THESIS

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QUANTITATIVE EASING: DID IT REALLY REDUCE SOVEREIGN YIELDS IN THE EMU?

ABSTRACT

The aim of this paper is to assess the effect of the asset purchase program of the European Central Bank on sovereign bond yields in European Monetary Union (EMU), by constructing a panel of euro-zone countries (AST, BEL, FIN, FRA, ITA, IRE, NET, SPA, POR) and not EMU countries (CAN, JAP, SWE, UK, US). The empirical analysis is preceded by a theoretical investigation of unconventional monetary tools of central banks, with special regards to quantitative easing. The results suggest possible impact of asset purchases on yields decline.

Keywords: Unconventional Monetary Policy, Euro-Area, Sovereign Yield, ECB, Panel Data, QE

PREFACE AND ACKNOWLEDGMENT

This paper is the result of a long and challenging path that has characterized my experience as master student at Erasmus University, and represents the effort of concentrating one year into one document. Frankly, it has required a bigger effort than I expected. Since the topic was essentially new to me, the theoretical discussion required a long and thorough work of bibliographic research. Collecting the data resulted to be difficult, often frustrating, and sometimes with failing outcomes. In addition, investigations of related fields with extra-information hard to retrieve, was necessary in order to truly understand what I was dealing with. However, writing this thesis turned out to be an extremely interesting activity, which eventually led me, not solely to study something, but actually to "learn" something.

For this reason, I need to thank, first of all, prof. Capser de Vries, who inspired in me a strong interest and passion for financial markets, banking and monetary economics, and for his very short activity as supervisor. I need to thank my supervisor prof. Lorenzo Pozzi and the second reader prof. Bas Jacobs; without which this paper would not exist. But I, also, have to be grateful to prof. Job Swank for his unlimited patience and availability in providing advices and suggestions. I also want to thank prof. Andreas Pick for his technical support on the implementation and the interpretation of the econometrical model, and Joost Bats of DNB for his precious insights on central banking mechanisms.

Last but not least, I want to thank my parents and my family for everything they did, and everything they still do, for me.

Thank you all

LIST OF ABBREVIATIONS

ABSP	Asset Backed Security Program
APP	Asset Purchase Program
BOJ	Bank of Japan
CB	Central Bank
CBPP	Cover Bond Public Purchase
CDS	Credit Default Swaps
CE	Credit Easing
DTSM	Dynamic Term Structure Models
ECB	European Central Bank
ELB	Effective Lower Bound
EMU	European Monetary Union
ES	Event Study
FE	Fixed Effects
FED	Federal Reserve
LSAP	Large Scale Asset Purchase
LS	Local Supply
LTRO	Long Term Refinancing Operation
MRO	Main Refinancing Operation
NCB	National Central Bank
OMO	Open Market Operation
OMT	Outright Monetary Transaction
PB	Portfolio Balance
PSPP	Public Sector Asset Purchase
QE	Quantitative Easing
SMP	Security Market Program
SMT	Segmented Market Theory
ZLB	Zero Lower Bond

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I INTRODUCTION

From the outbreak of the financial crisis in 2007 major central banks in western capitalisms have reacted vigorously in order to combat recession, engaging in conventional and unconventional policies. When the former reached their limitation (the nominal interest rate lower bound) the latter become a necessary tool for the monetary authority. The most prominent unconventional measure is the so-called quantitative easing (QE) which involves the purchase, operated by central banks, of various assets from the financial markets. The primary scope of this kind of policies is to reduce real long-term-rates in order to stimulate output and spending.

The European Central Bank (ECB) started with the Public Sector Purchase Program (PSPP) in 2015, which makes it a latecomer in QE. By that time many of the factors characterizing the early stages of the crisis like financial stress and speculation on bonds market were already relaxed. As consequence of previous monetary measures, yields on sovereign bonds were already on a long declining path, however deflation constituted a major threat to euro-area at that time. To face this challenge Euro-Tower engaged in massive purchases of sovereign bonds and other assets. From 2015 to 2017 the balance-sheet of the ECB has increase of almost 2 trillion of euros: a massive liquidity expansion. What results have the monetary authority achieved through its quantitative easing program?

The aim of this paper is to assess the effect of asset purchase programs (APP) on sovereign yields in the EMU. No focus is given on output or inflation. Implementing a panel regression of a group of major EMU countries, observing different QE indicators, macro fundamentals and risk factors, the analysis provides empirical evidences of "stock effects" in a model without time fixed effects, nevertheless identification need to be further addressed. The empirical analysis contains also a small contribution of the author.

The first part of the paper contains a theoretical excursus of liquidity trap as the rationale behind unconventional policies and a thorough treatment of major theories of QE, involving concepts like pure QE and credit easing. The study continues with an exposition of the operational mechanisms and an examination of most likely transmission channels according to a decomposition of long-term rates in neutral component and risk premium. This paper also includes a detailed report of the PSPP program implemented by the ECB.

II: UNCONVETIONAL MONETARY POLICY

II A: DISCUSSION

II A1: LIQUIDITY TRAP AND UNCONVENTIONAL MONETARY POLICY

"There is the possibility […], that, after the rate of interest has fallen to a certain level, liquidity-preference may become virtually absolute in the sense that almost everyone prefers cash to holding a debt which yields so low a rate of interest"
J.M.Keynes, 1936

In "normal" times, when an economy is not recessing or stagnating, the monetary authority tries to control to amount of cash (liquidity) within a system, according to the needs that the system has in order to achieve a specific target. In these times, the (conventional) measures adopted by the authority mainly consist in setting or influencing one or a complex of nominal interest rates, in light of the mandate it has to fulfill. The mandate involves the monetary policy in committing to a specific goal concerning economic fundamentals such as price stability and full employment. The European Central Bank, for instance, has a unique mandate of price stability around a level close but below the two percent of inflation, and conventionally conduce its policy through the so-called "Open Market Operations" (OMO). These kind of operations include the "Main Refinancing Operation" (MRO) and the "Long Term Refinancing Operation" (LTRO) which are loans to the banking system in which the ECB sets the nominal rate.

In regards of the mandate, inflation targeting characterizes conventional monetary policy of most central banks in western capitalism. It is a prescription according to which there is an interest rate that allows the monetary authority in targeting a specific level of inflation. One limit of this type of policy occurs when the nominal interest rate cannot be lowered, because, for example, is at its effective lower bond (ELB). The existence of a lower bound on nominal interest rate around the zero or negative level is due to existence of cash which are non-interest bearing obligation with a zero nominal interest rate (Buiter, Rahbari 2015). The existence of cost related to hold cash make the lower bound on interest rate more likely to be negative, rather than zero (zero-lower-bound or ZLB) as conventional wisdom suggest, in addition the existence of cash creates asymmetry in the efficacy of rates as monetary tool. Hence, once the rate has hit its ELB the monetary policy needs to find different channels to shoot inflation (Woodford, 2003). When the nominal rate equals, or is relatively close to, the

rate paid on reserves, bonds and money becomes equivalent and further expansion of the money base cannot push equilibrium towards higher level of prices, and the economy fall into a Liquidity Trap (Krugman, 1998). In a liquidity trap conventional monetary policy are no longer effective and unconventional measures come into game.

The goal of monetary expansions is generally to reduce the real cost of money (the real interest rate) and stimulate private borrowing and spending. The real interest-rate, expressed in equation 1, is the difference between the nominal interest rate and expected inflation. Thus, a reduction of the real interest rate must occur by a reduction in the nominal rate or by an increase in expected future price level.

$$r_t = i_t - E[\pi_{t+k}] \qquad (1)$$

In a situation of Liquidity trap, when the nominal interest rate has approached its ELB a reduction of the real interest rate can happen only via the expected inflation channel. However, as Krugman shows conventional monetary measures in a liquidity trap do not apply anymore because when the nominal interest rate is at its ELB further monetary expansion do not increase price level. This is because at the zero-lower-bound, bond and base (money) are perfect substitutes and any further decrease of the nominal interest rate does not generate increase in spending. Thus, QE is believed to act on the expected inflation channel. The key idea is that QE reduces long term rates, and a reduction in long term private borrowing cost will also push upwards investment and spending. Indeed, as Draghi (2014) explained, the worries that motivated new unconventional actions of the ECB arise due to "volatility and decline" of inflation expectations. Particularly worrisome was the downward revise of inflation that came out from the results of the Survey of Professional Forecasters for the fourth quarter of 2014 (fig. 2).

Observing figure 1 that plots the inflation rate in the euro-area and the MRO rate we can clearly see that Europe dropped twice in deflation: one in the outbreak of the financial crisis 2008-2009 and for a second and prolonged period between 2013 and 2016. We can see how the MRO have reached a level around the zero and remained there for the whole second period of deflation. This picture provides empirical evidence of the liquidity trap in which the Eurozone have fallen into, creating space for implementing unconventional or non-standard monetary policy.

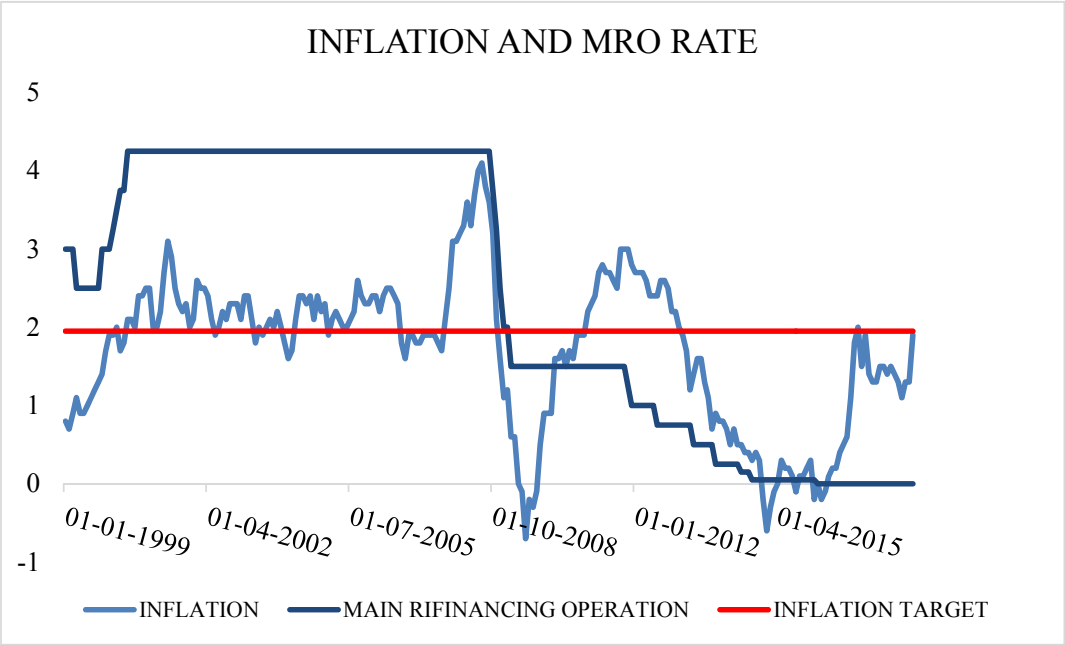


FIGURE 1. Inflation rate and Main Refinancing Operation Rate
SOURCE: ECB statistical data warehouse

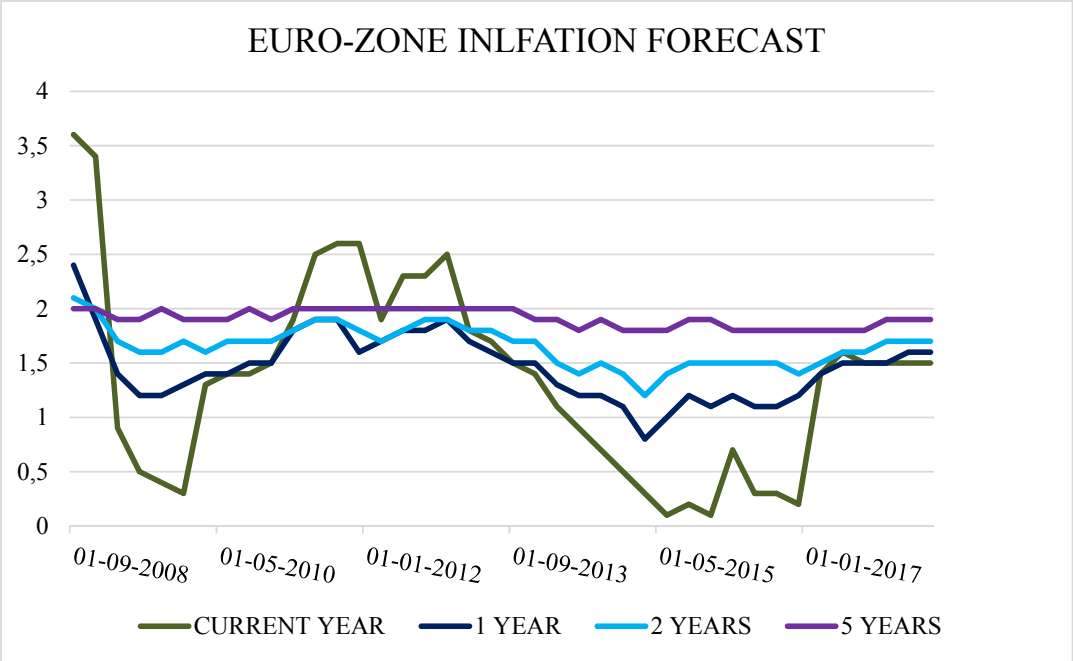


FIGURE 2. Inflation forecast of CB survey over the current year and over 1, 2 and 5 years horizon.
SOURCE: DATA STREAM

IIA2: THEORY OF QUANTITATIVE EASING

Unconventional monetary policy can be mainly divided into two classes: forward guidance and balance sheet policies. The former consists in explicit statement by the central banker regarding its future policy actions in order to influence expected path of short term rates. The latter involve changes in size and composition of central bank balance sheet (Woodford 2012).

Quantitative Easing belongs to the second class of policy since it involves purchases of financial assets from private banking sector by the central bank. Specifically it involves purchases of long term debt securities, either public or private, from financial monetary institutions in exchange of reserves which are claims towards the central bank. In such a way, the central bank is able to expand the monetary base further even once the nominal interest rate has approached the zero or negative levels.

One distinction generally made in literature of quantitative easing regards whether the focus of the policy is on the asset or liability side of the central bank balance sheet. In this regard literature has distinguished between "pure quantitative easing" and "credit easing" (CE). Pure quantitative easing refers to an expansion of the central bank balance sheet solely motivated by increasing the excess of reserves regardless of the type of security purchased. Thus, a pure quantitative easing program is only concerned about the liabilities side of the balance sheet increasing its size. On the other hand, credit easing involves changes in composition of the balance sheet and specifically of its asset side, keeping the size unchanged. Thus, a pure credit easing program would not affect the amount of reserves but would only change the composition of the assets switching conventional securities with unconventional ones (Shiratsuka 2009). This distinction was mainly made to separate the QE program implemented in Japan at the beginning of 2000, which was the first pioneering unconventional security purchase program, from the American one implemented to combat the recession in 2009 (Bernanke 2009). The reason of such is also due to the time and economic context in which the Japanese and American QE are inserted in, and the scope of the two programs. Indeed, the asset side-driven program works essentially as substitutes for private financial intermediaries, switching the amount of a specific debt security for another type, while the liability driven program works as buffer for funding liquidity risk in the financial market (Shiratsuka 2009). In fact, the American QE1 was implemented to change the mix of security held by the Central Bank and how it affects credit condition to households and firms (Bernanke, 2009), in reaction to a violent crisis in an economy highly market-

oriented in which credit conditions play an essential role. What the FED explicitly wanted to achieve was the reduction of credit spreads between treasury and non-treasury assets (Bernanke 2009). The Japanese program was implemented to react to a long period of growth stagnation with deflation risks and sluggish activity. In addition, the structure of the economy in Japan is characterized by a more prominent presence of Government and Depositary Financial institution compared to the US economy. Thus, the Japanese QE was mainly motivated to fund the banking sector (Ueda 2012).

Although the distinction just made, recent experience of unconventional monetary policy has shown that quantitative easing programs are often characterized by changes in both size and composition of balance sheet and thus by an increase in reserves on the liability side, and a change in debt security composition on the asset size. When we look at the large scale asset purchased (LSAP) of the ECB, in which both size and composition of the balance sheet are affected, the distinction between pure QE and CE becomes unimportant. Between 2014 to 2017 the current accounts at the Eurosystem have increased by 273%, while on the asset side the security hold for monetary purpose have more than decupled.

