

---

THE EFFECTS OF ECB'S MACRO-LIQUIDITY INJECTIONS ON  
PORTUGUESE FIRMS: THE RISK-TAKING CHANNEL

**Laura Fabiana Gomes Gouveia**

---

Dissertation

Master in Economics

---

Supervised by

**Manuel Duarte da Silva Rocha**  
**Sujiao Zhao**

---

September 2022



## **Acknowledgments**

To my supervisors, Professor Manuel Duarte Rocha and Professor Sujiao Zhao, for the continuous encouragement and valuable help throughout this journey. Thank you for all the support given during the elaboration of this dissertation and for all the knowledge transmitted.

To my mother, Isalina, and my father, Agostinho, for always providing me all the conditions to achieve my goals. To my brothers and sisters for always being there for me. To Emanuel, for its kind advices. I am eternally grateful for the support.

To Romualdo, for your patience, immense support, and care.

## **Abstract**

Excessive levels of central banks liquidity injections are among the reasons that banks are incentivized to take on higher risks. The previous 2008 financial crisis and the Euro area sovereign debt crisis are an example of this and more recently, the COVID-19 crisis, motivates to study the links of unconventional monetary policy with higher risk-taking capacity of banks, since the European Central Bank (ECB) has granted access to central bank liquidity to recover from these crises.

Particularly, the present work contributes to the analysis of the risk-taking channel, by studying the link between unconventional monetary policy and the evolution of firms' overdue credit, between April 2007 and August 2009. The main purpose is to verify how much Portuguese firms are exposed to banks receiving funding from the Eurosystem, and if such operations have caused an increase in credit risk, using firm-level data from the Central Credit Register database managed by Bank of Portugal. Thus, we apply a difference-in-differences methodology to examine the transmission of monetary policies of the ECB to firms with different exposures to banks working with ECB's liquidity injections to understand the effects of unconventional liquidity operations on credit supply and risk-taking.

The main findings indicate that ECB's liquidity operations implemented during the sample period analyzed were responsible for an increase in credit supply to firms with higher exposure to banks receiving more of such funding. The results of the unconventional monetary policy analysis suggest that ECB's macro-liquidity injections, for example longer-term refinancing operations (LTROs) with 6-months maturities, enhanced credit supply. Moreover, we show that Portuguese banks increased their risk flavor by observing an increase on firms' overdue credit after ECB's non-standard operations implementation in April 2008. Thus, our results suggest there is a positive relationship between unconventional monetary policy and Portuguese banks' risk-taking.

**JEL codes:** E44; E52; G21

**Keywords:** Monetary Policy; Credit Risk-Taking; TLTROs; Bank Lending

## Resumo

Níveis excessivos de injeções de liquidez por parte dos Bancos Centrais estão entre as razões pelas quais os bancos são incentivados a assumir riscos mais elevados. A anterior crise financeira de 2008, bem como a crise da dívida soberana da zona euro, são um exemplo disso e, mais recentemente, a crise da COVID-19, motiva o estudo da política monetária não convencional e a sua ligação com uma maior tomada de risco dos bancos, uma vez que o Banco Central Europeu (BCE) providenciou financiamento para recuperar destas crises.

Em particular, o presente trabalho contribui para a análise do canal de tomada de risco, estudando a ligação entre a política monetária não convencional e a evolução do crédito vencido das empresas entre abril de 2007 e agosto de 2009. O principal objetivo é observar o quanto as empresas estão expostas a bancos que recebem um maior montante de liquidez do BCE, e se tal exposição aumenta os níveis de crédito malparado, utilizando a informação disponível na base de dados “*Central Credit Register*”, gerida pelo Banco de Portugal. Assim, aplicamos a metodologia de diferença-em-diferenças para examinar a transmissão das políticas monetárias não tradicionais do BCE a empresas com diferentes exposições a bancos que trabalham com as injeções de liquidez do banco central, para compreender os efeitos destas na oferta e risco de crédito.

As principais conclusões indicam que as operações de liquidez do BCE implementadas durante o período da amostra analisado, foram responsáveis por um aumento na oferta de crédito a empresas mais expostas aos bancos que recebem mais deste tipo de financiamento. Os resultados da análise da política monetária não convencional sugerem que as injeções de liquidez do BCE, como por exemplo as operações de refinanciamento de longo prazo com maturidades de 6 meses, afetaram positivamente a oferta de crédito dos bancos. Além disso, mostramos que os bancos portugueses aumentaram os seus níveis de risco de crédito ao observarmos um aumento no total de crédito malparado das empresas após a implementação das operações não convencionais do BCE, no mês de abril de 2008. Assim, os nossos resultados sugerem que existe uma relação positiva entre a política monetária não convencional e um comportamento de risco por parte do sistema bancário português.

**JEL codes:** E44; E52; G21

**Keywords:** Política Monetária; Risco de Crédito; Financiamento Bancário

## Table of Contents

|                                                                                                    |           |
|----------------------------------------------------------------------------------------------------|-----------|
| <b>1. Introduction .....</b>                                                                       | <b>1</b>  |
| <b>2. European Unconventional Monetary Policy and Banks' Risk-Taking: A Literature Review.....</b> | <b>3</b>  |
| 2.1. ECB's Conventional Monetary Policy.....                                                       | 3         |
| 2.2. ECB's Unconventional Monetary Policy.....                                                     | 4         |
| 2.2.1. An Overview of the ECB's Unconventional Monetary Policy Measures .....                      | 6         |
| 2.2.2. Institutional Setting .....                                                                 | 10        |
| 2.2.2.1. The Eurosystem's Unconventional Monetary Policy Measures of 2007-2009                     | 10        |
| 2.2.3. The transmission channels of Unconventional Monetary Policy.....                            | 12        |
| 2.3. The Effects of Unconventional Monetary Policy: Empirical Evidence .....                       | 15        |
| 2.3.1. The Effects of Unconventional Monetary Policy Measures in the Banking System                | 15        |
| 2.3.2. Relation Between Unconventional Monetary Policy and Banks' Risk-Taking                      | 17        |
| <b>3. Empirical Strategy.....</b>                                                                  | <b>22</b> |
| 3.1. Identification.....                                                                           | 22        |
| 3.2. Data and Summary Statistics .....                                                             | 25        |
| 3.2.1. Data Sources.....                                                                           | 25        |
| 3.2.2. Summary Statistics.....                                                                     | 25        |
| 3.3. Empirical Results .....                                                                       | 29        |
| 3.3.1. Impact of ECB's Unconventional Monetary Policy Measures on Credit Supply                    | 29        |
| 3.3.2. Impact of ECB's Unconventional Monetary Policy Measures on Credit Risk                      | 33        |
| <b>4. Conclusion.....</b>                                                                          | <b>35</b> |
| <b>5. Appendix .....</b>                                                                           | <b>36</b> |

|                     |    |
|---------------------|----|
| 6. References ..... | 39 |
|---------------------|----|

## List of Tables

|                                                                   |    |
|-------------------------------------------------------------------|----|
| Table 1 - Variables Definition .....                              | 26 |
| Table 2. Summary Statistics. ....                                 | 27 |
| Table 3. Balance Checks .....                                     | 27 |
| Table 4. Firm Credit Supply Results – Static Specification .....  | 29 |
| Table 5. Firm’ Credit Supply Results – Dynamic Specification..... | 36 |

## List of Figures

|                                                                                           |    |
|-------------------------------------------------------------------------------------------|----|
| Figure 1. Sources of finance for non-financial corporations in the period 2004-2008 ..... | 11 |
| Figure 2. Effects of ECB's liquidity operations exposure .....                            | 32 |

# 1. Introduction

Since the 2008 Global Financial Crisis (GFC), an empirical literature regarding the relationship between monetary policy and banks' risk-taking has been growing. The period before the crisis was marked by a persisted low interest rate environment and reduced credit standards by the banking system, which encouraged banks to adopt a riskier behavior (Jimenez et al., 2014). Also, recent works have found evidence that high levels of liquidity injections by the Central Banks, including the European Central Bank (ECB), increase banks' credit risk (Bednarek et al., 2021; Carpinelli & Crosignani, 2021). More recently, the ECB has been using its liquidity support programs to face the consequences of the COVID-19 crisis. In this manner, it is of the utmost relevance to investigate whether ECB's liquidity injections into the banking sector can incentivize banks' risk-taking behavior.

The GFC and the Euro area sovereign debt crisis prompted the ECB to implement a set of extraordinary measures to bring inflation to its target in the medium term and guarantee the stability of the banking system, as conventional monetary policy became insufficient to achieve price stability when nominal interest rates reached the zero lower bound (ZLB) (Joyce et al. 2012). Those measures included the Asset Purchase Program (APP), the establishment of a negative rate for the deposit facility, forward guidance, and the Targeted Longer-Term Refinancing Operations (TLTROs). Under the APP, the ECB buys private and public sector assets from European supranational institutions (ECB, 2021). The targeted lending programs are intended to increase credit creation through longer-term funding operations offered to banks at attractive prices, while forward guidance is a form of communication by the ECB about the future course of monetary policy. All these measures aim to achieve the ECB's main goal, which is price stability.

Even though recent literature provides ample evidence that the ECB's funding contributes to an increase in banks' credit supply - thus providing support to the bank lending channel<sup>1</sup> - far less attention has been given to whether these non-standard measures motivate banks to lend more to riskier firms. By providing extra liquidity to the banking system, the ECB creates an incentive for banks to lend more by decreasing its lending standards, which in turn can induce in a risky behavior. This potential negative side of ECB's unconventional monetary policy led to the development of a growing literature that studied the impact of the non-standard measures

---

<sup>1</sup> The bank lending channel refers to the fact that Central Bank's decision can affect banks' lending behavior, which will have an impact on the real economy. The transmission channels of monetary policy are explained in more detail in subsection 2.2.3..

introduced by central banks and its transmissions mechanisms. This dissertation aims to empirically contribute to the analysis of the called risk-taking channel, as some authors such as Brana et al. (2019) and Demiralp et al. (2021) studied before. In doing so, we study the link between Portuguese banks' risk-taking and ECB's liquidity operations during April 2007-August 2009. Portugal is an excellent case study as most corporations are highly dependent on bank debt. Moreover, Portugal was one of the most affected countries by past crises and, consequently, in more need of ECB help (which hence resulted in the implementation of unconventional measures). Therefore, our study proposes to study the transmission of ECB's liquidity operations through banks' risky behavior, by examining if Portuguese banks lend more to firms that have a higher probability of default (i.e., present a higher level of overdue credit) after ECB's non-standard interventions after April 2008<sup>2</sup>.

The aforementioned circumstances motivate the study of the present work. As the banking industry has a prominent position in sustaining the flow of credit during economic downturns, it is important to understand the effects of ECB's monetary policy decisions on credit risk-taking. In addition, historical episodes of financial crisis, such as the GFC and the Euro area sovereign debt crisis, motivates the study of the impact of monetary policy on banks' lending behavior and its transmission mechanisms, as the ECB has used its non-standard tools to recover from both crises. Furthermore, the recent COVID-19 crisis has also highlighted the need to understand the transmission of unconventional monetary policy.

In this context, this dissertation intends to answer the following question: "do ECB's liquidity operations contribute to an increase in Portuguese banks' risk-taking behavior?". The main goal is to understand how unconventional monetary policies transmit to the real sector and if they can incentivize greater risk-taking by the Portuguese banking system. To answer the research question, first, a review of the literature related to ECB's non-standard measures and credit risk-taking will be conducted. Second, an empirical analysis of the impact of unconventional monetary policy on Portuguese firms' credit is made by applying a difference-in-differences methodology. We separate firms into two groups according to their exposure to banks receiving more or less of ECB's liquidity. Then, we investigate the impact of ECB's non-standard operations in firms' total credit and overdue credit. This allows to investigate how much Portuguese firms are exposed to banks receiving funding from the Eurosystem, as well as if such exposure increases credit supply and/or credit risk.

---

<sup>2</sup> April 2008 is the reference month of our specification. It is the date that the ECB started conducting the 6-month supplementary longer-term refinancing operations.

The present work is organized as follows. The following chapter presents a literature review on ECB's unconventional monetary policy and its transmission channels. Also, we present an empirical literature on ECB's non-standard measures and their effects on credit supply, as well their influence on banks' risk-taking behavior. Chapter 3 describes the empirical strategy and the procedures to answer our research question. Subsection 3.3 presents the empirical results, while finally chapter 4 concludes.

## **2. European Unconventional Monetary Policy and Banks' Risk-Taking: A Literature Review**

In this chapter, a literature review is made on Euro area unconventional monetary policy transmission and its effects, focusing on banks risk-taking. After briefly describing ECB's conventional monetary policy and its instruments, a more detailed analysis on unconventional monetary policy is presented, focusing on the non-standard measures adopted over the past years, and more recently, the ECB's actions in the context of the COVID-19 economic crisis. Moreover, the different transmission mechanisms of unconventional monetary policy are discussed. Then, an empirical literature regarding the linkage between unconventional monetary policy and banks' risk-taking behavior will be reviewed, looking also at the several contributions in the literature regarding the relationship between ECB's liquidity injections and credit risk.

### **2.1. ECB's Conventional Monetary Policy**

Before analyzing ECB's unconventional monetary policies implementation following the 2007 financial crisis, this section gives a brief description regarding the conduct of monetary policy before this event.

