationship between monetary policy and bank risk–taking. To address these concerns, we conduct robustness checks on the impact of macroeconomic conditions, correlation with the euro area business cycle, periods of financial distress, and large banks. Our findings survive each of these tests, which alleviates endogeneity concerns and confirms that the results we get are unlikely to be explained by monetary policy reacting to bank credit risk.

Our contribution to the existing literature is twofold. First, we empirically confirm the presence in the euro area of a risk–taking channel of monetary policy in the aftermath of the GFC. As a result, a low interest rate environment undoubtedly impacts risk–taking and requires interest rates to be complemented with other financial stability tools. Second, this paper is the first to our knowledge to present empirical evidence of a "search for yield" channel of monetary policy in the post–GFC euro area taken as a whole. Accordingly, we find that the inverse causal relation between interest rates and credit risk is increasing in bank leverage. This outcome provides a link to the theoretical literature on bank "search for yield" which posits that risk–taking is a function of leverage. While confirming Jiménez et al. (2014) insights (though restricted to the Spanish banking industry), this also points out an essential difference with the U.S. banking system where the negative link between risk–taking and interest rates is steeper for highly capitalized banks (Dell'Ariccia et al., 2017). As a result, time, geographical circumstances, and local banking market conditions are key elements for regulators and policymakers in understanding the impact of monetary policy on bank credit risk.

The remainder of the paper is organized as follows. Background literature is presented in Section 2.2 where we discuss the risk-taking channel of monetary policy transmission and its interdependencies with bank leverage. Next, Section 2.3 lays out the dataset and Section 2.4 the empirical methodology. Ultimately, Section 2.5 describes the findings and robustness checks, and Section 2.6 concludes.

2.2 Related literature

Early findings on the influence of a changing interest rate environment on banks' risk perception are provided by Hancock (1985), who analyze the interaction between bank profitability and monetary policy stance. Later, Asea and Blomberg (1998) demonstrate that banks change their lending standards — from tightness to laxity — systematically over the cycle. They suggest that loans extended on easier terms during expansions return to haunt banks as problem loans during contractions. This causes credit market imperfections to have a stronger impact on aggregate fluctuations during boom times, when the seeds of a future recession are sown.

More recently, a growing body of research has investigated the relationship between "low for long" interest rates and higher levels of bank risk. This link is introduced as the risk-taking channel of monetary policy transmission by Borio and Zhu (2012). Preliminary empirical evidence supports the idea that interest rates remaining low over an extended period trigger risk-taking in banking industries. However, in-depth analysis reveal more complex mechanisms involved in linking financial stability and monetary policy (De Nicolò et al., 2010). At least in the short-term, two opposite channels are operating.

The first channel implies a negative relationship between interest rates and bank risk-taking. This channel is explained by two main effects — the portfolio reallocation effect and the "search for yield" effect — working through the asset side of banks' balance sheets. The portfolio reallocation effect operates on the basis of valuations, incomes, and cash flows (Delis et al., 2017). Lower interest rates on safe assets boost banks' capital and collateral values, resulting in a reallocation in banks' portfolios towards riskier securities. As the hurdle rate for investment decreases, banks are inclined to undertake projects with either low return or high risk (Chodorow-Reich, 2014). This leads to reduction of banks' risk perception (Adrian and Shin, 2014), so risk-neutral banks (i.e., banks that do not internalize the losses they impose on depositors and bondholders) increase their demand for risky assets until equilibrium returns, whereas risk-averse banks reallocate their portfolios in a similar way under most utility functions[1]. This results in increasing riskiness of banks' portfolios (Fishburn and Porter, 1976) and worsening of the equilibrium risk of failure. Dell'Ariccia et al. (2014) notes that the magnitude of the portfolio reallocation effect depends on the market structure of the banking industry: it is minimal in the case of monopoly and maximal in the case of perfect competition.

In turn, the "search for yield" effect arises from pressures that monetary easing exerts on banks' profitability (Rajan, 2006). Declining interest rates indeed compress banks' margins and impair the yield on short-term assets compared to long-term liabilities. Some investment managers may have fixed rate obligations that force them to take on more risk when rates fall. A low interest rate environment also intensifies competition in the banking sector and negatively impacts the ability of banks to generate profits (Maudos and De Guevara, 2004). Eventually, it constrains banks to search for higher yields (typically derived from riskier positions) to save their credibility with investors (Buch et al., 2014).

[1]However, banks with decreasing absolute risk aversion tend to decrease their holding of risky assets instead.

The second channel implies a positive relationship between interest rates and bank risk-taking. It operates through the liability side of banks' balance sheets and is referred to in the literature as the "risk–shifting" effect (De Nicolò et al., 2010). The starting point is a maturity mismatch occurring in banks' balance sheets. As banks typically transform short-term loanable funds (e.g., deposits) into long-term loans, a cut in interest rates will improve intermediation spreads and banks' franchise value. As the demand function for loans is negatively sloped, a decline in deposit rates is only partially passed through to lending rates, causing expected net returns to rise. Such an increase in profit acts as an incentive to limit bank risk-taking to reap those gains. Therefore, riskier assets become less attractive. Eventually, this results in "shifting" value from shareholders to creditors and depositors[2].

Dell'Ariccia et al. (2014) provide a substantive contribution to the theoretical insights on the risk-taking channel of monetary policy and its interdependencies with leverage. This link is key in determining which of the two above-described channels will dominate. Under asymmetric information and limited liability, levered banks are willing to take more risk than is socially optimal (Keeley, 1990), as they generally opt for higher payoffs associated with riskier assets rather than safe investments generating a higher net present value. Highly levered banks consistently induce larger losses for depositors in the case of failure. Although banks' liabilities are

[2] An additional effect is sometimes described in the literature as the "Greenspan put" effect to account for agents' expectations of monetary policy stance (Farhi and Tirole, 2012; Diamond and Rajan, 2012). In short, if there are strong expectations of interest rates cuts in cases of future systemic threats in the banking industry, banks will tend to assume greater risk. Rather than an effective drop in interest rates, it is the implicit promise of lower rates that justifies this effect. This typically leads to a collective moral hazard issue.

priced correctly at the equilibrium, excess risk-taking occurs because investors are not able to observe banks' monitoring efforts. This moral hazard issue is one of the main rationales for prudential banking regulation to reduce leverage (De Nicolò et al., 2010).

These insights provide theoretical foundations for the relationship between the risk-taking channel of monetary policy and bank leverage during extended periods of low interest rates. On the one hand, the "risk–shifting" effect is a function of leverage and is driven primarily by limited liability. It is expected to be the strongest for highly levered banks, which, typically, are more exposed to agency problems. For instance, the "risk–shifting" effect may be stronger just ahead of a crisis, as leverage is high and competition limits the pass-through of interest rates to loan rates (in traditional "risk–shifting" models, highly levered banks tend to be more sensitive to interest rate changes). On the other hand, the "search for yield" effect points in the opposite direction but also tends to be most pronounced for highly levered banks, as they switch to riskier assets in higher proportions (Dell'Ariccia et al., 2017). This may be due to a higher degree of competition and a lower ability for such banks to adjust their capital structure.

Recent empirical research on the U.S. industry demonstrates the presence of a risk-taking channel of monetary policy transmission. For instance, Abbate and Thaler (2019) show that a low interest rate environment impairs banks' lending standards. Adrian and Shin (2014), in turn, suggest that such an environment leads to increased leverage and asset risks, as noted by Angeloni et al. (2015). For the euro area, the low interest rates' environment turns out to be a multi-faceted issue influencing lending standards (Maddaloni and Peydró, 2011), risk preferences, and profiles (Altunbas et al., 2014), in addition to interest rate margins (Claessens et al., 2018). This paper is part of the growing literature providing evidence of a risk-taking channel of monetary policy transmission in the euro area. However, the way in which interest rates influence bank risk-taking and how this relationship interacts with bank leverage still remain under-documented for bank-based and highly heterogeneous financial systems such as the euro area after the GFC. In what follows, we provide an empirical analysis that attempts to address this gap.

2.3 Data

This paper uses panel data from the euro area (excluding Estonia, Malta, and Slovakia due to incomplete data) to examine the interaction of monetary policy with leverage in bank risk-taking. We collect bank balance sheets and income statement data from Fitch Connect at an annual frequency over the period 2009–2017. The sample includes four categories of banks: retail and consumer banks, universal commercial banks, wholesale commercial banks, and private banks. Data on bank financials provide exclusively unconsolidated accounts, making the assumption that each subsidiary manages its own assets. This implies that foreign owned banks are classified abroad and not in their home country. Before running regressions, we apply an outlier rule to drop lines corresponding to missing data and extreme values. The final sample consists of 27,072 bank-year observations broken down into 3,898 banks from 16 countries[3]. Since 2008, banks have continued to scale back their physical presence across Europe, as the importance of widespread bank branch networks has reduced. According to the European Banking Federation (2017), the number of banks from the countries we examine reached a total of 4,682 entities in 2017, so our sample covers more than 83% of the banking systems surveyed.

Analyzing the impact of interest rates on risk-taking, Ashcraft (2006) notes that quarterly data reduce the ability to control for differences across banks in the response of loan demand to monetary policy, and also demonstrates the robustness of a stripped-down version of its results to data frequency. As Fitch Connect does not provide quarterly data[4], we consider annual data sound enough to explain the interaction of monetary policy with leverage in bank risk-taking. The fact that our empirical analysis focuses on the level of interest rates (which considers by nature a longer-term phenomenon) and only secondarily on their change also supports this view. In Appendix A, Table A1 provides variables' definition, source, and level, and Pairwise Pearson correlation coefficients in Table B1 show that independent variables used in the empirical methodology (see Section 2.4) are not highly correlated, so multicollinearity is not a major concern. Table B1 describes a slightly downward trend of the yearly average of leverage ratio over the sample period for EU banks. In what follows, we describe the choice of our dependent and explanatory variables.

[3]The countries in the analysis are Austria, Belgium, Cyprus, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania, Luxembourg, the Netherlands, Portugal, Slovenia, and Spain.

[4]Or only scarcely, which would considerably reduce the number of bank-year observations in the sample.

2.3.1 Bank credit risk

The present study is built at the loan level. As such, we consider an ex–ante credit risk rating indicator using the ratio of loan loss provision to gross loans (noted as *Loan loss provision* hereafter), and an ex–post credit risk rating indicator using the ratio of non-performing loans to gross loans (denoted as *Non-performing loans* hereafter). Descriptive statistics are reported in panel A from Table 2.1[5]. *Loan loss provision* index shows the share of gross loans used as an allowance for uncollected loans and loan payments to cover factors associated with potential loan losses (including bad loans, customer defaults, and renegotiated terms of a loan causing lower than previously estimated payments). An increase in *Loan loss provision* is associated logically with a riskier position. We collect a total number of 27,072 observations for this variable. In the wake of the GFC, *Loan loss provision* the annual average falls drastically between 2009 (72.94%, i.e., the sample's highest average value) and 2011 (19.86%, i.e., the sample's lowest average value). The variable remains relatively stable between 2012 (46.16%) and 2015 (46.49%) to decline again in 2016 (25.85%) and 2017 (22.72%).

In turn, *Non-performing loans* index identifies problems with asset quality in banks' loan portfolios and highlights the potential adverse exposure to earnings and asset market values due to worsening loan quality. Commercial loans are considered non-performing if the debtor has made zero payments of either interest or principal within 90 days, or is 90 days' past due payment. Regarding consumer loans, 180

[5] As Fitch Connect database provides bank financials expressed as a decimal, we left unchanged this measure unit. Apart from *HHI* variable which is also expressed as a decimal, all other variables are expressed as a percentage.

Table 2.1: Descriptive statistics

Variable	Unit	Mean	Median	Std. dev.	Minimum	Maximum	Observations	Banks	Countries
Panel A: Variables of interest									
Loan loss provision	Decimal	0.4382	0.2900	1.0318	-5.0000	5.0000	27,072	3,898	16
Non-performing loans	Decimal	0.0678	0.0421	0.0732	0.0000	0.6822	15,650	2,993	16
ECB rate	Percent	0.5775	0.5534	0.5049	0.0000	1.2788	27,072	3,898	16
Short-term rate	Percent	0.4252	0.2200	0.5784	-0.3300	1.3900	27,072	3,898	16
Medium-term rate	Percent	0.7905	0.5400	0.7158	-0.1500	2.0100	27,072	3,898	16
Long-term rate	Percent	2.1605	1.7133	1.6205	0.0900	22.4983	27,072	3,898	16
Leverage	Decimal	0.9057	0.9160	0.0652	0.0004	0.9990	27,072	3,898	16
Panel B: Bank-level controls									
Size	ln(€)	6.7612	6.5344	1.8367	1.1641	14.6225	27,072	3,898	16
ROAA	Decimal	0.3154	0.2600	0.7580	-9.7100	11.6000	27,072	3,898	16
Inefficiency	Decimal	0.6861	0.6786	0.2074	-1.3415	3.8791	27,072	3,898	16
Net loans	Decimal	0.5897	0.6108	0.1850	0.0000	0.9985	27,072	3,898	16
Panel C: Nationwide controls									
GDP	Percent	0.8341	1.6000	2.5822	-9.1000	8.8000	27,072	3,898	16
Inflation	Percent	1.2351	1.1000	0.9645	-1.7000	4.7000	27,072	3,898	16
HHI	Decimal	0.0794	0.0587	0.0594	0.0447	0.6962	27,072	3,898	16

Notes. The table reports summary statistics for the variables used in the empirical analysis. Variables' definitions are provided in Table A1 (see appendix section). The sample consists of bank panel data for 16 euro area countries over the period 2009-2017. Data on bank financials provide exclusively unconsolidated accounts, making the assumption that each subsidiary manages its own assets. This implies that foreign owned banks are classified abroad and not in the home country. The number of banks broken down by country is respectively: 327 banks in Austria; 40 banks in Belgium; 19 banks in Cyprus; 139 banks in Finland; 335 banks in France; 1,829 banks in Germany; 17 banks in Greece; 22 banks in Ireland; 676 banks in Italy; 21 banks in Latvia; 11 banks in Lithuania; 87 banks in Luxembourg; 37 banks in Netherlands; 119 banks in Portugal; 20 banks in Slovenia and 199 banks in Spain.

days' past due classifies them as non-performing. A high value for this ratio means greater bank risk. A total of 15,650 observations are gathered for this variable. The sample's highest mean value is observed in 2011 (7.63%) and the lowest is in 2017 (5.83%). *Non-performing loans* index is complementary to *Loan loss provision*, as it assesses ex–post the forecast quality of the ex–ante credit risk rating indicator. Figure D1 graphically shows the yearly average declining trends of these two bank credit risk proxies between 2009 and 2017.

2.3.2 Interest rates

To assess the interaction of monetary policy with leverage in bank risk-taking, we experiment with four types of interest rates: the central bank rate, a short-term rate, a medium-term rate, and a long-term rate. Data are collected from Eurostat and concern annual averages, for which descriptive statistics are reported in panel A from Table 2.1. The central bank rate is the annual average of the ECB policy rate on the main refinancing operations, which provides the bulk of liquidity to the euro area banking system. We use the 3-month and 12-month Euribor interbank rates as representative of the annual average of, respectively, the short-term and medium-term interest rates at which euro interbank term deposits are offered by prime banks to one another[6]. In turn, the long-term rate is the annual average of central government bond yields on the secondary market, gross of tax, with a residual maturity of approximately 10 years. These indicators are referred to, respectively, as *ECB rate*, *Short-term rate*, *Medium-term rate*, and *Long-term rate*, and they all account for 27,072 bank-year observations. As it is measured at the country-level, *Long-term rate* exhibits a higher standard deviation compared to other rates gauged at the European-level. Ultimately, it also helps to capture various aspects of the impact of monetary policy changes on leverage and risk-taking and acts as a robustness check for our empirical results.

The four rates used in the analysis broadly follow the same path: they all decline in 2009 and 2010 to reach a peak in 2011, and then decline constantly up to 2017. This makes *ECB rate*, *Short-term rate*, *Medium-term rate* and *Long-term rate* achieve their highest average in 2009 (with values of 1.28%, 1.22%, 1.61%, and 3.62%, respectively) and their lowest average in 2017 (with values of 0.00%, -

[6]We experiment with alternative interest rate maturities (i.e., 1-month, 6-months) in empirical estimations and find practically unchanged results.

0.33%, -0.15%, and 0.79%, respectively). Greece exhibits the highest *Long-term rate* average value over the sample period (9.40%), whereas Finland shows the lowest value, with an overall average of 1.10%. Figure D1 graphically shows the yearly average declining trends of monetary policy proxies used in our empirical analysis.

2.3.3 Bank-level controls

To avoid the omitted-variables' bias, we collect several bank-level indicators from Fitch Connect that may impact credit risk. The last variable of interest included in panel A from Table 2.1 measures how bank business relies on debt rather than fresh equity. *Leverage* variable is proxied by the ratio of short-term and long-term debt to total assets, also known as the debt-to-assets ratio. Though *Leverage* magnifies profits when asset yields more than offset borrowing costs, it may also magnify losses. A bank borrowing too much money might face bankruptcy during a business downturn, whereas a less-levered entity might survive. *Leverage* is an important element in shaping bank risk and is inversely related to tightening of capital requirements. This variable decreases continuously over the sample period, as it reaches its highest mean value in 2009 (91.80%) and the sample's lowest mean value in 2017 (89.53%). On average, the Netherlands' banking system relies the most on leverage between 2009 and 2017 (with an overall average of 91.92%) whereas Greece's shows the most moderate use of this financing strategy (85.65%).

We complement the *Leverage* variable with four other bank-level controls described in panel B from Table 2.1. *Size* index is gauged by the natural logarithm of bank total assets. Though the overall sample average value is 6.7612, it is worth noting that the yearly average log-transformed size of banks in the sample shows a constant increase between 2010 (6.6591) and 2017 (6.9237). A negative sign of the *Size* coefficient would confirm the theory that larger banks are more risk averse (Delis and Kouretas, 2011). Next, we consider *ROAA* as a bank profitability indicator. The return on average assets is proxied by the ratio of net income on average total assets and explains how well bank assets are being used to generate profits. After a decline between 2009 (29.87%) and 2013 (28.90%), *ROAA* rises steeply in 2014 (35.01%) to decrease again in 2015–2016 and then reach the sample's highest mean value in 2017 (i.e., 36.22%). A high level of profitability may be associated with higher risk-taking (especially in good times), as profits at time t may be allocated to more loans at time $t+1$. However, when a bank's balance sheet becomes too risky, the share of non-performing loans may also rise and hamper profitability. Eventually, this leads to reduction of bank risk assets. This may explain cyclical fluctuations we observe for *ROAA* over the sample period. Hence, the impact of *ROAA* on bank credit risk remains ambiguous.

In addition, we measure bank *Inefficiency*, thanks to the ratio of total expenses to total revenue. Theoretically, more efficient banks could perform better in terms of risk management, or else take greater risks to improve their revenues compared to their expenses. Therefore, the relation between *Inefficiency* and credit risk is not fixed and may go one way or the other. Following the 2008 financial crisis, EU banks from our sample reduced their level of expenses compared to their revenues up to 2014 (sample's lowest average value at 67.15%) to finally see a sharp increase in expenses until 2016 (sample's highest average value at 70.59%). Lastly, we control for the level of traditional banking intermediation in which banks are involved using the ratio of net loans to total assets (denoted as *Nets loans* hereafter). This proxy gauges the volume of total loans granted to banks' customers and, accordingly, are listed on the balance sheet assets side. The relationship between *Net loans* and credit risk strongly depends on customers' solvency and the quality of banks' screening standards. After an increase between 2009 and 2011 (sample's highest mean value at 59.75%), *Nets loans* declines markedly to the sample's lowest mean value in 2012 (58.46%). Afterwards, it experiences a constant growth phase, especially between 2014–2017.

Over the period 2009–2017, Table 2.1 shows that *Leverage* and *ROAA* constitute, on average, 90.57% and 31.54% of bank total assets, respectively. The share of *Nets loans* accounts for 58.97% of total assets, which means loans constitute, on average, the largest component of banks' balance sheets. This makes our focus on bank credit risk relevant and of special interest for the euro area banking industry over the period surveyed. In turn, total expenses represent, on average, 68.61% of banks' total revenue. Finally, as variations of bank *Size* are smoothed out by log-transformation, *ROAA* proxy appears to be particularly volatile compared to other bank-level controls, exhibiting a 75.80% standard deviation.

2.3.4 Nationwide controls

We augment the set of bank-level variables with three nationwide controls described in Table 2.1 (see panel C) and defined in Table A1. Conventionally, we include macroeconomic conditions in our estimations using the percentage change in the previous year of real GDP growth rate (noted as *GDP*). We also control for the general price level among countries in the sample (as referred to *Inflation* hereafter) through the annual average rate of change of the Harmonized Index of Consumer Prices. Both indicators are collected from the Eurostat database. Moreover, we compute the Herfindahl–Hirschman Index (denoted as *HHI*) to capture banking industries' concentrations, which may differ substantially from one country to another in the euro area.

Over the sample period, Lithuania presents the highest real GDP growth rate variation, with an overall average value of 3.30%, while Greece is ranked lowest, with an overall average of -3.00%. *GDP* exhibits the highest standard deviation among nationwide control variables. In turn, Ireland has the most stable inflation environment, with an overall average value of -0.0023% and Austria has an average value of 1.75%, which means that its domestic economy is relatively more impacted by price changes between 2009–2017. Broadly speaking, the European Central Bank (2017) emphasizes that banking systems in many of the larger countries are more fragmented, which reduces concentration levels. By contrast, banking systems in smaller euro area countries, with the exception of Austria and Luxembourg, tend to be more concentrated. In Austria, this higher level of fragmentation is due to a banking sector structure that is similar to those of the larger countries, whereas, in Luxembourg, it is attributable to the presence of a large number of foreign credit institutions. Our data support this view: with only 139 entities operating, the Finnish banking system is the most concentrated (according to the

HHI indicator, with an average value of 0.3968), whereas Germany has the most fragmented industry (with an average *HHI* of 0.0505) but holds the largest amount of assets at the country-level in the sample.

2.4 Empirical methodology

We employ dynamic panel techniques to investigate the relationship between interest rates and bank credit risk in the euro area between 2009–2017. The general empirical model to be estimated is as follows:

$$\begin{aligned} Risk_{b,c,t} \ = \ \alpha \ + \ \beta \ Risk_{b,c,t-1} \ + \ \gamma \ Rate_{c,t} \ + \\ \delta \ Bank_{b,c,t} \ + \ \zeta \ Macro_{c,t} \ + \ \lambda_b \ + \ \varepsilon_{b,c,t} \end{aligned} \tag{2.1}$$

where b, c and t subscripts, respectively, stand for bank b in country c at time t. Vector λ_b represents time invariant bank fixed effects, and $\varepsilon_{b,c,t}$ gauges the idiosyncratic error term for bank b in country c at time t, which is clustered at the bank-level. The dependent variable $Risk_{b,c,t}$ refers to the credit risk of bank b from country c at time t and is measured ex–ante via the *Loan loss provision* indicator and ex–post through the *Non-performing loans* variable. The $Risk_{b,c,t-1}$ index is the first-order auto-regressive term assessing the persistence of bank risk over time. Delis and Kouretas (2011) provide theoretical insights to explain why bank risk is persistent. First, given that risk-taking is usually procyclical, time is needed for banks to absorb macroeconomic shocks in their balance sheets. Second, bank risk may be delayed (or exacerbated) by regulatory capital requirements[7]. Third, as

[7]In the euro area, the Capital Requirements Directive IV package (CRD IV) became, on January 1, 2014, the new global standards on bank capital, with the purpose of tightening legislation

the banking industry is highly competitive, herding behaviors in this sector may be more pronounced than are those in other sectors and eventually impact risk stickiness over time. Discussions opposing the competition–fragility view to the competition–stability view provide clear evidence of the influence of competition on risk persistence (see Beck et al. (2013), Fu et al. (2014)). Finally, loans' performance may influence risk for an extended period of time, especially for relationship-banking entities or when the nationwide industry is being opaque. Accordingly, β coefficient may be interpreted as the speed of convergence to equilibrium. It ranges from 0 (i.e., very fast adjustment of bank risk to equilibrium) to 1 (i.e., very slow adjustment or impossibility to reach equilibrium), and values between 0 and 1 suggest that bank risk indeed persists but will eventually return to its average level.

The independent test variable $Rate_{c,t}$ is measured with four types of rates described in Section 2.3 and defined in Table A1: *ECB rate*, *Short-term rate*, *Medium-term rate* and *Long-term rate*. Consistent with the literature on the portfolio reallocation effect, we expect the coefficient of interest γ to be negative. $Bank_{b,c,t}$ is a set of bank-specific control variables (*Size*, *ROAA*, *Inefficiency* and *Net loans*) collected from Fitch Connect that may affect credit risk (see descriptive statistics in Table 2.1). $Macro_{c,t}$ is a set of country-specific controls (*GDP*, *Inflation* and *HHI*).

Based on Dell'Ariccia et al. (2017) methodology testing whether the effect of interest rates on bank credit risk depends on the level of leverage, we extend the empirical model presented in Equation 2.1 by including the *Leverage* variable and

on banking prudential requirements.

an interaction term, as follows:

$$Risk_{b,c,t} = \alpha + \beta\ Risk_{b,c,t-1} + \gamma\ Rate_{c,t} + \delta\ Leverage_{b,c,t} + \big(\zeta\ Rate_{c,t} * Leverage_{b,c,t}\big) + \eta\ Bank_{b,c,t} + \theta\ Macro_{c,t} + \lambda_b + \varepsilon_{b,c,t} \tag{2.2}$$

where $Leverage_{b,c,t}$ is the ratio of short-term and long-term debt to total assets (i.e., the debt-to-assets ratio). The focus of Equation 2.2 is on the interaction term between interest rates and bank leverage. A negative coefficient ζ would confirm the presence of a "search for yield" effect in our estimations. We estimate Equation 2.1 and Equation 2.2 using the System Generalized Method of Moments, where first-difference equations are instrumented with their own lags in levels, and levels' equations are instrumented with their own lagged first differences. In what follows, we treat interest rate variables and bank-level controls *Leverage*, *Size*, *ROAA*, *Inefficiency* and *Net loans* as endogenous, similarly to the dependent variable. In turn, nationwide controls *GDP*, *Inflation* and *HHI* enter the estimated equations as predetermined variables, because we assume that the banks surveyed are fully aware of their macroeconomic environment when choosing risk-taking strategies.

2.5 Discussion of findings

In this section, we present the main findings on the effect of monetary policy on bank credit risk in the euro area over the period 2009–2017 (Table 2.2 and Table 2.3). We further analyze how bank leverage may influence this relationship in Table 2.4 and Table 2.5.

Our results survive a battery of robustness tests to allay concerns about monetary policy endogeneity and the threat that interest rate changes may be exogenous to bank risk-taking (Table 2.6 to Table 2.9). Robust standard errors are clustered at the bank-level throughout the empirical analysis. We also check first-order and second-order autocorrelation using Arellano–Bond tests. The Hansen test controls for instruments' correlation with residuals.

2.5.1 Risk-taking channel of monetary policy: the "portfolio reallocation" effect

Table 2.2 presents general estimations based on Equation 2.1. Regressions (1) to (4) include the *Loan loss provision* index as a dependent variable, whereas the *Non-performing loans* index is used in regressions (5)–(8). The coefficients on the lagged dependent variables suggest that bank credit risk is much more persistent when using the *Non-performing loans* variable than the *Loan loss provision* variable, which returns more rapidly to equilibrium. Consistent with the portfolio reallocation effect, the relationship between interest rates and bank credit risk is significantly negative in all regressions (except in regression (8) for the relationship between *Non-performing loans* and *Long-term rate*). This first result provides evidence that a low interest rates' environment increases bank credit risk and supports findings from an extensive body of literature dedicated to this issue (see Adrian and Shin (2014); Altunbas et al. (2014); Buch et al. (2014); Neuenkirch and Nöckel (2018),

Table 2.2: Monetary policy conditions & bank credit risk in the EU (2009-2017): the portfolio reallocation channel

	Loan loss provision to gross loans				Non-performing loans to gross loans			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Loan loss provision$_{(t-1)}$	0.2587*	0.1252*	0.1362**	0.2115				
	(0.1525)	(0.0644)	(0.0661)	(0.2194)				
Non-performing loans$_{(t-1)}$					0.9485***	0.9072***	0.8950***	0.9966***
					(0.1045)	(0.0857)	(0.0727)	(0.1090)
ECB rate	-0.4070***				-0.0072***			
	(0.0928)				(0.0028)			
Short-term rate		-0.1478**				-0.0047***		
		(0.0606)				(0.0016)		
Medium-term rate			-0.1106**				-0.0038***	
			(0.0455)				(0.0012)	
Long-term rate				-0.1463*				-0.0044
				(0.0873)				(0.0035)
Size	-0.7531***	-0.6758***	-0.6361***	-1.3271***	-0.0180***	-0.0177***	-0.0154***	-0.0280*
	(0.1262)	(0.1393)	(0.1187)	(0.4337)	(0.0044)	(0.0050)	(0.0043)	(0.0155)
ROAA	0.3011	-1.0712***	-1.0994***	0.1221	-0.0158**	-0.0185**	-0.0146*	-0.0233***
	(0.3244)	(0.3221)	(0.3680)	(0.4082)	(0.0073)	(0.0080)	(0.0078)	(0.0069)
Inefficiency	-2.1151***	-4.0903***	-3.8556***	-2.5698**	-0.0812***	-0.1227***	-0.1147***	-0.1373***
	(0.6865)	(0.9507)	(0.9688)	(1.2698)	(0.0249)	(0.0254)	(0.0227)	(0.0219)
Net loans	-2.7018**	-1.4577	-1.4163	-1.2658	0.0119	-0.0139	-0.0232	0.0248
	(1.0663)	(0.9553)	(0.9499)	(1.3836)	(0.0457)	(0.0425)	(0.0392)	(0.0543)
GDP	-0.1143***	0.0028	-0.0047	-0.1253***	-0.0057***	-0.0014*	-0.0016**	-0.0061**
	(0.0187)	(0.0161)	(0.0170)	(0.0357)	(0.0012)	(0.0008)	(0.0007)	(0.0025)
Inflation	0.0139	-0.0185	-0.0140	-0.1690**	-0.0006	0.0038***	0.0039***	0.0016
	(0.0378)	(0.0209)	(0.0215)	(0.0733)	(0.0007)	(0.0012)	(0.0011)	(0.0028)
HHI	7.9615***	5.7946***	5.8391***	16.5397***	0.3423***	0.0542	0.0400	0.4585*
	(1.6433)	(1.4679)	(1.4192)	(4.2367)	(0.1259)	(0.0740)	(0.0774)	(0.2697)
Constant	8.0885***	8.5405***	8.1199***	11.2019***	0.1660***	0.2228***	0.2091***	0.2603**
	(0.9725)	(1.2541)	(1.1022)	(4.0268)	(0.0373)	(0.0474)	(0.0432)	(0.1275)
Observations	22,657	22,657	22,657	22,657	11,893	11,893	11,893	11,893
Number of banks	3,622	3,622	3,622	3,622	2,715	2,715	2,715	2,715
Wald χ^2	331.65***	212.66***	238.49***	236.78***	2,165.12***	923.22***	1,239.34***	1,410.80***
Arellano-Bond (1)	0.0000	0.0000	0.0000	0.0030	0.0000	0.0000	0.0000	0.0000
Arellano-Bond (2)	0.1500	0.2640	0.2050	0.5750	0.1530	0.1750	0.1330	0.2490
Hansen	0.0700	0.1870	0.2980	0.3190	0.4520	0.1360	0.2100	0.2890

Notes. The table reports coefficients and robust standard errors (in parentheses) for two-step system GMM dynamic panel estimations. Robust standard errors are clustered at the bank-level. The dependent variable is the ratio of loan loss provision to gross loans in regressions (1) to (4) and the ratio of non-performing loans to gross loans in regressions (5) to (8). All other variables are defined as in Table A1 (see appendix section). The Wald test shows the goodness-of-fit of regressions. The Arellano-Bond (1) and (2) tests report p-values for the null hypothesis that the errors in first differences regression do not exhibit, respectively, first-order and second-order autocorrelation. The Hansen test reports p-values for the null hypothesis that the instruments are not correlated with residuals. *Statistical significance at the 10% level. **Statistical significance at the 5% level. ***Statistical significance at the 1% level.

among others). This also confirms empirically the presence in the post–2008 euro area of a risk-taking channel (Borio and Zhu, 2012) as regards the effects of monetary policy on banks' risk-taking behavior.

Bank size coefficient is negative and highly significant, which means that larger banks are more capable at managing credit risk. We obtain a similar relation for our profitability indicator: the more profitable a bank, the better its risk management. The negative coefficients associated to the *Inefficiency* variable suggest that between

2009 and 2017, euro area banks' efficiency has come at the cost of higher credit risk. *Net loans* coefficient does not appear to be significant in estimations from Table 2.2, except in the relation between *Loan loss provision* and *ECB rate*. This suggests that when banks are more involved in traditional banking intermediation, they present a relatively lower credit risk.

This may be due to a better knowledge of risk profiles of their borrowers. Regarding macroeconomic variables, the relation between *GDP* and credit risk is significantly negative. This indicates that banks operating in a growing economy are inclined to reduce credit risk. Such a result shows that good economic conditions foster borrowers' repayment capacity. In turn, *Inflation* coefficient presents different results depending on the dependent variable used: a negative sign appears in the relation between *Loan loss provision* and *Long-term rate* relation, whereas a positive sign characterizes the relation between *Non-performing loans* and both *Short-term rate* and *Medium-term rate*. Finally, industry concentration is significant and positively related to bank credit risk: more concentrated banking industries seem to better manage credit risk over the period 2009–2017.

