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# **Monetary Policy Tightening, Banks' Maturity Mismatch, and Transmission Mechanisms: Evidence from Portugal**

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Dissertation

Master in Economics

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*What we do in life echoes in eternity*  
*Maximus, Gladiator*

## **Abstract**

Asset-liability maturity mismatch is a particular feature of the banking system arising from maturity transformation activities. During the COVID-19 pandemic, the mismatch of maturity of euro area banks grew, but the trend inverted after the start of the tightening of the monetary policy. We study how the recent monetary policy tightening affected banks' lending decisions and whether *ex-ante* banks' maturity mismatch, attenuated or amplified its transmission. Our analysis is based, on the December 2021 ECB's first monetary policy tightening announcement. The ECB Pandemic Emergency Purchase Programme (PEPP) unwinding decision affected euro area banks, through the cutback of an affordable financing stream, promoting overall financing costs rise. However, Portuguese banks experienced an increase in their clients' deposits, which may have shielded their lending activity. This allowed them to keep the maturity mismatch level registered before the policy shock. We study the differential effects of the PEPP unwinding decision and maturity mismatch on lending, for banks affected by this announcement. We further focus our analysis on the deposits patterns, to check whether banks did rely on them to finance their lending increase. With this in mind, we employ the traditional DiD model and a Triple DiD model, in which we examine bank-level data from Banco de Portugal. Our results show, that Portuguese banks whose balance sheet might have been affected by the PEPP unwinding decision, decreased their lending in 2022. However, these banks' maturity mismatch attenuated the monetary policy transmission, meaning, they increased their lending. These effects are only valid for credit granted to Households. Still, the results show that second semester *percentage changes* are not economically sizable. We further conclude that deposits were not responsible for the observed lending pattern.

**JEL codes:** *E43, E52, E58, G21*

**Keywords:** Monetary Policy, Banks' Maturity Mismatch, Difference-in-Differences, Bank Lending, PEPP

## Resumo

A incompatibilidade de maturidade entre ativos e passivos é uma característica do sistema bancário que provém da transformação de maturidades. Durante a COVID-19, a incompatibilidade de maturidade dos bancos da área euro cresceu, mas a política monetária contracionista inverteu a tendência. Estudamos como a recente política monetária contracionista afetou as decisões de empréstimos dos bancos, e se, a incompatibilidade de maturidade dos bancos *ex-ante*, atenuou ou amplificou a sua transmissão. A nossa análise baseia-se, no anúncio da primeira política monetária contracionista do BCE em dezembro de 2021. A decisão de reversão do programa de compra de emergência pandémica (PEPP), afetou os bancos da área do euro, através do corte de um fluxo de financiamento acessível, promovendo o aumento dos custos gerais de financiamento. No entanto, os bancos portugueses sofreram um aumento dos depósitos dos seus clientes, que porventura, podem ter protegido os seus níveis de empréstimos. Isto permitiu-lhes manter o nível de incompatibilidade de maturidade *ex-ante*. Estudamos os efeitos da decisão de reverter o PEPP e da incompatibilidade de maturidade nos empréstimos, para os bancos que foram afetados por este anúncio. Focamos ainda a nossa análise nos padrões de depósitos, para verificar se os bancos dependiam deles para financiar o aumento dos seus empréstimos. Empregamos o modelo tradicional e triplo de diferenças-em-diferenças, nos quais examinamos dados provenientes do Banco de Portugal. Os resultados mostram que os bancos, que foram afetados pela decisão, diminuíram os seus empréstimos em 2022. No entanto, a incompatibilidade de maturidade destes bancos atenuou a transmissão da política monetária, o que significa, que aumentaram mais os seus empréstimos. Estes efeitos são apenas válidos para o crédito concedido às famílias. Todavia, as variações percentuais do segundo semestre não são economicamente significativas. Concluimos ainda, que os depósitos não foram responsáveis pelo padrão de empréstimo apresentado.

**Códigos JEL:** *E43, E52, E58, G21*

**Palavras-chave:** Política monetária, Incompatibilidade de maturidade, Empréstimos bancários, Diferença-em-Diferenças, PEPP

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## 1. Introduction

Since the beginning of the COVID-19 pandemic, the global economic outlook has changed. As demand and output decreased, governments employed large-scale fiscal stimulus measures. At the same time, central banks implemented monetary incentives, by engaging in quantitative easing. One of the measures was the PEPP programme, which stands for the Pandemic Emergency Purchase Programme, started in March 2020. This programme, had the purpose of minimizing the pandemic effects on the monetary policy transmission, therefore providing, support for firms and households. It essentially worked, with the European Central Bank (ECB), buying public and private securities from banks, thereby, transferring to them liquidity.

The effects of supply bottlenecks, partially a consequence of the impact of the pandemic on economic activity, coupled with surging energy prices brought by the war in Ukraine, pushed up an already increasing inflation rate. Therefore, central banks had no choice but to tighten their monetary policies. Concerning the ECB, there was a continuous rise of its interest rates up to October 2023, ending the zero-interest rate monetary policy, that was in place from the beginning of 2016 to July 2022. According to the ECB vice-president Lane (2023), this was not the first Governing Council monetary policy tightening decision. The first move was in December 2021, when the central bank announced that the deadline for the net purchases, under the PEPP, would be March 2022.

Banks, as important financial intermediation agents, are influenced by central banks' monetary policy decisions, since these affect banks' financing costs<sup>1</sup>. One common thread of the banking system is maturity transformation (Paul, 2023). Banks invest in long-term assets, using short-term liabilities. In a simple way, banks gather their customers' deposit amounts (*e.g.* demand deposits) and use them to invest in long-term assets (*e.g.* long-term loans). This inherently creates a balance sheet maturity gap/mismatch<sup>2</sup> (English et al., 2018). The mismatch can also be due to the different repricing frequencies, *i.e.*, the fixed contractual period, where interest rates of assets or liabilities are adjusted (ECB, 2023). This phenomenon can make them exposed, to what the literature refers to as “interest rate risk” (Freixas & Rochet, 2008; Hoffmann et al., 2018). Interest rate risk arises when interest rates

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<sup>1</sup> Monetary policies affect banks, through financing costs raise, that in turn may affect their lending activities (Stein, 1998).

<sup>2</sup> Throughout this dissertation, mismatch and gap will be used interchangeably.

change, especially it becomes a major concern for banks, when short-term interest rates get very low or even negative (Vuilleme, 2016). Therefore, it is worth studying banks' maturity mismatch effects.

Banks' maturity mismatch in the literature, has been largely used, to explain changes in banks' interest rate margins, whenever interest rate changes occur<sup>3</sup> (English et al., 2018; Hancock, 1985). Theoretical studies have shown, that banks are affected by monetary policies, due to their maturity transformation (Abadi et al., 2023; Bernanke & Gertler, 1995). The literature further explains, that banks' maturity transformation activities are responsible for the positive correlation between interest rates and banks' interest margins (English et al., 2018; Flannery, 1981; Hancock, 1985). Some empirical papers have divided the temporal effects of a rise in interest rates on banks' interest margins. In the long-term, margins tend to increase, but short-term effects are conflictual<sup>4</sup> in the literature. These effects on interest margins can also help us understand, possible effects on banks' profitability. For instance, Altavilla et al. (2018) find that euro area banks with a higher maturity transformation level, are more prone to have a higher profitability when the yield curve hikes<sup>5</sup>. Another variable already used in the literature to assess this impact, and that is also related to banks' profitability, is stock prices. The effects of banks' maturity mismatch are also dependent on whether we consider a raise in short or long-term interest rates.

Given this potential impact on banks' profitability, interest rate changes induced by monetary policy have an impact on banks' lending decisions (Cavallino & Sandri, 2023). Yet these effects may differ across banks depending on banks' maturity mismatch. As such, it would be important to better understand how banks' maturity mismatch may affect the lending decisions of banks. The literature seems to have a gap regarding this question, since we found only two articles studying this: Gomez et al. (2021) and Gambacorta and Mistrulli (2004). For instance, Gomez et al. (2021) tackle this, using an empirical framework that captures the credit lending effects given a monetary policy shock. They find that when the Federal Reserve (FED) increases its interest rates, lending is less affected for banks with higher maturity mismatch. This interaction, between banks' maturity mismatch and lending, in this type of framework, enables us to label banks' maturity mismatch as an amplification or attenuating

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<sup>3</sup> Caused for instance by monetary policy decisions.

<sup>4</sup> These effects, are sustained by the theoretical premise mentioned earlier between maturity transformation and interest rate changes, caused for instance, by monetary policies.

<sup>5</sup> The yield curve is influenced by monetary policies. In December 2021, the yield curve was increasing.

mechanism of monetary policy transmission. In the latter case, banks' maturity mismatch was an attenuator factor of the monetary policy transmission, since banks' lending was less affected by high maturity mismatch banks.

Since we study besides the link between banks' maturity mismatch and lending, the effects of monetary policy on the latter, we must then understand the literature on monetary policy transmission channels. Various monetary policy transmission channels have been advanced in the literature, but we can point out two that are more relevant to the current work. The bank balance sheet channel suggests, that the raising of interest rates, diminishes borrowers' net worth, while the bank lending channel, advocates that tighter monetary policy conditions are associated with higher funding costs (Bernanke & Blinder, 1992) and higher borrower-lender agency costs (Holmstrom & Tirole, 1997; Jiménez et al., 2012). Thus, discouraging banks from granting loans. The empirical side of the literature has been looking at a variety of factors, through the aforementioned channels, such as liquidity (De Santis & Surico, 2014), size (Mkhaiber & Werner, 2021), capital (Jiménez et al., 2012), interest rates (Adrian & Shin, 2008; Kishan & Opiela, 2012) that affect the transmission mechanism. The banks' maturity mismatch, to the best of our knowledge, is yet, underexplored, except for the work by Gomez et al. (2021) and Gambacorta and Mistrulli (2004).

In this dissertation, I will be assessing how Portuguese banks were affected by the PEPP unwinding decision and whether *ex-ante* banks' maturity mismatch affected their *ex-post* lending. The results of our tests will enable us to evaluate the role of banks' maturity gap on monetary policy transmission, *i.e.*, if it acted as an attenuator or amplification factor. We use two Difference-in-Difference models, that will explore the difference, before and after the policy shock, on banks' lending and deposits. The latter variable will inform us about the possibility of the lending pattern being financed by deposits increase. This study will first add to the bank lending channel literature, the effects on lending that central banks' monetary policy tightening announcements can have. Then, it will add to the literature, on the role banks' maturity mismatch can play in determining credit granting. Finally, it will further contribute with an empirical example that analyses the effects of a monetary policy tightening on a group of banks, instead of a systematic shock that affects all banking system.

The rest of the dissertation is structured as follows. Chapter 2 presents the literature concerning to monetary policy transmission mechanisms and banks' maturity mismatch. Chapter 3, presents the institutional background of the dissertation. Chapter 4 describes the methodology to be applied. Finally, Chapter 5 presents the results and Chapter 6 concludes.

## 2. Literature Review

This chapter focuses on the review of the current literature regarding monetary policy transmission channels and banks' maturity mismatch. Both literature reviews are narrowed to help us better understand what is the current state of our research topic. Since we set our empirical strategy in a monetary policy context, we first address the monetary policy transmission channels literature, and then, the banks' maturity mismatch literature. At last, a review of the literature's key takeaways will be provided.

### 2.1. Monetary policy transmission channels: Literature Review

Central banks' mandate, has the main purpose of using its tools to achieve their desired macroeconomic targets, most commonly, inflation targets. In the literature, central banks' capacity to influence macroeconomic fundamentals, through monetary policy in the short-run, seems to be agreed between scholars, even though, some state, it may be losing its potency<sup>6</sup>. However, from which channel(s)/mechanism(s) it operates, it still been studied for decades, in the monetary economics literature, from the dawn of the first channel- interest rate channel by Keynes (1936), to very recent channels- deposit and collateral channels. Therefore, it still is an unsolved question. The positive aspects of this wide range of channels are that it brings attention to policymakers, mentions what possible instruments they can use, its right timing, the intensity which affects the real economy, and also, its possible drawbacks (Loayza & Schmidt-Hebbel, 2002). There are six different defined monetary policy transmission channels, in the literature at the moment. In a very straight and simple manner, a tightened monetary policy will increase the cost of capital through banks, Households, and firms (interest rate channel); decrease asset prices, and make borrowers struggle to raise funds (balance sheet channel); leading to a risk-off investment behaviour by banks (risk-taking channel); discouraging banks from extending loans (bank lending channel); forcing deposits to flow out of the banking system, making banks face tighter budget constraints (deposits channel); and, finally, making the collateral values decrease, which negatively impacts bank funding (collateral channel). These channels can be aggregated in different categories, which themselves, can also be distinct. For instance, they can be classified between the money view

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<sup>6</sup> There is a debate, whether monetary policy is actually losing its potency or not, but since it is a little bit far from our spectrum, it is not going to be addressed here. For more information on this, please check, *e.g.*, (Boivin and Giannoni, 2010; Friedman, 1968).

and the credit view (Bernanke & Gertler, 1995)<sup>7</sup>.

Therefore, this chapter will present some monetary policy transmission channels, with a special focus on the credit channel, but not beforehand, introduce the interest rate channel. The two subchannels of the credit channel, to be introduced, are the borrower net worth or balance sheet channel, and the bank lending channel. The latter one will matter the most for this dissertation.

### **2.1.1. Interest-rate/cost of capital channel**

According to Keynes (1936) in his novel book, “The General Theory of Employment, Interest Rate and Money”, monetary policy affects both short and long-term interest rates. This happens, since money indirectly affects other economic variables, through its influence on interest rates, a view reinforced later, by Fisher (1920) quantity theory of money and by Friedman (1968). Specifically, a monetary policy tightening first leads to an increase in long-term nominal interest rates. Since prices and wages are assumed to adjust slowly, this change in the nominal rate is transmitted to a change in different real rates and the cost of capital. The increase in the long-term real rates makes the cost of borrowing increase in both the money market and capital market. Then, all different types of investment in the economy contract. Finally, this decline in the aggregate demand, results, in a reduction in both output and employment levels. This transmission path of the monetary policy, which can be seen in Mishkin and Eakins (2012) article, is the essence of the interest rate or cost of capital channel. It reinforces the conclusions of the AD/AS model, developed by Hicks (1937) and later extended by Hansen (1953), in which, changes in the nominal money stock or the short-term nominal interest rates, are responsible for changes in the economy’s output. Mishkin (1995), stated, that it is the real rate, and not the nominal rate, that truly matters in this channel, since it is the real interest rate, that impacts both Households' and firms' investment decisions. Nowadays, the tightening of the monetary policy is done differently, by increasing central banks' interest rates, which will later reflect a higher cost of capital throughout the economy, beginning in the money market. Nevertheless, in the literature, the interest rate channel has been acknowledged as the main channel of monetary policy, and the one that lies at the heart of the remaining ones (Taylor, 1995).

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<sup>7</sup> The focus is this dissertation, is not to present the different classification’s nomenclatures that scholars have been giving in the literature. For that, please see, *e.g.*, (Boivin et al., 2010; Bernanke & Gertler, 1995).

Beginning in the 90's, scholars tried to prove the veracity of this channel in their empirical studies. The results were inconclusive. Romer and Romer (1990) article, researched in a series of episodes, the effects of contractionary monetary policy in the US, and found evidence of interest rate channel. Also, Taylor (1995) article, found empirical evidence that real interest rates are negatively related to durable consumption, business fixed investment, residential investment, and even inventory investment. Thus, the interest rate channel was significant, according to these authors. However, this conclusion was not consensual. Bernanke and Gertler (1995) article, came to the opposite conclusion, that monetary policy, could not significantly affect real borrowing' costs, and so, putting into question this channel. Later, in a kind of a common ground between these two opposite views, Boivin and Giannoni (2002) study, indicated, that monetary policy, through the interest rate channel, no longer produces the same level of response both in output and inflation, and so, it may have lost some potency. Within the euro area countries case, some studies also revealed the existence of the interest rate channel (Peersman & Smets, 2001; van Els et al., 2003). Therefore, Kuttner and Mosser (2002) article, affirmed in their article, that even though monetary policy is still effective, is not as much as it was once, and the sensitivity of the economies to interest rates, is still an open question.