Monetary policy is described as the central banks' actions to affect output and inflation through interest rates, money supply and credit amount (Mishkin, 2007). Before the GFC, it had become normal practice for monetary policy to be conducted through changes in short-term interest rates. According to Borio and Disyatat (2010), liquidity management operations, i.e., the control of a central bank's amount of funds in financial markets, played exclusively a supportive role "*to ensure that a market "reference rate", typically an overnight rate, tracks the desired interest rate level closely*" (p.2). Therefore, before the financial crisis, the ECB only relied on conventional monetary policy measures to achieve its primary monetary policy goal – price stability - which before the crisis period meant keeping inflation below but close to 2 percent over the medium term. Nowadays,

the ECB has a new symmetric 2 percent inflation target. Nevertheless, conventional monetary policy is when central banks adjust a short-term interest rate – their policy interest rate – to achieve their objectives and communicate about its future path (Borio & Zabai, 2016).

Within its monetary policy framework, the ECB carries out *open market operations* – one of the ECB’s standard monetary policy instruments – to influence the levels of its interest rates and manage liquidity in the financial markets (ECB, 2022a). These operations consist of purchases and/or sales of financial assets, and are divided by: i) regular operations - the MROs, carried out weekly to provide liquidity to European banks, and the longer-term refinancing operations (LTROs)<sup>3</sup>, created to provide longer-term refinancing to counterparties, normally having a maturity of 3 months; and ii) non-regular operations: LTROs with maturities up to four years, TLTROs, PELTROs (Pandemic Emergency Longer-Term Refinancing Operations), APP and PEPP (Pandemic Emergency Purchase Programme). After the GFC, the ECB relied mostly on this type of operations (non-regular), which will be described later when we discuss unconventional monetary policy.

The ECB sets three different interest rates every six weeks: i) marginal lending facility rate (MLFR), ii) deposit facility rate (DFR) and iii) rate on the MROs, called refinancing rate (ECB, 2022a). These are known as ECB’s key interest rates. The MLF determines the interest rate at which the Eurosystem provides liquidity to banks overnight. The DFR represents the rate at which banks can deposit their excessive liquidity with the Eurosystem overnight. These two rates are one of another ECB’s conventional instruments – *standing facilities* – and determine the levels within which the overnight rates in the interbank market fluctuate normally (ECB, 2022a).

The last ECB’s conventional instrument of monetary policy is called the “minimum reserve requirement”. Under this system, credit institutions are required to hold compulsory deposits in accounts with the national central banks (NCBs) (ECB, 2022a). These “minimum” or “required reserves” are established according to the size and composition of banks’ liabilities. Since January 2012, the minimum reserve ratio set by the ECB is 1%. (ECB, 2022a).

## **2.2. ECB’s Unconventional Monetary Policy**

In light of the interconnectedness of the last subsection, the GFC required the ECB to expand its set of monetary policy instruments to deal with the challenges brought by the stress in financial

---

<sup>3</sup> Under these operations, banks can borrow directly from the Eurosystem at the refinancing rate through reverse transactions.

markets and the banking system. The pre-crisis period (2003-2007) in the Euro area was marked by unusually low interest rates and a rapid increase in credit availability, which hence resulted in a domestic credit boom (rapid credit growth) - a key predictor of a banking crisis, as Lane (2012), for example, referred. The crisis deepened with the Lehman Brothers' failure, in September 2008. This financial shock prompted the ECB continued its attention into stabilizing the banking sector. To avoid the risk of spillovers and guarantee price stability, the ECB decided to decrease its key policy interest rates and implement non-standard policy measures (ECB, 2010). Since physical currency offers a zero nominal interest rate, the central bank is impaired when it comes to lower its conventional monetary policy instrument – the short-term nominal interest rate – below zero (Heider & Leonello, 2021). This zero lower bound (ZLB) constraint is the reason that many central banks could not achieve their financial goals through conventional methods, and thus were required to use non-standard instruments to restore economic activity. More specifically, when monetary authorities can no longer stimulate the economy and increase aggregate demand by reducing the short-term nominal rate, they turn to unconventional monetary measures.

Some authors (Joyce et al., 2012; Borio & Zabai, 2016) define unconventional monetary policy as when central banks try to influence financial conditions through changes on their balance sheet. Joyce et al. (2012) states *“the more common forms of unconventional monetary policy involve massive expansion of central banks' balance sheet and attempts at influencing interest rates other than the usual short-term official rates”* (p.272). In this sense, unconventional monetary policy differs from traditional monetary policy from the fact that central banks try to achieve its economic and financial objectives through changes in their balance sheets in terms of size and composition (most referred to as “quantitative easing” [QE]), and not by directly controlling their policy interest rates (Borio & Zabai, 2016). According to Borio and Zabai (2016), balance sheet policies translate in *“adjusting the size/ composition of the central bank balance sheet and influencing expectations about its future path to influence financial conditions beyond the policy rate”* (p.3).

Bernanke and Reinhart (2004) refer to unconventional monetary policy measures as alternatives when the short-term nominal interest rate is near or at the zero bound. Such strategies also involve the change in central banks' balance sheet composition and size, in addition to their credible commitment to maintain the short-term rate at low levels for a prolonged period. This embraces a clear communication by the central bank about the future course of the short-term rates to the public, following its assessment of the outlook for inflation and economic situation. Such strategy is known as forward guidance and it is one of the first non-traditional tools used by the ECB to stimulate the economy, given the ZLB. The purpose of this measure is to influence financial market participants' expectations about the future of monetary policy, since the well-functioning

of financial markets relies on agents' expectations (Bernanke & Reinhart, 2004). As Eggertsson and Woodford (2003) argued, and then highlighted by Bernanke and Reinhart (2004), the most effective way to change the long-term interest rates is by managing expectations about the future course of short-term interest rates. It is important to note that credibility plays a key element in expectations management, as emphasized by the authors.

Eggertsson and Woodford (2003) also referred that the transmission of monetary policy depends partly on long-term assets' prices and yields, which in turn depend on consumers, businesses, and investors' expectations. The authors claimed that unconventional monetary policy can result in a reduction of long-term bond yields, but only in the presence of a credible commitment by the central bank to keep interest rates low for a prolonged period. In fact, Eggertsson and Woodford (2003) highlighted that forward guidance is crucial for other central bank's measures to work effectively. For instance, as Andrade (2016) noted, the transmission of QE depends on financial market participants' expectations about the future course of interest rates. The transmission channels of UMP will be discussed in more detail in subsection 2.2.3..

### **2.2.1. An Overview of the ECB's Unconventional Monetary Policy Measures**

In this section, we will explore ECB's non-standard policy measures since the GFC, and more recently, in the context of the COVID-19 pandemic crisis.

Following the GFC, the ECB engaged in non-traditional monetary policy measures to support the banking system, in the context of the importance of banks in the transmission of monetary policy to the real sector (Barbiero et al., 2021). These measures comprehended, firstly, the introduction of the first supplementary LTROs with a maturity of six months. Then, the ECB switched from a variable rate tender format to a fixed-rate full allotment in the open market operations, where the interest rate is fixed by the ECB and the bids of counterparties are fully satisfied by the central bank. The weekly main refinancing operations (MROs) were carried through the full allotment policy, which main goal was to improve the liquidity situation of the European banks. The ECB also decided to expand the set of eligible assets that could be accepted as collateral. Additionally, the ECB participated in currency swap arrangements with the Federal Reserve to provide liquidity in foreign currency (dollars) to European banks (Lane, 2012). In 2009, the LTROs with one year maturity were announced to grant the banking system an opportunity to borrow money from the ECB at very low interest rates and were also conducted as fixed rate tender procedures with full

allotment. Furthermore, the ECB started to purchase covered bonds under the first covered bond purchase programme (CBPP1). (ECB, 2010).

During the end of 2009 and beginning of 2010, Euro area sovereign debt markets were experiencing increased volatility and perceived credit risk due to rising estimates of losses from the banking system, which was negatively affecting sovereign bonds by increasing its spread and decreasing its prices (Laine, 2012). Therefore, on May 2010, the ECB introduced the “Securities Market Programme” (SMP), with the main purpose of reestablishing the well-functioning of monetary policy transmission (ECB, 2010). Under the SMP, the ECB purchased government debt, mostly from the more affected countries by the crisis, which included Portugal. In May 2011, CBPP2 was implemented. Moreover, to support financial intermediation, the ECB announced two LTROs in December 2011, also known as very long-term refinancing operations (VLTROs), but the second LTRO was only conducted in February 2012. These operations were a complement to the MROs, with the particularity of reaching a maturity up to three years and the possibility of repayment after one year (ECB, 2011a). Also, towards the negative repercussions of the crisis, the ECB announced the outright monetary transactions (OMT), under which the central bank buys unlimited government bonds issued by Eurozone countries; however, this programme was not activated.

In 2014, the ECB announced a new set of UMP measures to avoid a deflation crisis as price levels were too low. As mentioned before, the ECB’s conventional monetary policy tools are its key interest rates. Since ECB’s key interest rates were already at very low levels, and thus reducing them would not result in an economic stimulus, different measures needed to be adopted to keep inflation in line with ECB’s primary goal and lower government bond yields.

The Governing Council of the ECB started practicing forward guidance in July 2013 when communicated its intentions to keep its key interest rates at present or lower levels for a prolonged period (ECB, 2022d). By communicating on the expected path of interest rates, the ECB can influence individuals’ (investors, businesses, and households) expectations and their economic decisions. For instance, if the ECB communicates that it is expected that interest rates remain at low levels in the future, the banking system may be more prone to set the interest rates for long-term loans also at a lower level, since it will be easier for them to borrow from the central bank if needed. This means households and businesses will be able to get cheaper funding, hence investment and spending will rise, as inflation and economic activity (ECB, 2022b).

Also, for the first time in Europe, nominal target interest rates were set below zero, referred as “negative interest rate policy (NIRP)”. In June 2014, the DFR successively reached negative levels,

from 0 to  $-0,10\%$ , reaching its lowest value ( $-0,50\%$ ) from September 2009 to July 2022. The main purpose of reaching the negative territory was to create an incentive for banks to lend money to investors and consumers instead of holding it as reserves, as they would need to pay the central bank if they decided to hold the cash. A present concern in the literature regards the relationship between negative interest rates and banks' risk-taking behavior. After the introduction of negative rates, there has been a growing debate in the literature about whether this unconventional monetary policy measure has effectively contributed to stimulate bank lending activity, and simultaneously, its potential negative side effects, such as increasing bank risk-taking (Heider & Leonello, 2021). Besides entering the negative territory, the ECB has also dealt with very low interest rates for a prolonged period. This environment raises concerns about the efficacy of the transmission of monetary policy through the bank lending channel, which will be reviewed later in subsection 2.2.3..

Furthermore, a first series of the targeted longer-term refinancing operations (TLTROs) was announced to grant the banking system with cheap long-term funding and contribute to an effective monetary policy transmission. Until now, the ECB has announced three series of TLTROs: i) TLTRO-I on 5 June 2014, ii) TLTRO-II on 10 March 2016 and iii) TLTRO-III on 7 March 2019. The TLTROs are targeted operations – as the name itself says – because the total borrowing that banks can ask the central bank is linked the total amount of loans they issue to the non-financial private sector, excluding credit for house purchase (Sugo & Vergote, 2020). In contrast to previous refinancing operations, the TLTROs offers funds at more attractive prices, which are conditional on participating banks achieving lending targets. Thus, the targeted lending operations create an incentive for banks to lend, especially in an economic downturn scenario, where banks are more reluctant to offer their funds to the real sector. In the first series, the ECB conducted 8 quarterly operations during the period of September 2014 and June 2016, where participating banks were entitled to an initial borrowing allowance equivalent to  $7\%$  of the total amount of their eligible loans<sup>4</sup> and the interest rate on these operations was linked to the rate on the MROs (ECB, 2014). The TLTRO-II consisted of 4 quarterly operations between June 2016 and March 2017, where counterparties were allowed to borrow a total amount of  $30\%$  of their eligible loans (Barbiero et al., 2021).

On January 2015, the Expanded asset purchase programme (APP) was announced and consists of 4 programs: i) Third Covered Bond Purchase Programme (CBPP3); ii) Asset-Backed Securities Purchase Programme (ABSPP); iii) Public Sector Purchase Programme (PSPP) and iv) Corporate

---

<sup>4</sup> Eligible loans refer to a bank's loan to businesses and households, except loans to households for house purchase.

Sector Purchase Programme (CSPP). Both the CBPP3 and ABSPP were announced by the ECB on 2014, where the Eurosystem bought covered bonds in the primary and secondary markets under the first programme, and asset-backed securities under the latter. Moreover, the PSPP was introduced in the following year and purchases of public sector securities were purchased by the Eurosystem in the secondary market. Also, on March 2016, the CSPP was announced by the ECB's Governing Council, which is a programme that consists of net purchases of securities issued by non-bank corporations by the Eurosystem.

More recently, with the COVID-19 crisis, the Governing Council of the ECB required again to strengthen monetary policy and its transmission mechanism through unconventional measures. Even though the pandemic exogenously affected the banking industry, it is crucial that monetary authorities support banks to continue to provide credit to the real economy. In this sense, the PEPP, a new short-term instrument introduced in March 2020, was created to face the consequences of the pandemic outbreak. The program consists of ECB's purchases of private and public sector securities, with all assets permitted in the APP being also eligible under the PEPP (ECB, 2021a). Complementarily, the third series of TLTROs was recalibrated to support bank lending provision to firms and households most jeopardized by the crisis. The recalibration of TLTRO-III included an expansion of the eligibility of the assets that could be used as collateral by banks. The ECB decided to reduce the interest rate on all TLTRO-III operations to -0.5% from June 2020 to June 2021, i.e., 50 basis points below the average rate applied in the MRO. Also, to prevent a credit squeeze during this period, the ECB created an incentive scheme for banks. Banks that achieve the lending performance threshold, the interest rate applied in TLTRO-III operations can be as low as -1%, that is, 50 basis points below the average interest deposit facility rate (Barbiero et. al, 2021).