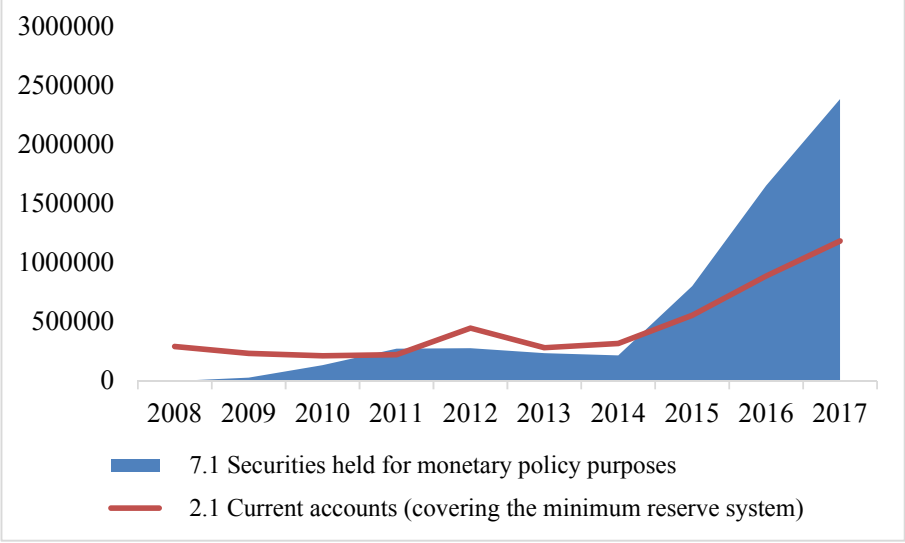


FIGURE 3: Current Accounts at the ECB and the amount of Security purchased in unconventional monetary operations

From a strictly theoretical point of view, Woodford (2012) underlines that once the short-term interest rate is constrained by the ZLB, a QE program aimed in lowering the rate through purchases of long-term government bonds, affect asset prices in the same way that

"Operation Twist" would do[1]. The point of Woodford is that a QE program that targets long term government bonds when the short-term rate equals the one on reserves is technically an asset side operation, although the purchases are funded by reserves with consequently increase in the size of the balance sheet.

For what concern the scope of QE, an asset purchase program is essentially a form of monetary expansion, obtained through unconventional methods, and its ultimate goal, as of any monetary expansion, is to increase expenditure and output. Conventional economic wisdom states, in a purely monetarist fashion, that monetary expansion, constituted by an increase in the money base, determines a proportional increase in price level and output. The basic idea is that any increase in liquidity generating excess of reserves would push, or simply allow, commercial bank to expand their credit activity financing households and firms and thus increasing the money supply (or broad money). But this argument has a fallacy: the monetary authority can determine the money base but has a limited influence on the money stock which is expanded by commercial banks, and monetary institutions in the euro-zone have been provided massive liquidity, in the immediate of the financial crises, which was mainly kept as excessive reserves (De Grauwe 2012). Nonetheless, as we discussed above, the existence of cash and thus the presence of an effective lower bound, establishes limits to the efficacy of monetary expansions. If Krugman "irrelevance" argument is correct, at the ELB a pure QE strategy is ineffective, because targeting exclusively the liability side, the increase in reserves would just be kept as excess by banks without an increase in lending. This situation of irrelevant monetary expansion theoretically can happen independently of the price level, with an economy being in deflation or inflation. According to Krugman the reason why monetary expansion become irrelevant, are not to be found in the monetary transmission and more specifically in the way financial intermediaries work, but it has to be found in the credibility of future commitment of monetary policy (Krugman, 1998). The problem is that a central bank pursuing price stability will interrupt its expansion action as soon as inflation has hit the target. Consequently, Market perceives any monetary expansion as temporary, given the price stability mandate. So, a Central Bank willing to achieve an increase in prices and output, need to be credible about its future commitment of monetary expansion and be "irresponsible" regarding inflation targeting (Krugman 1998). Market agents should not expect any policy reversion once inflation goes back to normality[2].

[1] Operation Twist was launched in 1961 by FED and consisted in selling short term bonds for long term government bonds

[2] This reasoning could explain the disappointing result of the Japanese QE (2001-2006) in which the Bank of Japan (BOJ) did not explicitly commit to any expansion once the inflation target was hit, and indeed the policy was quickly reversed after that inflation went back in positive area (Woodford 2012)

Moreover, open market operations involving debt security purchases must act as expectation management device in "signaling" about future interest-rate policy[3]: at the lower bound, security purchase can be effective in lowering yields and stimulate economy in a forward looking-rational expectation equilibrium, if the CB is able to modify the belief that private sector has upon its policy, in a way, of course, desired by the private sector. But the effect of open market operations does not occur through the purchase itself, but due the way they are interpreted, that can happen if the CB conducts a proper communication about its policy and explaining the rationale behind these operations (Eggertson, Woodford 2003).

Thus in the New Keynesian approach of Woodford and Krugman the two essential characteristics for QE to be effective are: (i) the policy must not be reversed; (ii) it must work by changing agents' expectation about future monetary policy.

[3] Eggertson and Woodford (2003) build a model of monetary policy at the ZLB in which (with the assumptions of complete markets and no borrowing limits) assets prices, output and price level do not depend on debt management policy, and central bank balance sheet, either the amount of debt hold on the asset side or the monetary base on the liability.

IIA3: MECHANISMS OF BALANCE SHEET POLICIES AND MONETARY TRANSMISSION

Beside the effect on inflation and output, QE is commonly assumed to affect asset prices and yields. The asset price affect is the main focus of this paper and in order to fully understand it we need to comprehend how long term-rate are priced and how the monetary authority can influence this mechanism via QE programs, which means to detect the so-called transmission channels. There is no convergent consensus about these channels in literature. In the next paragraph I will try to identify those related to how QE might impact long term sovereign bonds. To start with, we should look at how long term borrowing cost are determined, but before that it is important to briefly illustrate the operational mechanism of a QE program that increases the size and modifies composition of the balance sheet.

From a strictly operational prospective it should be underlined that QE can impact yields in two ways: through the implementation (the actual purchases) and through the announcement of the program. The implementation needs the CB to purchase securities from the private banking sector. These securities are purchased on the secondary market from private monetary institutions (commercial banks) in exchange of reserves. This is the way in which the monetary authority is able to increase the money base that is constituted by reserves and currency, the main components of the liabilities side of the CB balance sheet. From the prospective of commercial banks, the purchase merely requires a switch of their assets. Specifically, it involves a sale of a relatively safe and long maturity asset, for example a sovereign bond, in exchange of reserves, which can be considered as the most liquid asset. The announcement refers to the communication of the central bank towards the public about the upcoming program of purchase. These communications disclose the essential characteristics of the program such as the security markets in which the CB will intervene, the initial duration of the operations, the volume involved and the eligibility criteria of these securities. The disclosures are often coupled with forward guidance action relative to future short rates. There is a vast literature that attributes most of the effects of QE on the announcement and empirically tries to estimate these effects. The reader is invited to the literature review for a brief discussion of these studies.

COMMERCIAL BANK

ASSETS		**LIABILITIES**
RESERVES	↑	DEPOSITS
LOANS		EQUITY
CASH		
SECURITIES	↓	

CENTRAL BANK

ASSETS		**LIABILITIES**	
SECURUTIES	↑	RESERVES	↑
LOANS (to banks)		CURRENCY	
FOREGN RESERVES		NON MONETARY LIABILITIES	

A stylized balance sheet of a Central Bank and a representative Commercial Bank in a security purchase operation of Quantitative Easing

The increase in reserves for the private banking system has multiple beneficial effects. First it provides fresh liquidity to banks mitigating risk of credit crunch between financial intermediaries since banks pay each other with reserves. In normal times banks can go in excess or deficit of reserves and conventionally the institutions in deficit borrow from those in excess, or alternative they can borrow from the Central Banks which is the "bank of the banks". The ECB, for example, provides the deposit facility and the marginal lending facility to regulate inter-banking lending. In case of financial distress it can happen that banks do not trust each other anymore and inter-banking lending stops: the credit crunch. Hence, an increase in base, provides excess of reserves to banks relaxing the crunch, and easing credit transmission. Second, the fractional reserve system requires banks to keep a certain amount of reserves proportional to their deposits. They do so, for example, to meet customers withdrawals desires or regulatory requirements. Thus, the amount of reserves banks have might constitutes a limit to their lending activity. QE increases reserves into commercial banks' balance sheet allowing them to expanding credit to households and firms. This is how the monetary expansion is expected to work: the central bank increases the base and commercial banks increase the supply. It must be noticed that banks face also additional limits, other than those implied by the monetary authority, which might weak the monetary expansion such as demand for loans by the non-financial private sector, profitability of loans, credit risk and others (McLeay et al. 2014).

IIA4 TRANSMISSION CHANNELS

The illustration of the operational mechanism does not shed light over the transmission channels of balance sheet policies, and on how the monetary authority affects sovereign risk. To do so we must take a closer look at yields.

Long-term interest rate can be decomposed in the risk neutral component that depends on the expected future short-term interest rate, and the term premium, which includes different risk factors, some of them derived by the characteristics of the assets (like maturity and duration).

$$R_{t,j} = \sum_{j=0}^{n} E_t(i_{t+j}) + \rho \tag{2}$$

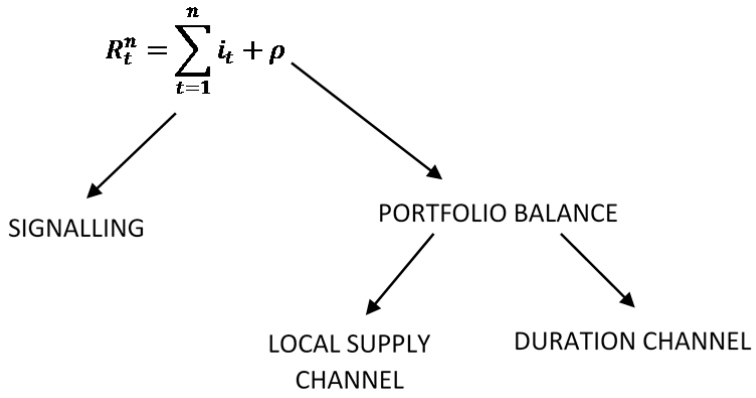
Equation 2 illustrates this relationship. It states that the rate of a long term security purchased at time *t* that pays back after *n* periods at time *j* is a linear relationship of the expected future short-term rate in each *n* period plus the term premium ρ.

The effect of QE on long-term rate might occur via both terms. Literature distinguishes these effects mainly in:

- Signaling channel, when balance sheet policies affect the expected path of future short-term-rate and it is often associated with the announcement of the program (Bauer, Rudebush 2013; Bhattarai et al. 2015).
- Portfolio Balance, or asset valuation channel, when QE affects the risk premium component (Andrade et al 2016).

Moreover, literature on portfolio balance distinguishes two additional channels:

- Local supply channel, which refers to the reduction of supply of bonds operated by the intervention of the CB (Gagnon et al. 2010, D'Amico and King 2010).
- Duration risk channel, consisting in the reduction of the aggregate duration of a specific bond in agent's portfolio consequently to CB open market operations (Bauer, Rudebush 2013).



Representation of the decomposition of long-term interest rate into Expected short-term rate and term premium with respective QE channels.

IIA 4.I Signaling Channel

As mentioned above in the New Keynesian approach, QE works as a sort of expectation-management device in signaling the future short-term-rate path to agents, enforcing forward guidance and the credibility of the monetary authority (Eggertson, Woodford 2003). It avoids that CB credibility counts solely on speeches (Woodford 2012). Another element characterizing this approach is that any effect on yields mainly occurs through the announcements of the program, and the event studies on the announcement dates of the FED and the ECB provide empirical evidences of this channel (Cagnon et al, 2010; Krishnamurty and Vissingjorensen 2011, Altavilla et al 2015, Andrade et al. 2016). If markets were efficient and perfectly functioning the information about the purchases should suffice to immediately impact asset prices and yields since that it would create arbitrage opportunity[4]. One of argument often brought up to support the role of QE in signaling monetary policy is that LSAP reinforce CB commitment because otherwise it would encounter losses on its balance sheet (Bhattarai et al 2015, Fewley and Neely 2013, Krippner and Thornton 2012, Andrade et al 2016). However, this aspect is highly controversial since the way in which the losses should be realized is not clear[5]. Moreover, given that central banks purchase debt securities denominated in the fiat currency which they are the only authority entitled to issue, the idea that they are balance sheet constrained seems not realistic (Buiter, 2008). As often stated by the authority itself, independent central banks can ultimately bear losses, because

[4] However, it is possible that markets are not perfectly functioning at the time QE programs are announced and thus the news effect could be slower than normal and perhaps requiring the purchases to actually happen to complete its effect (Cagnon et al 2010)
[5] Krippner and Thornton (2012), try in providing an explicative example: they claim that such losses can be realized if the FED engages in purchasing a certain amount of derivative contracts that would ensure the loss in case the short-term rates are raised.

essentially being the creator of its own currency it will always be able to meet its liabilities denominated in that currency (Rule, Bank of England 2015).

IIA 4.2 Portfolio balance Channel

The New Keynesian analytical framework essentially excludes effects on the term premium"ρ", which is the second component of the right-hand side of equation[6] (2). The term premium includes all other factors on top of the future short-term rate that agents account for when they price a long-term investment. QE might affect the term premium through the so-called *portfolio balance*, or *asset valuation channel* (Andrade et al 2016). This idea, originally attributed to Tobin (1958, 1969), is build up from the segmented market theory (SMT) and the preferred Habitat Theory (PHT) (Modigliani, Sutch 1966). The main assumption is that financial assets with different maturity are not viewed as perfect substitutes independently from their expected future flow of payoff, as conventional asset price theory would indicate. Modigliani and Sutch (1966) developed from the SMT the preferred-habitat-theory which combined SMT with the Keynesian risk premium model of Hicks. They integrate the view that long rates depend on expected short plus a premium, but that investors have different preferred habitat to the extent that they have preferences for specific maturity class of bonds (Modigliani, Sutch, 1966). From the time of its formulation, the SMT seems to have obtained limited success in academics and has been characterized by lack of formal model. Vayanos and Vila (2009) are the first who formulated a formal model of the preferred habitat theory upon which are based many other studies of portfolio balance (Cagnon 2011,Greenwood et al 2016), including the model developed by Altavilla et al. (2016). The model is composed by two classes of investors: the arbitrageurs, mean-variance optimizer with limited risk aversion, and preferred-habitat who invest only in specific maturity class of bond. Integration between segments occurs only through arbitrageurs, and how they integrate markets is the main focus of the model. Bond risk is modelled as compounded of short rate risk and demand risk. The short term is negatively correlated with the premium and thus high short-rates push arbitrageurs to short bond and invest in short-rate. The opposite happens when short-rates are low. This "carry-trade" made by arbitrageurs determines decline or increase in bond prices and yields. Thus, the asset price mechanism occurs if arbitrageurs are active on the market because they incorporate information on

[6] Woodford (2012) however, allows for the existence of a "safety premium", as evidenced by Krishnamurty and Vissing-Jorgensen (2011), on security with close to zero default risk like long term Treasury bond. Such security can be considered imperfect substitutes, and in somehow consistent with the SMT and the asset price mechanism.

current and future short rate, while preferred-habitat remain tied to their favorite investment. Hence, a central bank leading his policy through the short-term rate will be less effective if arbitrageurs show a high risk aversion, because in these circumstances they do not incorporate all information and forward rates underreact to change in short rates. The second factor that influences bonds market is demand for bond. In case of a shock in demand, constituted by a reduction in bond holding by investors with preference for a certain habitat, arbitrageurs (when risk neutral) "accommodate" the decrease buying bonds but ask a higher yield to compensate for future drop in prices. Thus in this framework exogenous demand shock do affect asset prices[7] (D'Amico and King 2010).

IIA 4.3 Critics to Portfolio Balance and Preferred Habitat

The Vayanos and Vila model is not foreign to critics. First of all, it is based on the assumption that preferred-habitat demand bonds only for the maturity they have preference for without moving to other class of bonds. This assumption is rather "extreme", as the authors themselves have defined, and it is crucial to obtain the portfolio balancing effects. The intuition that justifies the SMT is often found in the existence of clienteles such as pension funds, insurances, hedge funds and so on. These types of investors are commonly believed to provide real life example of preferred habitat, since they are often the main container of risk-free securities given that their main interest is to protect savings rather than obtain capital gains.

Concerning the "asset price mechanism", Woodford (2012) underlines that it is inconsistent with modern theories of asset prices according to which asset prices are evaluated for their state-contingent payoff in different states of the world. Woodford (2012) relies on two strict assumptions: (i) assets evaluation is based only on their returns; (ii) agents face no constraint to the position they can take. If the assumption holds, then no operation of the CB should impact equilibrium in the asset market, because the private sector offset CB intervention, in what is referred to "Wallace neutrality" (Wallace,1981). This is because New Keynesian models (Eggertson, Woodford 2003) are micro-funded based on the optimizer agent whose marginal utility derived from purchasing a certain security should not change, whatever the composition of the central bank balance sheet is. In addition, these agents incorporate private

[7] Evidence of demand shocks influencing asset yields are found also prior the Great Financial Crisis, in the so called *Asian savings glut*: large one-way flow on us governments bonds has contributed in downward pressing yields on those assets (McCauley, 2018).

and public sector, and they assume that increases in the CB balance sheet will be compensated by future increase in taxes[8] (Woodford, 2012).