Dell'Ariccia et al. (2014) provide theoretical insights on the link between industry concentration and the magnitude of the portfolio reallocation effect. Specifically, they suggest that it depends on how policy rate changes are reflected in lending rates, which, in turn, are related to the market structure of the banking industry. In the case of a monopolist facing an inelastic demand function, the magnitude of this effect is minimal, and the pass-through onto the lending rates is zero. Conversely, it is maximal in the case of perfect competition, when lending rates

Table 2.3: Monetary policy conditions & bank credit risk in the EU (2009-2017): portfolio reallocation channel & industry concentration

	Loan loss provision to gross loans							
	High competition	Low competition	High competition	Low competition	High competition	Low competition	High competition	Low competition
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Loan loss provision$_{(t-1)}$	0.7196*	0.3180**	-0.0773	0.2327*	-0.0263	0.2270*	0.4747*	0.1781
	(0.4187)	(0.1315)	(0.1477)	(0.1335)	(0.1028)	(0.1353)	(0.2715)	(0.1278)
ECB rate	-1.2456***	-0.2212***						
	(0.2276)	(0.0740)						
Short-term rate			-0.4076***	-0.1228**				
			(0.1522)	(0.0510)				
Medium-term rate					-0.7615***	-0.0949**		
					(0.1870)	(0.0404)		
Long-term rate							-0.4759**	-0.0610**
							(0.1946)	(0.0300)
Size	-1.8748***	-0.4148***	-1.2399***	-0.4132***	-2.7861***	-0.4273***	-5.0175***	-0.5080***
	(0.4788)	(0.1137)	(0.2767)	(0.1185)	(0.5630)	(0.1211)	(1.5790)	(0.1481)
ROAA	-1.0294***	-0.2174	-0.5542***	-0.2535	-0.7408***	-0.2562	-1.0045***	-0.7769***
	(0.3292)	(0.2021)	(0.1981)	(0.2071)	(0.2387)	(0.2038)	(0.3850)	(0.2428)
Inefficiency	-2.4643***	-3.6268***	-1.1509***	-4.0978***	-1.2032**	-3.9881***	-2.2286**	-4.4625***
	(0.7121)	(0.5251)	(0.4280)	(0.5989)	(0.5960)	(0.5806)	(0.9872)	(0.6492)
Net loans	-6.8717	-3.9824***	-8.7968***	-4.2368***	-15.7206***	-4.2978***	-21.9032***	-3.2809***
	(4.4461)	(0.9888)	(1.6953)	(0.9828)	(2.6207)	(0.9849)	(4.9065)	(0.7717)
GDP	0.0417	-0.0633***	0.1191***	-0.0488**	0.1573**	-0.0506**	-0.1986***	-0.0609**
	(0.0410)	(0.0225)	(0.0224)	(0.0232)	(0.0656)	(0.0230)	(0.0706)	(0.0255)
Inflation	0.1754**	0.0927*	-0.0761	0.0517	0.0484	0.0494	-0.1039**	0.0356
	(0.0817)	(0.0477)	(0.0463)	(0.0446)	(0.0655)	(0.0449)	(0.0450)	(0.0506)
HHI	54.5728***	-0.7631	13.2263**	-0.8291	10.3694	-0.7316	-56.8700***	2.0293
	(10.7174)	(1.4961)	(6.0817)	(1.6354)	(7.2017)	(1.5969)	(17.2956)	(1.2562)
Constant	15.7982***	8.5390***	13.6068***	9.0632***	28.1641***	9.1518***	51.5359***	9.4797***
	(5.0138)	(1.3616)	(1.7321)	(1.4093)	(4.4075)	(1.4415)	(13.8359)	(1.4478)
Observations	12,809	9,848	12,809	9,848	12,809	9,848	12,809	9,848
Number of banks	1,798	1,824	1,798	1,824	1,798	1,824	1,798	1,824
Wald χ^2	305.65***	591.72***	426.96***	535.43***	248.18***	536.31***	101.11***	617.88***
Arellano-Bond (1)	0.0110	0.0000	0.0040	0.0000	0.0000	0.0000	0.0030	0.0000
Arellano-Bond (2)	0.0850	0.4460	0.6910	0.6390	0.8930	0.6530	0.0440	0.9300
Hansen	0.2830	0.7830	0.4550	0.5630	0.0830	0.5590	0.6110	0.0540
Ho: Rate [High competition] = Rate [Low competition]	0.0000^a $\chi^2(1) = 20.26$		0.0613^b $\chi^2(1) = 3.50$		0.0004^c $\chi^2(1) = 12.71$		0.0330^d $\chi^2(1) = 4.55$	

Notes. The table reports coefficients and robust standard errors (in parentheses) for two-step system GMM dynamic panel estimations. Robust standard errors are clustered at the bank-level. The dependent variable is the ratio of loan loss provision to gross loans in all regressions. All other variables are defined as in Table A1 (see appendix section). High competition subsample in regressions (1), (3), (5) and (7) and low competition subsample in regressions (2), (4), (6) and (8) refer to observations for which *HHI* is, respectively, below and above the full sample median value. The Wald test shows the goodness-of-fit of regressions. The Arellano-Bond (1) and (2) tests report p-values for the null hypothesis that the errors in first differences regression do not exhibit, respectively, first-order and second-order autocorrelation. The Hansen test reports p-values for the null hypothesis that the instruments are not correlated with residuals. *Statistical significance at the 10% level. **Statistical significance at the 5% level. ***Statistical significance at the 1% level.
[a] χ^2-statistics p-values testing that ECB rate coefficient from high competition subsample = ECB rate coefficient from low competition subsample.
[b] χ^2-statistics p-values testing that short-term rate coefficient from high competition subsample = short-term rate coefficient from low competition subsample.
[c] χ^2-statistics p-values testing that medium-term rate coefficient from high competition subsample = medium-term rate coefficient from low competition subsample.
[d] χ^2-statistics p-values testing that long-term rate coefficient from high competition subsample = long-term rate coefficient from low competition subsample.

fully reflect policy rate changes. So, the portfolio reallocation effect should be greater within highly competitive banking industries and weaker as competition vanishes. In Table 2.3, we decompose the sample into two subsamples depending on the level of concentration of banking industries. The high competition subsamples in regressions (1), (3), (5), and (7) refer to observations for which the *HHI* variable is below the full sample median value. Regressions (2), (4), (6), and (8) are based on the low competition subsample. Though the relationship between interest rates and bank credit risk remains significantly negative, we observe that the magnitude of the portfolio reallocation effect is invariably greater in highly competitive industries.

Differences between samples in interest rate coefficients appear to be consistently significant, specifically at the 0% level for the *ECB rate* and the *Medium-term rate*, at the 3.3% level for the *Long-term rate*, and at the 6.1% level for the *Short-term rate*. For instance, a one percentage point decrease in the *ECB rate* is associated with a 1.24 basis-point increase in the *Loan loss provision* index for the high competition subsample compared to a 0.22 basis-point increase for the low competition subsample.

This confirms that the intensity of the interest rates' pass-through differs depending on industries' concentrations. It also empirically supports Dell'Ariccia et al. (2014) theoretical contributions on the role of market structure on the portfolio reallocation channel. Finally, we notice significant coefficients on the negative link between *Net loans* and *Loan loss provision*, which is consistent with a lower credit risk on behalf of entities oriented towards relationship-banking in competitive markets.

2.5.2 Leverage & risk-taking channel of monetary policy: the "search for yield" effect

Next, we consider the differential effect of bank leverage on the link between interest rates and credit risk to gauge the importance of the "search for yield" channel proposed by Rajan (2006). This theoretical framework suggests that banks are induced to switch to riskier assets (and higher yields) when monetary easing lowers the yield on short-term assets relative to long-term liabilities. If yields on safe assets remain low for long, banks may ultimately default on their long-term commitments, so that switching to riskier assets may improve the likelihood to match their obligations. Table 2.4 presents estimations based on Equation 2.2 inspired by Dell'Ariccia et al. (2017) methodology. Accordingly, we augment Equation 2.1 with both the *Leverage* variable and its interaction with interest rates. From a theoretical perspective, this interaction implies that leverage influences the relationship between interest rates and bank credit risk, as we consider that it is no longer linear. Therefore, the product term allows the *main* effect to depend on leverage levels in banks' balance sheets. The significance of the sum of the main effect and the interaction term is verified for each regression.

Consistent with the "search for yield" effect, the estimations provide statistically significant and negative coefficients on the interaction between bank leverage and interest rates (except for the link between *Non-performing loans* and *Long-term rate* variables in regression (8), similar to the results obtained for the portfolio reallocation channel). This effect is economically significant and implies that an

Table 2.4: Monetary policy conditions & bank credit risk in the EU (2009-2017): the search for yield channel

	Loan loss provision to gross loans				Non-performing loans to gross loans			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Loan loss provision$_{(t-1)}$	0.4061	0.2503	0.2137	0.1057				
	(0.2517)	(0.1582)	(0.1464)	(0.2957)				
Non-performing loans$_{(t-1)}$					0.7922***	0.8941***	0.8996***	0.7752***
					(0.1643)	(0.0705)	(0.0700)	(0.1632)
ECB rate	21.6855**				0.6260*			
	(9.8304)				(0.3195)			
Short-term rate		10.2116***				0.4684**		
		(3.9231)				(0.2238)		
Medium-term rate			7.0273**				0.4190**	
			(3.0889)				(0.1725)	
Long-term rate				9.9841**				0.1939
				(4.6545)				(0.1640)
Leverage	12.7952	-12.9236	-9.9524	7.4594	0.3738	-0.4439**	-0.1638	0.4904
	(15.1513)	(7.8741)	(8.2203)	(12.6645)	(0.2651)	(0.1872)	(0.2223)	(0.7779)
ECB rate * Leverage	-24.5949**				-0.7037**			
	(10.7679)				(0.3529)			
Short-term rate * Leverage		-11.3734***				-0.5094**		
		(4.3026)				(0.2456)		
Medium-term rate * Leverage			-7.8598**				-0.4594**	
			(3.3821)				(0.1893)	
Long-term rate * Leverage				-11.0468**				-0.2177
				(5.1681)				(0.1811)
Size	-0.5158	-0.3024	-0.4112	-1.0037	-0.0039	0.0081**	0.0073**	-0.0148
	(0.3589)	(0.2609)	(0.2689)	(0.8086)	(0.0044)	(0.0038)	(0.0034)	(0.0138)
ROAA	-0.6140	-1.2885**	-1.1371**	-1.4045	-0.0177	-0.0471***	-0.0429***	-0.0425**
	(0.5752)	(0.5335)	(0.5001)	(0.9903)	(0.0120)	(0.0159)	(0.0141)	(0.0199)
Inefficiency	-8.6627***	-7.9928***	-7.7933***	-8.9369*	-0.1021***	-0.1195***	-0.1378***	-0.1621***
	(1.9586)	(1.2105)	(1.1511)	(4.9187)	(0.0386)	(0.0295)	(0.0274)	(0.0299)
Net loans	-4.9848*	-3.2840**	-3.1902**	-8.7901***	-0.0542	-0.0947*	-0.0995*	-0.0641
	(2.6338)	(1.4833)	(1.4268)	(2.7663)	(0.1088)	(0.0568)	(0.0586)	(0.0731)
GDP	0.0887	0.0456	0.0379	0.2502	-0.0080***	-0.0039***	-0.0052***	-0.0045*
	(0.0610)	(0.0385)	(0.0331)	(0.2027)	(0.0016)	(0.0007)	(0.0009)	(0.0026)
Inflation	0.1374**	-0.0198	-0.0244	0.3461	0.0010	-0.0003	-0.0000	0.0000
	(0.0535)	(0.0416)	(0.0397)	(0.3251)	(0.0009)	(0.0005)	(0.0005)	(0.0025)
HHI	7.1456**	5.9137*	7.3718**	15.7611***	0.2913	0.0006	-0.0047	0.5603**
	(2.9214)	(3.1397)	(2.8823)	(6.0400)	(0.1993)	(0.0614)	(0.0605)	(0.2650)
Constant	0.6874	21.4371***	19.1939**	10.1467	-0.1991	0.5082***	0.2754	-0.1969
	(13.2896)	(7.5737)	(7.9607)	(14.6590)	(0.2125)	(0.1750)	(0.2014)	(0.7476)
Observations	22,657	22,657	22,657	22,657	11,893	11,893	11,893	11,893
Number of banks	3,622	3,622	3,622	3,622	2,715	2,715	2,715	2,715
Wald χ^2	256.88***	247.98***	253.70***	159.25***	2,100.20***	3,189.15***	3,814.27***	1,154.83***
Arellano-Bond (1)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Arellano-Bond (2)	0.1500	0.2300	0.2710	0.5960	0.1150	0.8100	0.6960	0.1870
Hansen	0.7190	0.0570	0.0440	0.4210	0.0360	0.0440	0.0760	0.6210
Ho: Rate + (Rate * Lev.) = 0	0.0028^a	0.0036^b	0.0069^c	0.0427^d	0.0219^a	0.0616^b	0.0175^c	0.1729^d
	$\chi^2(1)= 8.92$	$\chi^2(1)= 8.48$	$\chi^2(1)= 7.30$	$\chi^2(1)= 4.11$	$\chi^2(1)= 5.25$	$\chi^2(1)= 3.49$	$\chi^2(1)= 5.65$	$\chi^2(1)= 1.86$

Notes. The table reports coefficients and robust standard errors (in parentheses) for two-step system GMM dynamic panel estimations. Robust standard errors are clustered at the bank-level. The dependent variable is the ratio of loan loss provision to gross loans in regressions (1) to (4) and the ratio of non-performing loans to gross loans in regressions (5) to (8). All other variables are defined as in Table A1 (see appendix section). The Wald test shows the goodness-of-fit of regressions. The Arellano-Bond (1) and (2) tests report p-values for the null hypothesis that the errors in first differences regression do not exhibit, respectively, first-order and second-order autocorrelation. The Hansen test reports p-values for the null hypothesis that the instruments are not correlated with residuals. *Statistical significance at the 10% level. **Statistical significance at the 5% level. ***Statistical significance at the 1% level.
[a] p-values of χ^2-statistics testing that coefficients ECB rate + (ECB rate * Leverage) = 0.
[b] p-values of χ^2-statistics testing that coefficients Short-term rate + (Short-term rate * Leverage) = 0.
[c] p-values of χ^2-statistics testing that coefficients Medium-term rate + (Medium-term rate * Leverage) = 0.
[d] p-values of χ^2-statistics testing that coefficients Long-term rate + (Long-term rate * Leverage) = 0.

increase in credit risk caused by a low interest rate environment is more important for highly levered banks. We further analyze the link between *Loan loss provision* and interest rates in Table 2.5. We find that a decrease in *ECB rate* from its 75*th*

Table 2.5: Monetary policy conditions & bank credit risk in the EU (2009-2017): risk variations to interest rates depending on leverage

		High leverage	Low leverage	Differential effect
		(1)	(2)	(3)
Loan loss provision to gross loans	ECB rate	1.231177	0.304164	0.927013**
	Short-term rate	0.345047	-0.029482	0.374529***
	Medium-term rate	0.373908	0.005941	0.367967**
	Long-term rate	0.804607	-0.238504	1.043111**
Non-performing loans to gross loans	ECB rate	0.029906	0.003384	0.026522**
	Short-term rate	0.006285	-0.010489	0.016774**
	Medium-term rate	0.012046	-0.009461	0.021507**
	Long-term rate	0.022659	0.002100	0.020559

Notes. The table reports the impact on credit risk of a decrease in interest rates from their 75^{th} percentile to their 25^{th} percentile depending on the level of banking leverage (this effect being evaluated by assigning mean values to other covariates from our base specification in Table 2.4). Predictive margins in column (1) assess credit risk variations to decreasing interest rates for a bank with a relatively high ratio of short-term and long-term debt to total assets (i.e., at its 75^{th} percentile). Predictive margins in column (2) assess credit risk variations to decreasing interest rates for a bank with a relatively low ratio of short-term and long-term debt to total assets (i.e., at its 25^{th} percentile). The differential effect in column (3) reports the difference in credit risk variations – and its significance – between a highly-levered bank and a slightly-levered bank operating in a decreasing interest rates environment. *Statistical significance at the 10% level. **Statistical significance at the 5% level. ***Statistical significance at the 1% level.

percentile of 1.00% to its $25th$ percentile of 0.05% results in an increase in credit risk of 123.1 basis-point for a highly levered bank (i.e., at its 75^{th} percentile of 93.44%) and only of 30.4 basis-point for a bank with a low level of leverage (i.e., at its 25^{th} percentile of 89.47%)[8]. In this case, the differential effect of 92.7 basis-point between a highly levered and a lowly levered bank is significant. We find similar results for the relation between *Loan loss provision* and other interest rates, and also between *Non-performing loans* variable and *ECB rate*, *Short-term rate* and *Medium-term rate*.

Contrary to Dell'Ariccia et al. (2017), who shows that the effect of interest rates

[8]These results are evaluated by assigning mean values to other variables included in Equation 2.2.

on bank risk-taking is less pronounced for poorly capitalized banks in the U.S. banking system over the period 1997–2011, our results extend to the euro area Jiménez et al. (2014) findings for the Spanish industry from 2002 to 2008. In the same vein, we find that a lower overnight interest rate induces lowly capitalized banks to grant more loan applications to ex–ante risky firms than do highly capitalized banks and that, when granted, the committed loans are larger in volume and are more likely to be uncollateralized.

Implications drawn from this empirical evidence are two-fold. First, it supports the need to go beyond the traditional portfolio reallocation channel in the theoretical literature on bank leverage and monetary policy and, therefore, to consider alternative channels of bank risk-taking. Second, it is also confirmation that macroprudential policy is likely to influence the transmission mechanism of monetary policy (Angelini et al., 2014), as bank leverage is a key factor driving the risk-taking channel of monetary policy. As restricting leverage helps to contain EU banks' credit risk despite the post–2008 low interest rates' environment, our results support leverage ratio as a useful complement to monetary policy for meeting the twin objectives of price and financial stability.

2.5.3 Endogeneity of monetary policy & robustness checks

Whether considering the portfolio reallocation effect (Table 2.2) or the "search for yield" effect (Table 2.4 and Table 2.5), we have shown previously that banks operating in growing economies tend to lower risk-taking. Reasonably, we question our findings on the "search for yield" channel to be driven directly by macroeconomic conditions. For instance, banks may be more optimistic in boom times regarding the granting of loans, causing them to underestimate credit risk. They may also want to adjust their level of leverage depending on business cycles or the cost of capital. Therefore, it is crucial to check whether our results are endogenously determined by the state of the economy and to check for the presence of bias in our estimations.

We control for the effect of macroeconomic variations in Table 2.6, augmenting Equation 2.2 with an interaction term between interest rates and changes in real GDP growth rate (*GDP* variable gauges growth or recession in countries included in the sample). This new empirical configuration shows that coefficients on the interaction between interest rates and bank leverage are left significantly negative in regressions (1) to (7) when controlling for business cycle. Though the interaction between *Long-term rate* and *Leverage* variables when *Non-performing loans* is set as the dependent variable does not appear to be significant in Table 2.2 and Table 2.4, we notice in regression (8) from Table 2.6 a slightly significant and positive coefficient in the interaction term. This suggests there may be some endogeneity issues in regression (8), so we cannot draw any substantive conclusion based on this result. Such an outcome is likely to be explained by national economic conditions captured by central government bond yields when other interest rates are measured at the European level. It does not impact the quality of the other findings on the interaction between interest rates and leverage, and it allays our concerns on potential dependencies toward the macroeconomic environment. However, as a

Table 2.6: Monetary policy conditions & bank credit risk in the EU (2009-2017): search for yield channel & macroeconomic variations

	Loan loss provision to gross loans				Non-performing loans to gross loans			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Loan loss provision$_{(t-1)}$	0.1054***	0.0993***	0.1074***	0.2341***				
	(0.0247)	(0.0311)	(0.0286)	(0.0409)				
Non-performing loans$_{(t-1)}$					0.8118***	0.8789***	0.8799***	0.8842***
					(0.0864)	(0.0661)	(0.0588)	(0.0568)
ECB rate	10.7366*				0.8864***			
	(5.6078)				(0.3230)			
Short-term rate		9.0878**				0.4384*		
		(4.6262)				(0.2555)		
Medium-term rate			5.8765*				0.3212*	
			(3.4297)				(0.1670)	
Long-term rate				10.4285**				-0.0698*
				(4.3270)				(0.0417)
Leverage	-8.1266	-12.9513	-9.4909	1.3862	-1.1340**	-0.9355***	-0.9620***	-1.2634***
	(7.4036)	(8.6721)	(8.3747)	(17.7762)	(0.4787)	(0.2371)	(0.3008)	(0.3743)
ECB rate * Leverage	-12.8738**				-0.9762***			
	(6.1365)				(0.3508)			
Short-term rate * Leverage		-10.1682**				-0.4851*		
		(5.1124)				(0.2834)		
Medium-term rate * Leverage			-6.5502*				-0.3506*	
			(3.7847)				(0.1842)	
Long-term rate * Leverage				-11.9911**				0.0826*
				(4.9223)				(0.0468)
Size	-0.2052	-0.2878	-0.4299	-0.0868	0.0085***	0.0058**	0.0056**	-0.0000
	(0.1988)	(0.2977)	(0.2971)	(0.5291)	(0.0033)	(0.0028)	(0.0026)	(0.0023)
ROAA	-0.6684	-1.0917**	-0.9895**	-1.9538**	-0.0234***	-0.0178***	-0.0177***	-0.0105***
	(0.4467)	(0.5159)	(0.4981)	(0.8473)	(0.0054)	(0.0037)	(0.0037)	(0.0033)
Inefficiency	-7.9832***	-7.5934***	-7.1793***	-10.8041***	-0.0588***	-0.0424***	-0.0428***	-0.0214**
	(1.0728)	(1.2453)	(1.1606)	(2.3304)	(0.0139)	(0.0120)	(0.0109)	(0.0084)
Net loans	-1.9847	-3.6522**	-3.5025**	-3.4937**	-0.3715***	-0.2200***	-0.2304***	-0.1181***
	(1.5256)	(1.4630)	(1.3675)	(1.7822)	(0.1312)	(0.0599)	(0.0535)	(0.0407)
GDP	-0.2201***	0.0056	0.0194	-0.4154***	-0.0098***	-0.0075***	-0.0071***	-0.0039***
	(0.0802)	(0.0415)	(0.0524)	(0.1406)	(0.0018)	(0.0013)	(0.0012)	(0.0014)
ECB rate * GDP	0.3090***				0.0084***			
	(0.1106)				(0.0021)			
Short-term rate * GDP		0.0390				0.0047**		
		(0.0918)				(0.0021)		
Medium-term rate * GDP			-0.0023				0.0022	
			(0.0624)				(0.0013)	
Long-term rate * GDP				0.1698***				0.0001
				(0.0635)				(0.0002)
Inflation	0.0612*	-0.0569**	-0.0580**	0.1726**	-0.0003	0.0003	0.0000	-0.0027***
	(0.0350)	(0.0256)	(0.0240)	(0.0860)	(0.0010)	(0.0007)	(0.0006)	(0.0009)
HHI	12.2780***	8.7076***	9.0619***	10.5141**	-0.1291**	-0.0934**	-0.1038**	-0.0908**
	(2.6084)	(2.3345)	(2.3036)	(4.7440)	(0.0595)	(0.0473)	(0.0450)	(0.0378)
Constant	15.5085**	21.1907**	18.5839**	9.8002	1.2712**	0.9980***	1.0276***	1.2464***
	(7.5321)	(8.4511)	(8.1935)	(16.0906)	(0.5004)	(0.2314)	(0.2876)	(0.3634)
Observations	22,657	22,657	22,657	22,657	11,893	11,893	11,893	11,893
Number of banks	3,622	3,622	3,622	3,622	2,715	2,715	2,715	2,715
Wald χ^2	342.28***	285.90***	326.05***	207.61***	2,127.89***	1,749.54***	2,083.31***	2,801.93***
Arellano-Bond (1)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Arellano-Bond (2)	0.0890	0.3160	0.2400	0.1730	0.5890	0.7790	0.9530	0.1310
Hansen	0.0750	0.0890	0.0590	0.641	0.1260	0.2880	0.3070	0.1010

Notes. The table reports coefficients and robust standard errors (in parentheses) for two-step system GMM dynamic panel estimations. Robust standard errors are clustered at the bank-level. The dependent variable is the ratio of loan loss provision to gross loans in regressions (1) to (4) and the ratio of non-performing loans to gross loans in regressions (5) to (8). All other variables are defined as in Table A1 (see appendix section). The Wald test shows the goodness-of-fit of regressions. The Arellano-Bond (1) and (2) tests report p-values for the null hypothesis that the errors in first differences regression do not exhibit, respectively, first-order and second-order autocorrelation. The Hansen test reports p-values for the null hypothesis that the instruments are not correlated with residuals. *Statistical significance at the 10% level. **Statistical significance at the 5% level. ***Statistical significance at the 1% level.

precautionary measure, we remove the *Long-term rate* variable in the remainder of the empirical analysis to preserve results from endogeneity.

Similar to the portfolio reallocation effect, we investigate in Table 2.7 the link between industry concentration and the magnitude of the "search for yield" effect. We find that it is systematically greater in highly competitive banking industries represented in regressions (1), (3), and (5). As the portfolio reallocation effect, the "search for yield" effect better diffuses to banks' balance sheet in conditions of fair competition, and the two effects reinforce each other in this case. In turn, we expect the "search for yield" channel to be minimal in cases of banks operating on highly concentrated markets, as market power reduces the extent to which lending rates reflect changes in policy rates.

Differences in the "search for yield" intensity between high competition and low competition subsamples appear to be significant for estimations using *ECB rate* (at the 7.60% level) and *Short-term rate* (at the 1.19% level) variables as an interest rates' index. A one percentage point decrease in the ECB Bank interest rate induces a 97.34 basis-point increase in the "search for yield" effect for the high competition subsample and only a 9.64 basis-point increase for the low competition subsample. However, we do not find a significant difference between the two subsamples when using the *Medium-term rate* variable. Similar to the portfolio reallocation channel, we acknowledge the interaction between the local market structure of the banking industry and the impact of the "search for yield" channel on banks' balance sheets.

In a context of enhanced capital requirements since the GFC, we analyze in Table 2.8 whether capitalization is decisive in the way the interaction between bank leverage and interest rates influences credit risk. This offers insight into the impact of post–GFC changing regulations on the risk-taking channel of monetary policy:

Table 2.7: Monetary policy conditions & bank credit risk in the EU (2009-2017): search for yield channel & industry concentration

	Loan loss provision to gross loans					
	High competition	Low competition	High competition	Low competition	High competition	Low competition
	(1)	(2)	(3)	(4)	(5)	(6)
Loan loss provision$_{(t-1)}$	0.6906**	0.1203***	0.0089	0.1119***	0.0216	0.1159***
	(0.2837)	(0.0378)	(0.1325)	(0.0391)	(0.1869)	(0.0390)
ECB rate	86.4572*	8.5669**				
	(44.8865)	(3.8731)				
Short-term rate			34.7133***	8.2869**		
			(10.6880)	(3.4602)		
Medium-term rate					20.5578**	6.1250**
					(10.2904)	(2.6159)
ECB rate * Leverage	-97.3477**	-9.6475**				
	(49.4302)	(4.2760)				
Short-term rate * Leverage			-38.7745***	-9.3549**		
			(11.6979)	(3.8107)		
Medium-term rate * Leverage					-23.2207**	-6.8985**
					(11.2702)	(2.8856)
Leverage	109.3622***	-3.1004	56.8165***	-4.3308	67.8951***	-2.7336
	(20.1373)	(3.4138)	(7.2709)	(3.0649)	(8.1797)	(3.3766)
Size	0.4813	-0.1659	0.8044*	-0.1180	0.7824	-0.1202
	(0.7595)	(0.1114)	(0.4670)	(0.1114)	(0.5342)	(0.1069)
ROAA	-1.0622	-0.6630***	-0.1202	-0.6833***	0.3530	-0.6190***
	(1.8012)	(0.2335)	(0.7756)	(0.2390)	(0.6521)	(0.2140)
Inefficiency	-21.6812	-4.2780***	-3.7179	-4.8323***	0.8093	-4.5767***
	(13.5638)	(0.5862)	(4.8569)	(0.6528)	(5.4265)	(0.6279)
Net loans	-16.8065*	-4.0295***	-10.5605***	-3.4739***	-9.0702**	-3.6718***
	(9.5866)	(0.8975)	(3.3569)	(1.0511)	(4.5821)	(1.0669)
GDP	-0.0449	-0.0866***	0.0212	-0.0895***	0.0207	-0.0831***
	(0.1048)	(0.0265)	(0.0339)	(0.0271)	(0.0345)	(0.0271)
Inflation	0.0986	0.0424	-0.0757*	0.0339	-0.0246	0.0212
	(0.1090)	(0.0269)	(0.0458)	(0.0256)	(0.0536)	(0.0248)
HHI	15.2938	-1.7348	-30.6463**	-0.5921	-17.6772	-0.4771
	(26.8543)	(1.4543)	(12.2386)	(1.4473)	(15.2329)	(1.4693)
Constant	-76.9550***	10.4964***	-46.2523***	11.1884***	-60.9217***	9.7002***
	(19.7963)	(3.4256)	(10.7123)	(3.1255)	(13.0804)	(3.4506)
Observations	12,809	9,848	12,809	9,848	12,809	9,848
Number of banks	1,798	1,824	1,798	1,824	1,798	1,824
Wald χ^2	194.25***	621.74***	454.74***	580.82***	512.57***	585.03***
Arellano-Bond (1)	0.0020	0.0000	0.0000	0.0000	0.0160	0.0000
Arellano-Bond (2)	0.0490	0.8780	0.7910	0.7860	0.6510	0.8120
Hansen	0.0240	0.7790	0.0690	0.4640	0.0090	0.4010
Ho: Rate * Lev. [High competition] = Rate * Lev. [Low competition]	0.0760[a] $\chi^2(1) = 3.15$		0.0119[b] $\chi^2(1) = 6.32$		0.1475[c] $\chi^2(1) = 2.10$	

Notes. The table reports coefficients and robust standard errors (in parentheses) for two-step system GMM dynamic panel estimations. Robust standard errors are clustered at the bank-level. The dependent variable is the ratio of loan loss provision to gross loans in all regressions. All other variables are defined as in Table A1 (see appendix section). High competition subsample in regressions (1), (3) and (5) and low competition subsample in regressions (2), (4) and (6) refer to observations for which *HHI* is, respectively, below and above the full sample median value. The Wald test shows the goodness-of-fit of regressions. The Arellano-Bond (1) and (2) tests report p-values for the null hypothesis that the errors in first differences regression do not exhibit, respectively, first-order and second-order autocorrelation. The Hansen test reports p-values for the null hypothesis that the instruments are not correlated with residuals. *Statistical significance at the 10% level. **Statistical significance at the 5% level. ***Statistical significance at the 1% level.

[a] χ^2-statistics p-values testing that (ECB rate * Leverage) coefficients from high competition subsample = (ECB rate * Leverage) coefficients from low competition subsample.

[b] χ^2-statistics p-values testing that (Short-term rate * Leverage) coefficients from high competition subsample = (Short-term rate * Leverage) coefficients from low competition subsample.

[c] χ^2-statistics p-values testing that (Long-term rate * Leverage) coefficients from high competition subsample = (Long-term rate * Leverage) coefficients from low competition subsample.

Table 2.8: Monetary policy conditions & bank credit risk in the EU (2009-2017): search for yield channel & capitalization

	Loan loss provision to gross loans					
	Above Basel III minimum capital adequacy ratio	Under Basel III minimum capital adequacy ratio	Above Basel III minimum capital adequacy ratio	Under Basel III minimum capital adequacy ratio	Above Basel III minimum capital adequacy ratio	Under Basel III minimum capital adequacy ratio
	(1)	(2)	(3)	(4)	(5)	(6)
Loan loss provision$_{(t-1)}$	0.1001***	0.2797***	0.0713***	0.2316***	0.0692***	0.2345***
	(0.0294)	(0.0456)	(0.0260)	(0.0453)	(0.0266)	(0.0455)
ECB rate	7.7195**	36.4769***				
	(3.9205)	(12.0133)				
Short-term rate			7.4237**	30.9584***		
			(3.4244)	(9.6012)		
Medium-term rate					6.1120**	24.4484***
					(2.7217)	(7.6006)
Leverage	3.0698	25.9792**	-5.7537	9.9659	0.3527	18.0853
	(6.1608)	(11.9723)	(5.7176)	(10.7828)	(6.9926)	(11.7228)
ECB rate * Leverage	-9.1542**	-39.1924***				
	(4.3882)	(12.8141)				
Short-term rate * Leverage			-8.5068**	-33.0977***		
			(3.8700)	(10.2469)		
Medium-term rate * Leverage					-7.0961**	-26.1557***
					(3.0811)	(8.1119)
Size	-0.5242*	-0.0680	-0.3430	-0.2127	-0.6533	-0.2095
	(0.2790)	(0.1151)	(0.4471)	(0.1766)	(0.4879)	(0.1659)
ROAA	-0.2886	-0.7584	-0.7156	-0.5875	-0.6666	-0.5797
	(0.5320)	(0.4878)	(0.5159)	(0.4890)	(0.5019)	(0.4969)
Inefficiency	-6.2597***	-6.4971***	-7.9498***	-5.7403***	-7.6871***	-5.8607***
	(1.3526)	(1.3630)	(1.3485)	(1.4369)	(1.4322)	(1.4767)
Net loans	-1.5400	-4.4343**	-2.9000**	-5.5615***	-2.5105*	-5.6572***
	(1.4093)	(1.9737)	(1.4493)	(1.9235)	(1.4859)	(1.9637)
GDP	-0.0134	-0.0345	0.0488	-0.0339	0.0666*	-0.0309
	(0.0330)	(0.0245)	(0.0363)	(0.0288)	(0.0369)	(0.0286)
Inflation	-0.0259	-0.0025	-0.0972***	-0.0993**	-0.0735**	-0.0908*
	(0.0413)	(0.0565)	(0.0243)	(0.0481)	(0.0293)	(0.0495)
HHI	6.3180***	11.7287***	3.8095**	14.0280***	5.0778***	13.8689***
	(2.1692)	(3.2156)	(1.7223)	(4.2864)	(1.9521)	(3.9925)
Constant	5.9399	-16.9628	14.7843***	-0.9335	10.8658**	-8.4097
	(5.2718)	(11.2969)	(3.7458)	(10.5062)	(4.8568)	(11.1949)
Observations	13,182	9,475	13,182	9,475	13,182	9,475
Number of banks	2,782	2,310	2,782	2,310	2,782	2,310
Wald χ^2	298.19***	219.01***	263.46***	207.23***	258.29***	206.93***
Arellano-Bond (1)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Arellano-Bond (2)	0.0630	0.4060	0.2450	0.6260	0.2820	0.6670
Hansen	0.1330	0.2060	0.0240	0.4200	0.0590	0.4020
Ho: Rate * Lev. [Above Basel III] = Rate * Lev. [Under Basel III]	0.0000^a $\chi^2(1) = 46.86$		0.0000^b $\chi^2(1) = 40.38$		0.0000^c $\chi^2(1) = 38.27$	

Notes. The table reports coefficients and robust standard errors (in parentheses) for two-step system GMM dynamic panel estimations. Robust standard errors are clustered at the bank-level. The dependent variable is the ratio of loan loss provision to gross loans in all regressions. All other variables are defined as in Table A1 (see appendix section). Above Basel III minimum capital adequacy ratio subsample in regressions (1), (3) and (5) and under Basel III minimum capital adequacy ratio subsample in regressions (2), (4) and (6) refer to observations for which the equity-to-asset ratio is, respectively, above and below the Basel III minimum capital adequacy ratio that banks must maintain (i.e. 8%). The Wald test shows the goodness-of-fit of regressions. The Arellano-Bond (1) and (2) tests report p-values for the null hypothesis that the errors in first differences regression do not exhibit, respectively, first-order and second-order autocorrelation. The Hansen test reports p-values for the null hypothesis that the instruments are not correlated with residuals. *Statistical significance at the 10% level. **Statistical significance at the 5% level. ***Statistical significance at the 1% level.

[a] χ^2-statistics p-values testing that (ECB rate * Leverage) coefficients from above Basel III minimum capital adequacy ratio subsample = (ECB rate * Leverage) coefficients from under Basel III minimum capital adequacy ratio subsample.

[b] χ^2-statistics p-values testing that (Short-term rate * Leverage) coefficients from above Basel III minimum capital adequacy ratio subsample = (Short-term rate * Leverage) coefficients from under Basel III minimum capital adequacy ratio subsample.

