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THE EFFECTS OF ECB'S UNCONVENTIONAL MONETARY POLICY ON PORTUGUESE GOVERNMENT BOND YIELDS

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Abstract

In this dissertation we study the effects of the ECB unconventional monetary policy measures on 10-year Portuguese government bond yields. We conduct our analysis empirically using an ARDL model in which we include the Euro area shadow interest rates as a proxy of the stance of ECB monetary policy.
Our analysis presents several elements of novelty: first of all, we decided to concentrate only on one country, Portugal, while the majority of the study consider panel data samples; secondly, while there are studies that use shadow interest rates to analyse the effects of FED's unconventional monetary policy on US government bond yields, there are no relevant studies for Europe.
Moreover, we answer to a second research question investigating whether there are spillovers from the FED monetary policy on 10-year government bond yield. Our results suggest that ECB measure were effective in lowering the Portuguese government bond yields persistently and that the FED unconventional monetary policy did affect the Portuguese government bond yields even though this effect tend to vanish rapidly.

JEL: E52, E58, E65, G12

Keywords: bond markets, monetary policy, policy effects, Portugal, shadow interest rates

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Introduction

The global financial crisis, which began in August 2007 and worsened in September 2008, after the collapse of Lehman Brothers, had a severe impact on financial markets and spread worldwide with damaging effects on the real economy. This great turmoil in financial markets led the world's major banks to implement an expansive monetary policy by lowering key policy rates. However, once interest rates reached the Zero Lower Bound (ZLB), economic policy needed new methods to convey the economic stimulus: the unconventional monetary policies. The peculiarity of these policies in comparison with conventional monetary policies, is that they can be implemented without taking into account the interest rate level (Borio & Disyatat, 2010) and are characterized by tree main features: i) first of all, the use of communication (forward guidance) to reassure investors about the permanence of policy rate at low levels over extended policy horizons (expectation management); ii) the purchase of asset in the secondary market with the aim of affecting the relative supply of securities in the market place (alteration of the Central Bank portfolio); iii) the provision liquidity over the level needed to set the policy rate at zero, also called quantitative easing (Bernanke & Reinhart, 2004; Pattipeilohy *et al.*, 2013).

Together with monetary policy measures, the channels through which these impulses were transmitted to the real economy changed. This led to the development of a flourishing literature that not only studied the effects of the measures implemented by Central Banks, but also the transmission mechanisms involved. Some authors such as Gambacorta *et al.* (2012) and Haldane *et al.*(2016), studied the macroeconomic effects of the unconventional monetary policy measures, authors such as Wieladek & Garcia Pascual (2016) and Altavilla *et al.* (2015) focused their attention on the effects on asset prices and authors such as Andrade (2016) and De Santis (2016) investigated the effects on government bond yields.

Following these latter studies, this dissertation aims to analyse the effects that unconventional monetary policies had on 10-year Portuguese government bond yields. Therefore, we analysed these effects using an Autoregressive Distributed Lags (ARDL) model with quarterly data from January 1999 to January 2109.

However, our dissertation presents different points of innovation compared to the previous literature. First of all, we focus on one country: Portugal. We chose this country because is one of the most affected by the crisis and, consequently, one of the main recipients

of the unconventional measures (Jorgensen & Krishnamurthy, 2011). Moreover, we have not found any relevant literature focusing on the effects of unconventional monetary policy measures on government yields of Portugal alone, whereby there are plenty of studies covering Portugal together with other countries in panel data estimations.

A second element of novelty of this dissertation is the use shadow interest rates as a proxy for monetary policy since, in our literature review we have not found any author who has used the European Shadow Short Rates to analyse the effects on eurozone government bond yields.

In addition, using shadow rates we try to investigate whether US monetary policies had any effect on Portuguese 10-year government bond yields as in Varghese and Zhang (2018) and Lombardi and Zhu (2014).

The following chapters are organized as follows: in the first chapter we describe the conventional monetary policy measures and their transmission channels. In chapter two, we analyse unconventional monetary policy measures and their transmission channels. Chapter three is an *excursus* of the main monetary policies implemented by both the ECB and the Fed. In chapter four, we present a review of the literature on the effects of monetary policy measures in various dimensions, with a particular focus on government bond yields. Chapters five and six describe our econometric model and the discussion of its results, and finally, chapter seven concludes.

1. Conventional monetary policy and traditional transmission channels

During the colloquium held in honour of Otmar Issing in March 2006, Blanchard (2006) took a speech about the definition of monetary policy describing it as closer to art because "it is frequently confronted to new, poorly anticipated and poorly understood, contingencies" but also close to science due to all the rules and the targets that have been set in the past twenty years (p. 1). More rigorously, Mishkin (2007) refers to monetary policy as the action taken by Central Banks in order to affect "interest rates, the amount of credit available and the money supply" which can consequently affect financial markets but also the aggregate output and inflation.

Central Banks use monetary policy in order to reach some specific objectives that can vary for type and importance according to the different Central Bank mandates. In the last decades, the necessity of defining clearly the objectives of monetary policy has induced these institutions to focus mainly on price stability (Archer, 2009). Among the authors, Archer (2009) studies the type of legislation and the objectives of nearly 50 Central Banks showing that just few banks in the sample do not include price stability as a relevant goal in their laws and also that the majority of banks have multiple focuses. More deeply, when price stability, or its direct equivalent, is not legally included as one of the prime objectives of monetary policy, the objectives are defined in more general terms.[1] Moreover, still according to Archer (2009) the great majority of Central Banks operates under the assumptions that they have a policy responsibility for financial stability even if just a small number of them includes this goal explicitly in their statutes and with differ degrees of commitment. For example, the ECB in the Article 127 (1) of the Treaty on the Functioning of the European Union (TFEU), just specifies the role of "contributing to" financial stability together with the other institutions of the Eurosystem. Archer (2009) attributes the lack of a clear specification to the difficulties that exist in defining and measuring financial stability itself but also to the incompatibility that can arise with other policy objectives. Another objective that is listed in the above-mentioned publication is related to the payment system oversight function included especially in the laws that has been rewritten in the last decade.

[1] For further information see Archer, D. 2009: 17-55.

The Federal Reserve (FED) main objectives, as included in the Federal Reserve Act created in 1913 are "maximum employment, stable prices, and moderate long-term interest rates" in the United States. Thereafter, the Statement on Longer-Run Goals and Monetary Policy Strategy (2012) established a numerical longer-run goal for inflation which is an annual rate of increase of 2% in the price index for personal consumption expenditures. This can be obtained by controlling the availability and cost of credit and by steering the level of short-term interest rates (Fed, 2018).

In the Eurosystem, as laid down in Article 127(1) TFEU, the primary objective of the European Central Bank (ECB) is price stability, while support for the general economic policies of the European Union is only a secondary objective. The definition of price stability dates back to 1998 when the ECB defined it as a "year-on-year increase in the Harmonized Index of Consumers Prices (HICP) for the euro area of below 2%. Price stability is to be maintained over the medium term"(ECB, 2018a). Consequently, inflation above 2% is not consistent with price stability as well as very low inflation and especially deflation. Subsequently, in 2003, the Governing Council specified that, with regard to price stability, its objective would be to pursue inflation in the euro area at a level "below, but close to, 2% in the medium term" (ECB, 2018a). This definition is very similar to that of the FED.

The Central Bank role is well described, for example, in ECB (2011). The Central Bank is the only issuer of bank notes and reserves (monopoly supplier of the monetary base). It can also impact the conditions of the money market and the level of short-term interest rates. In the short term, a change in the policy interest rates set by the Central Bank triggers a number of transmission mechanisms and causes a reaction in the main economic variables such as output and inflation. Instead, in the long run the Central Bank is unable to affect the economic growth through the money supply due to the so called "long run neutrality of money" (ECB, 2011).

The modalities by which monetary policy measures affect the economy, and in particular on aggregate demand, are referred to as transmission mechanisms and involves different economic agents' actions at different levels. For this reason, monetary policy actions usually take a considerable amount of time to have effect on prices. Moreover, the size and strength of each monetary policy action are related to a particular state of the economy, which is variable and therefore unique, making the effects very difficult to estimate. For this reason, there is a huge literature about the transmission mechanisms of monetary policy (see *e.g.* Loayza & Schmidt-Hebbel, 2002; Taylor, 1995).

Among the authors that tried to identify these channels, Mishkin (2007) describes some of the main ones. The first is the interest rate channel which explains how policy-induced change in the policy interest rates affect also the money market interest rate and indirectly affects the lending and deposits rates set by banks for households and firms. In particular, according to the Keynesian view, expansionary monetary policy leads to a fall in the short-term real interest rates. According to the expectation hypothesis of term structure, the nominal long-term interest rate is determined by the average of the expected future short-term interest rates. There is, therefore, positive link whereby an increase (decrease) in the nominal short-term interest rate, if persistent over time, results in an increase (decrease) in the nominal long-term interest rate. In case that the nominal prices are slow to adjust, the nominal interest rates changes also reflect in a change of real long-term interest rates. This process lowers the real cost of borrowing causing a rise in fixed investment, residential housing investment and consumer durable expenditure, thereby producing a rise in the aggregate demand. This effect on aggregate demand is given by the characteristic of this transmission channel to influence the real interest rate, instead of the nominal one, which in turn impacts on business and consumer decisions (Mishkin, 2007).

Another important transmission channel is via the exchange rate effect on net exports. In a globalized economy it is also even more relevant to understand how monetary policy is able to affect net exports and the aggregate demand. As explained by Beyer *et al.* (2017), an expansionary monetary policy causes a decrease of domestic interest rates relatively to their foreign counterparts. Subsequently, the domestic currency becomes less attractive as investing currency with respect to the others and it depreciates relative to the foreign ones. If prices are sufficiently slow to adjust, the domestic goods become cheaper than the foreign ones. The imports decrease and the exports increase as well as aggregate demand.

Moreover, asset prices also play an important role in the mechanism of transmission of monetary policy (Meltzer, 1995). The asset price channel, which is related to Tobin's *q* theory (Tobin, 1969) associates monetary policy, its effects on equity valuation and the real economy (Beyer *et al.,* 2017). First, it is necessary to define the *q* as the market value of the firm divided by the cost of replacing capital. So, when *q* is high, the market price of a firm is high compared to the cost of replacing capital and the capital for new equipment is cheap compared to the market price of the firm. As a result, firms can issue stocks that are worth a high price compared to the cost of the new equipment they intend to purchase. Since firms can now buy more new investment goods with a small issue of stocks, the investment

spending increases. So, a monetary policy expansion, lowers real interest rates on bonds (considered an alternative to stock) and also their returns. This makes stocks more attractive relative to bonds and so their demand increases raising their price. Higher stock prices, correspond to an higher q and to higher investment spending that cause an increase in the aggregate demand.

The wealth effect channel is based on the life cycle theory stating that consumers' balance sheet can affect their spending decisions (Dan, 2013). In this context, consumption can be defined as the consumers' spending on nondurable goods and services. According to the life cycle consumption theory (Modigliani, 1971), consumers smooth their consumption over time in a way that consumption is not determined by today's income but by lifetime resources. These resources are determined by the individuals' human capital, real capital and financial wealth that is usually composed for the major part by stocks. Consequently, when the stock prices increase, the consumers' financial wealth raises, increasing also their lifetime resources that induce them to consume more. A monetary expansion lowers both real and nominal interest rates that leads to a rise in stock prices, an increase in consumers wealth and to an increase in consumption causing a rise in the aggregate demand. In addition, the asset price channel can also be applied to the real estate market (Mishkin, 1996). Considering the housing as equity, as the price of the houses increases compared to the cost of financing, there is an increase in the *q* of Tobin for residential construction. This, in turn, generates an increase in investment and an increase in aggregate demand. Furthermore, as explained earlier, the price of housing is part of the real capital of individuals, which in turn contributes to the determination of the overall wealth of individuals. Therefore, if the price of houses increases, so does the level of welfare of individuals, which affects their consumption decisions. Increased consumption will have a positive impact on aggregate demand.

The credit channel explains how the effects of monetary policy can be amplified by the presence of structural frictions in the financial market *i.e.* asymmetric information (Black & Rosen, 2007). Asymmetric information may translate in two parts: the adverse selection, which arises before the operation, and the moral hazard, which arises after the operation. Bernanke and Gertler (1995) divided this channel into two distinct sub-channels: the bank lending channel, which is based on the banks' willingness to provide loans to the market, and the balance-sheet channel, which is based on the ability of businesses and households to obtain loans from banks. These two channels are complementary but distinct.

The bank lending channel depends on the particular role that banks play in the financial system as they are specialized in solving problems such as asymmetric information in the credit market (Mishkin, 2007). This enables more economic agents to access credit that they would not otherwise have. Assuming that there is no perfect substitutability of retail bank deposits with other funding resources, an easing monetary policy generates a rise in bank reserves and deposits and, consequently, the amount of bank loans available. This allows more borrowers to access to credit generating a rise in investment spending and in the aggregate demand (for more information see also Beyer *et al.* (2017).