### **2.1.2. Credit channel**

According to Bernanke and Gertler (1995, p. 1) seminal article, although there is an agreement among economists that monetary policy affects the real economy in the short run, there is no consensus “about what happens in the interim”, which they classified as the “black box” of monetary policy mechanism. In their article, the authors pointed out, some problems of the only mechanism generally discussed at the time- the interest rate channel. According to them, the vast majority of empirical studies then, had not been successful in identifying quantitatively the effects of the cost of capital. Plus, the ones who did, could not rule out, the significant impact of the nonneoclassical determinants of spending<sup>8</sup>. Therefore, these determinants could be impactful in the transmission of the monetary policy and not the cost of capital solely. Another drawback pointed out by the authors, has to do with the presumption that the monetary policy has its strongest impact, on short-term interest rates, and the impact, eventually fades away as longer the maturity is. They argue, that monetary

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<sup>8</sup> The authors classified as nonneoclassical factors, such as, lagged output, sales and cash-flows, and as neoclassical the cost of capital variable.

policy has a large impact on purchases of long-lived assets, such as housing, that are influenced primarily by real long-term rates. Thus, monetary policy should have an impact on interest rates, no matter the maturity. Since there was this unsettledness around the interest rate channel debate, economists tried to come up with better alternatives, that tried to better describe the economic reality. Therefore, scholars tried to alleviate one strong assumption of the interest rate channel- the lack of role performed by financial markets, which were assumed, as frictionless. As noted by Bernanke and Gertler (1995), financial frictions may amplify the effects produced by monetary policies on the real economy. Therefore, according to Gertler and Gilchrist (1993) article, credit market imperfections, can be significant to the transmission of monetary policy in two complementary ways. It can, on one side, put pressure on some borrowers to choose firstly banks' credit, and on the other side, these bank-dependent borrowers may be too sensitive to riskless interest rates. So, scholars tried to study the impact that credit markets' frictions, such as information asymmetry, might had on the transmission of monetary policy. Thus, the credit channel was born in the literature, which stated, that monetary policies (monetary rates and reserve requirements) impact both GDP and prices through credit (Ciccarelli et al., 2015). It was coined, by the economist Ben Shalom Bernanke in his 1986 article- "Alternative Explanations of the Money-Income Correlation". In it, he used a VAR approach, to study the money-income correlation, and found evidence against their formulated hypothesis, of credit shocks explaining nothing in their model. So, reversely, that meant, credit shocks may explain something in the correlation. Therefore, the author suggested, that policymakers should pursue a conservative course of action, where it does not provoke destabilizing shocks to credit markets. This study marked the beginning of the end of the assumption established at the time, of markets' frictionless and the existence of only one asset price channel. Nine years later, Bernanke and Gertler (1995) article, suggested that this channel, should not be considered as both an independent and a pure alternative of the interest rate channel, but rather as an enhancement one. According to them, the credit channel theory, states that it acts as an amplifier of the monetary policy effects on interest rates. This occurs, by endogenous changes in the external finance premium<sup>9</sup>. This, in turn, exposes the magnitude of the imperfections in the credit markets, such as constraining lenders' ability to grant credit. The authors also state, that the changes in external finance premiums, have a

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<sup>9</sup> It is the difference between the costs of funds raised externally and funds raised internally.

positive correlation with changes in monetary policy, magnifying it. This channel of monetary policy transmission can be divided into two subchannels, as stated by Bernanke and Gertler (1995)- the balance sheet and the bank lending channels. These act as two sides of the same coin, in the sense that, while the bank lending channel, presumes that monetary policy can affect the supply of banks' loans, the balance sheet channel, presumes that monetary policy affects the demand for loans. So, these two subchannels, are a breakdown of the credit channel, in the law of supply and demand. A particular feature of them lies in the fact that banks are assumed to play an important role in the transmission process, since the loans they provide, are considered to be imperfect substitutes, compared to other funding options (Boivin et al., 2010).

The credit channel is not uncontroversial in the literature, since some authors could not find significant evidence of its existence, in its two subchannels (Ramsey, 1993; Romer & Romer, 1990). This identification problem is linked to the credit channel theory itself. Monetary policy, through credit supply and demand, impacts both borrowers' and lenders' balance sheets. The problem lies in the fact, that the changes on the balance sheets, due to monetary policy changes are not easy to observe, making it harder for scholars to identify the credit channel, through its subchannels. Researchers have tried, to alter from macro to microdata, to try to solve this issue. However, both of them cannot address it, sufficiently (Ciccarelli et al., 2015). Concerning macro data, since it uses credit data in an aggregated form, it does not supply enough information to identify supply, as noted by Bernanke and Gertler (1995). Also, it is not easy to isolate credit demand and supply. To try to suppress these problems, micro replaced macro data. Nevertheless, it cannot account for all effects of the monetary policy, only cross-sectional ones (Kashyap & Stein, 2000). Another possible drawback may reside in the possibility of being harder to separate firms' balance sheet channels from banks' lending channels (Gertler & Gilchrist, 1994).

Therefore, "approving" the credit channel of the monetary policy transmission, still is an unsolved question, waiting to be answered in a satisfactory manner in the literature.

### **2.1.3. Balance sheet channel**

At the meetings of the American Economic Association Greenspan (2004) showed his concern about banks' balance sheet state, addressing it as "headwinds" in the economy. According to Bernanke and Gertler (1995) article, the balance sheet channel refers to the effects that monetary policy might have on borrowers' balance sheets and income

statements, through their net worth, cash-flows, and liquid assets. So, a monetary policy tightening will increase the debt service, shrinking cash flows and collateral values (asset prices decrease). This will then have, a negative impact on borrowers' credit rating, which means, that lenders will require a higher premium to finance them. Moreover, this increase in the external finance premium increases firms' demand for loan contracts.

For instance, the balance sheet channel was initially addressed in Bernanke and Gertler (1989) financial accelerator framework<sup>10</sup>, in which the authors concluded, that a decrease in the net worth, raises asymmetric information between borrowers and lenders, thereby, making the external finance premium increase<sup>11</sup>. Theoretically, the balance sheet channel can either affect both firms' and Households' net worth. For instance, a monetary policy tightening may affect firms through asset price decreases, as well as its cash-flows, which diminishes a firm's net worth, thereby, subjecting them to the already mentioned asymmetric problems. In Bernanke and Gertler (1995) novel article, while using monthly data for the period between 1965 and 1993, the authors found, that firms' spending on durable goods is negatively impacted by monetary policy tightening. Moreover, the weakening of their balance sheets may continue to fall due to the continuous rise of external finance premiums, even after interest rates have started to decrease. Another article by Ashcraft and Campello (2007), also found empirical evidence of the balance sheet channel for firms' case. Their results of small business demand for loans corroborate the demand-driven transmission mechanism, that is independent of the bank lending channel, *i.e.* the supply of loans. In the case of Households, it may be translated into the housing prices, through collateral values. For instance, higher house prices may reduce the external finance premium. Some empirical papers have supported this idea, that changes in house prices, can, in turn, influence the ability of Households to get credit (Benito et al., 2006)<sup>12</sup>. In the case of the euro area banks, between 2008 and 2009, Ciccarelli et al. (2014) article, also found evidence of the balance sheet channel, for both firms and Households during this period.

### **2.1.3.1. Banks' balance sheet**

The balance sheet channel also applies to banks. The literature affirms, that banks' balance

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<sup>10</sup> The financial accelerator theory can be seen in Bernanke et al. (1996).

<sup>11</sup> The asymmetric information problems can be divided in adverse selection and moral hazard, please see Mishkin and Eakins (2012). Also, the entire explanation of the process of how asymmetric information can affect external finance premium can be seen in (Boivin et al., 2010).

<sup>12</sup> For other articles covering this question, please check, (*e.g.*, Iacoviello & Minetti, 2008).

sheet state, has a negative relationship with changes in interest rates. This bank channel is also influenced by agency frictions between banks and their lenders (Jiménez et al., 2012). For instance, a higher policy rate makes their cost of funding increase, which may contract their demand for funds (Bernanke & Gertler, 1995). Additionally, Igan et al. (2017) concluded, that after a monetary policy tightening, banks' funding costs rise, by increasing debt service and reducing assets and collateral values. This then, makes borrowers' creditworthiness shrink, and then, decreasing loans demand. In a broader perspective, Altavilla et al. (2021) study, also using euro area banks data, concluded that after a shock in monetary policy, bank strength, measured by some banks' characteristic variables, such as size and liquidity, affects their credit demand.

### **2.1.3.2. Unconventional monetary policies**

A recent research avenue in the literature, that I will not thoroughly explore, but it is important to mention, is the effects on banks of the zero-lower bound, or even negative interest rate policies<sup>13</sup>. An interesting article to mention then, would be from Bittner et al. (2022), which proposed to examine the interaction, between the transmission of policy rates to banks' funding costs and their balance sheet. For that, they used the German and Portuguese cases, during the zero-lower bound (ZLB) period. They concluded in that period, there was a strong policy pass-through to banks' funding costs for Portuguese banks, but a weak pass-through to German banks. Moreover, the traditional bank balance sheet channel is operated in both countries but with a different potency level. Also, in Heider et al. (2019) article, the authors concluded, that negative policy rates were not being transmitted by high-deposit banks to their depositors, which increased banks' funding costs, and thereby, their net worth.

This transmission channel still continues to be addressed in the literature, and some authors claim, that monetary policies are increasingly more impactful on banks' balance sheets, even though, some authors claim their potency, may be fading away (Adrian & Shin, 2008; Kishan & Opiela, 2012).

### **2.1.4. Bank lending channel**

As stated, the subchannel that deals with the study of the supply side of loans is the bank lending channel. According to economic textbooks, the well-known IS/LM model assumes

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<sup>13</sup> To have an insightful depiction please see, *e.g.*, (Altavilla et al., 2022; Albertazzi et al., 2021).

that banks are passive agents of monetary policy transmission. This means, that they act as a quiet conductor for funds between central banks and borrowers (Kishan & Opiela, 2000). However, economic research put into question this perspective, having as a central proposition, that monetary policy impacts banks through deposits. As they constitute the main source of funding for banks' loans, deposits act as the driving force of bank lending (Disyatat, 2011; Stein, 1998). In their seminal article, Bernanke and Blinder (1988) first addressed this matter, while introducing the bank lending channel (BLC). According to their work, monetary policy tightening pushes the deposits out of the banking system, leading to a shortfall in deposits, and thus, forcing banks to retrieve their lending. This close link between monetary policy and banks' deposits, can be motivated by two different arguments. The first one is presented by some scholars, such as Bernanke and Blinder (1988) and Kashyap and Stein (1995), which state that this close connection, is based on central banks' ability to shape the level of deposits through their control over banks' reserves. This view is not currently used, since central banks have not been conducting their monetary policies through bank reserves. The other argument is that the yield provided by deposits after the tightening policy, may not be as attractive as other assets. So, Households have no more incentive to hold them. In both arguments, banks are forced to seek more expensive ways of funding<sup>14</sup>, which makes them decrease their loan supply. For instance, a contractionary monetary policy decreases the core deposit funding of banks' loans, and thus, their lending. This in turn, eventually negatively affects the real economy, by reducing both investment and consumption levels.

For this channel to be effective, it needs to follow two assumptions. First, it needs to exist some bank-dependent borrowers, and second, monetary policy can actually affect banks' loans (Kishan & Opiela, 2000). Empirical wise, the traditional bank lending channel literature supported this last question (Bernanke & Blinder, 1992; De Santis & Surico, 2014; Gertler & Gilchrist, 1994; Kashyap & Stein, 1995; Peek & Rosengren, 1997). For instance, Bernanke and Blinder (1992) in their seminal article, used a VAR model with aggregated bank data and found out that in the short-term monetary policy does not affect banks' loans, but in the long-term it does. It affects loans in the way, that banks end old loans and turn down new ones. Another very cited article that also supported the traditional bank lending channel, was

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<sup>14</sup> According to Gambacorta and Mistrulli (2004), the market for bank debt has frictions and the non-reservable liabilities are mostly not insured, so banks are required to pay a premium for new debts. Also, reservable deposits cannot be completely offset by other alternatives, so banks have necessarily to experience more expensive funding ways.

from Kashyap and Stein (1995). In it, a monetary policy tightening makes deposits drain from the banking system, which means banks cannot frictionlessly cover this shortage with non-deposit external finance. Thus, banks contract their loan supply, which makes firms who are dependent on them, reduce their investment spending. Kashyap and Stein (2000) article, used a very big sample of almost 20-year panel data, to assess the existence of this channel, incorporating periods of monetary policy tightening and easing. The answer they reached, was affirmative, even though the authors warned, they cannot evaluate its quantitative importance. Specifically, they found that banks with less liquid balance sheets, and especially smaller banks, see their lending be more affected by monetary policy shocks.

Still, this traditional view of the bank lending channel faced early skepticism. For instance, one could argue, that the shortage of deposits may be countered by engaging in other alternative funding sources (Romer & Romer, 1990). Ramsey (1993) empirical article, pointed towards the marginal effect of banks' loans not being economically significant on industrial production, so the author concluded against this channel. Another argument would be, the fact that the monetary policy is no longer conducted directly through controlling banks' reserves, but instead, through changes in short-term interest rates, which made scholars doubt this channel depiction. Also, this traditional view focuses on the impacts that the reserve requirements have on demand deposits, but it does not shed any insights into banks' equity (Van den Heuvel, 2002). Finally, since the formulation of this traditional perspective, the financial system has changed, especially its level of innovation and the underlying deregulation. This then, may have affected the way banks' lending reacted to changes in monetary policy, especially after the aftermath of the global financial crisis (Gambacorta & Shin, 2018). Therefore, post-traditional bank lending channel articles, have continued to examine how the bank lending channel may have changed. They did this, by switching the focus to other banking variables, usually, *liquidity* (Ananou et al., 2021), as well as *size* (Berger & Black, 2011), *capital* (Dell'Ariccia et al., 2017), and *profitability* (Gunji & Yuan, 2010), which are the more studied ones. Succinctly, these papers demonstrate, that in tighter monetary policy periods, more liquid, profitable, bigger, and with higher capital ratios banks, can shield themselves more in these periods. For instance, Altavilla et al. (2021) article concluded that bank strength, measured by a group of bank characteristic variables, such as size and liquidity, after a monetary policy shock affects credit supply. Also, Cantú et al. (2022) concluded that large and well-capitalized banks, with high profitability and a low share of volatile funding sources, increase their loan supply and are more shielded from monetary

policy shocks.

#### **2.1.4.1. Unconventional monetary policy**

As mentioned, a large and increasing research avenue is regarding unconventional monetary policies. Specifically, its effects on banks' lending supply. Overall, the conclusions tend to be that this kind of monetary policy positively impacts banks' credit supply (Rodnyansky & Darmouni, 2017; Schelling & Towbin, 2022). An interesting insight is given to us by the Chakraborty et al. (2020) article, in which they found that quantitative easing (QE) can increase mortgage lending by banks, but it decreases commercial lending, having later on, real effects translated in firms reducing their investment. Benetton and Fantino (2021), using Italian banks' data, concluded that the first series of ECB TLTROs was beneficial to banks' loan supply. The TLTROs could have been an effective policy tool for channeling loans into productive projects, increasing loan amounts, and reducing the debt service of small firms. Another study of this kind belongs to García-Posada and Marchetti (2016), in which they used Spanish data and also concluded that the ECB' two very long-term refinancing operations (VLTROs), had a positive effect on banks' credit supply. Moreover, the greater the banks' illiquidity, the greater this effect. Also, the Bittner et al. (2022) study concluded that under negative monetary policy rates, euro area banks' funding structure matters for their credit supply. Specially, the importance of deposits in banks' liabilities compared to market-based funding, and also, the level of deposit rates. Oppositely to these findings, Heider et al. (2019) stated that negative policy rates negatively affected euro-area banks' lending.

#### **2.1.4.2. The role of bank capital in lending**

Of the above-mentioned researched banking variables, bank capital seems to have a special place in the literature, to the extent that it even got named as a parallel channel of the bank lending channel- the bank capital channel (Boivin et al., 2010). A very important distinction to make concerning banks' capital role in lending, between the bank capital channel (mentioned in the next chapter) and the bank lending channel, is that while the former is related to market imperfections regarding banks' equity, the latter, aims to markets' imperfections for banks' debt (Van den Heuvel, 2002). Following the bank lending channel, as said, a tighter monetary policy leads to a withdrawal of banks' deposits and since the market for banks' debt is imperfect, banks' external finance premium goes up. Banks' capital enters in this story, by the credit rating way. External rating is formulated according to banks'

capital “wealthiness”, which signals investors about their creditworthiness. So, one may infer that low-capitalized banks may experience a higher external finance premium. For instance, Kishan and Opiela (2000) divided their bank dataset, into 6 different asset sizes, and subdivided each into three capital leverage ratios. They concluded that undercapitalized banks were the most affected by monetary policy concerning their loans. They also found that this type of bank was bound to raise funds through their deposits. Since small banks’ loans can have a very significant impact on the real economy (Hancock & Wilcox, 1998), the authors concluded that their findings supported the bank lending channel.

### **2.1.5. Bank capital channel**

The bank capital channel, states that the financial condition of banks’ balance sheets plays an important role in their lending behavior (Boivin et al., 2010). This argument goes against the globally famous Modigliani-Miller theorem (Gambacorta & Mistrulli, 2004). According to the M&M theorem, the financial structure of firms (the same applies to banks) does not affect their investing decisions (Modigliani & Miller, 1958)<sup>15</sup>. For instance, the chain of events for this channel, starting with a monetary policy tightening, until the final result of banks’ retrieving loans, can be the following. Let us say, that either happens a fall in asset prices or a decrease in banks’ credit quality. This then, may reduce banks’ assets value. The consequent shortfall in banks’ capital, aligned with the increase in the external finance premium, may lead to a cut in their lending supply. This finally will eventually lead, to a decrease in aggregated demand.