However, Wallace neutrality hardly finds real life application[9]. Woodford (two) assumptions (necessary in order to have Wallace neutrality) are not realistic too, because private investors are not able to purchase unlimited amount of assets (contrary to the monetary authority which is not balance-sheet constraint (Gertler and Karadi, 2011)), and investors evaluating assets only for pecuniary returns does not match with of the presence of heterogeneous agents consistent with preferred habitat. The same apply to representative agent assumption (Joyce et al. 2012), which is the starting point of New Keynesian optimizing models[10]. Theoretically, Woodford is right when claiming that deviation from perfect markets are necessary for QE to work, but these deviations can be underpinned by a preferred habitat representation[11]. Euro-area experience shows that both imperfect substitutability between bonds and preferred habitat behavior exists[12]. Recent literature (Adriaan Boermans and Vermuelen 2018) on preferred-habitat in the EMU finds evidences of the existence of such investors given that specific characteristics of the euro-zone (the presence of home bias in investment decision, the possibility to employ euro-denominated bond as collateral or banking regulatory requirements) constitute natural incentives for some investors to act as preferred-habitat. Even though it is not evidence of portfolio balance, at least the theoretical conditions do exist. Indeed a strong home bias that characterizes financial and monetary institutions, especially for peripheral countries (Koijen et al. 2016), provide further support for preferred a habitat setting in the EMU[13]. On this line Krishnamurty and Vissing-Jorgensen (2011) formulate the safety premium channel justifying such premium with the existence of preferred-habitat in Treasury bond market in the US. Indeed, as Krishnamurty and Vissing-Jorgensen (2011), also Joyce at al. (2010) finds evidence of larger impact of QE announcements on safe assets like

[8] This refers to Modigliani-Miller theorem.

[9] Evidence from the Euro-area shows that investors not exposed to CB balance sheet are the one more involved in selling euro-denominated eligible securities, contrary to what irrelevance theory suggests (Koijen et al. 2016).

[10] Riedel (2009) formulates a model in which heterogeneous time preference, and heterogeneous economies, preferred habitat for consumption create humps affect the yield curve of long-term bonds, by affecting the share of consumption relative to the market size.

[11] Concerning deviation from market efficiency Kiyotaki and Moore (2008) build a model of a monetary economy with liquidity constraint and productivity shocks. They extend Tobin's Model by providing micro-foundations, showing that in case of non-perfectly functioning financial markets (e.g. borrowing constraints or liquidity shocks) quantity can influence prices of assets. Indeed, even if agent's utility is unaffected by the intervention of the government (or central bank), to the extent that the quantity of securities hold by the government does not influence expected utility of private sector, this can influence agents liquidity and hence their investment possibility. Thus, in correspondence of a liquidity shock, the CB can purchase bonds in exchange of money relaxing liquidity constraint for investors.

[12] Also US literature like King and D'Amico (2012) states that evidence of flow and stock effect of LSAP support preferred-habitat theories.

[13] They found that most of government bonds of the euro –area are hold by insurance companies, pension funds and banks. With regards to what they called the vulnerable countries (the PIIGS plus Cyprus), financial institutions have strong home bias, computed as percentage of securities issued end hold by institutions of the same country

treasury and high graded corporate, in contrast to smaller effects on more risky assets, suggesting preferred habitat behaviors.

Thus a lower degree of substitutability among sovereign bonds, the presence of heterogeneous agents, strong home bias and other characteristics of preferred habitat investors provides ground for PB effects, deviating from market efficiency, in QE policies.

IIA 4.4 Duration and Local supply

Duration channel consists in the reduction of the aggregate duration available on private market influencing arbitrageurs in downward pricing those assets. In other words, the CB is able to abstract duration from the market via the APP and to reduce the overall risk in agents' portfolios[14]. Some authors like Cagnon et al. (2011) affirmed that the LSAP of the FED have considerably reduced duration on the market, and thus the risk in investors' portfolio, and this have led them in demanding a smaller premium over treasury bonds. Euro-area evidence (Koijen et al. 2016) found that the purchases of the central bank consisted of a monthly reduction of 1.5% in of the whole euro-zone debt. Koijen et al. (2016) also finds coincidence between portfolio duration and euro area duration. Thus a central bank operating to reduce duration over euro-denominated security reduces portfolio duration in general.

A theoretical formulation of the local supply channel, according to the model of Altavilla et al. (2015) states that, if investors are forward-looking, the presence of preferred-habitat with inelastic demand for specific bonds allows the yields to move down when a reduction of supply reduces the stock available for private investors. D'Amico and King (2012) find evidence of local supply for US treasuries. However, this channel seems in general to be less supported by empirical works, especially for the Euro-area[15].

The discussion within this section highlights that QE, and more generally unconventional monetary policies represent a very broad topic of analysis with a large and vary literature and with effects and mechanisms that have been not yet fully recognized and comprehended. As stated by Andrade et al. (2016):

"*the key difficulty in assessing the impact of asset purchase policies is that their causal impact on the economy is still imperfectly understood*".

[14] Duration channel not only reduces risks about a specific debt, but it also improves financial condition of the banking sector for the share that they hold of that debt, in what often called "capital relief channel".

[15] De Santis and Holm-Hadulla (2017), estimate the effect of instrumented purchases volume (flows effects) on yield, but as they have stated such measure is boarder that local supply, and might capture also other channels.

IIA5: UNCONVENTIONAL MONETARY POLICY IN THE EMU

In this section I briefly outline the main events that have characterized unconventional policies of the Eurosystem and describe its main purchase program: the Public-Sector-Purchase-Program. I will not discuss those aspects related to forward guidance policies.

The ECB, as many other central banks, engages itself in non-standard monetary policy to react against the financial crisis that spread out from the mortgage crisis in the US. In addition to the conventional tool of the interest rate, the Eurosystem developed various unconventional policies, going from expanding and facilitating credit to the banking sector to purchase programs of debt security from financial markets. The first measure the ECB implemented was the expansion of the LTRO from three to six months at the end of March 2008. The following year the LTRO was further expanded to twelve months for three allotment dates. In the same year to sustain credit institutions of the area the ECB launched the first asset purchase program, which took the name of Covered Bond Purchase Program (CBPP or CBPP1). CBPP ended in June 2010 once the announced amount of 60 billion of securities was achieved. In November 2011, the Eurosystem launched a second covered bond purchase program (CBPP2). This round of purchases concluded on the 31th of October 2012 when it reached a nominal amount of 16.4 billion of euros. For both CBPP1 and CBPP2 the Eurosystem announced to hold the bought assets until maturity.

In 2010 The ECB implemented its first public sector purchase program, namely the Security Market Program (SMP), involving a total of 84,655 billion of debt security. The program was intended to support the peripheral countries of the union that were facing high spreads over their sovereign debts. The SMP was not accompanied by a specific period, nor by a detailed outline of the volume involving and the type of security. In addition, the purchases were not active during the whole period of the program (Eser, Schwaab 2015), hence it was not sufficient to mitigate the sovereign debt crisis in the euro-zone.

In December 2011 the ECB expanded the LTRO to thirty-six months in two allotment dates to support the banking sector. In august 2012 the ECB intervened again in the sovereign bond market through the so-called Outright Monetary Transaction (OMT) for those countries that comply with European Financial Stability Facility/European Stability Mechanism (EFSF/ESM) program.

In the last quarter of 2014 the ECB started the third covered-bond-purchase-program (CBPP3) and an asset-backed-security program (ABSP).

The first large-scale-asset-purchase program of sovereign debt of the ECB has been the PSPP implemented in March 2015. The formal announcement of the program occurred at the ECB press conference on the 22 of January 2015, but signals about it were already given in the last quarter of 2014 when private sector purchases (CBPP3 and ABSP) programs were implemented. The public sector purchases started in March, and they were involving a monthly total of 60 billion securities of both public and private bonds at their initial stage. The program was intended to last until September 2016, but conditional to the path inflation to its target, the purchase could be expanded further. The volume of the euro-area governments and agencies securities were based on the individual country's national bank share of the ECB Capital key. Concerning the reasons, officially QE was motivated by a period of low inflation that would be embedded into inflation expectation, reducing this term, thus increasing the real interest rate (Draghi, 2014). Given the effective lower bound, the nominal interest rate cannot be downwards adjusted, thus forcing the CB to intervene, outside the money market, in other asset markets influencing prices and quantity. The ECB outlined the channels through which they expected the program to work in a "pass-though" effect, that would have improved banking financing and lending condition, and a "portfolio balance" effect in investment decisions.

The scope of the PSPP was formalized by the ECB in the decision n.774 of 2015 as follow:

"The PSPP is a proportionate measure for mitigating the risks to the outlook on price developments, as it will further ease monetary and financial conditions, including those relevant to the borrowing conditions of euro area non-financial corporations and households, thereby supporting aggregate consumption and investment spending in the euro area and ultimately contributing to a return of inflation rates to levels below but close to 2 % over the medium term".

The purchases were constrained by two limits: one concerning the total amount of outstanding debt which could not go beyond the 33% of issuer debt and a second issue share limit of 25%. In regards of the security involved, the 88% must be issued by governments and recognized agencies while 12% by eligible international organization and multilateral development banks. In addition, the security must have a maturity between two and thirty years. From the operational side the 92% of the purchases are conducted by the NCBs and 8% directly by the ECB for risk sharing purposes.

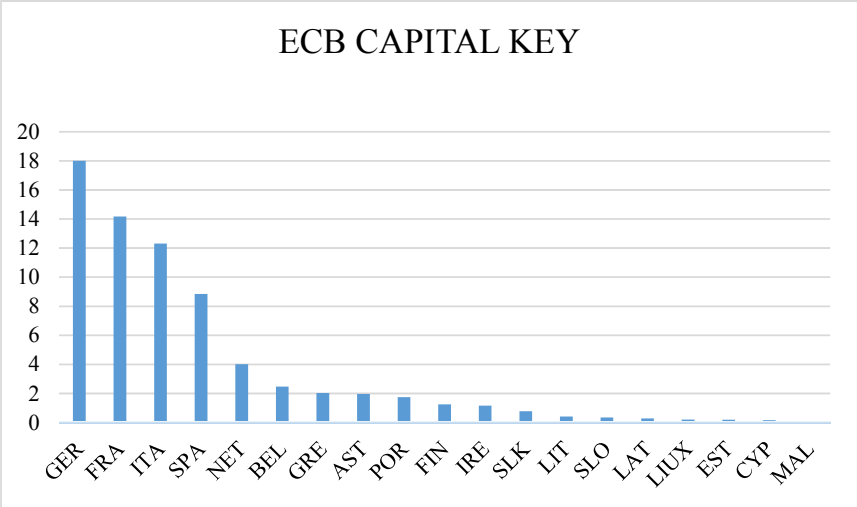


FIGURE 5: Capital key composition of the European Central Bank
Source: ECB

TABLE I: Monthly cumulative purchases during the PSPP program by country

PSPP QUARTERLY STOCK

	Austria	Belgium	Germany	Spain	Finland	France	Ireland	Italy	the Netherlands	Portugal
2015/Q1	1216	1528	11070	5447	774	8757	722	7609	2487	1074
2015/Q2	5045	6371	46332	22742	3237	36292	3016	31586	10344	4496
2015/Q3	8751	11008	80084	39304	5599	63329	5250	54787	17817	7770
2015/Q4	12641	15896	115625	56817	8086	91767	7583	79209	25612	11220
2016/Q1	16701	21022	152823	75160	10701	121577	9976	104797	34005	14844
2016/Q2	22750	28670	208269	103335	14615	165591	13251	144009	46365	19138
2016/Q3	27866	35119	255072	126387	17888	202538	15916	176160	56956	21840
2016/Q4	33200	41835	303946	150331	21291	240867	18565	209607	67824	24610
2017/Q1	39016	49092	355596	175946	23524	282372	20234	245584	79539	26617
2017/Q2	43564	54831	391897	194790	25477	315243	21790	274087	87808	28145
2017/Q3	47777	60152	425545	212299	26861	345617	23454	300571	95279	29570
2017/Q4	51961	65465	459318	230261	29163	375768	25284	326727	102783	31063
2018/Q1	53646	67649	473984	238498	30019	387960	26532	337208	106024	32475

In April 2016 the ECB announced the implementation of the Corporate-Bond-Purchase-Program (CPPP), bringing the total amount of purchases to 80 Billion. In December 2016, the Governing Council communicated the decision to modify the eligibility criteria of the PSPP, lowering the minimum maturity from 2 years to one, and to expand the program until, and potentially beyond, December 2017. In October 2017 the president and vice-president of the ECB announced the reduction of the purchases from 60 to 30 billion, starting from January 2018. In June 2018 the ECB announced the end of Quantitative Easing as security purchases from January 2019.

From March 2015, when PSPP started, to march 2018, the balance sheet of the ECB has increased of more than 3 trillion euros, going from 83% to 161% of the euro-area GDP. At the moment this document is written, inflation HICP is back to its target, unemployment is at 8.3%, and GDP growth around 2.5% in the euro-zone.

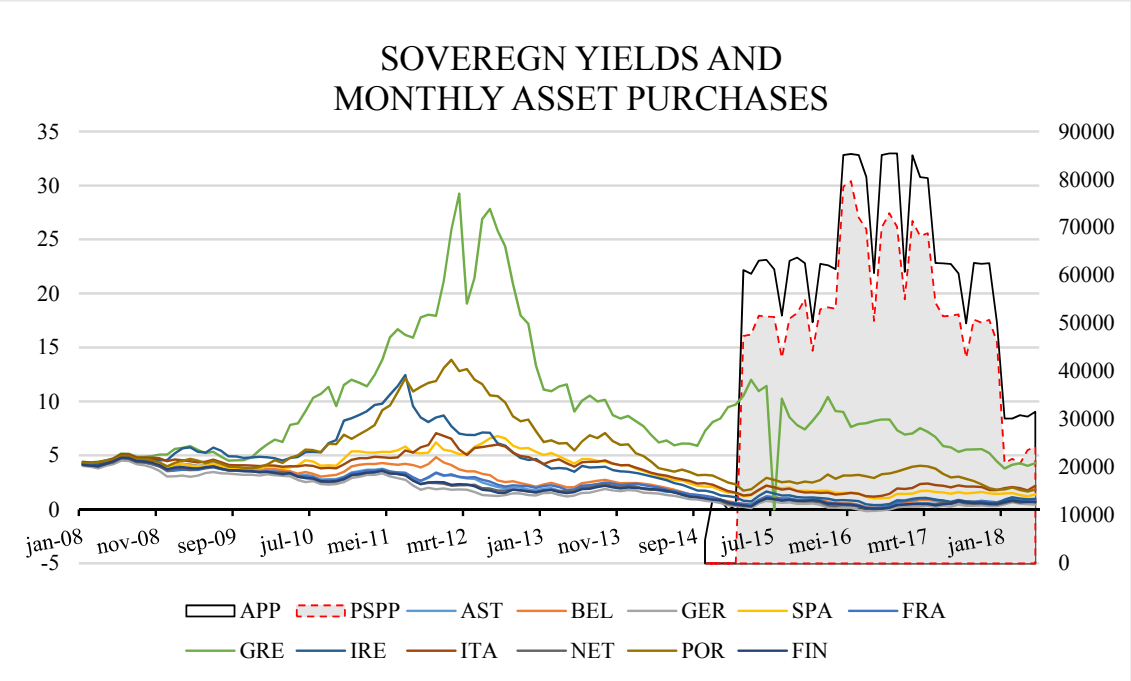


FIGURE 6: Sovereign yield of Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Portugal and Spain against the amount of purchases of the PSPP program (grey area) and the total amount of all purchase programs (Black line)
Source: ECB

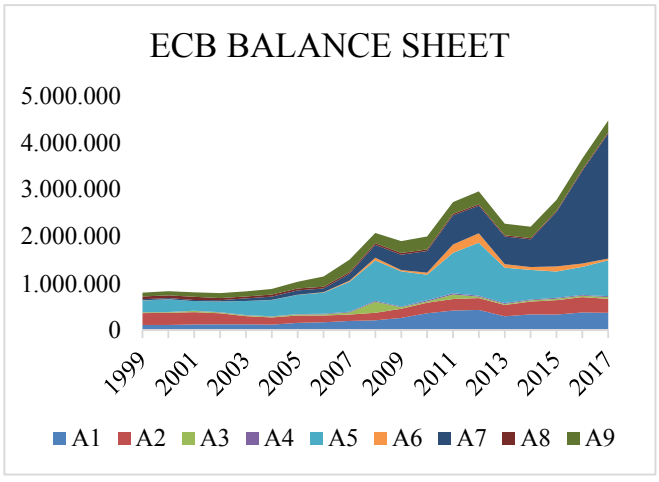


FIGURE 7: Composition of the asset side of the ECB balance sheet
A1 Gold and gold receivables
A2 Claims on non-euro area residents denominated in foreign currency
A3 Claims on euro area residents denominated in foreign currency
A4 Claims on non-euro area residents denominated in euro
A5 Lending to euro area credit institutions related to monetary policy operations denominated in euro
A6 Other claims on euro area credit institutions denominated in euro
A7 Securities of euro area residents denominated in euro
A8 General Government debt denominated in euro
A9 Other assets

TABLE II: This is an update and extended version of the table 1B of Fewley and Neely (2013)