The balance sheet channel is described by Bernanke and Gertler (1989) as generated by the agency costs in the financial system. According to their model, in periods of contraction of monetary policy, the asymmetrical information increases and lenders tend to prefer safer investments: shifting loans from small and medium-sized firms to large ones. The balance sheet channel is in turn divided into several sub-channels: the profitability channel, the cash flow channel, the unanticipated price level channel and the household liquidity effect channel (Bernanke & Gertler, 1989).

The profitability channel (Beyer *et al.*, 2017) is based on the hypothesis that the greater the firm's net worth, the stronger its financial position and the fewer problems of adverse selection and moral hazard associated with it. Therefore, if borrowers have more collaterals for loans, their potential losses are lower and this generates an increase in loans for investment expenses, as they are more likely to repay their debt. An expansionary monetary policy, reduces real interest rates on government bonds and decreases their demand compared to the demand for share. This leads to higher share prices (see asset price channel). As share prices are now higher, firms' net worth and profitability are also higher. This leads to an increase in investment spending and higher aggregate demand due to a decrease in adverse selection problems and moral hazard.

The cash flow channel was introduced by Bernanke and Gertler (1995) and is defined as an indirect channel. An expansionary monetary policy, increases consumers' spending and the demand for goods (as already described in the wealth effect channel), so also the revenues of companies increase. Assuming that fixed costs (such as interest and labour costs) remain constant in the short term, the cash flow rises as does the net worth of companies. With more liquidity it is easier for lenders to know whether companies will be able to pay their liabilities and the problems of adverse selection and moral hazard are lessened. This, in turn,

results in an easier access to credit, boosting lending, investment and economic activity in general.

As monetary policy is positively related to the price level, an additional channel can be identified: the price level channel (Mishkin, 1996). An expansionary monetary policy generates an increase in inflation and, as payments are set in nominal terms, the real value of liabilities decreases as the price level rises. This causes an increase in the net worth of the firm, reducing the probability of adverse selection and moral hazard. This leads credit institutions to be more willing to lend and to an increase in investment spending and aggregate demand.

The household liquidity effect channel operates through the change in consumers' durable goods and housing expenditure (Mishkin, 2007). The main assumption to consider for this channel is that durable goods and homes are very illiquid goods because it is difficult to define their quality (just like in the "lemons problem" developed by Akerlof (1978)) and this generates problems of asymmetric information. So, if a strong income shock occurs and consumers need to sell their durable assets and houses, they will expect a loss because of the impossibility of getting the full value of these assets in a distress sale. On the others side, if consumers hold financial asset they will sell them quickly for their full value and raise cash. Therefore, if consumers expect to be in a financial distress they will decide to hold fewer illiquid asset than liquid ones. Due to this reasoning, it is possible to conclude that when consumers hold less liquid asset they estimate a low probability of financial distress and are induced to consume more on housing and durable assets. An expansionary monetary policy, decreases interest rates and increases prices, raising the price of households' financial assets as well and decreasing their expectation to be involved in a financial distress. This is an incentive for durable assets and housing spending that fosters also the aggregate demand.

The transmission channels mentioned above are activated by various instruments that Central Banks use to achieve their policy objectives. These instruments, which are used in normal times and are therefore defined as "conventional", are implemented through changings in short-term interest rates, and can be collectively called "interest rate policy" (Borio & Disyatat, 2010). According to Mishkin (2007), one of the key tools for the implementation of monetary policy are the Open Market Operations (OMOs). The OMOs serve to signal the monetary policy stance and to manage the liquidity conditions of the banking sector allowing the Central Bank to indirectly steer the level of short term interest rates. These operations can be divided into open market purchases and open market sales

and are respectively the purchase or sale of public and private securities by the Central Bank (Mishkin, 2007). Open market purchases enlarge reserves and, hence, the monetary base, boosting the money supply and reducing short-term interest rates. At the opposite, open market sales reduce the money supply and increase the short-term interest rate. Open market operations can be categorized into two main types: dynamic open market operations, that have the objective of changing the volume of reserves and the monetary base, and defensive market operations that are aimed to counterbalance some exogenous factors that modify the level of reserves and the monetary base. Only counterparties that fulfil certain eligible criteria can participate to monetary policy operations and only some reliable assets can be considered eligible as collaterals (ECB, 2011). One of the principal characteristics of the open market operations is that they can be easily reversed to correct mistakes without damages.

Together with the OMOs, the Central Banks also set lending rates and act as lenders of last resort (Mishkin, 2007). To control short term interest rates in the money market and to restrict the volatility, the Central Banks set the rates to lend overnight credit to banks. As for the OMOs, also in this case, eligible collaterals are required for these operations. Since the lending rates of Central Banks are usually substantially higher than the corresponding money market rates, credit institutions normally use standing facilities in lack of other alternatives (lender of last resort). Because of this reason, borrowing from the Central Bank also give a signal about bad financial condition of the bank, so it is usually avoided.

Furthermore, Central Banks also set the interest rate on overnight deposits of credit institutions with them (Mishkin, 2007). Banks can decide freely whether to deposit their funds with the Central Bank or reinvest them in the market. This is why a change in the interest rate on deposits can make credit institutions more or less favourable to lend money to the real economy or to hold it as reserves. The lending rate and the deposit rate form a corridor within which money market interest rates fluctuate (Pattipeilohy *et al.*, 2013).

Another tool used by Central Banks is the reserve requirement that are the portions of deposits that banks must hold in a Central Bank account. The amount of required reserves is based on the reserve ratio, which is the percentage of the balance sheet value that each credit institution must hold with the Central Bank. The tool can help to manage monetary policy, since an increase in the reserve requirements generates a reduction in the monetary base and consequently a contraction in the money supply (Borio & Disyatat, 2010). Pattipeilohy *et al.* (2013) indicates two main purposes for the minimum reserve system: "to create sufficient structural demand for Central Bank credit and to contribute to stabilize the

money market interest rates". The reserve requirement, and hence the need of banks to hold them, increases their demand of credit. This makes easier for banks to manage the money markets rates.

In normal times, these tools are effective and sufficient to conduct monetary policy but in case of a large-scale financial crisis the transmission mechanisms can be distorted in a way that it could be necessary to use other types of measures. When markets experience a large-scale financial crisis, the conventional measures mentioned above are no longer effective. Jannsen, *et al.* (2015) found that, during the acute phase of a crisis, financial stress lowers the level of confidence and increases uncertainty. Consequently, the entire economy crumbles, due to the inability of markets to allocate capital productively and to efficiently assign investment expenditure. However, it is hard to prove how and which traditional transmission channels were impaired especially during the last global financial crisis that was characterized by an high degree of international synchronization (Jannsen *et al.*, 2015). This is the reason why the literature about this topic is very vast. As instance, the lending channel and the household and firms balance sheet channel were found to be altered in the acute phase of the crisis due to the lack of confidence in the markets, with negative effects on the GDP growth (see Ciccarelli, *et al.* 2013).

Between 2007-2008, and especially in the aftermath of the collapse of the Lehman Brothers in August 2008, all the major Central Banks in the world started providing liquidity to the credit markets through the conventional tools available, in order to restore financial stability: increasing open market operations and lowering the key policy interest rates. The main problem for the proper working of monetary policy stimulus, was then connected to the ZLB reached by the economy due to the negative shock. According to Bernanke and Reinhart (2004), when the short-term policy rate is at or near zero, lowering the target for the policy rate is no more a feasible option because the currency (which pays a nominal interest rate of zero) would be preferred to store value. In this case monetary policy makers need to start using the so called unconventional monetary policy measures, described in the next chapter.

2. Unconventional monetary policy

The crisis that hit global markets, which began in the United States in 2007 and spread globally in subsequent years, can be considered the worst economic disaster since the Great Depression of 1929. It started in 2007 when the US subprime market began to show signs of instability. From the housing market fear and uncertainty spread to financial markets and went beyond the American borders (Fawley & Neely, 2013). In September 2007 the British bank Northern Rock asked for help to the Bank of England due to a bank run and it was later nationalized by the British government in February 2008. The spread of uncertainty across the European borders generated a credit crunch that hit several banks including the Swiss bank UBS that had to issue new rights to cover the losses of assets linked to the US mortgage market. In August 2008 the BNP Paribas communicated to the investors that they could not take out their money from their fund because the bank was unable to value the asset in them due to the lack of liquidity in the market. However, the situation became critical in September 2008 when the US bank Lehman Brothers collapsed triggering the outbreak of the financial crisis. As mentioned in the previous chapter, since August 2007 all the major Central Banks reacted with the conventional monetary tools but soon it became clear that it was not enough to stimulate the economy. Therefore, since the end of 2008, but not at the same time, all major Central Banks (FED, BoE, BoE, BoJ and ECB) have implemented a number of other monetary policy instruments which are called unconventional (Fawley & Neely, 2013).

2.1. Unconventional monetary policy measures

Unconventional monetary instruments have been defined by many authors but when it comes to give a univocal definition the task can be tricky. Among the several works analysed during our literature review, two distinct interpretations emerged. Some of the authors (such as Jorgensen & Krishnamurthy, 2011; Pattipeilohy *et al.*, 2013) define as unconventional all the measures taken by Central Banks to deal with the crisis. This group also includes policies adopted in the presence of positive interest rates and the exceptional expansions (in terms of maturity and volume) of conventional programs already implemented in normal times. The other part of the authors (Andrade, 2016; Bernanke, 2009; Bernoth *et al.*, 2016b), which mainly

includes the most recent ones, provides a stricter definition of unconventional monetary policies, indicating with this term only the policies implemented when interest rate are close to the zero lower bound and are basically characterized by three main features: i) first of all, the use of communication (forward guidance) to reassure investors about the permanence of policy rate at low levels over extended policy horizons (expectation management); ii) the purchase of asset in the secondary market with the aim of affecting the relative supply of securities in the market place (alteration of the Central Bank portfolio); iii) the provision liquidity over the level needed to set the policy rate at zero, also called quantitative easing (Bernanke & Reinhart, 2004; Pattipeilohy *et al.,* 2013). The peculiarity of these policies compared to the interest rate policies implemented before the crisis, is that they can be implemented without taking into account the interest rate level (Borio & Disyatat, 2010). In this work, we have decided to follow this last definition because we consider it more detailed and in line with the definition given by the ECB (2020).

The unconventional policy measures have been categorized by many authors. For example Bernanke and Reinhart (2004) differentiate among three types of tools: shaping the interest rate expectations, changing the composition or expanding the size of the Central Bank's balance sheet.

Bernanke and Reinhart (2004) explain the first unconventional tool, also called forward guidance, starting from the concept that the pricing of long-term financial assets (mortgages, equities, etc.) is partly dependent on the entire expected future path of long-term interest rates and partly on current short-term interest rates. Thereby, Central Banks are able to affect the asset pricing influencing market participants' future expectations about the future short-term rates and about the further monetary policy measures they intend to implement, through announcements and commitments. In the case of key policy interest rates at or close to zero, if the Central Bank declares that the policy rate will remain low for a prolonged period of time, it can lower the expectations on future interest rates, support other asset prices and boost the aggregate demand.

At the base of this tool there is the commitment (Bernanke & Reinhart, 2004). Nevertheless, commitment is a double-edge sword. On one side, if the Central Bank undertakes to a certain goal, markets participants are more likely to believe in the announcement and to change their expectations about the future. On the other side

it is very difficult to fix a rule which includes how to react in all the possible future scenarios. About this point, Eggertsson and Woodford (2003), suggested to have a constant communication with the public and anticipate the announcement of changes in advance. The communication, indeed, helps to reach more alignment between the policy expectations of the public and the plans of the Central Bank. Finally, whatever the method to enhance credibility is, it is necessary to remember that shaping policy expectations cannot be considered an independent policy instrument in the long run (Bernanke & Reinhart, 2004).

The change in balance sheet composition, also called qualitative easing, is another potential lever for monetary policy. It has been defined by Buiter (2008) as a "shift in the composition of the assets of the Central Bank towards less liquid and riskier assets, holding constant the size of the balance sheet". More precisely, when applying this kind of unconventional monetary policies, the Central Bank starts purchasing long term securities and selling the short term ones in order to determine a decline in long term interest rates that are more related to investment decisions (Kuroda, 2013). The variation of the balance sheet composition can be implemented in different ways: changing terms, collateral or counterparties (Bagus & Howden, 2009). The effectiveness of these measures is explained by imperfect substitutability of assets theory (Bernanke & Reinhart, 2004). In other words, if the risk or liquidity characteristics of assets differs, changes in the relative demand by the Central Bank have the potential of changing the relative security prices (through changing in term, risk and liquidity premia).