[c] χ^2-statistics p-values testing that (Medium-term rate * Leverage) coefficients from above Basel III minimum capital adequacy ratio subsample = (Medium-term rate * Leverage) coefficients from under Basel III minimum capital adequacy ratio subsample.

banks complying with Basel III capital requirements would be better prepared to face the challenges induced by a "low for long" interest rates environment on their balance sheet. Therefore, we expect the "search for yield" effect to weaken as capitalization increases in light of the results obtained in Table 2.4, where highly levered banks are more sensitive to interest rate variations. We perform another sample split between banks having a capitalization level either above or below the minimal capital adequacy ratio required by the third instalment of the Basel Accords (fixed at 8% in total[9]) in response to the deficiencies in financial regulation and intending to decrease bank leverage.

Consistent with these predictions, we find the "search for yield" effect to be much larger for banks falling below the Basel III minimum capital adequacy ratio compared to banks complying with Basel Accords. As we notice in Table 2.8, differences in the search for a yield between the two subsamples are significant in every case. A one percent decrease in the *ECB rate* (*Short-term rate* and *Medium-term rate*, respectively) implies only a 9.15 basis-point increase (8.50 basis-points and 7.09 basis-points, respectively) in the "search for yield" effect for banks above the Basel III minimum capital adequacy ratio, whereas while it rises by 39.19 basis-points (33.09 basis-points and 26.15 basis-points, respectively) for banks below this threshold. This result suggests that there are nonlinearities in the way the "search for yield" effect operates on bank credit risk.

Table 2.9 reports additional robustness checks to address further endogeneity issues of monetary policy. First, we expect times of distress to match with relatively higher levels of bank leverage and cause the "search for yield" channel to be stronger. The last financial crisis was undoubtedly blamed in part on excessive

[9]Broken down according to the type of bank capital, namely 4.5% for "Core Tier 1" capital, 1.5% for "Additional Tier 1" capital, and 2% for "Tier 2" capital.

Table 2.9: Monetary policy conditions & bank credit risk in the EU (2009-2017): additional robustness checks

	Post–2010 period		Small banks		Low correlation with euro area GDP	
	Loan loss prov.	NPL	Loan loss prov.	NPL	Loan loss prov.	NPL
	(1)	(2)	(3)	(4)	(5)	(6)
Loan loss provision$_{(t-1)}$	0.1165***		0.2395		0.2427***	
	(0.0268)		(0.2249)		(0.0663)	
Non-performing loans$_{(t-1)}$		0.8954***		0.9614***		0.7559***
		(0.3290)		(0.1024)		(0.1082)
ECB rate	21.3225***	0.6466*	11.6356*	0.9995***	23.1933**	0.5067*
	(8.0979)	(0.3493)	(7.0029)	(0.3877)	(9.4413)	(0.2750)
Leverage	7.7058	-1.0961**	-9.1615	-0.4572	2.5856	-0.1677
	(12.4602)	(0.5054)	(10.0274)	(0.2784)	(4.5084)	(0.2036)
ECB rate * Leverage	-23.7801***	-0.6954*	-13.0515*	-1.0928**	-25.3788**	-0.5548*
	(8.8490)	(0.3857)	(7.9116)	(0.4287)	(10.3038)	(0.3054)
Size	0.1131	0.0013	-1.2502*	-0.0277	-0.1513	-0.0057
	(0.2767)	(0.0084)	(0.6719)	(0.0175)	(0.1937)	(0.0068)
ROAA	-0.8254	-0.0190**	-0.9173*	-0.0287***	-0.8501***	-0.0291**
	(0.5638)	(0.0082)	(0.4769)	(0.0077)	(0.1777)	(0.0128)
Inefficiency	-8.9742***	-0.0576**	-8.5168***	-0.1057***	-1.9546***	-0.0476**
	(1.4613)	(0.0240)	(2.5598)	(0.0237)	(0.3974)	(0.0221)
Net loans	-5.1438**	-0.2914**	-8.1133***	-0.2950***	-2.7246**	-0.1308*
	(2.0259)	(0.1167)	(1.8215)	(0.0837)	(1.1267)	(0.0768)
GDP	0.0422	-0.0066**	0.1932***	-0.0006	-0.0329	-0.0005
	(0.0356)	(0.0033)	(0.0701)	(0.0012)	(0.0537)	(0.0018)
Inflation	0.0418	-0.0086***	0.0355	-0.0018	-0.0448	0.0006
	(0.0395)	(0.0029)	(0.0592)	(0.0014)	(0.0476)	(0.0027)
HHI	6.5357*	-0.0336	-14.7648**	-0.1608	0.5187	-0.2262*
	(3.3360)	(0.3367)	(6.7498)	(0.1324)	(0.8352)	(0.1279)
Constant	1.5318	1.2245**	28.0134**	0.8529***	2.3072	0.3773
	(11.5810)	(0.5230)	(11.4795)	(0.2670)	(3.7602)	(0.2294)
Observations	19,860	11,084	18,113	9,011	1,968	992
Number of banks	3,562	2,682	2,965	2,159	462	233
Wald χ^2	246.09***	841.16***	103.26***	821.95***	106.34***	307.55***
Arellano-Bond (1)	0.0000	0.0090	0.0000	0.0000	0.0000	0.0010
Arellano-Bond (2)	0.1950	0.9460	0.2960	0.8650	0.5350	0.1220
Hansen	0.0580	0.4210	0.1990	0.3970	0.0220	0.6430

Notes. The table reports coefficients and robust standard errors (in parentheses) for two-step system GMM dynamic panel estimations. Robust standard errors are clustered at the bank-level. The dependent variable is the ratio of loan loss provision to gross loans in regressions (1), (3) and (5) and the ratio of non-performing loans to gross loans in regressions (2), (4) and (6). All other variables are defined as in Table A1 (see appendix section). Post–2010 period subsample in regressions (1) and (2) excludes the impact of the last financial turmoil. Small banks subsample in regressions (3) and (4) refers to banks for which assets are below the sample top quintile. Low correlation with euro area GDP subsample in regressions (5) and (6) refers to banks located in countries in which national GDP growth is not highly correlated with euro area GDP growth (i.e. below-median correlation). The Wald test shows the goodness-of-fit of regressions. The Arellano-Bond (1) and (2) tests report p-values for the null hypothesis that the errors in first differences regression do not exhibit, respectively, first-order and second-order autocorrelation. The Hansen test reports p-values for the null hypothesis that the instruments are not correlated with residuals. *Statistical significance at the 10% level. **Statistical significance at the 5% level. ***Statistical significance at the 1% level.

leverage. In this case, monetary policy may be more responsive to bank risk as the threat of a spate of insolvencies looms over the economy. Such a case typically corresponds to stronger monetary policy responses to financial volatility and exacerbates endogeneity bias in the empirical results. Therefore, we exclude the crisis period from our sample — starting in 2008, when the ECB initiated its first interest rate reduction, and ending in 2010 — and run our main specification described in Equation 2.2. Regressions (1) and (2) provide negatively significant coefficients for the interaction between interest rates and bank leverage. This result confirms the absence of endogeneity due to the 2008 global financial turmoil and provides additional robustness to our empirical analysis.

Second, we may assume that monetary policy transmits mainly to large banks' balance sheets, whereas small banks are impacted marginally (if impacted) by the "search for yield" channel. Endogeneity would be more of a concern for major banks whose loan portfolio is closely related to nationwide economic activities. Accordingly, we put aside top quintile banks (listed by assets' size), for which endogeneity may be challenging, to focus on small banks and check whether the "search for yield" channel is left unchanged. Similar to the full sample estimations in Table 2.4, columns (3) and (4) ensure negative and still significant interactions between interest rates and bank leverage, so our results are not contaminated by the inclusion of large banks. We conclude that small banks' balance sheets also transmit monetary policy stimulus to the economy.

Finally, in columns (5) and (6) from Table 2.9, we question whether monetary policy is driven by the euro zone business cycle. We do so by first classifying countries in our sample depending on the correlation of national economic conditions (gauged by the *GDP* variable) with euro area GDP growth (collected from Eurostat) and then testing the baseline model from Equation 2.2 only for banks located in countries below the median correlation. Once again, we find a negative and significant relation between credit risk and the interaction term including interest rates and bank leverage. Accordingly, this suggests that our findings are free from endogeneity caused by correlation with euro area cycles.

2.6 Conclusion

This study investigates, for the euro area, the effects of interest rates variations on bank credit risk over the period 2009–2017. We also analyze how this relationship interacts with the degree of bank leverage. Empirical evidence is provided that a low interest rate environment significantly triggers bank credit risk, which confirms the existence of a risk-taking channel of monetary policy transmission in the aftermath of the GFC. Our results also suggest that the degree of competition in national banking industries is key in the transmission of monetary policy to credit risk. As high competition lowers opportunity for banks to enjoy high market power, herding behaviors are likely to arise, intensifying the negative impact of interest rates on risk-taking.

Consistent with the "search for yield" effect, we also find that highly levered banks react most to changes in interest rates, taking more risks when monetary policy is eased. While confirming, for the whole euro area, Jiménez et al. (2014) insights into the Spanish banking industry, this indicates an essential difference with the U.S. banking system, where the negative link between risk-taking and interest rates is steeper for highly capitalized banks (Dell'Ariccia et al., 2017). One interpretation of such result is the presence of a "skin-in-the-game" effect (De Nicolò et al., 2010) in the European banking industry: the more a bank has to lose in case of failure (i.e., having high levels of capitalization), the less severe the moral hazard problem. Similarly, a bank with a high franchise value has a lot to lose and little incentive to take excessive risk, whereas a zombie bank is willing to take great risks to gamble for resurrection. Accordingly, the theoretical literature should consider alternative channels of bank risk-taking to fully understand the multiple facets of monetary policy's impacts on credit risk depending on countries, time, and local banking market conditions.

We also identify nonlinearities in the "search for yield" effect depending on the level of bank capitalization: it becomes increasingly more pronounced as capital is depleted and limited liability is more likely to be binding. This outcome has implications for the impact of post–GFC changing regulations on the risk-taking channel: banks complying with Basel III capital requirements would be better prepared to face the challenges induced by a "low for long" interest rates environment. Our results survive several robustness checks to allay concerns about monetary policy endogeneity. Specifically, we test whether our findings are not driven directly by national economic conditions, effects of the GFC before 2010, larger banks' behavior, or euro area economic conditions.

This paper has several policy implications. First, besides supporting new responsibilities to the European Central Bank (ECB) as regards macroprudential supervision (Diamond and Rajan, 2012) and on whether monetary policy should concern itself explicitly with financial stability, we emphasize the importance of considering banks heterogeneity and geographical circumstances to gauge the relative significance of monetary policy's risk-taking channel. The evidence presented here for the whole euro area suggests opportunities for further research on differences within euro area countries on the transmission of the common monetary policy. Second, results achieved for credit risk may differ from other types of risk-taking in banks' balance sheets. Indeed, several other channels exist through which interest rates bear on bank risk, including liquidity, market risk, and maturity mismatches (Adrian and Shin, 2009). Taking different aspects of bank risk into account might be also relevant in linking microprudential and macroprudential frameworks. We leave these issues for future research. Third, as leverage ratio is central to macroprudential measures for financial stability, this paper also links to literature dedicated to the impact of macroprudential regulation on monetary policy. We provide evidence that a macroprudential tool such as leverage ratio is effective in influencing the transmission mechanism of monetary policy (Angelini et al., 2014) and in modifying risk-taking. As Table C1 shows only a slight decrease in the yearly average of the leverage ratio for EU banks between 2009–2017, our results reiterate the need to keep restricting such indicator in the near future.

Lately, the COVID-19 pandemic has pushed euro area economies — and worldwide — into a Great Lockdown (Gopinath, 2020) accompanied by exceptional policy support from the ECB, including additional monetary policy easing and flexibility on macroprudential supervisory timelines, deadlines, and procedures. However, this papers shows that a strong and thorough macroprudential framework is more necessary than ever under a low interest rates environment that the pandemic is likely to further extend.

Appendix A. Variables' definition

Table A1: Variables' definition

Variable	Definition	Data source	Level
Panel A: Variables of interest			
Loan loss provision	Ratio of loan loss provision to gross loans. It indicates the ability of a bank to absorb losses from non-performing loans and to determine the quality of its loans	Fitch Connect	Bank
Non-performing loans	Ratio of non-performing loans to gross loans. It measures a bank health and efficiency by identifying problems with asset quality in the loan portfolio	Fitch Connect	Bank
ECB rate	Interest rate on the main refinancing operations (MRO) banks pay when they borrow money from the European Central Bank (ECB) for one week as they provide collateral to guarantee that the money will be paid back	Eurostat	Euro area
Short-term rate	3-month Euribor interest rate at which European banks lend one another funds denominated in euros whereby the loans have a maturity of 3 months. When the Euribor interest rates rise or fall, there is a high likelihood that the interest rates on banking products will also be adjusted	Eurostat	Euro area
Medium-term rate	12-month Euribor interest rate at which European banks lend one another funds denominated in euros whereby the loans have a maturity of 12 months. When the Euribor interest rates rise or fall, there is a high likelihood that the interest rates on banking products will also be adjusted	Eurostat	Euro area
Long-term rate	Central government bond yields on the secondary market, gross of tax, with a residual maturity of around 10 years. To compute this indicator, bonds are regularly replaced to avoid any maturity drift	Eurostat	Country
Leverage	Ratio of short-term and long-term debt to total assets, also known as the debt-to-assets ratio. It shows how a bank's assets and business operations are financed using debt	Fitch Connect	Bank
Panel B: Bank-level controls			
Size	Natural logarithm of a bank's total assets to proxy the scope of its business activities	Fitch Connect	Bank
ROAA	Return on average assets ratio as a measure of profitability of a bank's assets. It gauges financial performance by showing how well a bank's assets are being used to generate profits	Fitch Connect	Bank
Inefficiency	Ratio of total expenses to total revenue as a measure of a bank's inefficiency. It assesses the ability of a bank to turn assets into revenue (the lower such ability, the higher its inefficiency)	Fitch Connect	Bank
Net loans	Ratio of net loans to total assets referring to how much of a bank's assets are tied up in loans. It can be interpreted as the share of business devoted to traditional banking intermediation as an alternative to the ratio of off-balance sheet items to total assets for which data is many times missing in bank financial statements.	Fitch Connect	Bank
Panel C: Macro-level controls			
GDP	Percentage change on previous year of real GDP growth rate. It proxies a country's economic activity defined as the value of all goods and services produced less the value of any goods or services used in their creation	Eurostat	Country
Inflation	Annual average rate of change of the Harmonised Index of Consumer Prices (HICP) as the official measure of consumer price inflation in the euro area for the purposes of monetary policy and the assessment of inflation convergence	Eurostat	Country
HHI	Herfindahl–Hirschman Index (HHI) defined as the sum of the squares of the market shares of nationwide banks. Increases in the HHI indicate a decrease in competition or alternatively an increase in banking industry concentration	Author's calculation	Country

Notes. The table reports name, definition, data source and level of the variables employed in the empirical analysis. Descriptive statistics are reported in Table 2.1.

Appendix B. Pairwise Pearson correlations coefficients

Table B1: Pairwise Pearson correlations coefficients

Variable	1	2	3	4	5	6	7	8	9	10	11	12
1 ECB rate	1.0000											
2 Short-term rate	0.9622 (0.0000)	1.0000										
3 Medium-term rate	0.9703 (0.0000)	0.9933 (0.0000)	1.0000									
4 Long-term rate	0.7014 (0.0000)	0.6807 (0.0000)	0.6859 (0.0000)	1.0000								
5 Leverage	0.1174 (0.0000)	0.1133 (0.0000)	0.1130 (0.0000)	0.0178 (0.0033)	1.0000							
6 Size	-0.0391 (0.0000)	-0.0395 (0.0000)	-0.0402 (0.0000)	0.0188 (0.0020)	0.2391 (0.0000)	1.0000						
7 ROAA	-0.0282 (0.0000)	-0.0243 (0.0001)	-0.0256 (0.0000)	-0.0853 (0.0000)	-0.1832 (0.0000)	-0.0263 (0.0000)	1.0000					
8 Inefficiency	-0.0245 (0.0001)	-0.0290 (0.0000)	-0.0289 (0.0000)	-0.0440 (0.0000)	-0.0346 (0.0000)	-0.1666 (0.0000)	-0.3978 (0.0000)	1.0000				
9 Net loans	0.0084 (0.1673)	0.0098 (0.1071)	0.0099 (0.1025)	0.0264 (0.0000)	0.0453 (0.0000)	0.0235 (0.0001)	-0.0180 (0.0031)	-0.1105 (0.0000)	1.0000			
10 GDP	-0.3807 (0.0000)	-0.3280 (0.0000)	-0.2712 (0.0000)	-0.4640 (0.0000)	-0.0210 (0.0006)	0.0056 (0.3537)	0.0430 (0.0000)	0.0149 (0.0140)	-0.0378 (0.0000)	1.0000		
11 Inflation	0.4235 (0.0000)	0.3560 (0.0000)	0.4274 (0.0000)	0.3230 (0.0000)	0.0263 (0.0000)	-0.0398 (0.0000)	-0.0035 (0.5675)	0.0150 (0.0136)	0.0287 (0.0000)	0.1723 (0.0000)	1.0000	
12 HHI	-0.0618 (0.0000)	-0.0649 (0.0000)	-0.0615 (0.0000)	0.2529 (0.0000)	-0.1037 (0.0000)	0.0758 (0.0000)	0.0338 (0.0000)	-0.0592 (0.0000)	0.0586 (0.0000)	-0.0766 (0.0000)	-0.0151 (0.0131)	1.0000

Notes. The table reports correlation coefficients for the explanatory variables used in the empirical analysis and defined in Table A1.

Appendix C. Changes in leverage ratio in the post-2008 European banking industry

Table C1: Yearly average of leverage ratio for euro area banks (2009-2017)

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017
Leverage ratio	91.80%	91.58%	91.23%	90.84%	90.54%	90.08%	89.93%	89.58%	89.53%

Notes. The table reports changes in the ratio of short-term and long-term debt to total assets, also known as the debt-to-assets ratio, over the period 2009-2017 for the full sample used in the empirical analysis.

Appendix D. Credit risk & interest rates in the post-2008 European banking industry

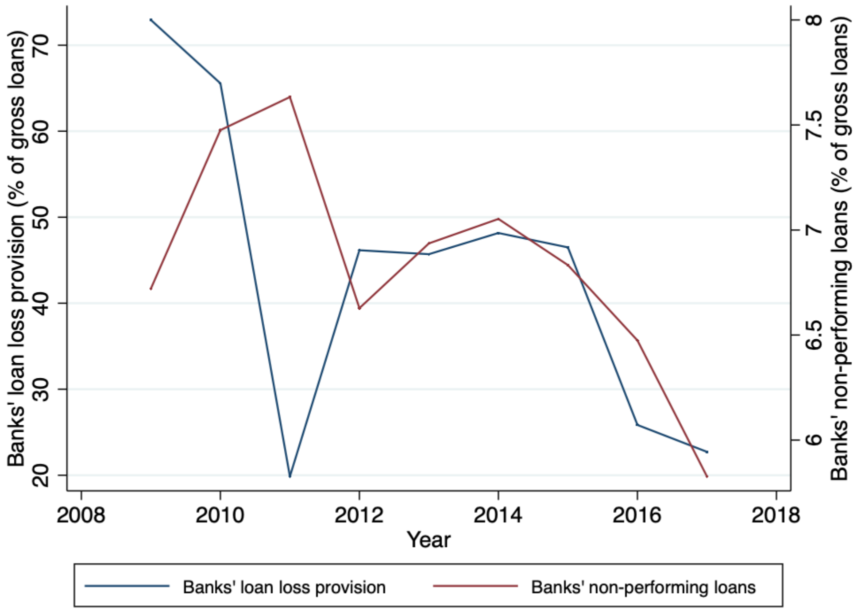


Figure D1: Yearly average of credit risk proxies for euro area banks (source: Fitch Connect, 2009-2017)

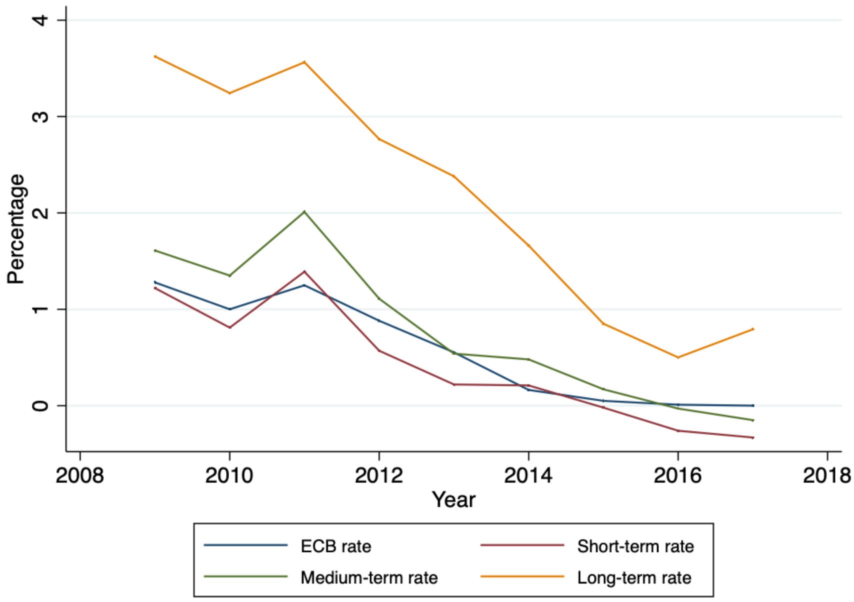


Figure D2: Yearly average of interest rates proxies in the euro area (source: Eurostat, 2009-2017)

Chapter 3

The joint influence of bank capital & funding liquidity on the monetary policy's risk-taking channel

3.1 Introduction

The 2008 global financial crisis (GFC) has been a milestone for banking regulation, suggesting a crucial need to understand how financial stability interacts with the real economy. Accordingly, risk-taking is considered to be a primary source of banks' vulnerability with the potential to be passed onto the whole banking industry or even undermine other sectors as systemic issues arise.

First, a broad literature seeks to understand the joint influence of capital and liquidity on banks' risk-taking (DeYoung et al., 2018). While banks have been required to maintain minimum capital ratios for three decades, the Basel III accords aim to strengthen capital thresholds at the same time as liquidity standards[1]. In addition to the existing capital-based regulation, the introduction of new liquidity requirements such as the net stable funding ratio (NSFR)[2] has led to debate in academic and policy arenas on the need for such regulatory tools, their interaction, and their potential contrasting effects on financial stability (Carletti et al., 2020). Still, banks' funding liquidity and their desired levels of equity are interrelated in ways that are not fully understood by regulators and researchers. Gorton and Winton (2017) examines such a path with the hypothesis of a "crowding-out of deposits" effect when higher capital ratios shift investors' funds from relatively liquid deposits (as a proxy for funding liquidity) to relatively illiquid equity capital. This mainly happens because deposits are insured and withdrawable at par value, whereas bank equity has a stronger stochastic value depending on the liquidity of the stock exchange as well as bank fundamentals (Distinguin et al., 2013).

Second, another growing strand of the literature (Adrian et al., 2019; Morais et al., 2019; Bonfim and Soares, 2018; Neuenkirch and Nöckel, 2018; Dell'Ariccia et al., 2017; Paligorova and Santos, 2017) has focused on the transmission of monetary policy to banks' risk, assuming that variations in monetary policy affect the risk appetite of financial intermediaries and shift the supply curve for credit to the real economy. The key results suggest that monetary policy easing decreases overall credit risk in the short run (due to borrowers' higher capacity to repay outstanding loans), but triggers risk-taking behavior in the medium term with a deterioration

[1] In this study, we focus exclusively on a specific type of liquidity, namely funding liquidity.

[2] The NSFR became a minimum standard applicable to all internationally active banks on a consolidated basis on January 1, 2018, although national supervisory committees may also apply it to any subset of entities of large internationally active banks or to all other banks (BIS, 2018).

in banks' asset quality. The existence of a "risk-taking channel of monetary policy transmission" (Borio and Zhu, 2012) is also well documented for the euro area. Under low interest rates, European banks are more likely to accept higher risk (Altunbas et al., 2014), lax lending standards (Maddaloni and Peydró, 2011), or low interest rate margins (Claessens et al., 2018).

Concerned by the close link between solvency and liquidity crises[3], the present study examines the joint influence of bank capital and funding liquidity on monetary policy's risk-taking channel since the introduction of the euro. As one of the largest bank-based financial systems worldwide (Bats and Houben, 2020), the euro area displays great diversity in banking industries, which makes it of special interest. Moreover, while the previous literature considers separately the causal relation from capital to funding liquidity and the transmission channel of monetary policy, this study is the first, to the best of our knowledge, to empirically investigate how credit risk is affected by the dual constraints of capital and funding liquidity in an environment of changing—and, lately, low—interest rates in the euro area.

Based on the triple interactions among monetary policy, equity capital, and funding liquidity[4], we use yearly data from 1999 to 2018 to show that euro area banks faced a "crowding-out of deposits" effect (Gorton and Winton, 2017) in the risk-taking channel of monetary policy before the GFC. These findings support the Basel III framework and need to strengthen the minimum funding liquidity

[3] Hong et al. (2014) evidence that liquidity risk leads to bank failures through systematic and idiosyncratic channels and was therefore an important contributor to banks' failures during 2009–2010.

[4] Following Acharya and Naqvi (2012), we use the ratio of total deposits to total assets to proxy for banks' funding liquidity in our empirical analysis.

standards concomitant to capital ratios to temper monetary policy transmission to credit risk. We also evidence a missing "crowding-out of deposits" effect on behalf of inefficient banks in the post-GFC period when interest rates decline to the zero lower bound. Accordingly, a trade-off arises between financial stability (achieved through higher capital ratios) and funding liquidity: when interest rates are low, imposing capital and funding liquidity standards on inefficient banks *at the same time* might further expose them to the risk-taking channel of monetary policy.

Our findings have major implications for bank regulators and policymakers in the euro area. We provide new insights into the joint influence of capital and funding liquidity regulation on monetary policy's risk-taking channel for inefficient banks in the post-GFC period. Hence, when interest rates are low, we suggest first addressing banks' inefficiency issues before requiring them to display simultaneously good levels of capital and funding liquidity. This outcome is all the more important given that the share of inefficient banks increased in most euro area countries (except for Belgium, Estonia, Finland, Greece, Malta, and Slovenia) between 2011 and 2018. The COVID-19 pandemic, which has led to the Great Lockdown (Gopinath, 2020), might also raise the interest of these results, as the low interest rate environment in the European banking industry is likely to extend further.

Accordingly, we present new empirical evidence extending the current literature in two directions. First, we add to the strand of the literature on the risk-taking channel of monetary policy in that the joint influence of capital and funding liquidity requirements on the latter has not yet been examined empirically for the euro area. Second, we assess the accuracy of the Basel III regulatory framework, particularly the extent to which funding liquidity regulation should consider the efficiency profiles of financial intermediaries before implementing uniform standards across the euro area.

The remainder of the paper is structured into five sections. Section 3.2 reviews the literature on the causal link between bank capital and funding liquidity as well as theories addressing the risk-taking channel of monetary policy. Section 3.3 presents the data and empirical strategy addressing our theoretical motivations, before Section 3.4 defines the variables of interest and controls. Section 3.5 discusses the empirical results and robustness checks, while Section 3.6 concludes.

3.2 Literature overview

We build our empirical approach by linking the causal relation between bank capital and funding liquidity with the framework of monetary policy's risk-taking channel. First, we briefly review the literature on how capital and funding liquidity affect banks' risk-taking behaviors (Subsection 3.2.1). We then discuss the causal link between capital and funding liquidity (Subsection 3.2.2) and theories on the risk-taking channel of monetary policy (Subsection 3.2.3).

3.2.1 Effects of capital & funding liquidity on banks' risk

Studies of the impact of capital on banks' risk lack consensus. Calem and Rob (1999) support the idea of a U-shaped relation: while under-capitalized banks lower risk as their level of capital rises, well-funded banks increase their risk-taking behavior in the long run. Jeitschko and Jeung (2005) note that banks' risk can be either negatively or positively related to capitalization depending on the relative forces of the incentives determining asset risk and risk/return of asset choices (i.e., the shareholder, manager, and deposit insurer). However, another stream of the literature suggests that banks with high levels of equity are less willing to take risks than banks with low equity.

Unlike established U.S. evidence, Altunbas et al. (2007) prove that inefficient European banks holding more capital appear to actually take on less risk. As shareholders of well-capitalized banks are risk-averse and fear huge losses in the case of default, Repullo (2004) argues that banks with high equity levels rather prefer to mitigate their risk-taking behavior. Similarly, Konishi and Yasuda (2004) find that capital requirements have reduced Japanese commercial banks' risk and Lindquist (2004) also suggest a negative relationship between capital buffers and risk-taking for Norwegian savings banks. Berger et al. (2008) establish that publicly traded U.S. bank holding companies actively manage their capital ratios, set target capital levels above well-capitalized regulatory minima, and make rapid adjustments toward their targets. Still in support of the risk reduction view, Hyun and Rhee (2011) and Lee and Hsieh (2013) evidence that banks restrict high-risk assets rather than issuing new equity when complying with capital requirements.

Regarding the relation between funding liquidity and banks' risk, Acharya and Naqvi (2012) theoretically show that excessive funding liquidity—proxied by the level of deposits on banks' balance sheets—induces greater risk-taking on the part of bank managers. This occurs when managerial performance is assessed on the basis of loan volume delivered to customers or when long-term risk is ignored in setting managers' premiums. As banks collect funds from depositors and lend them to borrowers, excess deposits might trigger managers' overconfidence in their lending practices and strengthen their belief that the bank will not experience any funding liquidity crisis in the near future. To induce bank managers to accept higher degrees of risk, Cheng et al. (2015) note that they need to be given higher compensation. However, to achieve such compensation levels, flexibility toward aggressive lending strategies is necessary, especially when funding liquidity is in abundance. Eventually, this creates the reverse causality of risk causing pay as opposed to pay causing risk.

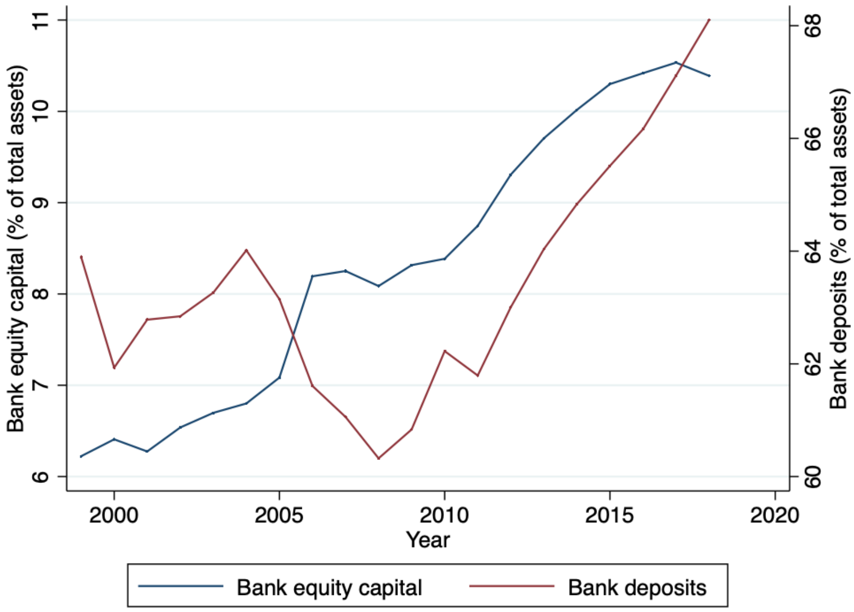
Similarly, Hong et al. (2014) show that systemic liquidity risk contributed to bank failures in 2009 and 2010, suggesting that an effective framework of funding liquidity risk management needs to target liquidity risk at both the individual and the system levels. Wagner (2007) argues that the higher funding liquidity of bank assets increases banking instability and the externalities associated with banking failures. Lucchetta (2007) also emphasizes that bank funding liquidity might rise because of monetary policy tightening. Higher risk-free interest rates boost risk-free bond investment, which, in turn, pushes up funding liquidity supply and stimulates interbank lending. This eventually results in massive investment in risky assets emanating from other banks. As pointed out by Keeley (1990), deposit insurance is also a breeding ground of moral hazard that leads to banks taking more risks: the higher the level of deposits, the higher the risk exposure of deposit insurers. Overall, there is a clear positive relationship between bank funding liquidity and risk-taking behavior.

3.2.2 The causal link between capital & funding liquidity

Among the theoretical literature on the relationship between bank capital and funding liquidity, Gorton and Winton (2017) suggest the presence of a "crowding-out of deposits" effect to explain why higher levels of bank capital reduce the volume of deposits. The reasoning goes as follows. Although equity capital reduces the probability of bank failure, to investors, bank equity is an information-sensitive asset that makes a poor hedge against liquidity needs. In the equilibrium in a banking system, investors hold deposits to the extent they need coverage against potential liquidity shocks. A system-wide increase in the required bank capital forces investors to reduce their deposit holdings in favor of equity, increasing the odds that the marginal bank shareholder will have to sell to meet his/her liquidity needs and increasing the resulting discount for expected trading losses. Once investors have acquired bank shares, they have an incentive to acquire costly information about the value of the bank. Although deposits are totally or partially insured and withdrawable at par value, bank equity capital has an important stochastic value depending on bank fundamentals and stock exchange liquidity (Distinguin et al., 2013). If capital ratios rise, then investors' funds shift from liquid deposits to illiquid bank equity.

Another consequence of rising capital adequacy ratios is the opportunity for banks to exit the industry because of the gap between the private and social costs of capital. While exit reduces the production of liquid demand deposits,

Figure 3.1: Trends in bank equity capital & deposits in the euro area (1999–2018)



Source: Fitch Connect (1999-2018).

Gorton and Winton (2017) emphasizes that this might lead to a "shadow banking" system and result in a socially suboptimal level of capital. Figure 3.1 illustrates the combined trends in bank equity and deposits in the euro area from 1999 to 2018. While capitalization steadily increased over the sample period, deposits as a share of banks' total assets declined from 2004 to 2007 before rising again after the GFC.

3.2.3 The risk-taking channel of monetary policy

Over the past decade, interest in the risk-taking channel of monetary policy has risen in the banking and financial literature. Since the GFC, unconventional monetary conditions have led banks to navigate a "low-for-long" interest rate environment, urging the need to understand monetary easing's impacts on risk-taking behaviors.

Dell'Ariccia and Marquez (2013) account for the existence of a "search-for-yield" effect through which the monetary policy channel operates. This occurs on the asset side of balance sheets when a drop in interest rates undermines bank profitability and leads either to monitoring laxity or riskier search-for-yield strategies. The final outcome is greater risk-taking in the banking industry overall.

Further, the "risk-shifting" effect occurs through the liabilities side of balance sheets when decreasing interest rates lower the cost of bank liabilities. As banks target a leverage ratio (Bruno and Shin, 2015), they choose to either increase market funding or expand credit (with the potential for covering riskier projects) to return to their target. Valencia (2014) and Dell'Ariccia and Marquez (2013) argue that such a strategy results in banks taking more risks. Moreover, if banks demand more assets, their price will rise and this will expand banks' balance sheets as well as leverage. Gambacorta (2009) suggests that a "low-for-long" interest rate environment might thus affect asset and collateral valuation and, therefore, reduce market volatility as well as risk perception.