DATE	PROGRAM	EVENT	DESCRIPTION	INTEREST RATE
3/28/2008	LTRO	press release	LTRO expanded: 6-month LTROs are announced.	
10/15/2008	FRFA	Governing Council press release	Refinancing operations expanded: All refinancing operations will be conducted with fixed-rate tenders and full allotment; the list of assets eligible as collateral in credit operations with the Bank is expanded to included lower- rated (with the exception of asset-backed securities) and non-euro-denominated assets.	
7/5/2009	CBPP/ LTRO	Governing Council press release	BPP announced/LTRO expanded: The ECB will purchase €60 billion in euro-denominated covered bonds; 12-month LTROs are announced.	ECB lowers the MRO rate by 0.25% to 1% and the MLF rate by 0.50% to 1.75%.
10/5/2010	SMP	Governing Council press release	SMP announced: The ECB will conduct interventions in the euro area public and private debt securities markets; purchases will be sterilized.	
6/30/2010	CBPP	Governing Council press release	CBPP finished: Purchases finish on schedule; bonds purchased will be held through maturity.	
6/10/2011	CBPP 2	Governing Council press release	CBPP2 announced: The ECB will purchase €40 billion in euro-denominated covered bonds.	
8/12/2011	LTRO	Governing Council press release	LTRO expanded: 36-month LTROs are announced; eligible collateral is expanded.	ECB lowers the MRO rate by 0.25% to 1%, and the MLF rate by 0.25% to 1.75%.
26/7/2012		Global Investment Conference	Draghi Pronounced the famous "Whatever it takes" at Global Investment Conference In London	
2/8/2012	OMT	ECB press conference	ECB President Mario Draghi indicates that the ECB will expand sovereign debt purchases. He proclaims that “the euro is irreversible.”	
6/9/2012	OMT	Governing Council press release	OMTs announced: Countries that apply to ESM for aid and abide by the ESM’s terms and conditions will be eligible to have their debt purchased in unlimited amounts on the secondary market by the ECB.	
4/9/2014		ECB press conference	Lowered the main refinancing rate by 10 bps to 0.05 percent and cut the deposit facility rate to -0.2 percent from -0.1 percent. The ECB also announced it would start buying securitized debt and covered bonds to ease the flow of bank funding to the economy.	Lowered MRO rate by 10 bps to 0.05 percent and cut the DF rate to -0.2 percent from -0.1 percent.
2/10/2014		ECB press conference	The European Central Bank left its benchmark interest rate on hold at 0.05 percent at its October 2nd meeting. Policymakers also decided to unveil the specifics of a plan to buy asset-backed securities and covered bonds.	
21/11/2014	ABSPP CBPP3	Frankfurt European Banking Congress	ECB announces to expand its balance sheet through purchases of ABS and Covered Bonds	
22/1/2015	PSPP	ECB press conference	The European Central Bank announced an asset purchase plan of 60 Billion euros a month and left key interest rates unchanged	
9/3/2015	PSPP	ECB press conference	The ECB starts purchasing euro-dominated public sector securities in the secondary market and continue to purchase asset-backed securities and covered bonds started in 2014. The combined monthly purchases of public and private sector securities will amount to €60 billion	
21/4/2016	CSPP	Governing Council press release	ECB announces the start of Corporate Sector Purchase Program (CSPP) in June, in a total of 80 billion for the all APP	
1/6/2016	CSPP	Governing Council press release	ECB starts implementing the CSPP	
12/8/2016	PSPP	ECB press conference	ECB extends the purchasing program until December 2017	
26/10/2017	PSPP	ECB press conference	ECB announces to cut Bond -Buying to 30Billions	
14/6/2018	PSPP	ECB press conference	The ECB announced to terminate its quantitative easing program at the end of 2018	

IIA6: DETERMINANTS OF SOVEREIGN RISK IN THE EMU

In a world of uncertainty, for any investment decision that an agent may take, there will always be some sort of risk-return trade-off, to the extent that in security markets higher risks are compensated with higher returns. Conceptually, the interest rate can be defined as the subjective risk that market agents perceive when they price a risky investment[16]. Thus, if the decomposition of long-term rates, as explicated above, is correct, sovereign bonds yields represent the subjective risk that agents perceive in influencing the term premium. I assume normally this term mainly depends on macroeconomic and financial factors, while the expected future short term rate merely depends on monetary policy.

Conventionally, the price of sovereign bonds refers to financial theory like portfolio theory, according to which it is consequence of different risk measures. However, the sensitivity at which agents price different factors can change according to the specific economic and time context in which they are inserted[17].

Among the sources of risk most commonly identified we find *default risk* that consists in a country unable or unwilling to repay its debt. Country's default is a situation that occurred, often in the past, when a country was borrowing not in its own currency or when a large part of its debt was denominated in a foreign currency (for instance Argentina 2001). From this prospective, euro-zone countries face a similar problem since they gave away their national monetary sovereignty when they joined the union, thus they issue sovereign debt in a currency over which they have no direct control. In addition, the ECB by law cannot directly finance public debt of a member state. Default risk is generally measured by means of fiscal variables, overall Debt/GDP ratio and deficit/GDP ratio[18].

Another source of risk is *Liquidity*, which can be defined as the ease and speed at which an asset can be sold at fair market value (Bodie, Kane, Marcus, 2014). Thus, Liquidity risk consists in the difficulty of selling the asset at a future date. It is conventionally measured by the bid-ask spread, which is the differential between the ask price (the price you would pay to

[16] A first distinction useful to state is between interest rate and yield. The interest rate generally refers to the coupon that a certain bond pays, expressed as annual percentage, of their par value. It is a fixed characteristic of the contract, also called the coupon rate. The yield on the other hand is an artificial measure of the return of an asset given its maturity.

[17] Specifically, market agents value the same information differently according to the economic situation, contrary to what efficiency market predicts (De Grawue and Ji, 2012). Indeed, many studies (Afonso et al 2015, Fratzsher, and Beirne 2013, De Grauwe and Ji 2012) on the EMU find changes in fundamental pricing behavior for EMU bonds before and after the crisis of 2007-2009. Beirne and Fratzsher (2013) show that fiscal fundamentals have been systematically underpriced before the crisis and overpriced after the crisis. This type of finding is also consistent with previous studies realized at the beginning of the crisis (Shuknekt 2010).

[18] However during the crisis the ECB managed to bypass the treaty law without violating it, and acting as Lend of Last Resort (LOLR) for sovereign debt (De Grauwe 2012, Buiter and Rahbari 2012).

buy a security from a dealer) and the bid price (slightly lower price the dealer would pay to buy that security.

Other sources of risk can come from regional or global factors (Codogno et al. 2003). Indeed, *systemic risk* that arises when financial conditions of a country are threatened by a financial crisis occurred elsewhere, is particularly relevant for the EMU which is structurally area subject to financial stress and speculative actions, perhaps more than other advanced economic areas. It is important to control for these financial stress factors, especially since our sample incudes the whole period of the sovereign debt crisis.

Another factor that many studies take into account is the *economic activity* of a country, often proxy by the growth rate, since an increase in growth rate increases debt sustainability.

One other risk factor often taken into account when analyzing long-term rates is *inflation* risk. A long-term investment needs the interest rate to hedge from the increase in price level in order to be profitable[19].

One more factor influencing risk premium in the euro-zone is characterized by risk of *redenomination*, corresponding to the risk that a specific euro-denominated debt will be converted in a new devaluated currency (De Santis 2015). Apparently, this risk was high during the sovereign crisis of 2011-2012[20], and it is strictly linked with the possibility of a country exiting the euro (Cœuré, 2013), thus strongly dependent with evolvements happening in the political arena at country-level. Support for this argument comes from recent events related to political turmoil in Italy and Spain[21] associated with increases in bond spreads, similarly to what occurred in Greece in 2015. The OMT operation of the ECB had, indeed, the main scope of functioning as device to lower redenomination risk (Cœuré, 2013) contributing in yield declining from July 2012 (De Santis 2015).

Ultimately, we must consider that the choice of which fundamental must be included in explaining sovereign risk is not a trivial task as Beirne and Fratzscher (2013) underline in their study:

"…the choice of the empirical model for the pricing of sovereign risk is far from uncontroversial as there is a multitude of potential fundamentals that may influence the sustainability of debt and thus the price of sovereign risk…"

[19] This element is not always present in sovereign risk analysis. Perhaps in a world characterized by central banks with a price stability mandate and or in time of recession when the economy is threatened by deflation, inflation risk becomes less relevant. I have decided instead to control for inflation since it should represent the most basic form of risk in a long term investment.

[20] Mario Draghi in the press conference on the 14th of June of 2018

[21] For example see the Bloomberg article "*Italy Falls Into Political Chaos as Populists Slam President'*

II B: LITERATURE REVIEW

The literature regarding QE is vast and varies with remarkable differences of analytical approach, methodology and focus. My aim here is to briefly summarize some of the works that had major influence on my research dividing them in theoretical and empirical researches.

IIB1: THEORETICAL STUDIES

Concerning the theoretical literature on QE, one of the most influencing works is doubtless the Woodford (2012) paper presented at the Jackson Hole symposium in 2012. The paper regards both forward guidance and Balance sheet policies as main unconventional monetary measures. In regards of balance sheet policies, Woodford explains the difference between credit easing and pure quantitative easing. The author raises several questions to many common beliefs around the mechanism of QE: specifically, he strongly criticizes the portfolio-balance effect. The author, also, treats the Japanese experience in balance sheet expansion, highlighting the limitations of the program and providing arguments regarding its scarce results. The overall conclusion of Woodford is that QE can operate only through a signaling channel affecting agents' expectation over future path of the short rate, establishing what is sometimes referred as the New Keynesian interpretation of balance sheet policies (Meaning and Warren 2015). Woodford relies some of his conclusions on previous works based on the Japanese experience like Ueda (2012). Ueda formulates first the classification of unconventional monetary policies in forward guidance and quantitative easing, and further sub classified the latter into pure QE and credit easing as taken in this paper. Shiratsuka (2009) explicates thoroughly balance sheet policies and what are the scopes of a liability-side driven policy and those of an asset-side driven policy.

Joyce et al (2012) offer a detailed and interesting summary of the portfolio-balance in light of the critics of Woodford. They state that the representative agent's assumption that constitutes the foundation of Woodford and Eggertson (2003) is extreme, at least as the one of imperfect substitution among bond classes in Vayanos and Vila (2009). Thus, the New-Keynesian theoretical argument against the portfolio-balance shows, from a theoretical prospective, equal fragility as the object they are criticizing. They also provide a brief summary of the main empirical works on portfolio balance, some of them cited in this review.

Regarding portfolio balance one of the most cited works is Vayanos and Vila (2009), since it is the first formulating a model for the SMT. The model poses the essential assumptions of not-perfect substitutability between bonds' classes, and agents' heterogeneity essential to obtain portfolio balance effects. Even though often subject to criticisms, this paper constitutes the theoretical base of most assessments of unconventional monetary policy acting via portfolio balance effect.

Bhattarai, Eggertson and Gafarov (2015) present a signaling theory for quantitative easing that starts from the assumption of neutrality of open market operations, since switching debt from private to public sector have no effect on agents pricing behavior. According to their model QE can affect only expected short-term rates and not the term premium, which excludes portfolio balance effects. Their main conclusion is that government policies that shorten total duration provides incentives to keep future short-term rates low, by signaling it to the private sector. According to Bhattarai et al. the incentive is given by possible future losses on the central bank balance sheet.

IIB2: EMPIRICAL STUDIES

One of the most cited empirical assessment on QE is Krishnamurty and Vissing-Jorgensen (2011). In this paper the authors analyze QE1 and QE2 programs of the FED by mean of the "Event Study" methodology followed by a regression analysis and provide a discussion about the channels through they expect QE to work. Specifically, they list seven channels namely signaling, duration risk, liquidity, safety premium, prepayment risk premium, default risk and inflation. The event study provides evidence of the effect of quantitative easing policy of the FED to the extent of a reduction of the 10-years US Treasury bond yield by 160 bps. The main channel that contributed in this reduction was the safety premium. However, the regression analysis, obtained regressing the spread between corporate bonds and treasury on a maturity-based measure of supply of treasury plus some default controls, shows effects of much smaller magnitude, in the order of 4 and 11 bps. An earlier study of Gagnon, Raskin, Ramache and Sack (2010) found evidence of a reduction in long-term yields in the US during QE1 implementing both an event-study and a time series analysis. Using two-day data, they observe a set of 8 events constituting their baseline and found a reduction of 10-year treasury yield of 90 bps as cumulative effect. The authors state that these effects have been attributed mainly through a reduction of term premium rather than signaling of future policy, and that it has been obtained with a reduction of bond supply by the FED. In their time series analysis they regress the 10-year yield term premium on a set of macro controls and measures of the supply of long term debt (under the assumption that the term premium is exogenous in respect to bond supply). The results, obtained with OLS, show a reduction of 10-years treasury yield due to a reduction of bond supply of about 6 bps. The work of Gagnon et al. is also one of the most cited papers regarding portfolio balance: it provides an intuitive explanation of the idea of Tobin applied on monetary policies, and an easy way to test its validity. The interpretation of the portfolio balance as transmission channel assumed in this research mainly relies on their work. However, a later replication of the model of Gagnon et al. made by Thornton (2012) using the same time series regression show that once a time trend is taken into account in the analysis, there is no more evidence of any portfolio balance effect. All measures of bond supply included in Gagnon et al become not significant, suggesting that a portfolio-balance effect cannot explain the reduction of yields. Christiansen and Rudebush (2012) employ dynamic-term-structure-models (DTSM) on the US and UK market to detect the effect of signaling through interest rate expectation and portfolio balance on term premium. They found a greater effect of signaling in the US and a greater term

premium effect in the UK. Regarding the effect in the US they found a cumulative decline over 8 announcements of almost 100 bps, while on the 10-year Gilt yield in the UK is about -43 bps. However the authors do not separate the overall effect into its channels. Buer and Rudebush (2013) analyze the effect of the FED large scale asset purchase on interest rates observing the signaling channel, identified as the effect of non-standard policies on the risk-neutral component. The authors implemented event-study methodology observing different rates, and by mean of assumptions they separate the effect of the different channels. Bauer and Rudebush assume that changes in the OIS rates reflects the signaling, while movements in the yields-OIS spread represents the portfolio balance. The results of the event studies show a cumulative reduction of 10-years yields of 89bps. They then decompose the total effect into risk neutral and term premium, employing a DTSM descending it in various alternatives. These estimates are stronger in magnitude since the reduction is equal to 93, 94 and 102 bps, and the decomposition go from 31 to 46 bps reduction attributed to the risk neutral component, and 47 to 71 bps of reduction attributed to the term premium for 10-year yields. The interpretation given by the authors is that of an evidence of the signaling channel and that purchase program made up by the FED served as reinforcing expectation over short term rate. D'Ámico and King (2012) find evidence of local supply channel in the US. Cahill, D'Amico, Li, and Sears (2013) conduct an investigation of the effect of QE on treasury yields through a 5 episodes ES. Their main focus is to separate duration from local supply and estimate the individual channels, once other pre-announcement factors have exhausted their affect. Contrary to previous studies D'Amico et al. employ security-specific intra-day data which allow them to observe the effect of monetary policy by duration/maturity and Liquidity characteristics. The identification procedure goes as follow: local supply is detected observing difference in yields between securities included in the purchase program and those excluded. Indeed the included ones show a more persistent (considered as more hours after the FOMC announcement) decrease while those excluded show tendency of reversing their previous decline, which would suggest the existence of a local supply channel. Moreover the effect on yields differ for duration, specifically the authors observe that the yield change reaction is convex in duration. They construct an ad hoc measure of Local Supply and Duration channel by characteristics of the security and insert these measures in a regression analysis. They found an effect of local supply shock between 5 events that range from -1.8bps to -7.8 bps and that of duration shock range from -1.5 to -8.5bps.

Concerning the British literature on QE Joyce and Tong (2012) implement a panel analysis of gilt-specific data, at high frequency. They analyze both the effect of the purchases and the announcement, and find a reduction of gilt yield in a range between 10 to 120bps, depending on when the announcement was made and on the maturity of the security with longer maturity asset being the most beneficial.

Furthermore, about the European literature, Eser and Shwaab (2015) employed a panel regression on a group of EMU peripheral countries estimating the effect of the SMP, the very first purchase program implemented by the ECB in 2010. They estimated an impact of the purchase that vary from -1 and -2 bps for Italy and -16 and -21 in Greece. One of the first works on the PSPP is Andrade, Breckfelder, De Fiore, Karadi, and Tristani (2016). They found effect on asset prices around the announcement while scarce evidence of any effect during the purchases. Andrade et al. focus primarily on the asset-valuation channel in its two sub-channels of duration risk and capital relief. They evaluate this channel looking at bank asset prices in correspondence of the APP announcements and found evidence of it. They first perform an assessment regarding the effect of the PSPP on bond yields, employing an event-study analysis around the dates of the announcement (22 January 2015) and the implementation (9 March 2015) of the PSPP. They observe a decline in yields for all class maturity and interpret this as a reduction of duration on the market. The bank-level analysis shows evidence of asset valuation channel since the share of sovereign holding has explanatory power for bank stock prices and the higher the exposure of a bank to sovereign bonds the higher the increase in stock. They then analyze expectations about inflation in consequence of the announcements, and show how the fall in disagreement (which constitutes an improvement around inflation expectation) is consistent with a signaling interpretation of the ECB policy. Interestingly, they also study the persistency of the announcement, since is often attributed to QE measures to not have long lasting effects (The net effect of QE1 on 10 year treasury in the US is found to be positive in many studies). They employed a VAR on daily data and found that the half-life of the effect of APP on sovereign bond yield is one year.