The alteration of the size of the Central Bank balance sheet, is the third possible tool of unconventional monetary policy. Through the purchase and sale of securities, the Central Bank is able to influence the overall supply of reserves and the money supply. For this kind of measures, Smaghi (2009) differentiate among direct quantitative easing and direct credit easing. Bernanke *et al.* (2004) defined quantitative easing, initially used to describe the measures undertaken by the bank of Japan between 2001 and 2006, as the increase in the size of the Central Bank's balance sheet over the necessary level in order to bring the short-term interest rate to zero. This operation is done by the Central Bank, through the expansion of reserves, buying securities which are mainly long-term government bonds (Spiegel, 2001). According to Ugai (2007), the quantitative easing is a policy with three main characteristics: i)

the supply of liquidity to a level that exceeds the required reserves; ii) the conditional commitment to maintain this high reserve level for a prolonged period of time; iii) and the increase of the purchase of government bonds to support the targeted reserve level. As indicated by Mishkin (2007), the purchase of this type of securities is preferred for two reasons. The first one is that sovereign yields serve as a benchmark for pricing riskier privately issued securities, while the second reason is that if long-term interest rates fall, it stimulates investments and hence the aggregate demand and consequently supporting the price stability. Banks play an important role in every quantitative easing programme because if, for example, Central Banks want to incentive loans to the private sector they will mainly purchase bonds from banks that can use the additional liquidity to give more credit to the real economy agents. Banks could decide to store this liquidity as reserves at the Central Bank but, when the rate on deposits is almost null, banks have no incentive to deposit their liquidity as reserves.

According to Mishkin (2007) The change in balance sheet composition can be carried out directly or indirectly, meaning that the Central Bank can directly purchase public and private securities from the market or acquire them as collaterals during transactions with financial institutions (such as the OMOs). In the latter case, the increase in the monetary base is determined endogenously by the banking system on the base of their liquidity demand and on the state of stress of the banking system (in case of a high level of stress banks will tend to have excesses of reserves at the Central Bank account, increasing the size of its balance sheet).

Quantitative easing is different from the conventional measure called credit easing which is described by Borio and Disyatat (2010) as a policy that focus on the asset side of the Central Bank's balance sheet to improve credit flows in specific markets (see also (Bernanke, 2009; Yellen, 2009). The term includes the extension of credit to private entities (banks and non-banks) but also the purchase of Treasury and government-sponsored enterprise debt. The effectiveness of this measure depends on the importance that the asset purchased have in the financing of households and firms which is different from country to country. Smaghi (2009) highlights some issues relative to this measure. First of all, the effect of purchasing privately issued securities presents no differences with the effect of purchasing government bonds regarding the money supply or the monetary base. Secondly,

buying privately issued securities imply that the Central Bank has direct contacts with the private sector, acquiring credit risk as a normal bank would do. This increases the risk profile of the Central Bank balance sheet. Moreover, these outright purchases need to be carefully planned to avoid allocative distortion among firm or regions (it is easy that big firms get advantages by the programme but it is harder to be sure that small and medium size companies get an equal treatment).

Although current literature is very interested in studying the effects of unconventional monetary policy, it is important to remember that they cannot be considered new: Ferguson *et al.* (2015) pointed out that they have been already adopted in the past by Central Banks . As reported by this study there have been several balance sheet expansions since 1900. For instance, the Bank of Japan registered a 33,5 percentage points increase of balance sheet relative to GDP in 1944 and a rise of around 30 percentage points since 1997 (Ferguson *et al.*, 2015). Moreover, as D'Amico and King (2012) showed, these unconventional measures cannot be considered new neither for their intents: they were considered normal during the 1960s and 1970s, when the preferred habitat theory was popular. In fact, during these years the FED experimented them increasing the holding of long-term government bonds through the Operation Twist. This kind of policies became unconventional only during the 1980s due to the diffusion of the expectation hypothesis which rejected their effectiveness from a theoretical point of view (D'Amico & King, 2012). Nevertheless, during the global financial crisis the unconventional monetary policies has been taken again in consideration in order to stimulate the economy when the ZLB became binding.

2.2 The transmission effects of the unconventional monetary policies.

The mechanisms through which unconventional measures affect the real economy have been the subject of many studies that have tried to identify them and explain how they work. Among them, Haldane *et al.* (2016) discussed the different mechanisms and the various frictions and distortions these mechanisms rely on. The channels identified are: the monetary policy signalling channel, the portfolio rebalancing channel, the liquidity effect channel, the exchange rate channel, the confidence/uncertainty channel and the bank lending channel. As it is possible to

notice, some of these channels are the standard ones, mentioned in the previous chapter, while others are more specific of unconventional measures.

The signalling channel is based on the set of all information that economic agents collect about the future path of monetary policy (Haldane *et al.*, 2016). It relies on agents having imperfect information, so, by providing a credible signal about the future path of nominal interest rates the unconventional monetary tools can influence consumption and investment decisions. Bauer and Rudebusch (2013) studied how, through this channel, Central Banks can directly affect the risk neutral component of interest rates: the announcements may signal to markets that the Central Bank has changed its views on the future economic conditions or that the policy function has changed as well as the policy objectives. In these cases, investors may alter their future investment strategies. As stated by Eggertsson and Woodford (2003) the management of expectations is the key of a successful monetary policy all the times. In facts, independently from the zero lower bound situation, the key element of this transmission channel is the expectations of the private sector with regard to future short-term interest rates. Short-term rates, indeed, can influence long-term equilibrium interest rates, exchange rates and the prices of other assets. According to Eggertsson and Woodford (2003) the signalling channel is effective only if there is a credible commitment by the Central Bank to keep the interest rate low, even after the economy recovers. The main problem connected to the analysis of this channel is that it is hard to find evidences about its existence due to the presence of random disturbances (Elbourne *et al.*, 2018).

The confidence/uncertainty channel is complementary to the signalling channel and it is described by Haldane *et al.* (2016) as the level of trust that the Central Bank transmits to the market through its announcement and actions. In other words, if the market participants judge the Central Bank as trustworthy, the level of uncertainty in the market will decrease as well as the market volatility and this, in turn, will generate an improvement of future market conditions.

The portfolio rebalancing channel bases on the imperfect substitutability of assets introduced by Tobin (1969). According to the theory, assets of different maturities are imperfect substitutes among each other both from the asset side and from the liability side. Given this assumption, the structure of rates depends upon relative supplies of assets. More precisely, an increase in the supply of an asset causes

its rate to rise relative to other asset rates. This creates limits to arbitrage (see also Brunner & Meltzer (1973) and McCallum (2000)). Subsequently, Bernanke *et al.* (2004) associated the imperfect substitutability principle to unconventional monetary tools explaining that an open-market purchase generates a rise in the amount of money relative to nonmoney assets in the public portfolio. As a result, attempts by the private sector to rebalance portfolios tend to drive up prices and bring down returns on non-monetary assets, when assets are imperfect substitutes. Higher assets prices and lower yields thereby stimulate the economy.

The liquidity effect channel is generated by the dysfunctionality of markets, such as the imperfect substitutability among assets, and by the presence of transaction costs (Haldane *et al.*, 2016). Jorgensen and Krishnamurthy (2011) explained that an unconventional asset purchase, that implies buying long-term securities and paying for them by increasing the deposits at the Central Bank, increases the amount of liquidity in the market. The reason is that reserve deposits are composed of more liquid assets (such as treasury bonds) than long-term securities. The increase of liquidity reduces the liquidity premia and increases trading of market assets. Jorgensen and Krishnamurthy (2011) also argue that the most important characteristic of this channel is that it generates a raise in treasury yields and, since Treasury bonds carry a high liquidity premium price during crises, it can reduce this liquidity premium and increase yields.

The exchange rate channel works in the same way as described by Mishkin (2015) for conventional monetary policy tools: in the short run, a monetary expansion induces a depreciation of domestic currency making domestic goods cheaper by comparison with foreign ones. This increases exports and decreases imports generating an increase in aggregate demand (see chapter 1).

The bank lending channel relies on the inability of some market participants to substitute bank loans. As explained by Bridges and Thomas (2012), an expansionary monetary policy increases the aggregate demand for bonds and equities with a consequent increase in asset prices. Since banks have a higher level of liquid assets than before, and also the value of these assets increases, the lending constrains decrease and banks are encouraged to lend more to the private sector than they would have done otherwise. As a result, more bank lending to household and firms should support higher level of consumption and investment (Benford *et al.*, 2009).

The fiscal channel was referred to by Bernanke *et al.* (2004) and it is based on the governments' substitution of seigniorage for direct taxes such as income taxes. A sufficiently large money injection decreases the interest rate level and can relieve the governments' budget constraints. This, in turn, allow governments to reduce taxation or to increase the government spending without changing public's holding of government debt.

The risk taking channel is a name first coined by Borio and Zhu (2012) to describe how monetary policy is able to affect the market participants decisions of increasing their risk exposure. These decisions crucially influence the financial decisions and consequently the real economy decisions. In particular, an expansionary monetary policy, decreasing the interest rates level, lowers the cost of funding for banks and other economic agents, thereby affecting their decision to be more risk-exposed. In this case, banks will be more willing to lend to the private sector and this raises the investment and consumption level (Bruno & Shin, 2015).

According to Haldane *et al.* (2016), all these channels rely on the presence of some friction in the market that the authors divided into two main groups: the information frictions which may arise due to the imperfect information of private agents regarding the future monetary policy reaction function and the future state of the economy; and market frictions caused by the imperfect substitutability among different classes of assets, by investors having a preferred habitat for bonds of a particular duration or credit risk or from limits to arbitrage between certain assets.

3. Monetary Responses to the Crisis: ECB and FED

"Different economies and financial structures require different crisis responses" (Gros *et al.,* 2012). This is an important starting point to understand why the events that followed the burst of the global financial crisis generated different reactions in the two sides of the Atlantic.

3.1. The Response of the ECB

As first reaction to the tensions in the market, the ECB used the conventional tools at its disposal. In August 2007, the Governing Council started a supplementary liquidity-providing longer term refinancing operation in order to fix the malfunctioning in the money market (ECB, 2007). In the following months the ECB undertook mainly liquidity provisions through the traditional operations (renewing and enlarging the amount of the existing Longer-Term Refinancing Operations), to support the normalization of the money market and steer the EONIA towards the targeted level. Moreover, after the uprising of elevated pressure in the short term funding market the ECB, with FED's collaboration, created a swap line in order to offer US dollar funding to the Eurosystem counterparties (ECB, 2007). In the beginning of 2008, the situation became tense and the ECB started to take more drastic measures.

After the collapse of Lehman Brothers, in September 2008, the inter-bank market froze causing a sharp decrease of interbank lending and an increase in liquidity demand. To face this situation, the Governing Council started a series of measures, subsequently referred to as "Enhanced Credit Support", providing unlimited credit to banks at a fixed rate (fixed rate full allotment) with an extended maturity and an enlarged range of assets eligible as collaterals. These measures aimed at restoring the normal functioning of the inter-bank market, which had been seriously damaged by the uncertainty about the creditworthiness among banks. The Enhanced credit support was composed by several main blocks (Pattipeilohy *et al.,* 2013):

i) an unlimited provision of liquidity through the two principal refinancing operations, the Longer-Term Refinancing Operations (LTROs) and the Main Refinancing Operations (MROs). The liquidity was supplied through "fixed rate tenders with full allotment", giving to banks an unlimited access to the

Central Bank liquidity at the main refinancing rate. The only restriction was the quality of the collaterals;

ii) an extension of the list of assets eligible as collaterals to facilitate credit provisions to banks (ECB, 2008). The ECB enlarged the collateral list through the admission of marketable debt instruments denominated in other currencies than the euro, certificates of deposits (CDs) and other debt instruments issued by credit institutions. Moreover, it also decreased the threshold for both marketable and non-marketable assets from A- to BBB-, except for Asset Backed Securities (ABSs);

iii) an increase in the list of eligible counterparties for refinancing operations;

iv) an extension of the maturity of LTROs to six months from March 2008 and, later, to twelve months, in May 2009;

v) the help to fulfil the reserve requirement on average during the maintenance period in order to avoid significant changes in the overnight rates in case of liquidity shocks. The ECB started assisting this front-loading process by offering more liquidity early in the maintenance period and less in the end, in order to allow banks to fulfil their reserve requirements early. The excess of liquidity was progressively reabsorbed through the Fine-tuning operations. In this way the net liquidity balance could remain at zero (Svendsen, 2014).

vi) a liquidity provision of foreign currency, mainly US dollars, through a swap line;

vii) the introduction of the first Covered Bond Purchase Programme (CBPP1) from July 2009. The CBPP1 aimed at improving the functioning of the transmission mechanisms, of supporting the financing conditions in the Euro Area, of facilitating the real economy credit provisions and generating positive spillovers to other markets. In this context the interest rate setting remained conductive for the setting of the monetary stance (González-Páramo, 2011).

In 2010, the sovereign crisis blew up due to the problems of uncertainty about the sustainability of the Greek public debt. The doubts quickly spread also to other European countries such as Ireland, Portugal, Italy and Spain worsening the already existing tensions in financial markets and increasing the malfunctioning in the transmission mechanism of monetary policy. The ECB had to reduce the difference in financing conditions faced by companies and households among the various countries of the Euro Area.

Therefore, on the 10th May 2010, the ECB introduced the Securities Market Programme (SMP) in order "to address the severe tensions" in certain market segments "by ensuring sufficient depth and liquidity" (ECB, 2010). The SMP consisted in the purchase of private and public debt and was implemented unconditionally, i.e. no targets in terms of volume to be purchased or performance levels to be achieved have been specified. Moreover, all the operations done within this programme were sterilized not to affect the monetary stance which was still driven by the key policy interest rates (Manganelli, 2012) and did not affected the size of the Central Bank balance sheet.