Moreover, on 30 April 2020, the ECB announced the initial series of seven PELTROs to be implemented with an interest rate that is 25 basis points below the MROs, which was at 0%, and with full allotment. These operations aimed to serve as a liquidity backstop to European banking groups and support the transmission of monetary policy (ECB, 2020a). The ECB temporarily expanded the range of assets that can be used as collateral to support and facilitate borrowing conditions and has been less strict about the amount of capital banks are required to preserve as a buffer to face harder times, to make sure banks have a higher lending capacity (ECB, 2021b).

These non-traditional monetary policy measures were implemented by the ECB to bring inflation to its 2% target level and to help the European banking system keep providing credit to the real economy during difficult times. Therefore, asset purchases constitute an important monetary

policy measure to achieve ECB's inflation goal, complemented with TLTROs, forward guidance and negative interest rates.

## **2.2.2. Institutional Setting**

Our analysis covers the period from April 2007 to August 2009. In this subsection, we describe the main features of the ECB's unconventional monetary policy measures during this period and the challenges inherent to their implementation in an environment of financial market tension, as well as the reason why we choose this sample period for our analysis.

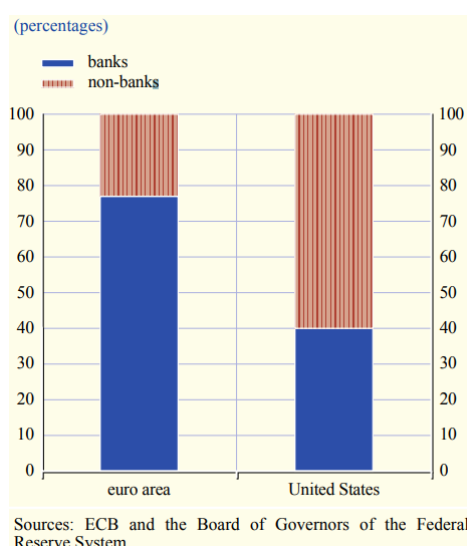
### **2.2.2.1. The Eurosystem's Unconventional Monetary Policy Measures of 2007-2009**

Our model covers the period of the beginning of the malfunctioning of the money markets (August 2007) due to changes of investors and consumers' risk perceptions regarding banks intermediation of funds, as the latter had increased their risk-taking in the period before, as previously mentioned in the literature review. As a result of this, the transmission of the monetary policy stance was impaired. Such obstacles in maintaining an effective monetary policy transmission to the economy led the ECB to implement unconventional monetary policy measures, which meant to be temporary (ECB, 2011). It is important to note that, during our empirical analysis, ECB's key interest rates had not reached the ZLB, and unconventional monetary policy was seen as a complement to ECB's conventional methods to achieve its goals. Nevertheless, the ECB decided to provide liquidity to financial intermediaries through supplementary 3-month and 6-month LTROs under a variable rate format, while continuing with the regular 3-month LTROs. The objective was to support funding for banks and restore the well-functioning of euro area money markets (ECB, 2008).

Following the Lehman Brothers' failure, in September 2008, the pass-through from ECB's interest rates to money market rates and banks' access to liquidity was impaired (ECB, 2011). Thus, the ECB adopted a few extraordinary measures, in October 2008, to avoid a severely contraction in banks' lending supply. It is important to guarantee that banks keep lending to the real sector, as they play an important role in the transmission of monetary policy. Figure 1 shows that during the period from 2004 to 2008, European non-financial corporations were highly dependent on

financial system banks' financing (ECB, 2011). According to the figure, in the Euro area, more than 70% of non-financial corporations were having access to funds through the banking system, in comparison to only 40% in the U.S.. In fact, in the Euro area, banks are traditionally the principal source of finance to firms and households. Thus, banks response to ECB's actions plays a crucial channel through which monetary policy impacts the economy (ECB, 2008).

**Figure 1. Sources of finance for non-financial corporations in the period 2004-2008**



Source: ECB Monthly Bulletin October 2010.

Therefore, the ECB started with the implementation of a fixed-rate full allotment in all its refinancing operations, i.e., the central bank decided to switch from variable rate tenders to fixed rate rates tenders, allocating the entire amount of liquidity requested by the counterparties at a fixed rate<sup>5</sup>. This meant that there was no limit on the amount a bank could borrow from the central bank, if they pledge sufficient adequate collateral<sup>6</sup> (ECB, 2008). Another important measure of the ECB was to expand the list of assets that could be accepted as collateral. Furthermore, the ECB expanded the maturity of the LTROs to 12 months, in June 2009. Moreover, the ECB provided US dollars liquidity arranged via swap lines with the FED (Lane, 2012). All these non-standard measures are characterized as “*enhanced credit support*” policies and had as its primary focus the banking system. Note that, during this time, specifically from October 2008 to May 2009, ECB's rate on its MROs lowered from 4.25% to 1%. (ECB, 2011).

<sup>5</sup> The rate was fixed by the ECB.

<sup>6</sup> Includes covered bonds, corporate bonds, government bonds, among other debt securities (Carpinelli & Crossignani, 2021).

Against this economic background, we have chosen this sample period (April 2007 – August 2009) to identify a clear connection between ECB’s liquidity injections and the evolution of Portuguese firms access to banks’ credit. Particularly, the sample starts in April 2007 because the stress in interbank markets due to the GFC started only in August 2007, thus allowing to understand better the impact of ECB’s unconventional measures on credit supply. Also, Portuguese firms were heavily dependent on bank debt at that time, which means the transmission of ECB’s funding to banks could have important implications for firms access to credit. We do not extend our sample period beyond August 2009 because in the next following months, ECB started with another round of unconventional monetary policy measures to deal with the consequences of the Euro area sovereign debt crisis. For instance, on May 2010, the ECB implemented the SMP. Previous studies, for example García-Posada and Marchetti (2016), highlight the fact that the literature on liquidity injections by the ECB faces a major challenge that regards to disentangle the effects of liquidity operations from the impact of other central bank’s unconventional measures that had been adopted simultaneously. Thus, finishing our sample period in August 2009 allows to identify the full liquidity impact underlying ECB’s non-standard measures after the GFC that aim explicitly to support bank credit.

### **2.2.3. The transmission channels of Unconventional Monetary Policy**

The transmission mechanism of monetary policy is defined as the process through which central banks’ monetary policy decisions have an impact on the real economy and, specifically, on inflation levels (ECB, 2022). Many authors (Borio & Disyatat, 2010; Andrade et al., 2016; Albertazzi et al., 2021; Brana et al., 2019) have studied how non-standard monetary policy affects the real economy, identifying the theoretical channels and explaining how they work. In this section, we will focus on and describe the following channels: i) *signaling channel*; ii) *bank lending channel*; iii) *portfolio rebalancing channel* and v) *risk-taking channel*. The latter will be given more emphasis throughout the following sections, as this dissertation focuses on the linkage between banks’ risk-taking and unconventional monetary policy measures.

The *signaling channel* relies on the central bank communication to the public about the future path of short-term interest rates and future balance sheet adjustments (Borio & Disyatat, 2016). Since financial market participants have imperfect information, a clear signal provided by the central bank regarding the future level of nominal interest rates and/or the implementation of balance sheet policies can influence agents’ expectations, and hence their investment choices. As mentioned before, a crucial aspect of expectations management depends on the credibility of the

central bank (Eggertsson & Woodford, 2003). For instance, in the ZLB context, if financial market participants expect short-term rates to be low in the future due to central bank's announcement and commitment, they will bid down long-term bond yields and bid up asset prices, boosting aggregate demand (Bernanke & Reinhart, 2004). Therefore, the efficacy of this channel relies on the private sector's expectations about the future path of short-term rates and in central banks' credibility. According to Jorgensen and Krishnamurthy (2011), asset purchases (QE) can increase a central bank's credibility to keep interest rates low in the future, because the central bank would incur losses on the assets bought if the rates would increase.

The *bank lending channel* supports the important role of the banking system in the transmission of monetary policy. Through this channel, unconventional monetary policy measures are expected to have an impact on the economy via banks' credit supply. More specifically, an expansionary monetary policy increases bank reserves and asset prices, and consequently lowers banks' lending constraints by decreasing interest rates and improving the liquidity situation of the banking sector (Apergis & Christou, 2015). Thus, large liquidity injections from the central bank are expected to increase loan supply, especially from banks more exposed to central banks' operations. This increases credit availability and stimulates borrowing from businesses and consumers, thereby increasing aggregate output. However, the transmission of negative rates raises to the economy concerns about its efficacy through the bank lending channel, as already mentioned before.

First, a policy rate cut from a conventional point of view about monetary policy is commonly seen as a good method to stimulate the economy and achieve central bank's objectives. However, when interest rates are already very low, a policy rate cut may not have expansionary effects (Parriès et al., 2020). Generally speaking, investors will deposit their funds in the banking system as long as the deposit rate is superior to the return of another investment option. If not, investors may decide to buy bonds or even hold cash instead. This perfect substitutability between banknotes and deposits creates a ZLB on retail deposit rates (Heider & Leonello, 2021). Because investors have the option of holding cash and not deposit their money in a bank, financial intermediaries can only decrease its deposit rates to a certain point. Thus, beyond the ZLB constraint, a policy rate cut has less impact on banks' funding costs due to the imperfect pass-through to deposit rates (Heider & Leonello, 2021; Parriès et al. 2020). In other words, the pass-through of negative rates to deposit rates faces a ZLB constraint, while simultaneously, the pass-through of negative rates to lending rates does not. This can decrease banks' profitability.

In this context, some authors, for example, Parriès et al. (2020), Heider and Leonello, (2021), Brunnermeier and Koby (2018), point out that in an environment of very low interest rates, and

even negative rates, further expansionary monetary policy stimulus might result in a contractionary impact instead and reduce banks' credit supply. In other words, this literature refers to the existence of a "reversal rate", which Brunnermeier and Koby (2018) defined it as "*the rate at which accommodative monetary policy reverses its intended effect and becomes contractionary for lending*" (p.8). As Parriès et al. (2020) mentioned, when the policy rate is reduced to very low levels, the spread between the policy rate and deposit rate turns negative, decreasing banks' net worth. Thereby, Heider and Leonello (2021) refers to the existence of a reversal rate if a policy rate cut negatively impacts banks' net worth and hence forces banks to reduce their credit supply because of regulatory constraints. With low interest rates, the pass-through of a reduction in the central bank's policy rate to banks deposit rates is weaker than the pass-through to lending rates (Heider & Leonello, 2021). As mentioned before, banks' profitability can decrease as a result. Thus, an expansionary monetary policy becomes contractionary, and a reversal occurs – a policy rate cut does not increase the amount of banks' lending supply, it decreases instead. This circumstance makes banks less prone to do screening on borrowers, as screening is costly and since banks are already facing losses on their profits, the incentives to perform screening of borrowers decrease. Financial intermediaries perform screening because loans are risky, and this process increases the probability of the loan being total repaid. Hence, if a policy rate cut below the reversal rate results in less screening, this means that banks increase their risk-taking because of such situation (Heider & Leonello, 2021). Moreover, in a context of low interest rates and a policy rate cut occurs decreasing banks' net interest income, banks may decide to invest in higher-yielding alternatives to compensate for this lost, thus taking on more risk (Brunnermeier and Koby, 2018; Heider & Leonello, 2021).

The *portfolio rebalancing channel* is based on the premise of imperfect substitutability of assets – assets are imperfect substitutes in investors' portfolios - presented by Tobin (1969). According to Bernanke and Reinhart (2004), if money and other financial assets are imperfect substitutes, a large increase in money supply (e.g., purchase of securities by the ECB) will result in attempts from investors to rebalance their portfolios. This behavior will increase prices and decrease yields on non-money assets. In other words, as Paludkiewicz (2021) explained, when the central bank purchases a particular asset, this raises its price and lower its yield, which in turn can result in a search by investors for higher-yielding alternatives. For instance, the compression in yields in safe assets may incentive banks to lend more to companies and households (ECB, 2015). Such increase in banks' lending will stimulate investment and consumption.

Borio and Zhu (2012) introduced the concept of *risk-taking channel*, defining it as the channel through which changes in monetary policy increases banks' risk exposure. A prolonged period of

low interest rates softens banks' lending standards and makes them more willing to lend to the private sector. Such decrease in credit standards can result in a higher incentive for banks to increase their risk-taking (Bonfim & Soares, 2018; Maddaloni & Peydró, 2011). The risk-taking channel operates through the search-for-yield mechanism, which occurs through the asset side of financial intermediaries (Bonfim & Soares, 2018). As Maddaloni and Peydró (2011) explained, low policy rates decrease the attractiveness of riskless assets and may induce banks to search for higher yielding options, such as loans, increasing their risk-taking. Bonfim and Soares (2018) and Dell'Ariccia et al. (2014) also add the fact that an expansionary monetary policy reduces banks' cost of funding and so decreases the incentive for banks screening of borrowers, which in turn increases their risk-taking.

### **2.3. The Effects of Unconventional Monetary Policy: Empirical Evidence**

The effects of unconventional monetary policy measures in the economy have been much studied in the literature. In section 2.3.1, we review the effects of such operations in the banking system, with particular attention to the European banking sector. Since our focus is the linkage between non-standard policy measures and banks' risky behavior, in section 2.3.2 we study the influence of unconventional policies on banks' risk-taking.