According to Gambacorta and Mistrulli (2004), the bank capital channel is embedded in three foundations. Firstly, banks’ equity market is imperfect, in the sense agency costs block banks from easily issuing new equity (Stein, 1998). The second one will be mentioned in the next Chapter- banks’ interest rate risk due to maturity transformation activities. Van den Heuvel (2006), corroborated this foundation, stating that maturity transformation, can also have a significant importance on this channel. For example, after a monetary policy tightening, normally, loans cannot be renegotiated as easily as deposits. Therefore, the interest rates associated with banks’ assets, will adjust slower compared to banks’ liabilities interest rates. The maturity mismatch will then make, banks have lower profits and thus, the capital. Assuming the equity is insufficient and it is too costly to issue new shares, banks can either

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<sup>15</sup> According to Modigliani and Miller’s (1958), their theorem is only valid under the assumption that capital markets are perfect.

reduce their lending or else fail to match the regulatory capital requirements. For instance, Gambacorta and Mistrulli (2004), concluded that bank capital plays an important role in the dissemination of monetary policy shocks to lending. The effects are stronger, for those who have larger maturity mismatches. Finally, the last foundation refers to the regulatory capital requirements connected to their credit supply, that banks have to satisfy (Van den Heuvel, 2006).

Overall, the literature has been supporting this channel. For instance, Wang (2020) built a model, where banks' lending ability depends on their equity status. Low monetary policy rates, contract deposit spreads, and widened loan spreads make banks' interest margins increase, thereby, affecting their capital accumulation. This then, positively impacts banks' credit supply. Another study by Gambacorta and Shin (2018), revealed that after a monetary policy tightening, banks well-capitalized can shield their lending since their funding costs are more manageable to them. Lopez et al. (2020) concluded, that when monetary policy rates are negative, this does not have a positive effect on banks' profitability, and hence their capital, since they offset it with increases in non-interest income, but banks manage to increase their lending. Finally, Bittner et al. (2022) used bank data from four-euro area countries, to study the transmission mechanisms on them. They found, that in Germany and Finland, the bank capital channel is absent, whereas, for Portugal and Italy, they found evidence of it. However, they warned that in the latter, it depends on the transmission of monetary policy to deposit rates, since in Portugal and Italy, the effect of high deposit banks' funding cost dominates.

## **2.2. Banks' maturity mismatch: Literature Review**

Banks are pivotal financial intermediaries with special features. Economic textbooks state, that banks reduce transaction costs, due to economies of scale and their expertise, lessen asymmetric information, both adverse selection and moral hazard, and also hedge conflicts of interest between parties (Mishkin & Eakins, 2012). Its existence is justified by the demand for funds from economic agents, with long-term financial needs, from economic agents, with surplus liquidity (Hicks, 1946). Schumpeter (1912) affirmed in his article, that banks help filter projects characterized as productive investments, helping them get funding, which in turn, contributes to innovation and economic growth. Other articles, both theoretical and empirical, have concluded the same, also stating that their existence improves not only economic growth but also, capital accumulation, productivity, etc. (King & Levine, 1993;

Levine & Zervos, 1998). These effects on the real economy, are an output of several functions performed by banks, whether it is commercial banks, investment banks, or shadow banking entities (Segura & Suarez, 2017). One of these functions is qualitative asset transformation (Bhattacharya & Thakor, 1993). It means, that banks, finance assets with longer maturities than liabilities (maturity transformation), they also fund illiquid loans with liquid liabilities (liquidity), and they monitor borrowers to reduce default risk (credit risk). The first feature, maturity transformation, and its inherent consequence of maturity mismatch will be our focus in this sub-chapter. The main goal will be to conclude, if banks' maturity mismatch can affect lending volumes, after a monetary policy shock. This will enable us to understand, whether banks' maturity mismatch, can act as an attenuating or an amplification mechanism of monetary policies' transmission channels. With this in mind, first, it will be presented banks' maturity mismatch, as one key feature of the banking system. After explaining its nature, and what it means to the banking system, it will be presented its theoretical literature, and then, its empirical literature. This last one will be divided into three subsections, relative to the relationship between changes in interest rates, and the most used banking variables: interest margins, stock prices, and lending. The latter variable is the one to focus on, but the first two, may indirectly affect bank lending, and thus, it is important to mention them.

One common thread of the banking system is maturity transformation. This means banks invest in long-term assets using short-term liabilities (Paul, 2023). Usually, the preferred long-term assets, are concerned with bank loans, and the short-term liabilities, are its costumers' deposit amounts. This banking activity naturally creates a maturity mismatch in the balance sheet of banks (English et al., 2018). The maturity mismatching can also be due to the repricing frequencies, *i.e.*, the fixed contractual period where interest rates of assets or liabilities are adjusted (ECB, 2023). According to Greenbaum and Thakor (2007), banks may see maturity gap, as a positive factor in their profitability, as long as the yield curve presents term premia. Therefore, banks may have an incentive to engage in such activities (Brunnermeier & Oehmke, 2013). By doing so, banks' maturity mismatch, can make them exposed, to what the literature refers to as "interest rate risk" (Freixas & Rochet, 2008; Hoffmann et al., 2018). It concerns the risk, that comes up when interest rates change, altering the value of banks' financial instruments (Sara Noorali, 2005). Especially, it becomes a major concern for banks, when short-term interest rates get very low or even negative (Vuillemeey, 2016). According to Hellwig (1994), it can assume two forms: reinvestment

opportunity risk and valuation risk. The former is concerned with the possibility of banks having to reprice their maturity contracts at a prejudice rate, while the latter, is regarding the risk, that the net present value of their loans and deposits decreases. This risk to banks' financial well-being, makes it worth studying the maturity mismatch thoroughly.

### **2.2.1. Theoretical literature**

One of the first contributions to the theoretical literature, that acknowledged the importance of banks' maturity mismatch on financial stability, was Diamond and Dybvig (1983) article. It helped increase the awareness of the negative impact, it can have on the real economy, in the case of bank runs events. Another theoretical contribution was made in the following year, by Flannery and James (1984), but regarding a different factor- interest rate risk. After the aftermath of the 2008 global financial crisis, scholars turned again the theoretical research focus, to the inefficiencies related to maturity transformation, since it played such a vital role in its unfolding. For instance, Segura and Suarez (2017) formulated a model, where banks define debt maturity, according to the systemic risk, and their customers' preference for short maturities, in line with Diamond and Dybvig (1983). They concluded in their model, that banks work with excessive maturity transformation, which translates into an equilibrium socially inefficient. Brunnermeier and Oehmke (2013) model, also indicated the existence of inefficient banks' maturity mismatch, and therefore, financial regulators should limit it. These articles, agreed upon the conclusion, that excessive banks' maturity mismatch is hazardous for the stability of the financial system, therefore acting as an amplification mechanism during a crisis (Brunnermeier, 2009; Gorton, 2009). This amplification factor can then, have serious repercussions on the real economy, negatively affecting some important variables, such as productivity (Andreasen et al., 2013).

Even before this greater awareness of its possible negative impacts on financial stability, banks' maturity mismatch had already been subject to various theoretical studies, that linked it to banks' balance sheets, to see if and how it can affect them. One popular research avenue is regarding banks' interest rate margins, to study, whether changes in market interest rates affect their margins. Usually, the theoretical literature reaches their conclusions, on this matter, by basing their models on Thomas and Saunders (1981) model, and then extending it (Angbazo, 1997; Bologna, 2018; Entrop et al., 2015; Maudos & Fernández de Guevara, 2004). In this original model, banks are risk-averse financial intermediaries, where they charge a fee for providing liquidity, without waiting for a maturity matching transaction. Scholars

then, try to alleviate some of the model's assumptions, to answer their research questions. They have first shown, that banks are affected by monetary policies, due to their maturity transformation (Abadi et al., 2023; Bernanke & Gertler, 1995). Then, they explain this effect, by stating, that banks' maturity transformation activities are responsible for the positive correlation between interest rates<sup>16</sup> and banks' interest margins (Bologna, 2018; Flannery, 1981; Hancock, 1985). For instance, Abadi et al. (2023) conclude, that interest rate cuts, lead to a decrease in banks' margins, especially for those with small initial maturity mismatch. Thus, causing a reduction in their lending. Also, Bologna (2018) article, indicated this positive relationship between Italian banks' maturity gap and their interest margins. The author claims, that a higher maturity transformation, raises more banks' net interest margins, as steeper the yield curve and higher short-term rates are. From a theoretical viewpoint, and according to these results, banks by having greater interest margins, will have higher profits, which can shield their activities, such as lending, when facing tighter monetary policies (Kashyap & Stein, 1995). We then, may suggest, that banks' maturity mismatch, may act as an attenuating factor in Abadi et al. (2023) and Bologna (2018) articles. Inconveniently, a possible obstacle to this conclusion may reside in the fact, that the positive relationship between interest rates and banks' interest margins, first introduced by Samuelson (1945) article, is not consensual in the theoretical literature (Drechsler et al., 2021; Hancock, 1985). This means, that the literature cannot inform us how banks' activities, such as lending, may be affected by this relationship, since banks' profitability<sup>17</sup>, impacts the level of lending they grant to the real economy (Brunnermeier & Sannikov, 2014; Cavallino & Sandri, 2023). Therefore, banks' maturity gap, can be either acknowledged as an amplification mechanism (Adrian & Boyarchenko, 2012; Adrian & Song Shin, 2010; Cúrdia & Woodford, 2016; Van den Heuvel, 2006) or as an attenuating mechanism (Andreasen et al., 2013). For instance, in Van den Heuvel (2006) article, a monetary policy tightening, makes banks' interest margin decrease, making them struggle to rebuild their capital since they can only rely on their profits to do so. Therefore, banks would reduce their credit granting. According to the author, this chain of events happens, due to banks' maturity mismatch, and so, it plays as an amplification mechanism. Another article by Di Tella and Kurlat (2021), indicates that banks' maturity mismatch amplifies the effects of monetary shocks on the cost of liquidity. Their model

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<sup>16</sup> Some of the mentioned articles, used market interest rates and not central banks' interest rates, and thus, it becomes important to mention that monetary policies affect market interest rates (Ellingsen & Soderstrom, 2001), and so, we can connect monetary policies to the articles' conclusions.

<sup>17</sup> As said, banks' profitability is influenced by banks' interest margins.

shows, that the maturity gap is larger in periods of low interest rates, and so, the amplification effect is greater. An opposite conclusion is reached by Andreasen et al. (2013) paper, while using a DSGE model, claiming that the higher banks' maturity mismatch is, the less the economy's investment, consumption, and output fall, in reaction to a monetary policy tightening. This may allow us, to classify the maturity gap as an attenuating factor. Therefore, even though, we know that banks' maturity mismatch seems to indirectly affect bank lending, through the relationship between interest rates and their interest margins, we cannot explicitly say what is its role in the transmission of monetary policies. Thus, let us check the empirical literature takeaways on this.

### **2.2.2. Empirical literature**

The majority of the empirical literature connects banks' maturity mismatch and interest rate risk (English et al., 2018; Gomez et al., 2021). This normally translates into assessing, how banks' maturity gap affects their equity (*e.g.* profitability, stock prices) or their activities (*e.g.* lending). Several empirical articles have concluded, that (excessive) banks' maturity mismatch, was a key driver of the 2008 global financial crisis (Bologna, 2015; IMF, 2013). Therefore, after it, the number of articles that studied banks' maturity mismatch grew.

#### **2.2.2.1. Banks' lending**

With respect to the role of banks' maturity gap in the relationship between interest rates and banks' lending, there are only two articles that deals with this matter, to my knowledge. It is important to bear in mind, that this is one goal of this dissertation. Therefore, is compulsory to mention Gomez et al. (2021) article, since it has a very similar research question to mine. Using the income gap measure<sup>18</sup>, the authors found out that after the FED tightened its monetary policy, US banks with a larger income gap, experienced greater earnings, which made them reduce less their investment and lending, compared to the remaining. This means that the bank's income gap (negatively) affects the transmission of monetary policy, behaving thus, as an attenuating factor. They conclude, that the income gap is a major driver in banks' profitability reaction to changes in interest rates. Interestingly, the reason why banks reduce their lending is the surplus of cash-flows driven by a greater income gap and not the increase in equity value. Thus, these results support the bank lending channel and not the balance sheet channel. The other article is from Gambacorta and Mistrulli (2004), already presented

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<sup>18</sup> This measure is later explained.

in the bank capital channel subsection 2.1.5. However, this article reaches a different conclusion. Banks' maturity mismatch amplifies the negative effect of monetary policy tightening, decreasing lending.

Since the literature cannot provide us yet, a satisfactory number of articles, that directly connect banks' maturity mismatch and their lending, it is mandatory we find indirect effects, through other variables. Therefore, the most used banking variables in the empirical literature, that have been studied, and concluded that affect banks' lending, are interest margins and stock prices (Brunnermeier & Sannikov, 2014; Cavallino & Sandri, 2023; Dietrich & Wanzenried, 2011).

#### **2.2.2.2. Banks' interest margins**

Some of the works mentioned in the theoretical part, also use data to "feed" their models, to see what they indicate. For instance, Bologna (2018) article, as already mentioned, extended Thomas and Saunders (1981) model, and corroborated what the theoretical literature had previously concluded- maturity mismatch, plays a vital role in the performance of banks' interest margins. Using Italian banks' data, the author's model indicated that during a steep yield curve period, the higher the banks' maturity gap is, the higher its interest rate margins will be. However, this conclusion is not time neutral, in the sense, that it does not stand if the maturity mismatch, across time, gets "excessive", which will eventually lead, to the opposite effect on banks' interest margins. This means, that the classification of maturity mismatch between amplification or attenuating mechanisms, may be time-dependent<sup>19</sup>.

Purely empirical papers tend also to achieve different conclusions, concerning the effect of interest rate changes on banks' interest margins, thereby, making the classification of the maturity gap, as an amplification or attenuating mechanism, harder. For instance, Alessandri and Nelson (2015) and Borio et al. (2017), divided the temporal effects of a rise in interest rates, on banks' interest margins and the role of maturity gap in it. In Borio et al. (2017) article, when short-term interest rates are high and the yield curve is steep, banks' short-term interest margins increase, as in Bologna (2018) article. This occurs, due to maturity transformation. In Alessandri and Nelson (2015), the conclusion is slightly different. In the short term, the interest margins decrease, due to banks' maturity mismatches, whereas in the long term, it increases. In a recent article, Paul (2023) concluded the same, that a (expected)

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<sup>19</sup> As previous stated, maturity mismatch by positively affecting banks' interest margins, and thereby, profitability, it can have a positive impact in their activities, such as, lending (e.g. Cavallino & Sandri, 2023).

positive level of short-term interest rates, makes banks' net interest margins decrease. Oppositely, expected long-term rates, translated into term premiums, make them increase, a statement also corroborated by Altavilla et al. (2018) paper. Moreover, these effects are amplified for banks, that engage more in maturity transformation.

Additionally, since this dissertation is concerned with a euro area country, there is an interesting article by Altavilla et al. (2018), in which, the authors used euro area banks data, to study the effects of different monetary policy implementations on banks' profitability. They found out, that banks with a higher maturity transformation level, are more prone to have a higher profitability when the yield curve hikes. Whereas, in the specific case of unconventional monetary policies, such as quantitative easing, it makes the yield curve flatter, and thus, reduces banks' maturity transformation returns, thereby, decreasing bank's net interest margins (Altavilla et al., 2018). Thus, in tighter monetary policy periods, the maturity gap may act as an attenuating factor, whereas, in softer monetary policy periods, it may act as an amplification mechanism.

### **2.2.2.3. Banks' stock prices**

There are some studies, that connect banks' maturity mismatch and their stocks' returns. However, this is only worth mentioning, if banks' stocks can affect their profitability, which as mentioned, affects banks' activities, such as lending. It seems to be plausible, that stocks by being shares of the banks' equity value, can influence their activities. For instance, the 2008 financial crisis, made global market stocks fall dramatically. This, as we know, made banks struggle to keep their banking activities, and even in extreme cases, made them close their doors. So, it seems in historical terms, banks' stocks may affect their normal activities as financial intermediaries. Moreover, we can name some empirical articles that corroborate this conclusion. For instance, Dietrich and Wanzenried (2011) article concluded, while using data from 453 Swiss banks, that the higher the stock market capitalization is, the higher banks' profitability becomes. Therefore, we may indirectly connect banks' stocks and their activities, such as lending. In two already mentioned articles, Paul (2023) and English et al. (2018), evaluate the role of US banks' maturity transformation in stock prices. Paul (2023) concluded, that banks that have a larger maturity gap, see their stock prices increase, when (expected) long-term interest rates increase. However, when (expected) short-term interest rates increase, their stocks decline. These reactions, are the same for banks' interest margins, that the author reached in the same article mentioned. Thus, once again, a bank's maturity

gap, may act as an amplification or attenuating factor, depending on the interest rate maturity considered. Regarding English et al. (2018) article, the authors concluded, that banks that engage more in maturity transformation, see their stock prices decrease less when experiencing an unexpected rise in the yield curve. Therefore, in this study, banks' maturity mismatch may act as an attenuating factor in the transmission of monetary policy.

### **2.3. Literature key takeaways**

After reviewing the literature on banks' maturity mismatch, and the monetary policy transmission mechanisms, we can now conclude the following. The role of maturity mismatch in the transmission of monetary policies is largely under-explored. The only exceptions are Gomez et al. (2021) and Gambacorta and Mistrulli (2004). The former article, considers banks' maturity gap as an attenuating factor of monetary policy transmission, while the latter an amplification mechanism. Since we only have these articles, we cannot infer the role of maturity gap on the monetary policy directly. Thus, it was decided to research its role, in the relationship between interest rate changes and other banking variables. These variables, in turn, may indirectly affect banks' lending. Its choice, also resided in the fact, that they are the most used banking variables in the literature.