While most empirical studies (Morais et al., 2019; Paligorova and Santos, 2017; Angeloni et al., 2015; Ioannidou et al., 2015; Altunbas et al., 2014) find a negative relationship between monetary policy and banks' risk, evidence is mixed in the U.S. case. For instance, Dell'Ariccia et al. (2017) show that this negative relationship is less pronounced for weakly capitalized banks or during financial distress. While Delis et al. (2017) evidence that monetary policy easing lessens banks' risk in the short run but raises it in the medium run, Buch et al. (2014) highlight important differences depending on the type of bank: small domestic banks increase their exposure to risk, while foreign banks behave the same but only when interest rates are "too low for too long."

Finally, the risk-taking channel is stronger for banks with lower levels of liquidity (Brissimis and Delis, 2010), smaller banks (Buch et al., 2014), and those involved in non-traditional banking activities than for other banks (Altunbas et al., 2014). Maddaloni and Peydró (2011) also draw on agency issues to justify that the impact of monetary easing on lending standards is amplified under weak capital supervision.

3.3 Data & empirical strategy

3.3.1 Data

The sample includes banks from the euro area (EA11-1999, EA12-2001, EA13-2007, EA15-2008, EA16-2009, EA17-2011, EA18-2014, EA19-2015) over 1999–2018. Annual unconsolidated financial statements are taken from the Fitch Connect database for the following bank categories: private, retail & consumer, trade finance, trading & investment, trust & processing, universal commercial, and wholesale commercial. We exclude bank-year observations with missing information on total assets over the full sample period. We also consider data from Eurostat to compute the macroeconomic controls. As outlier values may distort our results, all the variables except the macroeconomic controls are winsorized at the 5^{th} and 95^{th} percentiles, as it is common in the literature (Acharya and Mora, 2015)[5].

The final sample consists of 58,280 bank-year observations for 4,023 euro area

[5] We found qualitatively similar results for variables winsorized at the 1^{st} and 99^{th} percentiles.

Table 3.1: Variables' description & summary statistics

	Description	Unit	Source	Obs.	Mean	Median	Std. dev.	Min.	Max.
Panel A: Variables of interest									
LLP	Loan loss provisions over the total gross loans of the bank	%	Fitch Connect	58,280	0.6025	0.4400	0.7803	-0.6200	2.7100
NPL	Non-performing loans over the total gross loans of the bank	%	Fitch Connect	22,029	6.1806	3.9900	5.9493	0.3500	22.1800
ECB rate	ECB main refinancing rate at the end of the year	%	Eurostat	58,280	1.5357	1.0000	1.4683	0	4.7500
Taylor residuals	Residuals of the regression of the ECB rate on country contemporaneous GDP growth and inflation, applied to the country where the bank is headquartered	p.p.	Eurostat	58,280	-2.14e-09	-0.5931	1.3726	-3.1598	3.1450
EONIA	Weighted average at the end of the year of all overnight unsecured lending transactions in the interbank market	%	Eurostat	58,280	1.4410	0.7100	1.6501	-0.3600	4.3900
Taylor residuals EONIA	Residuals of the regression of the EONIA rate on country contemporaneous GDP growth and inflation, applied to the country where the bank is headquartered	p.p.	Eurostat	58,280	-1.05e-08	-0.5295	1.5261	-3.4372	2.7725
EURIBOR 1-month	Representative short-term interest rate series with 1-month maturity at the end of the year (benchmark at which euro interbank term deposits are offered by prime banks to one another)	%	Eurostat	58,280	1.5376	0.8900	1.6961	-0.3700	4.3300
EURIBOR 6-month	Representative short-term interest rate series with 6-month maturity at the end of the year (benchmark at which euro interbank term deposits are offered by prime banks to one another)	%	Eurostat	58,280	1.7783	1.4300	1.6941	-0.2700	4.7300
EURIBOR 12-month	Representative medium-term interest rate series with 12-month maturity at the end of the year (benchmark at which euro interbank term deposits are offered by prime banks to one another)	%	Eurostat	58,280	1.9388	1.6100	1.6775	-0.1700	4.8300
Capital	Equity capital over the total assets of the bank	%	Fitch Connect	58,280	8.5902	7.4500	5.0872	3.1100	32.3600
High capital	Dummy = 1 if the bank' equity capital over total assets is above the full sample median value (computed for each country-year combination) ; = 0 otherwise	{0,1}	Fitch Connect	58,280	0.4999	0	0.5000	0	1
Deposits	Total deposits over the total assets of the bank	%	Fitch Connect	58,280	63.4840	70.8000	22.0906	3.4900	87.4000
Liquid assets	Natural logarithm of the total liquid assets of the bank	ln(€)	Fitch Connect	58,252	18.2474	18.0217	1.7517	15.1268	22.0424
Panel B: Bank-level controls									
Size	Natural logarithm of the total assets of the bank	ln(€)	Fitch Connect	58,280	20.3412	20.1909	1.6074	17.4860	23.6317
Profitability	Operating profits over the total assets of the bank	%	Fitch Connect	58,280	0.7025	0.6200	0.6729	-0.5800	2.7700
Inefficiency	Expenses over the total revenues of the bank	%	Fitch Connect	58,280	68.8822	69.1400	13.7607	35.0600	98.9600
Net loans	Net loans over the total assets of the bank	%	Fitch Connect	58,280	58.1675	61.0800	18.5655	7.3700	87.0100
Panel C: Country-level controls									
Real GDP	Percentage change on previous period of the GDP at market prices (chain linked volumes)	%	Eurostat	58,280	1.3192	1.7000	2.2110	-9.1000	25.2000
Recession	Dummy = 1 if the real GDP is negative ; = 0 otherwise	{0,1}	Eurostat	58,280	0.1510	0	0.3580	0	1
Unemployment	Percentage of the active population being unemployed	%	Eurostat	58,280	7.6845	7.6000	3.1663	1.9000	27.5000
Government debt	General government consolidated gross debt (percentage of GDP)	%	Eurostat	58,280	77.1308	72.1000	23.0970	6.1000	181.2000
NF corporations debt	Non-financial corporations consolidated debt (percentage of GDP)	%	Eurostat	58,280	56.9857	49.3000	25.3042	31.3000	256.6000

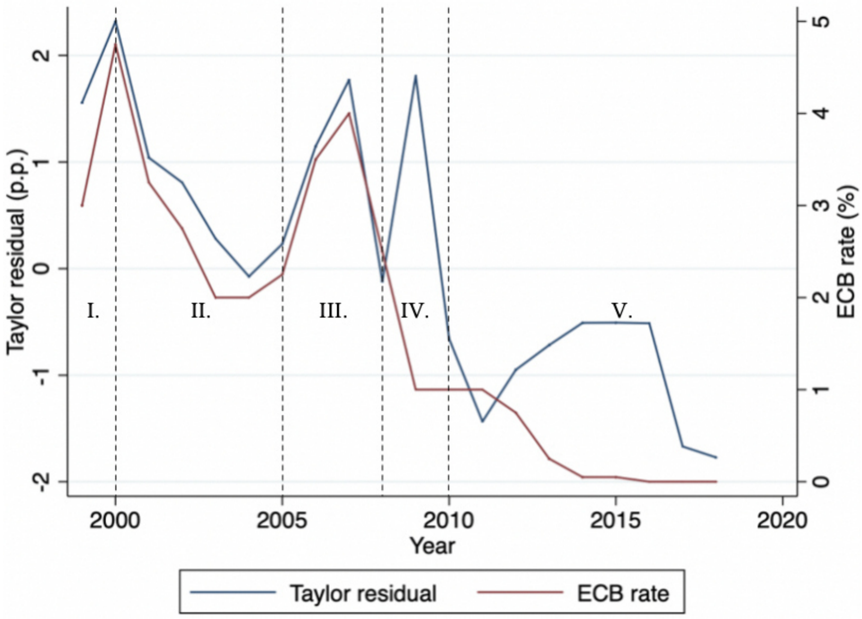
Notes. The table reports the description, along with the unit, source, number of observations, mean, median, standard deviation, minimum, and maximum for the variables used in the empirical analysis. The sample consists of yearly bank panel data from euro area countries (EA11–1999, EA12–2001, EA13–2007, EA15–2008, EA16–2009, EA17–2011, EA18–2014, EA19–2015) over the period 1999–2018. The top and bottom 5% observations of all variables have been winsorized to limit the impact of extreme values, except for country–level controls, ECB rate, Taylor residuals, EONIA, Taylor residuals EONIA, EURIBOR 1–month, EURIBOR 6–month, and EURIBOR 12–month.

banks. Table 3.1 presents the description, source, and summary statistics of the winsorized variables used in the empirical analysis. Table A1 in the Appendix compares the country-level aggregates of total assets from the banks included in the final sample using data from Fitch Connect between 1999 and 2018. The last row of the table reports a weighted average ratio (computed using the number of banks available in Fitch Connect for each country) of 83.59%, indicating the representativeness of our sample.

On average, loan loss provisions and non-performing loans (our bank credit risk proxies) represent 0.60% and 6.18% of the total gross loans of banks included in the final sample, respectively. With a value of 0.78%, the standard deviation of loan loss provisions is notably lower than that of non-performing loans (5.95%). The monetary policy indicators display a mean value of -2.14e-09 percentage points for the Taylor residuals, 1.54% for the ECB rate, 1.44% for the EONIA, 1.67% for the 3-month EURIBOR, and 1.94% for the 12-month EURIBOR. The average share of equity capital to banks' total assets is 8.59% and this increased steadily from 1999 to 2018 in the euro area (see Figure 3.1). Following Acharya and Naqvi (2012) and Khan et al. (2017), we proxy for bank funding liquidity using the ratio of deposits to total assets, which displays an average value of 63.48% throughout the sample period.

In addition, the bank-level controls report an average share of operating profits to banks' total assets of 0.70% and a standard deviation of 0.67%. Expenses represent 68.88% of banks' total revenues on average (with a standard deviation of 13.76%), and net loans display a mean value of 58.17% relative to banks' total assets (with a slightly higher standard deviation of 18.57%). We also include four country-level controls to examine the impact of the macroeconomic environment on the way bank capital and funding liquidity interact in the risk-taking channel of monetary policy. The mean percentage change on the previous period of real GDP is 1.32% over the sample period, with a standard deviation of 2.21%. On average, the share of the unemployed relative to the active population is 7.68% in the euro area. We also investigate the debt level of public sector and non-financial firms. In terms of the share of GDP, the average consolidated gross debt of general government is 77.13% between 1999 and 2018 in the euro area compared with 56.99% for non-financial firms. The standard deviations of both debt indicators are 23.10%

Figure 3.2: ECB main refinancing rate & estimated Taylor residuals for the euro area (1999-2018)



Source: Fitch Connect (1999-2018).

and 25.30%, respectively.

Table B1 in the Appendix reports the pairwise cross-correlation coefficients of the variables used in the empirical analysis. We do not find the bank-level explanatory variables to be highly correlated, indicating that multicollinearity is not a major issue in our estimations. The correlation coefficients of the monetary policy indicators (ECB rate and Taylor residuals) with the risk-taking proxies are 0.17, -0.05, 0.22, and 0.04, respectively. The correlation coefficients of deposits (funding liquidity proxy) with bank credit risk are -0.12 and -0.20, respectively.

Figure 3.2 reports the evolution of the ECB rate and Taylor residuals from 1999 to 2018. For a more indepth analysis on the conduct of monetary policy since the euro area was implemented, we divide the sample period into five subperiods:

I. To contain inflationary pressures against the backdrop of strong economic growth, increasing import prices, and high monetary growth, key interest rates first rose from 1999 to mid-2000 (European Central Bank, 2011);

II. In response to receding inflationary pressures in an environment of subdued economic growth, marked adjustments in financial markets, and high geopolitical uncertainty, interest rates were cut between May 2001 and June 2003 and then left unchanged until December 2005 (European Central Bank, 2011);

III. Owing to increasing inflation against the background of sound economic growth and a rapid expansion in the supply of money and credit, the degree of monetary policy accommodation was then gradually reduced. With upside risks to price stability prevailing until mid-2008, interest rates rose again, bringing the main refinancing rate to 4.25% in July 2008 (European Central Bank, 2011);

IV. Taking account of the subdued inflationary pressures in a setting in which financial strains had weakened the economic outlook and significantly diminished upside risks to price stability, the ECB rate was reduced between October 2008 and May 2009 and then remained at the 1% level until April 2011 (European Central Bank, 2011);

V. The last subperiod corresponds to the low interest rate environment in the euro area starting from 2011 and remaining at historical lows.

3.3.2 Empirical strategy

To investigate the causal link between bank capital and funding liquidity in the risk-taking channel of monetary policy, we use a panel regression with heteroskedasticity-robust standard errors. The empirical model includes both bank-level and country-level controls (described in Table 3.1 and discussed in Subsection 3.4.4), which may modify the monetary policy impact on banks' risk-taking. Bank-, country-, and time-specific effects are captured using bank, country, and year dummies, respectively.

The baseline specification developed to initially examine the way the risk-taking channel of monetary policy has operated since the launch of the single currency is as follows:

$$\begin{aligned} Risk_{b,c,t} \;=\; \alpha \;+\; \beta\; Monetary_{c,t} \;+\; \gamma\; Capital_{b,c,t} \\ +\; \delta\; Liquidity_{b,c,t} \;+\; \zeta\; Controls_{b,c,t} \\ +\; \eta_b \;+\; \theta_t \;+\; \varepsilon_{b,c,t} \end{aligned} \tag{3.1}$$

where the b, c, and t subscripts stand for bank b headquartered in country c in year t, respectively. The coefficients β, γ, δ, ζ, η, and θ reflect the extent to which the relative factors contribute to the change in the dependent variable. While α serves as a constant variable, $\varepsilon_{b,c,t}$ represents the heteroskedasticity-robust standard errors for bank b headquartered in country c in year t. Standard errors are clustered by banks in the preliminary analysis (see Table 3.2) and then clustered at the bank and country levels in the remaining empirical analysis. The coefficients η_b and θ_t account for omitted bank-specific and time fixed effects, respectively. The dependent variable $Risk_{b,c,t}$ is measured alternatively by loan loss provisions and non-performing loans. The three independent variables of interest used in the empirical analysis are $Monetary_{c,t}$, $Capital_{b,c,t}$, and $Liquidity_{b,c,t}$, which assess the monetary policy stance, level of bank capitalization, and level of funding liquidity (proxied by deposits), respectively.

The $Controls_{b,c,t}$ include a set of bank- and country-specific variables. The list of bank-level controls are those commonly adopted in the literature. Consistent with Bonfim and Soares (2018); Dell'Ariccia et al. (2017); Delis et al. (2017), and Khan et al. (2017), we consider bank size, profitability, inefficiency, and net loans (see Subsection 3.4.4 for definitions and a discussion) as potential determinants of banks' risk-taking. We also include macroeconomic variables in our panel regressions to investigate the joint influence of bank capital and funding liquidity on the risk-taking channel of monetary policy. Further, we use the four nationwide controls discussed in Subsection 3.4.4: economic growth, unemployment, government debt, and non-financial firms' debt.

To examine the compositional changes of bank capital and funding liquidity on the risk-taking channel of monetary policy, we extend Equation 3.1 by drawing on the methodology of Jiménez et al. (2014) and Delis et al. (2017) based on the triple interaction coefficients. For our empirical analysis, we assess the following specification:

$$\begin{aligned} Risk_{b,c,t} \; = \; \alpha \; + \; \beta \; Monetary_{c,t} \; + \; \gamma \; Monetary_{c,t} * High\ capital_{b,c,t} \\ + \; \delta \; Monetary_{c,t} * Liquidity_{b,c,t} \; + \; \zeta \; High\ capital_{b,c,t} * Liquidity_{b,c,t} \\ + \; \eta \; Monetary_{c,t} * High\ capital_{b,c,t} * Liquidity_{b,c,t} \; + \; \theta \; Controls_{b,c,t} \\ + \; \iota_b \; + \; \kappa_c \; + \; \lambda_t \; + \; \varepsilon_{b,c,t} \end{aligned} \tag{3.2}$$

where $High\ capital_{b,c,t}$ is a dummy equaling 1 if bank equity capital is above the full sample median value computed for each country-year combination and 0 otherwise. Here, we are particularly interested in the coefficient η on the triple interactions among monetary policy, bank capital, and funding liquidity. Considering a cycle of monetary easing, a positive (negative) coefficient on this "triple" implies that banks with high levels of capital and low (high) levels of funding liquidity are inclined to more risk-taking, which might therefore exacerbate the strength of the risk-taking channel of monetary policy. The variables $Monetary_{c,t}$, $High\ capital_{b,c,t}$, and $Liquidity_{b,c,t}$ in their simple forms and in the double interactions are included in Table 3.3 to Table 3.8 but left unreported for the ease of readability of the results. We briefly define the variables included in Equation 3.1 and Equation 3.2 in the following section.

3.4 Variables' definition

3.4.1 Bank risk-taking

The dependent variable $Risk_{b,c,t}$ is the vector of the alternative bank credit risk variables for bank b in country c in year t. Banks' risk-taking is assessed using the two ratios of loan loss provisions to banks' total gross loans (LLP) and non-performing loans to banks' total gross loans (NPL). LLP captures the asset quality of banks (Delis et al., 2014) and shows the share of gross loans used as an allowance for uncollected loans and loan payments to cover possibilities of impairments. An increase in LLP is associated with a riskier position. In turn, NPL identifies problems with asset quality in bank loan portfolios and highlights the potential adverse exposure to earnings and asset market values due to worsening loan quality. A high value of this ratio also means greater risk-taking by banks. Table 3.1 presents the summary statistics for both indicators.

3.4.2 Monetary policy

To capture the monetary policy stance, we first use the ECB's main refinancing rate (*ECB rate*) at the end of each year[6]. In addition, we consider a Taylor rule residual as an alternative measure to examine the exogenous component of monetary policy (Dell'Ariccia et al., 2017). *Taylor residuals* are the residuals of rolling regressions of *ECB rate* on CPI inflation and the difference between current and previous

[6] We obtain qualitatively similar results when computing the annual average of the ECB policy rate.

real GDP. We proceed by following the essence of the methodology proposed by Maddaloni and Peydró (2011). Figure 3.2 shows the trend of these two monetary policy proxies.

To check the robustness of our results, we also run Equation 3.2 using *EONIA*, *EURIBOR 3-month*, and *EURIBOR 12-month*. Table 3.8 reports the results. While *EONIA* represents the weighted average at the end of the year of all overnight unsecured lending transactions in the interbank market, *EURIBOR 3-month* and *EURIBOR 12-month* stand for the short-term interest rate with a 3-month maturity at the end of the year and the medium-term interest rate with a 12-month maturity, respectively. Table 3.1 (panel A) provides the summary statistics.

Since the major contribution of Borio and Zhu (2012) on the risk-taking channel of monetary policy, numerous theoretical (Acharya and Naqvi, 2012; Dell'Ariccia and Marquez, 2006) and empirical (Ioannidou et al., 2015; Bekaert et al., 2013) studies have documented that lax monetary policy is associated with higher risk-taking in the banking industry. As a result, we expect to observe a negative relationship between, on the one hand, *LLP* and *NPL* and, on the other hand, *ECB rate* and *Taylor residuals*.

3.4.3 Bank capital & funding liquidity

This empirical study analyzes how the causal link between bank capital and funding liquidity influences the way monetary policy acts on the risk-taking behavior of banks. To this end, we consider the *Capital* variable as the ratio of equity capital to banks' total assets to proxy for the level of capitalization of each financial intermediary in the final sample.

Similarly to Khan et al. (2017), we use the ratio of total deposits to total assets as a proxy for funding liquidity. Following Acharya and Naqvi (2012), we assume that banks with high levels of deposits benefit from lower bankruptcy risk and might encourage managers to take more risk as they are less likely to face a funding crisis in the near future. Another reason relates to deposit insurance acting as a put option on the assets of banks. Hence, banks display greater risk-taking when their levels of deposits rise because of deposit insurance contracts. Accordingly, we anticipate a positive relationship between the *Deposits* variable and credit risk proxies *LLP* and *NPL*. Panel A in Table 3.1 provides a description and the summary statistics for the capital and funding liquidity proxies.

3.4.4 Control variables

The bank-level controls used in our estimations are commonly adopted in the literature. Consistent with Dinger and te Kaat (2020); Danisman and Demirel (2019) and Lee and Hsieh (2013), we use the natural logarithm of total assets to measure bank *Size*. We also consider three additional ratios that might be important factors in shaping banks' risk: the ratio of operating profits to total assets as a measure of *Profitability*, the ratio of expenses to total revenues as an *Inefficiency* indicator, and the ratio of net loans to total assets (*Net Loans*) as a proxy for banks' involvement in financial intermediation. If we assume that larger banks better manage risk than smaller banks, then a negative relationship prevails between *Size* and the risk-taking indexes. We also expect a negative relation between, on the one hand, *Profitability*, *Inefficiency*, and *Net loans* and, on the other hand, the credit risk proxies. As too high risks might lead to greater volumes of problem loans and eventually affect profitability, we anticipate a negative relationship between *Profitability* and banks' risk-taking.

Moreover, if greater risks explain the high technical efficiency levels (as they are responsible for the level of banks' income, the latter therefore acting as an incentive for greater risk-taking), a negative link is most likely between *Inefficiency* and both *LLP* and *NPL*. In addition, the relation between *Net loans* and banks' risk-taking behavior strongly depends on the quality of the screening of borrowers. A positive sign implies low screening standards, whereas a negative sign means sound screening practices. Panel B in Table 3.1 reports the summary statistics of the variables controlling for bank characteristics and activities.

We also include country-level controls in the panel regressions to consider the impact of the macroeconomic environment on banks' risk-taking. We enrich our model with the percentage change in the previous period of GDP at market prices (*Real GDP*), the percentage of the active population being unemployed (*Unemployment*), the level of general government debt expressed as a percentage of GDP (*Government debt*), and the level of non-financial firms' debt as a share of GDP (*NF firms debt*). Panel C in Table 3.1 shows the summary statistics of the variables controlling for the macroeconomic conditions in which euro area banks operate.

3.5 Discussion of findings

In this section, we present early results on the joint influence of bank capital and funding liquidity on the risk-taking channel of monetary policy in Subsection 3.5.1 and account for endogeneity issues regarding monetary policy in Subsection 3.5.2. From that point, we provide comprehensive results on the presence of a "crowding-out of deposits" effect before the GFC in the euro area banking industry (Subsection 3.5.3) and, interestingly, the absence of such an effect among inefficient banks in the aftermath of the GFC (Subsection 3.5.4). Subsection 3.5.5 provides several robustness checks.

3.5.1 Preliminary analysis

Table 3.2 provides the results of a preliminary analysis on the risk-taking channel of monetary policy specified in Equation 3.1 over 1999 to 2018. OLS panel regressions are estimated with standard errors clustered at the bank level; both bank-level and country-level controls are included. When they are significant, the monetary policy proxies *ECB rate* and *Taylor residuals* display negative relationships with risk-taking. The impact of *ECB rate* on bank credit risk is economically significant, as a one standard deviation decrease implies that *LLP* rises by 0.0765 in regression (1) and *NPL* increases by 1.0945 in regression (3). Conversely, the economic impact of *Taylor residuals* is also significant, as a one standard deviation decrease causes *NPL* to increase by 0.4869 in regression (4).

Capital appears to be negatively related to credit risk, suggesting that well-

Table 3.2: Preliminary analysis on the risk-taking channel of monetary policy transmission (1999–2018)

	LLP		NPL	
	(1)	(2)	(3)	(4)
ECB rate	-0.0521***		-0.7454**	
	(0.0041)		(0.2912)	
Taylor residuals		-0.0093		-0.3547***
		(0.0185)		(0.0570)
Capital	-0.0078***	-0.0049*	-0.1514***	-0.1057***
	(0.0026)	(0.0029)	(0.0348)	(0.0323)
Deposits	0.0010*	0.0015**	0.0107	0.0208**
	(0.0006)	(0.0006)	(0.0087)	(0.0082)
Size	-0.1752***	-0.1428***	-1.9282***	-1.3575***
	(0.0191)	(0.0229)	(0.3491)	(0.2813)
Profitability	-0.8497***	-0.8411***	-1.5779***	-1.6816***
	(0.0142)	(0.0146)	(0.0875)	(0.0889)
Inefficiency	-0.0346***	-0.0342***	-0.0418***	-0.0443***
	(0.0008)	(0.0008)	(0.0048)	(0.0049)
Net loans	-0.0034***	-0.0033***	-0.0933***	-0.0980***
	(0.0006)	(0.0006)	(0.0083)	(0.0083)
Real GDP	-0.0072***	0.0043	0.3581***	0.1582***
	(0.0013)	(0.0036)	(0.0448)	(0.0226)
Unemployment	0.0497***	0.0513***	0.5105***	0.5220***
	(0.0020)	(0.0029)	(0.0415)	(0.0390)
Government debt	0.0003	0.0005	0.0335***	0.0637***
	(0.0005)	(0.0009)	(0.0101)	(0.0072)
NF corporations debt	0.0008*	0.0006	0.0027	-0.0002
	(0.0005)	(0.0005)	(0.0136)	(0.0131)
Constant	6.8287***	6.1399***	49.4208***	34.0709***
	(0.4234)	(0.4947)	(8.2046)	(6.4740)
Bank-level controls	Yes	Yes	Yes	Yes
Country-level controls	Yes	Yes	Yes	Yes
Bank fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	No	Yes	Yes	No
Clustered s.e.	Bank	Bank	Bank	Bank
Adjusted R-squared	0.6609	0.6643	0.8167	0.8109
Sample period	1999-2018	1999-2018	1999-2018	1999-2018
Observations	57,792	57,792	21,813	21,813

Notes. The table reports results of estimating panel regressions regarding banks' credit risk in the euro area (EA11–1999, EA12–2001, EA13–2007, EA15–2008, EA16–2009, EA17–2011, EA18–2014, EA19–2015) over the period 1999–2018. Description and summary statistics of all variables used are reported in Table 3.1. The dependent variables are the ratios of loan loss provision to gross loans (*LLP*) in regressions (1) and (2), and non-performing loans to gross loans (*NPL*) in regressions (3) and (4). The variables of interest are the two measures of interest rates (*ECB rate* and *Taylor residuals*), the measure of bank equity capital (*Capital*), and the measure of bank funding liquidity (*Deposits*). Both bank–level and country–level controls are included and reported. All regressions include bank fixed effects. Year fixed effects are also included in regressions (2) and (3). *P*–values are computed using heteroskedasticity–robust standard errors clustered by banks (in parentheses). *Statistical significance at the 10% level. **Statistical significance at the 5% level. ***Statistical significance at the 1% level.

capitalized banks are less risky. A one standard deviation increase in bank capitalization decreases *LLP* by 0.0397 in regression (1) and lowers *NPL* by 0.7702 in regression (3). Consistent with the theoretical predictions of Acharya and Naqvi

(2012) and empirical results of Khan et al. (2017), we find that funding liquidity (proxied by *Deposits*) significantly increases the risk-taking behavior of banks (a one standard deviation increase in funding liquidity raises *LLP* by 0.0331 in regression (2)).

We include bank characteristics in all the panel regressions as well as bank and year fixed effects to capture other unobservable factors that may affect risk-taking. As reported in Table 3.2, most of these controls are significant and in the expected direction. *Size* appears to be negatively linked to bank credit risk, which implies that larger banks display better risk management. *Profitability* is also an important component in taming bank credit risk, as evidenced by the negative coefficients related to this indicator. The negative *Inefficiency* coefficients confirm that higher technical efficiency is responsible for riskier positions. The negative sign of the *Net loans* proxy indicates that banks granting higher volumes of loans have better risk management. This result suggests the greater ability to reduce information asymmetries on behalf of banks highly involved in traditional financial intermediation.

As regards the country-level controls, the *Real GDP* coefficient is negative and insignificant when *LLP* is used as the dependent variable and significantly positive when we use *NPL* as the dependent variable[7]. Interestingly, *Unemployment* is positively related to banks' risk-taking behavior: a one standard deviation increase in unemployment leads *LLP* to increase by 0.1574 in regression (1) and *NPL* to

[7] Delis and Kouretas (2011) argue that during more favorable macroeconomic conditions, banks increase their lending in search of higher yields; hence, a positive relationship between GDP growth and banks' risk is expected.

rise by 1.6164 in regression (3). While there is no significant relationship between *Government debt* and *LLP*, public debt is positively linked to *NPL* (see regressions (3) and (4)). However, the *NF firms debt* index is only significantly positive in regression (1), as a one standard deviation increase in non-financial sector debt results in a 0.0202 upward shift in *LLP*.

Next, we examine the compositional change of bank capital and funding liquidity on the risk-taking channel of monetary policy over the full sample period (see Table 3.3). We estimate Equation 3.2, which includes the triple interactions among monetary policy, capital, and funding liquidity (the simple forms and double interactions of these variables are included but left unreported for ease of readability). The bank-level and country-level controls are included, but the latter are left unreported for brevity. Also included are the bank*country fixed effects and year fixed effects in regressions (2), (4), (6), and (8). Standard errors are clustered at the bank-country level in regressions (3), (4), (7), and (8).

Interestingly, the η coefficients on the triple interactions are mostly negative and statistically significant regardless of the *ECB rate* or *Taylor residuals* we use to examine monetary policy. However, it is still impossible to interpret these early findings because interest rates presented different trends from 1999 to 2018 (see Figure 3.2). Accordingly, we would not reach the same conclusions on capital and funding liquidity interactions whenever monetary policy is eased or tightened.

The results of the bank-level control variables are in line with those in Table 3.2. Before further exploring the above early findings, we address endogeneity issues regarding the response of monetary policy to bank credit risk in Subsection 5.2.

Table 3.3: The joint influence of bank capital & funding liquidity on the monetary policy's risk-taking channel: early findings (1999–2018)

	LLP				NPL			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ECB rate * High capital * Deposits	-0.0008***	-0.0008***			-0.0036*	-0.0033†		
	(0.0001)	(0.0001)			(0.0020)	(0.0020)		
Taylor residuals * High capital * Deposits			-0.0010***	-0.0009***			-0.0084**	-0.0070*
			(0.0003)	(0.0003)			(0.0035)	(0.0034)
Size	-0.1468***	-0.1161***	-0.1566***	-0.1188***	-1.1538***	-1.2680***	-1.0303	-1.3093**
	(0.0078)	(0.0083)	(0.0252)	(0.0207)	(0.0979)	(0.1035)	(0.6744)	(0.4885)
Profitability	-0.8497***	-0.8393***	-0.8505***	-0.8405***	-1.7123***	-1.7153***	-1.7509*	-1.6974**
	(0.0047)	(0.0048)	(0.0571)	(0.0558)	(0.0473)	(0.0471)	(0.8387)	(0.7874)
Inefficiency	-0.0345***	-0.0341***	-0.0346***	-0.0342***	-0.0430***	-0.0410***	-0.0437*	-0.0412**
	(0.0003)	(0.0003)	(0.0035)	(0.0035)	(0.0024)	(0.0025)	(0.0214)	(0.0188)
Net loans	-0.0033***	-0.0032***	-0.0034***	-0.0032**	-0.0997***	-0.0948***	-0.0998***	-0.0956***
	(0.0003)	(0.0003)	(0.0010)	(0.0012)	(0.0032)	(0.0032)	(0.0109)	(0.0091)
Constant	6.3772***	5.5875***	6.5933***	5.6062***	31.2929***	34.8970***	26.4888*	32.7562***
	(0.1696)	(0.1864)	(0.4900)	(0.4707)	(2.1941)	(2.3378)	(14.9636)	(11.2471)
Bank-level controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country-level controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
(Bank*Country) fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	No	Yes	No	Yes	No	Yes	No	Yes
Clustered s.e.	—	—	Bank & Country	Bank & Country	—	—	Bank & Country	Bank & Country
Adjusted R-squared	0.6622	0.6657	0.6609	0.6653	0.8118	0.8164	0.8109	0.8162
Sample period	1999-2018	1999-2018	1999-2018	1999-2018	1999-2018	1999-2018	1999-2018	1999-2018
Observations	57,792	57,792	57,792	57,792	21,813	21,813	21,813	21,813

Notes. The table reports results of estimating panel regressions regarding banks' credit risk in the euro area (EA11–1999, EA12–2001, EA13–2007, EA15–2008, EA16–2009, EA17–2011, EA18–2014, EA19–2015) over the period 1999–2018. Description and summary statistics of all variables used are reported in Table 3.1. The dependent variables are the ratios of loan loss provision to gross loans (*LLP*) in regressions (1) to (4), and non–performing loans to gross loans (*NPL*) in regressions (4) to (8). The variables of interest in triple interactions are included and reported. For ease of readability, all the variables of interest and the variables of interest in double interactions are included but left unreported. Bank–level controls are included and reported. For brevity, country–level controls are included but left unreported. All regressions include bank*country and year fixed effects. *P*–values are computed using heteroskedasticity–robust standard errors multiclustered at the bank and country level (in parentheses). †The coefficient has a *p*–value that equals 10.5 percent. *Statistical significance at the 10% level. **Statistical significance at the 5% level. ***Statistical significance at the 1% level.

3.5.2 Endogeneity of monetary policy

Our empirical approach relies on the key assumption that monetary policy changes are exogenous to banks' risk. Since the GFC, regulators and policymakers have discussed at length the need for monetary policy to include financial stability as an explicit target. Therefore, we perform several checks and sample splits to address endogeneity issues and eliminate risks of bias in our estimations (see Table 3.4).