#### **2.3.1. The Effects of Unconventional Monetary Policy Measures in the Banking System**

This dissertation is associated to empirical studies focusing on central bank liquidity injections into the banking system, such as asset purchases and refinancing operations with longer maturities, and its influence on banks' lending behavior.

Some authors studied the relationship between unconventional monetary policy and banks' lending activity. For instance, Afonso and Sousa-Leite (2020) analyzed the transmission of the first two series of TLTROs to bank credit supply for the Euro area and specifically for Portugal, having concluded that the targeted operations incentivized banks to lend more to the real sector, while contributing to an improvement in financial conditions. They used a sample of 19 European countries and divided into "more vulnerable countries", like Portugal, Greece, and Italy, and "less vulnerable countries" as Germany, France, and Austria, and found that TLTROs impacted more strongly the latter group, since that for each additional euro borrowed under ECB's target operations, banks from less vulnerable countries increased the annual credit granted by 2.5 euros,

according to the authors results. In the same line, Balfoussia and Gibson (2015) found a positive relationship between the implementation of TLTROs and financial conditions. In addition, Benetton and Fantino (2021) studied the effects of TLTROs Italian banks' credit supply to firms by estimating a difference-in-differences model. According to their model, the authors found that banks participating in TLTRO-I and II decreased their rates to the same firm by approximately 20 basis points more in comparison with non-participating banks. Moreover, their findings show that more affected banks also decreased their fraction of government bonds, while simultaneously increasing their loan supply to Italian firms. Furthermore, banks that participate on ECB's TLTROs can substitute market-based funding with borrowing from the Central Bank, which can reduce the supply of bonds, and hence bank bond yields decline. According to Andreeva and Garcia-Posada (2021), this scenario increases competitiveness in lending markets and non-participating banks will try to protect their market share by easing credit standards as well. Overall, this also can result in lower lending rates and higher credit supply.

However, Laine (2021) found that TLTRO-II had a significantly effect on lending to businesses but not to households, and a negative effect on government bond purchases. This last result is not surprising, because Carpinelli and Crosignani (2021) found that a large part of the VLTROs were to purchase governments bonds, which was not the main goal of these operations and this is one of the reasons why ECB has implemented the TLTROs, to target bank lending to non-financial corporations and to households, except for borrowing for house purchases.

Furthermore, Darracq-Paries and De Santis (2015) studied the effects of VLTROs for the largest eleven European countries in banks' lending, employing BLS data to identify credit supply shocks and estimating a panel VAR model over the period 2003Q1-2011Q4. They interpreted the 3-year LTROs as a credit supply shock, which size was computed by using simultaneously the April 2012 BLS and the special ad-hoc questions on the LTROs conducted in February 2012. The results are in line with previous conclusions already mentioned, i.e., VLTROs contributed to support financial intermediaries lending capacity and to a decline in the net tightening of credit standards for loans to the non-financial sector.

Gambetti and Musso (2017) used a structural VAR model to investigate the macroeconomic effects of the ECB's APP on Euro area real GDP (Gross Domestic Product) and HICP (Harmonized Index of Consumers Prices) inflation, introduced in January 2015. They found that the APP positively impacted Euro area GDP and inflation, while activating a portfolio rebalancing channel and a bank lending channel in the Euro area, through a significant decline in European banks' lending rates. On the contrary, Lewis and Roth (2019) do not find evidence that ECB's

APP activated a portfolio rebalancing channel nor a bank lending channel in Germany. The authors employed a VAR model and discovered that lending rates tended to rise over the medium term in response to asset purchases from the ECB, which means that borrowing did not become cheaper in Germany after the implementation of ECB's unconventional monetary policy measure. To justify this failure in APP to reduce lending rates, Lewis and Roth (2019) argue that the program activated a risk-taking channel, as Germany banks offered riskier loans to the real economy. Arce et al. (2021) studied the effects of CSPP on Spanish firms' financing conditions around its announcement date (March 2016). The authors, by using information available in Bank of Spain's Central Credit Register, found a "substitution effect" generated by this programme, that is, the CSPP increased the issuance of bonds by firms, while decreasing their demand for bank loans. However, this decline in bank loans after the announcement of the CSPP positively affected companies that do not issue bonds, as the banking sector reallocated their supply of credit towards these smaller firms, without increasing their risk-taking, according to the authors findings. In fact, the reallocation of credit was towards less leveraged and more profitable firms. Furthermore, the authors concluded that TLTRO-II program, in combination with CSPP, enhanced the positive impact on credit supply.

However, Kenourgios and Ntaikou (2019) discovered that during the crisis period (2009-2016), unconventional monetary policy had no statistically significant effect on banks' lending. The authors examined the impact of non-standard measures on bank credit supply and performance in the Euro area following the evolution of bank-specific variables across 3 different countries: i) eurozone, ii) core, and iii) peripheral, during the period of 2000 to 2016. Their conclusion demonstrates a lack of capacity of the ECB to influence bank credit decisions and profitability during the crisis. Also, they found that liquidity risk, measured by total loans to total deposits, played a key role in determining the lending strategy of banks during 2009 to 2016. Although, the authors realized an underestimation of this type of risk by banking groups of weaker economies, such as GIIPS', given the positive correlation between liquidity risk and banks' credit supply during the unconventional monetary policy strategy. Importantly, before the crisis period, monetary policy was effective in the Euro area, according to the authors.

### **2.3.2. Relation Between Unconventional Monetary Policy and Banks' Risk-Taking**

During the period before the GFC, specifically from 2002 to 2005, most central banks of advanced countries had maintained the nominal interest rates at historically low levels, which encouraged a

risky behavior from the banking system, translating into a decrease in credit standards (Jimenez et al., 2014). In response to the crisis, the ECB implemented unconventional monetary policy measures to restore the stability of financial markets. These extraordinary measures and its transmission to the economy have led to a growing debate in the literature about how central bank's decisions can incentivize greater risk-taking by the banking sector. Some studies, for example, Bonfim and Soares (2018) and Jimenez et al. (2014) show that a standard cut in interest rates can transmit to the economy through financial intermediaries' risk-taking, also referred to as the risk-taking channel. We contribute to the discussion by analyzing the relationship between ECB's unconventional liquidity operations on banks' risk-taking during the period from April 2007 to August 2009, using Portugal as our study reference.

In this context, most studies on the Euro area are related to the LTROs with a maturity of 3 years, created in 2011-2012. These mostly focus in one country and use loan-level data from central credit registers (managed by its the national central bank) to study shifts in credit supply using Khwaja and Mian (2008) methodology. On one hand, Carpinelli and Crosignani (2021) studied the transmission of LTROs to Italian banks, from December 2010 to June 2012, and showed that ECB liquidity provision was fundamental to banks during the wholesale market dry-up phase. Using national credit registry with supervisory data on banks' security holdings, the authors found that the LTROs helped to avoid a further deterioration of the Italian banks' intermediation capacity, but when comparing less exposed banks to this intervention to more exposed ones, with firm-level data, they showed the latter increased their credit supply towards large, low-profitability and riskier firms after the liquidity operations. On the other hand, Andrade et al. (2019), by using a sample of bank-firm credit relationships of 24 French banks from September 2011 to September 2012, found that LTROs did not increase banks risk-taking and that the operations had an overall positive impact on the banking system, contributing to support credit supply, especially to larger borrowers. Bednarek et al. (2021) identified a rise in credit risk for German banks because of central bank liquidity injections, using bank-firm level data from national credit registry during 2009Q1-2014Q4. This increase in banks risk-taking seems to be unrelated to bank-specific characteristics, such as size or liquidity, according to the authors. Paludkiewicz (2019) studied the existence of a yield-induced portfolio-rebalancing channel also for the case of Germany, during January 2013 until December 2015, and found that banks experiencing large average yield declines in their securities, because of unconventional monetary policy measures, especially the APP, increase more their credit supply to the real sector when compared to other banks. In this sense, the author found evidence that unconventional monetary policy decreases bond yields, hence giving the banking system an incentive to rebalance their portfolio towards higher-yielding

alternatives. Furthermore, Paludkiewicz (2019) found that German banks more exposed to ECB's liquidity operations increased more their contingency reserves between 2013 and 2015, which translates into a sign of more risk-taking. However, while measuring ex post credit risk by constructing the growth rate of loan losses, the author did not find that these banking groups faced more losses.

We contribute to the existing literature of one-country samples regarding the impact of ECB's liquidity operations in credit supply by studying other large European country – Portugal – that was also very affected by the past 2008 financial crisis and Euro area sovereign debt crisis<sup>7</sup>. Instead of loan-level data, we exploit a firm-level analysis to study how ECB's macro-liquidity interventions affected Portuguese firms' total credit and whether there is link between these operations with higher risk-taking capacity of the Portuguese banking system. To achieve this, we examine the evolution of firms' overdue credit throughout our sample period to measure credit risk, similarly to other studies present in the literature, such as García-Posada and Marchetti (2016) and Benetton and Fantino (2021) that used the non-performing loan ratio (NPL ratio) to measure the quality and riskiness banks' credit portfolio.

Other authors, such as Albertazzi et al. (2021), Brana et al. (2019), Altavilla et al. (2020) and Demiralp et al. (2021), studied the effects of unconventional monetary policy in the Euro area focusing on a larger study sample size. For starters, Albertazzi et al. (2021) used two samples for examining the portfolio rebalancing channel around ECB's APP: i) one covering the entire Euro area, divided by type and country and ii) another using individual bank holding data for the largest 25 Euro area banking groups. The authors found evidence that the APP induced banks to take on more risk by shifting their investment towards riskier assets, which confirmed the existence of a search-for-yield mechanism. A reduction in safe long-term yields after the announcement of the APP in 2014 reduced banks' lending rates and incentivized them to search for higher expected returns, such as loans. However, as loans are less liquid than other banks' assets and have a higher probability of default, this increases banks' risk-taking. In addition, Brana et al. (2019) presents evidence of banks' risk-taking using a dynamic panel model with a threshold effect and two different measures of credit risk: i) Distance to Default and the ii) asymmetric Z-score, to study the effects of nonstandard monetary policy measures through a sample of 126 banks in 20 European countries over the period between 2000 and 2015. They found that a decrease in interest rates incentives a higher risk-taking by banks, and additionally that central bank's liquidity

---

<sup>7</sup> Note that our empirical analysis does not include the analysis of the effects of ECB's unconventional monetary policy measures in credit supply during the Euro area sovereign debt crisis. Nevertheless, Portugal was significantly affected by this occurrence.

operations activate the risk-taking channel. Thus, according to Brana et al. (2019), banks' risk-taking is associated with an expansive monetary policy, such as liquidity injections or cuts of the central bank's key interest rates.

Regarding the framework previously mentioned in our literature about the transmission of negative rates to the economy (more precisely, subsection 2.2.3), one could say that NIRP may result in a contractionary effect. Nevertheless, the findings of Altavilla et al. (2020), from a sample of 121 European banks analyzed during the period of 2007 to 2018, does not show a negative impact on banks' profitability. The authors demonstrate that when the ECB decided to keep the deposit facility rate at a negative level, the transmission mechanism changed mostly for less healthy banks, suggesting that bank health contributes significantly for the effectiveness of the transmission of monetary policy under NIRP. To measure bank health, the authors used a dummy that captured banks without an investment grade rating, CDS spreads and non-performing loans (NPL). Moreover, their conclusions show that banks facing charges on their liquid holdings have more incentive to invest and reduce their liquid assets due to the cost imposed by the negative rates.

In fact, according to Demiralp et al. (2021), this abovementioned unconventional monetary policy measure has been expansionary in the Euro area by incentivizing banks to lend more through the portfolio rebalancing channel. More specifically, by using a sample with 241 European banks with balance sheet data from 2010Q1 to 2017Q3, the authors show that banks exposed to negative rates may alter the composition of their portfolios by engaging in a search for yield, to compensate losses in their net interest margins. As mentioned before, the pass-through of negative rates to deposit rates faces a ZLB constraint, while simultaneously, the pass-through of negative rates to lending rates does not. This can decrease banks' profitability. However, Demiralp et al. (2021) argued that European banks facing NIRP do not decrease their profits. In fact, the authors showed evidence that these banks tend to increase their credit supply and, importantly, they highlighted the importance of banks' excess liquidity for this expansionary effect. Apparently, financial intermediaries that depend more on retail deposits have higher incentive to use ECB's large liquidity provision (e.g., through the APP and TLTROs) to grant loans to the real sector (Demiralp et al., 2021). Overall, Demiralp et al. (2021) found that NIRP is effective in Europe, especially when combined with ECB's liquidity injections, such as the APP and TLTROs, but also increases a bank's risky behavior.

Studies such as Luck and Zimmermann (2020) and Matthys et al. (2020) found no relationship between unconventional monetary policy and banks' risk-taking in the United States (US). For instance, Luck and Zimmermann (2020) studied the employment effects of Federal Reserve's

(FED) QE by using firm-level data on investment and employment and presented evidence that large-scale asset purchases (LSAPs) can impact the real sector through a bank lending channel, like conventional monetary policy. According to the authors, LSAPs may increase employment levels through an increase in supply of bank loans. They highlight the fact that firms more exposed to banks receiving more of FED's liquidity increased capital investment and employment more than firms that did not borrow as much from this group of banks. Moreover, Matthys et al. (2020) found an association between easing monetary policy measures and lower loan spreads, especially a reduction for riskier firms, indicating no evidence of higher risk-taking in the syndicated loan market in the period analyzed (from 2008 and 2015).