One of these variables was banks' interest margins. We know that it affects banks' profitability, and so, it may have an impact on banks' lending decisions (Cavallino & Sandri, 2023). Some articles reach different conclusions, regarding the relationship between interest rates and interest margins. This happens in the theoretical literature (Andreasen et al., 2013; Cúrdia & Woodford, 2016), and in the empirical literature (Alessandri & Nelson, 2015; Borio et al., 2017; English et al., 2018). In the latter literature, we can dive into more granular conclusions, since the articles tend to divide the effects of interest changes temporarily, *i.e.*, short-term and long-term interest rates. The difference in conclusions seems to occur in short-term interest rate effects, and not in long-term ones. When the yield curve is steep, banks' interest margins tend to increase, due to maturity transformation, but concerning short-term interest rates, the conclusions are ambiguous. Therefore, banks' maturity mismatch, may be classified as an attenuating mechanism of monetary policy in the long-term, but in the short-term, its role may be more dubious.

The other mentioned banking variable, was stock prices. Here the literature is somewhat inconclusive. In Paul (2023) article, banks' maturity gap acts as an attenuating mechanism when long-term interest rates increase, just as in English et al. (2018) article. However, with

short-term interest rates increasing, the maturity mismatch acts as an amplification mechanism.

Overall, even though the literature remains inconclusive, it seems that banks' maturity gap may have an impact on both banks' balance sheets and bank lending decisions, surrounding monetary policy shocks.

In this dissertation, we first add to the bank lending channel literature, the effects on lending that central banks' monetary policy tightening announcements can have. To our best knowledge, the literature has not yet delved into this topic. Furthermore, we intend to add to this discussion, the role of maturity mismatch in monetary policy transmission, by providing empirical evidence using a monetary policy shock that only affected a group of banks (*e.g.*, the unwinding of the PEPP programs in December 2021) instead of a systematic shock that affects the whole banking system, *e.g.* the policy rate raise in July 2022. Relying on Portuguese data and in a Difference-in-Differences identification strategy, we hope to provide new evidence on the effect of a bank's pre-shock funding structure, more specifically, asset-liability maturity mismatch on the transmission of monetary policies to the credit market. We further check possible effects on banks client's deposits.

### 3. Institutional Background

With the surge of the COVID-19 pandemic, the world's economies started to experience major cutbacks in their growth. Therefore, the ECB implemented the Pandemic Emergency Purchase Programme (PEPP), starting in March 2020. It was a temporary asset purchase programme, with the main goal of minimizing COVID-19 potential risks to banks and supporting banks' lending by providing liquidity and cheap funding. Later, with the war breaking in Ukraine, the pandemic's late effects on supply chains combined with energy and commodity prices, pushed up an already increasing inflation rate. This has led, to inflationary pressures worldwide. Back then, the ECB was determined to pursue their unchanged key interest rates, unlike other central banks, there were no countermeasures to push back the inflation surge. It was when the euro area inflation rate was already at 5%, that the ECB expectation was that inflation was a temporary phenomenon and much driven by energy and food prices, and not necessarily core inflation, but that proved to be wrong. Nevertheless, in December 2021, the Governing Council announced their first contractionary decision, by stating that the PEPP would come to an end in March 2022. Additionally, a few months later, in July 2022, the ECB raised its three key interest rates by 50 basis points, which set the beginning of a continuous rise until October 2023. Furthermore, in October of that year, the governing council announced that the TLTRO III<sup>20</sup> interest rates, would be indexed to the key interest rates, being so, one more instrument to fight inflation<sup>21</sup>.

#### 3.1. Unwinding of the pandemic emergency purchase programme

To answer our research question, we stage our empirical strategy in a fairly recent event- the ECB PEPP unwinding announcement in December 2021. The reasoning behind this choice is related to the commonly acknowledged importance of this decision. It has been first accepted, that it was the primary tightening measure undertaken by the ECB to fight off inflation, and not the raising of the key interest rates in July 2022<sup>22</sup>. Moreover, until then, there was a prolonged accommodative monetary policy, it can be observed several of its effects on euro area financing conditions, in short periods after its announcement. For

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<sup>20</sup> For a more thorough depiction of this instrument, please check the following ECB website- <https://www.ecb.europa.eu/mopo/implement/omo/tltro/html/index.en.html>

<sup>21</sup> To learn about other measures undertaken by the ECB, please see Table A6.

<sup>22</sup> Philip Lane is an ECB vice-president, that has stated multiple times that the PEPP December 2021 decision was the first measure undertaken by the central bank (e.g., <https://www.ecb.europa.eu/press/key/date/2023/html/ecb.sp230712~d950906f00.en.html>; [https://www.ecb.europa.eu/press/key/date/2023/html/ecb.sp230216\\_1~f8cf2cd689.en.html](https://www.ecb.europa.eu/press/key/date/2023/html/ecb.sp230216_1~f8cf2cd689.en.html)).

instance, these effects can be confirmed by market and survey information. We can see in Figure A3, that monetary policy expectations of future higher interest rates, by market participants, were incorporated just after the ECB December 2021 announcement.

Furthermore, from the APP<sup>23</sup> implementation in mid-2014 onwards, euro area banks in general, were subject to an increase in securities buyouts<sup>24</sup>. According to BdP (2021) monetary policy implementation report, Portugal followed the same pattern. By December 2021, Banco de Portugal by itself, had bought close to 15 billion euros of Portuguese sovereign debt securities from Portuguese banks in 2020 and 2021, concerning PEPP. However, in the following year, this number plummeted to not even 1 billion euros<sup>25</sup>. According to APB (2021) overview of the Portuguese bank sector report, Portuguese banks on average, in December 2021 had the largest share of debt securities, compared to other countries and the euro area average. Thus, Portuguese banks seem to have been exposed to the unwinding of the monetary policy, since they no longer could count on this financing stream.

One of this exposure was through financing costs rise (Figure A4). This made banks reshuffle their financing sources. Particularly, Portuguese banks, reacted by decreasing the weight of deposits on ECB as a financing source, from 9,4% in December 2021 to 3,6% in December 2022<sup>26</sup>. This decrease, made them stop being more dependent on this financing stream, compared to euro area banks, on average<sup>27</sup>.

Fortunately, Portuguese banks can rely much more on their clients' deposits than euro area banks<sup>28</sup>. We can see in Figure A5, that deposits to NFCs and Households, kept increasing after the PEPP shock. Portuguese banks in December 2021, had 304 billion euros worth of deposits from their clients, increasing to 323 billion euros by December 2022<sup>29</sup>. Also, in

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<sup>23</sup> APP stands for Asset Purchase Programmes, started in mid-2014, with the same goal of the PEPP of providing liquidity, even though with different rationales ([https://www.europarl.europa.eu/cmsdata/211392/2\\_OFCE-final.pdf](https://www.europarl.europa.eu/cmsdata/211392/2_OFCE-final.pdf)).

<sup>24</sup> Under the PEPP, different kind of bank's assets could be bought, such as, sovereign debt securities.

<sup>25</sup> This same change can be seen with housing bonds buyouts.

<sup>26</sup> It is important to point out, that Portuguese bank deposits on the ECB, had achieved in December 2021 an all-time high since December 2014.

<sup>27</sup> According to the Portuguese Bank Association (APB), in December 2021, ECB funding for Portuguese banks weighted 9,4%, compared to 8,1% for euro area banks. By December 2022, ECB funding for Portuguese banks value decreased to 3,6% and euro area banks to 5,1%.

<sup>28</sup> This high level of dependency on deposits can be seen in the Portuguese Bank Association (APB) 2022 overview of the Portuguese bank sector report. Moreover, as already mentioned Bittner et al. (2022) also concluded this.

<sup>29</sup> Please see Portuguese Bank Association (APB) 2022 overview of the Portuguese bank sector report.

December 2021, deposits represented about 68% of total financing sources, and in the following year, besides deposits' interest rate remaining the same, it rose to 73%. However, the reliance on deposits in 2022, depends on the maturity one considers. According to the APB (2022) overview of the Portuguese bank sector report, although demand deposits rose in 2022, long-term deposits fell.

Now that we know what happened to different banks' financing sources, is important to assess how their credit granting evolved. We can see in Figure A6, that credit to NFCs and Households rose after December 2021, having a slight decrease at the end of the year. Credit to Households had a greater growth rate than to NFCs in 2022. This difference between Households' and NFCs' growth rates can be explained by the distinct maturities. In 2022, credit to Households was highly leveraged by long-term credit, whereas, credit to NFCs had a very different evolution. Its long-term credit kept decreasing after December 2021, and what made its aggregated credit increase, was essentially the short-term credit.

### **3.2. Banks' maturity mismatch**

We propose to study whether banks' maturity mismatch, between assets and liabilities, can affect their lending. Thus, it becomes important to study banks' maturity mismatch during this period.

According to the ECB (2023) Financial Stability Review, before the beginning of the ECB interest rate hike policy, the euro area banks had a larger maturity mismatch (Figure A7). This was partially driven by the progressive surging of the average loan repricing period. Since low interest rates cause interest rate margins to shrink, and thereby, banks' profitability to decrease, banks implemented this maturity strategy to try to offset this decrease<sup>30</sup>. Simultaneously, the repricing period of deposits declined, since depositors preferred overnight deposits over term ones. The opposite happened to the maturity gap after the end of 2021 when the ECB started its monetary policy tightening. The deposit repricing period increased since term deposits offered a higher yield compared to overnight deposits. All these events can be seen in Figure A7.

Regarding Portuguese banks, the average values of banks' maturity mismatch are smoother, before December 2021, compared to euro area banks, in our sample. We can see in Figure A8, that a few months before the policy announcement, there was a noticeable decrease in

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<sup>30</sup> Longer maturities are associated with higher premiums.

the median values. Yet for Portuguese banks, the decrease lasted only a few months, then it started rising again in September, until the end of 2022. The rise observed at the end of 2022, was due to simultaneously an increase in the maturity of assets and a decrease in the maturity of liabilities.

A further analysis of the maturity mismatch can be made when we consider in our data, that banks engaged in the PEPP and banks not engaged. Figure A9, first shows that *PEPP banks* are more maturity mismatched, than *non-PEPP banks* during the entire sample period. Moreover, *PEPP banks'* distribution, is more concentrated, and thus, the IQR (Inter Quartile Range) is smaller. This means *PEPP banks'* values are more homogeneous, and so, some of its values are considered outliers. On the other hand, *non-PEPP banks* have a more spread-out distribution of values.

If we compare banks with different maturity mismatches<sup>31</sup> (Higher Maturity Mismatch and Lower Maturity Mismatch), we observe several patterns. As we see in Figure A10 and Figure A11, credit to NFCs for Lower Maturity Mismatch banks, compared to December 2021, *PEPP banks* granted less after the PEPP unwinding, even though, during less than 3 months. *Non-PEPP banks* after the policy shock, kept lending less than its December 2021 value, but the upward trend was maintained. As to the difference between PEPP and *non-PEPP banks'* lending, classified by having Higher Maturity Mismatch, kept lending more relative to December 2021, throughout the sample period. As to credit to Households, Lower Maturity Mismatch banks, increased their lending compared to December 2021, after the policy shock for *non-PEPP banks* and relatively decreased for *PEPP banks*. The same difference can also be seen for Higher Maturity Mismatch banks, but this time *PEPP banks* decreased their lending and *non-PEPP banks* increased relative to December 2021, after the unwinding decision.

Therefore, it seems that the PEPP unwinding decision had a relative effect more noticeable for credit to Households than to NFCs. Also, for the same maturity mismatch level, there is a difference in lending decisions between *PEPP* and *non-PEPP banks* and between credit to NFCs and Households. Interestingly, *PEPP banks'* lending to Households seems to be affected by the maturity mismatch level, after December 2021, while lending to NFCs, seems not. The same conclusion can be made for *non-PEPP banks*.

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<sup>31</sup> These groups were set according to the median – HMM have values above the maturity mismatch median, and the LMM banks have values below.

## 4. Methodology

### 4.1. Empirical Design

To address our research question, we use a Difference-in-difference (DiD) methodology. This method, in particular, is very useful for quantifying the effects of policies, especially when using microdata (Puhani, 2012). When only a segment of a population undergoes a policy application, called a *treatment group*, a *control group*, that does not experience the policy application, can be utilized to assess average changes in the variable of interest, before and after the policy. One then, compares the post-intervention outcomes with the pre-intervention outcomes, for the *treatment group*, and then, assesses the same difference for the *control group*, to evaluate the policy effects. This allows us to have greater control over endogeneity concerns. However, this model has some particular assumptions, that can undermine the causal interpretation of the DiD estimators. The parallel trends assumption states, that without the policy implementation, the *treatment group*, would have kept the same parallel trend over time as the *control group* (Sant’Anna & Zhao, 2020). The problem arises, if the observed characteristics, that are assumed to be associated with the evolution of the outcome, are not balanced between the two groups. Another concern is, the existence of confounding events, that may bias our results and suggest that the policy has an impact when in fact the effects are spurious since they are not driven by the policy.

We employ two different DiD models. The first is the common Double DiD model, which aims to study how banks previously engaged in the PEPP in December 2021, were affected by the unwinding, through their lending behavior. We study this, through the analysis of the lending difference between the *treatment group* and the *control group*, before and after December 2021. We know, that the PEPP unwinding only affected some banks. Therefore, to find which banks were affected, and since we have no exact information on the identity of these banks, we had to rely on a different approach. On 4<sup>th</sup> June 2020, the ECB decided to increase the initial PEPP package by 80%, a 600 billion euros increase. Since this was a very big increase, from a low funding cost source, this may have triggered a reaction from these Portuguese banks, regarding the liquidity incoming from the central bank. Thus, we checked the central bank funding ratio<sup>32</sup>, to give us a hint about this. We first computed the quarterly difference of this variable for each bank, to capture the change between the beginning of the PEPP in March 2020, and its value readjustment in June. Since there was a such big increase

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<sup>32</sup> This variable can be checked in Table A8.

at the beginning of June 2020, we then kept the banks that had a positive change in that quarter. We created a dummy variable equaling 1 for these banks, named *PEPP banks*, which corresponds to the *treatment group*, and 0 for the *non-PEPP banks*, which represents the *control group*.

As explained in detail in the next chapter, we use three different sets of dependent variables, to test the formulated hypothesis used in the following OLS baseline regression:

$$Y_{i,t} = \sum_{t=1}^n \beta_{1,t} * Period_t * PEPP\ banks_i + \sum_{t=1}^n C_t * Period_t * Banks'\ Char_i + \alpha_i + \lambda_t + \varepsilon_{i,t} \quad (4.1)$$

, where  $i$  and  $t$  denotes banks and months, respectively.  $Y_{i,t}$  corresponds to the dependent variables.  $Period_t$  is a time dummy variable, that equals one in December 2021 until the end of 2022, covering the entire period of the monetary policy. As such, we consider the ECB PEPP unwinding announcement in December 2021, and not the first increase in key interest rates in July 2022, as the start of the new policy. As shown above, euro area financing conditions were changed after this date.  $PEPP\ banks_i$  is the treatment variable, transformed as a dummy, indicating banks belonging to the *treated group*. We furthermore, employ a time varying vector,  $Banks'\ Char_i$ , containing all control variables used. In the Double DiD specification, we will only include the bank size variable. Finally, to deal with endogeneity concerns, we capture time fixed effects  $\lambda_t$  and bank fixed effects  $\alpha_i$  (not captured by the control variables). This means, that any unobserved characteristics or events, whether time related or bank related, are captured by these. We use clustered standard errors at the bank level since it is reasonable that over time, there may be correlation between error terms within banks.

After this generalized view given by the Double DiD model, we further employ a Triple DiD. Here in the Triple DiD model, we have a third interaction term, the maturity mismatch- $Maturity\ mismatch_i$ . Therefore, the coefficients will inform us about the effects for *PEPP banks* (second difference), according to the maturity level (third difference) and after the policy shock (first difference). For this, we use a continuous variable that allows us to consider all levels of banks' maturity mismatch in the regressions. With the Triple DiD model, we test if differences between maturity mismatch levels, before and after December 2021, affected bank lending in our empirical setting. The use of this treatment variable is also backed up by some literature, such as Gambacorta and Mistrulli (2004), that show banks,

with larger maturity mismatches, are more affected by monetary policy shocks, through their capital.

For our two proposed models, we first adopt a *dynamic* specification, to assess how the policy effects changed over time, and to contemplate deviations from the parallel trend assumption. In this specification, we estimate, separately, disaggregated  $t$  periods differences before and after treatment. This also allows us, to infer possible confounding effects<sup>33</sup>. For further analysis, we calculate the *percentage changes* between June to December 2022, to check how our outcome variables changed.

## 4.2. Variables

### 4.2.1. Banks' maturity mismatch

In the empirical literature, is common to adopt two different concepts to measure banks' maturity mismatch- the income gap and the maturity gap. The income gap is a common measure used for measuring banks' interest rate sensitivity and is a cash-flow concept. It is computed as the ratio of, the difference between the book value of assets and liabilities, that either reprice or mature within a year and banks' total assets (Mishkin & Eakins, 2012). According to Haddad and Sraer (2020), a high value means that banks have a lower exposure to long-term fixed-rate assets. One advantage of this measure is that it applies to all interest-earning assets and liabilities. One disadvantage is that it does not take into account the maturity or the repricing of both assets and liabilities, beyond the one-year horizon (Paul, 2023).