Altavilla, Carboni and Motto (2015) is probably one the very first assessments of the PSPP. The authors underline the financial context in which the European program is inserted, which see a relative more relaxed situation, financially speaking, compared to LSAP1 in the US and APF1 in the UK. One of the main contribution of these paper is a proper model of segmented markets, able to explain transmission channel of the ECB policies, extending the work of

Vayanos and Vila (2009). Moreover Altavilla et al. offers the first event-study analysis of the announcement of the PSPP program providing evidences of the effect of PSPP on sovereign bond yields: with a drop around 50bps for the Italian security and around 35bps for the Spanish ones using intraday data. They also carry out a more elaborated analysis employing a regression of daily change of the yield of a given asset on a set of dummy related to the policy event plus a set of controls. The result show a drop in yield of magnitude of 75 bps for Italy and 80bps for Spain in a 1-day window, and 60 and 65bps in a 2-day window. When the macro controls are excluded the drops are respectively of 60 and 65 bps for Italy and Spain. The paper also constitutes a first assessment of the transmission channels for the euro-zone. De Santis (2016) estimates the impact of the news regarding PSPP on sovereign bonds. The author implemented a panel VECM with 9 EMU countries and constructs the variable "news" that captures the effect of the announcement of the program, to employ in the dynamic equation. A similar News indicator is employed in my research. The estimated reduction of sovereign yields is of 63 bps. De Santis and Holm-Hadulla (2017) conducted an analysis of the flow effect of asset purchase on sovereign bonds. They used security specific data at daily frequency estimating the effect through a two stage least square. They found a significant flow effect that lowers the yield of not only the securities purchased, but across other security classes as well. The average estimated impact of the flow effect is around 7 bps. Altavilla, Canova and Ciccarelli (2016) analyze the pass-through of unconventional monetary policy to the banking sector using banks-balance-sheet level data. The authors claim that the measures adopted by the ECB have significantly improved landing conditions in the Eurozone. Koijen, Koulischer, Nguyen and Yogo (2016) analyze the effect of QE on asset prices using security-level data, from the Centralised Securities Database, and constructing proper measure of duration able to track the reduction of euro-denominated sovereign debt as consequence of the purchases of the ECB. They also construct an instrumental variable strategy to estimate the effect of the announcement on yields finding an effect ranging between -1.7 and -4.5.

Blot. Creel, Hubert, Labondance (2017) assess the role of market sentiment and ECB policy on sovereign yields for the four major EMU countries. They employed a time series regression analysis, whose main specification is very close to what made in this research, but based on country level instead of panel. Blot et al. regress the long term sovereign yield on a QE indicator, namely the number of security held for monetary purposes, a measure of market sentiment, namely the Composite Indicator of Systemic Risk, and a broad set of

macro controls. Their results show a negative and statistically significant effect of the QE policy variable that goes from 43 bps impact for Spain, and 13 bps for Germany.

TABLE III

AUTHOR	**YEAR**	**CB**	**MAIN FOCUS**	**METHODOLOGY**	**RESULTS (Estimated effect on Sovereign Yields)**
Cagnog, Raskin, Remache, Sack	2010	FED	Portfolio Balance	Event study (ES), Time series (TS)	-90bps (ES); -6bps (TS)
Krishnamurthy and Vissing-Jorgensen	2011	FED	Transmission Channels	Event Study; Regression analysis	-160bps on 10y T-Bills
Thornthon	2012	FED	Portfolio Balance Effectiveness Test	Time series	Not Significant
Christiansen and Rudebush	2012	FED BOE		Event Study	-100bcp US -43bps
Bauer and Rudebush	2013	FED	Signaling Channel on risk-neutral component	Model free, DTSM	-89bps (Model Free); -93 to -102 bps (DTSM)
Cahill, D'Amico, Li and Sears	2013	FED	Local Supply and Duration Risk	Event Study, Regression	-8.9 average effect -4.7 LS and -4.2 DR
Eder, Schwaab	2014	ECB	SMP	Panel Regression	-16 and -21 (GRE)
Altavilla, Carboni and Motto	2015	ECB	SMT Model	Event Study	-75 and -60 bps (ITA) -80 and -65 bps (SPA)
De Santis	2016	ECB	"News" Effect	Panel VECM	-63bps
De Santis and Holm-Hadulla	2017	ECB	Flow Effects of QE		-7bsp
Blot, Creel, Hubert, Labodance	2017	ECB	Market Sentiment and QE	Time series	-43bps (SPA) -13bps (GER)
Koijen, Koulischer, Nguyen and Yogo	2016	ECB	Portfolio Blanca/ Duration channel	IV	-1.7 and -4.5.

III: EMIRICAL ANALYSIS

III A: METHODOLOGY

Empirical researches on the effects of QE policies may differ significantly depending on the specific aim and object that the researcher preset. Given the broad discussion around QE, its effects can be multiple and it could raise several research questions and consequently might bring to a wide set of methodology that can be potentially employed. In addition, the specific program and central bank taken into account also influences the choice of which empirical methodology to employ. The focus of this paper is to analyze the effect of quantitative easing program of the ECB on sovereign yields. What I intend to estimate is whether QE has reduced long term rates.

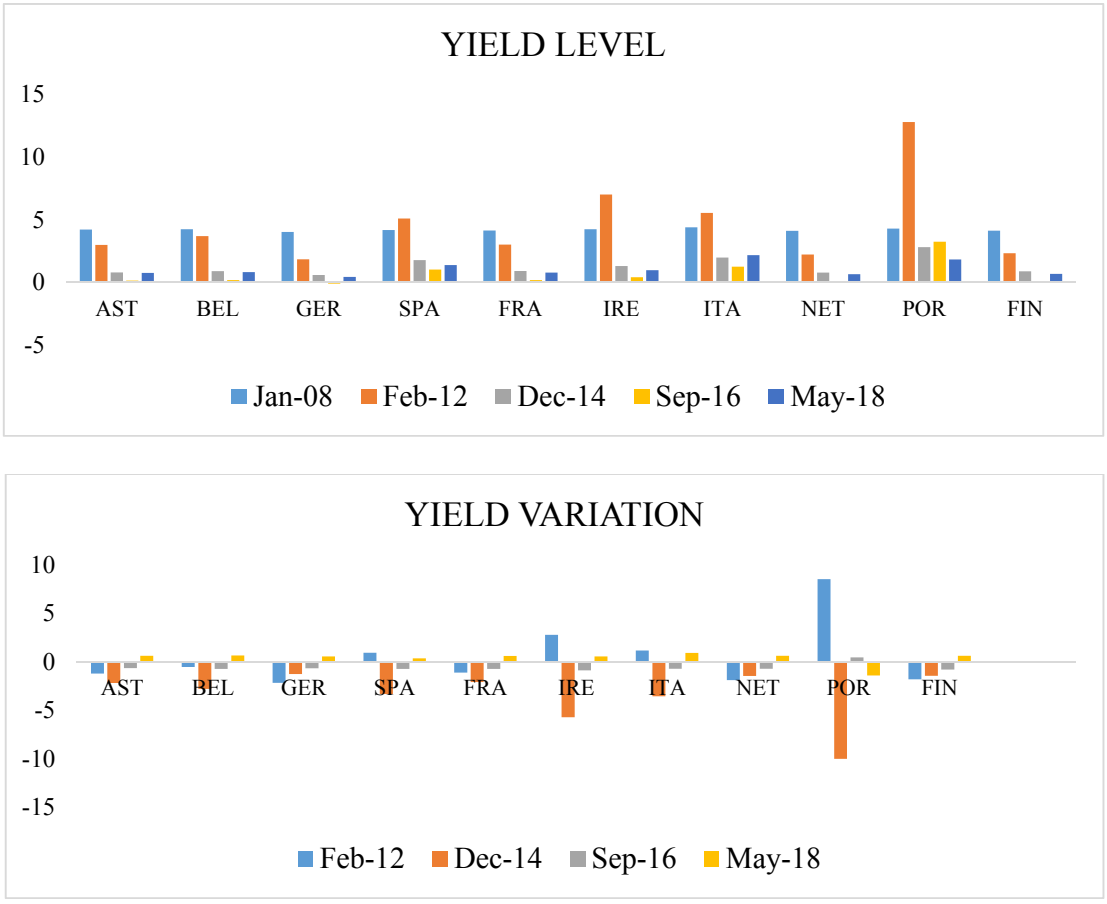


FIGURE 8: Sovereign yield expressed in actual level and variation
Source: ECB

As I have shown long-term rates in the euro-zone have systematically dropped from the third quarter of 2012 (fig. 6), and they have continued to decrease during the PSPP program, even though they slightly increase in correspondence of the beginning of the purchases. Between the first half of 2012, when financial stress was seriously threatening the euro structure and December 2014, at the verge of QE, all the EMU countries analyzed here show substantial drops in yields after OMT was lunched, especially those peripheral areas most hit by the crisis (as shown in figure 8).

What remains to verify is whether QE had actually an impact, in which way it did it, and what would be the best way to measure this impact.

First of all I will narrow the estimation to the implementation, and thus I will try to estimate a causal relationship between purchases of sovereign bonds by the ECB and yields, disregarding any empirical estimation of the announcement effect. One reason is that literature has provided sufficient evidence (Altavilla at al. 2016) of the impact of the announcement on euro bond yields by means of event study methodology. Another reason is given by the difficulty in finding a suitable measure of the announcement effect to be included in a linear regression. A possible way to solve this could be following the approach of De Santis (2016) and construct an indicator of the "news" around QE approaching the actual program that would indicate the intensity of signals regarding PSPP given to markets. The underlining assumption is that the announcements (disclosing speech of the monetary authority) would substantially increase the number of news delivered by specialized agencies like Bloomberg, whose users are mainly professionals, and thus a greater intensity of news can proxy the effect of the announcements in a regression analysis. I have constructed such a variable and it can be employed in a model without time fixed effects. More details on this variable can be found in the data appendix. Assuming that it is possible to proxy the announcement, the core of my analysis stays in the relationship between purchases and yields.

Regarding the implementation, the empirical approach could focus on the program as whole or alternatively, it could focus on the individual channels and estimate, when it is possible, the effect of these channels. However, the identification of the channels for empirical purposes can be problematic. If we exclude the signaling, it is left to identify the portfolio-balance effect which is decomposed into local supply and duration.

To identify the local supply we must be able to measure the variation in sovereign bond stock held by the market and how the intervention of the CB alters these stocks. We would need

available information about the whole aggregate of a specific debt security of a certain country existing on the market in a given data, and perhaps divided for maturity classes. If this was the case, we could have observed the dynamics of the total amount outstanding debt security issued by governments with original maturity equal to ten years and remaining maturity greater than one year. With successive transformations, a researcher could have proxy the local supply channel according to theory. The ECB statistical data warehouse releases monthly series of the total amount outstanding of government debt of the EMU countries. If we assume that the amount of debt held by the NCB is a good approximation of the purchases conducted by the Eurosystem (given that 92% of the actual purchases are realized by NCBs), it is possible to measure how these amounts count over the total outstanding and their monthly variation. Thus, the ratio of NCB government debt over the total outstanding represents my measure of local supply. This measure though must be considered as a "rudimental" indicator of local supply, forced by the lack of data. Indeed, one problem related to this approach is the lack of information about the specific security characteristics like duration and maturity. The ECB statistical data warehouse allows us to separate the aggregate debt between those with less or more than one year to maturity and it is, indeed, possible to exclude the latter (in line with the eligibility criteria of the PSPP). However no information is available regarding the original maturity, remaining maturity and duration.

The second channel is duration and it consists, as we explicated above, in the reduction of the overall duration within investors' portfolios, hence a reduction of risk and consequently downward pricing of sovereign risk by investors. If we could imagine visualizing a big portfolio composed by every portfolio of all agents active on the market, and compute the duration of a specific sovereign debt issued by a certain country at a given date, we could actually observe the pattern of the portfolio's duration and its evolution during QE. We would expect to see a significant reduction of overall duration during the whole purchase program, and this to be negatively correlated with sovereign risk. However, given the information available to the author, it is not possible to measure such an aggregate; hence it is not possible to measure the duration channel individually[22].

Alternatively, one could try to estimate the effect of the portfolio balance, without decomposing it. Literature on portfolio balance has employed transformed series of debt aggregates. Gagnon et al (2011) use the total amount of debt publicly held with maturity

[22] Koijen et al. (2016) measured average duration of sovereign securities from the Centralized Securities Database, which

greater than 1 year net of FED purchases divided by GDP. Contrary to the USA this level of detail about debt aggregates is not available for the EMU[23].

The lack of data that can properly allow measuring the individual channels is certainly disappointing and constitutes a great limit to the ambition of this research. With no channels to measure, it is still possible to estimate the general effect of QE on yields. This requires finding a causal relationship between the purchases of the ECB on countries long-term rates. In order to achieve such a result I will employ a panel data estimation of 9 EMU countries (Austria, Belgium, Finland, France, Ireland, Italy, The Netherlands, Spain and Portugal) with a sample of monthly data from July 2006 to May 2018 [24]. In order to reduce omitted variable bias, in addition to an indicator of quantitative easing, we must take into account all other factors that are commonly believed to influence the price of sovereign risk. In the "data appendix" I will provide a detailed list and discussion of the risk factors and the variables used to measure them. The baseline regression will have the following form:

$$R_{i,t} = \alpha + \beta' X_{i,t} + \gamma' QE_{i,t} + \vartheta_{it}; \tag{3}$$

Where $R_{i,t}$ represents the sovereign risk indicator of country i at time t. $QE_{i,t}$ is the quantitative easing variable, here expressed as country specific. The choice of a country-specific QE indicator allows us to include time fixed effects in the model, which with cross-section invariant indicator cannot be estimated. An alternative formulation of equation (3) without period fixed effect, employing a QE common for all countries will be performed. $X_{i,t}$ represents a set of macro controls that includes risk factor indicators commonly employed to measure sovereign risk. Assuming the disturbances follow a two way error component (Balatagi, 2008):

$$\vartheta_{it} = \delta_i + \mu_t + \varepsilon_{i,t} \tag{3.1}$$

Where δ_i and μ_t are respectively the country fixed effects and the period fixed effects. The term $\varepsilon_{i,t}$ is the idiosyncratic error of the model.

Country fixed effect represents those entity-specific aspects that are constant over time allowing for slope heterogeneity. Period fixed effect represent those underlining aspects that

[23] In addition, is not possible to construct a monthly series of portfolio balance like in Gagnog et al (2011) because it would require a monthly GDP.

[24] Not all series are updated until the last observation

changes over time and are common through entities. It has to be kept in mind that the introduction of fixed effects generate a loss of degrees of freedom of ($NT - T - N - K$), where N are the number of cross-sections, T is the number of time instants and K are the additional regressors. In a panel with a large time dimension like the one in this paper, the introduction of time fixed effects generates a substantial loss in degrees of freedom. In such a case when introducing fixed effects a researcher faces a trade-off between precision in estimates (in other word a reduced omitted variable bias) and degrees of freedom.

III B: RESULTS

Table one displays the outcome of the baseline regression based on equation (3) with yields as dependent variable. The main regressor is *log*(PSPP) which is the logarithm of the cumulative amount of purchases of government security by country and represents the stock effect of QE. The coefficient of *log*(PSPP) is the semi-elasticity of yield in respect to a change in the amount of securities purchased. The macro controls included are the fiscal variables (Debt to GDP ratio, and government balance to GDP ratio), real growth rate as indicator of economic performance, the inflation rate, the Bid-Ask Spread as liquidity risk indicator, sovCISS as systemic risk indicator and Periphery. Column (2) presents the estimated coefficient of the specification without fixed effects and White period standard errors for heteroscedasticity. The QE variable *log*(PSPP), shows the right sign and is significant with an estimated impact of 15 bps of reduction in sovereign yields. Fiscal variables have the right sign but are not significant and their impact is low in size with a coefficient of Debt to GDP ratio close to zero. Real Growth rate is not significant and has a positive sign, contrary to what expected. Inflation also is not significant. Indicators of Liquidity and systemic risk are significant and with an estimated impact of 6 and 4 bps of increase in yield. Periphery, which embodies, the effect of the sovereign crisis over the peripheral countries, is significant and has the highest explanatory power accounting for 48 bps of yield increase. Thus, column (2) suggests that QE indeed had an impact on sovereign yields, that fiscal variable have little explanatory power and that the sovereign crisis explains an increase in rate of about 0,5 percent point for the GIPSI[25]. The regression in column (3) introduces time and cross-section fixed effects: Log(PSPP) now shows the wrong sign and turns out to be not significant. The impact of periphery is remarkably reduced and not significant. The remaining regressors, excluding Real Growth rate show the right sign. The introduction of fixed effects makes QE variables no more impacting on yields, suggesting that purchases had no effect. However, it is possible that fixed effects soak up the impact of purchases on yield, as it is likely to happen to periphery. If this is the case column (3) do not necessarily implies that QE had no effects.

[25] GIPSI refers to Greece, Ireland, Portugal, Spain and Italy. Greece is not included in my analysis, thus the acronym here refers to the remaining countries.

TABLE 1: Baseline Regression. Equation (3) including sovereign yields as dependent variable. For each variables are reported the coefficient and the *t-statistic* between brackets. The st. errors are White period.