Other studies, for example, Dang and Dang (2020), used a different methodology to study how monetary policy decisions affected Vietnamese banks' risk-taking during 2007 and 2018, did not find that an expansionary monetary policy action through cuts of interest rate is associated with banks risky behavior. The researchers concluded that when the central bank injects high levels of liquidity into the economy banks are more likely to engage in riskier investments, but the same is not verified when interest rates are reduced. Overall, the authors found evidence that a monetary policy easing through cuts of interest rates is not associated with an increase in banks' risk-taking, but unconventional monetary measures can be associated with an increase in banks' risk-taking. Furthermore, they found a negative relationship between Vietnamese banks' capitalization and the probability of default, i.e., the more capitalized a bank is, the less probability it has of declaring insolvency. Also, they based on the idea that more liquid assets can reduce a bank's credit risk, which differs from the results of Brana et al. (2019) that found that a more liquid bank is more prone to engage in riskier investments.

Most papers taken into consideration in our literature review, found a positive association between unconventional monetary policy and banks' credit supply, while there is still some evidence for an increase in risk-taking resulting from these non-standard monetary policy measures, especially when the central bank injects high levels of liquidity into the economy. Against this background, the purpose of this dissertation is to study the effects of ECB's macro-liquidity operations, using Portugal as a reference. More specifically, we aim to investigate whether unconventional monetary policy operates through a risk-taking channel, which there is lack of evidence regarding this subject and Portugal. Portugal provides an ideal setting to analyze the risks in the banking industry associated with ECB's unconventional monetary policy measures given that firms are highly dependent on bank debt.

### 3. Empirical Strategy

We examine whether and how central bank liquidity injection affects credit supply by exploring credit access of Portuguese firms who have different exposure to the ECB's liquidity provision via their relationship banks, using a difference-in-differences approach.

#### 3.1. Identification

To study the transmission of unconventional monetary policies of the ECB to Portuguese firms, we perform a difference-in-differences model, taking inspiration from previous works (Benetton & Fantino, 2021; Carpinelli & Crossignani, 2021; Andrade et al., 2018).

In this manner, using panel data for all firms operating in Portugal at monthly frequency, we study the link between ECB's macro-liquidity injections and firms' credit growth before and after ECB's unconventional monetary policies between April 2007-August 2009.

In doing so, firms' total available credit, including potential credit, is examined because the purpose is to understand whether ECB's intervention programmes had an impact on credit supply. In other words, we want to understand if the ECB managed to achieve its main goal, which is to provide financing to the real sector through encouraging the banking system to lend more to non-financial corporations and households<sup>8</sup>. Moreover, we also examine firms' total overdue credit to study if there is an increase in banks' risk-taking behavior after ECB's unconventional monetary policies measures, that is, if these operations raised bank's risk flavor by extending loans to firms that are more likely to default.

Our treatment variable is ECB's liquidity injection, referred in our specification as *Centrbankloan\_asset* and calculated as the total amount of ECB's liquidity injection into each bank during the sample period over total assets. To facilitate the data frequency, we further aggregate the treatment variable at the firm level, weighted by the credit share of firm's relationship bank in April 2008. In this sense, our treatment variable, which is the *Centrbankloan\_asset*, being calculated between April 2007 and August 2009, will hence capture the effects of the following ECB's unconventional monetary policy measures: i) supplementary 3-month LTROs; ii) LTROs with 6 months maturities; iii) the implementation of the fixed-rate full allotment in all refinancing operations; iii) U.S dollar providing operations and iv) 12-months LTROs (also known as 1-year

---

<sup>8</sup> However, we will only be analyzing the transmission of ECB's policies to non-financial corporations.

LTRO). These non-standard operations were conducted during our sample period to support the banking system and guarantee they continued to lend to the real sector.

We classify firms into different groups according to their exposure to banks with high or low liquidity injection from the central bank, estimating different versions of the OLS regression. First, we use a binary treatment specification, where *Centrbankloan\_asset* – the treatment variable – is defined as a dummy variable that equals one for firms working with banks that occupy the top three deciles of the treated variable distribution. This variable will be called *treated2*. During our analysis, we exploit three different specifications to examine firms credit access to banks: i) one with no control variables, ii) a second one, controlling for firm’ characteristics and finally, iii) a third specification controlling for firm’ and bank’ characteristics. The control variables are specified below in in this subsection.

The main goal is to see if the groups of firms that are working with banks with higher liquidity from the ECB receive more credit after ECB’s intervention. In this way, it would be possible to understand how much Portuguese firms are exposed to banks receiving funding from the central bank and if this type of macro-liquidity injections from ECB help firms increase their borrowing from banks.

To do so, we estimate the following equation:

$$(1) \quad \text{Credit}_{it} = \beta_t * \text{Period}_t \times \text{Centrbankloan\_asset}_i + \alpha_t \text{Period}_t \times \text{FirmCharact}_i + \alpha_t \text{Period}_t \times \text{BankCharact}_i + \varrho_{mt} + \gamma_{jt} + \varepsilon_{it}$$

where the dependent variable is the total credit or overdue credit to firm *i* in month *t*. We take the logarithm of the dependent variable plus 1 to allow for nonlinear relationships and temporary relationship suspensions, due to seasonalities for instance. Our variable of interest is *Centrbankloan\_asset* which captures ECB’s liquidity operations, such as the ones already mentioned before in our empirical specification. The variable is measured as of April 2008 when the ECB allotted its first supplementary 6-month LTRO (ECB, 2008). Our coefficient of interest is  $\beta_t$ , which measures how firm’s exposure to banks that receive more ECB’s liquidity injections affects their access to credit after the shock.

To quantify the size of the effect, we use a static specification in which the pre- and post- ECB liquidity injection periods are collapsed, and the variable *Period* takes the value of 1 for the pre-intervention period (from April 2007 to April 2008), and zero otherwise.

We also construct a dynamic specification<sup>9</sup> that allows examining the impact of ECB's liquidity operations on firm's credit access over time. *Period* in this specification represents a series of dummies that takes the value of 1 for each month contained in our sample period. Note that April 2008 is omitted as it is used as our reference period. The coefficients  $\alpha_t$  capture the time-varying differences in the amount of credit extended to firms borrowing from banks more exposed to ECB's liquidity injections relative to other firms. By also observing the evolution of firms' overdue credit, we can investigate the linkage between unconventional monetary policy and bank risk-taking, i.e., the risk-taking channel. This procedure applied will help to answer our research question.

Taken together, our difference-in-differences methodology demonstrates the evolution of firms' credit after ECB's first unconventional monetary policy intervention (the treatment) for firms working with banks more exposed to these type of macro-liquidity operations provided by the central bank (treated firms) versus firms working with banks less exposed to ECB's interventions (control firms).

As pointed by Andrade et al. (2018), who studied the causal impact of the 3-year LTROs on French banks' supply of credit to firms, this analysis brings some identification challenges, one of them being related to the fact that banks' decision in participating in ECB's operations are endogenous and evolve around a set of banks' characteristics that simultaneously influences banks' loan supply. Following Andrade et al. (2018), Benetton and Fantino (2021) and Carpinelli and Crossignani (2021), to overcome this, we decided to control for a group of observed banks' characteristics that are aggregated at the firm-level, including liquidity ratio, capital ratio, size (measured by the log transformed value of banks' total assets) and overdue loans ratio. We control for banks' size, capital ratio, and liquidity ratio to control for the nonrandom composition of ECB's liquidity, as exposed banks tend to be larger and more levered, according to Carpinelli and Crossignani (2021). We also control for overdue loans ratio to measure the riskiness of banks' credit portfolio, following the previous studies mentioned. Similar to the treatment variable, we aggregate the bank-side variable at the firm level.

We control for firm's specific factors associated with borrowing behavior (firm's characteristics) in both equations. Such control variables include total assets in thousand euros, return on assets (ROA), measured by earnings before interest, tax, depreciation, and amortization (EBITDA) over firms' total assets and leverage (total assets minus total liabilities over total assets). Banks'

---

<sup>9</sup> By using a dynamic specification, we can quantify the effect of firms' exposure in each month contained in our sample period.

characteristics are also aggregated at the firm-level.  $\rho_{mt}$  and  $\gamma_{jt}$  are respectively firm fixed-effects and time fixed-effects. Therefore, the empirical strategy involves a variation of the Khwaja and Mian (2008) fixed-effects approach, where bank characteristics are aggregated at the firm-level and, hence, the heterogeneity in the transmission mechanism to firms is explored.

## 3.2. Data and Summary Statistics

### 3.2.1. Data Sources

To perform our analysis, we merge three different databases on firms and banks characteristics, using the software Stata. We make use of information taken from the Central Credit Register (CCR) firm-level data and Central Balance Sheet (CB) data managed by Banco de Portugal, as well as information on banks characteristics from the Monetary Financial Institution Statistics (MFI) aggregated at the firm level to study if the behavior of the latter differs with a bank's financial situation.

To identify the group of firms that work with banks receiving ECB's extra liquidity, we use the CCR firm-level database<sup>10</sup>, which contains monthly information collected by Banco de Portugal regarding credit supply by all credit-granting institutions to all firms operating in Portugal, since 1999. We also use this dataset to get access to the total amount of firms' overdue credit, which allows us to investigate the risk-taking channel, as referred to previously.

To capture how different characteristics of firms can influence banks risk-taking behavior, we use the CB dataset that provides annual data on economic and financial information on non-financial corporations in Portugal since 2006<sup>11</sup>. Finally, to use information regarding banks' characteristics, we calculate firm-level weighted average bank characteristics. This includes banks' size, liquidity ratio, capital ratio and overdue loans ratio. The final sample consists of a monthly panel for the period from April 2007 to August 2009 and it is obtained by merging all data sources.

### 3.2.2. Summary Statistics

The analysis begins with presenting descriptive statistics on the main variables.

Table 1 presents the definition of the variables used in our model and table 2 reports summary statistics between April 2007 and August 2009 for the dependent, control and treated variables,

---

<sup>10</sup> This database is made available by BPLIM (Banco de Portugal Microdata Research Laboratory).

<sup>11</sup> The information in this database is collected through Informação Empresarial Simplificada (IES).

which includes 197 641 observations. All variables are winsorized at the 1<sup>st</sup> and 99<sup>th</sup> percentile to attenuate the impact of outliers in the sample.

**Table 1 - Variables Definition**

| Variables            | Definition                                                                                                          |
|----------------------|---------------------------------------------------------------------------------------------------------------------|
| Treated1             | Dummy variable that equals one for firms working with above median exposure banks and zero otherwise                |
| Treated2             | Dummy variable that equals one for firms working with above the top three deciles exposure banks and zero otherwise |
| Total Credit         | Firms' total credit amount, including potential credit                                                              |
| Credit               | Logarithm of one plus firms' total credit amount, including potential credit                                        |
| Total Overdue Credit | Firms' total amount of overdue credit                                                                               |
| Overdue_Credit       | Logarithm of one plus firms' total amount of overdue credit                                                         |
| Profitability        | Firms' ROA (EBITDA)                                                                                                 |
| Leverage             | Firms' assets minus firms' liabilities over firms' total assets                                                     |
| Assets               | Firms' total assets                                                                                                 |
| Liquidity Ratio      | Banks' liquid assets over total assets                                                                              |
| Capital Ratio        | Banks' total capital over total assets                                                                              |
| Size                 | Log transformed value of banks' total assets                                                                        |
| Overdue Loans Ratio  | Banks' total overdue loans over total loans                                                                         |

Notes: This table provides the description of the variables used in our empirical approach.

*Source: Own elaboration*

According to table 2, firms borrowed on average a total amount of 422 thousand euros from banks during this period. The total amount of overdue credit was on average 1 600 euros. Banks' share of overdue loans represented around 3% of their total loans, on average. The median of banks' capital ratio was equal to about 8% and their liquidity ratio equal to 0,6 on average. We also report some statistics concerning firm characteristics. We exhibit the distribution on firms' assets, equal

to 1 300 euros on average and their ROA was equal to about 3% on average. Firms' leverage ratio was almost equal to 1, showing a median of 0,9.

**Table 2. Summary Statistics.**

| Variables                   | Mean      | Q1    | Median | Q3     | Std. Dev.   | N      |
|-----------------------------|-----------|-------|--------|--------|-------------|--------|
| <i>treated1</i>             | 0,47      | 0     | 0      | 1      | 0,50        | 197641 |
| <i>treated2</i>             | 0,17      | 0     | 0      | 0      | 0,38        | 197641 |
| <i>Total Credit</i>         | 421647,70 | 13000 | 47574  | 193937 | 1372428,88  | 197641 |
| <i>Total Overdue Credit</i> | 1598,94   | 0     | 0      | 0      | 10788,31689 | 197641 |
| <i>Profitability</i>        | 0,03      | -0,00 | 0,06   | 0,14   | 0,31        | 197002 |
| <i>Leverage</i>             | 0,94      | 0,56  | 0,80   | 0,98   | 0,95        | 197002 |
| <i>Assets</i>               | 1272,76   | 86,8  | 236,72 | 728,65 | 3835,87     | 197641 |
| <i>Liquidity Ratio</i>      | 0,58      | 0,47  | 0,55   | 0,67   | 0,19        | 197617 |
| <i>Capital Ratio</i>        | 0,08      | 0,05  | 0,08   | 0,10   | 0,03        | 197641 |
| <i>Size</i>                 | 10,4      | 9,81  | 10,78  | 11,43  | 1,19        | 197641 |
| <i>Overdue Loans Ratio</i>  | 0,03      | 0,02  | 0,03   | 0,04   | 0,02        | 197641 |

Notes: This table shows the mean, first quartile (Q1), median, third quartile (Q3), standard deviation and number of observations of each variable presented for the firm-level sample. Variables are measured as of April 2008 (reference month). All variables are winsorized at the 1<sup>st</sup> and 99<sup>th</sup> percentile.