On October 2011 the Governing Council announced also the second Covered Bond Purchase Programme (CBPP2) to face the still existing tensions in the bond market. In addition, it also reintroduced the swap line in collaboration with the FED. By December of 2011 key policy rates were reduced: Main Refinancing Operations rate was at 1%, the Main lending facility rate was at 1.75% and the Main Deposit facility rate was at 0.25%. Additionally, the Governing Council decided to conduct two Longer Term Refinancing operations with a maturity of 36 months (Very Longer-Term Refinancing Operations) with the possibility of repaying earlier after one year. At the same time, also the list of collaterals eligible for these transactions was enlarged and the reserve ratio was "temporary" reduced from 2 to 1 percent (Pattipeilohy *et al.*, 2013).

In spite of these efforts the ECB was still facing the possibility of a credit crunch and the risk of deflation (Hartmann & Smets, 2018). At the beginning of July 2012, the key policy interest rates, already low, were further reduced to 0.25% for the main refinancing operations, to 1.50% for the marginal lending facilities and to 0.00% for the deposit facilities. When the interest rates are close to the ZLB, they are no longer effective to transmit the monetary stimulus, so the Central Bank had to introduce unconventional measures. This moment represents a real turning point in the ECB's monetary policy because measures had never before been used in the Eurosystem.

Therefore, the ECB initially used a series of announcement to ensure that the monetary policy would have remained accommodative for an extended period of time. on the 26th of July 2012 the president Mario Draghi did the famous "whatever it takes" speech in London in order to calm the market strains (Bernoth *et al.*, 2016). Subsequently, on the 2nd of August 2012 the Governing Council announced its intention to introduce the Outright Monetary Transactions (OMTs) to purchase sovereign bonds in the secondary market. This measure was intended to contrast the uprising fears in the bond market. These fears were,

indeed, affecting the expectations about banks' health conditions: lending among banks in the inter-bank market is usually done using sovereign debt as collaterals and the decline in the valuation of portfolio government bonds leads to a deterioration of banks' balance sheet. Consequently, these tensions were altering the stability of banks to provide credit to the real economy. A necessary condition for the implementation of the OMTs was its strict conditionality to the European Financial Stability Facility/European Stability Mechanism (EFSF/ESM) programme which imposed macroeconomic adjustments and precautionary programmes specific for each country. Moreover, the OMT targeted the short-term segment of the yield curve, and treasuries with maturities between one and three years (the ones most affected by tensions). Even if this programme was never implemented, it generated a very positive impact in lowering the yields of the treasury bonds of the most peripheral countries of the Euro zone and thereby of Germany and France (Fernandes & Mota, 2014).

In May 2013 the key policy interest rates were set almost at zero: the main refinancing operation rate was set at 0.50%, the marginal lending facility rate was at 1.00% and the deposit facility rate reached the 0.00%. In order to stimulate the market, the ECB used for the first time an explicit forward guidance when, on July 2013, the Governing Council announced that the key policy interest rates would have remained stable for "a prolonged period of time".

In June 2014 the ECB set for the first time negative interest rates (the deposit facility rate decreased to -0.10%) and introduced the Targeted Longer Term Refinancing Operations (TLTROs) to support bank lending to the real economy. In this occasion the ECB provided financing to credit institutions for periods up to four years at a very attractive conditions to ease the private sector credit conditions. In September 2014 the interest rates were reduced again by the Governing Council at 0.05%, the marginal lending facility rate was at 0.30% and the deposit facility rate reached the -0.20%.

In October 2014 the ECB also introduced liquidity provisions though the Asset Purchase Programme (APP) which involved the purchase of private and public sector securities to exert downward pressure on the term structure of interest rates, strengthening the transmission mechanism of monetary policy, facilitating the provision of credit to the real economy, loosening constraints on indebtedness for real economy agents and contributing to a sustained adjustment of the inflation rate over the medium to long term.

In January 2015 the Governing Council announced an enlargement of the APP (Expanded APP) which started in March 2015 growing to comprise four different measures:

i) the third Covered Bond Purchase Programme (CBPP3), launched in September 2014; ii) the Asset Backed Securities Programme (ABSPP), also launched in September 2014; iii) the Public Sector Purchase Programme (PSPP) started in March 2015; and iv) the Corporate Sector Purchase Programme (CSPP) introduced in April 2016. The Expanded APP born as an open-ended programme (it should have lasted at least until September 2016) and had the scope of increase the price stability in the Euro zone. With these large scale purchases it is possible to say that the ECB adopted the quantitative easing approach, as other banks were already doing (Gambetti & Musso, 2017).

The programme was, then, subsequently adjusted and recalibrated in the following years. In December 2015 the ECB decided to prolongate the programme at least until March 2017 and at the same time lowered the deposit facility rate at -0.3%. Moreover, in March 2016 the ECB, in order to pursue its objectives of financial stability and to reconduct the inflation lower but close to 2% started another series of operations (ECB, 2016):

i) the main refinancing operation rate was decreased to 0.00% as well as the marginal lending facility rate and the deposit facility rate that reached respectively 0.25% and -0.40%;
ii) the amount of monthly issued securities was enlarged as well as the list of the asset eligible for regular operations starting to include investment grade Euro-denominated bond issued by non-bank corporations (CSPP);
iii) Four new Targeted Long-Term Refinancing Operations (TLTRO II) with maturity of four years conducted at a rate equal to the present deposit facility rate.

In April 2017 the APP was prolonged until December 2017, but the improving economic conditions boosted the debate regarding a possible ending of the programme (Speciale, 2017). Consequently, in the following October the Governing Council announced the intention of halving the amount of purchase from the beginning of January 2018 and continue the purchase until September 2018, even beyond if necessary (ECB, 2017). They also announced the reinvestment of the of the maturing debt from the APP, for a prolonged period of time after the end of the net purchases.

In June 2018, after the positive projection about the recovering of the Eurosystem, the Governing Council announced the procedure of phasing out from unconventional monetary policies: after September 2018 the amount purchased should have been halved again until December 2018, when the programme should have ended (ECB, 2018b). Moreover, the

ECB would have continued reinvesting the maturing debt over 2019 and until necessary and would have maintained the policy interest rates at low levels at least "through summer 2019". In December 2018 the Governing Council announced the resolution of the APP by the end of the same month, confirmed its decision of continuing to reinvest the principal payments from maturing securities purchased and to keep the policy interest rates low, until the complete economic recovery (ECB, 2018c).

In March 2019 the Governing Council announced of a new round of quarterly Targeted Longer-Term Refinancing Operations (TLTRO-III) from September 2019 to March 2021, in order to preserve good lending conditions for the banking system and to facilitate the correct functioning of the transmission channels (ECB, 2019c).

In July 2019, since the medium term inflation was consistently below the levels expected, the Governing council announced the possibility of reintroducing the unconventional instruments, such as a further cut in interest rates or a new APP, if needed (ECB, 2019b).

In September 2019 some important changes were made (ECB, 2019a):

i) The interest rate on deposit facilities was reduced to -0.50, while the main refinancing operation rate and the marginal lending facility rate stayed unchanged.

ii) The Governing Council announced the restart of the APP from the 1st of November 2019. This programme is meant to last until it is necessary and to finish shortly before the increase of interest rates.

iii) The condition for the TLTRO-III were changed in order to improve the lending conditions for banks. In addition, the maturity of the operations was extended from two to three years.

iv) A "two-tier system" for reserve remuneration was announced. This measure is intended to support the bank-based transmission mechanisms of monetary policy ensuring the exemption from the negative deposit facility rate of part of the excess of liquidity held by banks.

All these programmes are still ongoing.

3.2 The Response of the FED

The FED reacted to the tensions registered in the financial markets in the second half of 2007 with the decision of decreasing the key policy interest rates. Between

September 2007 and June 2008 the FED steadily reduced the level of interest rates to counteract the shutdown of the financial market (Cecchetti, 2008). At the same time, the US Central Bank broadened the set of counterparties for liquidity operations and opened a series of swap facilities with other Central Banks to provide dollars to foreign markets. Furthermore, as the domestic interbank market was frozen, the FED provided liquidity to banks at an interest rate and amount determined by a single price auction (Term Auction Facility, TAF). Unlike open market operations, this mechanism made it possible to inject liquidity to a wider variety of counterparties and against a wider selection of collaterals (Fed, 2009).

Although, the situation was still getting worse, the threat of the rising inflation, induced a pause in the process of rate cuts (Gros *et al.*, 2012). In fact, between June and September 2008 the FED decided to hold its policy rates at 2%. Nevertheless, the sudden precipitation of the economic condition in the following months induced the FED to continue to decrease the interest rate level (Gros *et al.*, 2012).

In March 2008 the FOMC announced the Term Securities Lending Facility and created the Primary Dealer Lending Facility (PDLF). The former measure consists in a lending programme with 28 days maturity and enlarged list of collateral admissible for the transactions (AAA and Aaa rated MBS). The latter measure consisted in the authorization of the 19 primary dealers for open market operations to borrow directly from the FED, pledging a large list of collaterals including investment-grade corporate securities, MBS and ABS. The direct lending to primary dealers had two main purposes: to ensure short-term funding for investment banks and to reduce spreads between the ABS improving their liquidity in financial markets (Cecchetti, 2008).

In October 2008 the FED convinced the congress to pass the Trouble Asset Relief Programme with the purpose of increasing the liquidity of the money market and secondary mortgages markets by purchasing the Mortgage Backed Securities and, thereby, reducing the risk of losses of the agents holding them (CBO, 2012). It also allowed the surviving of Goldman Sachs and Morgan Stanley which were reclassified as bank holding companies for regulatory purposes which guaranteed them the access to cheap overnight lending. The idea behind these decisions was to lend money at very low rate to every financial institution to avoid bankruptcies (CBO, 2012).

By mid-December 2008 the interest rates were close to zero and ZLB became binding (interest rates could not be reduced further). Moreover, since borrowing from

the discount window can be interpreted as a signal of alert about the soundness of the bank, the low interest rates were ineffective to stimulate the market. To face this situation, FED had to introduce new unconventional measures. Aiming to encourage more borrowing, the FED set up the Term Auction Facilities (TAFs) to lend at a rate determined through competitive auctions (FED, 2017).

In November 2008 the FED announced the first Large Scale Asset Purchases (LSAPs), also called Quantitative Easing 1 (QE1), started in December 2008. Initially the programme aimed to purchase just the debt issued by the government-sponsored enterprises, Fannie Mae and Freddie Mac, and agencies-backed mortgage backed securities with the objective of increasing the availability of credit for the purchase of houses. Nevertheless, in March 2009 the FOMC announced an expansion of the amount purchased including also longer term Treasury securities to improve conditions in the private credit market (Kuttner, 2018).These measures aimed at stimulating the mortgage backed securities market at lower rates on residential mortgages to incentive the house market (Engen *et al.*, 2015). In the late 2008 the FED also started using the forward guidance to signal the future federal funds rates levels.

In November 2010 the FED launched the Quantitative Easing 2 (QE2), purchasing long-term securities to lower long-term interest rates and consequently affect the yield curve. This second programme aimed at stimulating investment spending.

The Maturity Extension Programme (MEP) was announced in September 2011. It initially involved the purchase of 6- to 30-years Treasuries and the sales of the same quantity of 1- to 3-years "to put downward pressure on long-term interest rate and help make broader financial conditions more accommodative" (FED, 2011). The difference between this programme and the other LSAPs is that this one was fully sterilized.

Finally, in September 2012 the FED implemented the Quantitative Easing 3 (QE3) which consisted in the purchase of MBSs and long-term Treasuries. These last purchases were meant to be open-ended until the economic situation and, in particular the job market, would have improved and unemployment would have been reduced. It lasted until the end of 2014.

All the already mentioned policies were combined with constant announcement about the future path of monetary policy (forward guidance) ensuring that the interest

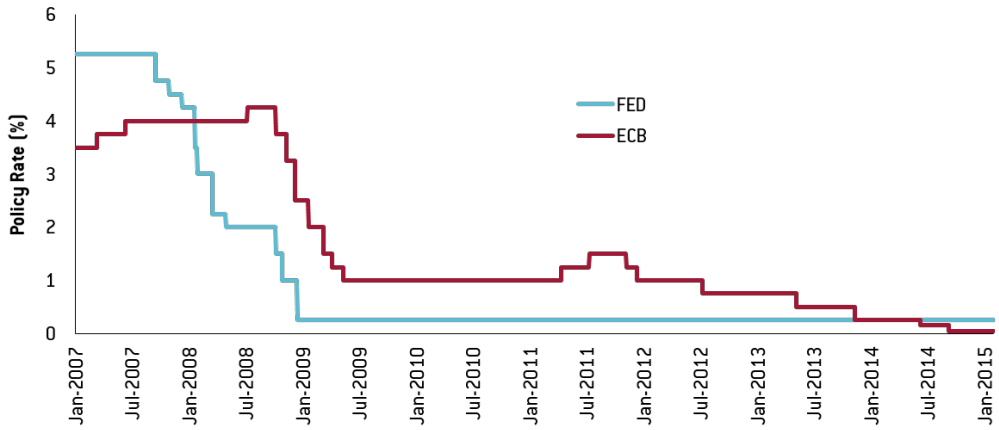
rates would have remained low for a prolonged period of time. In particular, while at the beginning of the crisis period forward guidance was mainly qualitative and vague, starting from the FOMC announcement of the 12th of December 2012 it became more explicit mentioning the specific targets the Central Bank wanted to reach before changing its policies (Kuttner, 2018).