	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*
coefficient (*t-statistics*)			*FE*	*FE*	*FE*	*FE*	*Cross-Section FE*
constant	***4.15***	***1.94***	***-0.08***	***1.55***	***0.13***	***-0.79***	***6.12***
	(20.84)	*(9.37)*	*(-0.24)*	*(1.10)*	*(0.36)*	*(-0.89)*	*(5.87)*
Log(PSPP)	***-0.28***	***-0.15***	***0.05***			***-0.17***	
	(-16.70)	*(-8.21)*	*(0.52)*			*(-1.80)*	
Log(NCB_debt)				***-0.15***			
				(-1.02)			
Log(SHMP)							***-0.54***
							(-9.26)
Local Supply					***-0.01***		
					(-2.51)		
News							***-0.02***
							(-7.14)
Debt to GDP		***0.00***	***0.02***	***0.02***	***0.02***	***0.02***	***0.00***
		(0.54)	*(3.15)*	*(3.72)*	*(3.60)*	*(2.64)*	*(-0.38)*
Government Balance to GDP		***-0.03***	***-0.06***	***-0.06***	***-0.06***	***-0.07***	***-0.15***
		(-0.62)	*(-1.89)*	*(-1.76)*	*(-1.74)*	*(-1.29)*	*(-8.33)*
Real Growth rate		***0.03***	***-0.01***	***-0.01***	***-0.01***		
		(1.08)	*(-0.68)*	*(-0.51)*	*(-0.55)*		
Unemployment						***0.14***	***0.20***
						(2.01)	*(5.41)*
Inflation		***0.10***	***0.06***	***0.07***	***0.07***	***0.23***	***0.52***
		(1.49)	*(2.03)*	*(2.11)*	*(2.02)*	*(4.73)*	*(8.12)*
Bid-Ask Spread		***0.06***	***0.05***	***0.05***	***0.05***	***0.06***	***0.06***
		(4.04)	*(4.59)*	*(4.47)*	*(4.46)*	*(4.83)*	*(5.10)*
sovCISS		***0.04***	***0.04***	***0.04***	***0.04***	***0.03***	***0.02***
		(7.35)	*(9.61)*	*(9.77)*	*(9.75)*	*(2.39)*	*(3.90)*
Periphery		***0.48***	***0.04***	***0.06***	***0.05***		
		(2.05)	*(0.26)*	*(0.32)*	*(0.27)*		
R^2*_adjusted*	*0.40*	*0.79*	*0.94*	*0.94*	*0.94*	*0.90*	*0.90*
DW	*0.04*	*0.13*	*0.33*	*0.33*	*0.33*	*0.22*	*0.40*
n	*1989*	*1218*	*1218*	*1218*	*1218*	*1218*	*918*
Period	*2000M01 2018M05*	*2006M07 2017M12*	*2006M07 2017M12*	*2006M07 2017M12*	*2006M07 2017M12*	*2006M07 2017M12*	*2009M07 2017M12*

Column (2): Equation (3) without fixed effects employing *Log(PSPP)* as QE variable
Column (3): Equation (3) with cross-section and time FE employing *Log(PSPP)* as QE variable
Column (4): Equation (3) with cross-section and time FE employing *Log(NCB_debt)* as QE variable
Column (5): Equation (3) with cross-section and time FE employing *Local Supply* as QE variable
Column (6): Equation (3) with cross-section and time FE employing *CLIFS* as financial stress indicator instead of sovCISS. Column (7): Equation (3) with cross-section and time FE employing cross-section invariant variables and VIX indicator instead of sovCISS.

Another possible explanation is that time fixed effects absorbs the long declining trend of yields consequently to introduction of the OMT. However, without properly identifying the OMT in the regression it is not possible to distinguish between the OMT and other unobservable time effect in the euro-area. Column (4) and column (5) are replications of column (3) employing different indicators of QE. In column (4) the logarithm of government debt held by NCBs replaces *log*(PSPP). Although the estimated coefficient is negative and consistent in size with column (2), it is not statistically significant. Column (5), instead, employs my constructed measure of local Supply. The coefficient of LS is the elasticity of yield in respect to local supply, expressed as quota of Government debt held by the Eurosystem over the total outstanding. Contrary to logarithm of monetary amounts, which are difficult to interpret because the purchased amounts are significantly different for every county, LS is easy to interpret as the elasticity of yield to increase in government debt held by the central bank. The estimated coefficient is statistically significant and negative but very small of approximately 1 bps, which indicates that the ECB should purchase, on average, the whole country debt to reduce the yield of one percent point if this relation is truly linear. Column (6) Replicates column (3) with alternative controls: unemployment is included in place of Real Growth rate and CLIFS in place of sovCISS while Periphery is excluded. The estimated coefficients change compared to column (2). *Log*(PSPP) shows the right sign and an estimated coefficient of 17 bps on yield reduction but is not significant. Unemployment rate is significant with an estimated impact on yield increase of 14 bps while inflation has the greatest explanatory power impacting rates with an estimated increase of 23 bps. Column (7) run a regression without time fixed effect, which allows to employ cross-section invariant variables. Regression (7) employs log(SHMP) as QE variable, the VIX Index as systemic risk variable and includes the variable News. The coefficient of News represents the impact on yields of one additional Bloomberg news responding to the criteria imposed above. The sample size also changes, since SHMP begins in July 2009 during the financial Crisis. Indeed the estimated intercept is much higher. The common measure of QE is significant and impacts yield with a reduction of about 54 bps. News also result significant but with a small coefficient of around -2bps. All the regressors are significant and have the proper sign with the exception of Debt to GDP ratio. Regression (7) confirms the results of column (2) of a statistically significant impact of QE on yields when time fixed effects are not included in the model. Table one also indicates that fiscal variables and real GDP growth have a limited explanatory power for sovereign yields in the EMU contrary to what conventional wisdom

suggests but in line with related literature (De Grauwe, Ji 2012)[26]. The Liquidity risk indicator is consistent in any regression, resulting significant and impacting yield with an estimated increase of about 6bps. The systemic risk indicators also result significant and consistent in magnitude in all regressions.

Thus, overall table one suggests potential effect of asset purchases during the PSPP program on yields in a specification when fixed effects are not included. Time fixed effects could absorb long lasting effects of OMT or soak up QE, and without tracking redenomination risk if difficult to distinguish between the OMT and other unobservable time effects. Theoretical implications of these results support the presence of portfolio balance effects consistent with SMT and preferred habitat.

The baseline model shows some limitations, that here are taken into account by performing alternatives models. A first problem arising from table one is the presence of serial correlation. Serial correlation occurs when the residuals are correlated between each other and could be caused by several factors such as omitted variables, neglected slope heterogeneity and neglected dynamic (Pasaran 2015). It generally means that some sort of "structure" in the residuals has not been captured by the model. Consequently to serial correlation, standard errors estimations might be not correct and some of the t-stats resulted significant may actually fall in the rejection region. In time-series analysis, the problem is often solved by including past lags of the dependent variable among the regressors. Applying this procedure in panel data transforms the model from static into dynamic and the model assumes the following form:

$$y_{it} = \alpha + \theta' y_{it-1} + \gamma' QE_{i,t} + \beta' X_{i,t} + \delta_i + \mu_t + \varepsilon_{i,t} \quad (4)$$

Dynamic panel regressions like equation 5 are commonly considered to suffer of bias in the estimator. This is because the lag dependent variable is, by construction, correlated with the error component, even if the residuals do not show serial correlation (Baltagi, 2008). Moreover the correlation of even one regressor with the disturbances makes all estimations inconsistent (smearing effect). However, is conventionally considered that for large T and small N the dynamic panel bias can be negligible (Nickell, 1981).

[26] It also must be remember that these three variables were quarterly and then extended to monthly, which of course have influenced the performance of their estimator. The bad performance of Real Growth rate might suggest that perhaps a measure based on the forecasted growth is more appropriate in pricing sovereign risk

Table two shows the results of the dynamic panel specification performed on yield and using log(PSPP), Log(NCB_debt) and Local Supply to proxy QE. The model is estimated with time and cross-section fixed effects and standard errors are White period. Introducing lag dependent modifies substantially the estimation, since most of the explanatory power is embedded in the lag that explains around 91 bps, but corrects for serial correlation according to the Durbin-Watson statistics. Now, most of regressors lose their explanatory function. Outside of Inflation, Bid-Ask Spread and CLIFS indicator, the remaining regressors show the wrong sing and are not significant. The QE variables show no impact on yields. Fiscal variables and Unemployment rate also have no explanatory power.

Table 2: Dynamic Panel regression. Equation (4) including sovereign yields as dependent variable and the lagged value as indipendent. For each variables are reported the coefficient and the *t-statistic* between brackets. The st. errors are White period.

coefficient (*t-statistics*)	*(1)*	*(2)*	*(3)* FE
constant	***0.02***	***-0.62***	***-0,10***
	(0.21)	*(-1.59)*	*(-1,26)*
$Yield_{-1}$	***0.91***	***0.91***	***0,91***
	(35.01)	*(36.18)*	*(34,69)*
log(PSPP)	***0.00***		
	(-0.20)		
log(NCB_debt)		***0.06***	
		(1.45)	
Local Supply			***0,58***
			(1,66)
Debt to GDP	***0.00***	***0.00***	***0,00***
	(0.19)	*(0.01)*	*(-0,10)*
Government Balance	***-0.02***	***-0.02***	***-0,02***
	(-2.98)	*(-3.14)*	*(-2,69)*
Inflation	***0.03***	***0.03***	***0,01***
	(2.71)	*(2.79)*	*(1,25)*
unemployment	***0.00***	***0.00***	***0,03***
	(0.11)	*(0.71)*	*(2,82)*
Bid-Ask Spread	***0.01***	***0.01***	***0,01***
	(2.63)	*(2.81)*	*(2,87)*
CLIFS	***0.00***	***0.01***	***0,01***
	(4.02)	*(4.39)*	*(4,95)*
Periphery	***0.09***	***0.08***	***0,08***
	(2.18)	*(1.85)*	*(1,97)*
R^2_adjusted	*0.99*	*0.99*	*0,99*
DW	*1.74*	*1.75*	*1,76*
n	*1218*	*1218*	*1218*
period	2006M07 2017M12	2006M07 2017M12	2006M07 2017M12

Column (1): Equation (4) with cross-section and time FE employing *Log(PSPP)* as QE variables
Column(2): Equation (4) with cross-section and time FE employing *Log(NCB_debt)* as QE variables
Column (3) Equation (4) with cross-section and time FE employing *Local Supply*.

The results of table two also suggests the presence of unit root for yields that potentially undermines the estimations of table 1, making more difficult to interpret the results even when are statistically significant. Thus is necessary to assume that exist an underlining cointegration relation between yields and fundamentals[27].

Potential unit-roots in the series are one aspect that has been disregarded so far. Sovereign yields and monetary stock, such as the QE variables included in the analysis, are likely to be integrated series. Conventionally, integrated variables becomes stationary once the series is differentiated, indeed differentiation is a standard procedure in time series analysis when variables have unit-roots. The analysis of unit-root in panel data can represent a hard task and strongly dependent on a set of assumptions. Here, I will not proceed with a formal unit-root panel analysis but, I will perform an alternative model by regressing the first difference of the dependent (yield) on the first difference of QE variables. The specification will have the following form:

$$\Delta y_{it} = \alpha + \gamma' \Delta QE_{i,t} + \beta' \Delta X_{i,t} + \delta_i + \mu_t + \varepsilon_{i,t} \quad (5)$$

Performing such regression slightly changes the economic meaning of the analysis. Indeed, now the focus shifts on the variation in long-term-rate, rather than the level, corresponding to a variation in the volume of security purchased. The latter is the so-called "flow effect" of QE. The set of controls included in (5) is in first difference or, if assumed to be stationary, kept in level. Table three presents the results for the differentiated specification which, according to the Durbin-Watson statistics, seems to not suffer of serial correlation. Column (4) employ as QE measure the variation in Local Supply. The estimated effect is accounting for -0.6 bps for a one percent variation of total debt hold by the Eurosystem, but it is not significant. The specification in column (4) accounts for unit-root and serial correlation, and employs a homogeneous measure for all countries. This estimates represents the most qualitative result, which does not provide evidence of flow effects, and thus of PB affects. The size of the coefficients in (4) are probably biased suffering from omitted variable in the specification[28].

[27] De Santis (2016) finds a cointegration relation between yields and fundamentals in a panel VECM model.
[28] It must be underlined that for a specification like equation (5) a VECM model would have delivered more accurate estimates. A VECM model would have required finding a cointegration relation between rates and fundamentals. To find such a relation is not an easy task, especially in panel data.

Table 3: Regression in first difference. Equation (5) including the variation of yield as dependent and QE *Flow effect* as main regressor. For each variables are reported the coefficient and the *t-statistic* between brackets. The st. errors are White period.

	(1)	(2)	(3)	(4)	(5)
coefficient		FE	FE	FE	Cross-section FE
(*t-statistics*)					
constant	***-0.02***	***-0.09***	***0.00***	***-0.09***	***-0.05***
	(-0.81)	*(-3.82)*	*(-0.01)*	*(-3.82)*	*(-0.98)*
Δlog(PSPP)	***-0.01***	***0.02***			
	(-3.09)	*(0.48)*			
Δlog(NCB_debt)			***-0.13***		
			(-1.92)		
Δlog(SHMP)					***-0.20***
					(-3.38)
Δ(Local Supply)				***-0.06***	
				(-1.34)	
news					***0.00***
					(-4.03)
government balance	***-0.01***	***-0.01***	***-0.02***	***-0.01***	***-0.01***
	(-2.66)	*(-4.75)*	*(-4.75)*	*(-4.84)*	*(-4.03)*
Inflation	***0.02***	***0.02***	***0.01***	***0.02***	***0.11***
	(4.18)	*(1.97)*	*(2.76)*	*(2.10)*	*(4.69)*
Δunemployment	***-0.01***	***-0.08***	***-0.02***	***-0.08***	***-0.02***
	(-1.69)	*(-1.90)*	*(-1.93)*	*(-1.93)*	*(-0.27)*
ΔBid-Ask Spread	***0.00***	***0.01***	***0.00***	***0.01***	***0.01***
	(0.28)	*(4.27)*	*(2.64)*	*(4.29)*	*(6.55)*
ΔCLIFS	***0.00***	***0.01***	***0.00***	***0.01***	
	(-0.31)	*(4.53)*	*(2.20)*	*(3.59)*	
VIX					***0.00***
					(-0.37)
R^2_adjusted	*0.02*	*0.52*	*0.44*	*0.52*	*0.09*
DW	*1.60*	*1.75*	*1.75*	*1.75*	*1.70*
n	*1242*	*1242*	*1242*	*1242*	*909*
period	2006M07 2017M12	2006M07 2017M12	2006M07 2017M12	2006M07 2017M12	*2009M08 2017M12*

Column (1): Equation (5) without FE employing the flows of PSPP as QE variable
Column (2): Equation (5) with time and cross-section FE employing the flows of PSPP as QE variable
Column (3): Equation (5) with time and cross-section FE employing the first difference of *log(NCB_debt)* as QE variable
Column (4): Equation (5) with time and cross-section FE employing the first difference of Local Supply[29]
Column (5): Equation (4) with cross-section FE employing cross-section invariant variables

Differentiating the variables does not provide any solid evidence of flow effects, hence does not support previous findings.

[29] $\Delta(Local\ Supply) = \frac{(Government\ debt\ hold\ by\ Eurosystem)_t}{(Total\ Outstanding)_t} - \frac{(Government\ debt\ hold\ by\ Eurosystem)_{t-1}}{(Total\ Outstanding)_{t-1}}$

Table 4: Regression on restricted sample. Replication of table 1 without Ireland and Portugal. For each variables are reported the coefficients and the *t-statistics* between brackets. The st. errors are White period.

	1	2	3	4
Coefficient		FE	FE	Cross-section FE
(t-stat.)				
constant	**1.41**	**1.23**	**2.26**	**8.34**
	(2.47)	(3.09)	(2.24)	(8.19)
log(PSPP)	**-0.21**	**-0.10**		
	(-16.16)	(-1.00)		
log(NCB_debt)			**-0.13**	
			(-1.45)	
log(SHMP)				**-0.63**
				(-12.77)
news				**-0.02**
				(-13.28)
Government Balance	**0.01**	**0.00**	**0.01**	**-0.01**
	(0.75)	(-0.76)	(2.96)	(-0.90)
Inflation	**0.09**	**0.07**	**0.04**	**-0.07**
	(2.37)	(1.43)	(3.43)	(-1.88)
unemployment	**0.31**	**0.12**	**0.02**	**0.43**
	(4.53)	(1.53)	(0.79)	(4.36)
Bid-Ask Spread	**0.09**	**0.19**	**0.09**	**0.15**
	(8.47)	(5.72)	(5.76)	(4.68)
CLIFS	**0.02**	**0.02**	**0.03**	**0.01**
	(8.66)	(2.36)	(16.36)	2.27
R^2_adjusted	0.64	0.95	0.98	0.90
DW	0.09	0.25	0.39	0.63
n	967	967	967	714
period	2000M01 2017M12	2000M01 2017M12	2000M01 2017M12	2009M07 2017M12

Column (1): Equation (3) without fixed effects employing *Log(PSPP)* as QE variable
Column (2): Equation (3) with cross-section and time FE employing *Log(PSPP)* as QE variable
Column (3): Equation (3) with cross-section and time FE employing *Log(NCB_debt)* as QE variable
Column (4): Equation (3) with cross-section and time FE employing cross-section invariant variables and VIX indicator instead of sovCISS.