First, we are concerned that our results are driven by the business cycle. This would happen if capital or funding liquidity fluctuates with the economic conditions or because the risk-taking scale adjusts endogenously with the state of the economy

Table 3.4: The joint influence of bank capital & funding liquidity on the monetary policy's risk-taking channel: endogeneity issues

	Business cycle and recession		Crisis years excluded		Large banks excluded		Lagged bank–level controls	
	LLP (1)	NPL (2)	LLP (3)	NPL (4)	LLP (5)	NPL (6)	LLP (7)	NPL (8)
Taylor residuals * High capital * Deposits	-0.0009*** (0.0003)	-0.0072* (0.0035)	-0.0008*** (0.0002)	-0.0100** (0.0037)	-0.0012*** (0.0003)	-0.0217*** (0.0049)		
Taylor residuals * High capital$_{(t-1)}$ * Deposits$_{(t-1)}$							-0.0011** (0.0004)	-0.0091** (0.0035)
Size	-0.1195*** (0.0207)	-1.3667** (0.4789)	-0.1205*** (0.0224)	-1.1296** (0.5290)	-0.1351*** (0.0367)	-1.5088** (0.6229)		
Profitability	-0.8390*** (0.0571)	-1.6640** (0.7789)	-0.8279*** (0.0480)	-1.5484* (0.8209)	-0.8893*** (0.0417)	-1.6085* (0.8937)		
Inefficiency	-0.0340*** (0.0035)	-0.0416** (0.0189)	-0.0338*** (0.0028)	-0.0359* (0.0178)	-0.0408*** (0.0026)	-0.0492* (0.0246)		
Net loans	-0.0032** (0.0012)	-0.0933*** (0.0088)	-0.0021* (0.0010)	-0.0837*** (0.0105)	-0.0037*** (0.0009)	-0.1100*** (0.0121)		
Size$_{(t-1)}$							0.0506** (0.0189)	-0.4945 (0.4250)
Profitability$_{(t-1)}$							-0.2217*** (0.0551)	-1.5342* (0.8101)
Inefficiency$_{(t-1)}$							-0.0099*** (0.0023)	-0.0478* (0.0241)
Net loans$_{(t-1)}$							-0.0014 (0.0021)	-0.0576*** (0.0107)
Taylor residuals * Real GDP	0.0062 (0.0039)	0.0218 (0.0655)						
Recession dummy	0.0717*** (0.0216)	-1.3776*** (0.2431)						
Taylor residuals * Recession dummy	-0.0040 (0.0321)	-0.8106 (0.5766)						
Constant	5.5323*** (0.4439)	33.8520*** (10.6635)	5.6155*** (0.4898)	26.6196** (12.0047)	6.3223*** (0.7455)	37.2944** (13.3954)	0.2506 (0.6340)	14.4510 (10.3097)
Bank-level controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country-level controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
(Bank*Country) fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered s.e.	Bank & Country	Bank & Country	Bank & Country	Bank & Country	Bank & Country	Bank & Country	Bank & Country	Bank & Country
Adjusted R-squared	0.6656	0.8175	0.6814	0.8409	0.6892	0.8226	0.4805	0.8272
Sample period	1999-2018	1999-2018	1999-2007/ 2011-2018	1999-2007/ 2011-2018	1999-2018	1999-2018	1999-2018	1999-2018
Observations	57,792	21,813	48,270	18,792	43,237	14,256	51,226	20,263

Notes. The table reports results of estimating panel regressions regarding banks' credit risk in the euro area (EA11–1999, EA12–2001, EA13–2007, EA15–2008, EA16–2009, EA17–2011, EA18–2014, EA19–2015) over the period 1999–2018 (except in regressions (3) and (4)). Description and summary statistics of all variables used are reported in Table 3.1. The dependent variables are the ratios of loan loss provision to gross loans (*LLP*) in regressions (1), (3), (5) and (7), and non–performing loans to gross loans (*NPL*) in regressions (2), (4), (6) and (8). The variables of interest in triple interactions are included and reported. For ease of readability, all the variables of interest and the variables of interest in double interactions are included but left unreported. Current and lagged bank–level controls are included and reported. For brevity, country–level controls are included but left unreported. All regressions include bank∗country and year fixed effects. *P*–values are computed using heteroskedasticity–robust standard errors multiclustered at the bank and country level (in parentheses). †Qualitatively similar results are obtained when using the *ECB rate* variable to proxy the monetary policy stance. *Statistical significance at the 10% level. **Statistical significance at the 5% level. ***Statistical significance at the 1% level.

(Dell'Ariccia et al., 2017). We control directly for changes in the economic cycle in regressions (1) and (2). We include the interaction terms between the monetary policy proxy *Taylor residuals* and state of the economy based on *Real GDP*; the time-specific *Recession* dummy takes one if *Real GDP* is negative and zero otherwise. We find that the coefficients on the triple interactions among interest rates, capital, and funding liquidity remain negative and statistically significant[8]. These

[8] We found qualitatively similar results using *ECB rate* as the proxy for monetary policy.

results are a first step in allaying concerns that our results are influenced by a cyclical bias in risk ratings or close links among capital, funding liquidity, and economic cycles.

Second, monetary policy is likely to be more responsive to risk-taking behavior during periods of financial instability. Therefore, endogeneity issues should be more of a concern in times of crisis. In regressions (3) and (4), we rerun our main regressions from Equation 3.2 excluding the GFC period (2008 to 2010) when monetary policy responded strongly to financial stability. Again, the triple interactions among monetary policy, bank capital, and funding liquidity are significantly negative. This result confirms the absence of endogeneity due to the GFC turmoil and provides additional robustness to our empirical results.

Third, endogeneity might be more of a concern for large national banks than smaller financial institutions affected primarily by regional shocks. Columns (5) and (6) in Table 3.4 report the regression results when removing large banks from the sample, with large banks defined as those with total assets in the top quartile of the full sample (with a value of 21.372). Similarly to the estimates including large banks, we continue to find significant and negative triple interactions, which confirms that our results are not contaminated by the inclusion of large financial institutions.

Endogeneity bias might also arise from the reverse causality between the bank-level variables (Delis et al., 2017). To rule out that possibility, we rerun Equation 3.2 using the bank-specific characteristics in their lagged form (lagged by one year), as this methodology provides robust estimates of the effects of bank-level coefficients.

Once again, we observe that the triple interactions among interest rates, capital, and funding liquidity remain negative and statistically significant. Taken together, the above tests and sample splits confirm that our empirical results are unaffected by the endogenous response of monetary policy to banks' risk-taking.

3.5.3 The "crowding-out of deposits" effect before to the GFC

Figure 3.2 shows the interest rate variations in the early days of the euro area. At the beginning of the euro system, interest rates initially rose in 1999 and the first half of 2000. However, because of insufficient observations, we exclude this short subperiod (identified under area *I.* in Figure 3.2) from our analysis.

We examine two distinct subperiods of monetary policy before the outbreak of the GFC. First, from 2000 to 2005, interest rates were cut in response to inflationary pressures in an environment of subdued economic growth, marked adjustments in financial markets, and high geopolitical uncertainty. This moment, shown under area *II.* in Figure 3.2, typically reflects the first prolonged period of decreasing interest rates in the euro area. Second, interest rates again rose from December 2005 until mid-2008 as the subprime crisis hit the European banking industry. After a prolonged period of monetary policy easing, the ECB communication changed in October 2005, signaling a possible increase in interest rates. In the words of Bonfim and Soares (2018), *"this leads to a substantial revision of interest rate expectations"* as *"this revision was fast and sizeable."* This moment is identified under area *III.* in Figure 3.2. Accordingly, the end of 2005 was a key turning point in pre-GFC monetary policy.

We analyze this turning point in Table 3.5. In regressions (1) and (3), we define the *low interest rate expectations* subsample as the first prolonged period of decreasing interest rates from 2000 to 2005. In addition, we build in regressions (2) and (4) the *high interest rate expectations* subsample as the pre-crisis monetary tightening between 2006 and 2008. Interestingly, we find significantly different signs from one sample to the other regarding the triple interactions among interest rates, bank capital, and funding liquidity.

In the *low interest rate expectations* subsample, we observe the significantly positive sign of *triples*. This result implies that when interest rates edge higher, well-capitalized banks with relatively low levels of deposits display greater risk-taking. Similarly, we identify negative triple interactions in the *high interest rate expectations* subsample, meaning that when interest rates are expected to rise, well-capitalized banks with relatively less funding liquidity also increase their risk exposure. This confirms that financial institutions concerned with the "crowding-out of deposits" effect (Gorton and Winton, 2017) (i.e., displaying low levels of deposits when equity capital is high) are more sensitive to the risk-taking channel of monetary policy regardless of whether interest rates are eased (2000–2005) or tightened (2006–2008).

Accordingly, in the presence of such a "crowding-out of deposits" effect, imposing capital and funding liquidity standards on the banking industry simultaneously would help offset the monetary policy transmission to credit risk. This result supports the Basel II specifications in the pre-crisis period, namely, adopting systems

Table 3.5: The "crowding-out of deposits" effect before the GFC (2000–2008)

	LLP			
	Low interest rate expectations	High interest rate expectations	Low interest rate expectations	High interest rate expectations
	(1)	(2)	(3)	(4)
ECB rate * High capital * Deposits	0.0012***	-0.0029***		
	(0.0004)	(0.0004)		
Taylor residuals * High capital * Deposits			0.0012***	-0.0025***
			(0.0003)	(0.0005)
Size	-0.0984	-0.0102	-0.1012	-0.0102
	(0.0808)	(0.0913)	(0.0816)	(0.0916)
Profitability	-1.1212***	-0.9219***	-1.1206***	-0.9257***
	(0.1325)	(0.1876)	(0.1325)	(0.1891)
Inefficiency	-0.0485***	-0.0394***	-0.0485***	-0.0390***
	(0.0056)	(0.0097)	(0.0056)	(0.0096)
Net loans	-0.0036	-0.0019	-0.0037	-0.0021
	(0.0030)	(0.0022)	(0.0030)	(0.0024)
Constant	6.5261***	2.8793	8.1035***	2.2800
	(1.3834)	(2.3797)	(1.3178)	(2.3350)
Bank-level controls	Yes	Yes	Yes	Yes
Country-level controls	Yes	Yes	Yes	Yes
(Bank*Country) fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Clustered s.e.	Bank & Country	Bank & Country	Bank & Country	Bank & Country
Adjusted R-squared	0.7207	0.6873	0.7213	0.6891
Sample period	2000-2005	2006-2008	2000-2005	2006-2008
Observations	12,109	9,209	12,109	9,209
Ho: (Rate * High capital * Deposits) [Low expectations] = (Rate * High capital * Deposits) [High expectations]	0.0000^a F(1,10) = 124.22		0.0000^b F(1,10) = 129.16	

Notes. The table reports results of estimating panel regressions regarding banks' credit risk in the euro area (EA11–1999, EA12–2001, EA13–2007, EA15–2008, EA16–2009, EA17–2011, EA18–2014, EA19–2015) over the subperiods 2000–2005 and 2006–2008. Description and summary statistics of all variables used are reported in Table 3.1. The dependent variable is the ratio of loan loss provision to gross loans (*LLP*) in all regressions. Low interest rate expectations subsample in regressions (1) and (3), and high interest rate expectations subsample in regressions (2) and (4) refer to observations from, respectively, the subperiod 2000–2005 and and the (pre–crisis) subperiod 2006–2008. The variables of interest in triple interactions are included and reported. For ease of readability, all the variables of interest and the variables of interest in double interactions are included but left unreported. Bank–level controls are included and reported. For brevity, country–level controls are included but left unreported. All regressions include bank∗country and year fixed effects. *P*–values are computed using heteroskedasticity–robust standard errors multiclustered at the bank and country level (in parentheses). *Statistical significance at the 10% level. **Statistical significance at the 5% level. ***Statistical significance at the 1% level.

[a] *p*-value of F-statistics testing the null hypothesis that the coefficient (ECB rate * High capital * Deposits) from *Low interest rate expectations* subsample equals the coefficient (ECB rate * High capital * Deposits) from *High interest rate expectations* subsample.

[b] *p*-value of F-statistics testing the null hypothesis that the coefficient (Taylor residuals * High capital * Deposits) from *Low interest rate expectations* subsample equals the coefficient (Taylor residuals * High capital * Deposits) from *High interest rate expectations* subsample.

to measure and monitor funding liquidity risk as well as evaluating the adequacy of capital ratios. We now explore whether these results hold after the GFC.

3.5.4 The missing "crowding-out of deposits" effect for inefficient banks after the GFC

Area *IV.* in Figure 3.2 reflects the GFC period during which the ECB rate was drastically reduced between October 2008 and May 2009 because of subdued inflationary pressures, weakened economic conditions, and diminished upside risks to price stability (European Central Bank, 2011). Subperiod *IV.* is a time of high uncertainty, calling for special attention that goes beyond the scope of this study. Although we provide show in Subsection 3.5.2 that our results are not contaminated by the endogenous response of monetary policy to banks' risk-taking during the GFC (see columns (3) and (4) in Table 3.4), we do not analyze this short and exceptional subperiod and rather focus on the post-crisis years.

We observe in area *V.* in Figure 3.2 that the post-GFC period signals the start of decreasing interest rates fueled by monetary authorities' actions to stimulate economic growth and prevent deflation. As a result, the ECB rate for main refinancing operations has stagnated at the 0% level since March 16, 2016. Table 3.6 focuses on the 2011–2018 subperiod to study the triple interactions among monetary policy, equity capital, and funding liquidity in the post-GFC period.

The *Inefficient banks* subsample in regressions (1) and (3) includes banks whose ratio of expenses to total revenues is above the full sample quintile. Conversely, the *Efficient banks* subsample in regressions (2) and (4) groups banks with a ratio of expenses to total revenues below the 15^{th} percentile of the full sample. Interestingly, we find significantly different results depending on bank efficiency. Inefficient banks exhibit significantly negative triple interactions among interest rates, bank capital, and deposits. As we consider a period of decreasing interest rates, this suggests that inefficient banks take more risk if they display high levels of equity capital and funding liquidity *at the same time*. Given the positive relation between capital and deposits, this result speaks of the absence of a “crowding-out of deposits" effect among inefficient banks in the wake of the GFC.

Table 3.6: The missing "crowding-out of deposits" effect for inefficient banks after the GFC (2011–2018)

	LLP		NPL	
	Inefficient banks	Efficient banks	Inefficient banks	Efficient banks
	(1)	(2)	(3)	(4)
Taylor residuals * High capital * Deposits	-0.0048**	0.0030*	-0.0436*	0.0224*
	(0.0022)	(0.0018)	(0.0248)	(0.0132)
Size	-0.0561	-0.0899	-1.7970*	-2.1790***
	(0.0670)	(0.0622)	(1.0253)	(0.5234)
Profitability	-0.4794***	-0.6264***	-0.5730*	-1.1579***
	(0.1306)	(0.0464)	(0.2876)	(0.2009)
Inefficiency	-0.0290***	-0.0413***	-0.0135	-0.0772***
	(0.0026)	(0.0033)	(0.0198)	(0.0194)
Net loans	-0.0030	-0.0004	-0.0886***	-0.0530**
	(0.0029)	(0.0020)	(0.0225)	(0.0210)
Constant	4.5062**	4.7262***	43.0005*	54.8903***
	(1.5755)	(1.4004)	(22.0729)	(13.3650)
Bank-level controls	Yes	Yes	Yes	Yes
Country-level controls	Yes	Yes	Yes	Yes
(Bank*Country) fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	No	No	No	No
Clustered s.e.	Bank & Country	Bank	Bank & Country	Bank
Adjusted R-squared	0.5553	0.7924	0.8700	0.8901
Sample period	2011-2018	2011-2018	2011-2018	2011-2018
Observations	5,120	3,783	2,103	2,512
Ho: (Taylor residuals * High capital * Deposits) [Inefficient banks] =	0.0027		0.0159	
(Taylor residuals * High capital * Deposits) [Efficient banks]	F(1,18) = 12.12		F(1,18) = 7.08	

Notes. The table reports results of estimating panel regressions regarding banks' credit risk in the euro area (EA11–1999, EA12–2001, EA13–2007, EA15–2008, EA16–2009, EA17–2011, EA18–2014, EA19–2015) over the period 2011–2018. Description and summary statistics of all variables used are reported in Table 3.1. The dependent variables are the ratios of loan loss provision to gross loans (*LLP*) in regressions (1) to (2), and non–performing loans to gross loans (*NPL*) in regressions (3) to (4). *Inefficient banks* subsample in regressions (1) and (3) and *Efficient banks* subsample in regressions (2) and (4) refer to observations for which the ratio of expenses over the total revenues is, respectively, above the full sample 80^{th} percentile and below the full sample 15^{th} percentile. The variables of interest in triple interactions are included and reported. For ease of readability, all the variables of interest and the variables of interest in double interactions are included but left unreported. Bank-level controls are included and reported. For brevity, country–level controls are included but left unreported. All regressions include bank∗country and year fixed effects. *P*–values are computed using heteroskedasticity–robust standard errors multiclustered at the bank and country level in the *Inefficient banks* subsample, and clustered at the bank level in the *Efficient banks* subsample (in parentheses). *Statistical significance at the 10% level. **Statistical significance at the 5% level. ***Statistical significance at the 1% level.

After 2010, the least efficient credit institutions are more sensitive to the risk-taking channel of monetary policy when they have high levels of capital and funding liquidity simultaneously. This means that the concomitant capital ratios and NSFR would become counterproductive in taming risk-taking behaviors. Accordingly, the Basel III requirements on capital and funding liquidity might exacerbate the risk-taking behavior of inefficient banks in such a low interest rate environment. Conversely, the results suggest a positive sign of *triples* regarding efficient banks in regressions (2) and (4) in Table 3.6. As interest rates decline between 2011 and 2018, this shows that efficient banks increase credit risk if they deal with high levels of equity capital but low levels of deposits. Similarly to before the GFC (see Subsection 3.5.3), banks recovering in terms of efficiency after the GFC continue to display a “crowding-out of deposits" effect, which makes the case for the Basel III regulation on capitalization and funding liquidity. As reported in Table 3.6, the results are significantly different from one subsample to another, confirming this empirical evidence.

Table 3.7 reports the distribution of inefficient banks between 2011 and 2018 in the euro area. Surprisingly, most national banking industries increased their share of inefficient banks between 2011 and 2018, apart from Belgium, Estonia, Finland, Greece, Malta, and Slovenia. In 2011, Germany and Italy had the highest shares of inefficient banks in the euro area (39.58% and 23.58%, respectively)[9]. In 2018, Germany and Italy still accounted for an important share of inefficient banks in the euro area (35.03% and 16.56%, respectively), with Austria accounting for 22.29% (compared with 8% in 2011).

We also note two trends in the euro area depending on industry concentration (see the Herfindahl–Hirschman indexes reported in Table 3.7). On the one side, Austria, Cyprus, France, Germany, and Portugal have a growing share of inefficient banks as well as a deconcentration of their national industry. On the other side, Ireland, Italy, Luxembourg, the Netherlands, Slovakia, and Spain are banking industries that have a rising share of inefficient banks but higher levels of concentration. This means that banking industry concentration does not systematically help solving banks' efficiency issues. Nevertheless, we leave this open path for future

[9]This result is partly due to the relatively large number of banks in these countries.

Table 3.7: Distribution of inefficient banks & industry concentration in the euro area after the GFC (2011–2018)

	National banking industry				Euro area banking industry	
	Share of inefficient banks in 2011 (%)	HHI in 2011 (%)	Share of inefficient banks in 2018 (%)	HHI in 2018 (%)	Share of inefficient banks in 2011 (%)	Share of inefficient banks in 2018 (%)
	(1)	(2)	(3)	(4)	(5)	(6)
Austria	15.8333	2.1377	34.7222	1.5911	8.0000	22.2930
Belgium	34.2857	6.2380	20.8333	6.7527	2.5253	0.6369
Cyprus	11.1111	20.8619	50.0000	16.0124	0.2105	0.8918
Estonia	50.0000	48.0814	0.0000	28.4678	0.6348	0.0000
Finland	37.5000	13.6083	36.8421	9.5563	1.2632	1.7834
France	18.1818	0.7472	25.8964	0.7367	10.1043	8.2803
Germany	10.9430	0.2990	18.2724	0.2660	39.5779	35.0318
Greece	35.2941	13.9481	23.0769	21.0623	1.2632	0.3822
Ireland	6.2500	8.2020	36.3636	11.5075	0.2105	0.5096
Italy	18.6978	0.8837	35.2303	1.0939	23.5788	16.5605
Latvia	–	–	35.7143	15.8885	–	0.6369
Lithuania	–	–	0.0000	28.3741	–	0.0000
Luxembourg	16.0000	4.0777	39.2857	4.4837	1.6842	2.8025
Malta	22.2222	25.2688	15.3846	24.7308	0.4211	0.2548
Netherlands	25.9259	5.3175	26.0870	6.3388	1.4736	0.7643
Portugal	37.5000	8.3619	37.9630	7.6314	1.8947	5.2229
Slovakia	6.6667	12.9610	8.3333	17.8392	0.2105	0.1274
Slovenia	23.5294	16.3592	7.6923	15.7431	0.8421	0.1274
Spain	22.6563	2.1384	28.1553	3.0692	6.1053	3.6943

Notes. The table reports changes in banks' inefficiency and industry concentration in the euro area (EA11–1999, EA12–2001, EA13–2007, EA15–2008, EA16–2009, EA17–2011, EA18–2014, EA19–2015) between 2011 and 2018. We compute in columns (1) and (3) the share of inefficient banks (i.e., observations for which the ratio of expenses over the total revenues is above the full sample 80^{th} percentile) in each national banking industry in 2011 and 2018, respectively. Columns (2) and (4) report the Herfindahl–Hirschman Index (HHI) (i.e., the sum of the squares of the market shares of banks within the national industry as a measure of the amount of competition among them) in each national banking industry in 2011 and 2018, respectively. For each country, we also compute in columns (5) and (6) the share of national inefficient banks regarding the whole euro area banking industry in 2011 and 2018, respectively.

research.

Banks' inefficiency in the euro area remains an unaddressed issue. However, our results suggest that inefficiency is a key factor in the risk-taking channel of monetary policy when the dual constraints on capital and funding liquidity are implemented under Basel III. Accordingly, inefficient banks in the euro area are a major concern if regulators want to strengthen capital and funding liquidity standards simultaneously in such a "low-for-long" interest rate environment.

3.5.5 Robustness checks

First, we explore the robustness of our results with respect to four alternative measures of interest rates. Regressions (1), (2), (3), and (4) in Table 3.8 rely

Table 3.8: The joint influence of bank capital & funding liquidity on the monetary policy's risk-taking channel: robustness checks (1999–2018)

	LLP				NPL			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Funding liquidity								
EONIA * High capital * Deposits	-0.0005**							
	(0.0002)							
EURIBOR 1-month * High capital * Deposits		-0.0005**						
		(0.0002)						
EURIBOR 6-month * High capital * Deposits			-0.0005**					
			(0.0002)					
EURIBOR 12-month * High capital * Deposits				-0.0005**				
				(0.0003)				
Assets liquidity								
ECB rate * High capital * Liquid assets					-0.1474*			
					(0.0718)			
Taylor residuals * High capital * Liquid assets						-0.1430*		
						(0.0811)		
EONIA * High capital * Liquid assets							-0.1233**	
							(0.0553)	
Taylor residuals EONIA * High capital * Liquid assets								-0.1083*
								(0.0620)
Size	-0.1174***	-0.1172***	-0.1168***	-0.1165***	-1.1413**	-1.1062**	-1.1216**	-1.0732**
	(0.0204)	(0.0204)	(0.0204)	(0.0203)	(0.4427)	(0.4185)	(0.4404)	(0.4142)
Profitability	-0.8397***	-0.8399***	-0.8401***	-0.8402***	-1.6577**	-1.6530**	-1.6580**	-1.6581**
	(0.0558)	(0.0558)	(0.0558)	(0.0558)	(0.7614)	(0.7670)	(0.7661)	(0.7697)
Inefficiency	-0.0341***	-0.0341***	-0.0341***	-0.0341***	-0.0399**	-0.0398**	-0.0401**	-0.0401**
	(0.0035)	(0.0035)	(0.0035)	(0.0035)	(0.0172)	(0.0178)	(0.0172)	(0.0177)
Net loans	-0.0032**	-0.0032**	-0.0032**	-0.0032**	-0.1019***	-0.1031***	-0.1021***	-0.1038***
	(0.0012)	(0.0012)	(0.0012)	(0.0012)	(0.0099)	(0.0105)	(0.0099)	(0.0106)
Constant	5.5744***	5.5746***	5.5822***	5.5918***	43.1969***	36.8051***	42.0255***	37.1554***
	(0.5035)	(0.5036)	(0.5054)	(0.5075)	(11.9889)	(10.6366)	(11.7963)	(10.5612)
Bank-level controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country-level controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
(Bank*Country) fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clustered s.e.	Bank & Country	Bank & Country	Bank & Country	Bank & Country	Bank & Country	Bank & Country	Bank & Country	Bank & Country
Adjusted R-squared	0.6654	0.6654	0.6654	0.6654	0.8179	0.8177	0.8178	0.8173
Sample period	1999-2018	1999-2018	1999-2018	1999-2018	1999-2018	1999-2018	1999-2018	1999-2018
Observations	57,792	57,792	57,792	57,792	21,807	21,807	21,807	21,807

Notes. The table reports robustness checks of estimating panel regressions regarding banks' credit risk in the euro area (EA11–1999, EA12–2001, EA13–2007, EA15–2008, EA16–2009, EA17–2011, EA18–2014, EA19–2015) over the period 1999–2018. Description and summary statistics of all variables used are reported in Table 3.1. The dependent variables are the ratios of loan loss provision to gross loans (*LLP*) in regressions (1) to (4), and non–performing loans to gross loans (*NPL*) in regressions (5) to (8). The variables of interest in triple interactions are included and reported. For ease of readability, all the variables of interest and the variables of interest in double interactions are included but left unreported. Bank–level controls are included and reported. For brevity, country–level controls are included but left unreported. All regressions include bank∗country and year fixed effects. *P*–values are computed using heteroskedasticity–robust standard errors multiclustered at the bank and country level (in parentheses). *Statistical significance at the 10% level. **Statistical significance at the 5% level. ***Statistical significance at the 1% level.

on *EONIA*, *EURIBOR 1-month*, *EURIBOR 6-month*, and *EURIBOR 12-month*, respectively to explain the triple influence of monetary policy, capitalization, and funding liquidity on bank credit risk (the dependent variable is *LLP*). The findings from the triple interactions remain significant and quantitatively similar to the baseline results in Table 3.3 when applying these alternative identification schemes. The maturity of interest rates used to conduct monetary policy does not appear to affect the coefficients on the *triples*, which remain negative and statistically significant at the 5% level.

Second, we contrast our findings to examine another aspect of liquidity in banks' balance sheets in the remaining regressions in Table 3.8, namely *Liquid assets* (measured by the natural logarithm of the total liquid assets of banks included in our final sample). As our key results remain qualitatively robust, we observe that they are quantitatively more important than our early findings using the full sample period and *NPL* as the dependent variable (see Table 3.3). Finally, we combine the alternative Taylor residuals computed from *EONIA* with our asset liquidity indicator in regression (8) and find similar results to those provided in our baseline analysis. In summary, the previous results on funding liquidity have direct implications for the NSFR in the Basel III framework. Conversely, the robustness checks on assets liquidity are more relevant for the liquidity coverage ratio, which goes beyond the scope of this research.

3.6 Concluding remarks

This study examines the joint influence of capital and funding liquidity on the risk-taking channel of monetary policy. Based on previous studies suggesting that bank equity and funding liquidity are closely intertwined, we draw on the methodology of Jiménez et al. (2014) and Delis et al. (2017) to investigate the triple interactions among monetary policy, capital, and deposits (as a proxy for funding liquidity) to assess their simultaneous impact on credit risk.

Using an extensive dataset on the euro area from 1999 to 2018, we provide empirical evidence that before the GFC, banks concerned with the "crowding-out of deposits" effect (Gorton and Winton, 2017) (i.e., displaying low levels of deposits when equity capital is high) are more sensitive to the risk-taking channel of monetary policy. However, in the aftermath of the GFC, only efficient banks continue to display such an effect. Under low interest rates, inefficient banks become more sensitive to the risk-taking channel of monetary policy if they have to comply with capital and funding liquidity requirements *at the same time*. Under this scenario, concomitant capital ratios and the NSFR might be counterproductive in taming risk-taking behaviors. These results have important implications for bank regulators and policymakers.

First, our findings on the "crowding-out of deposits" effect before the GFC make the case for the Basel III accords, as imposing capital and funding liquidity standards simultaneously helps offset the monetary policy transmission to credit risk. Second, this study argues for special treatment for banks unable to recover in terms of efficiency after the GFC. As inefficient banks lack the "crowding-out of deposits" effect, it might be harmful for them to require funding liquidity standards along with the existing capital ratios. The growing share of inefficient banks in most euro area countries between 2011 and 2018 also suggests that inefficiency is a major concern when regulators strengthen capital and funding liquidity standards *simultaneously* under "low-for-long" interest rates.

Risk persistence due to strong regulation (Delis and Kouretas, 2011) might explain this scenario. In particular, capital requirements and liquidity guarantees might broaden moral hazard, leading to inefficient and risky investments or portfolio rebalancing toward trading activities over a considerable period. Whereas prolonged low interest rates erode banks' income and franchise value, only financial institutions able to fix moral hazard (due to strengthened capital and funding liquidity regulation) eventually mitigate the risk-taking channel of monetary policy. In line with Distinguin et al. (2013), our results also question the implementation of uniform funding liquidity requirements when less efficient banks seem to manage their credit risk differently in the face of a low interest rate environment (which the Covid-19 pandemic is likely to extend further).

Appendix A. Distribution of euro area banks

Table A1: Distribution of euro area banks

	Banks available in Fitch Connect database	Banks included in the final sample	Percentage of total assets of banks in the final sample against total assets of banks available in Fitch Connect database (%)
	(1)	(2)	(3)
Austria	787	617	93.0342
Belgium	161	48	88,9235
Cyprus	40	16	68,3288
Estonia	20	10	30,0331
Finland	90	51	89,3512
France	779	304	92,8296
Germany	3,057	1,850	76,5214
Greece	42	20	95,2358
Ireland	100	22	76,1783
Italy	1,074	638	93,2960
Latvia	36	15	32,3420
Lithuania	17	6	20,7673
Luxembourg	214	74	77,0354
Malta	35	15	38,3876
Netherlands	122	29	65,6468
Portugal	165	111	92,7406
Slovakia	37	15	57,2920
Slovenia	40	18	32,9301
Spain	319	164	92,9204
Euro area	**7,135**	**4,023**	**83,5905**[a]

Notes. To deal with sample representativeness, we compute in column (3) the ratio of total assets of banks in our final sample to total assets of nationwide banking system available in Fitch Connect database from 1999 to 2018. Bank categories included in the sample are: private banks, retail & consumer banks, trade finance banks, trading & investment banks, trust & processing banks, universal commercial banks and wholesale commercial banks.

[a] Weighted average of the percentage of total assets of banks in the final sample against total assets of banks available in Fitch Connect database (based on the number of banks available for each country).

Appendix B. Pairwise Pearson cross-correlation coefficients

Table B1: Pairwise Pearson cross-correlation coefficients

Variables	LLP	NPL	Taylor residuals	ECB rate	Capital	Deposits	Size	Profi-tability	Inefficiency	Net loans	Real GDP	Unem-ployment	Govt. debt	NF corp. debt
LLP	1.0000													
NPL	0.6363	1.0000												
	(0.0000)													
Taylor residuals	0.2152	0.0448	1.0000											
	(0.0000)	(0.0000)												
ECB rate	0.1749	-0.0503	0.9348	1.0000										
	(0.0000)	(0.0000)	(0.0000)											
Capital	-0.0413	0.0947	-0.2461	-0.2357	1.0000									
	(0.0000)	(0.0000)	(0.0000)	(0.0000)										
Deposits	-0.1210	-0.1970	-0.0651	-0.0627	-0.2515	1.0000								
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)									
Size	-0.0345	-0.1106	-0.0397	-0.0389	-0.2729	-0.2690	1.0000							
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)								
Profitability	-0.3325	-0.3418	-0.0858	-0.0553	0.3295	-0.0623	-0.0522	1.0000						
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)							
Inefficiency	-0.1294	-0.0405	-0.0032	-0.0080	-0.0636	0.2203	-0.2369	-0.4535	1.0000					
	(0.0000)	(0.0000)	(0.4336)	(0.0528)	(0.0000)	(0.0000)	(0.0000)	(0.0000)						
Net loans	-0.0492	-0.0346	0.0318	0.0236	-0.1071	-0.0323	0.0495	-0.0085	-0.1075	1.0000				
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0411)	(0.0000)					
Real GDP	-0.1406	-0.2183	-0.0000	0.2073	-0.0081	0.0687	-0.0012	0.1222	-0.0042	-0.0625	1.0000			
	(0.0000)	(0.0000)	(1.0000)	(0.0000)	(0.0492)	(0.0000)	(0.7702)	(0.0000)	(0.3094)	(0.0000)				
Unemployment	0.3017	0.4483	0.2130	0.1286	-0.0388	-0.1524	0.1034	-0.1735	-0.0760	0.0263	-0.1887	1.0000		
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)			
Govt. debt	0.1396	0.5632	-0.2984	-0.3592	0.2052	-0.1715	-0.0207	-0.0615	-0.0242	0.0721	-0.2605	0.3190	1.0000	
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)		
NF corp. debt	0.0498	0.2385	-0.0751	-0.0431	0.0666	-0.1630	0.1629	-0.0493	-0.1403	-0.1024	-0.0204	0.1816	-0.0410	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	

Notes. The table reports the correlation coefficients of variables used in the empirical analysis for 4,023 euro area banks over the period 1999 to 2018, with a final sample of 58,280 observations at annual frequency. The top and bottom 5% observations of all variables except macroeconomic variables have been winsorized to limit bias impact in our results. *P*–values are reported in parentheses.

Chapter 4

Monetary policy, credit risk, & profitability: The influence of relationship lending on cooperative banks' performance

4.1 Introduction

Following 10 years of accommodating monetary policy, the European Central Bank (ECB) has provided forward guidance in response to the COVID-19 pandemic on the future path of key interest rates, saying that it expects them to remain at their present or even lower levels[1]. Therefore, it seems that the term "low-for-long" is

[1]See the ECB press release on monetary policy decisions on April 30, 2020, ecb.europa.eu/press/pr/date/2020/html/ecb.mp200430 1eaa128265.en.

now more relevant than ever when it comes to future trends in interest rates in the European banking industry. While promoting economic recovery and enhancing banks' balance sheets, persistent low interest rates might also significantly erode bank credit risk—through the risk-taking channel of monetary policy transmission (Borio and Zhu, 2012)—as well as profitability through low market valuations and price-to-book ratios well below one (Claessens et al., 2018).

Owing to their strong commitment to traditional financial intermediation, cooperative banks might be more vulnerable in terms of credit risk and profitability under low rates, as they are more dependent on interest income than their non-cooperative counterparts. Accordingly, these credit institutions are compelled to balance their historical *cooperative ethos* (Ayadi et al., 2010) and their ability to survive in the banking industry, which decreasing interest rates make all the more competitive. Most cooperative groups have addressed this issue through structural consolidation, which aims to reduce the operational costs associated with decentralized (and, sometimes, unprofitable) networks of local and regional branches. Ultimately, however, this reduces geographical coverage, which seriously hampers customer proximity, a key element in relationship lending (Elsas, 2005) and the identity of cooperative banks. Table A1 confirms this trend for European cooperative banks: between 2010 and 2019, the overwhelming majority of cooperative brands in the European banking sector experienced a sharp rise in the number of customers per branch, an indicator used to proxy for the territorial coverage of cooperative banks[2] (EACB, 2020a), with—in the most extreme cases—increases rising to 174%

[2]The higher the index, the lower is the territorial coverage of cooperative banks.

and 208% for the cooperative groups Österreichischer Volksbanken in Austria and Rabobank in the Netherlands, respectively.

These figures raise fundamental questions about the ability of cooperative banks to either stand apart from the competition through relationship lending or move further away from their *raison d'être* as interest rates remain low. Specifically, can cooperative banks opting for consolidation in such a low interest rate environment preserve their specificities or behave similarly to their non-cooperative counterparts in terms of credit risk and profitability? What changes in credit risk and profitability have cooperative banks, despite their increasingly small interest margins, chosen to preserve their relationship lending model? To date, answers to these questions are largely elusive in the literature.