All the unconventional measures started to be unwound by the beginning of 2015.

3.3 A Comparison between FED and ECB

As we can see, since 2007 the kind of policies adopted by ECB and FED are quite different for promptness and scale of interventions. What is possible to notice is that the FED was generally more reactive than ECB. This evidence emerges by comparing the movements in the key policy interest rates: FED decreased the interest rates more rapidly than ECB (see figure 1). When the housing market collapsed the US Central Bank started to aggressively cut the federal funds rate level, while the ECB acted more gradually in order to maintain price stability (ECB's objective).

Figure 1. Interest rate settings by ECB and FED during the global financial crisis



Source: http://bruegel.org/2016/01/the-ecb-and-the-fed-a-comparative-narrative/

Consequently, the US rate reached the ZLB earlier than the ECB and since 2009 started using forward guidance to stimulate the markets. On the other side the ECB started to use this tool only in the second half of 2013.

Moreover, looking at the kind of measures adopted by the two Central Bank we can say that, in the early phase of the crisis, the FED used mainly quantitative easing programme, directly buying MBSs and Treasury securities, while the ECB mainly adopted credit easing tools to provide liquidity to bank. The reason behind this different behaviour of the ECB can be explained in two ways (Degli Antoni & Zanotti, 2014). First of all, the Maastricht Treaty forbid to the ECB to directly purchase the Treasuries of member states countries, so it can only operate in the secondary market. While reason is related to the importance that bank credit has in the Euro zone for the transmission of the monetary stance to the real economy.

4. The Effects of the Unconventional Monetary Policy

The unconventional monetary policy is a hot topic and the literature has deeply analysed the effects of these policies from different points of view. Since our focus is on the impact of unconventional monetary policy in the Euro area, in section 4.1, we analyse the most common methods to measure the stance of monetary policy. Moreover, in section 4.2, we give an overview of the main effects of the ECB monetary policy. Finally, section 4.3 describes the main conclusions on the effects of monetary policy on government bond yields in times of crisis.

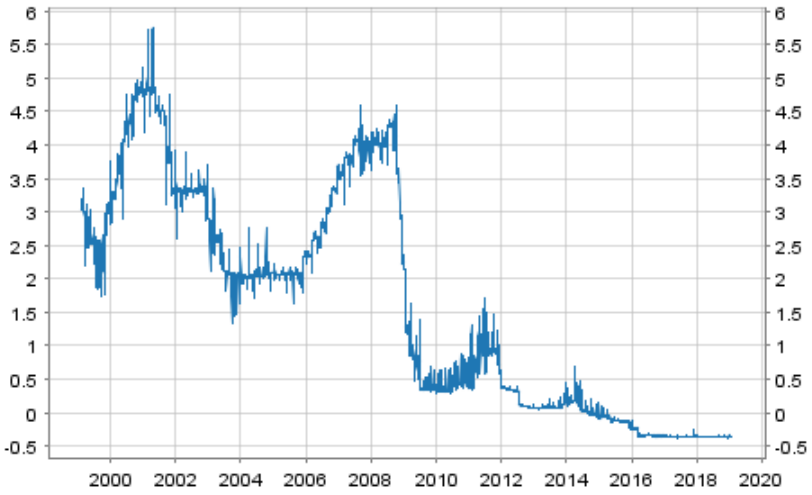
4.1. Methods to Analyse the Stance of Monetary Policy

Since the beginning of the financial crisis, the literature focused on the effectiveness of unconventional policies to achieve the results of boosting the economy and restore the functioning of the transmission channels that were altered due to the financial stress (see chapter 2). However, the analysis is hindered by different identification issues highlighted by Kozicki, *et al.* (2011). The first one is related to the simultaneous implementation of the unconventional measures by different Central Banks that makes difficult to isolate one measure from spillovers. The second problem is connected to the existing lags between the financial developments, macroeconomic activity and inflation. In crisis periods the challenge is even harder considering that the majority of the impact is transmitted through the announcements than through the other direct channels. The third issue identified is that, since the monetary policy is implemented together with the fiscal policy, the same policy can have different effects on the macroeconomic variables depending on the different measures implemented by governments. In addition, the rapid response of expectations and trust to policy announcements can create rapid reactions in asset prices which can be seen as evidence of the effectiveness of the policy but can also create a misleading effect when credit conditions are sufficiently tight. Finally, it is important to consider that countries that have undertaken unconventional policies have been the hardest hit by the crisis. The measurement of effectiveness can be influenced by imbalances in their financial markets.

Plenty of studies tried to face these problems with different approaches. We can classify the studies that try to assess the effectiveness of the unconventional monetary policies by the methodology used. The most common method to measure monetary policy is the time series of the short-term interbank interest rate (EONIA). As pointed out by

Elbourne *et al.* (2018) although this instrument can be very reliable in normal times, it is not very accurate when approaching ZLB. As a matter of fact, the figure below displays that the EONIA has barely changed since 2009 because, being between the marginal lending facility rate and the deposit facility rate, it is subject to zero lower bound as well.

Figure 2 EONIA (1999-2019)



Weighted rate for the overnight maturity, calculated by collecting data on unsecured overnight lending in the euro area provided by banks belonging to the EONIA panel. From dataset: EON: EONIA: Euro Interbank Offered Rate.
Source: https://sdw.ecb.europa.eu/quickview.do?SERIES_KEY=198.EON.D.EONIA_TO.RATE

Some authors tried to figure this problem out using various approaches. One solution is to use the changes in the balance sheet size of the Central Bank as a direct measure of the stance of monetary policy *(i.e.* Bernoth *et al.* (2016); (Boeckx *et al.*, 2014; Gambacorta *et al.*, 2012; Haldane *et al.*, 2016; Pattipeilohy *et al.*, 2013). The problem related to the studies that analyse the balance sheet as a proxy of the stance of monetary policy is that when the structure of changes in the balance sheet becomes predictable the policy does not cause shocks anymore and economic agents starts to adapt before and gradually in a way that the effects are not identifiable anymore (Hansen *et al.*, 1991). A solution to this bias is to use event studies, that focus on the analysis of a single monetary policy measure but are less suited to capture persistent effects (Haldane *et al.,* 2016).

Shadow rates are an alternative approach to assess the stance of unconventional monetary policy. This instrument is a synthetic indicator that emulates the policy interest rate in normal times and it is able capture information about the monetary policy stance when the ZLB is binding and non-interest rate policies are undertaken (Lombardi & Zhu, 2014).

Initially, they were introduced by Fischer (1995) through its Shadow Rate Term Structure Model (SRTSM) but as pointed out by Kim and Singleton (2012) this tool was model specific and, therefore, is not suitable to work otherwise. The following literature tried to overcome this issue, creating shadow rates that are suitable to be applied directly in models containing discrete-time data and at the same time give a reliable approximation of the monetary policy rates (Wu & Xia, 2016). One of the main properties of this methodology is that the shadow rate can capture the effects of monetary policy on current economic conditions and the market expectations about the future policy actions (Mouabbi & Sahuc, 2019).

Several authors tried to estimate the shadow interest rate through different models (Bauer & Rudebusch, 2013). Nevertheless, the common dynamics among the different shadow rates point to the same conclusions even though the model choices influence the level of shadow rates. Among the authors, Krippner (2012) and Krippner (2013b) proposed an approximation of instantaneous forward rates in continuous time, Lombardi and Zhu (2014) create a shadow interest rate based on the dynamic factor modelling and Wu and Xia (2016) created an approximation of the shadow rate using an analytical approximation of the forward rate and applied it to discrete time data to calculate the effects of the US monetary policy actions. The shadow interest rates of Krippner (2011-2015) are different since they have more constrains than the ones estimated by Wu and Xia and therefore, they are more robust and able to better represent the a priori beliefs about the future relevant monetary policy actions (Damjanović & Masten, 2016). We chose these shadow rates due to their efficacy but also due to their availability over the time period considered. Furthermore, choosing shadow rates to assess the effects of unconventional monetary policy on Portuguese 10-year government bonds yields is a novelty element of this dissertation. Many authors have used shadow rates to study the effects of unconventional monetary policies on key economic variables such as output growth, inflation and asset prices. Among them we can find Claus and Krippner (2014), Halberstadt and Krippner (2016) and Damjanović and Masten (2016) for the Euro-area, Lombardi and Zhu (2014) and Wu and Xia (2016) for the US. However, in our literature review we have not found any author who has used the European Shadow Short Rates to analyse the effects on eurozone government bond yields.

4.2 The Effects of ECB Responses to the Crisis: an Overview

Looking at the effect of the ECB's responses to the crisis, on output at the aggregate Euro-area level, many authors found them effective. The authors that analyse the effect of

the conventional measures undertook at the beginning of the financial crisis (from 2007 to 2013) show positive results: Gambacorta *et al.* (2012) found out that an increase of balance sheet of 3% leads to an increase of output by between 6 and 15 basis points (bps). However, Boeckx *et al.* (2014) demonstrated how these positive effects on real GDP are short-lived, peaking after one year but then slowly returning to the previous value. All the results of the studies suggest that the initial measures implemented by the ECB were quantitatively similar to monetary response in normal times (Boeckx *et al.*, 2014). Subsequent studies, analysed the effect of the single policies implemented: for instance Altavilla *et al.* (2014) analysed the effect of the OMT announcements comparing a "policy" and "non-policy" scenario and finding positive effects on the main macroeconomic variables.

Focusing on unconventional measures, Haldane *et al.* (2016) using four different identification schemes, found that the APP had positive effects on the main macroeconomic variables. However, they also argue that the declared purpose of a policy measure and the method of execution, matter more than the balance sheet expansion itself. Later studies, such as Elbourne *et al.* (2018) and Mouabbi and Sahuc (2019), confirmed the positive and significant effects of the measures implemented by the ECB stating that, without them, there would have been a substantial output loss. Nevertheless, some different results appear from cross-country analysis (Burriel, 2016). The unconventional monetary policies had different effects among the euro-area countries due to their heterogeneity. As a result of these policies, the Baltic countries displayed the highest increase of output whereas the effects were very small or not statistically significant in the countries most affected by the crisis such as Portugal, Greece and Spain (Burriel, 2016).

The results on inflation are very similar to those of output, with overall positive effects. On one side, Burriel (2016) demonstrated that reducing the shadow rate by 25 bps generates an rise of inflation by 10 bps. These effects tend to increase over the medium term (Gambetti & Musso, 2017). On the other side, there are various authors that found the effects not statistically significant (Altavilla *et al.*, 2014; Boeckx *et al.*, 2014; Elbourne *et al.*, 2018). The unconventional measures influenced also the neighbouring countries (Czech Republic, Denmark, Hungary, Poland, Sweden and the UK): while conventional instruments affected output and inflation in a similar way in both euro and non-euro countries, non-conventional instruments had a slow and limited effect on the real economy, leaving inflation unchanged (Kucharčuková *et al.*, 2016).

The effects of unconventional measures were not just limited to output and inflation but affected also banks and corporate profitability as well as the public sector (public debt and expenditure). According to Hachula *et al.* (2016) the unconventional monetary shocks were effective in rising the primary expenditures mainly due to a rise in public consumption. However, these effects were very different among member countries because of the different responses of fiscal authorities and widened the intra-euro trade balances. As a consequence, crisis-hit countries lost price competitiveness against Germany (Hachula *et al.,* 2016).

Studies such as Wieladek and Garcia Pascual (2016) and Altavilla *et al.* (2015) found that the measures undertook by the ECB increased the price of public and private assets with three main consequences for banks: i) the higher their exposure to sovereign bonds, the higher the prices of bank stocks have risen; ii) stock prices increased more, the larger the increase in their country's overall stock price index; iii) however, for a given exposure to government bonds, banks located in the Euro area experienced a smaller increase in stock prices. In addition, the increase in bank share prices is lower, the greater the decline in the sovereign yield of the country in which the bank is situated (Andrade, 2016). At the opposite, Lenza *et al.* (2010) and Koijen, *et al.* (2018) showed how the overall impact on banks profitability was positive.

The effects of monetary policy measures have been studied also through the analysis of the yield curve. The majority of the papers taken into consideration in our literature review, found that the ECB unconventional policies were effective in decreasing the yields of government bonds (see table 1 and section 4.3).

4.3 The Effects Monetary Policy Responses to the Crisis on the Government Bond Yields

In paragraph 4.2, we discussed how unconventional monetary policies had positive effects on the main macroeconomic variables. In this paragraph, we decided to focus on the literature that addressed the same question we decided to investigate in this dissertation: the effects of monetary policies on government bond yields. In doing so, we compared several studies mainly concerning the euro area but also the US, UK and Japan. A first conclusion we came to is that monetary policies have been effective in decreasing yields on government bonds of all maturities. By focusing on the effects of ECB policies we can make an initial distinction between the studies we have considered. As already discussed in chapter 2, there

is a divergence of opinion between authors who consider all monetary policies implemented by the ECB in response to the economic crisis as unconventional and authors who consider only quantitative easing and forward guidance measures as unconventional. Therefore, for the sake of completeness of our discussion, we have decided to include the results of both groups.