A last problem is the remarkable presence of outliers in the data, especially when plotting dependent variables against fiscal fundamentals. The vast majority belong to Ireland and Portugal. Thus, I have performed a series of regression as in Table one but for a reduced sample without the two peripheral countries. The results can be found in table four and the estimations are in line with those of table one: the QE variables are not significant once time fixed effects are included in the model.

Table 5: Control Group. Replication of table 1 for the control group. For each variables are reported the coefficient and the *t-statistic* between brackets. The st. errors are White period.

	(1)	*(2)*	*(3)*	*(4)*
Coeficient	US,UK,SWE	US,UK,SWE	CAN, JAP, SWE, UK,US	CAN, JAP, SWE, UK,US
(t-stat.)		FE	FE	FE
constant	***3***	***3,42***	***2,20***	***0,00***
	(1,10)	*(4,31)*	*(2,12)*	*(0,42)*
Log(QE)	***0,23***	***-0,08***	***-0,09***	***-0,07***
	(7,69)	*(-1,02)*	*(-0,99)*	*(-0,47)*
Debt to GDP	***-0,04***	***0,01***	***0,01***	
	(-9,97)	*(2,69)*	*(2,95)*	
*Governmet Balace To GDP**	***0,02***	***0,09***		
	(1,27)	*(4,38)*		
Real Growth rate	***0,08***	***-0,10***	***-0,04***	***0,00***
	(3,33)	*(-5,40)*	*(-2,03)*	*(0,32)*
Inflation	***0,20***	***0,00***	***0,01***	***0,00***
	(4,89)	*(-0,12)*	*(0,35)*	*(-0,83)*
Bid-Ask Spread	***-0,47***	***-0,08***	***-0,21***	***-0,01***
	(-7,10)	*(-1,37)*	*(-3,75)*	*(-3,03)*
*Financial Stress Indicator***	***0,03***	***-0,01***		
	(6,64)	*(-1,40)*		
R^2_adjusted	*0,49*	*0,92*	*0,94*	*0,52*
DW	*0,17*	*0,23*	*0,21*	*2,29*
n	*431*	*395*	*689*	*692*
Period	2003M01 2018M08	2006M01 2018M03	2006M01 2018M03	2006M01 2018M03

*Quarterly series of government balance for Canada and Japan are not available.

** For Canada and Japan was not possible to find Indicator homogeneous to those of Sweden, UK and US.

Column (1): model without fixed effects for the United States, United Kingdom and Sweeden

Column (2): fixed effects model with White period St. Errors for the United States, United Kingdom and Sweeden

Column (3): fixed effects model with White period St. Errors for Canada, Japan, United States, United Kingdom and Sweeden

Column (4): employs the first difference of yields Δy_t on the first difference of the logarithm of monetary aggregates employed as QE indicator for Canada, Japan, United States, United Kingdom and Sweeden

Last, I have performed the baseline regression on a panel of not EMU countries, which forms the control group. The data description for this panel can be found in table VII in appendix C. Our baseline regression applied to the control group does not show any evidence of relationship between QE and yields. However, must be noticed that this panel aggregates countries with different experiences of balance sheet policies, not homogeneous among them, and difficult to compare with those of the EMU countries. In addition, the data set for this panel is poor compared to the study group one, and employs measures of QE which are not homogeneous.

In appendix C, I have replicated table one and three for sovereign spread and CDS[30]. Table six, for instance, reproduces table one for spreads. When replacing yields with spread, which is the gap between the country long-term-rate and its benchmark (the German 10 year government bond rate), one would expect to find similar results to those of table one. However, sovereign spread is a more specific measure of sovereign risk compared to nominal rates. Theoretically if both the yields of the observed country and its benchmark drop the same amount, then the spread would be unchanged and an analysis on both measures will deliver different results. Table six, overall, does not confirm the results of Table one. The impact of QE on Spreads is substantially less evident than the impact on yields. If we look at figure 10 in the appendix B, that plots the spread with Germany during the period of PSPP, we can clearly see that most of them show a stationary pattern and, for the Italian rates, the discrepancy even increased during the first semester of 2017. Consequently the results of table two are not excessively surprising. Moreover, the aim of the ECB was that of a reduction in long term rates and not of a reduction in regional spreads, which occurred after the "Whatever it takes" speech: It is likely that spreads reflects more redenomination risk than yields and consequently OMT had major impact on them. In addition, Germany was not excluded from the purchase program and actually it was the first country for purchase volume in respect to the ECB capital key. No impact of QE on spreads can be interpreted as evidence against portfolio balance. Indeed, the effect of QE on sovereign spreads is a stronger evidence of the impact on the term premium, given that all EMU countries share the same risk-neutral component. The analysis of flow effect on spreads delivers similar results of those of yields.

Table seven replicates table one for CDS, which is an alternative measure of risk for debt securities, and does not offer any evidence of QE effect in all specifications.

As a very last comment, I want to highlight that from table one, six and seven we can notice how the "news effect" of De Santis (2016) have a very limited impact, large as few bps, contrary to what of a much greater magnitude the author has estimated in his panel VECM regression.

It is hard to connect these results with previous works essentially because of methodology dissimilarities with previous literature. Indeed I am not aware of panel data on EMU countries estimating the effect of asset purchases on yields. The only comparable work is Eser and Shwaab (2015) which adopts an estimation method similar to that of equation (3). However the differences are remarkable: (i) they employed daily data; (ii) their sample size

[30] Table two is not replicated for CDS and Spreads because it delivers the same results as for Yields. Table three is not replicated for CDS because there is no evidence of the effect of QE on CDS.

goes from October 2008 to December 2011, and is focused on the SMP which is in no way comparable to the PSPP. Same frequency of data and a similar set of controls can be found in De Santis (2016), which though uses a panel VECM, manly to identify the effect of news.

Overall, the empirical findings obtained here do not provide solid evidence of the effect of QE purchases on yields decline, and they cannot be interpreted as causal effect. Nevertheless, from these results is not possible to exclude potential impact of QE.

The identification requires deeper investigation in addition to model improvements: in absence of a valid instrument (given that instrumenting ECB purchases is quite complicated and rarely found in literature[31]), the ideal would be to measure and track the individual channels, accessing security-level databases. Moreover redenomination risk also must be taken into accounts because being essentially the only source of risk that might fall completely out of the sphere of influence of the CB. Tracking redenomination risk might as well contribute in disentangle OMT form time fixed effects, and perhaps better isolate the direct effect of QE though its channels.

The results constitute an interesting finding even in light of the theoretical debate. Indeed from them is not possible to exclude that PB effects manifested during PSPP that can provide evidence of preferred habitat behavior in the EMU and deviation for market efficiency consistent with recent literature. This offers additional motivation for further research.

[31] Koijen et al. (2016) employs an IV strategy for the ECB purchases.

IV: CONCLUSIONS

This analysis of unconventional monetary policies and large scale asset purchase in the euro-zone suggests possible effects of quantitative easing on sovereign yields. By mean of a panel regression analysis of nine EMU economies, it is possible to provide evidence of yield reduction as consequence of asset purchases of the Eurosystem, which highlights the presence of stock effects of QE. However, the identification of the causal relation requires deeper investigation and methodology diversification.

The results are fragile and evidences drop when time fixed effects, that likely absorb the effect of OMT, are included in the model or when unit-root are taken into account.

The impossibility to disentangle the OMT from fixed effects and to track redenomination risk effects on term premium represents an additional challenge.

Moreover different conclusion must be drowning about the effect of QE on sovereign risk measured by yield spreads and credit default swaps. Still, in regards of the empirical analysis conducted here, it must be underlined that the limited possibility to identify and properly estimate the effects of the transmission channels narrows the investigative possibility for inference purpose.

These elements together provide ground for further research on the topic.

The analysis, also, highlights that the debate around unconventional monetary policy is still open, and there is no convergent consensus about its effects and mechanisms in academic literature. Specifically, the debate seems to be polarized between what we can call the "New Keynesian" approach and that of major central banks. The former consists in identifying the signaling channel as only possible way through which balance sheet policies operate, while the latter emphasizes possible portfolio-balance channels on financial markets. It is not trivial to assess the validity of the theoretical foundations of one approach against the other. Equally is difficult to observe empirical investigations able to dismantle the foundations of one or the other. Thus, I would rather be prudent in standing for one of the sides. However, the results, here obtained, suggest the presence of some degree of portfolio-balance effect consistent with preferred habitat and segmented market theories.

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DATA APPENDIX

The data-set is composed by variables that try to capture both the risk factors and the effects of unconventional monetary policy[32].

DEPENDENT VARIABLES

As dependent variables are employed 3 different measures: The country 10-years Government Bond Yield, the differential in 10-years government bond yields between country '*i*' and Germany, and the Credit Default Swaps. The CDS are given by Data Stream with monthly frequency. The sovereign yields are obtained on a monthly base from the ECB statistical data warehouse, while the spreads are computed by the author. The economic interpretation of these 3 measures is not equivalent. Yields represent the subjective risk that agents perceive when invest in that specific bond, while spread is a proper measure of sovereign risk in the EMU since it is the gap in yields with the benchmark. Employing one measure or the other can lead to different results.

INDEPENDENT VARIABLES

Default Risk. Fiscal variables are employed to measure default risk. Specifically, Debt/GDP and Government Balance/GDP. The latter is expected to be negatively correlated with the dependent variable since any improvement of Government Balance, which means a reduction of public deficit, should impact positively Sovereign Risk. Public debt, instead, is expected to be positively correlated with sovereign risk. As discussed above, the role of fiscal variables in determining sovereign risk is controversial. Moreover, the intervention of the ECB as LOLR should have reduced the impact of such variables, from the second half of 2012. The series are obtained from EUROSTAT and the frequency is quarterly. The quarterly value has been extended to each month of the quarter to create the monthly series following the approach of De Santis (2016).

Liquidity Risk. As proxy of liquidity risk I have decided to employ the Bid-Ask spreads. The expected sign is positive since any increase of the spread should indicate a worsening of the liquidity condition of government bonds. The series has been constructed by the author from Bloomberg data about BID price and ASK price of government bonds.

[32] Due to lack of free and available data is not possible to observe Redenomination risk at country level. Thus this factor needs to be disregarded in this research.

Economic Performance. The real growth rate is employed as indicator of economic performance. The expected sign is negative, as any improvement in the economic performance should drive a reduction in yields. The quarterly data are obtained from the OECD. The quarterly value has been extended to each month of the quarter to create the monthly series. I will also employ the unemployment rate as alternative measure. For lack of data was not possible to employ the forecast of the real growth rate and being in line with many recent studies (De Santis 2016).

Systemic/International Risk. To proxy international risk the VIX indicator is employed, in line with many studies on sovereign bonds. It is expected to be positively correlated with sovereign risk. The VIX indicator cannot be employed in a model with time FE. However it is possible to employ financial stress indicator designed for the euro-area. Financial stress Indicator: To measure this factor I will employ the sovereign CISS indicator constructed by the ECB. "SovCISS" is a composite stress indicator for EMU countries (Kremer et al. 2012). It is expected to have positive sign. Alternative measure can be CLIFS (country level index of financial stress) which is still a series released by the ECB.

QE News. To proxy the announcement effect of the PSPP I have constructed a variable composed by news about the program. Specifically it has been constructed summing the news article containing jointly the words "Mario Draghi", "Quantitative Easing" and "Euro Member" from BLOOMBERG terminal. The approach come from De Santis (2016), and the obtained series is in line with what the author constructed. The expected sign is negative. See the appendix B for a line graph of this series.

QE Purchases. The purchases can be measured in different ways. A first distinction is whether one focuses on country specific indicator or common indicators for all countries. A second distinction can be made dividing the variables in "stock effect" and "flow effect". The latter are the monthly purchases, while the former are the cumulative amount. For what concern the country specific indicator one can look at the monthly amount of asset purchased by the CB for each country during the PSPP program. I will label this variable as PSPP and I will apply a logarithm transformation (logPSPP). The series starts in March 2015, thus I have assigned the value of 1 before that date, which subject to logarithm takes value 0. LogPSPP is the main independent variable in this analysis. Other country specific indicator that can be employed comes from the NCB balance sheet items. As explained above the greater majority of the purchases are conducted by NCBs. Thus the size of NCBs balance sheet or the number

of government debt securities held by NCBs can be employed. The first one though may not be appropriate since it requires a proper analysis for each specific country to be considered as a valid one. The second aggregate looks instead more reasonable and easy to compare with the PSPP variable.

Instead of country-specific variables, a common indicator for the whole region, that will capture the effect of the overall program on the individual countries, can be employed. One measure is the amount of securities held for monetary purposes (SHMP) like in Blot et al (2017). This is a monthly series released by the ECB starting in 2009. I have applied a logarithmic transformation to this series. The difference between SHMP and PSPP is that the first measure includes purchases not exclusively of sovereign bonds but also of those securities included in other programs. Consequently SHMP is as broader measure of QE and cannot be considered specifically for the PSPP. All the measures mentioned here represent the general effect of the APP on yield but cannot be interpreted in terms of channels, which require specific measures able to express the effect of each channel.

Local Supply Channel. In the attempt of measuring the local supply channel I have employed the ratio of government debt held by NCBs over the total outstanding amount of government debt with a maturity greater than one year. Similarly this could be achieved simply by diving the purchases occurred during the PSPP program over the total outstanding amount. The choice of the NCB aggregate is motivated by the possibility of obtaining a continuous series, instead of one that starts in correspondence of the purchases. In addition the two aggregate show a very high correlation of about 84%.

Periphery. This variable is constituted by a dummy series that takes the value 1 for the peripheral countries (IRE, ITA, POR and SPA) during the period 2008m11 to 2012m11. This variable is meant to capture the high spikes in yields caused by the sovereign debt crisis that saw the peripheral countries heavily attacked on financial markets. It is expected to be positively correlated with yields. The estimated coefficient will show the average yield increase of being a peripheral country compared to core countries included in our sample (AST, BEL, FIN, FRA, NET).

TABLE IV

DEPENDENT VARIABLE	INDICATOR	DESCRIPTION		SOURCE	FREQUENCY
10-y sovereign bond yield	Sovereign Risk	long term interest rate		ECB	Monthly
Country spread with German bonds	Sovereign Risk	Sovereign Risk Indicator		ECB	Monthly
CDS	Sovereign Risk	Credit Default Swaps		Data Stream	Monthly
INDEPENDENT VARIABLES		**DESCRIPTION**	**EXPECTED SIGN**	**SOURCE**	
Debt/GDP	Risk Factor	Default Risk expressed via Fiscal indicator	(+)	Eurostat	Quarterly
Government Balance	Risk Factor	Default Risk expressed via Fiscal indicator	(-)	Eurostat	Quarterly
10 years-bid ask-spread	Risk Factor	Liquidity Risk Indicator	(+)	Bloomberg	Monthly
VIX Index	Risk Factor	Systemic Risk	(+)	Bloomberg	Monthly
sovCISS	Risk Factor	Financial Stress	(+)	ECB	Monthly
Real Growth rate	Risk Factor	Economic Performance	(-)	OECD	Quarterly
Periphery	Debt Crisis	Dummy =1 for IRE, ITA, POR, SPA from 2008m11 to 2012m11	(+)		
QE VARIABLES					
ΔLog(PSPP) Flow Effect	Monetary Policy	Number of securities purchased by the ECB during the PSPP program (Mar2015-Ongoing)	(-)	ECB	Monthly
Log(PSPP) Stock Effect	Monetary Policy	Cumulative amount of securities purchased by the ECB during the PSPP program (Mar2015-Ongoing)	(-)	ECB	Monthly
Log(SHMP) Stock Effect	Monetary Policy	Amount of securities held for monetary purpose by the Eurosystem	(-)	ECB	Monthly
Log(NCB_debt) Stock Effect	Monetary Policy	Amount of government debt hold by NCB	(-)	ECB	Monthly
LS (Local Supply)	Monetary Policy	Ratio of government debt hold by NCB over total outstanding	(-)	ECB	Monthly
News	Monetary Policy	Bloomberg News about PSPP	(-)	Bloomberg	Monthly
ALTERNATIVE					
Unemployment	Risk Factor	Economic Performance	(+)	ECB	Monthly
CLIFS	Risk Factor	Financial Stress	(+)	ECB	Monthly