As to the maturity gap, it measures the difference between assets' weighted average repricing period and liabilities weighted average repricing period (Altavilla et al., 2018; English et al., 2018; Paul, 2023)<sup>34</sup>. A high positive value means that the weighted assets maturity is higher than the weighted liabilities maturity. The following equation defines the maturity gap of bank  $i$  at month  $t$ .

$$Maturity\ Gap_{i,t} = \sum_j m_{A,j} \frac{Asset_{j,i,t}}{\sum_j Asset_{j,i,t}} - \sum_j m_{L,j} \frac{Liability_{j,i,t}}{\sum_j Liability_{j,i,t}} \quad (4.2)$$

In this dissertation, we measure banks' maturity mismatch using the maturity gap, since it is

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<sup>33</sup> Please check Table A6.

<sup>34</sup> These cited papers, adopted in their articles more granular and comprehensive data, that would go beyond one year in order to not incur in the same problem, as the previous measure.

the most widely used in the literature (Paul, 2023), and also, it encompasses information on the maturity of assets that mature or reprice beyond a year. We use the (Paul, 2023) mid-point value approach, for the maturity  $m_j$  in each asset/liability category  $j$ . Please check the details in appendix 7.1.

The EBA publishes guidelines to euro area banks so that they can measure their interest rate risk using different methods<sup>35</sup>. The measures suggested by EBA are cash-flows-based and are net interest income-based or economic value-based.

#### 4.2.2. Other variables

We used two sets of dependent variables for the Double DiD analysis and one additional set for robustness purposes. The first set contains three credit variables, not disaggregated at maturity level and measured using logs of (1) *Total credit*, (2) *Credit to NFCs*, and (3) *Credit to Households*. The second set contains six credit variables, disaggregated at the maturity level, measured using logs of: (1) *Short-term credit to NFCs*, (2) *Medium-term credit to NFCs*, (3) *Long-term credit to NFCs*, (4) *Short-term credit to Households*, (5) *Medium-term credit to Households* and (6) *Long-term credit to Households*. Finally, the last set has four deposit variables, also measured using logs of (1) *Total deposits*, (2) *Demand deposits*, (3) *Short-term deposits*, and (4) *Long-term deposits*. For further description of these variables, please refer to Table A7. As to the control variables used, we follow the related literature and include, the *equity ratio* (Bittner et al., 2022), *deposit ratio* (Bittner et al., 2022), *bank size* (Jiménez et al., 2014), *securities ratio* (Jiménez et al., 2014) and *interbank liquidity ratio* (Bottero et al., 2022). Moreover, we also included the *central bank funding ratio*<sup>36</sup>, the *interest rate on new loans to NFCs*, and the *interest rate on new loans to Households* to further capture heterogeneity across banks. The details of these controls are reported in Table A8. Furthermore, all independent variables refer to the end of December 2021. This not only addresses endogeneity issues but also ensures that we use values that represent *ex-ante* banks' characteristics, *i.e.*, before the change in monetary policy.

#### 4.3. Data

In 2016, Banco de Portugal created a microdata research laboratory (BPLIM), to assemble microdata of Portuguese banks into well-defined datasets, upon which, the bank provides

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<sup>35</sup> For a more profound insight, please check this link: <https://www.eba.europa.eu/activities/single-rulebook/regulatory-activities/supervisory-review-and-evaluation-process-step-0>

<sup>36</sup> Used to identify the *PEPP banks* and *non-PEPP banks*.

periodical reports. We use the Monetary Financial Institutions (MFIs) and the Historical Series of the Portuguese Banking Sector (SLB) datasets. The former is a monthly dataset, updated annually, that begins in September 1997 and ends in December 2022. It contains Portuguese banks' balance sheet information. The information covers assets and liabilities sides. The dataset is also informative about the maturity of some assets and liabilities. The latter dataset contains information on the various financial statements, such as balance sheets and income statements, and also, more detailed information, such as human resources and interest rates data. This dataset is also updated annually, and at the moment covers the period between 1990 to 2021.

We removed banks that did not grant credit to either Households or NFCs and did not take deposits. Finally, all missing values were removed from the sample dataset. The final sample covers 50 banks (set in December 2021) and 1199 observations between January 2021 to December 2022. We have 10 *PEPP banks* (treatment group) and 40 *non-PEPP banks* (control group) in December 2021. Table A9 shows the mean of maturity mismatch for these banks, filtered by two maturity mismatch levels.

#### 4.4. Descriptive statistics

In this chapter, we present some descriptive statistics. We assess differences between banks' characteristics in December 2021, since these may play a main role in the differential effects observed across banks in the aftermath of the policy shock. We performed a *t*-test, to assess statistically significant differences in the proposed variables, between *PEPP* and *non-PEPP banks*. As we can see in Table A10, *bank size* (proxied by *Total Assets*), *equity* and *securities ratios*, as well as, *interbank liquidity* and *central banks funding ratios*, exhibit a statistically significant difference between the means of the two banks' groups. This means, that on average, *PEPP banks* are bigger, have a lower weight of equity in their assets, as opposed to their securities, and have a higher interbank liquidity and central bank funding, than *non-PEPP banks*. Looking at remaining controls, the two banks' groups seem to have similar characteristics, in terms of *deposit ratio*, and *interest rates on new loans*. In these controls, *non-PEPP banks* have a greater value than *PEPP banks*. For banks' maturity mismatch, we see that, on average, there are no statistically significant differences between *PEPP* and *non-PEPP banks*. Finally, all dependent variables seem to also exhibit statistically significant differences between the two groups, except for medium-term credit to Households. Based on this, we use in our baseline empirical strategy, the following controls- *bank size*, *equity ratio*, *securities ratios*, and *interbank*

*liquidity ratio*. We did not use the *central banks funding ratio*, since we already use it for the *PEPP banks* formula so, we may avoid multicollinearity concerns.

We present in Table A11 and Table A12 the summary statistics for the outcome and the independent variables, respectively. Finally, we further compute Pearson (parametric) coefficients for the independent variables. As we can observe in Table A13, we can exclude the possibility of a strong ( $\geq 0.9$ ) correlation between the independent variables we use in our baseline specifications, since the vast majority, exhibit weak correlation coefficients.

## 5. Results

This chapter analyzes how the PEPP unwinding decision affected Portuguese banks' balance sheets. Then we study the banks' maturity mismatch role in it. These analyses are done between January 2021 to December 2022.

To address the first question, we exploit the effects of the PEPP unwinding decisions, between *PEPP* and *non-PEPP banks*. Then, we introduce to this analysis, the maturity mismatch as a second treatment variable, alongside the *PEPP banks* dummy, to check its role in the lending decisions of these banks. To achieve this, we apply the DiD models. We apply the conventional Double DiD model, to compare the difference in bank lending between *PEPP* and *non-PEPP* banks, before and after the unwinding of the PEPP programs. We then introduce our third difference, banks' asset-liability maturity mismatch, to further compare the difference in bank lending between *PEPP* and *non-PEPP banks*, which leads to our Triple-Difference estimation strategy. We also analyze *ex-ante* deposits as a possible source of financing *ex-post* lending.

To explore the time-varying effect, we first use the *dynamic* specification, in which we interact the treatment variables with monthly indicator variables, relative to December 2021, therefore, allowing the treatment effect to vary over time. We then calculate the *percentage change* of the outcome variables, between June and December 2022. The convention is to show estimates with a few month lags, given that policy effects often take time to materialize. Finally, we analyze the results upon which we believe we can formulate important answers to our research question.

### 5.1. The effect of monetary policy tightening

According to the institutional background chapter, overall, Portuguese banks increased their lending in 2022. The results we obtained in Figure 1 from the *dynamic* treatment effects in the Double DiD model show that the *PEPP banks*' lending decreased more than *non-PEPP banks*, after December 2021. This was driven by both credits granted to NFCs and Households. We can see in the upper left graph below, that *PEPP banks* and *non-PEPP banks* did not have a different trend before the policy shock. After the PEPP unwinding decision, from January to April, although the sign of the coefficient is different (positive) there is no statistical significance. Therefore, we cannot draw conclusions about them. However, from

August onwards, we have statistically significant estimates<sup>37</sup>. They show that *PEPP banks* increased less their lending to NFCs, compared to *non-PEPP banks*. Thus, the PEPP unwinding announcement had an amplification effect on the monetary policy transmission for *PEPP banks* but the effect took time to materialize. In the significant estimate of November 2022, the effect is economically meaningful - *PEPP banks* decreased lending to NFCs by 17% ( $100 * [\exp(0.158) - 1]$ ) more than *non-PEPP banks* after the unwinding announcement in December 2021.

Furthermore, we can see in the upper right-hand side graph, that after the policy shock, *PEPP banks* granted less credit to Households, than *non-PEPP banks*. However, it is important to point out that we get statistically significant estimates throughout 2022, only if we consider a 90% confidence interval. Just as with lending to NFCs, there is no difference between the trend of both groups.

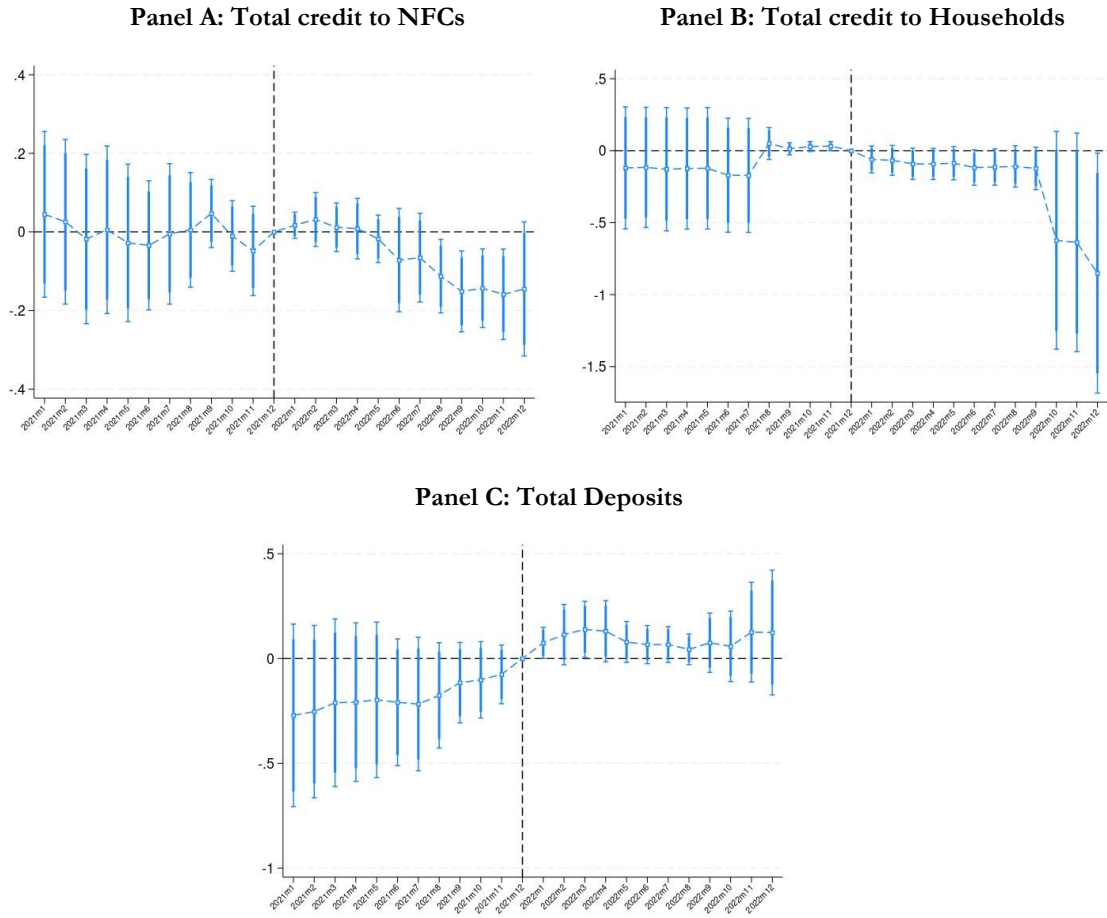
When we disaggregate credit by maturity, the results follow the same conclusions, except for short-term lending to Households. From June to August 2022, *PEPP banks* lent more than *non-PEPP banks*. For instance, in August 2022 *PEPP banks* increased more their short-term lending to Households by 80% ( $100 * [\exp(0.592) - 1]$ ), than *non-PEPP banks*, relative to December 2021. However, it is important to state that this result might have been driven by a possible pre-trend.

We have further seen in the institutional background chapter, that deposits rose in 2022, which may have been the reason, for the overall increase of total credit by *PEPP banks*. This can be concerning, since that would mean, that the results we've seen may be misleading. Since in the lower left graph, we have a noticeable pre-trend, we cannot draw inferences about the *ex-post* differential effects between both groups. Nevertheless, we can still conclude, that the negative impact of the unwinding of PEPP on *PEPP banks*' lending doesn't seem to be related to the diminishing ability of attracting deposits by both bank groups. The graph shows no different trend before the policy shock, and therefore, it cannot explain the differential lending difference between banks after the shock.

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<sup>37</sup> This is also true for the December estimate, but only when considering 90% confidence interval.

**Figure 1- Double DiD: Dynamic treatment effects**



Note: The dashed vertical line refers to the December 2021 monetary policy shock. The connected dots are the monthly estimates, while the thicker and the thinner spikes represent 90% and 95% confidence intervals, respectively. The upper left graph is concerned with credit to NFCs, the upper right graph represents credit to Households, and the lower graph is total deposits. We can see four significant estimates in August and November 2022 in the upper left graph and two significant estimates in the lower graph. The upper right graph also exhibits significant estimates, but only with a 90% confidence interval. Overall, we cannot confidently exclude concerns over pre-trend effects, except for the upper left graph. Moreover, the parallel trend assumption before December 2021 is visible in these graphs.

In the following table, we have presented all credit variables, and the coefficients for June, September, and December 2022. The latter estimates corroborate what we saw in the *dynamic* graphs- *PEPP banks* decreased more their lending than *non-PEPP banks*, between December 2021 and December 2022. Namely, *PEPP banks*, after the policy shock experienced a decrease in their lending to Households, compared to *non-PEPP banks*, and relative to December 2021. We can further observe that the June and September 2022 estimates are significant, meaning that the effect was present in different months of the year. These estimates also exhibit a scaling up of the effect throughout 2022. We can also observe a

positive and significant<sup>38</sup> *percentage change* in short-term and long-term credit to Households for these banks. However, these are driven by pre-trends.

As to NFCs estimates, these show that June, September, and December 2022 coefficients are also significant, as expected. Furthermore, these are economically sizable, but in a lower magnitude than Households. For instance, in September 2022 *PEPP banks* decreased less their lending to NFCs by 16% ( $100 * [\exp(0.151) - 1]$ ), than *non-PEPP banks*, relative to December 2021.

As to deposit results, we have also assembled in Table 2 all deposit variables and present coefficients for the same months. We can observe, that *PEPP banks' demand deposits* and *long-term deposits* estimates are positive, while *short-term deposits* estimates are negative. However, as also concluded before, besides all these estimates not being statistically significant, the unobserved different pre-trend between the groups, show that deposits cannot explain the significant *ex-post* effects seen in lending to NFCs and Households.

**Table 1- Double DiD: Credit**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Total credit to NFC	Short-term credit to NFC	Medium-term credit to NFC	Long-term credit to NFC	Total credit to Households	Short-term credit to Households	Medium-term credit to Households	Long-term credit to Households
Jun. 2022 X PEPP Banks	-0.071*** (0.065)	-0.031 (0.232)	-0.052 (0.136)	0.002 (0.082)	-0.116* (0.061)	0.590*** (0.255)	-0.092 (0.176)	-0.101** (0.057)
Sep. 2022 X PEPP Banks	-0.151*** (0.051)	-0.163 (0.142)	-0.050 (0.152)	-0.026 (0.095)	-0.122* (0.073)	0.560 (0.342)	-0.136 (0.190)	-0.101 (0.068)
Dec. 2022 X PEPP Banks	-0.145* (0.084)	-0.217 (0.329)	-0.410* (0.244)	0.059 (0.172)	-0.850*** (0.414)	0.249 (0.169)	-1.19 (0.770)	-0.697** (0.384)
Bank Chars.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	1199	1199	1199	1199	1199	1199	1199	1199
Adjusted R-squared	0.995	0.962	0.981	0.995	0.997	0.959	0.977	0.994

Note: This table shows us the differential coefficients between *PEPP* and *non-PEPP* banks, before and after the policy shock. Below the coefficients, we find the standard errors clustered at the bank level in parentheses. All variables are measured as logarithms. \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.10$ . The *total credit to Households*, December 2022 estimate value in the table may lack the economic intuition behind it. We may suppose that this value in particular may suffer from a reporting problem in the data. Nevertheless, it seems appropriate to extrapolate from the graph and table, that *PEPP banks* continued to relatively decrease their lending in this month, as well, but with an inferior magnitude.

<sup>38</sup> It is significant, but one must remember the possible pre-trend.