*Source: Own elaboration*

Our identification strategy separates firms into two groups according to their exposure to banks receiving more or less of ECB's liquidity injections. Table 3 provides a comparison of firms working with banks above the three top deciles of the treatment variable (*Centrbankloan\_asset*), that is, using the variable *treated2*. The sample period in this analysis is the pre-intervention (April 2007-April 2008). Thus, we can learn about treated firms' characteristics before ECB's interventions.

**Table 3. Balance Checks**

|                             | Mean      |           | Test of Differences |                 |  | Obs.     |         |
|-----------------------------|-----------|-----------|---------------------|-----------------|--|----------|---------|
|                             | Treated2  | Control   | t-statistic         | p-value         |  | Treated2 | Control |
| <i>Total Credit</i>         | 380549,63 | 430196,13 | 6,07                | 1,26444<br>E-09 |  | 34031    | 163610  |
| <i>Total Overdue Credit</i> | 1700,04   | 1577,91   | -1,9                | 0,05742<br>6272 |  | 34031    | 163610  |

|                                  |         |         |        |                 |  |       |        |
|----------------------------------|---------|---------|--------|-----------------|--|-------|--------|
| <i>Profitability</i>             | 0,01    | 0,03    | 9,67   | 3,96156<br>E-22 |  | 33922 | 163610 |
| <i>Leverage</i>                  | 0,98    | 0,94    | -8,66  | 4,81237<br>E-18 |  | 33922 | 163610 |
| <i>Assets</i>                    | 1060,84 | 1316,84 | 11,20  | 3,93607<br>E-29 |  | 34031 | 163610 |
| <i>Liquidity Ratio</i>           | 0,58    | 0,59    | 4,91   | 8,94096<br>E-07 |  | 34031 | 163610 |
| <i>Capital/ Assets</i>           | 0,05    | 0,08    | 153,53 | 0               |  | 34031 | 163610 |
| <i>Size</i>                      | 10,21   | 10,5    | 38,33  | 0               |  | 34031 | 163610 |
| <i>Overdue Loans/Total Loans</i> | 0,03    | 0,04    | 44,24  | 0               |  | 34031 | 163610 |

Note: This table compares the characteristics of firms working with banks with above the three decile (high) and below the three decile (low) ECB's liquidity injections exposure. All variables are winsorized at the 1% and 99%.

*Source: Own elaboration*

The group of high exposure firms differs on characteristics that we incorporate as control variables in equation 1. In table 3 we present the: i) mean of the control variables between firms more exposed to banks working with higher amounts of ECB's liquidity (treated group) and firms less exposed (control group), ii) number of observations of the two groups and iii) test of differences. According to the table, firms working with banks more exposed to ECB's liquidity operations tend to have less levels of credit amount and more overdue credit relatively to firms less exposed. Moreover, these types of firms tend to be smaller, that is, they have a less amount of total assets in comparison with the control group. However, firms more exposed to banks with more ECB's liquidity tend to be less profitable and work with banks with a smaller liquidity ratio. This last observation regarding the liquidity ratio is different from what the previous literature suggested, because some authors (García-Posada & Marchetti, 2016) found that banks more exposed to ECB's extraordinary liquidity interventions presented a higher liquidity ratio. For instance, according to García-Posada and Marchetti (2016), banks that participated in ECB's VLTROs in Spain had more liquid assets than non-participating banks and the authors justified this fact because the former needed to pledge more collateral to acquire funds in the open market operations. Furthermore, exposed firms tend to work with smaller banks and with a smaller capital ratio. According to this balance check, firms borrowing from banks that are more exposed to ECB liquidity injection are significantly different from the rest of the firms in terms of credit performance, profitability, leverage, and bank' liquidity.

### 3.3. Empirical Results

#### 3.3.1. Impact of ECB's Unconventional Monetary Policy Measures on Credit Supply

We first test whether the ECB's liquidity operations affect Portuguese firms' credit supply estimating equation (1) at the firm-level. Table 4 presents the estimates of our static difference-in-differences model that studies the amount of firms' total credit before and after ECB's unconventional monetary policy measures in our sample period. The regression compares the credit supply of firms with high exposure to banks more affected by these operations, i.e., treated firms, with firms less exposed, the also called control firms.

**Table 4. Firm Credit Supply Results – Static Specification**

| Binary Treatment         |                      |                      |                      |
|--------------------------|----------------------|----------------------|----------------------|
|                          | OLS                  | OLS                  | OLS                  |
|                          | (1)                  | (2)                  | (3)                  |
| <b>Period x Treated2</b> | -0.023***<br>(0.001) | -0.028***<br>(0.001) | -0.020***<br>(0.001) |
| <b>Assets</b>            | -                    | 0.485***<br>(0.001)  | 0.482***<br>(0.001)  |
| <b>Profitability</b>     | -                    | -0.101**<br>(0.002)  | -0.098***<br>(0.002) |
| <b>Leverage</b>          | -                    | 0.112***<br>(0.001)  | 0.113***<br>(0.001)  |
| <b>Size</b>              | -                    | -                    | 0.028***<br>(0.001)  |
| <b>Capital Ratio</b>     | -                    | -                    | -1.508***<br>(0.022) |
| <b>Liquidity Ratio</b>   | -                    | -                    | -0.001***<br>(0.000) |
| <b>Overdue Loans</b>     | -                    | -                    | 0.139***             |

|                           |           |            |         |
|---------------------------|-----------|------------|---------|
|                           |           |            | (0.031) |
| <b>Firm Controls</b>      | No        | Yes        | Yes     |
| <b>Bank Controls</b>      | No        | No         | Yes     |
| <b>Observations</b>       | 5204301   | 5192305    | 5191925 |
| <b>Adjusted R-squared</b> | 0.921     | 0.925      | 0.925   |
| * p<0.10                  | ** p<0.05 | *** p<0.01 |         |

Notes: This table presents the estimates of firms' credit supply regression using the monthly firm-level sample over the period from April 2007 to August 2009. The dependent variable is the log of total credit plus one, including potential credit. Treated2 is a dummy variable that equals one for firms with higher exposure to banks more affected by ECB's liquidity operations and zero otherwise. Period is a dummy variable that takes the value of one for firm-level observations in the period April 2007-April 2008 (pre-intervention period), and zero otherwise. All variables are measured as of April 2008. The regressions include firm-fixed effects and time-fixed effects. \*\*\*, \*\* and \* indicates statistical significance at the 1%, 5% and 10% level, respectively.

Columns (1) to (3) report the results for firms' total credit, including potential credit. We consider the exposure variable related to ECB's liquidity injections, while controlling for potentially relevant time-variant firm and bank characteristics, except for column (1), where we do not use any control variables. Our results demonstrate that the coefficient associated with the interaction variable  $Period \times Centrbankloan\_asset$ ,  $\beta_t$ , is negative in all specifications and statistically significant. For instance, the results in column (1) indicate that one percentage point increase in firms' exposure with banks more affected by ECB's liquidity injections led to a 0.02% drop in those firms' total amount of credit before the implementation of unconventional monetary policy. In other words, firms with high exposure to banks receiving more of ECB's liquidity, from April 2007 to April 2008, had their credit reduced more than firms with less exposure before the shock. These estimates indicate that ECB's liquidity injections had a positive impact in treated firms' access to credit, as they seem to have less credit before the central bank's non-standard measures implementation, according to Table 4 results. Thus, there seems to be evidence for a bank lending channel during ECB's liquidity operations in the period analyzed, since Portuguese firms more exposed to banks more affected by ECB's unconventional operations had less access to credit before central bank's actions.

Table 5 (see appendix) also reports our dynamic specification using equation 1. The first set of empirical results – columns (1) to (3) – reports the OLS estimations using the variable *credit* as the dependent variable, which is measured by the log firms' total credit amount, including potential

credit, plus one. In column (1) we estimate the impact of ECB's liquidity operations on firms' total credit using no control variables. The results show that there is a significant increase in treated firm' credit after April 2008, indicating that firms that work with banks with more ECB's liquidity injection increased their credit more than less exposed firms after ECB's unconventional monetary policy measures. For instance, analyzing column (1), in September 2008 treated firms had their total credit amount increased relatively to control firms by approximately 2 basis points on average. This effect became stronger and significant over time.

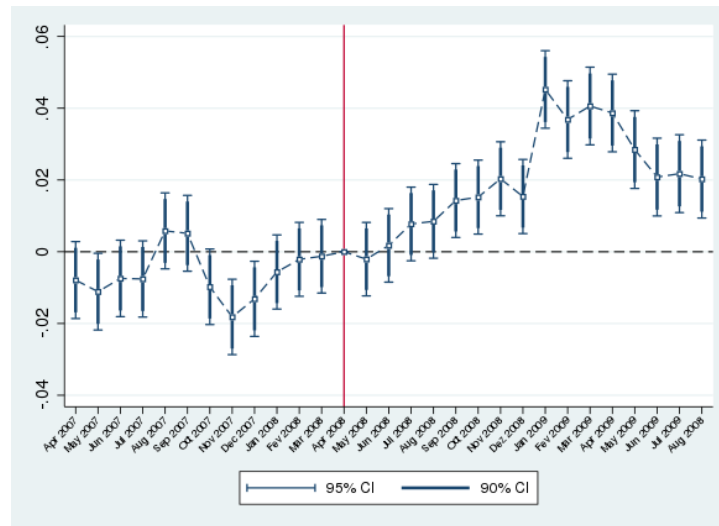
In table 5, column (2), we control only for firms' characteristics. By controlling for firms' assets, ROA, and leverage, we first notice larger effects in magnitude compared to the OLS estimates in the first column. On average, firms borrowing more from banks that are more exposed to ECB's liquidity injections have their credit increased relative to firms borrowing less from these group of banks, as the coefficient associated with the interaction variable  $Period \times Centrbankloan\_asset$ ,  $\beta_t$ , becomes positive and significant after April 2008. For instance, treated firms received more credit in December 2008, three months after ECB's decision to switch to a fixed-rate full allotment in all its refinancing operations, by about 5 basis points relative to non-treated firms. With respect to the controls, column (2) shows that larger and more leveraged firms tend to have more access to banks' credit, given the positive coefficient of the interaction variable  $Period_t \times FirmCharact_t$ ,  $\alpha_t$ . Also, a higher ROA is related with lower credit access from non-financial corporations to banks, given the negative coefficient sign.

With respect to the controls, column (3) shows the results for the most complete specification we have. Since we wish to examine the heterogeneity in the transmission of monetary policies of the ECB, we control for banks' specific factors to check the robustness of our results to potential confounders. First, we can see that ECB's unconventional monetary policy measures had an overall positive and significant impact on firms' borrowing, as the interaction variable  $Period \times Centrbankloan\_asset$ ,  $\beta_t$ , is positive and significant after our reference date. Also in table 5, column (3), we found that the size of banks positively affects firms' credit growth level, which is consistent with previous findings (Andrade et al. 2018). According to the estimate, firms borrowing from larger banks had their credit increased by approximately 2 basis point on average, given the coefficient of the interaction variable  $Period_t \times BankCharact_t$ ,  $\alpha_t$ , is positive. In contrast, the coefficient  $\alpha_t$  regarding capital ratio is negative and significant after ECB's intervention. This also confirms previous results on the negative impact of the crisis on banks' lending behavior. For instance, García-Posada and Marchetti (2016) also found a negative relationship between capital ratio and non-financial corporations' credit growth during the period of 2011-2012, justifying this

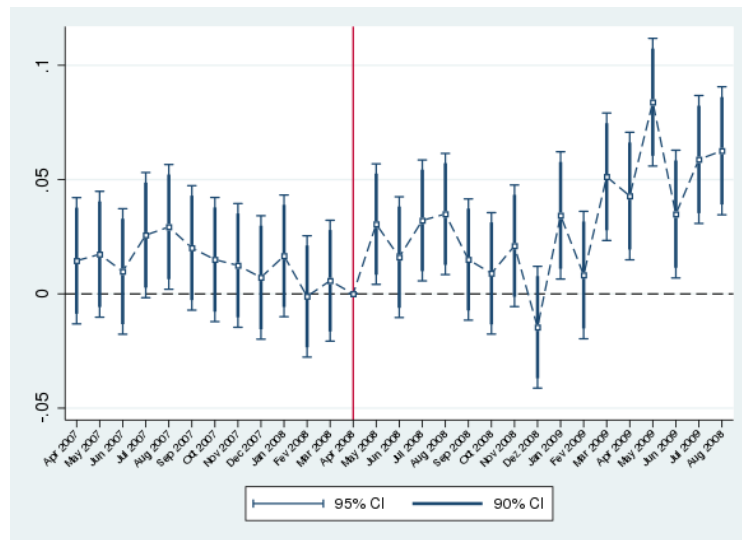
with the fact that weaker credit demand forced under-capitalized banks to cut their lending and increase capital instead. Since our sample period covers a very stressful time in Euro area financial markets, this result is not surprising.

Figure 2 reports the results of our dynamic regression in equation 2 in a graph.