To extend these lines of research and determine the impact of relationship lending on credit risk and profitability in a low interest rate environment, we investigate the unconsolidated statements of cooperative and non-cooperative banks from 10 euro area countries between 2010 and 2019, a period characterized by historical monetary easing by the ECB. We also rely on the territorial coverage proxy proposed by the European Association of Co-operative Banks (EACB, 2020a) to classify cooperative banks in our sample as *consolidated* (Groeneveld, 2015) (i.e., above the median value of the number of customers per branch in 2019) or *relationship-based* (i.e., below the median value). Moreover, to be consistent with the empirical findings that bank credit risk and profitability might be jointly determined (Athanasoglou et al., 2008), we estimate a simultaneous equations model. Our final dataset consists of 3998 banks, including 1862 non-cooperative banks (46.6% of the full sample) and 2136 cooperative banks (among which 151 are consolidated and 1985 are relationship-based).

Based on this empirical framework, we extend the literature in several directions. First, we find no evidence of the presence of a risk-taking channel of monetary policy for consolidated cooperative banks, whereas such a channel is extensively found in the euro area for non-cooperative banks. Consolidated cooperative banks therefore tend to stand out from their non-cooperative counterparts in terms of monetary policy transmission to their credit risk. Second, we highlight that the profitability of cooperative banks preserving their relationship lending model is more severely hit by a low interest rate environment than that of cooperative banks opting for consolidation. This raises issues about the middle-term durability of relationship lending in a low interest rate environment. Third, we find that non-cooperative banks and relationship-based cooperative banks are both concerned by the risk-taking channel of monetary policy transmission, which increases their credit risk under accommodating monetary policy conditions.

Nevertheless, we suggest that such similarities do not occur for the same reasons, as relationship lending is associated with a fundamentally different lending process than transactions-based lending technologies that devote significantly lower proportions of their assets to lending to small businesses (Berger and Udell, 2002). Accordingly, the greater the relationship lending strategy of a cooperative bank, the greater is its willingness to undertake credit risk, which is particularly valuable to high-risk firms and small businesses, as they are often informationally opaque and have far fewer external finance alternatives than large companies.

In Section 4.2, we provide the motivation for the study and review the literature on relationship lending as well as the effects of expansionary monetary policy on bank credit risk and profitability. Section 4.3 discusses the empirical methodology, while Section 4.4 outlines the data used in the sample. Section 4.5 describes our findings and Section 4.6 concludes.

4.2 Motivation for the study & related literature

4.2.1 Motivation for the study

Cooperative banking emerged in the United States during the 19th century as a solution to imperfect markets, especially those featuring information asymmetries between bank associates and borrowers (Hansmann, 1996). In Europe, it appeared in the second half of the 19th century at the instigation of Franz Hermann Schulze-Delitzsch and, later, Frédéric-Guillaume Raiffeisen who both helped disseminate credit unions in Austria, France, Germany, Italy, and Spain. Nowadays, cooperative banks have gained prominence across the European Union (EU). In 2019, the European Association of Co-operative Banks recorded more than 213 million customers, 85 million members (which represents one in every five European citizens), 42,521 branches, 4154 billion Euro in deposits, and 7932 billion Euro in total assets (EACB, 2020b).

As stated by Ayadi et al. (2010), a key characteristic of cooperative banks is their *cooperative ethos* linked to a strong focus on retail banking: cooperative banks know their customers relatively well, including their risk profiles (Lang et al., 2016), and can collate a great deal of soft information (which is hard to collect) on their creditworthiness (Berger et al., 2005). Their strong local presence and customer proximity also reduce information asymmetries in lender–borrower relationships (Fiordelisi and Mare, 2014).

Branch expansion also benefits local economic growth and offers tailored services to local people (Bernini and Brighi, 2018). Cooperative banks might even be geographically concentrated in some EU countries (e.g., Italy and Germany) and engage in local monopolistic competition to capture a strong comparative advantage in developing close customer relationships (Catturani and Stefani, 2016). Consequently, they end up being key financing partners of small and medium-sized enterprises as well as retail customers looking for a bank receptive to their needs.

Nevertheless, a low interest rate environment (Altavilla et al., 2018) also provides fertile ground for the risk-taking channel of monetary policy (Borio and Zhu, 2012). In times of monetary easing such as those in the euro area since the global financial crisis, credit institutions are highly likely to undertake credit risk in response to squeezed profits from traditional interest-generating activities. Facing low rates and the associated higher competition in the banking industry, cooperative banks have strived to make their model a strength. For instance, their business model comprises simpler structures less impacted by the global financial crisis than those of non-cooperative banks (McKillop et al., 2020), even in countries severely hit economically and socially (Lang et al., 2016). Moreover, their stakeholder organization (based on the principle of "one person, one vote") allows members to be directly involved in the cooperative's management to exert checks and balances at each business level. Greater transparency and the improved identification of customers' creditworthiness might ultimately minimize credit risk, even when monetary policy is eased for a prolonged period. This provides us with the first hypothesis tested in this study.

Hypothesis 1 *Thanks to the specificities of their business model, cooperative banks are less exposed to the risk-taking channel of monetary policy than non-cooperative banks.*

Relationship lending—on which cooperative banks have historically relied—also has potential weaknesses. Among them lies a stronger dependence on domestic interest income, which becomes a major challenge in a low interest rate environment[3]. In the short run, the negative impact on profitability can be mitigated by cost cutting and focusing on non-interest income. However, in the longer term, capitalization issues might encourage consolidation as financial institutions merge in the pursuit of economies of scale (Altavilla et al., 2018; Bexley, 2016). As banking institutions grow larger and more organizationally complex through consolidation, Berger and Udell (2002) note that they are ultimately less likely to choose to make relationship loans.

Accordingly, the cooperative banking sector has responded to lax monetary policy reducing their territorial coverage since the global financial crisis, mainly because maintaining extensive networks of local branches implies significant organizational

[3] Another problem identified by Meyer (2018) is that cooperative banks have increasingly less room to implement differentiated interest rates (i.e., below market rates (Agarwal and Hauswald, 2010)) than the rest of the banking industry owing to their better knowledge of customers' creditworthiness (Meyer, 2018; Ayadi et al., 2016).

costs (Bernini and Brighi, 2018)[4]. Yet, branch closure seriously hampers the relationship lending model and dwindles the comparative advantage cooperative banks have so far used to stand out in the banking industry (Jovanovic et al., 2017)[5]. Therefore, "low-for-long" interest rates (Claessens et al., 2018) might jeopardize the local-based model of cooperative banks and shed light on their dilemma of how to reduce costs while preserving their regional entrenchment.

Assuming that bank performance is impaired by low interest rates (Bikker and Vervliet, 2018), the second hypothesis of this study differentiates cooperative banks opting for consolidation (to reduce their organizational costs and, ultimately, the impact of monetary easing on their profitability) and cooperative banks preserving their relationship lending model through (costly) decentralized territorial coverage.

Hypothesis 2 *The profitability of cooperative banks preserving their relationship lending model is more severely hit by a low interest rate environment than that of cooperative banks opting for consolidation.*

Examining the role of the bank–customer relationship in credit risk, Jiménez and Saurina (2004) highlight that a close relationship increases the willingness of the bank to take more risk. This occurs primarily because individuals and non-financial companies can benefit from a close relationship with their bank through easier access to credit (i.e., the amount of credit they obtain, how much it costs them, the protection they have during recessions, and even the implicit insurance

[4] See Table A1 on the upward trend of the number of clients per branch—a proxy for customer proximity—of European cooperative banks between 2010 and 2019.

[5] Jovanovic et al. (2017) also points out that branch closure leads to the greater use of online banking, which hinders cooperative banks' key values regarding customer proximity.

of the cost of finance) (Petersen and Rajan, 1994). A direct result of such a close bank–customer relationship is the production of informational rents for the bank involved (Rajan, 1992), enabling it to exercise a degree of market power (at least in the future). Banks might ultimately be prepared to finance riskier borrowers or projects: the more they develop relationship lending, the greater is their credit risk willingness.

By contrast, when a firm or an individual has a relationship with several banks, none of them can monopolize their information on the borrower's quality and thus cannot extract rents, which considerably diminishes the incentive to finance higher-risk borrowers (Jiménez and Saurina, 2004). Nevertheless, Boot (2000) stresses that relationship lending might also help alleviate adverse selection and moral hazard problems.

Peltoniemi (2007), furthermore, investigates data on small businesses' loans from a major Finnish bank, finding that a long-term bank–firm relationship is beneficial, especially for high-risk firms that are, interestingly, more likely to provide personal guarantees. As the relationship matures, the loan premiums for risky firms decrease at a higher rate than those for safe firms, meaning that high-risk firms tend to preserve a long-term relationship with their bank to derive economic benefits. Ultimately, lasting bank–firm relationships are particularly valuable and desirable to small businesses.

In line with these theoretical predictions, we test whether, in a low interest rate environment, cooperative banks committed to relationship lending are willing to assume increased credit risk[6]. In times of low interest rates such as the 2010–2019 period considered in the present analysis, we therefore expect to observe a negative relationship between the monetary policy stance and credit risk of relationship-based cooperative banks.

As shown in Table 4.1 and Table A2, we approximate the strength of the relationship between a cooperative bank and its customers through the territorial coverage of its local branches. Based on the most recent data provided by the European Association of Co-operative Banks (EACB, 2020a), a cooperative bank is considered to be *consolidated* (i.e., with lower territorial coverage and, therefore, little commitment to relationship lending) when the number of clients per branch is above its 2019 median value. Conversely, a cooperative bank is categorized as *relationship-based* (i.e., with higher territorial coverage and, therefore, strong commitment to relationship lending) when the number of clients per branch is below its 2019 median value.

This methodological choice is driven by Berger and Udell (2002), who consider that such banks are more often headquartered closer to potential relationship customers, thereby reducing the problems associated with transmitting soft information about the local firm, owner, and community to senior management. Accordingly, this leads us to the third hypothesis empirically assessed in this study.

Hypothesis 3 *Cooperative banks preserving their relationship lending model in a low interest rate environment are prone to assume greater credit risk than coopera-*

[6] For illustrative purposes, Table 4.3 shows that, on average, the loan loss provision of relationship-based cooperative banks is higher than that of consolidated cooperative banks (this difference being not significant, though).

tive banks opting for consolidation.

4.2.2 Related literature

Our empirical analysis draws on three strands of the literature dedicated to the impact of monetary policy on credit institutions: the risk-taking channel of monetary policy transmission (Section 4.2.2.1), the impact of interest rates on bank profitability (Section 4.2.2.2), and the response of cooperative banking and relationship lending to monetary policy stances (Section 4.2.2.3). We discuss these three strands below.

4.2.2.1 The risk-taking channel of monetary policy transmission

In the aftermath of the global financial crisis, a growing debate ensued on whether risk-taking incentives at financial institutions are shaped by the monetary conditions prevailing in the economy (Caselli et al., 2020). As such, monetary policy might affect bank risk through two mechanisms (Angeloni et al., 2015).

On the one hand, a first channel operates through changes in the composition of the asset side of banks' balance sheets (Delis et al., 2017) when a prolonged period of low interest rates induces banks to *search for yields* by making riskier assets more attractive than safe bonds. This leads to higher procyclical risk within the financial system (Rajan, 2006) and a growing number of weakened bank portfolios (Dell'Ariccia and Marquez, 2006).

The second channel, on the other hand, refers to the impact of monetary policy on banks' funding as they find it more profitable to adjust the combination of capital and short-term funding by increasing leverage (Valencia, 2014). However, theory predicts that the effects of interest rates on leverage depend on the extent to which banks can change their capital structures (Dell'Ariccia et al., 2014) and whether the yield curve is upward sloping.

As low interest rates boost asset and collateral values while reducing volatility, banks might also downsize their estimates of probabilities of default and assume higher risk positions (Delis et al., 2017). Analyzing the Spanish banking industry, Jiménez et al. (2014) find that lower overnight rates lead weakly capitalized banks to grant more credit and higher loan volumes with fewer collateral requirements to ex-ante risky borrowers than higher rates. Using a factor-augmented vector autoregressive model for the United States between 1997 and 2008, Buch et al. (2014) prove that small domestic banks significantly increase the supply of new loans to high-risk borrowers following an expansionary monetary policy shock.

Recently, Bikker and Vervliet (2018) indicate that a low interest rate environment might cause banks to reduce their level of credit loss provisioning and expand their trading activities to reduce their reliance on lending business. Exploring the existence of an international bank lending channel, Schmidt et al. (2018) also find that monetary policy tightening abroad reduces credit supply at home, particularly for US monetary policy changes.

Based on a sample of commercial, savings, and cooperative banks in the euro area between 2001 and 2008, Delis and Kouretas (2011) present strong empirical evidence that low interest rates increase bank risk-taking, although this effect is less pronounced for French institutions, which hold a relatively low level of risk assets on average. Further, the distributional effects of interest rates on bank risk-taking due to individual bank characteristics reveal that the impact of interest rates on risk assets is diminished for banks with higher equity capital and amplified for banks with higher off-balance sheet items. In the same vein, Bonfim and Soares (2018) demonstrate that the impact of monetary policy on risk-taking strategies is stronger among banks with weaker capital ratios and larger liquidity buffers than others.

When analyzing both conventional and unconventional monetary policy measures, Brana et al. (2019) find that loosening monetary policy may have harmful effects on bank risk-taking but that such a relation is non-linear: when interest rate indicators are below a certain threshold, the negative relationship between bank risk and monetary policy is stronger. In particular, accounting for central banks' balance sheet policy indicates that additional liquidity encourages banks to take riskier positions. Similarly, Vari (2020) shows that interbank market fragmentation might disrupt the transmission of monetary policy by leading short-term interest rates to depart from central bank policy rates.

4.2.2.2 The impact of interest rates on bank profitability

Investigating how macroeconomic and bank variables affect banks' net interest income and profitability, Demirgüç-Kunt and Huizinga (1999) find that higher interest rates are associated with higher net interest margins and profits, especially in countries where interest rates on deposits are more likely to be controlled and below the market level. Based on a sample of European, American, and Japanese international banks, Borio et al. (2017) find a positive relationship between the level of short-term rates and slope of the yield curve, on the one hand, and bank profitability, on the other hand. This suggests that the positive impact of the interest rate structure on net interest income dominates the negative impact on loan loss provision and non-interest income. They point out that such an effect is stronger when interest rates are low and the slope is steep (i.e., when non-linearities are present), indicating that unusually low interest rates and an unusually flat term structure erode bank profitability over time.

Alternatively, Genay (2014) argue that interest rate changes have a greater short-run impact on small banks, as they depend more on the traditional intermediation of retail deposits and loans than larger banks, many of which are priced based on floating (prime) rates. While large US banks typically have a greater ability to manage interest rate risks and are less affected by low rates, Covas et al. (2015) find that their funding cost advantage and net interest margins have declined more than those of small banks since the global financial crisis. Moreover, Busch and Memmel (2015) analyze the German banking industry where the long-run effect of a 100 basis point change on net interest margins is small (at around 7 basis points) in "normal" interest rate environments.

Differences between small and large banks in terms of monetary policy impacts on profitability also arise from differences in the compositions of their assets and liabilities, in the competition for funds and lending opportunities, and in their business models (Claessens et al., 2018). Accordingly, Gomez et al. (2020) suggest that US banks' assets are more sensitive to interest rate risks than are their liabilities, while such sensitivity varies across banks and might lead lending to respond differently to monetary policy depending on how bank financing is affected. In this case, the variations in exposure to interest rate changes across banks are due to differences in competition in deposit and loan markets. Conversely, Drechsler et al. (2017) find that deposit interest rates tend to change less with monetary policy changes in markets where deposit competition is lower.

English et al. (2018) show that an increase in interest rates results in higher interest margins for about a year, after which bank profits turn significantly negative. Following increases in the level and slope of the yield curve, reductions in profits reflect a shift in the composition of banks' balance sheets. In particular, increases in rates lead to an outflow of core deposits, which are an inexpensive source of funding relative to market alternatives. Ultimately, changes in interest rates only have moderate and transitory effects on bank earnings.

4.2.2.3 Response of cooperative banking & relationship lending to monetary policy stances

Elsas (2005) defines relationship lending as a long-term implicit contract between a bank and its debtor, which leads the former, thanks to information production and repeated interaction with the borrower over time, to accumulate private information, thereby establishing close ties. Such ties create benefits for the lending institution such as intertemporal smoothing, increased credit availability, the enhancement of the borrower's project payoffs, and more efficient decisions if borrowers face financial distress. Therefore, relationship lending is one of the most important technologies employed by banks to extend credit to informationally opaque small businesses without strong financial ratios, collateral, or credit scores (Berger and Udell, 2002). It allows them to obtain bank financing by augmenting relatively weak hard information with soft information gained over time through contact with firms, their owners, and their local communities at a variety of levels.

As local institutions, cooperative banks acquire specialized knowledge by cultivating relationships between staff and customers. The resulting proximity facilitates access to soft information, defined by Berger and Udell (2002) as information difficult to quantify, verify, and transmit through the layers of management and ownership of a banking organization[7], which is used to mitigate information asymmetry and more readily provide credit to informationally opaque borrowers. By contrast, large credit institutions have little commitment to relationship lending, as they would rather place weight on hard information (also called transactions-based technologies) and are more open to borrowers with lower informational opacity (McKillop et al., 2020). Indeed, Uchida et al. (2012) points out that even if large banks appear to have an equivalent potential to underwrite relationship loans, they choose instead to focus their resources on transactions lending.

Neuberger et al. (2008) suggest that localism and cooperative ownership are positively related to the relational orientation of financial institutions, as they avoid the organizational diseconomies and coordination problems often associated with large, multilayered institutions opting for standardized credit policies based on hard information (Berger and Udell, 2002). Moreover, Presbitero and Zazzaro (2011) find

[7]For instance, appraisals of real estate might require the expertise of individuals with specialized knowledge of local markets.

that where relationship lending techniques are already widely used by numerous cooperatives and savings banks, an increase in out-of-market competition drives them to further cultivate their relationship ties with customers. More recently, Donker et al. (2020) highlight that borrowing from relationship lenders lowers the loan spread by 17 basis points compared with borrowing from non-relationship lenders, implying that relationship lenders can benefit borrowers. They also show that borrowers often choose to remain with their relationship bankers because of the more favorable loan terms and high costs of switching lenders.

Based on the contracts database of a French cooperative bank, Dereeper et al. (2020) show that a strong bank–firm relationship results in a lower spread for loan applications during the high phase of the business cycle, while, in a downturn, the stronger the bank–firm relationship, the higher is the interest rate. Importantly, this means that weaker interest rates appear only in normal or good periods, while the hold-up problem only arises during economic recessions. Focusing on the EU banking industry, Kuc and Teply (2019) find structural differences in the priorities and behavior of European cooperative and commercial banks in a low interest rate environment: commercial banks tend to focus on maintaining their profitability, whereas cooperative banks favor stability by increasing their capital buffers.

While Hasan et al. (2014) provide evidence that Polish cooperative banks lend more to small businesses than large domestic and foreign-owned banks, Ferri et al. (2014) conclude that stakeholder banks decrease their loan supply to a lesser extent than shareholder banks following a monetary policy contraction. In particular, cooperative banks continued to smooth the impact of tighter monetary policy on their lending during the global financial crisis, acknowledging that the presence of stakeholder banks in the economy has the potential to reduce credit supply volatility. In turn, Agarwal and Hauswald (2010) prove that interest rates might even decrease with the length and strength of the relationship between a cooperative bank and firm, as borrower proximity facilitates the collection of soft information. Finally, cooperative banks might decide to set loan interest rate and saving rate ceilings (Ferrari et al., 2018) to protect borrowers by offering access to credit at reasonable interest rates.

4.3 Methodology

We investigate the contribution of monetary policy to explaining banks' credit risk and profitability depending on whether they display a cooperative ownership structure and, if so, whether they manage their network of local branches on a centralized basis. Based on the most recent data provided by EACB (2020b) on the 2019 territorial coverage of European cooperative banks, we compute the median value of the number of clients per branch of the cooperative banks included in our sample (see Table A1). We then categorize a cooperative bank as relationship-based[8] (Cornée, 2014; Bülbül et al., 2013; Stein, 2012) (consolidated) if the number of clients per branch is below (above) the 2019 median value described above.

As previous studies suggest that credit risk and profitability might be linked by a bidirectional causal relationship (Athanasoglou et al., 2008), we consider a

[8]The *relationship-based* category includes cooperative banks with a relatively high territorial coverage of local branches (i.e., a strong commitment to relationship lending) as opposed to consolidation and integration (Ory and Lemzeri, 2012).

dynamic simultaneous equations system to deal with endogeneity issues. In the first equation, we regress the credit risk index on a set of explanatory variables identified in the literature to which we add profitability variables (using several proxies; see below) and the monetary policy stance. In the second equation, we regress the profitability variable on a set of independent variables also identified in the literature in addition to the credit risk proxy and an indicator of monetary policy. All bank-level data originate from Fitch Connect, while all country-level data stem from Eurostat (except for spreads, which are retrieved from Thompson Reuters Eikon; see Table 4.1). The empirical model to be estimated is specified by the following dynamic simultaneous equations system (the subscripts b and t denote bank and time, respectively):

$$\begin{cases} LLP_{b,t} = \alpha_{b,t} + \beta LLP_{b,t-1} + \gamma \Pi_{b,t} + \delta MP1_t \\ \qquad + \zeta EDC1_{b,t-1} + \eta RealGDP_t + \varepsilon_{b,t} \\ \Pi_{b,t} = \theta_{b,t} + \iota \Pi_{b,t-1} + \kappa LLP_{b,t} + \lambda MP2_t \\ \qquad + \mu EDC2_{b,t-1} + \nu RealGDP_t + \xi_{b,t} \end{cases} \tag{4.1}$$

Where:

- $LLP_{b,t}$ is the loan loss provision to total gross loans ratio of bank b at year t to measure credit risk ;
- $LLP_{b,t-1}$ is the lagged loan loss provision to total gross loans ratio of bank b at year $t-1$ to consider the persistency of bank credit risk, as proposed by Delis and Kouretas (2011) ;

- $\Pi_{b,t}$ is the profitability proxy (either *ROAA*, *NIM*, *PTP* or *CTI*, see Section 4) of bank b at year t ;
- $\Pi_{b,t-1}$ is the lagged profitability proxy (either *ROAA*, *NIM*, *PTP* or *CTI*) of bank b at year $t-1$ to leave open the possibility for profitability to adjust over time, as suggested by Claessens et al. (2018) ;
- $MP1_t$ is the monetary policy index included in the credit risk equation at year t, namely either *EURIBOR-1M* or *EURIBOR-6M* ;
- $MP2_t$ is the monetary policy index included in the profitability equation at year t, namely either *Spread:10Y-3M* or *Spread:10Y-6M* ;
- $EDC1_{b,t-1}$ are the endogenous controls included in the credit risk equation of bank b at year $t-1$ (see Table 4.4 to Table 4.9) ;
- $EDC2_{b,t-1}$ are the endogenous controls included in the profitability equation of bank b at year $t-1$ (see Table 4.4 to Table 4.9) ;
- $Real\ GDP_t$ is the macroeconomic control variable at year t gauging the annual percentage change on previous year in a country's real gross domestic product.

We estimate System 4.1 using generalized method of moments (GMM), which is robust to the distribution of errors and which accounts for the heteroskedasticity of errors (Ullah et al., 2018). We also include in the regressions cross-sectional fixed effects and heteroskedasticity-robust standard errors clustered at the bank level. As previous empirical studies of credit risk and profitability highlight the potential endogeneity with most bank-level controls[9], we follow the methodology of Distinguin et al. (2013) by instrumenting all the bank-level explanatory variables

[9] For each equation of System 4.1, we run the Hausman test to confirm the presence of endogeneity both in the credit risk and in the profitability equations.

(i.e., *EDC1* in the credit risk equation and *EDC2* in the profitability equation) by their one-year lagged value. While the two variables of interest (i.e., credit risk and profitability) are not lagged, using a simultaneous GMM equations system addresses endogeneity issues. As both bank-level controls and bank fixed effects enable us to control for each bank's credit risk and profitability, the results of our estimations can be interpreted as the direct effects of a change in monetary policy on banks' credit risk and profitability. In addition, the regressions of credit risk and profitability both control for general economic conditions (through the *Real GDP* variable) to further acknowledge the difficulty in addressing endogeneity in monetary policy.

On the one hand, in the credit risk equation (see the results in Table 4.4 to Table 4.8), the dependent variable is measured by the ratio of loan loss provision to total gross loans, which reflects banks' credit risk profiles. The robustness checks in Table 4.9 also include a measure of banks' overall risk using the Z-score index (IJtsma et al., 2017). These two choices of bank risk proxies are guided by Khan et al. (2017) and Houston et al. (2010). The Z-score represents the number of standard deviations below the mean by which profits would have to fall to deplete the bank's equity capital. Despite being widely used in the literature (Delis et al., 2014; Ramayandi et al., 2014), a high Z-score indicates lower overall risk-taking by a bank (i.e., greater stability). As a measure of the distance from insolvency (Laeven and Levine, 2009), this is computed as follows:

$$Zscore_{b,t} = \frac{ROAA_{b,t} + Equity_{b,t}}{\left(Standard\ deviation\ of\ ROAA\right)_b} \tag{4.2}$$

Where:

- $ROAA_{b,t}$ equals the return on average assets of bank b at year t ;
- $Equity_{b,t}$ equals the ratio of total equity over total assets of bank b at year t ;
- *Standard deviation of* $ROAA_b$ equals the standard deviation of asset returns of bank b over the full sample period.

The bank-level controls in the credit risk equation are the bank characteristics and activities commonly adopted in the literature. Similarly to Dinger and te Kaat (2020); Abbate and Thaler (2019) and Khan et al. (2017), we consider the natural logarithm of total assets (*Size*) as well as the ratio of net loans to total assets (*Net loans*) as potential determinants of credit risk (in addition to the profitability proxies described hereafter). To gauge the monetary policy stance within the credit risk equation, we employ two maturities (1-month and 6-month maturities) of the benchmark rate at which euro interbank term deposits are offered by prime banks to one another (*EURIBOR-1M* and *EURIBOR-6M*, respectively). These respectively represent the short- and medium-term interest rate series for domestic money markets affecting credit risk management by euro area banks. We control for the macroeconomic conditions using the *Real GDP* variable in the credit risk equation.

On the other hand, following Elekdag et al. (2020) and Altavilla et al. (2018), we use four indicators of profitability in the profitability equation described in the second part of System 4.1:

- $ROAA_{b,t}$, the return on average assets of bank b in year t. The higher this index, the better is bank profitability;

- $NIM_{b,t}$, the net interest margin of bank b in year t. The higher this index, the better is bank profitability;

- $PTP_{b,t}$, the pretax profit over total assets of bank b in year t. The higher this index, the better is bank profitability;

- $CTI_{b,t}$, the cost to income ratio of bank b in year t. As increases in this index imply lower bank profitability, whereas increases in the other profitability proxies represent higher bank profitability, we multiply the values for this ratio by -1 to provide a more consistent interpretation among the profitability proxies. In other words, a higher value indicates greater profitability in all instances. Hereafter, we use the -*CTI* variable name to refer to the bank cost to income ratio.

Based on Claessens et al. (2018), we additionally use the ratios of total equity to total assets (*Equity*) and total liquid assets to total assets (*Liquid assets*) as the bank-level controls affecting profitability. We also proxy for monetary policy in the profitability equation using the slope of the yield curve between 10-year government bond yields and 3-month (6-month) implied sovereign bond yields accounted for by the *Spread:10Y-3M* variable (*Spread:10Y-6M*). Similarly to the credit risk equation, we control for the business cycle using the *Real GDP* variable in the profitability equation.

4.4 Data & sample

We assemble a unique dataset from different sources to investigate the impact of monetary policy on banks' credit risk and profitability depending on whether they display a cooperative ownership structure and, if so, whether they are committed to relationship lending. Table 4.1 lists the variables used in the empirical analysis along with the methodological approaches and data sources. Panel A summarizes the variables of interest on credit risk, profitability, and the monetary policy stance. Panel B covers bank-level controls and panel C macroeconomic controls. Panel D describes the four subsamples used in the study, namely, cooperative banks, non-cooperative banks, consolidated cooperative banks, and relationship-based cooperative banks.

Unconsolidated bank-level balance sheets and income statements are collected from Fitch Connect at an annual frequency, and these include three categories of banks: Retail & Consumer, Universal Commercial, and Wholesale Commercial. To address the potential of outliers to distort the results, all the bank-level variables are winsorized at the 5^{th} and 95^{th} percentiles, thresholds commonly accepted in the literature (Beltratti and Stulz, 2012). The final dataset consists of 30,467 observations from 3998 banks in 10 euro area countries[10] between 2010 and 2019.

Table 4.2 reports the descriptive statistics of the bank- and country-level variables for the full sample (panel A) as well as the Pearson correlations of the bank-level variables (panel B). We do not find the bank indicators employed as explana-

[10] Austria, Finland, France, Germany, Italy, Luxembourg, the Netherlands, Portugal, Slovenia, and Spain.

Table 4.1: Definitions

Variable	Methodological approach	Data source
Panel A: Variables of interest		
LLP	Loan loss provision over a bank's total gross loans as the ability to absorb losses from non-performing loans in its balance sheet (determining the quality of its loans).	Fitch Connect
Zscore	Natural logarithm of the following ratio: the sum of *ROAA* and *Equity* to the numerator, and the standard deviation of *ROAA* to the denominator. It relates a bank's capital level to variability in its returns, indicating how much variability in returns can be absorbed by capital without the bank becoming insolvent. It acts as a an accounting-based measure of the distance to default (see also Equation 2).	Fitch Connect
ROAA	Return on average assets as the net income over a bank's average total assets.	Fitch Connect
NIM	Net interest margin as the difference between interest income (i.e., gross interest and dividend income) and interest expense over a bank's total earning assets (i.e., total loans, total securities, investments in property and earning assets not otherwise categorized).	Fitch Connect
PTP	Pre-tax profit over a bank's total assets.	Fitch Connect
CTI	Cost to income ratio as total operating costs (including administrative and fixed costs) over a bank's total operating income.	Fitch Connect
EURIBOR-1M	Benchmark rate at which euro interbank 1-month term deposits are offered by prime banks to one another. It acts as a representative short-term interest rate series for domestic money markets.	Eurostat
EURIBOR-6M	Benchmark rate at which euro interbank 6-month term deposits are offered by prime banks to one another. It acts as a representative medium-term interest rate series for domestic money markets.	Eurostat
Spread:10Y-3M	Difference between a central government bond yield on the secondary market with 10 years' residual maturity and its 3-month implied sovereign bond yield.	Thompson Reuters Eikon
Spread:10Y-6M	Difference between a central government bond yield on the secondary market with 10 years' residual maturity and its 6-month implied sovereign bond yield.	Thompson Reuters Eikon
Panel B: Bank-level controls		
Size	Natural logarithm of a bank's total assets as a measure of its size.	Fitch Connect
Equity	Total equity over a bank's total assets as a measure of its capital adequacy.	Fitch Connect
Net loans	Net loans over a bank's total assets as a measure of its commitment to traditional financial intermediation.	Fitch Connect
Liquid assets	Liquid assets (including cash, reserves representing surplus, securities and interbank loans with very short maturity) over a bank's total assets as a measure of its level of liquidity.	Fitch Connect
Panel C: Macroeconomic controls		
Real GDP	Annual percentage change on previous year in a country's real gross domestic product (in volume).	Eurostat
Recession	Dummy variable that equals 1 when *Real GDP* is negative, and 0 otherwise.	Eurostat
Panel D: Bank classifications		
Cooperative banks	Retail & Consumer banks, Universal Commercial banks and Wholesale Commercial banks displaying a cooperative ownership structure.	EACB (2020a)
Non-cooperative banks	Retail & Consumer banks, Universal Commercial banks and Wholesale Commercial banks displaying a non-cooperative ownership structure.	Fitch Connect
Consolidated cooperative banks	Cooperative banks displaying a number of clients per branch above the full sample median in 2019.	EACB (2020b)
Relationship-based cooperative banks	Cooperative banks displaying a number of clients per branch below the full sample median in 2019.	EACB (2020b)

Notes. This tables reports name, methodological approach and data source of all variables used in the empirical analysis, as well as definition of classifications used to build subsamples cooperative, non-cooperative, consolidated cooperative and relationship-based cooperative banks.

tory variables to be highly correlated, so multicollinearity is not a major concern in the estimations. The correlation coefficients of credit risk, *LLP*, with the profitability proxies, *ROAA*, *NIM*, *PTP*, and *CTI*, are -0.100, 0.085, -0.144, and -0.174, respectively. Table 4.3 refines the summary statistics by dividing the full sample into the four subsamples described above.

Table 4.2: Full sample descriptive statistics & bank variables' correlations

Panel A: Descriptive statistics	Unit	Mean	Median	Std. dev.	Min.	Max.	Obs.	Banks	Countries
Bank-level variables									
LLP	%	0.419	0.230	0.830	-1.010	2.630	30,467	3,998	10
Zscore	std. dev.	4.668	4.312	3.351	0.987	41.875	30,135	3,941	10
ROAA	%	0.368	0.280	0.448	-0.490	1.850	30,467	3,998	10
NIM	%	2.085	2.150	0.731	0.200	3.380	30,467	3,998	10
PTP	%	0.571	0.490	0.557	-0.530	2.400	30,467	3,998	10
CTI	%	69.040	68.690	13.698	39.270	99.430	30,467	3,998	10
Size	ln(€)	20.375	20.225	1.708	17.451	23.860	30,467	3,998	10
Equity	%	10.019	8.790	5.914	3.660	37.650	30,467	3,998	10
Net loans	%	58.204	60.810	18.682	8.540	86.760	30,467	3,998	10
Liquid assets	%	16.110	11.390	14.189	2.270	63.390	30,467	3,998	10
Country-level variables									
EURIBOR-1M	%	0.114	0.130	0.472	-0.400	1.180	30,467	3,998	10
EURIBOR-6M	%	0.371	0.310	0.614	-0.300	1.640	30,467	3,998	10
Spread:10Y-3M	%	1.537	1.242	1.124	-0.270	10.292	30,467	3,998	10
Spread:10Y-6M	%	1.383	0.999	1.003	-1.010	10.049	30,467	3,998	10
Real GDP	%	1.537	1.500	1.488	-4.100	4.900	30,467	3,998	10
Recession	{0,1}	0.059	0.000	0.237	0.000	1.000	30,467	3,998	10

Panel B: Bank-level variables' correlations	LLP	Zscore	ROAA	NIM	PTP	CTI	Size	Equity	Net loans	Liquid assets
LLP	1.000									
Zscore	-0.023	1.000								
ROAA	-0.100	0.072	1.000							
NIM	0.085	0.022	0.055	1.000						
PTP	-0.144	0.100	0.958	0.130	1.000					
CTI	-0.174	0.011	-0.314	-0.156	-0.361	1.000				
Size	-0.009	-0.088	-0.088	-0.289	-0.084	-0.251	1.000			
Equity	0.070	0.204	0.377	0.021	0.362	-0.000	-0.312	1.000		
Net loans	-0.070	-0.066	-0.084	0.273	-0.064	-0.131	0.140	-0.202	1.000	
Liquid assets	-0.050	0.034	0.098	-0.318	0.047	0.178	-0.107	0.163	-0.585	1.000

Notes. This table reports descriptive statistics for the full sample and bank-level variables' Pearson's correlations of the yearly data for 3998 banks from 2010 to 2019. The top and bottom 5% of all observations for bank-level variables have been winsorized to limit the impact of extreme values on empirical results.