**Table 2- Double DiD: Deposits**

	(1)	(2)	(3)	(4)
	Total deposits	Demand deposits	Short-term deposits	Long-term deposits
Jun. 2022 X PEPP Banks	0.066 (0.045)	0.239* (0.134)	-0.085 (0.134)	0.107 (0.205)
Sep. 2022 X PEPP Banks	0.075 (0.070)	0.164** (0.086)	-0.196 (0.144)	0.165 (0.217)
Dec. 2022 X PEPP Banks	0.124 (0.148)	0.174 (0.115)	-0.121 (0.289)	0.018 (0.262)
Bank Chars	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes
Observations	1199	1199	1199	1199
Adjusted R-squared	0.997	0.996	0.983	0.959

Note: This table shows us the differential coefficients between *PEPP* and *non-PEPP* banks, before and after the policy shock. Below the coefficients, we find the standard errors clustered at the bank level in parentheses. All variables are measured as logarithms. \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.10$ .

## 5.2. The role of maturity mismatch

In this section, we add a third interaction term- the maturity mismatch. The Triple DiD model, allows us to check the role of maturity mismatch, in the Triple difference estimates between the two bank groups. Moreover, it can help us understand whether the results we saw previously changed due to their role.

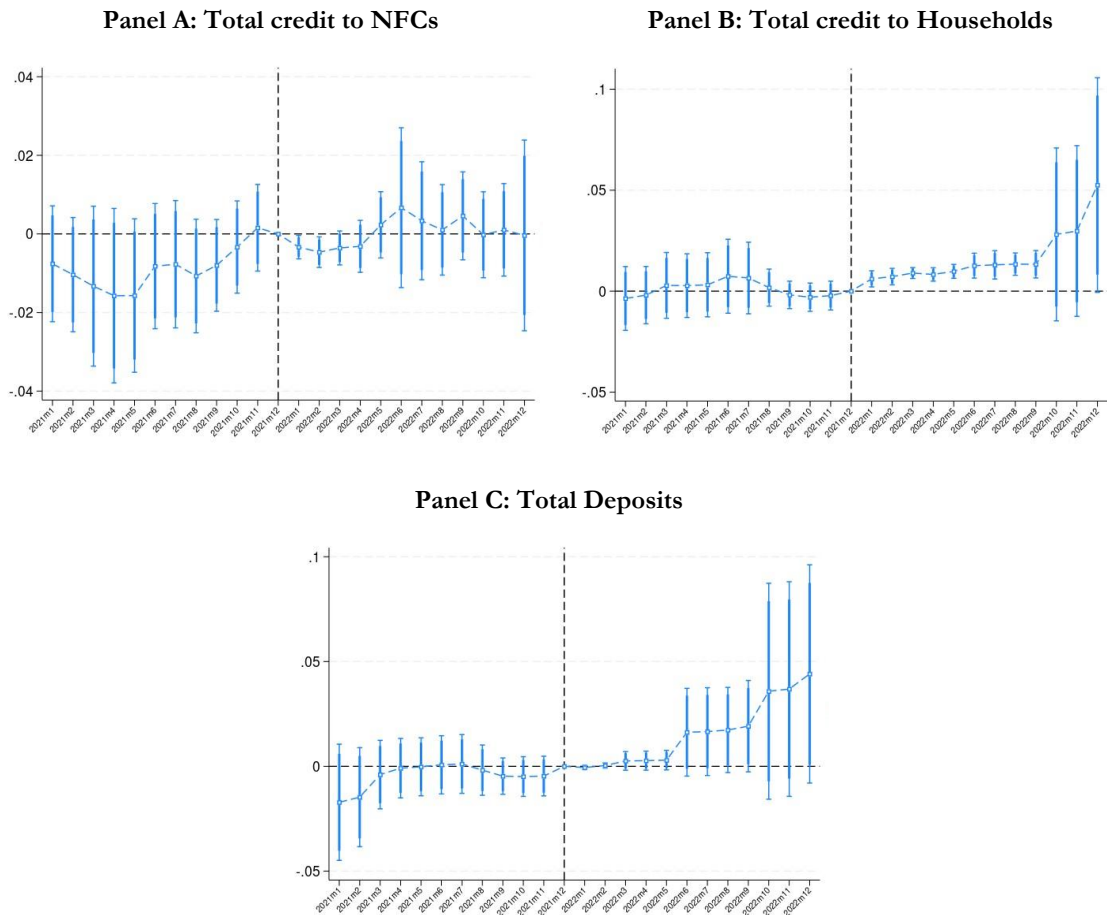
As observed in Table 3, in the upper left graph below, the majority of *ex-post* estimates for the Triple term ( $Period_t * PEPP\ banks_i * Maturity\ mismatch_i$ ) are non-significant and driven by a pre-trend. This means that we cannot assess whether higher maturity mismatched *PEPP banks*, increased or decreased more their lending to NFCs, than *non-PEPP banks* after the policy shock.

As to credit granted to Households, we observe in the upper right graph, that before the policy shock, the parallel trend assumption was met, meaning both groups did not have a different trend. After the shock, the estimates show, that the *PEPP* unwinding decision, made *PEPP banks* lend more credit to Households than *non-PEPP banks*. Considering the December 2022 coefficient, a *PEPP bank* experiencing a one standard deviation of its maturity mismatch, would relatively increase its lending to Households by 5% ( $100 * [\exp(0.05) - 1]$ ), compared to December 2021. Therefore, for higher maturity

mismatched *PEPP banks*, their maturity gap acted as an attenuator factor of the December 2021 monetary policy decision.

Just as we did for the Double DiD, we also want to know what happened to deposits. We can see in Table 4, that before the policy shock, there was no trend difference between banks since the *ex-ante* coefficients were non-significant. However, particularly in August and September, we have statistically significant estimates at a 90% confidence interval. Notwithstanding, the positive coefficients we see may not be the underlying mechanism of why higher maturity mismatched *PEPP banks* were able to lend more after the shock. Since, the increase in credit was already happening before, and we cannot confidently exclude pre-trend concerns.

**Figure 2- Triple DiD: Dynamic treatment effects**



Note: The dashed vertical line refers to the December 2021 monetary policy shock. The connected dots are the monthly estimates, while the thicker and the thinner spikes represent 90% and 95% confidence intervals, respectively. The upper left graph is concerned with credit to NFCs, the upper right graph represents credit to Households, the lower left graph represents total deposits, and the lower right graph is medium-term credit to Households. We can see numerous significant estimates in 2022 in the right-hand side graphs. Moreover, we can exclude concerns over pre-trend effects in all graphs, except for the Panel D graph. Finally, the parallel trend assumption before December 2021 is visible.

As to the *percentage changes* in the second semester, we can observe in Table 3 below, the same conclusions we have made. *PEPP banks'* lending to Households increased more than *non-PEPP banks* after the PEPP unwinding decision. *Total credit to Households* estimates were significant in June, September, and December 2022, so the effect is visible. These estimates further show the scaling up of the effect throughout the second semester. Higher maturity mismatched *PEPP banks* increased four percentage points their lending to Households, between September and December, compared to *non-PEPP banks*. We can further observe statistically significant coefficients in *medium-term credit to Households*. However, these are driven by pre-effects, and thus, we cannot make conclusions based on them. The table also shows the non-significant estimates for credit to NFCs, as expected. Therefore, adding the maturity mismatch interaction term provokes a different lending pattern on *PEPP banks*, but only for Households. The effect of lending to NFCs seems to be non-existent. Finally, the deposits coefficients Table 4 also indicates that these did not play a role in determining the lending to Households results, since we again have non-significant estimates, and the respective graph we observed, exhibits no different pre-trend between the groups.

**Table 3- Triple DiD: Credit**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Total credit to NFC	Short-term credit to NFC	Medium-term credit to NFC	Long-term credit to NFC	Total credit to Households	Short-term credit to Households	Medium-term credit to Households	Long-term credit to Households
PEPP Banks X Jun. 2022 X Maturity Mismatch	0.007 (0.010)	-0.015 (0.024)	0.034* (0.017)	0.012 (0.016)	0.013*** (0.003)	-0.018 (0.015)	0.033*** (0.005)	0.016 (0.010)
PEPP Banks X Sep. 2022 X Maturity Mismatch	0.005 (0.006)	-0.010 (0.017)	0.040** (0.017)	0.015 (0.019)	0.013*** (0.003)	-0.048 (0.047)	0.034*** (0.007)	0.019* (0.011)
PEPP Banks X Dec. 2022 X Maturity Mismatch	-0.000 (0.012)	-0.016 (0.031)	-0.002 (0.043)	0.026 (0.034)	0.053* (0.026)	-0.020 (0.024)	0.111*** (0.030)	0.044* (0.026)
Bank Chars	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1199	1199	1199	1199	1199	1199	1199	1199
Adjusted R-squared	0.996	0.963	0.983	0.995	0.998	0.961	0.975	0.994

Note: This table shows us the *percentage change* coefficients between *PEPP* and *non-PEPP* banks, before and after the policy shock. All variables are measured as logarithms. \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.10$ .

**Table 4- Triple DiD: Deposits**

	(1)	(2)	(3)	(4)
	Total deposits	Demand deposits	Short-term deposits	Long-term deposits
PEPP Banks X Jun. 2022 X Maturity Mismatch	-0.011 (0.007)	-0.006 (0.010)	0.000 (0.010)	-0.011 (0.021)
PEPP Banks X Sep. 2022 X Maturity Mismatch	-0.009 (0.006)	0.001 (0.005)	0.002 (0.014)	-0.016 (0.020)
PEPP Banks X Dec. 2022 X Maturity Mismatch	-0.006 (0.010)	-0.006 (0.012)	0.005 (0.030)	-0.037 (0.025)
Bank Chars	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes
Observations	1199	1199	1199	1199
Adjusted R-squared	0.998	0.997	0.983	0.950

Note: This table shows us the *percentage change* coefficients between *PEPP* and *non-PEPP* banks, before and after the policy shock. All variables are measured as logarithms. \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.10$ .

### 5.3. Summary

Based on our results, *PEPP banks* decreased more their lending than *non-PEPP banks*, after the December 2021 monetary policy decision. The decrease happened to the credit granted to both NFCs and Households, even though it was more prominent in the latter. According to the literature review, the decrease in lending might be due to a decrease in deposits that flow out of the banking system. However, the deposit results confirm that this change in lending was not triggered by a decrease in deposits – the effect on deposits is the reverse. Based on this, we may raise the chance that it was the *PEPP* unwinding decision that made *PEPP banks* relatively decrease their lending.

When we introduced the role of banks' maturity mismatch, we saw different results. *PEPP banks* after December 2021, increased more their lending to Households, than *non-PEPP banks*. This means, that the *ex-ante* maturity mismatch of these banks, had a changing effect on their lending decisions. A higher maturity mismatch level, made these banks increase more their lending than *non-PEPP banks*. Even though maturity mismatch differences between *PEPP* and *non-PEPP banks* affected differently the lending decisions between these groups, the magnitude of the effect itself, may be considered not economically sizable, ( $\approx 5\%$ ), considering December 2022 estimate.

Therefore, we can conclude, that the maturity mismatch acted as an attenuator factor of monetary policy transmission mechanisms, particularly, through credit granted to Households by *PEPP banks*. This conclusion follows Gomez et al. (2021) results – lending

is less affected for banks with higher maturity mismatch. Our results show an even more prominent attenuating effect, since *PEPP banks*' lending increases, instead of decreasing less, as in the latter article. The mechanism linking maturity mismatch and lending could also be the same as Gomez et al. (2021), meaning that *PEPP banks*' maturity mismatch could have led to an increase in profitability, and the surplus of cash-flows shielded them more from the monetary policy tightening.

Thus, even though, the *t*-test table informs that there was no statistically significant difference between the two groups, we saw in Figure A9 that *PEPP banks* throughout the entire sample period, had higher maturity mismatch values. Moreover, we have concluded in the sub-chapter 3.2, that while comparing to December 2021 values, *PEPP banks*' lending to Households seems to be affected by the maturity mismatch level after December 2021, while lending to NFCs, seems not. Our DiD results also corroborate this.

Based on our results, it seems *ex-ante* maturity transformation activities, that lead to maturity mismatch, could have "compensated" these banks by mitigating the negative effects of the monetary policy tightening on lending. This conclusion follows Brunnermeier and Oehmke (2013) statement, that banks may have an incentive to engage in maturity transformation activities, since these may be a positive factor for their profitability.

The results obtained, add to the bank lending channel and bank capital channel literature an empirical example of attenuation effects in the monetary policy transmission, provoked by banks' maturity mismatch role.

#### 5.4. Robustness test

In this subsection, we present the *percentage change* in Table 5, which reflects regressions with the interest rate controls presented in Table A8<sup>39</sup>. This will enable us to check for different conclusions, since according to the interest rate channel, in sub-chapter 2.1.1, banks are impacted through interest rate raises, which may then affect lending volumes. Moreover, even though the *t*-test Table A10, shows no statistical difference in interest rate applied to credit to NFCs and Households, between the two banks' groups, we still observe a noticeable difference between the values. We present the results with maturity mismatch as the additional interaction term since we want to particularly check whether the increase, we observed in credit to Households by *PEPP banks* is influenced by *ex-ante* interest rates.

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<sup>39</sup> We use the *interest rate on new loans to NFCs* to the outcome credit to NFCs variables, and the *interest rate on new loans to Households* to the outcome credit to Households variables.

Looking at the table, we see that our results are robust to this specification. *Total credit to Households* estimates continue to be significant, and in the case of the December 2022 estimate, the significance level is even higher. However, the effect magnitude in these coefficients continues to be small. Higher maturity mismatched *PEPP banks* increased their lending to Households by 4.7% ( $100 * [\exp(0.046) - 1]$ ) one year after the policy shock, compared to *non-PEPP banks*. Finally, the *total credit to NFCs* is still non-significant, which means, that adding interest rate as control does not change the baseline conclusion.

**Table 5- Credit: Interest rates control**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Total credit to NFC	Short-term credit to NFC	Medium-term credit to NFC	Long-term credit to NFC	Total credit to Households	Short-term credit to Households	Medium-term credit to Households	Long-term credit to Households
PEPP Banks X Jun. 2022 X Maturity Mismatch	0.007 (0.008)	-0.014 (0.019)	0.023** (0.011)	0.001 (0.003)	0.014*** (0.003)	-0.008 (0.013)	0.026*** (0.007)	0.014 (0.009)
PEPP Banks X Sep. 2022 X Maturity Mismatch	0.009 (0.006)	-0.005 (0.013)	0.025** (0.011)	0.001 (0.004)	0.015*** (0.004)	-0.066 (0.069)	0.029*** (0.008)	0.016* (0.010)
PEPP Banks X Dec. 2022 X Maturity Mismatch	0.001 (0.008)	-0.018 (0.019)	0.026** (0.010)	-0.000 (0.004)	0.046*** (0.011)	-0.012 (0.024)	0.094** (0.040)	0.032*** (0.011)
Bank Chars	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1199	1199	1199	1199	1199	1199	1199	1199
Adjusted R-squared	0.996	0.961	0.982	0.995	0.998	0.959	0.978	0.994

Note: This table shows us the *percentage change* coefficients between *PEPP* and *non-PEPP* banks, before and after the policy shock. All variables are measured as logarithms. \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.10$ .

## 6. Conclusion

This dissertation analyzes, whether banks' maturity mismatch affects bank lending. We set our empirical framework, on a tightening monetary policy event. In December 2021, the ECB announced that the PEPP would come to an end on March 2022, to help reverse the high inflation taking place in the euro area. This unwinding decision, affected euro area banks through the cut-back of an affordable financing stream, raising overall financing costs. Portuguese banks, in particular, did not seem to have been significantly impacted by this, since their credit rose in 2022. However, this increase might have been sustained by an increase in deposits from their clients. Thanks to this shield, they managed to maintain the asset-liability maturity mismatch level that they had, before the PEPP unwinding decision. The maturity mismatch, according to the literature, can affect bank lending (Cavallino & Sandri, 2023; Gomez et al., 2021). Therefore, Portuguese banks may have been influenced by this balance sheet feature, in terms of the credit granted and deposits, throughout 2022. The literature on monetary policy transmission mechanisms is very vast. There is a continuous need to identify and completely understand the different transmission mechanisms. At the moment, there are six identified channels in the literature, some more understood than others. Even the mechanisms backed up by a lot of studies, that propose to understand it better, cannot provide us with robust answers. The bank lending channel, in particular, is the monetary policy transmission mechanism that looks at how monetary policy affects bank lending. This line of research focuses on the supply side of bank loans, and so, it has been researched how banks' characteristics are influenced by monetary policy, which in turn, may affect bank credit supply. We study how the December 2021 monetary policy affected banks' lending, and whether, their maturity mismatch influenced lending decisions. If it increases lending, we may say that it has an attenuator role/factor, but if lending decreases, it has an amplification role of the monetary policy transmission through banks.

Our research question has not been deeply studied in the literature, since to our best knowledge, only two articles tackle this matter – Gomez et al. (2021) and Gambacorta and Mistrulli (2004). However, our study differs in some aspects, since we use as policy shock a central bank's announcement, that affects only a group of banks and not the all banking system. Moreover, we also use a different method of measuring maturity mismatch. Thus, we hope we can help fill this research gap in the bank lending and bank capital channels literature, by providing an empirical example of the role banks' maturity mismatch can have

on banks' lending, in a monetary policy context.