It is also important to note that the studies considered in this dissertation differ from each other in a number of factors such as the time period, the sample of countries, the methodology and the maturity of the government bonds analysed. For this reason, the results presented are not directly comparable but give us a general idea of the effects of unconventional monetary policies (see Table A1- Appendix A).

Among the authors who covered the phase of conventional monetary policies in response to the crisis, Pattipeilohy *et al.* (2013) found that the LTRO generates a moderate and temporary reduction of 10-year government bonds in Italy and Portugal (respectively of -50 bps and -150 bps) and a larger reduction in Greek 10-year government bonds (-400 bps). The results are more pronounced in the case of shorter maturities. In line with the previous results, Krishnamurthy *et al.* (2017) studied the effects of LTROs, SMP and OMT across countries dividing them into two groups: the weaker countries, also called GIIPS (Greece, Italy, Ireland, Portugal and Spain) and the others. Their results show that there were strong effects in the GIIPS countries but not significant results in the others: - 200 bps for Italy and Spain, -500 bps for Portugal and Ireland and -1000 bps for Greece. This sharp decrease in yields can be attributed to a fall in the risk of default (37% of the total reduction) , in the redenomination risk (13% of the total reduction) and in lack of liquidity in distressed markets (50% of the total reduction). Altavilla *et al.* (2014) evidenced how the OMT announcements have been more effective in decreasing the yields in more stressed countries compared to the core ones. According to them, the different level of liquidity between sovereign markets and the non-linearity of the changes in yields produces a segmented and heterogeneous environment in the euro area.

Note that, in the aforementioned studies, the effects of monetary policies are particularly pronounced in Greece. Zettelmeyer *et al.* (2013) focused on the effects on Greek government bonds and provided several explanations for such a large impact: i) the ECB's purchases of government bonds through the SMP programme may have made these assets more reliable in the investors' eyes; ii) by purchasing large amounts of government bonds in a stressed market, the ECB may have lowered the cost of finding a buyer and, consequently,

the liquidity premia associated to these securities; iii) through the portfolio rebalancing channel (see chapter 2).

Focusing on studies that have investigated unconventional policies such as the APP and forward guidance in the Euro area, the effects of these measures are less intense (varying from -13 bps (Koijen et al., 2018) to -69 bps (De Santis, 2016)) and had a greater effect during the announcement period than at the time of implementation (see Andrade, 2016; and De Santis, 2016). As for conventional measures, Altavilla *et al.* (2015) and Varghese and Zhang (2018) showed the APP have lowered sovereign bond yields and that the effects are more pronounced in highly stressed countries. The decrease is larger for countries with lower GDP per capita, and higher sovereign risk (Koijen *et al.*, 2018). Moreover, the magnitude of the effects rises with the maturity of the bond because longer maturities are more affected by market expectations and because the ECB targeted bonds with relative lower prices to affect their yields (Andrade, 2016).

As De Santis (2016) pointed out, the effects generated by the APP are not very dissimilar from the one estimated for the QE in other countries even if the APP was launched during relatively calm financial condition. Markets have probably used the experience of other Central Banks to anticipate the potential impact of the APP programme.

The effects of the QE in UK, US and Japan have very similar results to the ones previously mentioned. As for the APP, the other QE programmes led to a substantial reduction in government bond yields with higher impact on longer maturities (Christensen & Rudebusch, 2012; D'Amico & King, 2012; Ueda, 2012). In particular, Joyce and Tong (2012) found that the success of the QE was associated with expectations on higher demand and inflation. In addition, the effects of the second round of QE were weaker due to the improve in liquidity and market functioning and due to the learning by experience of the market participants. Christensen and Rudebusch (2012) compared the effects of the BoE QE to the ones generated by the LSAP in US finding influences of FED's decisions on UK markets. Furthermore, while in UK the reduction in yields is mainly caused by the term premium component, in the US the expectation component had a key role in lowering the yields. The difference depends on the different level of communication (stronger forward guidance in US) and on the different market structure (US government bond market is considered more liquid than the UK market).

5. The Effects of the Unconventional Monetary Policy on 10-year Government Bond Yields

As aforementioned in the previous chapter, our literature review shows that unconventional monetary policies have been effective in lowering government bond yields not only in Europe, but also globally. We have mentioned how the world's major Central Banks (ECB, FED, BoE and BoJ) have implemented unconventional monetary policies which, among other things, affected on government bond yields, by lowering them in different amounts in regard with the country concerned.

Similarly, our research attempts to assess the effects of ECB policies on 10-year government bond yields in Portugal. We chose this country for multiple reasons: first of all, Portugal is one of the so called GIIPS (Greece, Italy, Ireland, Portugal and Spain) countries, which are the ones most affected by the crisis and the main recipients of the unconventional measures (Jorgensen & Krishnamurthy, 2011). Secondly, there is plenty of literature about unconventional monetary policy effects that include Portugal in panel data analysis (see *e.g.* Banco de Portugal, 2015; Eser & Schwaab, 2016; Jorgensen & Krishnamurthy, 2011; Koijen *et al.*, 2018; Pattipeilohy *et al.*, 2013) but we did not find any relevant study that focuses on Portugal alone. In contrast to this trend, we have preferred to perform an econometric analysis focused on a single country. The reason is that this type of analysis include country-specific economic factors, which are omitted in the case of panel data estimation (Pinho & Barradas, 2018b; Poghosyan, 2014).

Moreover, following Ehrmann and Fratzscher (2017) we decided to focus on the effect on unconventional monetary policies on 10-year government bond yields because of their high level of liquidity in the market and because it is the most common maturity length considered in the related literature.

5.1 The empirical model

To study the effects of unconventional monetary policies on Portuguese 10-year government bond yields, we have built an *ad hoc* specification. In doing so, we have taken inspiration from the models discussed in our literature review. As a starting point, we used

the Akram and Das (2017) model, which evaluates the effects of ECB short-term interest rates on government bond yields in the Eurozone.

Our specification differentiates from their analysis for various factors. The most essential is the purpose: our paper aims to investigate the effects of the ECB's unconventional measures on government bond yields, which is why we have replaced Central Bank policy short rates with Krippner (2013a) shadow interest rates. The latter are considered an effective measure of the stance of monetary policy and are suitable for different types of models (Wu & Xia, 2016). Another difference with the Akram and Das (2017) model is the number of control variables we used. Following Kontonikas *et al.* (2012), in Equation (1),we have taken into account the main drivers of government bond yield by including not only economic growth, inflation rate and fiscal variables but also global risk aversion. We then specify a second version of our specification in which we also intend to investigate the influence of the FED's monetary policy on Portuguese government bond yields. Therefore, in Equation (2) we added the FED's shadow rates as in Varghese and Zhang (2018) and Lombardi and Zhu (2014).

$$GB10_t = \beta_0 + \beta_1 GDP_t + \beta_2 INFL_t + \beta_3 DEBT_t + \beta_4 DEBT^2_t + \beta_5 CA_t + \beta_6 VIX_t + \beta_7 SR\_EU_t + \mu_t \quad (1)$$

$$GB10_t = \beta_0 + \beta_1 GDP + \beta_2 INFL_t + \beta_3 DEBT_t + \beta_4 DEBT^2_t + \beta_5 CA_t + \beta_6 VIX_t + \beta_7 SR\_US_t + \beta_8 SR\_EU_t + \mu_t \quad (2)$$

As previously mentioned, the dependent variable, $GB10_t$, is the Portuguese 10-year government bond yields and it is expressed as function of the Eurozone shadow interest rates (SR_EU_t) and other control variabels (see the summary of data and labels in Table A2-Annex).

The GDP_t variable represents the macroeconomic situation of the country. We used the GDP growth rate expressed in year-over-year percentage change. A growing country has a higher probability of being able to repay its debt over time and thereby the interest rates on government bonds tend to fall (Poghosyan, 2014). So the sign of the coefficient β_1 is expected to be negative.

Along with output, another variable that is widely considered a key determinant of government bond yields is inflation, $INFL_t$. For this variable we used the Harmonized Consumers Price Index (HICP) calculated in year-over-year percentage change. The rate of inflation is positively related to yields through Fisher's equation. Moreover, in the Neo-

Keynesian view, an increase in inflation induces policy makers to increase interest rates in the short term that also determines a raise in interest rates in the long term (Laubach, 2009; Banco de Portugal, 2015).

The $DEBT_t$ is the government consolidated gross debt as a percentage of the nominal Gross Domestic Product (GDP). Since a higher level of public debt should correspond to a higher risk of default, to higher default risk premium required by market agents and thereby to higher yields (Banco de Portugal, 2015). Moreover, assuming that the Ricardian equivalence does not subsist, a fiscal expansion can induce the crowding out of private investors and lead to a new equilibrium with a lower level of capital. The scarcity of capital causes an increase in the marginal cost of capital, which is the real interest rate that causes a rise in government bond yields (Engen & Hubbard, 2004). Then, following De Santis (2016) and Kontonikas et al. (2012), we also added the government's consolidated gross debt squared, $DEBT^2_t$, to capture the possible non-linear effects of debt on goverment bond yields, and, as for $DEBT_t$, the expected sign is positive.

Our specification also contains the current account balance as a percentage of GDP, CA_t. This variable has been included to represent the competitiveness of the country in relation to foreign countries. A current account with a positive sign indicates that the country is a net exporter while a current account with a negative sign indicates that the country is a net importer. Consequently, as the current account increases, the risk of insolvency and the default risk premium required by the market decreases, thereby reducing government bond yields (Mota *et al.,* 2015).

Since the period covered by our study is characterized by the crisis and therefore by a high level of uncertainty, we considered it necessary to include a variable representing the global risk aversion. Therefore, following Eser and Schwaab (2016) we introduced the Chicago Board Options Exchange's Market Volatility Index, VIX_t. The VIX is called "the investors' fear gauge" as it jumps up at times of greatest instability (Whaley, 2000). We expect that as the degree of market volatility increases, so does the risk aversion of market agents as well as the risk default premia and thus Portuguese government bond yields.

To quantify the effects of the ECB measures in reaction to the crisis, we introduced in our specification the ECB Shadow Interest Rates, SR_EU_t. As we have previously mentioned in chapter 4, shadow rates are interest rates that correspond to policy short term

interest rates above the ZLB but are also able to go below the zero level when unconventional tools are undertaken. This make shadow interest rates extremely versitile and suitable for different types of estimation (Wu & Xia, 2016). In this study we used the Shadow rates for the Euro area estimated according to Krippner (2011-2015) shadow/lower bound framework with two factors (Reserve Bank of New Zealand, 2020). The implementation of unconventional monetary policy measures at Zero Lower Bound corresponds to a decrease in shadow interest rates, hence, according to Claus, Claus, and Krippner (2014), we expect a positive relation with yields.

In the equation (2) we also chose to investigate the influence of FED monetary policy on Portuguese government bond yields, SR_US_t. Following Varghese and Zhang (2018) and Lombardi and Zhu (2014), we have therefore used the shadow interest rates for the US estimated by Krippner (2011-2015) shadow/lower bound framework with two factors as a proxy for the monetary policy of the FED (Reserve Bank of New Zealand, 2020). According to our literature review, US monetary policy has a strong impact on Europe's 10-year government bond yields, although the effect does not persist over time (Rogers & Wright, 2014). Therefore we expect a positive relation betweeen US Shadow interest rates and government bond yields.

Following Kilponen et al. (2015), we decided to address the structural breaks caused by the sovereign debt crisis by adding a dummy variable, $CRISIS2010_t$, which takes the value of 0 for all periods before 2010Q2 and 1 for all periods from 2010Q2 onwards, when the sovereign debt crises started.

5.2 Data and Methodology

Our model is based on quarterly data for the period between the first quarter of 1999 and the first quarter of 2019. The starting year, 1999, was chosen because it is the year in which the euro was introduced, as well as the year in which Portuguese government bonds were first issued in the common currency. As we can see from Table A1 in Appendix A our data were taken from different sources (Eurostat, ECB Statistical Data Warehouse, Federal Reserve Bank Economic Database and Reserve Bank of New Zealand). Some of the data has been converted from monthly to quarterly, such as 10-year government bond yields, HICP and shadow interest rates, for both Europe and the United States:

We first checked the reliability of our data through the descriptive statistics (see Table A3- Annex). After this preliminary data analysis, we decided to test the stationarity of our time-series. This step is fundamental to choose the most suitable estimation model (Shrestha & Bhatta, 2018). Therefore, we have run the Unit Root Test: all the variables have been tested for levels and for first difference. We choose the version with interception and no trend of the Augmented Dickey Fuller criterion (ADF) as it is the most commonly used in the related literature. In Table 1, we show the results we obtained. As we can observe, only some of the time series are stationary at levels, I(0), but they are all stationary at first difference, and hence are I(1).