Bank risk-taking is gauged by two indexes: *LLP* for credit risk (see Table 4.4 to Table 4.8) and *Z-score* for overall risk (see the robustness checks in Table 4.9). The mean *LLP* for the full sample is 0.419%, with a standard deviation of 0.830%. Interestingly, Table 4.3 indicates that, on average, non-cooperative banks display higher *LLP* (as well as a higher standard deviation) than cooperative banks in the euro area between 2010 and 2019. While both consolidated and relationship-based cooperative banks exhibit, on average, lower *LLP* than non-cooperative banks, there

Table 4.3: Summary statistics of cooperative, non-cooperative, consolidated cooperative & relationship-based cooperative banks' variables

	LLP	Zscore	ROAA	NIM	PTP	CTI	Total assets (€ billion)	Equity	Net loans	Liquid assets
Panel A: Cooperative banks										
Mean	0.402	4.511	0.342	2.234	0.532	69.192	1.670	9.561	59.330	14.941
Median	0.250	4.399	0.300	2.240	0.520	68.970	0.316	9.070	60.190	11.340
Std. dev.	0.779	1.688	0.294	0.536	0.368	11.082	4.320	3.189	14.024	11.485
Min.	-1.010	1.285	-0.490	0.200	-0.530	39.270	0.038	3.660	8.540	2.270
Max.	2.630	41.875	1.850	3.380	2.400	99.430	23.000	37.650	86.760	63.390
Panel B: Non-cooperative banks										
Mean	0.437	4.843	0.396	1.922	0.613	68.873	4.370	10.523	56.966	17.396
Median	0.210	4.136	0.230	2.020	0.450	68.320	1.410	8.380	61.780	11.450
Std. dev.	0.883	4.529	0.570	0.870	0.707	16.090	6.780	7.860	22.665	16.569
Min.	-1.010	0.987	-0.490	0.200	-0.530	39.270	0.038	3.660	8.540	2.270
Max.	2.630	41.617	1.850	3.380	2.400	99.430	23.000	37.650	86.760	63.390
Test t-statistic[a]	3.717***	8.576***	10.597***	-37.962***	12.748***	-2.029**	41.809***	14.231***	-11.055***	15.141***
Panel C: Consolidated cooperative banks										
Mean	0.372	4.299	0.399	1.663	0.578	66.170	11.300	9.347	67.003	16.352
Median	0.240	4.416	0.400	1.600	0.560	64.970	11.200	8.745	72.325	13.820
Std. dev.	0.593	0.858	0.324	0.541	0.444	11.708	8.450	3.674	14.550	10.262
Min.	-1.010	1.788	-0.490	0.200	-0.530	39.270	0.038	3.660	8.540	2.270
Max.	2.630	6.435	1.850	3.380	2.170	99.430	23.000	37.650	86.760	63.390
Test t-statistic[b]	2.519**	4.194***	-0.165	10.301***	1.700*	5.761***	-33.805***	5.199***	-15.255***	2.172**
Panel D: Relationship-based cooperative banks										
Mean	0.404	4.529	0.337	2.281	0.528	69.444	0.869	9.579	58.690	14.823
Median	0.250	4.396	0.300	2.280	0.510	69.270	0.285	9.080	59.600	11.020
Std. dev.	0.793	1.738	0.290	0.508	0.360	10.991	2.420	3.145	13.788	11.574
Min.	-1.010	1.285	-0.490	0.200	-0.530	39.270	0.038	3.660	8.540	2.270
Max.	2.630	41.875	1.850	3.380	2.400	99.430	23.000	37.650	86.760	63.390
Test t-statistic[c]	-1.370	-4.590***	7.103***	-40.823***	4.607***	-9.979***	106.647***	-2.453**	20.210***	4.486***
Test t-statistic[d]	3.359***	7.808***	11.195***	-43.164***	13.000***	-3.547***	59.025***	13.525***	-7.875***	15.411***

Notes. This table reports the summary statistics of cooperative, non-cooperative, consolidated cooperative and relationship-based cooperative banks' variables from 2010 to 2019. All variables are expressed in percentage, except *Total assets* expressed in € billion (see Table 4.1 for definitions). Unconsolidated bank-level balance sheets and income statements are reported by Fitch Connect and winsorized at the 5% level. We consider a bank cooperative if it displays a cooperative ownership structure (EACB, 2020a). We consider a bank consolidated cooperative if it displays a cooperative ownership structure with a number of clients per branch above the full sample median in 2019, and relationship-based cooperative if it displays a cooperative ownership structure with a number of clients per branch below the full sample median in 2019 (see Table A2). T-statistics test the null hypothesis of identical means between, respectively, [a]cooperative and non-cooperative, [b]consolidated cooperative and non-cooperative, [c]relationship-based cooperative and consolidated cooperative, and [d]relationship-based cooperative and non-cooperative banks subsamples. *, **, *** indicate significance at the 10%, 5% and 1% level, respectively.

is no significant difference between the two groups of cooperative banks in terms of the average *LLP*. The full sample mean *Z-score* is 4.668, with a standard deviation of 3.351. Table 4.3 shows that, on average, the overall risk of non-cooperative banks is significantly lower (i.e., with a greater *Z-score* value)—although much more volatile—than cooperatives'. Relationship-based cooperative banks perform significantly better regarding overall risk than consolidated cooperative banks.

Bank profitability is measured by four indicators, namely, *ROOA*, *NIM*, *PTP*, and *CTI*, with the latter having the highest standard deviation. The means are, respectively, 0.368%, 2.085%, 0.571%, and 69.040%. On average, cooperative banks fare significantly better in terms of *NIM*, which might be linked to their higher share of net loans to total assets (59.330% on average) relative to non-cooperatives' (mean value of 56.966%). In addition, the *NIM* index is significantly higher for relationship-based cooperative banks (mean value of 2.281%) than for consolidated cooperative banks (1.663% on average). Alternatively, consolidated cooperative banks, on average, gain better results than relationship-based cooperative banks for *ROAA* (0.399% vs. 0.337%), *PTP* (0.578% vs. 0.528%), and *CTI* (66.170% vs. 69.444%). Specifically, the differences in *CTI* between consolidated and relationship-based cooperative banks most likely reflect the higher costs required to set up and maintain decentralized branch networks.

As expected, non-cooperative banks are significantly larger than cooperative banks on average (4.370€ billion vs. 1.670€ billion), while consolidated cooperative banks (11.300€ billion) are larger than relationship-based cooperative banks (0.869€ billion). The full sample mean *Equity* is 10.019%, with a standard deviation of 5.914%. Non-cooperative banks are better capitalized (mean value of 10.523%) than cooperative banks (9.561%), which might reflect the fact that cooperative banks are more involved in traditional financial intermediation, while non-cooperative banks engage more in capital market transactions to fund themselves in wholesale markets (Claessens et al., 2018). Interestingly, relationship-based cooperative banks display significantly better capitalization levels (9.579% on average) than consolidated cooperative banks (9.347%). In turn, the mean proportions of *Net loans* and *Liquid assets* in banks' total assets are, respectively, 58.204% and

16.110%; the former is slightly more volatile (18.682%) than the latter (14.189%). On average, cooperative banks hold a higher share of loans (59.330%) than non-cooperatives' (56.966%), as do consolidated cooperative banks (67.003%) compared with relationship-based cooperative banks (58.690%). Regarding the mean levels of liquid assets in the euro area, non-cooperative banks outperform (17.396% of total assets) cooperative banks (14.941%) between 2010 and 2019, while consolidated cooperative banks (16.352% of total assets) outperform relationship-based cooperative banks (14.823%).

We next collect from Eurostat the yearly averages of the euro interbank offered rates at which 1-month (*EURIBOR-1M*) and 6-month (*EURIBOR-6M*) term deposits are offered by prime banks to one another. We also collect the annual percentage changes in countries' real gross domestic product (*Real GDP*) compared with the previous year. Thompson Reuters Eikon provide the data on the spreads (i.e., slopes of the yield curve) between central governments' bond yield in the secondary market with 10 years' residual maturity as well as the 3-month (*Spread:10Y-3M*) and 6-month (*Spread:10Y-6M*) implied sovereign bond yields. The averages of *EURIBOR-1M*, *EURIBOR-6M*, *Spread:10Y-3M*, *Spread:10Y-6M*, and *Real GDP* are 0.114%, 0.371%, 1.537%, 1.383%, and 1.537%, respectively. Understandably, monetary policy indexes based on spreads over longer periods display higher standard deviations (1.124% for *Spread:10Y-3M* vs. 1.003% for *Spread:10Y-6M*). In turn, *Real GDP* varies considerably across the observations, with a low of -4.100% and a high of 4.900% over the full sample period and a standard deviation of 1.488%.

To explore the different impacts of monetary policy on bank credit risk and profitability by ownership structure, a bank is classified as a cooperative if it displays a cooperative ownership structure as defined by EACB (2020a) and a non-cooperative otherwise. Specifically, cooperative banks are owned by their customers, follow the cooperative principle of "one person, one vote" and require their members to control both the governance systems and capital of their cooperatives. In addition, we examine the different impacts of monetary policy on bank credit risk and profitability depending on banks' commitment to relationship lending (Agarwal et al., 2018) by distinguishing consolidated cooperative banks from relationship-based cooperative banks (Groeneveld, 2017). As described in Table A2, a cooperative bank is considered to be relationship-based (i.e., have wider geographic coverage and closer customer relationships) if the number of clients per branch is below the 2019 median value (i.e., 3413 clients per branch) computed on the basis of EACB (2020b) data[11].

Branches' centralization strategies used to reduce a bank's territorial coverage are usually based on medium-term decisions and require time to be implemented (the closure of local branches and internal restructuring do not happen overnight). Accordingly, we assume that our sample period is sufficiently short to consider which centralization strategies observed in 2019 (i.e., the year in which the most recent data are available from the European Association of Co-operative Banks) have been relatively steady for each cooperative group in the sample since 2010. Therefore, the categorizations of cooperative banks in 2019 are considered to represent their

[11] These data are elaborated by Tilburg University and based on inputs of the members of the European Association of Co-operative Banks. The list of full members is available from http://www.eacb.coop/en/about/membership/full-members.html.

strategic decisions taken in 2010.

For brevity, we use *LLP*, *Z-score*, *ROAA*, *NIM*, *PTP*, *-CTI*, *Size*, *Equity*, *Net loans*, *Liquid assets*, *EURIBOR-1M*, *EURIBOR-6M*, *Spread:10Y-3M*, *Spread:10Y-6M*, and *Real GDP* to refer to the loan loss provision to gross loans ratio, natural logarithm of the Z-score index, return on average assets ratio, net interest margin, pretax profit to total assets ratio, cost to income ratio, natural logarithm of total assets, ratio of equity to total assets, ratio of net loans to total assets, ratio of liquid assets to total assets, benchmark rate at which euro interbank 1-month term deposits are offered, benchmark rate at which euro interbank 6-month term deposits are offered, difference between 10-year government bond yields and 3-month implied sovereign bond yields, difference between 10-year government bond yields and 6-month implied sovereign bond yields, and annual percentage change in a country's real GDP from the previous year, respectively.

4.5 Main findings

To test the effects of expansionary monetary policy on bank credit risk and profitability depending on whether banks display a cooperative ownership structure and, if so, whether they are committed to relationship lending, we estimate System 4.1. In the credit risk equation, we regress the loan loss provision ratio on profitability, the monetary policy index, and a set of determinants commonly used in the literature. We use four indicators of bank profitability: *ROAA*, *NIM*, *PTP*, and *-CTI*. In the profitability equation, we regress one by one our four proxies of bank profitability on the credit risk indicator, the measure of monetary policy, and a set of explanatory variables outlined in the literature. The presumably endogenous bank-level indicators are instrumented by their one-year lagged value. Regarding our two variables of interest (i.e., credit risk and profitability), which are not lagged, we address the endogeneity issue by estimating a dynamic simultaneous equations system using GMM techniques.

4.5.1 The effects of a interest rates on credit risk & profitability: preliminary results

We first examine the effect of a interest rates on credit risk and profitability for the full sample. Table 4.4 reports the GMM dynamic panel regression results from System 4.1. The significant and negative signs of both *EURIBOR-1M* and *EURIBOR-6M* in the credit risk equation confirm the presence of a risk-taking channel of monetary policy (Altunbas et al., 2014) in the euro area between 2010 and 2019. Here, the risk-taking channel is slightly more intense when based on the medium-term *EURIBOR-6M* rate than on the*EURIBOR-1M* rate.

The *ROAA* and *PTP* ratios are both significantly and negatively related to credit risk, while the opposite occurs for *NIM* and *-CTI* (this result is also confirmed in the simultaneous profitability equation). Therefore, obtaining extra (interest) income implies taking more credit risk when monetary policy is eased; this result is a direct consequence of the risk-taking channel of monetary policy transmission (Neuenkirch and Nöckel, 2018). Moreover, the negative and significant signs of the *Real GDP*

Table 4.4: Credit risk & profitability in a low interest rate environment (2010-2019)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Credit risk equation								
LLP lagged	0.563***	0.561***	0.558***	0.550***	0.563***	0.561 ***	0.559***	0.550***
	(54.765)	(57.196)	(52.812)	(56.364)	(55.040)	(57.503)	(53.092)	(56.619)
ROAA	-0.146***				-0.147***			
	(-8.284)				(-8.318)			
NIM		0.039***				0.042***		
		(4.435)				(4.728)		
PTP			-0.149***				-0.149***	
			(-9.931)				(-9.941)	
-CTI				0.007***				0.007***
				(-15.359)				(-15.453)
Size	-0.002	0.007**	-0.003	-0.011***	-0.002	0.007**	-0.003	-0.011***
	(-0.830)	(2.291)	(-1.109)	(-4.114)	(-0.880)	(2.379)	(-1.154)	(-4.180)
Net loans	-0.001***	-0.002***	-0.001***	-0.002***	-0.001***	-0.002***	-0.001***	-0.002***
	(-4.014)	(-5.221)	(-3.893)	(-5.184)	(-3.992)	(-5.299)	(-3.870)	(-5.171)
EURIBOR-1M	-0.021**	-0.027***	-0.017**	-0.032***				
	(-2.575)	(-3.072)	(-2.037)	(-3.784)				
EURIBOR-6M					-0.027***	-0.033***	-0.024***	-0.036***
					(-4.392)	(-4.927)	(-3.767)	(-5.579)
Real GDP	-0.132***	-0.134***	-0.130***	-0.132***	-0.133***	-0.135***	-0.130***	-0.132***
	(-37.468)	(-37.250)	(-37.199)	(-37.006)	(-37.227)	(-37.111)	(-36.950)	(-36.876)
Profitability equation								
ROAA lagged	0.695**				0.695***			
	(57.994)				(57.974)			
NIM lagged		0.896***				0.898***		
		(199.297)				(200.791)		
PTP lagged			0.710***				0.710***	
			(61.656)				(61.686)	
-CTI lagged				0.771***				0.771***
				(100.513)				(100.336)
LLP	-0.052***	0.012***	-0.076***	0.898***	-0.053***	0.012***	-0.078***	0.921***
	(-12.245)	(3.401)	(-14.441)	(-9.108)	(-12.082)	(3.496)	(-14.167)	(-9.135)
Equity	0.008***	0.000	0.009***	-0.015	0.008***	0.000	0.009***	-0.016
	(10.557)	(0.699)	(10.146)	(1.076)	(10.551)	(0.566)	(10.129)	(1.187)
Liquid assets	0.000	-0.001***	-0.000	-0.042***	0.000	-0.001***	-0.000	-0.042***
	(1.391)	(-4.887)	(-1.013)	(7.685)	(1.408)	(-4.689)	(-0.992)	(7.570)
Spread:10Y-3M	0.010***	0.027***	0.012***	0.664***				
	(3.777)	(11.825)	(3.826)	(-9.821)				
Spread:10Y-6M					0.014***	0.023 ***	0.016***	0.559***
					(4.141)	(8.864)	(3.865)	(-7.010)
Real GDP	0.004**	0.015***	0.008***	0.064	0.005***	0.012***	0.009***	-0.017
	(2.167)	(9.278)	(3.836)	(-1.351)	(2.692)	(7.644)	(4.151)	(0.365)
Observations	26,146	26,146	26,146	26,146	26,146	26,146	26,146	26,146
Banks	3,998	3,998	3,998	3,998	3,998	3,998	3,998	3,998

Notes. This table reports the results of estimating dynamic simultaneous equations System 4.1 using two-step GMM for an unbalanced panel of European Retail & Consumer, Universal Commercial and Wholesale Commercial banks. Our base sample includes 3 998 banks from 10 countries over the period 2010-2019. Unconsolidated bank-level balance sheets and income statements are reported by Fitch Connect and winsorized at the 5% level. Country-level data are gathered from Eurostat and Thompson Reuters Eikon. See Table 1 for the definition of all explanatory variables, and Table 4.2 for descriptive statistics and correlations. Estimations include one credit risk index (*LLP* in regressions (1) to (8)), four profitability indicators (*ROAA* in regressions (1) and (5), *NIM* in regressions (2) and (6), *PTP* in regressions (3) and (7), and *-CTI* in regressions (4) and (8)), and four monetary policy measures (*EURIBOR-1M* and *Spread:10Y-3M* in regressions (1) to (4), and *EURIBOR-6M* and *Spread:10Y-6M* in regressions (5) to (8)). In both the credit risk and the profitability equations, all bank-level explanatory variables which are presumably endogenous in the existing literature are instrumented by their one-year lagged value. Time fixed effects are included in all regressions. *P*-values are computed using heteroskedasticity-robust standard errors clustered for banks, and *z*-statistics are reported in parentheses. *, **, *** indicate significance at the 10%, 5% and 1% level, respectively.

coefficients show that bank credit risk rises in economic downturns. Although the *Size* coefficients are contradictory depending on the profitability proxy used as the explanatory variable in the credit risk equation, a higher share of *Net loans* in a bank's assets seems to limit credit risk.

Focusing on the determinants of profitability, we observe a positively significant relationship between our interest rate proxies and profitability, confirming Borio et al. (2017)'s results on the positive link between short-term rates and bank profitability, which tends to erode as a low interest rate environment extends over time. Conversely, the increase in the spread between 10-year government bond yields and the euro interbank deposits rate is associated with better profitability. We also note the stronger dependence of *-CTI* on the monetary stance (with a significant coefficient of 0.664 for *Spread:10Y-3M* and 0.559 for *Spread:10Y-6M*) than the other profitability proxies. When significant, the level of capitalization (*Equity*) and business cycle (*Real GDP*) both improve bank profitability. A higher share of *Liquid assets* in total assets is achieved at the expense of lower bank profitability (see the negative coefficients, when significant).

4.5.2 The effects of interest rates on credit risk & profitability: cooperative & non-cooperative banks

We delve deeper into the influence of monetary policy on bank credit risk and profitability by separating cooperative banks from non-cooperative banks. The regression results are presented in Table 4.5 for cooperative banks and Table 4.6 for

Table 4.5: Cooperative banks' credit risk & profitability in a low interest rate environment (2010-2019)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Credit risk equation								
LLP lagged	0.537***	0.578***	0.507***	0.548***	0.539***	0.580***	0.510***	0.550***
	(48.858)	(55.562)	(42.970)	(52.236)	(49.378)	(56.295)	(43.429)	(52.738)
ROAA	-0.577***				-0.577***			
	(-19.269)				(-19.302)			
NIM		0.057***				0.068***		
		(4.586)				(5.411)		
PTP			-0.551***				-0.549***	
			(-21.007)				(-20.970)	
-CTI				0.013***				0.013***
				(-18.053)				(-18.182)
Size	0.013***	0.024***	0.016***	-0.011***	0.012***	0.025***	0.016***	-0.011***
	(4.251)	(7.398)	(5.051)	(-2.921)	(4.097)	(7.682)	(4.914)	(-3.096)
Net loans	-0.001*	-0.001**	-0.001**	-0.001*	-0.001*	-0.001**	-0.001*	-0.001*
	(-1.898)	(-2.244)	(-1.970)	(-1.861)	(-1.764)	(-2.152)	(-1.848)	(-1.714)
EURIBOR-1M	0.031***	0.011	0.061***	0.010				
	(3.082)	(0.987)	(5.873)	(0.918)				
EURIBOR-6M					0.006	-0.014	0.031***	-0.011
					(0.749)	(-1.580)	(3.867)	(-1.336)
Real GDP	-0.130***	-0.130***	-0.122***	-0.122***	-0.129***	-0.130***	-0.122***	-0.122***
	(-31.231)	(-30.239)	(-29.046)	(-29.134)	(-30.751)	(-29.788)	(-28.505)	(-28.776)
Profitability equation								
ROAA lagged	0.576***				0.575***			
	(35.877)				(35.872)			
NIM lagged		0.886***				0.890***		
		(204.913)				(209.013)		
PTP lagged			0.581***				0.583***	
			(38.485)				(38.703)	
-CTI lagged				0.708***				0.706***
				(63.681)				(63.550)
LLP	-0.091***	-0.004	-0.133***	1.555***	-0.098***	-0.006	-0.138***	1.596***
	(-20.097)	(-1.335)	(-23.342)	(-10.502)	(-20.537)	(-1.619)	(-23.444)	(-10.354)
Equity	0.009***	0.002**	0.010***	0.071***	0.009***	0.002**	0.010***	0.073***
	(8.360)	(2.257)	(8.029)	(-2.844)	(8.102)	(1.997)	(7.754)	(-2.920)
Liquid assets	0.001***	-0.001***	-0.000	-0.068***	0.001***	-0.001***	-0.000	-0.068***
	(5.083)	(-5.192)	(-0.413)	(9.928)	(4.988)	(-4.942)	(-0.480)	(9.944)
Spread:10Y-3M	0.020***	0.037***	0.023***	0.603***				
	(7.759)	(14.762)	(7.358)	(-6.945)				
Spread:10Y-6M					0.032***	0.036***	0.033***	0.450***
					(10.159)	(11.907)	(8.723)	(-4.340)
Real GDP	-0.002	0.015***	0.003	-0.004	0.001	0.011***	0.005**	-0.115**
	(-0.907)	(8.366)	(1.519)	(0.067)	(0.740)	(6.417)	(2.357)	(2.090)
Observations	13,701	13,701	13,701	13,701	13,701	13,701	13,701	13,701
Banks	2,136	2,136	2,136	2,136	2,136	2,136	2,136	2,136

Notes. This table reports the results of estimating dynamic simultaneous equations System 4.1 using two-step GMM for an unbalanced panel of European Retail & Consumer, Universal Commercial and Wholesale Commercial banks displaying a cooperative ownership structure. Our base sample includes 2 136 banks from 10 countries over the period 2010-2019. Unconsolidated bank-level balance sheets and income statements are reported by Fitch Connect and winsorized at the 5% level. Country-level data are gathered from Eurostat and Thompson Reuters Eikon. See Table 4.1 for the definition of all explanatory variables, and Table 4.2 for descriptive statistics and correlations. Estimations include one credit risk index (*LLP* in regressions (1) to (8)), four profitability indicators (*ROAA* in regressions (1) and (5), *NIM* in regressions (2) and (6), *PTP* in regressions (3) and (7), and *-CTI* in regressions (4) and (8)), and four monetary policy measures (*EURIBOR-1M* and *Spread:10Y-3M* in regressions (1) to (4), and *EURIBOR-6M* and *Spread:10Y-6M* in regressions (5) to (8)). In both the credit risk and the profitability equations, all bank-level explanatory variables which are presumably endogenous in the existing literature are instrumented by their one-year lagged value. Time fixed effects are included in all regressions. P-values are computed using heteroskedasticity-robust standard errors clustered for banks, and z-statistics are reported in parentheses. *, **, *** indicate significance at the 10%, 5% and 1% level, respectively.

Table 4.6: Non-cooperative banks' credit risk & profitability in a low interest rate environment (2010-2019)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Credit risk equation								
LLP lagged	0.546***	0.541***	0.546***	0.538***	0.545***	0.540***	0.545***	0.538***
	(34.621)	(34.742)	(34.298)	(34.661)	(34.669)	(34.793)	(34.346)	(34.701)
ROAA	-0.029				-0.030			
	(-1.520)				(-1.524)			
NIM		0.041***				0.042***		
		(3.612)				(3.663)		
PTP			-0.047***				-0.047***	
			(-2.899)				(-2.899)	
-CTI				0.004***				0.004***
				(-7.514)				(-7.531)
Size	-0.021***	-0.015***	-0.023***	-0.029***	-0.022***	-0.015***	-0.023***	-0.029***
	(-4.370)	(-2.888)	(-4.654)	(-5.682)	(-4.378)	(-2.884)	(-4.661)	(-5.693)
Net loans	-0.001***	-0.002***	-0.001***	-0.002***	-0.001***	-0.002***	-0.001***	-0.002***
	(-2.893)	(-4.404)	(-2.914)	(-3.852)	(-2.908)	(-4.440)	(-2.929)	(-3.870)
EURIBOR-1M	-0.066***	-0.073***	-0.067***	-0.077***				
	(-5.231)	(-5.531)	(-5.293)	(-5.879)				
EURIBOR-6M					-0.054***	-0.061***	-0.055***	-0.063***
					(-5.659)	(-6.006)	(-5.724)	(-6.341)
Real GDP	-0.139***	-0.140***	-0.138***	-0.140***	-0.140***	-0.142***	-0.139***	-0.141***
	(-24.600)	(-24.515)	(-24.633)	(-24.444)	(-24.625)	(-24.606)	(-24.657)	(-24.546)
Profitability equation								
ROAA lagged	0.723***				0.723***			
	(50.992)				(50.997)			
NIM lagged		0.898***				0.898***		
		(136.651)				(136.970)		
PTP lagged			0.740***				0.740***	
			(55.019)				(55.039)	
-CTI lagged				0.798***				0.799***
				(80.259)				(80.407)
LLP	-0.027***	0.025***	-0.044***	0.515***	-0.028***	0.026***	-0.045***	0.534***
	(-4.262)	(4.526)	(-5.633)	(-3.847)	(-4.306)	(4.641)	(-5.676)	(-3.970)
Equity	0.007***	-0.000	0.008***	-0.024	0.007***	-0.000	0.008***	-0.025*
	(8.508)	(-0.116)	(8.104)	(1.564)	(8.532)	(-0.210)	(8.122)	(1.675)
Liquid assets	-0.000	-0.001***	-0.001*	-0.030***	-0.000	-0.001***	-0.001*	-0.029***
	(-0.785)	(-3.630)	(-1.868)	(4.161)	(-0.783)	(-3.545)	(-1.869)	(4.068)
Spread:10Y-3M	0.005	0.017***	0.007	0.522***				
	(1.129)	(4.797)	(1.210)	(-5.158)				
Spread:10Y-6M					0.007	0.015***	0.010	0.452***
					(1.446)	(3.728)	(1.577)	(-4.003)
Real GDP	0.010***	0.018***	0.013***	0.179**	0.011***	0.016***	0.014***	0.137*
	(3.348)	(6.259)	(3.613)	(-2.248)	(3.642)	(5.736)	(3.922)	(-1.715)
Observations	12,445	12,445	12,445	12,445	12,445	12,445	12,445	12,445
Banks	1,862	1,862	1,862	1,862	1,862	1,862	1,862	1,862

Notes. This table reports the results of estimating dynamic simultaneous equations System 4.1 using two-step GMM for an unbalanced panel of European Retail & Consumer, Universal Commercial and Wholesale Commercial banks displaying a non-cooperative ownership structure. Our base sample includes 1 862 banks from 10 countries over the period 2010-2019. Unconsolidated bank-level balance sheets and income statements are reported by Fitch Connect and winsorized at the 5% level. Country-level data are gathered from Eurostat and Thompson Reuters Eikon. See Table 4.1 for the definition of all explanatory variables, and Table 4.2 for descriptive statistics and correlations. Estimations include one credit risk index (*LLP* in regressions (1) to (8)), four profitability indicators (*ROAA* in regressions (1) and (5), *NIM* in regressions (2) and (6), *PTP* in regressions (3) and (7), and *-CTI* in regressions (4) and (8)), and four monetary policy measures (*EURIBOR-1M* and *Spread:10Y-3M* in regressions (1) to (4), and *EURIBOR-6M* and *Spread:10Y-6M* in regressions (5) to (8)). In both the credit risk and the profitability equations, all bank-level explanatory variables which are presumably endogenous in the existing literature are instrumented by their one-year lagged value. Time fixed effects are included in all regressions. *P*-values are computed using heteroskedasticity-robust standard errors clustered for banks, and *z*-statistics are reported in parentheses. *, **, *** indicate significance at the 10%, 5% and 1% level, respectively.

non-cooperative banks.

First, we show that variations in *ROAA* do not significantly affect non-cooperative banks' credit risk[12] as opposed to cooperative banks. This might be explained by the greater business diversification of non-cooperative banks resulting in a weaker relation between return on assets and credit risk. As cooperative banks are more involved in traditional financial intermediation[13], they often access fewer diversification opportunities, which exacerbates the link between return on assets and credit risk, as shown in regressions (1) and (5) in Table 4.5.

Second, the *Size* variable seems to affect credit risk differently depending on the ownership structure of banks. In particular, cooperative banks' size appears to be positively related to credit risk (except when the cost to income ratio gauges profitability in the credit risk equation; see regressions (4) and (8) in Table 4.5), which suggests that cooperative ownership and asset growth ultimately increase credit risk. By contrast, the regression results in Table 4.6 show the significantly negative relation between non-cooperative banks' size and credit risk. Accordingly, the greater non-cooperative banks' assets, the better is their credit risk management.

Third, the signs of the monetary policy coefficients in the credit risk equation conflict with one another when distinguishing between cooperative and non-cooperative banks. Confirming the results for the full sample presented in Table 4.4, non-cooperative banks continue to display significantly negative *EURIBOR-1M* and *EURIBOR-6M* coefficients, consistent with the risk-taking channel in the 2010–2019

[12]However, the significance of the -0.029 *ROAA* coefficient in regression (1) from the credit risk equation in Table 4.6 is at the 12.8% level.

[13]See the significantly different means in net interest margins between cooperative and non-cooperative banks in Table 4.3.

euro area banking industry previously identified. However, the non-significance of the *EURIBOR-1M* and *EURIBOR-6M* coefficients in regressions (2), (4), (5), (6), and (8) from the credit risk equation in Table 4.5 supports, at least at the bank level, Caselli et al. (2020)'s insights into the capacity of bank ownership diversity to buffer the impact of exogenous monetary policy shocks on credit risk.

Fourth, the positive and significant *EURIBOR-1M* and *EURIBOR-6M* coefficients in regressions (1), (3), and (7) in Table 4.5 suggest that cooperative banks' credit risk decreases in a low interest rate environment compared with their non-cooperative counterparts[14]. This result provides, at least partially, empirical confirmation of Hypothesis 1, which claims that cooperative banks are less exposed to the risk-taking channel of monetary policy than non-cooperative banks thanks to the specificities of their business model. What matters now is to determine whether this result persists equally for consolidated and relationship-based cooperative banks.

Differentiating cooperative banks from non-cooperative banks does not alter the sign of the monetary policy indexes *Spread:10Y-3M* and *Spread:10Y-6M* in the profitability equation. However, greater significance levels in the interest rate coefficients of cooperative banks are noted, which confirms their higher sensitivity to monetary policy. Consequently, cooperative banks' profitability might be relatively more exposed when interest rates remain at historical lows for a long time.

[14] This is supported by the summary statistics in Table 4.3, which show that cooperative banks' mean *LLP* is significantly different (and in this case, lower) than that of non-cooperative banks.

4.5.3 The effects of a interest rates on credit risk & profitability: consolidated & relationship-based cooperative banks

We now examine in detail the credit risk and profitability of cooperative banks that, despite the pressure exerted by low interest rates on their balance sheets, preserve a relationship-based network of local branches to maintain their commitment to relationship lending (McKillop et al., 2020). The regression results are presented in Table 4.7 for consolidated cooperative banks and Table 4.8 for relationship-based cooperative banks.

First, the differences in the *Size* coefficient signs between consolidated cooperative and relationship-based cooperative banks suggest that a cooperative bank increasing its business volume—in terms of assets—while remaining committed to relationship lending is more prone to credit risk (as suggested by the significantly positive *Size* coefficients in Table 4.8). By contrast, the greater the size of consolidated cooperative banks' assets, the better is their credit risk management (as suggested by the significantly negative *Size* coefficients in Table 4.7).

Second, the dependence of credit risk on the volume of net loans appears to be lower for relationship-based cooperative banks, as shown by the differences in the significance level of the *Net loans* variables from one group to another. When consolidated, cooperative banks granting more loans perform better in terms of credit risk, which could mean that a positive volume effect is operating[15].

[15] On average, consolidated cooperative banks display a significantly higher net loans to assets ratio than non-consolidated cooperative banks over the full sample period (see Table 4.3).

Table 4.7: Consolidated cooperative banks' credit risk & profitability in a low interest rate environment (2010-2019)

	(1)	(2)	(3)	(4)	(5)	(6)
Credit risk equation						
LLP lagged	0.343***	0.346***	0.335***	0.337***	0.337***	0.327***
	(6.483)	(6.053)	(5.868)	(6.207)	(5.731)	(5.559)
ROAA	-0.575***			-0.572***		
	(-5.497)			(-5.454)		
NIM		0.147**			0.152**	
		(2.370)			(2.421)	
-CTI			0.010***			0.011***
			(4.326)			(4.375)
Size	-0.013	-0.034*	-0.105***	-0.016	-0.035*	-0.107***
	(-0.870)	(-1.807)	(-5.317)	(-1.023)	(-1.822)	(-5.390)
Net loans	-0.001	-0.005***	-0.005***	-0.001	-0.005***	-0.005***
	(-0.550)	(-4.161)	(-2.725)	(-0.567)	(-4.177)	(-2.707)
EURIBOR-1M	0.261***	0.285***	0.263***			
	(6.403)	(6.146)	(6.264)			
EURIBOR-6M				0.198***	0.221***	0.205***
				(6.167)	(6.121)	(6.204)
RealGDP	0.076***	0.083***	0.088***	0.084***	0.091***	0.095***
	(2.932)	(2.729)	(2.936)	(3.157)	(2.945)	(3.143)
Profitability equation						
ROAA lagged	0.550***			0.547***		
	(11.931)			(11.754)		
NIM lagged		0.882***			0.882***	
		(46.883)			(46.657)	
-CTI lagged			0.837***			0.832***
			(25.165)			(24.083)
LLP	-0.174***	0.087***	2.105***	-0.174***	0.087***	2.028***
	(-10.217)	(5.183)	(3.645)	(-10.254)	(5.148)	(3.648)
Equity	0.012***	0.004**	0.223***	0.012***	0.004**	0.224***
	(3.332)	(2.358)	(2.718)	(3.330)	(2.385)	(2.742)
Liquid assets	-0.002**	-0.000	0.014	-0.002**	-0.000	0.012
	(-2.117)	(-0.562)	(0.614)	(-2.137)	(-0.551)	(0.525)
Spread:10Y-3M	0.012	-0.005	0.138			
	(1.269)	(-0.585)	(0.424)			
Spread:10Y-6M				0.015	-0.006	0.499
				(1.519)	(-0.795)	(1.421)
Real GDP	-0.029***	-0.016**	-0.077	-0.029***	-0.017**	-0.020
	(-3.577)	(-2.026)	(-0.298)	(-3.525)	(-2.029)	(-0.079)
Observations	1,071	1,071	1,071	1,071	1,071	1,071
Banks	151	151	151	151	151	151

Notes. This table reports the results of estimating dynamic simultaneous equations System 4.1 using two-step GMM for an unbalanced panel of European Retail & Consumer, Universal Commercial and Wholesale Commercial banks displaying a cooperative ownership structure with a number of clients per branch above the full sample median in 2019 (see Table A2 and EACB (2020a)). Our base sample includes 151 banks from 5 countries over the period 2010-2019. Unconsolidated bank-level balance sheets and income statements are reported by Fitch Connect and winsorized at the 5% level. Country-level data are gathered from Eurostat and Thompson Reuters Eikon. See Table 1 for the definition of all explanatory variables, and Table 4.2 for descriptive statistics and correlations. Estimations include one credit risk index (*LLP* in regressions (1) to (6)), three profitability indicators (*ROAA* in regressions (1) and (4), *NIM* in regressions (2) and (5), and *-CTI* in regressions (3) and (6)), and four monetary policy measures (*EURIBOR-1M* and *Spread:10Y-3M* in regressions (1) to (3), and *EURIBOR-6M* and *Spread:10Y-6M* in regressions (4) to (6)). In both the credit risk and the profitability equations, all bank-level explanatory variables which are presumably endogenous in the existing literature are instrumented by their one-year lagged value. Time fixed effects are included in all regressions. P-values are computed using heteroskedasticity-robust standard errors clustered for banks, and z-statistics are reported in parentheses. *, **, *** indicate significance at the 10%, 5% and 1% level, respectively.