With this in mind, we use two quasi-experimental models, the traditional Double DiD and a Triple DiD. In these, we split our bank sample into *PEPP banks* (treated group) and *non-PEPP banks* (control group), to check the cross-sectional difference between these banks, before and after the December 2021 PEPP unwinding decision. We first analyze credit and deposit differences between *PEPP banks* and *non-PEPP banks*, and then we add to this, the maturity mismatch of these banks, to check its role in determining the outcome variables.

Based on our results, banks' maturity mismatch seems to have affected *PEPP banks*' lending, leading to an increase, and thus, acting as an attenuator factor of the tight monetary policy shock. This conclusion goes along with Gomez et al. (2021). If we do not consider the effect of the maturity mismatch, *PEPP banks* granted less credit to both NFCs and Households than *non-PEPP banks*. Moreover, when we analyzed the *percentage changes* table, we observed that the estimates besides being significant, credit to Households coefficients seemed to be bigger than credit to NFCs, and so, a more sizable effect. It can be stated, that these lending pattern shifts may have been driven by the monetary policy and not by deposits, since these, show non-significant *ex-ante* estimates and no different pre-trends between *PEPP banks* and *non-PEPP banks*. These results add to the bank lending channel literature, on the effects of lending that central banks' monetary policy tightening announcements can have.

After considering *ex-ante* maturity mismatch level differences between these banks, we observe a completely different pattern in lending to Households. *PEPP banks* after December 2021, granted more credit than *non-PEPP banks*. The lending pattern after the policy shock is only significant for Households. However, the effect does not seem to be economically sizable ( $\approx 5\%$ ), one year after the policy shock. The *percentage change* tables further show the significant estimates between June and December 2022 for credit to Households and none for credit to NFCs. Once more, deposits did not seem to have affected the lending pattern in 2022, since the pre-trend seems to be the same for both groups. Therefore, this result adds to the bank lending and bank capital empirical literature.

In our analysis, we further noticed some significant estimates for the different credit and deposit maturity levels. However, these were driven by pre-trend effects. This means, the PEPP unwinding decision did not affect specifically maturity levels, but instead affected the aggregated credit and deposit values.

Finally, we checked for different patterns when considering interest rate controls, since according to the literature, these influence bank lending. Our results for the Triple model are

robust to this specification, meaning higher maturity mismatched *PEPP banks* did increase more their lending to Households than *non-PEPP banks*, after the policy shock.

Therefore, we then may conclude that banks' maturity mismatch performed as an attenuator factor of monetary policy transmission mechanisms, particularly, through credit granted to Households by *PEPP banks*. As we have seen, these banks had an *ex-ante* higher maturity mismatch level, compared to *non-PEPP banks*. Therefore, this feature helped them shield their lending activities. This idea corroborates Brunnermeier and Oehmke (2013) statement, that engaging in maturity transformation activities, "compensates" banks in monetary policy tightening periods, through higher profitability.

However, our study has an important limitation. Due to the lack of information on the datasets we used, concerning the maturities of assets and liabilities, we relied on a different approach to measure them. We used Paul (2023) mid-point value method, for measuring the maturity of assets and liabilities, to then compute, the maturity gap. This approach has the limitation of providing the same maturity value for all banks in each asset/liability category, and thus, it limits maturity heterogeneity across banks. Therefore, it would be interesting for future studies to delve into new measurement approaches, since there is a lack of alternatives in the literature.

Furthermore, the results we found regarding the lending to Households in the Triple DiD, may be also explained by an increase in demand for loans Altavilla et al. (2021). This is something we could not control since this would require access to confidential loan-level credit register data.

## 7. Appendix

### 7.1. Banks' maturity mismatch variable construction

The MFI dataset we use has information about the maturity of some assets and liabilities<sup>40</sup>. Yet, we miss maturity information for assets and liabilities. For instance, on the asset side, we have *Credit* divided into three different maturity *tranches*- up to 1 year, from 1 year to 5 years, and more than 5 years. *Securities* are divided into three *tranches*: up to 1 year, from 1 year to 2 years, and more than 2 years. On the liabilities side, *Deposits* have five maturity *tranches*: deposits redeemable up to 90 days, more than 90 days, deposits and equivalent up to 1 year, from 1 to 2 years, and more than 2 years. Securities' liabilities have the same maturity *tranches* on the asset side.

There are several limitations to the maturity measurement we use: first, it does not provide maturity information to the other asset and liabilities instruments, *e.g.*, *trading liabilities*. Second, we do not have specific maturities for each balance sheet item on subsets of maturities or *tranches*. Thus, heterogeneity about banks' different maturity values, within each *tranche*, is not available.

As in Paul (2023), we use a mid-point value approach in each *tranche*. For instance, for the *tranche* credit with maturity from 1 year to 5 years, the mid-point value will be 36 months. In the specific case, when a *tranche* had only a minimum maturity value, we used Double of the value of the previous *tranche*, just as in Paul (2023)<sup>41</sup>. For other assets and liabilities, we assumed the following: for *banknotes and coins*, the value assigned was 0, since these are very liquid assets; for *Equity Securities*, the value was the same as longer fixed-income securities (more than 2 years). The *fixed assets* and *miscellaneous assets* were excluded.

Regarding liabilities, we assigned demand deposits the value of 0, since they can be withdrawn by depositors at any time. As for trading liabilities, according to the dataset manual, from 2015 onwards, the respective code was aggregated in one, of the previous ones, the codes 450 (maturity up to 1 year) and 460 (more than a year). Using the mid-point approach, the code 450 had a maturity of 6 months, and the code 460 of 12 months. Since the trading liabilities' code from 2015 onwards resulted in the aggregation of these, we used once more the mid-point approach, to obtain a maturity value of 9 months. *Capital and reserves*

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<sup>40</sup> For the following description, it may be useful to check the dataset manual provided by BPLIM-  
[https://github.com/BPLIM/Manuals/blob/master/BBS/JUN23/manual\\_BBS\\_Jun2023.pdf](https://github.com/BPLIM/Manuals/blob/master/BBS/JUN23/manual_BBS_Jun2023.pdf)

<sup>41</sup> For instance, for the credit and equivalent- more than 5 years *tranche*, the calculated value of the previous *tranche*- credit and equivalent- from 1 year to 5 years, was multiplied by 2 in order to obtain its value.

and *Miscellaneous liabilities* were excluded.

Weighted maturities were computed for each bank in every month, by multiplying the weight of each asset/liability in total assets by the assigned maturity values. We then subtract the weighted asset maturity from the weighted liabilities maturity to get banks' maturity gap values for each bank every month.

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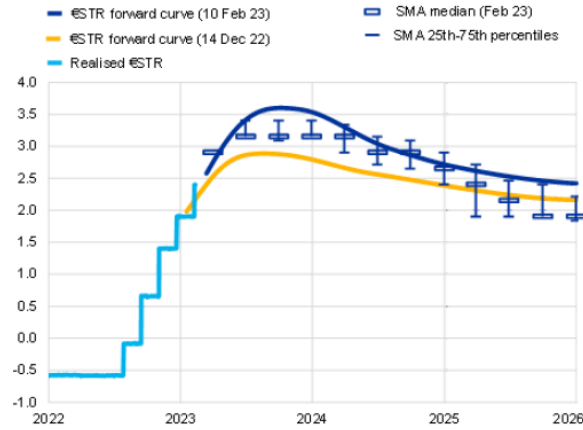
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## 9. Annex

### 9.1. Figures

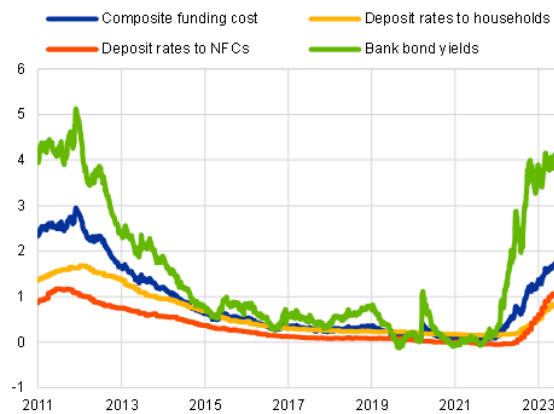
Figure A3- €STR forward curve and SMA expectations on the deposit facility rate



Note: The bars depict the median of responses to the February 2023 SMA (Survey of Monetary Analysts) survey on expectations regarding future deposit facility rates. The values are in percentages per annum.

*Source: ECB*

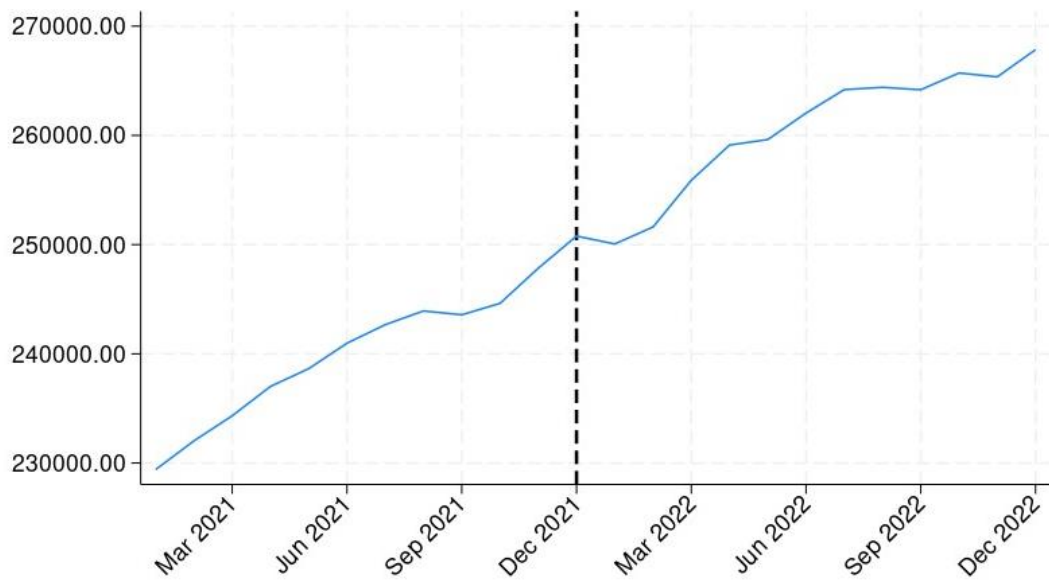
Figure A4- Euro area banks' funding costs (%)



Note: This figure shows different sources of banks' financing costs, between January 2011 and May 2023. More specifically, daily bank bond yields; monthly deposit rates on new business volumes, weighted by outstanding amounts, and finally, composite funding cost, calculated as a weighted average of the cost of deposits and market debt funding (with the respective outstanding amounts on bank balance sheets used as weights). The latest observations are 4 July 2023 for bond yields and May 2023 for the remaining.

*Source: ECB*

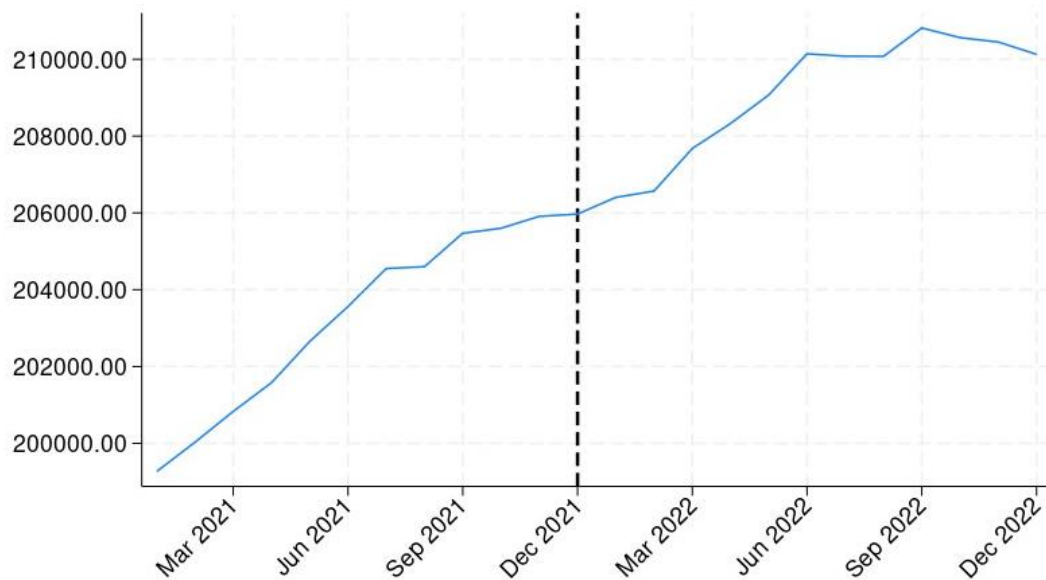
**Figure A5- Portuguese banks' deposits from NFCs and Households**



Note: The vertical dashed line marks the PEPP unwinding decision as the policy shock. The values are in millions of euros.

*Source: Own elaboration*

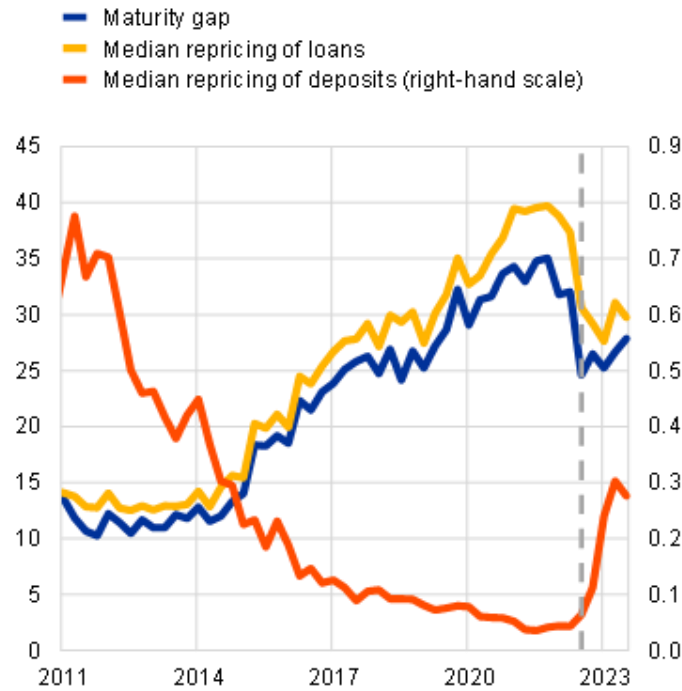
**Figure A6- Credit granted by Portuguese banks**



Note: The vertical dashed line marks the PEPP unwinding decision as the policy shock. The values are in millions of euros.

*Source: Own elaboration*

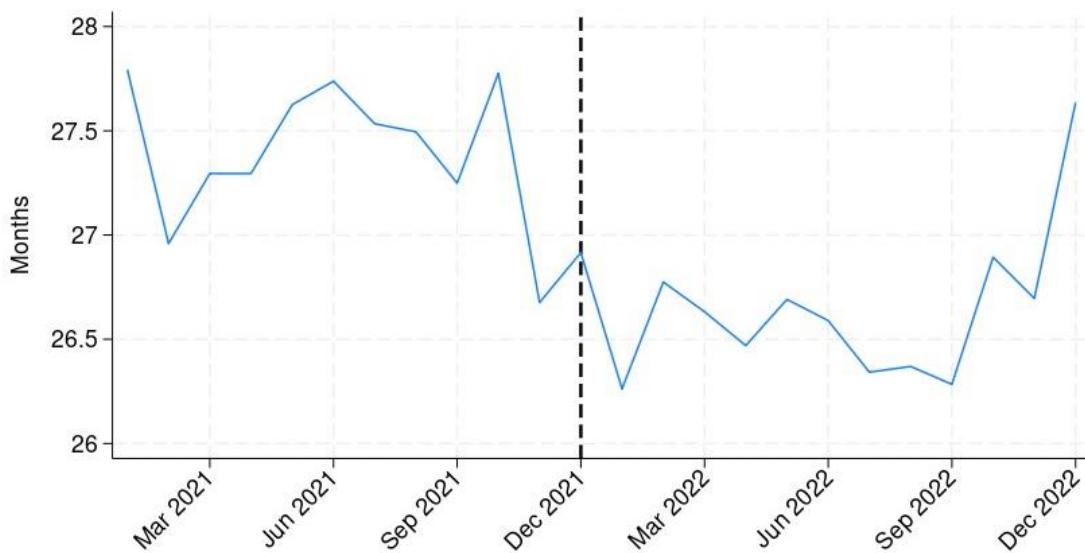
**Figure A7- Euro area banks' monthly maturity mismatch from Q1 2011 to Q2 2023**



Note: This figure indicates the euro area banks' monthly maturity gap, representing the median of each quarter. It is based on 330 MFIs and the dashed line represents the start of the hiking cycle in July 2022.