Table 1. ADF Unit Root Test (with Intercept and no Trend)

Variables	Level	First difference
GB10	-2.493	-4.472***
GDP	-1.588	-4.865***
INFL	-0.972	-4.646***
DEBT	-1.588	-4.865***
CA	-0.962	-5.477**
VIX	-3.647***	-8.372***
SR_US	-2.920**	-5.843***
SR_EU	-0.893	-5.540***

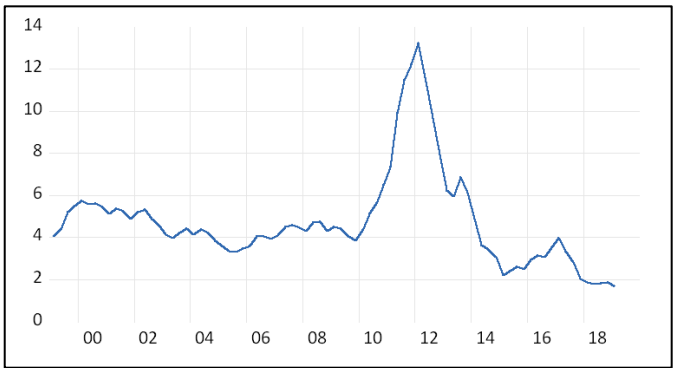
Notes: 1)***,** and * represent statistical significance at the 1 percent, 5 percent and 10 percent level, respectively; 2) The null hypothesis of the ADF test is that the series contains unit roots.

Since our data include some time-series of order of integration I (0) and some of order of integration I (1), we have therefore decided to proceed using the Auto-Regressive Distributed Lag (ARDL) Estimation (Pesaran & Shin, 1998; Pesaran, Shin, & Smith, 2001) . This consists of a model based on Ordinary Least Squares (OLS) and is particularly suitable for specifications containing mixed order of integration time series - I(0) and I(1). The main characteristics of this approach are that it takes different optimal number of lags for each regressor and that it avoids the adverse effects of multicollinearity associated with including many lags of the independent variable as regressors (Shrestha & Bhatta, 2018).

We have estimated our model using the econometric software Eviews which automatically selects the optimal number of lags for each variable, given a maximum number of lags. Following Pesaran et al. (2001) we then set the maximum number of lags to four and used the Akaike Information Criterion (AIC) as the most commonly used in the literature we analyzed (see Akram and Das, 2017; Pinho and Barradas, 2018). In addition, we have chosen to estimate our model with the intercept but without trend because, based on the

graphical representation of the 10-year Portuguese government bond yields in Figure 3, it is the most appropriate method.

Figure 3 Ten Year Portuguese Government Bond Yields (%)



Source: Federal Reserve Bank of St. Louis economic data
https://fred.stlouisfed.org/series/IRLTLT01PTM156N

Subsequently, we conducted some tests to assess the goodness of our model. First of all, we performed some diagnostic tests such as residual and stability diagnostics. then we investigated the presence of cointegration for both versions of our specification (1) and (2).

We checked for serial correlation and heteroskedasticity between the residuals, respectively through the LM Test and the Heteroskedasticity Test. The results are summarized in Table 2. As we can see the residuals are not serially correlated because the F-statistic is less than p-value, and they are homoscedastic.

Table 2. Serial Correlation and Heteroscedasticity Test

Estimation	Test	F-statistic	P-value
Estimation (1)	Serial correlation Heteroscedasticity	0.030 0.033	0.862 0.857
Estimation (2)	Serial correlation Heteroscedasticity	0.463 0.475	0.614 0.544

We then tested the normality of the model through the Normality test whose results are presented in table 3. The p-value of Jarque Bera's test is not significant for (1) and (2) so we can say that the residuals are distributed according to a normal distribution.

Table 3. Jarque Bera Test

Estimation	F-statistic	Prob.
Estimation (1)	1.149	0.568
Estimation (2)	0.824	0.662

Finally, we verified the stability of the model through the CUSUM Test whose results are shown in Figure 4 and 5. Both our specifications are stable at 5%.

Figure 4 CUSUM Test for Estimation (1)

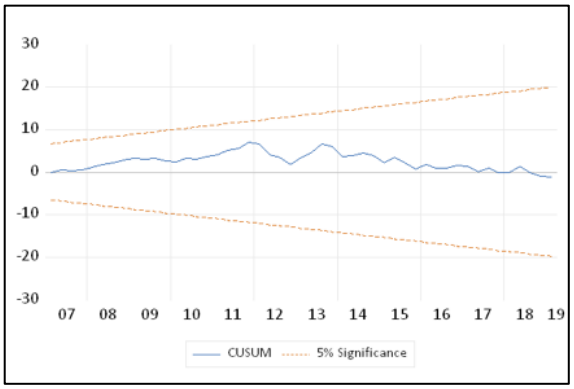
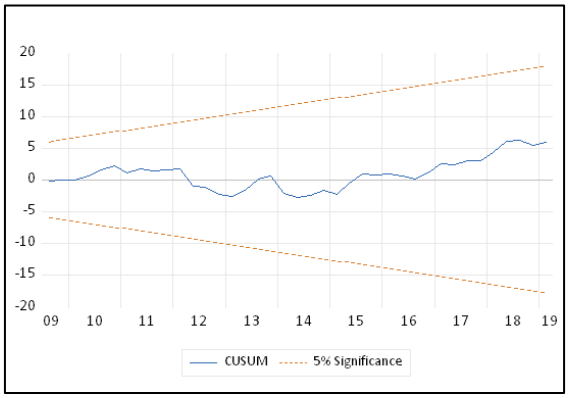


Figure 5. CUSUM Test for Estimation (2)



After that, we carried out the Bounds Test to determine the presence of cointegration and, therefore, the existence of a long-term relations among our variables (see Table 4). According to this test, we reject the null hypothesis of no cointegration if the F-statistic value is higher of the upper bound.[2]

[2]The critical values for the Bound Test are indicated by Eviews.

Table 4. Bounds Test

Estimation	F-statistic	Critical Value	Lower Bound Value	Upper Bound Value
Estimation (1)	12.802	10% 5% 2.5% 1%	1.92 2.17 2.43 2.73	2.89 3.21 3.51 3.90
Estimation (2)	15.336	10% 5% 2.5% 1%	1.85 2.11 2.33 2.62	2.85 3.15 3.42 3.77

The Bounds test indicates the presence of long-run relationship among variables for both our specifications.

6. Results and Discussion

As our variables were successful in the diagnostic tests, we moved on to estimate the long-term and the short-term results. Our estimation was made for (1) and (2), both with and without the dummy variable. For simplicity, we will therefore call I equation (1), II equation (1) with the dummy, III equation (2) and IV equation (2) with the dummy.

Table 5 describes the long-term relation for all four cases considered. The European shadow interest rates are the only significant long-term variable. The sign is positive and confirms the persistence of the effects of unconventional monetary policy measures as already seen in Koijen *et al.* (2018) for other Euro-Area countries.

Table 5. Long-run Estimates for the 10-year Portuguese Government Bond Yields for Case I, II, III and IV

Long-run estimation of $GB10_t$				
Variable	**I**	**II**	**III**	**IV**
$ß_0$	0.521	6.822	6.449	7.638
	(3.594)	(3.135)	(4.512)	(4.794)
GDP_t	0.262	-0.085	0.213	0.143
	(0.165)	(0.141)	(0.162)	(0.193)
$INFL_t$	-0.463	-0.215	-0.619	-0.586
	(0.373)	(0.286)	(0.382)	(0.372)
$DEBT_t$	0.105	-0.060	0.037	0.006
	(0.090)	(0.078)	(0.070)	(0.083)
$DEBT^2_t$	0.001	0.000	0.000	0.000
	(0.001)	(0.000)	(0.000)	(0.000)
CA_t	0.0461	0.199	0.0327	0.285
	(0.189)	(0.155)	(0.142)	(0.151)
VIX_t	0.124***	0.065	0.041	0.030
	(0.032)	(0.028)	(0.041)	(0.044)
SR_US_t	-	-	-0.319*	-0.295
			(0.107)	(0.110)
SR_EU_t	0.669***	0.506***	0.618***	0.593***
	(0.159)	(0.109)	(0.109)	(0.112)
CRISIS2010	-	4.768***	-	3.763***
		(0.995)		(1.063)
Observations	77	77	77	77

Note: ***, **,* indicate statistical significance respectively at 1%, 5% and 10% level.

Table 6, 7, 8, and 9 show the short-term results for all four cases analysed. As displayed, the Eviews software has selected the optimal number of lags for each variable. In all four cases, the error correction term, ECT, is highly significant and negative. This is further confirmation of the stability of our models and of their convergence in the long term. In addition, the speed of adjustment determines that 31, 43.8, 40.3 and 41.9 basis points

(bps) of any deviation from the long- run relation are corrected in one quarter respectively. Furthermore, from Tables 7 and 9, we note that the dummy we have introduced contributes to increase the level of significance of the model (the values of R-squared and adjusted R-squared are greater in cases where the dummy is contained). The sovereign debt crisis started in May 2010 has positively affected the level of Portuguese government bonds yields.

Regarding our control variables, we can observe that they all have the expected sign except for the current account. The results suggest that good macroeconomic performance is associated with a reduction in Portuguese government bond yields. Yields of 10-year Portuguese government bonds decrease as economic growth increases, inflation decreases and the debt-to-GDP ratio falls. The growth of GDP has a negative impact. As mentioned above, this sign could be justified by the assumption that a growing country is more likely to be able to pay back its debt, so government bond yields fall. These effects take about half a year to be significant: as shown in Tables 8 and 9. Among the other variables, we found a positive and significant coefficient for inflation. A possible explanation is that the interest rate on government bonds expressed in nominal form is subject to inflation.

Concerning the effect that the fiscal condition of Portugal has on 10-year Portuguese government bond yields, our results show that the current account is not significant. Moreover, the debt-to-GDP ratio, where significant, confirms our expectations that an increase in debt, corresponds to an increased risk of government default and increases the level of government bonds. The squared debt-to-GDP ratio presents significant and positive coefficients in all our estimations showing a convex relationship. This means that that the higher the squared debt-to-GDP ratio, the higher the effect of a given increase in debt-to-GDP ratio on yields.

From Table 8 and 9, we can see that the VIX has a positive effect on the yields of Portuguese government bonds. We therefore have a positive confirmation of the impact that uncertainty and fear in global markets have on individual countries' government bonds that are not considered as refuge assets. However, the effect of volatility is not very persistent and tends to disappear after one quarter.

Focusing on the core variable of our study, the shadow rates for the euro area, we found that in all four versions of our model the coefficients are significant and positive at the 1 percent level. In accordance with our literature review, the models demonstrate that the implementation of unconventional monetary policies, corresponding to a decrease in European shadow interest rates, has led to an actual decrease in the level of Portuguese 10-

year government bonds. From the tables below we note that this effect is between 38.6 and 56.5 bps.

Investigating the effects of US monetary policy on Portuguese government bonds (cases III and IV), we found that the effect is significant and positive, as already predicted by Rogers et al. (2014) for Euro Area countries. The effect of these spillovers is about 30 bps. However, we can see that this effect is not immediate and takes longer time to be transmitted (one to three quarters) than domestic monetary policy.

Table 6. Short-Run Estimation for the 10-year Portuguese Government Bond Yields for Case I

Short-run estimation of $GB10_t$ - CASE I		
Variable	**Coefficient**	**Std. Error**
$\Delta\ GB10_{t-1}$	0.424***	0.060
$\Delta\ GDP_t$	0.043	0.037
$\Delta\ GDP_{t-1}$	0.089	0.040
$\Delta\ INFL_t$	0.657**	0.183
$\Delta\ INFL_{t-1}$	-1.333	0.269
$\Delta\ INFL_{t-2}$	-0.216	0.281
$\Delta\ INFL_{t-3}$	1.140***	0.205
$\Delta\ DEBT_t$	0.192	0.081
$\Delta\ DEBT_{t-1}$	-0.184	0.074
$\Delta\ DEBT_{t-2}$	-0.197	0.079
$\Delta\ DEBT_{t-3}$	0.125***	0.020
$\Delta\ DEBT^2_t$	0.000	0.000
$\Delta\ DEBT^2_{t-1}$	0.001***	0.000
$\Delta\ DEBT^2_{t-2}$	0.002***	0.000
$\Delta\ CA_t$	-0.065	0.037
$\Delta\ CA_{t-1}$	-0.080	0.037
ΔVIX_t	0.007	0.007
$\Delta\ SR\_EU_t$	0.386***	0.070
$\Delta\ SR\_EU_t$	-0.124	0.073
Ect_{t-1}	-0.310***	0.027
Observations	77	
ARDL Lag structure	(1,2,4,4,3,2,1,2)	
R-squared = 0.876	**Adjusted R-squared = 0.835**	

Note: The symbol Δ indicates the first difference; ***, **,* indicate statistical significance respectively at 1%, 5% and 10% level.