Table 4.8: Relationship-based cooperative banks' credit risk & profitability in a low interest rate environment (2010-2019)

	(1)	(2)	(3)	(4)	(5)	(6)
Credit risk equation						
LLP lagged	0.543***	0.579***	0.546***	0.545***	0.581***	0.548***
	(49.265)	(55.044)	(51.071)	(49.744)	(55.742)	(51.494)
ROAA	-0.563***			-0.563***		
	(-18.159)			(-18.184)		
NIM		0.047***			0.059***	
		(3.526)			(4.427)	
-CTI			0.013***			0.013***
			(17.486)			(17.615)
Size	0.016***	0.038***	0.004	0.016***	0.039***	0.003
	(3.863)	(9.267)	(0.866)	(3.749)	(9.418)	(0.722)
Net loans	-0.001*	-0.001	-0.000	-0.001	-0.000	-0.000
	(-1.744)	(-1.234)	(-1.077)	(-1.610)	(-1.137)	(-0.928)
EURIBOR-1M	0.008	-0.014	-0.019*			
	(0.820)	(-1.179)	(-1.837)			
EURIBOR-6M				-0.012	-0.035***	-0.034***
				(-1.564)	(-3.937)	(-4.302)
Real GDP	-0.136***	-0.136***	-0.128***	-0.136***	-0.137***	-0.129***
	(-32.423)	(-31.744)	(-30.451)	(-32.076)	(-31.432)	(-30.281)
Profitability equation						
ROAA lagged	0.571***			0.571***		
	(33.591)			(33.645)		
NIM lagged		0.873***			0.877***	
		(179.529)			(184.538)	
-CTI lagged			0.695***			0.693***
			(58.170)			(57.930)
LLP	-0.086***	-0.010***	1.590***	-0.093***	-0.013***	1.650***
	(-18.732)	(-2.929)	(10.154)	(-19.219)	(-3.553)	(10.012)
Equity	0.009***	0.002**	0.050*	0.009***	0.002**	0.053**
	(7.935)	(2.338)	(1.887)	(7.608)	(2.021)	(2.011)
Liquid assets	0.001***	-0.001***	-0.073***	0.001***	-0.001***	-0.073***
	(6.096)	(-6.254)	(-10.178)	(6.003)	(-6.012)	(-10.186)
Spread:10Y-3M	0.020***	0.042***	0.592***			
	(7.855)	(15.611)	(6.500)			
Spread:10Y-6M				0.033***	0.043***	0.388***
				(9.909)	(13.148)	(3.459)
Real GDP	0.001	0.017***	-0.012	0.003*	0.013***	-0.144**
	(0.282)	(8.923)	(-0.213)	(1.832)	(7.336)	(-2.549)
Observations	12,630	12,630	12,630	12,630	12,630	12,630
Banks	1,985	1,985	1,985	1,985	1,985	1,985

Notes. This table reports the results of estimating dynamic simultaneous equations System 4.1 using two-step GMM for an unbalanced panel of European Retail & Consumer, Universal Commercial and Wholesale Commercial banks displaying a cooperative ownership structure with a number of clients per branch below the full sample median in 2019 (see Table A2 and EACB (2020a)). Our base sample includes 1 985 banks from 7 countries over the period 2010-2019. Unconsolidated bank-level balance sheets and income statements are reported by Fitch Connect and winsorized at the 5% level. Country-level data are gathered from Eurostat and Thompson Reuters Eikon. See Table 4.1 for the definition of all explanatory variables, and Table 2 for descriptive statistics and correlations. Estimations include one credit risk index (*LLP* in regressions (1) to (6)), three profitability indicators (*ROAA* in regressions (1) and (4), *NIM* in regressions (2) and (5), and *-CTI* in regressions (3) and (6)), and four monetary policy measures (*EURIBOR-1M* and *Spread:10Y-3M* in regressions (1) to (3), and *EURIBOR-6M* and *Spread:10Y-6M* in regressions (4) to (6)). In both the credit risk and the profitability equations, all bank-level explanatory variables which are presumably endogenous in the existing literature are instrumented by their one-year lagged value. Time fixed effects are included in all regressions. *P*-values are computed using heteroskedasticity-robust standard errors clustered for banks, and z-statistics are reported in parentheses. *, **, *** indicate significance at the 10%, 5% and 1% level, respectively.

Third, unlike previous results, the credit risk of consolidated cooperative banks is positively correlated with the business cycle variable, *Real GDP* (see Table 4.7) in stark contrast to relationship-based cooperative banks that show countercyclical credit risk (see the significantly negative *Real GDP* coefficients in Table 4.8). However, such a finding is in line with Beck et al. (2018) emphasizing that a greater presence of relationship banks is associated with fewer credit constraints during cyclical downturns, which is particularly beneficial for smaller, younger, and more opaque firms when recession hits. Conversely, this easing effect mainly benefits safe firms in times of economic booms and is positively associated with firm investment and growth. As a result, relationship banks can smooth the negative impact of cyclical downturns after having acquired sufficient information on borrowers during good times.

Fourth, the *Spread:10Y-3M* and *Spread:10Y-6M* variables in the profitability equation display higher significance levels in the relationship-based cooperative banks subsample. Accordingly, cooperative banks committed to relationship lending are concerned by higher profitability dependence on monetary policy in a low interest rate environment. This result confirms, for relationship-based cooperative banks, Borio et al. (2017)'s evidence of the link between short-term rates and the slope of the yield curve; this effect is even stronger when the slope is steeper and bank size smaller (Genay, 2014). Therefore, we provide empirical support to Hypothesis 2, which proposed that the profitability of cooperative banks preserving their relationship lending model is more severely hit by a low interest rate environment than that of cooperative banks opting for consolidation.

Finally, consolidated cooperative banks display a great capacity to buffer the impact of exogenous monetary policy shocks on credit risk. This interpretation is led by the highly significant and positive *EURIBOR-1M* and *EURIBOR-6M* coefficients in Table 4.7[16]. However, the ability of relationship-based cooperative banks to reduce their exposure to the risk-taking channel of monetary policy when interest rates are low differs in reality. When significant, the *EURIBOR-1M* and *EURIBOR-6M* coefficients turn negative, as shown in regressions (3), (5), and (6) in Table 4.8. Unlike consolidated cooperative banks, cooperative banks committed to relationship lending actually increase their willingness to raise credit risk in a low interest rate environment. Hence, we confirm Hypothesis 3 that proposed that cooperative banks preserving their relationship lending model in a low interest rate environment are prone to assume greater credit risk than cooperative banks opting for consolidation.

Although this result is similar to the estimations for non-cooperative banks (see Table 4.6), we posit that such a similarity is not explained by the same reasons, mainly because non-cooperative banks and relationship-based cooperative banks organize their business models and engage with customers in a different way. This important difference is consistent with the contribution of Jiménez and Saurina (2004) on the role of the bank–customer relationship in credit risk as well as supports Peltoniemi (2007)'s view on (long-term) bank–firm relationships being beneficial to high-risk firms. The present study, however, is the first—to the best of our

[16] Such an ability is even stronger for consolidated cooperative banks than cooperative banks more broadly (compare with the coefficients in Table 4.5).

knowledge—to find such results for the cooperative banking industry in the euro area by singling out consolidated cooperatives and relationship-based cooperatives.

4.5.4 Robustness checks

To further address the assumption that interest rate changes are exogenous to credit risk (i.e., that monetary policy does not respond to the riskiness of newly issued loans), we undertake additional robustness checks. Table 4.9 presents the results.

First, endogeneity is likely to be more of a concern for nationwide banks whose loan portfolios reflect economic activity across the country than it is for small, local banks primarily affected by local shocks (Dell'Ariccia et al., 2017). Therefore, we re-estimate System 4.1 excluding large banks from the sample[17] for which endogeneity is more of a concern. Columns (1) and (2) in Table 4.9 report the results. We find similarly significant coefficients to our preliminary results in Table 4.4. In particular, the negative coefficients of the *EURIBOR-1M* and *EURIBOR-6M* variables and positive coefficients of *Spread:10Y-3M* and *Spread:10Y-6M* are similar to those obtained in the full sample. This suggests that our results are not contaminated by the inclusion of large banks.

Moreover, our results might also be driven by the business cycle, as credit risk might adjust endogenously with the state of the economy. We thus control for direct changes in the economic activity in regressions (3) and (4) by including a *Recession* dummy[18] and its interaction with the monetary policy proxies (in both the credit

[17] That is, banks with assets in the top quartile of the full sample.
[18] The dummy variable equals 1 when the *Real GDP* variable is negative and 0 otherwise.

Table 4.9: Credit risk & profitability in a low interest rate environment (2010-2019): robustness checks

	Without large banks		Impact of business cycles		*-Zscore* as dependent variable			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Credit risk and overall risk equations								
LLP lagged	0.546***	0.547***	0.559***	0.552***				
	(47.057)	(48.713)	(51.609)	(54.821)				
-Zscore lagged					1.001***	1.001***	1.001***	1.001***
					(1678.206)	(1678.664)	(1654.162)	(1653.980)
ROAA	-0.171***							
	(-8.076)							
NIM		0.024**			-0.014***	-0.013***		
		(2.088)			(-6.227)	(-6.034)		
PTP			-0.154***					
			(-10.296)					
-CTI				0.007***			-0.001***	-0.001***
				(-14.945)			(9.055)	(9.016)
Size	-0.008	0.004	-0.005*	-0.013***	-0.005***	-0.005***	-0.002***	-0.002***
	(-1.471)	(0.810)	(-1.957)	(-4.825)	(-8.146)	(-8.059)	(-2.708)	(-2.733)
Net loans	-0.002***	-0.002***	-0.001***	-0.001***	0.000***	0.000***	0.000***	0.000***
	(-4.976)	(-5.347)	(-2.989)	(-4.155)	(5.572)	(5.500)	(4.390)	(4.382)
EURIBOR-1M			-0.068***		-0.018***		-0.020***	
			(-7.737)		(-8.082)		(-9.556)	
EURIBOR-6M	-0.024***	-0.028***		-0.073***		-0.016***		-0.017***
	(-3.151)	(-3.268)		(-10.765)		(-9.137)		(-10.780)
RealGDP	-0.134***	-0.135***			-0.008***	-0.008***	-0.008***	-0.008***
	(-31.683)	(-31.428)			(-10.346)	(-10.762)	(-10.865)	(-11.304)
Recession			0.695***	0.660***				
			(26.604)	(18.458)				
EURIBOR-1M * Recession			-0.247***					
			(-4.334)					
EURIBOR-6M * Recession				-0.044				
				(-1.018)				
Profitability equation								
ROAA lagged	0.690***							
	(50.137)							
NIM lagged		0.882***			0.897***	0.898***		
		(136.040)			(197.190)	(198.663)		
PTP lagged			0.710***					
			(61.796)					
-CTI lagged				0.771***			0.774***	0.773***
				(100.102)			(102.889)	(102.357)
LLP	-0.058***	0.004	-0.078***	0.887***				
	(-11.710)	(0.989)	(-14.712)	(-8.865)				
-Zscore					-0.001	-0.001	-0.039	-0.039
					(-0.993)	(-0.915)	(1.630)	(1.602)
Equity	0.008***	-0.001	0.009***	-0.015				
	(9.111)	(-1.010)	(10.163)	(1.068)				
Liquid assets	0.000	-0.001***	-0.000	-0.041***	-0.001***	-0.001***	-0.046***	-0.046***
	(0.774)	(-4.553)	(-1.286)	(7.496)	(-4.854)	(-4.659)	(8.555)	(8.435)
Spread:10Y-3M			0.026***		0.030***		0.910***	
			(7.046)		(14.763)		(-13.770)	
Spread:10Y-6M	0.019***	0.034***		0.337***		0.028***		0.891***
	(4.472)	(9.965)		(-4.010)		(12.209)		(-11.497)
Real GDP	0.003	0.013***			0.015***	0.012***	0.018	-0.045
	(1.357)	(6.942)			(9.234)	(7.623)	(-0.373)	(0.942)
Recession			0.131***	4.351***				
			(2.605)	(-4.217)				
Spread:10Y-3M * Recession			-0.054***					
			(-4.408)					
Spread:10Y-6M * Recession				-0.647**				
				(2.179)				
Observations	19,432	19,432	26,146	26,146	25,983	25,983	25,983	25,983
Banks	3,196	3,196	3,998	3,998	3,941	3,941	3,941	3,941

Notes. This table reports the results of estimating dynamic simultaneous equations System 4.1 using two-step GMM for an unbalanced panel of European Retail & Consumer, Universal Commercial and Wholesale Commercial banks. Our base sample includes 3 998 banks from 10 countries over the period 2010-2019. Unconsolidated bank-level balance sheets and income statements are reported by Fitch Connect and winsorized at the 5% level. Country-level data are gathered from Eurostat and Thompson Reuters Eikon. See Table 1 for the definition of all explanatory variables, and Table 2 for descriptive statistics and correlations. Estimations include one credit risk index (*LLP* in regressions (1) to (4)), one measure of banks' overall risk (*Zscore* in regressions (5) to (8)), four profitability indicators (*ROAA* in regression (1), *NIM* in regressions (2), (5) and (6), *PTP* in regression (3), and *-CTI* in regressions (4), (7) and (8)), and four monetary policy measures (*EURIBOR-1M* and *Spread:10Y-3M* in regressions (3), (5) and (7), and *EURIBOR-6M* and *Spread:10Y-6M* in regressions (1), (2), (4), (6) and (8)). In the credit risk, the overall risk and the profitability equations, all bank-level explanatory variables which are presumably endogenous in the existing literature are instrumented by their one-year lagged value. Without large banks subsample in regressions (1) and (2) refers to banks for which *Size* variable is below the full sample top quartile. Time fixed effects are included in all regressions. *P*-values are computed using heteroskedasticity-robust standard errors clustered for banks, and *z*-statistics are reported in parentheses. *, **, *** indicate significance at the 10%, 5% and 1% level, respectively.

risk and the profitability equations). Again, we continue to obtain the same significant signs on the link between monetary policy and both bank credit risk and profitability.

We rerun our estimations using another indicator of bank risk commonly used in the literature (Ramayandi et al., 2014), namely, the Z-score (see Table 4.1 and Equation 2 for the methodological approach to build the index). As stressed by Khan et al. (2017), model specifications using the *Z-score* as the dependent variable should not include *ROAA* or *Equity* as controls because the Z-score index is a function of these two indicators. As such, there is a significant risk of obtaining misleading results. Therefore, regressions (5) to (8) do not use the *ROAA* variable in the overall risk equation or the *Equity* variable in the profitability equation. In addition, as noted earlier, because reductions in the *Z-score* imply higher bank risk, whereas increases in *LLP* convert to higher credit risk, we multiply the values of banks' Z-scores by -1 to facilitate a more consistent interpretation. Once again, our results on the influence of interest rate variations on credit risk and profitability remain unchanged.

Together with the fixed effects and GMM estimation techniques, those robustness checks confirm that our main results hold, alleviating any concerns that the empirical analysis is contaminated by an endogenous response of monetary policy to bank credit risk.

4.6 Conclusion

This study analyzes the effects of monetary easing on bank credit risk and profitability in 10 euro area countries between 2010 and 2019. Specifically, we investigate how such effects depend on bank ownership structures and, for cooperative banks, how they interact with relationship lending practices. Building on previous studies indicating that credit risk and profitability are jointly determined, we consider a simultaneous equations system to examine how relationship lending implemented by cooperative banks influences their performance in a low interest rate environment.

The main results are threefold. First, we find no evidence of the presence of a risk-taking channel of monetary policy for consolidated cooperative banks, whereas such a channel is extensively shown in the euro area for non-cooperative banks. Therefore, consolidated cooperative banks do not seem to raise their credit risk significantly when monetary policy is eased, distinguishing them from non-cooperative banking institutions. Second, we highlight that the profitability of cooperative banks preserving their relationship lending model is more severely hit by a low interest rate environment than that of cooperative banks opting for consolidation. This raises issues about the middle-term durability of relationship lending given the longstanding low interest rates in the European banking industry. Third, we find that non-cooperative banks and relationship-based cooperative banks are both concerned by the risk-taking channel of monetary policy transmission, which increases their credit risk under accommodating monetary policy conditions. Nevertheless, we suggest that such similarities do not occur for the same reasons because relationship lending is associated with a fundamentally different lending process than transactions-based lending technologies that devote significantly lower proportions of their assets to lending to small businesses (Berger and Udell, 2002).

Under "low-for-long" interest rates, non-cooperative banks prioritize maintaining their profitability at the expense of higher credit risk (Kuc and Teply, 2019), whereas relationship-based cooperative banks increase their capital buffers (on average, the capitalization of relationship-based cooperative banks is significantly higher than that of consolidated cooperative banks) to ensure access to credit, including for risky local businesses. As a close bank–customer relationship produces informational rents for the cooperative banks involved, such banks exercise some degree of market power and are better prepared to finance riskier borrowers and projects. While one might be concerned about the durability of relationship lending when interest rates are close to the zero lower bound, this insight points to the crucial impact of the bank–customer relationship on the development of regional and local economies. Accordingly, the greater the relationship lending strategy of a cooperative bank, the greater is its willingness to undertake credit risk, which is particularly valuable to high-risk firms and small businesses, as they are often informationally opaque and have far fewer external finance alternatives than large companies.

The conclusions presented in this paper suggest that further research on the impact of the risk-taking channel of monetary policy on relationship-based cooperative banks may yield new insights into alternative transmission mechanisms to the traditional channels already identified in the literature on commercial (i.e., non-cooperative) banking. Specifically, comparing customer risk profiles with the duration of relationship lending in a low interest rate environment is a promising path toward better understanding the “local virtues” driven by cooperative banks committed to relationship lending.

Appendix A. European cooperative banking: trends in the total number of clients per branch (2010-2019)

Table A1: European cooperative banking: trends in the total number of clients per branch (2010-2019)

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2010-2019 % change
Austria											
Österreichische Raiffeisenbanken	2,071	2,142	2,050	2,187	2,268	2,281	2,400	2,486	2,497	2,246	+ 8.45%
Österreichischer Volksbanken	1,468	n.a.	1,714	1,758	2,345	2,284	2,935	3,307	3,649	4,017	+ 173.64%
Finland											
OP Financial Group	7,460	7,781	8,112	9,304	9,395	9,562	9,857	10,811	11,732	11,063	+ 48.30%
France											
Crédit Agricole	n.a.	4,655	3,000	5,385	5,514	4,505	4,727	5,977	6,000	6,190	+ 32.98%[a]
Crédit Mutuel	5,000	n.a.	3,280	5,135	5,681	5,837	5,851	6,124	6,354	6,840	+ 36.80%
BPCE	n.a.	n.a.	n.a.	4,781	4,500	4,375	3,900	4,000	4,032	4,032	- 15.67%[c]
Germany											
Cooperative Financial Network - Bundesverband der Deutschen Volksbanken und Raiffeisenbanken (Volksbanks, Raiffeisenbanks, Sparda-banks, PSD banks, and DZ banks)	2,227	2,247	2,270	2,298	2,349	2,529	2,545	2,701	2,852	3,211	+ 44.19%
Italy											
Cooperative Financial Network (Raiffeisen, Banco Popolare, and Credito Cooperativo)	1,302	1,360	n.a.	1,347	1,351	1,359	1,392	1,410	1,417	1,417	+ 8.83%
Luxembourg											
Banque Raiffeissen	2,594	2,297	2,649	2,174	2,330	2,732	2,732	3,126	3,179	3,225	+ 24.33%
The Netherlands											
Rabobank	8,306	11,467	8,959	13,850	16,088	16,996	20,471	19,144	20,293	25,606	+ 208.28%
Portugal											
Credito Agricola	1,710	1,685	1,659	1,786	1,611	1,778	2,080	2,242	2,501	2,580	+ 50.88%
Slovenia											
Dezelna Banka Slovenije d.d.	n.a.	992	992	1,000	1,000	1,000	1,428	1,084	1,111	1,114	+ 12.30%[a]
Spain											
Unión Nacional de Cooperativas de Crédito	n.a.	n.a.	2,267	2,303	2,037	2,097	2,165	2,218	2,165	2,185	- 3.62%[b]
Banco de Crédito Cooperativo	n.a.	n.a.	n.a.	n.a.	3,037	2,668	2,953	3,117	3,335	3,600	+ 18.54%[d]

Notes. This table reports the total number of clients per branch of consolidated and relationship-based cooperative banks included in our sample, for each year between 2010 and 2019. When available, hand-collected data stem from 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019 and 2020 annual reports published by the European Association of Co-operative Banks. For further information, see http://www.eacb.coop/en/about/annual-reports.html. [a]2011-2019 % change. [b]2012-2019 % change. [c]2013-2019 % change. [d]2014-2019 % change.

Appendix B. Consolidated & relationship-based cooperative banks in the euro area (2019)

Table B1: Consolidated & relationship-based cooperative banks in the euro area (2019)

	Home country	Number of clients	Number of legally independent local or regional cooperative banks	Number of branches (in home country)	Number of clients per branch
Panel A: Consolidated cooperative banks					
Österreichischer Volksbanken	Austria	1,072,639	9	267	4,017
OP Financial Group	Finland	3,894,000	147	352	11,063
Crédit Agricole	France	52,000,000	39	8,400	6,190
Crédit Mutuel	France	34,200,000	18	5,000	6,840
BPCE	France	30,000,000	29	7,440[a]	4,032
Rabobank	Netherlands	9,500,000	89	371	25,606
Banco de Crédito Cooperativo	Spain	3,441,666	18	956	3,600
Panel B: Relationship-based cooperative banks					
Österreichische Raiffeisenbanken	Austria	4,000,000	368	1,781	2,246
Cooperative Financial Network - Bundesverband der Deutschen Volksbanken und Raiffeisenbanken (Volksbanks, Raiffeisenbanks, Sparda-banks, PSD banks, and DZ banks)	Germany	30,000,000	841	9,344	3,211
Cooperative Financial Network (Raiffeisen, Banco Popolare, and Credito Cooperativo)	Italy	6,000,000[b]	259	4,234	1,417
Banque Raiffeissen	Luxembourg	122,547	1	38	3,225
Credito Agricola	Portugal	1,684,462	79	653	2,580
Dezelna Banka Slovenije d.d.	Slovenia	87,977	1	79	1,114
Unión Nacional de Cooperativas de Crédito	Spain	7,064,825	42	3,233	2,185
Median value		5,000,000	41	1,369	3,413

Notes. This table reports for the year 2019 the home country, the total numbers of clients, legally independent local or regional cooperative banks, branches (in home country) and clients per branch of consolidated and relationship-based cooperative banks included in our sample. Prime source is EACB (2020b), which was elaborated in collaboration with Tilburg University and based on European Association of Co-operative Banks Members input (financial indicators on 31.12.2019). [a]Data from 2018. [b]Value calculated by Tilburg University which bears the full and sole responsibility, as it is neither reported nor formally approved by the respective cooperative banks.

Chapter 5

General conclusion

Since the single currency was implemented, monetary policy has been the backbone of the European banking industry. In the aftermath of the Global Financial Crisis (GFC), the European Central Bank (ECB) had no choice but to resort to unconventional measures to push inflation up to target. Since then, this posture changed very little, and even intensified with the advent of the global COVID-19 pandemic.

As interest rates remained stuck at historically low levels, the method of problematizing the risk-taking channel of monetary policy transmission gradually changed. While early work demonstrated the existence of this channel, its amplitude, and its interactions with bank-specific characteristics, a new line of research recently focused on the financial stability implications of the extension of the risk-taking channel over time. The goal of this thesis was to contribute new insights on both sides of the fence.

Chapter 2 explored the existence of the bank risk-taking channel in the post-GFC euro area, as well as its interaction with banking industry competition and leverage (through a search for yield effect). I also identify nonlinearities in the risk-taking channel depending on the level of bank capitalization. In contrast with previous evidence for the U.S. banking industry, these results point to the importance for theoretical studies to consider alternative channels–in addition to the traditional portfolio rebalancing channels–and confirm that time, geographical circumstances, and local banking market conditions are key in understanding the impact of monetary policy on credit risk.

Despite an extensive literature on the risk-taking channel of monetary policy, the joint influence of bank capital and funding liquidity on the latter remains poorly documented. However, this prospect is crucial when monetary policy is implemented under the concomitant capital and liquidity standards stipulated by the Basel III accords. Using data on the euro area from 1999 to 2018 and triple interactions among monetary policy, equity capital, and deposits (as a proxy for funding liquidity), Chapter 3 suggested that banks concerned with a crowding-out of deposits effect before the GFC are more sensitive to the risk-taking channel of monetary policy. These results support the need to implement capital and funding liquidity ratios simultaneously to mitigate the monetary policy transmission to credit risk. The findings also highlight the absence of this effect among less efficient banks in the aftermath of the GFC. Accordingly, for inefficient banks operating in a low interest rate environment, a trade-off arises between financial stability and funding liquidity. These results have implications for euro area bank regulators advocating uniform funding liquidity requirements across a variety of banking systems under low-for-long interest rates.

Lastly, I used a simultaneous equations framework in Chapter 4 to investigate the effects of monetary easing on cooperative banks' performance depending on their commitment to relationship lending. While I do not find evidence of a risk-taking channel of monetary policy for consolidated (i.e., less committed to relationship lending) cooperative banks, I show that the profitability of relationship-based cooperative banks is more severely hit in a low interest rate environment compared to consolidated cooperative banks. This finding raises issues on the mid-term durability of relationship lending under low-for-long rates. Moreover, both non-cooperative banks and relationship-based cooperative banks tend to increase credit risk under monetary accommodation. However, these similarities do not occur for the same reasons: while the former prioritize profitability through higher credit risk when interest rates fall, the latter rather increase their capital buffers to ensure credit access to customers, which consist mainly of small businesses and high-risk firms. This last part of the thesis argues for greater consideration for bank business model diversity, and how it influences the mechanism of monetary transmission within the European banking industry.

The present doctoral thesis has several implications regarding the monetary policy and potential adjustments in the near future of the euro area. Specifically, I propose three lines of thought to gain a more precise understanding of the risk-taking channel of monetary policy transmission, namely bank leverage, bank efficiency, and bank ownership structures.

Chapter 2 suggested that euro area banking industry is concerned with a "skin-in-the-game" effect (De Nicolò et al., 2010) involving that the more a bank has to lose in case of failure (i.e., having high levels of capitalization), the less severe the moral hazard problem. This means that banks with a high franchise value have a lot to lose and little incentive to take excessive risk, whereas zombie banks are willing to take great risks to gamble for resurrection (as it seems to be the case in the U.S. banking industry). Accordingly, policymakers should tackle the issue of bank leverage when reviewing solutions to tame the risk-taking channel of monetary policy in the euro area (and, especially, when interest rates prolong at extremely low levels).

In turn, Chapter 3 highlighted that inefficient banks facing low interest rates are unable to comply *at the same time* with capital and funding liquidity requirements without increasing their level of credit risk. This requires a closer look at changes in the share of European banks which have not succeeded in regaining satisfactory levels of efficiency since the GFC. In terms of potential adjustments for the monetary policy, this contribution provides insights on why concomitant capital requirements, funding liquidity requirements and low interest rates may ultimately be an explosive combination in terms of financial stability.

As an essential part of the euro area banking industry, cooperative banks and the way they preserve their business model and relationship lending practices also interact with monetary policy. Chapter 4 evidenced that consolidated cooperative banks are not significantly exposed to the risk-taking channel of monetary policy. This result may be due to the adoption of hybrid forms of organizational structures (i.e., halfway between decentralized cooperatives' and non-cooperatives') leading to new credit risk strategies when interest rates remain low. Thus, this would be worth exploring this avenue in future research dedicated to risk-taking channel of monetary policy.

By way of complement, relationship-based cooperative banks increase their capital buffers to ensure access to credit when interest rates are low, including for risky local businesses. As a close bank–customer relationship produces informational rents for the cooperative banks involved, they exercise some degree of market power and are better prepared to finance riskier borrowers and projects. This insight points to the crucial impact of the bank–customer relationship on the development of regional and local economies when evaluating how small and territorial-based banks are impacted by the risk-taking channel of monetary policy. Implementing policies without taking into account the specificities of these banks would eventually lead them to exit the banking industry with, potentially, a considerable impact on the access to credit for a large number of individuals and local businesses in the euro area.

Undoubtedly, the future of monetary policy is called on to play an active role in addressing financial stability risks. While low and stable inflation promotes financial stability, it also increases the likelihood that excess demand pressures show up first in credit aggregates and asset prices, rather than in goods and services prices. Accordingly, in some situations, a monetary response to credit and asset markets may be appropriate to preserve both financial and monetary stability (Pfister and Sahuc, 2020). As a result, credit risk and financial stability must be a concern for the ECB when the financial sector ends up being unable to absorb all of its losses with possible cascading defaults if it is not bailed out.

Still, uncertainties remain on the linkages between easy money and low rates, on one hand, and risks to financial stability, on the other. Monetary easing does work in part by increasing the propensity of investors and lenders to take risks but in periods of recession or financial stress, encouraging investors and lenders to take reasonable risks is an appropriate goal of policy. Though, problems arise when, because of less-than-perfectly rational behavior or distorted institutional incentives, risk-taking goes too far. Vigilance and appropriate policies, including macroprudential and regulatory policies, are therefore essential. In addition, evidence is still sorely lacking on whether new monetary tools pose greater stability risks than the generally low rate environment expected to persist even when monetary policy is at a neutral setting (Bernanke, 2020).

In a speech delivered at *The ECB and Its Watchers XXI* web conference on 30 September 2020, Claudio Borio, Head of the Monetary and Economic Department of the Bank for International Settlements (BIS), voiced the idea that the tools central banks use in a crisis are actually becoming increasingly indistinguishable from those employed in normal times (Borio, 2020). Somehow surprisingly, such tools proved more effective than expected in influencing financial conditions and bank behavior over time, but also appear to exhibit diminishing effectiveness and long-term side effects.

So there are grounds to believe that monetary tools have diminishing effectiveness, as there are limits to how far interest rates can be lowered and credit spreads compressed. The compression of bank interest margins can also weaken their lending capacity in the longer term, and it becomes increasingly obvious that the lower interest rates are, the smaller the impact on economic activity (the impact of the duration of low rates also being a key issue) is.

Partly as a result, the wide-ranging emergency measures taken to address the COVID-19 pandemic further reduced the policy room for maneuver, reminding us that an economy with small safety margins is exposed and vulnerable. Therefore, the priority in the future of the euro area and research to undertake will be to rebuild policy buffers, not just in monetary policy, but also in prudential and fiscal policies.

Chapter 6

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Essays on the Risk-Taking Channel of Monetary Policy Transmission in the Euro Area

Abstract: The thesis contributes to the recurrent debates in the macroeconomics of banking regarding the risk-taking channel of monetary policy transmission. As the unifying theme of the present essays, I tackle this issue from three different angles with a special focus on the euro area banking industry. I rely on available data–at both the bank-level and the country-level–and different identification strategies to deliver up-to-date empirical evidence contributing to a deeper understanding of the monetary policy impacts on credit risk.

In the first chapter of the thesis, I investigate how the risk-taking channel of monetary policy interacts with the degree of leverage in banks' balance sheets after the Global Financial Crisis of 2008 (GFC). Using dynamic panel techniques, I first find significant statistical evidence that credit risk is negatively associated with variations in interest rates, while competition in national banking industries tends to enhance this effect. I also suggest that this negative relationship is most pronounced for banks with relatively high levels of leverage, which is consistent with a "search for yield" effect. These results for the euro area are strikingly different from the U.S. banking industry, confirming that time, geographical circumstances, and local banking market conditions are key in understanding the impact of monetary policy on credit risk. Moreover, the results point to the importance of considering alternative channels of risk taking in addition to traditional portfolio rebalancing channels in theoretical studies.

The second chapter investigates the joint impact of bank capital and funding liquidity on the monetary policy's risk-taking channel. Using data on the euro area from 1999 to 2018 and triple interactions between monetary policy, bank equity, and funding liquidity, I shed light on a "crowding-out of deposits" effect prior to the GFC, which supports the need for simultaneous capital and funding liquidity ratios to mitigate the monetary transmission to bank credit risk. Interestingly, the analysis also highlights a missing crowding-out of deposits effect among low-efficiency banks in the aftermath of the GFC. Consequently, a trade-off arises between financial stability and increased funding liquidity, requiring a special treatment for inefficient banks operating in a low interest rate environment. These results challenge the implementation of uniform funding liquidity requirements across the euro area as by the Basel III framework suggests.

The third and last chapter extends the analysis to the special case of cooperative banks and relationship lending in the euro area. These financial intermediaries tell a different story between countries and therefore imply different responses to a common monetary policy. Accordingly, I find no evidence of the presence of a risk-taking channel of monetary policy for consolidated (i.e., less committed to relationship lending) cooperative banks, whereas the results indicate extensive evidence of a risk-taking channel in the euro area for non-cooperative banks (see also the previous chapters of the thesis). Therefore, consolidated cooperative banks seem not to raise their credit risk significantly when monetary policy is eased. Further, I highlight that the profitability of cooperative banks preserving their relationship lending model is more severely hit by a low interest rate environment compared to cooperative banks opting for consolidation. This finding raises issues on the mid-term durability of relationship lending as interest rates have been low for an extended period in the European banking industry. I ultimately find that both non-cooperative banks and relationship-based cooperative banks are concerned about the risk-taking channel of monetary policy transmission, which results in an increase in their credit risk under accommodating monetary conditions. Nevertheless, I suggest that such similarities do not exist for the same reasons, as relationship lending is associated with a fundamentally different lending process than transactions-based lending technologies, which devote significantly lower proportions of their assets to lending to small businesses.

Keywords: Monetary policy; Risk-taking channel; Credit risk; Euro area banks.

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