Source: ECB Financial Stability Review, November 2023

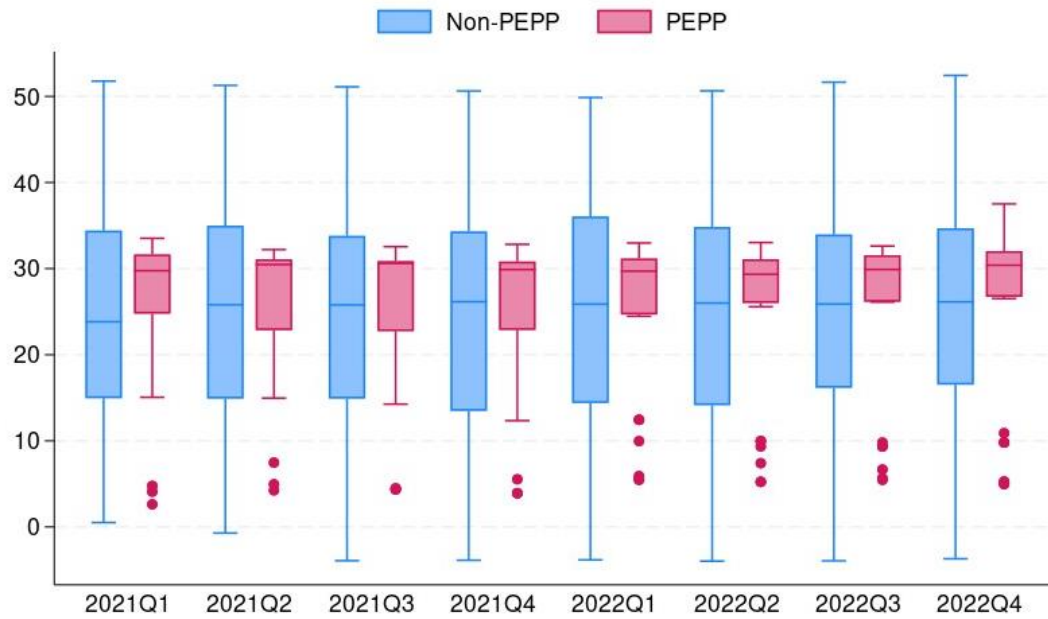
**Figure A8- Portuguese banks' maturity mismatch**



Note: The vertical dashed line marks the PEPP unwinding decision as the policy shock. The values are monthly medians.

Source: Own elaboration

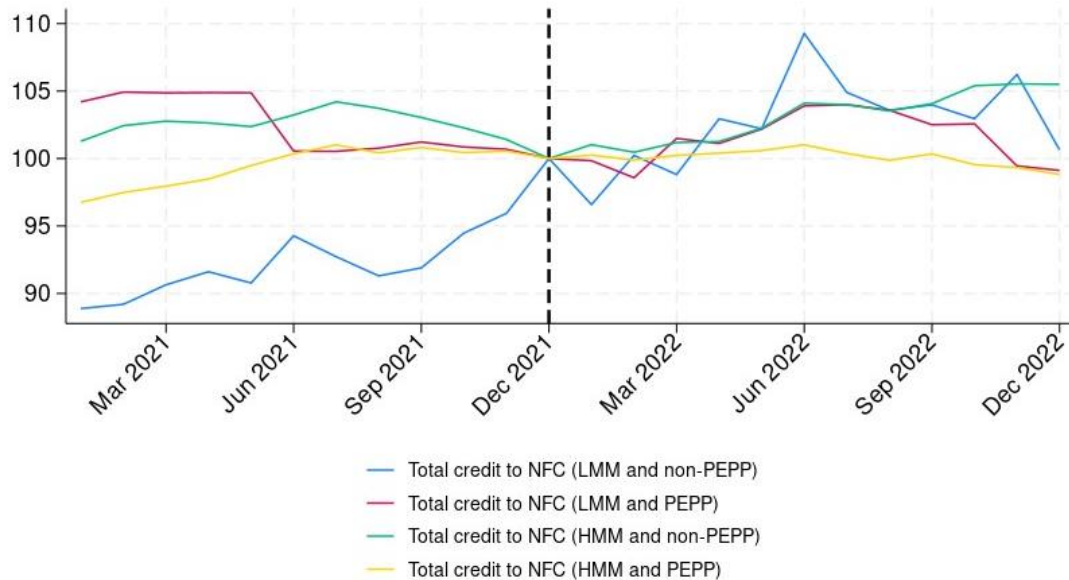
**Figure A9- PEPP vs. non-PEPP banks' maturity mismatch**



Note: The maturity mismatch values are in months. The red dots are considered outliers since their values are 1.5 times lower than the IQR (Inter Quartile Range).

*Source: Own elaboration*

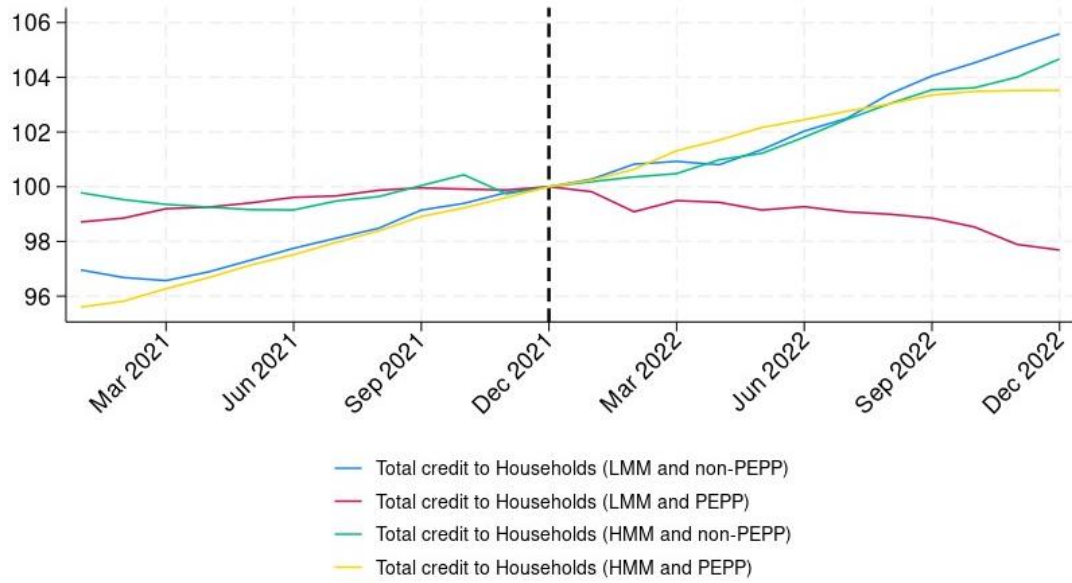
**Figure A10- Credit granted to NFCs by PEPP vs. non-PEPP banks and HMM vs. LMM banks**



Note: The vertical dashed line marks the PEPP unwinding decision as the policy shock. The values are indexed in December 2021.

*Source: Own elaboration*

**Figure A11- Credit granted to Households by PEPP vs. non-PEPP banks and HMM vs. LMM banks**



Note: The vertical dashed line marks the PEPP unwinding decision as the policy shock. The values are indexed in December 2021.

*Source: Own elaboration*

## 9.2. Tables

**Table A6- ECB monetary policies review**

<b>Date</b>	<b>Decisions</b>	<b>Details</b>
Dec-2021	Announcement of the terminus date of the pandemic emergency purchase programme (PEPP)	It was a temporary asset purchase by the ECB to euro area banks, with the main goal of minimizing COVID-19 potential risks to the monetary policy transmission mechanisms. In December 2021, the governing council announced their first contractionary decision, by stating that the PEPP would come to an end in March 2022.
Mar-2022	Announcement of the gradual elimination of pandemic measures	Gradual elimination, between July 2022 and March 2024, of the temporary measures to relax the framework for collateral assets and control of risk adopted during the pandemic crisis. It was on this month that the PEPP came to an end.
Jun-2022	Implementation of the transmission protection instrument (TPI)	In order to support the effective smooth transmission of the normalization of the monetary policy across all euro area countries. This meant, that under established parameters, the Eurosystem <sup>42</sup> would be able to make purchases on secondary markets of securities issued in jurisdictions registering a non-justified degradation of the financing conditions that jeopardize the monetary policy transmission on the euro area <sup>43</sup> .
	Stop the asset purchase programme (APP)	Starting to sell the assets of the APP, in a non-hazardous way for the monetary policy integrity, beginning in March 2023, with a monthly average of 15 billion euros.
	Announcement of the start of a continuous rise of the key interest rates	Increase of the three key interest rates by 50 basis points in July 2022. At the end of 2022, the sum of these raises was 2,5 percentage points.
Sep-2022	Suspension of the two-tier system for remunerating excess reserve holdings	The underlying multiplier of this mechanism was set to zero <sup>44</sup> .
Oct-2022	The TLTRO III interest rates revised	From November 2022, the TLTRO III interest rates were indexed to the average applicable key interest rates. Thus, these operations became much less attractive. A final policy decision was linked to the ECB requirement to credit institutions to hold deposits on accounts with their national central bank, called minimum or required reserves.

Note: This table contemplates the most important measures taken by the ECB in its monetary policy tightening until the end of 2022.

<sup>42</sup> The Eurosystem is composed by the ECB and all euro area national central banks.

<sup>43</sup> For a more thorough insight, please check the following link: <https://www.ecb.europa.eu/press/pr/date/2022/html/ecb.pr220721~973e6e7273.en.html>

<sup>44</sup> For a more thorough insight, please check the following link: <https://www.ecb.europa.eu/mopo/two-tier/html/index.en.html>

**Table A7- Dependent variables**

<b>Variables</b>	<b>Definition</b>
Total credit	Credit granted to NFCs plus Households
Total credit to NFCs	Credit granted to NFCs only
Total credit to Households	Credit granted to Households only
Short-term credit to NFCs	Credit with maturity up to 1 year granted to NFCs only
Medium-term credit to NFCs	Credit with maturity between 1 and 5 years granted to NFCs only
Long-term credit to NFCs	Credit with a minimum maturity of 5 years granted to NFCs only
Short-term credit to Households	Credit with maturity up to 1 year granted to Households only
Medium-term credit to Households	Credit with maturity between 1 and 5 years granted to Households only
Long-term credit to Households	Credit with a minimum maturity of 5 years granted to Households only
Total deposits	All deposits from NFCs plus Households
Demand deposits	Demand deposits from NFCs plus Households
Short-term deposits	Deposits with maturity of up to 1 year from NFCs plus Households
Medium-term deposits	Deposits with maturity between 1 and 2 years from NFCs plus Households
Long-term deposits	Deposits with a minimum maturity of 2 years from NFCs plus Households

Note: This table contemplates all dependent variables calculated using data from the SLB dataset.

**Table A8- Control variables**

<b>Control variables</b>	<b>Based on</b>	<b>Computation</b>
Equity ratio	<i>(Bittner et al., 2022)</i>	Difference between total assets and total liabilities over total assets
Deposit ratio	<i>(Bittner et al., 2022)</i>	Demand deposits plus deposits redeemable at notice plus other deposits with maturity up to 1 year, all over the value of total assets
Bank size	<i>(Jiménez et al., 2014)</i>	Neperian logarithm of banks' total assets
Securities ratio	<i>(Jiménez et al., 2014)</i>	Cash plus debt and equity securities, all over total assets
Interbank liquidity ratio	<i>(Bottero et al., 2022)</i>	Interbank notes and coins, plus interbank credit with a maturity of up to 1 year (the shortest maturity available in the MFIs dataset), minus interbank demand deposits, deposits redeemable at notice, and interbank debt securities issued with a maturity of up to 1 year, all divided by total assets
Central banks funding ratio	<i>MFI</i>	Ratio of all liabilities to central banks, divided by total assets
Interest rate on new loans to NFCs	<i>SLB</i>	Interest rate on new loans to both NFCs, measured as a percentage
Interest rate on new loans to Households	<i>SLB</i>	Interest rate on new loans to both Households, measured as a percentage

Note: All the information was removed from the mentioned articles or MFI and SLB (only the interest rate variable) datasets.

**Table A9- PEPP vs non-PEPP and HMM vs LMM banks**

	<b>Mean</b>	<b>N</b>
PEPP and HMM banks	30.218	7
PEPP and LMM banks	14.051	3
non-PEPP and HMM banks	36.060	19
non-PEPP and LMM banks	13.637	21
<b>Observations</b>	-	50

Note: HMM banks have maturity mismatch values above the median, and the LMM banks have maturity mismatch below the median.

**Table A10- t-test results**

	<b>Non-PEPP banks</b>	<b>PEPP banks</b>	<b>Diff.</b>	<b>S.E.</b>	<b>N</b>
Total credit	783.773	17461.901	-16678.128***	(4828.975)	50
Total credit to NFC	260.805	6642.053	-6381.248***	(1730.315)	50
Total credit to Households	522.968	10819.848	-10296.880**	(3218.259)	50
Short-term credit to NFC	57.291	1049.573	-992.282***	(301.919)	50
Short-term credit to Households	51.281	205.142	-153.861*	(77.953)	50
Medium-term credit to NFC	59.532	1168.719	-1109.187***	(312.659)	50
Medium-term credit to Households	39.032	129.662	-90.630	(50.670)	50
Long-term credit to NFC	143.981	4423.761	-4279.780***	(1146.144)	50
Long-term credit to Households	432.655	10485.044	-10052.389**	(3121.689)	50
NFC demand deposits	160.381	4832.678	-4672.297***	(1426.115)	50
Total deposits	649.023	22482.088	-21833.065***	(6682.932)	50
Demand deposits	412.800	12888.492	-12475.692**	(3913.105)	50
Short-term deposits	174.956	7709.102	-7534.146**	(2900.552)	50
Long-term deposits	49.947	1664.664	-1614.717**	(515.798)	50
Banks maturity mismatch	24.288	25.368	-1.081	(3.579)	50
Equity ratio	0.181	0.111	0.070**	(0.034)	50
Deposit ratio	0.609	0.525	0.084	(0.064)	50
Bank size	6.601	9.402	-2.801***	(0.800)	50
Securities ratio	0.022	0.349	-0.327***	(0.066)	50
Interbank liquidity ratio	0.016	0.106	-0.090**	(0.031)	50
Central Banks funding ratio	32.767	4075.923	-4043.156***	(1043.432)	50
Interest rates on new loans	3.441	2.870	0.571	(0.938)	39
Interest rates on new loans to NFCs	3.064	2.766	0.298	(0.730)	34
Interest rates on new loans to Households	3.453	2.626	0.828	(1.134)	30

Note: This table contemplates all variables calculated, using SLB and MFI datasets.

**Table A11- Outcome variables: Summary statistics**

	<b>Mean</b>	<b>Std.Dev.</b>	<b>P10</b>	<b>Median</b>	<b>P90</b>
Total credit	4,128.715	9,369.249	23.390	227.130	20,809.150
Short-term credit	343.373	719.597	0.870	23.870	1,324.650
Medium-term credit	344.313	709.139	0.000	31.990	1,147.520
Long-term credit	3,441.028	8,023.069	0.300	149.100	16,504.740
Total credit to NFC	1,540.816	3,475.899	0.000	111.440	7,763.380
Total credit to Households	2,587.900	6,034.252	0.000	70.970	9,769.420

Note: The *total credit*, short, medium, and long-term credit variables, aggregate the sum of *credit to NFCs* and *Households*. The values presented are set at December 2021.

**Table A12- Independent variables: Summary statistics**

	<b>Mean</b>	<b>Std.Dev.</b>	<b>P10</b>	<b>Median</b>	<b>P90</b>
Banks maturity mismatch	24.504	12.617	6.726	26.916	39.416
Equity ratio	0.167	0.179	0.044	0.103	0.336
Deposit ratio	0.592	0.290	0.090	0.633	0.904
Bank size	7.161	1.980	5.142	6.749	10.626
Securities ratio	0.087	0.176	0.000	0.000	0.416
Interbank liquidity	0.034	0.092	0.000	0.000	0.130
Central Banks funding	841.398	2,164.594	0.000	0.000	3,975.090
Interest rates on new loans	3.294	2.597	0.675	2.541	7.980

Note: The *interest rate on new loans*, aggregates the sum of the *interest rate on new loans to NFCs* and the *interest rate on new loans to Households*. The values presented are set at December 2021.

**Table A13- Pearson correlation**

	Banks' maturity mismatch	Equity ratio	Deposit ratio	Bank size	Securities ratio	Interbank liquidity ratio	Central banks funding ratio	Basel III ratio	Interest rates on new loans to NFCs	Interest rates on new loans to Households
Banks' maturity mismatch	1.0000									
Equity ratio	0.1074 0.4577	1.0000								
Deposit ratio	0.1116 0.4403	- 0.4735* 0.0005	1.0000							
Bank size	0.2868* 0.0434	- 0.3732* 0.0076	-0.0734 0.6125	1.0000						
Securities ratio	0.0484 0.7384	-0.1340 0.3535	-0.1180 0.4145	0.6097* 0.0000	1.0000					
Interbank liquidity ratio	-0.0677 0.6403	-0.1033 0.4751	-0.1177 0.4154	0.2817* 0.0475	0.3657* 0.0090	1.0000				
Central banks funding ratio	0.1596 0.2681	-0.1641 0.2549	-0.0481 0.7402	0.7465* 0.0000	0.8010* 0.0000	0.4026* 0.0037	1.0000			
Interest rates on new loans to NFCs	-0.0816 0.6463	0.1297 0.4648	-0.2825 0.1837	-0.2335 0.1837	-0.1394 0.4317	-0.1283 0.4697	-0.2608 0.1363	-0.0172 0.9460	1.0000	
Interest rates on new loans to Households	-0.3858* 0.0352	0.3885* 0.0339	- 0.5960* 0.0005	-0.2746 0.1419	-0.2968 0.1113	-0.0308 0.8715	-0.2786 0.1361	0.2148 0.4243	0.8833* 0.0000	1.0000

Note: The upper values correspond to the r-values and the lower values are the respective *p*-values. The values presented are set at December 2021.