**Figure 2. Effects of ECB's liquidity operations exposure**



Panel (A): Credit



Panel (B): Overdue Credit

*Source: Own elaboration.*

Notes: This figure shows point estimates and confidence intervals of firms' exposure to banks more affected by ECB's liquidity operations coefficient using the firm-level data sample over the period of April 2007 to August 2009 and a

dynamic specification regression, which corresponds to columns (1) and (3) of Table 5. The dependent variables are the log of firms' total credit plus one and the log firms' total overdue credit in Panel (A) and (B), respectively. The red line marks the cut-off date (April 2008). The regressions include firm-fixed effects and time fixed-effects

More specifically, it shows the estimates of the coefficient  $\beta_t$  for each month in the sample (April 2008 is the cut-off date). Panel (A) demonstrates the effects on firms' total credit over time. The dynamic specification reports an increase in firms' credit from June 2008, which is 2 months after the start of the supplementary 6-month LTROs. This increase gets more pronounced in 2009, almost a year after the referred ECB's liquidity intervention. From March 2009, firms' total credit slowly starts to decrease, even though its amount still surpasses the amount of firms' credit before ECB's liquidity injections. It is important to note that, according to figure 2, there are no signs of preexisting differential trends as firm' exposure to banks receiving higher amounts of ECB's liquidity injections does not have a significant impact on credit supply before the shock.

### **3.3.2. Impact of ECB's Unconventional Monetary Policy Measures on Credit Risk**

Our goal is to explore the link between unconventional monetary policy and credit risk, that is, to study the existence of a risk-taking channel by examining the transmission of ECB's liquidity operations during the sample period to Portuguese firms, calculating the impact of such interventions in firms' overdue credit. Banks receiving more of ECB's funding may be more prone to increase their risk-taking by lending more to riskier firms. This can happen because high levels of liquidity into the financial system

Thereby, we estimate equation 1, with the slight difference regarding our previous analysis that now the dependent variable is the transformed logarithm of firm' overdue credit in month  $t$ . The other variables remain the same as equation 1.

In table 5, columns (4), (5) and (6) we estimate the impact of ECB's liquidity injections in firms' total amount of overdue credit. Column (4) has no control variables, while in column (5) we control for firms' characteristics only and in column (6) we control for firms' and banks' specific factors. When controlling for banks' characteristics, the coefficient of the interaction variable of  $Period \times Centralkloan\_asset$ ,  $\beta_t$ , is more pronounced and significant over time.

In figure 2, panel (B) reports the effects of ECB's liquidity operations over time on firms' overdue credit. As we can see, a positive and significant impact is shown immediately after our cut-off point

(April 2008), decreasing a month later. A more pronounced decrease happens in December 2008 (8 months after the start of the 6-month supplementary LTROs in April 2008), however it is not statistically significant. Credit overdue starts to increase in 2009, showing its higher and significant level in May 2009, which reveals that firms' exposure to banks more affected with ECB's liquidity interventions seems to affect credit risk after such operations. Overall, we see a significant increase in firms' total overdue credit over the months, suggesting there is evidence for an increase in banks' risk-taking during the period analyzed.

## 4. Conclusion

The present work carries out an analysis to investigate the linkage between unconventional monetary policy and banks risk-taking. To this end, we have taken inspiration of previous studies, such as Benetton and Fantino (2021) and Carpinelli and Crossignani (2021), and hence a difference-in-differences methodology was applied to study Portuguese firms' total credit before and after ECB's liquidity operations, using firm-level data over April 2007-August 2009. Then, we observe the impact of ECB's non-standard interventions in firms' overdue credit to understand if financial intermediaries increased their risk-taking by lending more to firms with a higher chance of default.

Our results are in line with the previous literature, showing that unconventional monetary policy measures were effective in achieving ECB's main goal with its implementation during our analysis, which was supporting banks' lending supply. More precisely, our estimates indicate that firms had less access to credit before the ECB's liquidity operations in April 2008. The pass-through of ECB's liquidity injections, during our sample period, to the real sector translated in more credit for firms more exposed to banks with higher amounts of ECB's funds, which is the goal of monetary policy operations. Thereby, the results suggest that unconventional monetary policy can be expansionary and help the ECB achieve its main economic goals.

In addition, we observe the impact of ECB's non-standard interventions in firms' overdue credit to understand if financial intermediaries increased their risk-taking by lending more to firms with higher chance of default. Our estimates suggest that there is a link between ECB's macro-liquidity operations and banks risk-taking, as firms' overdue credit levels significantly increased after its implementation. This highlights a tradeoff of expansionary monetary policy, that is, the objective of supporting banks' lending may simultaneously increase financial intermediaries' risk-taking capacity, which will have negative repercussions in the future. Thus, the conclusions of this dissertation can be relevant for policy makers in responding to events of economic turbulence. Moreover, it would be interesting to develop future research in line with the present work, such as to study the effects of other unconventional monetary policies measures on banks' credit risk. For example, there is studies concerning ECB's asset purchases and its link with banks risk-taking, but there is lack of evidence for the Portuguese case.

## 5. Appendix

**Table 5. Firm' Credit Supply Results – Dynamic Specification**

| Binary Specification |         |          |         |          |          |         |
|----------------------|---------|----------|---------|----------|----------|---------|
|                      | OLS     | OLS      | OLS     | OLS      | OLS      | OLS     |
|                      | (1)     | (2)      | (3)     | (4)      | (5)      | (6)     |
| Treated2 ×           |         |          |         |          |          |         |
| April 2007           | -0.01*  | -0.02*** | -0.01   | 0.03*    | 0.03*    | 0.02    |
|                      | (-2.42) | (-3.38)  | (-0.95) | (2.13)   | (2.55)   | (1.14)  |
| May 2007             | -0.01   | -0.01*   | -0.01   | 0.02     | 0.03*    | 0.02    |
|                      | (-1.60) | (-2.52)  | (-1.54) | (1.74)   | (2.08)   | (1.34)  |
| June 2007            | -0.01   | -0.01*   | -0.00   | 0.01     | 0.02     | 0.01    |
|                      | (-1.23) | (-2.04)  | (-0.87) | (0.96)   | (1.32)   | (0.80)  |
| July 2007            | -0.01   | -0.01    | -0.00   | 0.03*    | 0.04**   | 0.03    |
|                      | (-1.02) | (-1.71)  | (-0.88) | (2.49)   | (2.83)   | (1.95)  |
| August 2007          | 0.01    | 0.01     | 0.01    | 0.03*    | 0.04**   | 0.03*   |
|                      | (1.84)  | (1.26)   | (1.63)  | (2.56)   | (2.78)   | (2.20)  |
| September 2007       | 0.01**  | 0.01*    | 0.01    | 0.02     | 0.02     | 0.02    |
|                      | (2.69)  | (2.14)   | (1.52)  | (1.55)   | (1.76)   | (1.54)  |
| October 2007         | -0.00   | -0.00    | -0.01   | 0.02     | 0.02     | 0.02    |
|                      | (-0.09) | (-0.77)  | (-1.26) | (1.62)   | (1.80)   | (1.17)  |
| November 2007        | 0.00    | -0.00    | -0.01** | 0.02     | 0.02     | 0.01    |
|                      | (0.60)  | (-0.10)  | (-2.81) | (1.64)   | (1.78)   | (0.99)  |
| December 2007        | -0.00   | -0.00    | -0.01   | 0.01     | 0.01     | 0.01    |
|                      | (-0.15) | (-0.67)  | (-1.86) | (0.69)   | (0.82)   | (0.55)  |
| January 2008         | -0.01   | -0.00    | -0.01   | 0.03*    | 0.03*    | 0.02    |
|                      | (-1.60) | (-1.79)  | (-1.11) | (2.15)   | (2.26)   | (1.51)  |
| February 2008        | -0.00   | -0.00    | -0.00   | 0.01     | 0.01     | 0.00    |
|                      | (-0.74) | (-0.90)  | (-0.57) | (0.59)   | (0.66)   | (0.10)  |
| March 2008           | -0.00   | -0.00    | -0.00   | 0.01     | 0.01     | 0.01    |
|                      | (-0.32) | (-0.42)  | (-0.24) | (0.72)   | (0.73)   | (0.53)  |
| April 2008           | -       | -        | -       | -        | -        | -       |
| May 2008             | 0.00    | 0.00     | -0.00   | 0.03*    | 0.03*    | 0.03*   |
|                      | (0.42)  | (0.44)   | (-0.36) | (2.33)   | (2.26)   | (2.22)  |
| June 2008            | 0.00    | 0.00790  | 0.00232 | 0.0156   | 0.0140   | 0.0139  |
|                      | (1.49)  | (1.62)   | (0.45)  | (1.24)   | (1.12)   | (1.03)  |
| July 2008            | 0.01**  | 0.0139** | 0.00809 | 0.0221   | 0.0185   | 0.0265* |
|                      | (2.71)  | (2.84)   | (1.55)  | (1.75)   | (1.47)   | (1.97)  |
| August 2008          | 0.01*   | 0.0126** | 0.00882 | 0.0233   | 0.0193   | 0.0277* |
|                      | (2.31)  | (2.58)   | (1.69)  | (1.85)   | (1.53)   | (2.06)  |
| September 2008       | 0.02*** | 0.02***  | 0.01**  | -0.00321 | -0.00788 | 0.00600 |

|                        |            |            |            |           |           |           |
|------------------------|------------|------------|------------|-----------|-----------|-----------|
|                        | (3.49)     | (3.84)     | (2.84)     | (-0.25)   | (-0.62)   | (0.45)    |
| <b>October 2008</b>    | 0.02***    | 0.0221***  | 0.0156**   | -0.00515  | -0.0103   | 0.00231   |
|                        | (4.11)     | (4.51)     | (2.98)     | (-0.41)   | (-0.82)   | (0.17)    |
| <b>November 2008</b>   | 0.02***    | 0.0228***  | 0.0209***  | -0.00390  | -0.0100   | 0.0117    |
|                        | (4.19)     | (4.64)     | (3.98)     | (-0.31)   | (-0.79)   | (0.87)    |
| <b>December 2008</b>   | 0.02***    | 0.0244***  | 0.0163**   | -0.0316*  | -0.0391** | -0.0236   |
|                        | (4.24)     | (4.96)     | (3.10)     | (-2.48)   | (-3.08)   | (-1.74)   |
| <b>January 2009</b>    | 0.05***    | 0.0510***  | 0.0523***  | -0.00161  | -0.00929  | 0.0217    |
|                        | (9.30)     | (10.10)    | (9.67)     | (-0.12)   | (-0.71)   | (1.56)    |
| <b>February 2009</b>   | 0.04***    | 0.04***    | 0.04***    | -0.04**   | -0.05***  | -0.01     |
|                        | (7.05)     | (7.73)     | (7.71)     | (-2.95)   | (-3.60)   | (-0.78)   |
| <b>March 2009</b>      | 0.0347***  | 0.0377***  | 0.0404***  | -0.00203  | -0.0108   | 0.0255    |
|                        | (6.72)     | (7.43)     | (7.46)     | (-0.16)   | (-0.82)   | (1.83)    |
| <b>April 2009</b>      | 0.03***    | 0.04***    | 0.04***    | -0.01     | -0.0183   | 0.0182    |
|                        | (6.47)     | (7.33)     | (7.52)     | (-0.69)   | (-1.40)   | (1.30)    |
| <b>May 2009</b>        | 0.0270***  | 0.0314***  | 0.0334***  | 0.0176    | 0.00684   | 0.0520*** |
|                        | (5.21)     | (6.20)     | (6.16)     | (1.34)    | (0.52)    | (3.72)    |
| <b>June 2009</b>       | 0.0230***  | 0.0276***  | 0.0269***  | -0.0210   | -0.0333*  | 0.00194   |
|                        | (4.45)     | (5.43)     | (4.96)     | (-1.60)   | (-2.54)   | (0.14)    |
| <b>July 2009</b>       | 0.0273***  | 0.0320***  | 0.0288***  | -         | -0.0123   | 0.0258    |
|                        |            |            |            | 0.0000679 |           |           |
|                        | (5.26)     | (6.29)     | (5.30)     | (-0.01)   | (-0.94)   | (1.84)    |
| <b>August 2009</b>     | 0.0282***  | 0.0335***  | 0.0270***  | 0.00525   | -0.00824  | 0.0301*   |
|                        | (5.44)     | (6.58)     | (4.96)     | (0.40)    | (-0.63)   | (2.15)    |
| <b>Assets</b>          |            | 0.471***   | 0.470***   |           | -0.148*** | -0.149*** |
|                        |            | (349.33)   | (347.90)   |           | (-42.55)  | (-42.80)  |
| <b>ROA</b>             |            | -0.0647*** | -0.0652*** |           | 0.144***  | 0.149***  |
|                        |            | (-11.76)   | (-11.85)   |           | (10.16)   | (10.51)   |
| <b>Leverage</b>        |            | 0.140***   | 0.139***   |           | 0.0277*** | 0.0283*** |
|                        |            | (70.87)    | (70.72)    |           | (5.45)    | (5.57)    |
| <b>Size</b>            |            |            | 0.0184***  |           |           | -0.000135 |
|                        |            |            | (11.82)    |           |           | (-0.03)   |
| <b>Capital Ratio</b>   |            |            | -0.960***  |           |           | 0.258     |
|                        |            |            | (-17.58)   |           |           | (1.84)    |
| <b>Liquidity Ratio</b> |            |            | 0.00240*** |           |           | 0.00306** |
|                        |            |            | (5.92)     |           |           | (2.93)    |
| <b>Overdue Share</b>   |            |            | 0.685***   |           |           | 1.448***  |
|                        |            |            | (7.89)     |           |           | (6.47)    |
| <b>Constant</b>        | 10.94***   | 8.114***   | 7.912***   | 0.731***  | 1.379***  | 1.279***  |
|                        | (16995.28) | (1264.30)  | (711.43)   | (448.88)  | (83.37)   | (44.61)   |

|                      |           |                |         |         |         |         |
|----------------------|-----------|----------------|---------|---------|---------|---------|
| <b>Firm controls</b> | No        | Yes            | Yes     | No      | Yes     | Yes     |
| <b>Bank controls</b> | No        | No             | Yes     | No      | No      | Yes     |
| <b>Observations</b>  | 5204301   | 5192305        | 5191925 | 5204301 | 5192305 | 5191925 |
| * p<0.05             | ** p<0.01 | ***<br>p<0.001 |         |         |         |         |

Notes: This table reports the estimates of a dynamic difference-in-differences regressions using the firm-level sample over the period of April 2007 to August 2009. The dependent variables are the log of one plus firms' total credit and the log of one plus firms' total overdue credit in columns (1) to (3) and (4) to (6), respectively. Firm controls and bank controls are measured in the reference date (April 2008). The regressions include firm-fixed effects and time fixed-effects. \*\*\*, \*\* and \* indicates statistical significance at the 1%, 5% and 10% level, respectively.