Table 7. Short-Run Estimation for the 10-year Portuguese Government Bond Yields for Case II

Short-run estimation of $GB10_t$ - CASE II		
Variable	**Coefficient**	**Std. Error**
$\Delta\ GB10_{t-1}$	0.461***	0.072
$\Delta\ GB10_{t-2}$	0.105	0.090
$\Delta\ GB10_{t-3}$	0.219	0.075
$\Delta\ GDP_t$	0.034	0.042
$\Delta\ GDP_{t-1}$	0.116	0.041

$\Delta\ INFL_t$	0.581	0.188
$\Delta\ INFL_{t-1}$	-0.221	0.268
$\Delta\ INFL_{t-2}$	-0.239	0.283
$\Delta\ INFL_{t-3}$	1.061***	0.207
$\Delta\ DEBT_t$	0.159	0.081
$\Delta\ DEBT_{t-1}$	-0.198	0.075
$\Delta\ DEBT_{t-2}$	-0.276**	0.084
$\Delta\ DEBT^2_t$	0.000	0.000
$\Delta\ DEBT^2_{t-1}$	0.001***	0.000
$\Delta\ DEBT^2_{t-2}$	0.002***	0.000
$\Delta\ DEBT^2_{t-3}$	0.001***	0.000
$\Delta\ CA_t$	-0.067	0.037
$\Delta\ CA_{t-1}$	-0.060	0.038
ΔVIX_t	0.005	0.007
ΔVIX_{t-1}	0.010	0.007
$\Delta\ SR\_EU_t$	0.419***	0.068
$CRISIS2010_t$	0.617***	0.089
Ect_{t-1}	-0.438***	0.041
Observations	77	
ARDL Lag structure	(4,2,4,3,4,2,2,1)	
R-squared = 0.886	**Adjusted R-squared = 0.840**	

Note: The symbol Δ indicates the first difference; ***, **,* indicate statistical significance respectively at 1%, 5% and 10% level.

Table 8. Short-Run Estimation for the 10-year Portuguese Government Bond Yields for Case III

Short-run estimation of $GB10_t$ - CASE III		
Variable	**Coefficient**	**Std. Error**
$\Delta\ GB10_{t-1}$	0.380***	0.061
$\Delta\ GB10_{t-2}$	0.166	0.071
$\Delta\ GB10_{t-3}$	0.259***	0.059
$\Delta\ GDP_t$	0.146	0.035
$\Delta\ GDP_{t-1}$	0.093	0.034
$\Delta\ GDP_{t-2}$	-0.128***	0.035
$\Delta\ GDP_{t-3}$	-0.129**	0.038
$\Delta\ INFL_t$	0.626***	0.153
$\Delta\ INFL_{t-1}$	-0.025	0.220
$\Delta\ INFL_{t-2}$	-0.109	0.224
$\Delta\ INFL_{t-3}$	0.774***	0.169
$\Delta\ DEBT_t$	0.054	0.068
$\Delta\ DEBT_{t-1}$	0.372***	0.071
$\Delta\ DEBT_{t-2}$	0.345***	0.079
$\Delta\ DEBT^2_t$	0.001	0.000
$\Delta\ DEBT^2_{t-1}$	0.002***	0.000
$\Delta\ DEBT^2_{t-2}$	0.002***	0.000
$\Delta\ DEBT^2_{t-3}$	0.000***	0.000
$\Delta\ CA_t$	-0.006	0.030
ΔVIX_t	0.005	0.006
ΔVIX_{t-1}	0.036***	0.006
ΔVIX_{t-2}	0.019	0.006
$\Delta\ SR\_US_t$	-0.004	0.059
$\Delta\ SR\_US_{t-1}$	0.297***	0.062
$\Delta\ SR\_US_{t-2}$	-0.096	0.059
$\Delta\ SR\_US_{t-3}$	-0.238**	0.064

Δ SR_EU_t	0.564***	0.065
Δ SR_EU_{t-1}	-0.163	0.067
Ect_{t-1}	-0.403***	0.029
Observations	77	
ARDL Lag structure	(4,4,4,3,4,1,3,4,2)	
R-squared = 0.938	**Adjusted R-squared = 0.902**	

Note: The symbol Δ indicates the first difference; ***, **,* indicate statistical significance respectively at 1%, 5% and 10% level.

Table 9. Short-Run Estimation for the 10-year Portuguese government bond yields for case IV

Short-run estimation of $GB10_t$ - CASE IV		
Variable	**Coefficient**	**Std. Error**
Δ $GB10_{t-1}$	0.386***	0.061
Δ $GB10_{t-2}$	0.188	0.073
Δ $GB10_{t-3}$	0.273***	0.061
Δ GDP_t	0.135	0.036
Δ GDP_{t-1}	0.093	0.035
Δ GDP_{t-2}	-0.127**	0.038
Δ GDP_{t-3}	-0.127**	0.039
Δ $INFL_t$	0.060***	0.155
Δ $INFL_{t-1}$	-0.051	0.221
Δ $INFL_{t-2}$	-0.137	0.225
Δ $INFL_{t-3}$	0.784***	0.171
Δ $DEBT_t$	0.044	0.068
Δ $DEBT_{t-1}$	0.375***	0.074
Δ $DEBT_{t-2}$	0.353***	0.081
Δ $DEBT^2_t$	0.000	0.000
Δ $DEBT^2_{t-1}$	0.002***	0.000
Δ $DEBT^2_{t-2}$	0.002***	0.000
Δ $DEBT^2_{t-3}$	0.000***	0.000
Δ CA_t	-0.009	0.030
ΔVIX_t	0.004	0.006
ΔVIX_{t-1}	0.038***	0.006
ΔVIX_{t-2}	0.020**	0.006
Δ SR_US_t	-0.010	0.060
Δ SR_US_{t-1}	0.286***	0.063
Δ SR_US_{t-2}	-0.098	0.060
Δ SR_US_{t-3}	-0.246***	0.066
Δ SR_EU_t	0.565***	0.067
Δ SR_EU_{t-1}	-0.155	0.067
$CRISIS2010_t$	0.218***	0.056
Ect_{t-1}	-0.419**	0.031
Observations	77	
ARDL Lag structure	(4,4,4,3,4,1,3,4,2)	
R-squared = 0.939	**Adjusted R-squared = 0.901**	

Note: The symbol Δ indicates the first difference; ***, **,* indicate statistical significance respectively at 1%, 5% and 10% level.

From our analysis, we can therefore conclude that the ECB's monetary policy has contributed to the decline in Portuguese 10-year government bond yields in both the short

and long run. By contrast, the effects of the FED's monetary policy are significant and positive in the short run but do not persist in the long run.

7. Conclusions

In this dissertation we study the impact that the ECB's unconventional monetary policies undertaken to face the global financial crisis, started in August 2007, on 10-year Portuguese government bond yields. We analyse these effects empirically, using an ARDL model on quarterly data. By doing so, we created an *ad hoc* specification taking into account the main drivers of government bond yields by including not only economic growth, inflation rate and fiscal conditions but also global risk aversion. We then created a second version, introducing a dummy variable to include the structural break in our data, caused by the sovereign debt crisis started in May 2010.

To represent the stance of ECB monetary policy we used Krippner's (2012) shadow interest rates for the euro area, that move as the policy short term interest rates above the ZLB but are also able to go below the zero level when unconventional tools are undertaken. These shadow rates are a robust proxy of monetary policy.

Our results are in line with the previous literature, showing that unconventional monetary policy measures were effectively useful to decrease Portuguese 10-year government bond yields. More precisely, 1 percent decrease in shadow interest rates correspond to a decrease between 38.6 and 56.5 bps in Portuguese 10-year government bond yields and these effects persist over time.

In addition, using Krippner's (2012) shadow interest rates for the US we also investigated the FED's monetary policy spillovers on Portuguese 10-year government bond yields. The results confirm the findings in our literature review, showing that the impact of FED's monetary policy on the level of Portuguese government bond yields is smaller, about 30 bps, and it is not persistent in the long run.

We believe that these results can be useful for policy makers as a further confirmation of the efficacy of the unconventional monetary policy when lowering the policy interest rates is no longer a suitable option. Moreover, we also believe that this dissertation can be used as baseline for the development of future research concerning the effects of unconventional monetary policies on government bond yields with focus a on other GIIPS countries individually to better contextualize our results.

Appendix A

Table A1. Effects of the monetary responses to the crisis on Government bond yields

Area	Author and year	Sample time	Measure	Methodology	10-y Government Bonds reduction
Euro-area	(Pattipeilohy *et al.*, 2013)	2010-2012	SMP LTRO	panel regression	between -30 bps for IT and -400 for GR
Euro-area (DE, FR, IT, ES)	(Altavilla *et al.*, 2014)	1999 - 2012	OMT	event study	- 100 bps (IT, ES); not significant in DE, FR
Euro-area (GR)	(Zettelmeyer *et al.*, 2013)	2010-2012	SMP	event study	between -80 bps and -190 bps
Euro-area (DE, FR, IT, ES)	(Altavilla *et al.,* 2015)	2014-2015	APP	event study (high-frequency data)	between -30 and -50 bps (DE, FR); between -60 and -80 bps (IT, ES)
Euro-area	(Andrade, 2016)	1999-2015	APP	Event study	-45 bps
Euro-area (AT, BE, DE, FI, FR, IE, IT, NL, PT, ES)	(De Santis, 2016)	2004 - 2015	APP	event study (error correction model)	on average -69 bps
Euro-area (GR, IE, IT, PT, ES)	(Krishnamurthy *et al.*, 2017)	2010-2012	SMP OMT LTRO	Event study	- 200 bps (IT, ES); -500 bps (PT, IE); -1000 bps (GR).
Euro-area	(Koijen *et al.*, 2018)	2014-2015	APP	Simple regression	average -13bps
Euro-area (DE, FR, IT, ES)	(Varghese & Zhang, 2018)	2007-2016	APP	Event-study	around -17 and -25 bps (IT and ES)
Euro-area (AT, BE, DE, FI, FR, IE, IT, NL, PT, ES)	(Banco de Portugal, 2019)	2000-2019	APP	Simple regression	-60 bps
UK	(Christensen & Rudebusch, 2012)	2009-2011	QE1 QE2	Event-study on announcements	-43 bps
UK	(Joyce & Tong, 2012)	2009-2010	QE1	Event study	-80 bps
UK	(Churm *et al.,* 2015)	2009-2010	QE2 QE3	Event-study	-45 bps
US	(Christensen & Rudebusch, 2012)	2008-2009	LSAP	Event-study on announcements	-89 bps
US	(D'Amico & King, 2012)	2009-2012	LSAP	event study	-224 bps (bonds)
US	(Liu *et al.* 2019)	1965-2011	LSAP	DSGE model	around -40 and -60 bps
Japan	(Ueda, 2012)	1999-2011	QE1	Simple regression	around -15 bps
Japan	(Arai, 2017)	1998-2013	QE1	Event-study on announcements	-14 bps

Note: For the Euro-area AT is Austria, BE is Belgium, DE is Germany, FI is Finland, FR is France, GR is Greece, IE is Ireland, IT is Italy, NL is Netherlands, PT is Portugal and ES is Spain. For the measures: SMP is Securities Markets Programme, LTRO is Longer-Term Refinancing Operation, OMT is Outright Monetary Transaction, APP is Asset Purchase Programme, QE is Quantitative Easing and LSAP is Large-Scale Asset Purchase.

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Annex

Table A2. Data description

Variable Labels	Data Description	Frequency	Sources
$GB10_t$	Long term government bond yields (10 years); interest rate	Monthly converted to quarterly	Federal Reserve Bank of St. Louis economic data
GDP_t	Total GDP year-over-year percentage change; percentage	Quarterly	OECD Database
$INFL_t$	Inflation rate; percentage	Monthly converted to quarterly	Eurostat
$DEBT_t$	Gross government debt consolidated as percentage of GDP; percentage	Quarterly	ECB Statistical Data Warehouse
CA_t	Current account balance percentage of GDP; percentage	Quarterly	OECD Database
VIX_t	Volatility Index Chicago Board Options Exchange; levels	Quarterly	Federal Reserve Bank of St. Louis economic data
SR_EU_t	Krippner Shadow short rates; interest rate	Monthly converted to quarterly	Reserve Bank of New Zealand
SR_US_t	Krippner Shadow short rates; interest rate	Monthly converted to quarterly	Reserve Bank of New Zealand
$CRISIS_t$	Dummy variable; from 1991Q1 to 2010Q2 = 0; from 2010Q2 to 2019Q1 = 1	Quarterly	Authors' Calibration

Table A3. Descriptive Statistics for each variable

	$GB10_t$	GDP_t	$INFL_t$	$DEBT_t$	CA_t	VIX_t	SR_EU_t	SR_US_t
Mean	4.766	0.983	2.020	92.483	-5.816	19.894	1.031	0.434
Median	4.348	1.445	2.300	78.848	-7.844	18.204	0.968	1.190
Maximum	13.223	4.809	4.400	135.247	2.443	58.596	6.538	4.831
Minimum	1.670	-4.528	-0.867	54.037	-12.773	10.308	-5.203	-7.336
St. Deviation	2.275	2.284	1.309	31.112	4.989	7.834	3.017	3.151
Skewness	1.799	-0.873	-0.301	0.208	0.409	2.016	-0.106	-0.657
Kurtosis	6.738	2.986	2.209	1.324	1.497	9.614	2.346	2.417
Observations	81	81	81	81	81	81	81	81