## 6. References

- Albertazzi, U., Becker, B., & Boucinha, M. (2021). Portfolio rebalancing and the transmission of large-scale asset purchase programs: Evidence from the Euro area. *Journal of Financial Intermediation*, 48. <https://doi.org/ARTN10089610.1016/j.jfi.2020.100896>
- Altavilla, C., Burlon, L., Giannetti, M., Holton, S. (2020). "Is there a zero lower bound? The effects of negative policy rates on banks and firms". ECB Working Paper Series No. 2289, June
- Andrade, P., Breckenfelder, J. H., De Fiore, F., Karadi, P., & Tristani, O. (2016). The ECB's asset purchase programme: an early assessment. ECB Working Paper Series No. 1956
- Andreeva, D. C., & Garcia-Posada, M. (2021). The impact of the ECB's targeted long-term refinancing operations on banks' lending policies: The role of competition. *Journal of Banking & Finance*, 122. <https://doi.org/ARTN10599210.1016/j.jbankfin.2020.105992>
- Apergis, N., & Christou, C. (2015). The behaviour of the bank lending channel when interest rates approach the zero lower bound: Evidence from quantile regressions. *Economic Modelling*, 49, 296-307.
- Arce, O., Mayordomo, S., & Gimeno, R. (2021). Making Room for the Needy: The Credit-Reallocation Effects of the ECB's Corporate QE. *Review of Finance*, 25(1), 43-84. <https://doi.org/10.1093/rof/rfaa020>
- Balfoussia, H., & Gibson, H. (2015). Financial conditions and economic activity: the potential impact of the targeted longer-term refinancing operations (TLTROs). *Bank of Greece*, Working paper, No. 194, 1-24
- Barbiero, F., Boucinha, M., & Burlon, L. (2021). TLTRO III and bank lending conditions. ECB Economic Bulletin. Issue 6/2021 [https://www.ecb.europa.eu/pub/economic-bulletin/articles/2021/html/ecb.ebart202106\\_02~35bf40777b.en.html#toc4](https://www.ecb.europa.eu/pub/economic-bulletin/articles/2021/html/ecb.ebart202106_02~35bf40777b.en.html#toc4)
- Bednarek, P., Dinger, V., te Kaat, D. M., & von Westernhagen, N. (2021). To whom do banks channel central bank funds? *Journal of Banking & Finance*, 128. <https://doi.org/ARTN10608210.1016/j.jbankfin.2021.106082>
- Benetton, M., & Fantino, D. (2021). Targeted monetary policy and bank lending behavior. *Journal of Financial Economics*, 142(1), 404-429. <https://doi.org/10.1016/j.jfineco.2021.05.002>

- Bernanke, B. S., & Gertler, M. (1995). Inside the Black-Box - the Credit Channel of Monetary-Policy Transmission. *Journal of Economic Perspectives*, 9(4), 27-48.  
<https://doi.org/DOI10.1257/jep.9.4.27>
- Bernanke, B. S., & Reinhart, V. R. (2004). Conducting monetary policy at very low short-term interest rates. *American Economic Review*, 94(2), 85-90.
- Bonfim, D., & Soares, C. (2018). The Risk-Taking Channel of Monetary Policy: Exploring All Avenues. *Journal of Money Credit and Banking*, 50(7), 1507-1541.  
<https://doi.org/10.1111/jmcb.12500>
- Borio, C., & Disyatat, P. (2010). Unconventional monetary policies: an appraisal. *The Manchester School*, 78, 53-89
- Borio, C., & Zhu, H. B. (2012). Capital regulation, risk-taking and monetary policy: A missing link in the transmission mechanism? *Journal of Financial Stability*, 8(4), 236-251.  
<https://doi.org/10.1016/j.jfs.2011.12.003>
- Borio, C., & Zabai, A. (2016). Unconventional monetary policies: an appraisal. BIS Working Paper Series No. 570, July.
- Brana, S., Campmas, A., & Lapteacru, I. (2019). (Un)Conventional monetary policy and bank risk-taking: A nonlinear relationship. *Economic Modelling*, 81, 576-593.  
<https://doi.org/10.1016/j.econmod.2018.07.005>
- Brunnermeier, M., & Koby, Y. (2018). The Reversal Interest Rate. NBER Working Paper Series No. 25406, December.
- Carpinelli, L., & Crosignani, M. (2021). The design and transmission of central bank liquidity provisions. *Journal of Financial Economics*, 141(1), 27-47.  
<https://doi.org/10.1016/j.jfineco.2020.06.025>
- Chen, M. H., Wu, J., Jeon, B. N., & Wang, R. (2017). Monetary policy and bank risk-taking: Evidence from emerging economies. *Emerging Markets Review*, 31, 116-140.  
<https://doi.org/10.1016/j.ememar.2017.04.001>
- Dang, V. D., & Dang, V. C. (2020). The conditioning role of performance on the bank risk-taking channel of monetary policy: Evidence from a multiple-tool regime. *Research in International Business and Finance*, 54. <https://doi.org/ARTN10130110.1016/j.ribaf.2020.101301>

- Darracq-Paries, M., & De Santis, R. A. (2015). A non-standard monetary policy shock: The ECB's 3-year LTROs and the shift in credit supply. *Journal of International Money and Finance*, 54, 1-34. <https://doi.org/10.1016/j.jimonfin.2015.02.011>
- Dell'Ariccia, G., Laeven, L., & Marquez, R. (2014). Real interest rates, leverage, and bank risk-taking. *Journal of Economic Theory*, 149, 65-99. <https://doi.org/10.1016/j.jet.2013.06.002>
- Demiralp, S., Eisenschmidt, J., & Vlassopoulos, T. (2021). Negative interest rates, excess liquidity and retail deposits: Banks' reaction to unconventional monetary policy in the euro area. *European Economic Review*, 136. <https://doi.org/ARTN10374510.1016/j.euroecorev.2021.103745>
- ECB. (2008a). *Supplementary six-month longer-term refinancing operations and continuation of the supplementary three-month longer-term refinancing operations*. [Media]. <https://www.ecb.europa.eu/press/pr/date/2008/html/pr080328.en.html>
- ECB. (2008b). The role of banks in the monetary policy transmission mechanism. ECB Monthly Bulletin, August.
- ECB. (2010a). The ECB's response to the financial crisis. ECB Monthly Bulletin, October.
- ECB. (2010b). *ECB decides on measures to address severe tensions in financial markets*. [Press Releases]. <https://www.ecb.europa.eu/press/pr/date/2010/html/pr100510.en.html>
- ECB. (2011a). *ECB announces measures to support bank lending and money market activity*. [Press Releases]. [http://www.ecb.europa.eu/press/pr/date/2011/html/pr111208\\_1.en.html](http://www.ecb.europa.eu/press/pr/date/2011/html/pr111208_1.en.html)
- ECB. (2011b). The ECB's non-standard measures – impact and phasing-out. ECB Monthly Bulletin, July.
- ECB. (2020a). *ECB extends pandemic emergency longer-term refinancing operations*. [Press Release]. <https://www.ecb.europa.eu/press/pr/date/2020/html/ecb.pr201210~8acfa5026f.en.html>
- ECB. (2020b). *ECB prolongs support via targeted lending operations for banks that lend to the real economy*. [Press Release].

- [https://www.ecb.europa.eu/press/pr/date/2020/html/ecb.pr201210\\_1~e8e95af01c.en.html](https://www.ecb.europa.eu/press/pr/date/2020/html/ecb.pr201210_1~e8e95af01c.en.html)
- ECB. (2021a). *Pandemic Emergency Purchase Programme*. [Explainers]. <https://www.ecb.europa.eu/mopo/implement/pepp/html/index.en.html>
- ECB. (2021b). Economic, Financial and Monetary Developments. ECB Economic Bulletin, Issue 6. <https://www.ecb.europa.eu/pub/pdf/ecbu/eb202106.en.pdf>
- ECB. (2022a). *The Eurosystem's Instruments*. [Monetary Policy]. <https://www.ecb.europa.eu/mopo/implement/html/index.en.html>
- ECB. (2022b). *Transmission Mechanism of Monetary Policy*. [Monetary Policy]. <https://www.ecb.europa.eu/mopo/intro/transmission/html/index.en.html>
- ECB. (2022c). FAQs on TLTRO III operations. [Monetary Policy]. <https://www.ecb.europa.eu/mopo/implement/omo/tltro/html/tltro-qa.en.html>
- ECB. (2022d). What is forward guidance?. [Explainers]. [https://www.ecb.europa.eu/ecb/educational/explainers/tell-me/html/what-is-forward\\_guidance.en.html](https://www.ecb.europa.eu/ecb/educational/explainers/tell-me/html/what-is-forward_guidance.en.html)
- Eggertsson, G. B., & Woodford, M. (2003). Optimal monetary policy in a liquidity trap. Retrieved from <https://www.nber.org/papers/w996>
- Gambetti, L., & Musso, A. (2017). "The macroeconomic impact of the ECB's expanded asset purchase programme (APP)". ECB Working Paper Series No. 2075, June
- Heider, F., & Leonello, A., (2021). "Monetary policy in a low interest rate environment: reversal rate and risk-taking". ECB Working Paper Series No. 2593, October
- Jimenez, G., Ongena, S., Peydro, J. L., & Saurina, J. (2014). Hazardous Times for Monetary Policy: What Do Twenty-Three Million Bank Loans Say About the Effects of Monetary Policy on Credit Risk-Taking? *Econometrica*, 82(2), 463-505. <https://doi.org/10.3982/Ecta10104>
- Jorgensen, A., & Krishnamurthy, A. (2011). The Effects of Quantitative Easing on Interest Rates: Channels and Implications for Policy. *Brookings papers on economic activity*, 43, 215-287.
- Joyce, M., Miles, D., Scott, A., & Vayanos, D. (2012). Quantitative Easing and Unconventional Monetary Policy - an Introduction. *Economic Journal*, 122(564), F271-F288. <https://doi.org/10.1111/j.1468-0297.2012.02551.x>

- Kenourgios, D., & Ntaikou, D. (2019). ECB's unconventional monetary policy and bank lending supply and performance in the euro area. *Journal of Economics and Finance*, 45, 211-224. <https://doi.org/10.1007/s12197-019-09503-6>
- Khwaja, A. I., & Mian, A. (2008). Tracing the Impact of Bank Liquidity Shocks: Evidence from an Emerging Market. *American Economic Review*, 98(4), 1413-1442. <https://doi.org/10.1257/aer.98.4.1413>
- Laine, O. (2021). The Effect of Targeted Monetary Policy on Bank Lending. *Journal of Banking and Financial Economics*, 1(15), 25-43. <https://doi.org/10.7172/2353-6845.jbfe.2021.1.3>
- Lane, R. (2012). The European Sovereign Debt Crisis. *Journal of Economic Perspectives*, 26(3), 49-68. <https://doi.org/10.1257/jep.26.3.49>
- Lewis, V., & Roth, M. (2019). The financial market effects of the ECB's asset purchase programs. *Journal of Financial Stability*, 43, 40-52. <https://doi.org/10.1016/j.jfs.2019.05.001>
- Luck, S., & Zimmermann, T. (2020). Employment effects of unconventional monetary policy: Evidence from QE. *Journal of Financial Economics*, 135(3), 678-703. <https://doi.org/10.1016/j.jfineco.2019.07.004>
- Maddaloni, A., & Peydro, J. (2011). Bank Risk-taking, Securitization, Supervision, and Low Interest Rates: Evidence from the Euro-area and the US Lending Standards. *Review of Financial Studies*, 24(6), 2121-2165. <https://doi.org/10.1093/rfs/hhr015>
- Matthys, T., Meuleman, E., & Vander Vennet, R. (2020). Unconventional monetary policy and bank risk taking. *Journal of International Money and Finance*, 109. <https://doi.org/ARTN10223310.1016/j.jimonfin.2020.102233>
- Mishkin, F. S. (2007). The economics of money, banking, and financial markets: Pearson education.
- Paludkiewicz, K. (2019). Unconventional Monetary Policy, Bank Lending and Security Holdings: The Yield-Induced Portfolio-Rebalancing Channel. *Journal of Financial and Quantitative Analysis*, 56(2), 531-568. <https://doi.org/10.1017/S0022109019001054>
- Pariès, M., Kok, C., & Rottner, M. (2020). Reversal Interest Rate and Macroprudential Policy. ECB Working Paper Series No. 2487, November.

- Rossi, B. (2021). Identifying and estimating the effects of unconventional monetary policy: How to do it and what have we learned? *Econometrics Journal*, 24(1), C1-C32.  
<https://doi.org/10.1093/ectj/utaa020>
- Sugo, T., & Vergote, O. (2020). "Who takes the ECB's targeted funding?". ECB Working Paper Series No. 2439, July.
- Tobin, J. (1969). A General Equilibrium Approach to Monetary Theory. *Journal of Money, Credit and Banking*, 1(1), 15-29.