APPENDIX A

TABLE V Correlation Matrix

	YIELD	LOG(PSPP)	LOG(NCB_GDEBT)	LOG(SHMP)	LS	NEWS	DEBT	GOVBAL	GR	UN	INF	BAS	SOVCISS	CLIFS	VIX
YIELD	1.00	-0.55	-0.18	-0.45	-0.14	-0.30	0.25	-0.66	-0.32	0.41	0.30	0.59	0.88	0.51	0.37
LOG(PSPP)	-0.55	1.00	0.45	0.79	0.48	0.07	0.11	0.39	0.31	-0.09	-0.23	-0.14	-0.44	-0.44	-0.41
LOG(NCB_GDEBT)	-0.18	0.45	1.00	0.42	0.24	0.03	0.42	0.12	0.11	0.31	-0.10	-0.13	-0.07	-0.26	-0.26
LOG(SHMP)	-0.45	0.79	0.42	1.00	0.49	0.07	0.20	0.43	0.33	-0.05	0.10	-0.02	-0.30	-0.47	-0.56
Local Supply	-0.14	0.48	0.24	0.49	1.00	0.00	0.06	0.08	0.53	0.10	-0.23	0.06	-0.11	-0.19	-0.30
NEWS	-0.30	0.07	0.03	0.07	0.00	1.00	0.10	0.13	0.20	0.03	-0.31	-0.09	-0.27	-0.19	-0.12
Debt to GDP	0.25	0.11	0.42	0.20	0.06	0.10	1.00	-0.07	-0.01	0.26	-0.04	0.20	0.21	-0.15	-0.18
Government Balance to GDP	-0.66	0.39	0.12	0.43	0.08	0.13	-0.07	1.00	0.15	-0.52	0.06	-0.17	-0.62	-0.57	-0.33
Real Growth rate	-0.32	0.31	0.11	0.33	0.53	0.20	-0.01	0.15	1.00	-0.13	-0.12	-0.17	-0.31	-0.25	-0.16
Unemployment	0.41	-0.09	0.31	-0.05	0.10	0.03	0.26	-0.52	-0.13	1.00	-0.15	0.17	0.44	0.18	0.00
Inflation	0.30	-0.23	-0.10	0.10	-0.23	-0.31	-0.04	0.06	-0.12	-0.15	1.00	0.23	0.38	0.03	0.09
Bid-Ask Spread	0.59	-0.14	-0.13	-0.02	0.06	-0.09	0.20	-0.17	-0.17	0.17	0.23	1.00	0.44	0.12	0.09
SOVCISS	0.88	-0.44	-0.07	-0.30	-0.11	-0.27	0.21	-0.62	-0.31	0.44	0.38	0.44	1.00	0.55	0.37
CLIFS	0.51	-0.44	-0.26	-0.47	-0.19	-0.19	-0.15	-0.57	-0.25	0.18	0.03	0.12	0.55	1.00	0.60
VIX	0.37	-0.41	-0.26	-0.56	-0.30	-0.12	-0.18	-0.33	-0.16	0.00	0.09	0.09	0.37	0.60	1.00

TABLE VI Statistics

	Mean	Median	Maximum	Minimum	Std. Dev.	Observations
YIELD	3.626224	3.96	13.85	0.03	1.798691	1989
SPREAD	0.792423	0.3	12.03	-0.05	1.38662	1989
CDS	110.0787	63.285	1015.759	11.025	131.6692	1090
PSPP	13904.99	1	396686	1	50554.56	1989
NCB_GDEBT	42873.83	14256	454517	75	69441.16	1989
SHMP	662306	269558	2523969	4232	763814.9	963
Local Supply	0.11031	0.086734	0.5042	0.001444	0.09598	1989
NEWS	2.579186	0	93	0	9.220602	1989
Debt to GDP	76.49172	70.5045	134.978	23.519	28.61968	1944
Government Balance	-2.859119	-2.681	6.855	-32.051	3.861289	1890
Real Growth Rate	1.711069	1.642876	27.74388	-9.140538	3.229237	1944
Unemployment	8.783575	8.27	26.3	3.07	4.144672	1989
Inflation	1.845067	1.865672	7.103064	-6.542969	1.447449	1989
Bid-Ask Spread	0.027289	0.009	1.461	0	0.091515	1288
sovCISS	0.182025	0.0891	0.9786	0.0082	0.207156	1917
CLIFS	0.128539	0.0922	0.8596	0.0074	0.110159	1989
VIX	19.80186	17.74	59.89	9.51	8.066854	1989

APPENDIX B

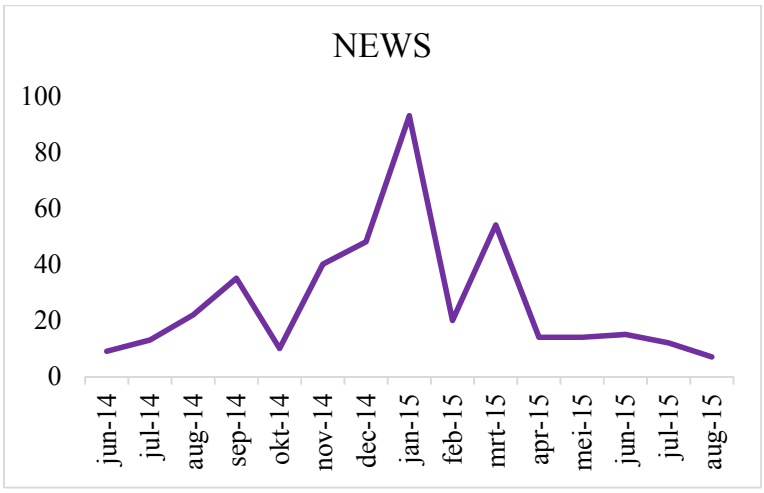

FIGURE 9: Line chart of the monthly number of news displayed by a Bloomberg terminal employing as searching criteria the words "Mario Draghi", "Quantitative Easing" and "Euro Member".
Source: BLOOMBERG

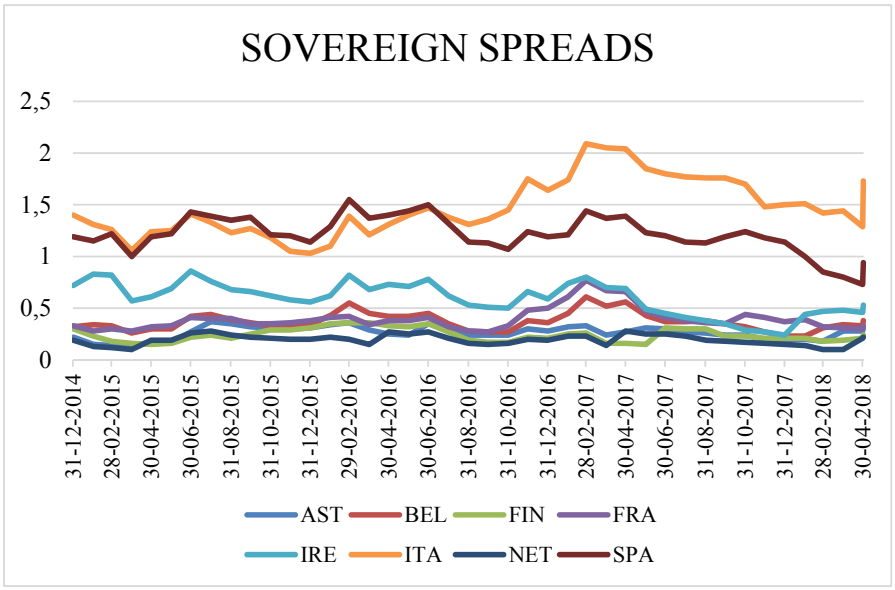

FIGURE 10: Sovereign Bond Spreads with benchmark (Germany) of Austria, Belgium, Finland, France, Ireland, The Netherlands and Spain for the whole period of the PSPP program
Source: ECB

APPENDIX C

TABLE 6: Baseline Regression. Equation (3) including sovereign spread as dependent variable. For each variables are reported the coefficients and the *t-statistics* between brackets. The st. errors are White period.

	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*
coefficient (*t-statistics*)			FE	FE	FE	FE	Cross-Section FE
constant	**0.79**	**-1.57**	**-2.12**	**-0.48**	**-1.90**	**-2.87**	**-4.54**
	(3.96)	(-3.94)	(-6.31)	(-0.34)	(-5.22)	(-3.23)	(-4.71)
Log(PSPP)	**0.00**	**0.03**	**0.05**			**-0.18**	
	(0.16)	(2.49)	(0.52)			(-1.80)	
Log(NCB_debt)				**-0.15**			
				(-1.03)			
Log(SHMP)							**0.13**
							(2.32)
Local Supply					**-0.01**		
					(-2.51)		
News							**0.00**
							(-1.70)
Debt to GDP		**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.00**
		(4.44)	(3.15)	(3.73)	(3.60)	(2.64)	(0.25)
Government Balance		**-0.07**	**-0.06**	**-0.06**	**-0.06**	**-0.07**	**-0.10**
		(-3.39)	(-1.89)	(-1.76)	(-1.74)	(-1.28)	(-5.28)
Real Growth rate		**0.02**	**-0.01**	**-0.01**	**-0.01**		
		(2.07)	(-0.68)	(-0.50)	(-0.55)		
Unemployment						**0.14**	**0.26**
						(2.01)	(8.27)
Inflation		**-0.02**	**0.06**	**0.07**	**0.07**	**0.23**	**0.35**
		(-0.30)	(2.03)	(2.11)	(2.02)	(4.73)	(4.95)
Bid-Ask Spread		**0.07**	**0.05**	**0.05**	**0.05**	**0.06**	**6.05**
		(6.73)	(4.59)	(4.47)	(4.46)	(4.83)	(5.08)
sovCISS		**0.04**	**0.04**	**0.04**	**0.04**	**0.03**	**0.02**
		(5.53)	(9.62)	(9.78)	(9.75)	(2.39)	(4.18)
Periphery		**0.03**	**0.04**	**0.06**	**0.05**		
		(0.09)	(0.25)	(0.32)	(0.27)		
R^2_adjusted	0.00	0.85	0.91	0.91	0.91	0.85	0.87
DW	0.02	0.26	0.33	0.33	0.33	0.22	0.30
n	1989	1218	1218	1218	1218	1218	918
Period	2000M01 2018M05	2006M07 2017M12	2006M07 2017M12	2006M07 2017M12	2006M07 2017M12	2006M07 2017M12	2009M07 2017M12

Column (2): Equation (3) without fixed effects employing *Log(PSPP)* as QE variable
Column (3): Equation (3) with cross-section and time FE employing *Log(PSPP)* as QE variable
Column (4): Equation (3) with cross-section and time FE employing *Log(NCB_debt)* as QE variable
Column (5): Equation (3) with cross-section and time FE employing *Local Supply* as QE variable
Column (6): Equation (3) with cross-section and time FE employing *CLIFS* as financial stress indicator instead of sovCISS.
Column(7): Equation (3) with cross-section and time FE employing cross-section invariant variables and VIX indicator instead of sovCISS

TABLE 7: Baseline Regression. Equation (3) including CDS as dependent variable. For each variables are reported the coefficients and the *t-statistics* between brackets. The st. errors are White period.

	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*
coefficient (*t-statistics*)			FE	FE	FE	FE	Cross-Section FE
constant	**129.71**	**-117.93**	**-112.63**	**129.67**	**-91.96**	**-173.26**	**-368.60**
	(27.53)	(-2.94)	(-3.39)	(0.39)	(-1.67)	(-2.09)	(-4.03)
Log(PSPP)	**-5.79**	**1.05**	**6.16**			**-4.17**	
	(-7.40)	(0.53)	(0.93)			(-0.49)	
Log(NCB_debt)				**-21.81**			
				(-0.68)			
Log(SHMP)							**10.81**
							(1.89)
Local Supply					**-35.31**		
					(-0.22)		
News							**-0.06**
							(-0.27)
Debt to GDP		**1.45**	**1.08**	**1.14**	**1.13**	**1.34**	**0.95**
		(3.95)	(2.00)	(2.64)	(2.13)	(1.93)	(1.03)
Government Balance		**-4.83**	**-7.07**	**-6.74**	**-6.92**	**-8.17**	**-9.45**
		(-1.57)	(-2.91)	(-2.81)	(-3.38)	(-2.14)	(-3.85)
Real Growth rate		**0.81**	**-1.27**	**-0.96**	**-1.30**		
		(0.86)	(-0.96)	(-0.62)	(-0.85)		
Unemployment						**6.92**	**11.43**
						(0.73)	(1.53)
Inflation		**-2.45**	**6.55**	**7.17**	**6.57**	**18.85**	**24.56**
		(-0.54)	(1.830	(1.64)	(1.30)	(2.82)	(3.64)
Bid-Ask Spread		**5.69**	**4.32**	**4.32**	**4.33**	**4.78**	**4.88**
		(4.99)	(4.01)	(3.76)	(3.78)	(4.23)	(4.51)
sovCISS		**2.49**	**2.40**	**2.38**	**2.38**	**2.27**	**0.02**
		(3.39)	(3.49)	(3.33)	(3.30)	(1.81)	(4.18)
Periphery		**-12.43**	**-18.98**	**-16.59**	**-19.14**		
		(-0.85)	(-1.93)	(-1.25)	(-1.67)		
R^2_adjusted	0.05	0.75	0.86	0.86	0.86	0.82	0.81
DW	0.07	0.39	0.50	0.50	0.50	0.42	0.51
n	1090	1045	1045	1045	1045	1045	918
Period	2008M01 2018M05	2008M01 2017M12	2008M01 2017M12	2008M01 2017M12	2008M01 2017M12	2008M01 2017M12	2009M07 2017M12

Column (2): Equation (3) without fixed effects employing *Log(PSPP)* as QE variable
Column (3): Equation (3) with cross-section and time FE employing *Log(PSPP)* as QE variable
Column (4): Equation (3) with cross-section and time FE employing *Log(NCB_debt)* as QE variable
Column (5): Equation (3) with cross-section and time FE employing *Local Supply* as QE variable
Column (6): Equation (3) with cross-section and time FE employing *CLIFS* as financial stress indicator instead of sovCISS. Column (7): Equation (3) with cross-section and time FE employing cross-section invariant variables and VIX indicator instead of sovCISS

Table 8: Regression in first difference. Equation (5) including the variation of Spreads as dependent and QE *Flow effect* as main regressor. For each variables are reported the coefficient and the *t-statistic* between brackets. The st. errors are White period.

	(1)	*(2)*	*(3)*
coefficient	FE	FE	Cross-Section FE
(*t-statistics*)			
constant	**0,02**	***-0.06***	**0,23**
	(0,32)	*(-2.97)*	(1,57)
Δlog(PSPP)	**0,03**		
	(0,64)		
Δlog(SHMP)			**-0,21**
			(-1,88)
Δ(Local Supply)		***-0.06***	
		(-1.34)	
news			
government balance	**-0,02**	***-0.02***	**-0,02**
	(-2,67)	*(-2.70)*	(-3,17)
Inflation	**0,01**	***0.02***	**-0,01**
	(2,71)	*(2.10)*	(-1,22)
Δunemployment	**-0,02**	***0.08***	**-0,04)**
	(-1,93)	*(1.93)*	(-2,58)
Δbid-ask spread	**0,03**	***0.01***	**0,03**
	(2,65)	*(3.59)*	(1,46)
Δclifs	**0,04**	***0.01***	
	(2,20)	*(4.29)*	
Vix			**0,01**
			(2,01)
R^2_adjusted	0,32	*0.41*	0,08
DW	1,73	*1.76*	1,79
n	1242	*1242*	909
Period	2006M07 2017M12	*2006M07 2017M12*	2009M08 2017M12

Column (1): Equation (5) with time and cross-section FE employing the flows of PSPP as QE variable
Column (2): Equation (5) with time and cross-section FE employing the difference in Local Supply as QE variable
Column (3): Equation (5) with cross-section FE employing cross-section invariant variables.

Table VII: Data description of the control group

Variable	Country	Source	Frequency	Description/transformation
YIELD	CAN	Bloomberg	M	
	JAP	BOJ	M	
	SWE	ECB	M	
	UK	ECB	M	
	US	FED	M	
QE	CAN	Bank of Canada	M	Total asset-security under repo - treasury bill - bond over 10 year maturity
	JAP	BOJ	M	Government Bonds hold by BOJ
	SWE	Bloomberg	M	Riksbank Balance sheet size
	UK	BOE	M	Gilts Purchased by the BOE
	US	FED	M	FED holding of Federal Debt
Debt to GDP	CAN	Statistics Canada	Q	Quarterly value assumed to be constant over the 3 months
	JAP	Japan Statistics Bureau	Q	Quarterly value assumed to be constant over the 3 months
	SWE	Eurostat	Q	Quarterly value assumed to be constant over the 3 months
	UK	Eurostat	Q	Quarterly value assumed to be constant over the 3 months
	US	FED	Q	Quarterly value assumed to be constant over the 3 months
Government Balance to GDP	SWE	Eurostat	Q	Quarterly value assumed to be constant over the 3 months
	UK	Eurostat	Q	Quarterly value assumed to be constant over the 3 months
	US	FED	Q	Quarterly value assumed to be constant over the 3 months
Real Growth Rate	CAN	OECD	Q	Quarterly value assumed to be constant over the 3 months
	JAP	OECD	Q	Quarterly value assumed to be constant over the 3 months
	SWE	OECD	Q	Quarterly value assumed to be constant over the 3 months
	UK	OECD	Q	Quarterly value assumed to be constant over the 3 months
	US	OECD	Q	Quarterly value assumed to be constant over the 3 months
Inflation	CAN	Bloomberg	M	
	JAP	Bloomberg	M	
	SWE	ECB	M	
	UK	ECB	M	
	US	FED	M	
Bid-Ask Spread	CAN	Bloomberg	M	
	JAP	Bloomberg	M	
	SWE	Bloomberg	M	Author calculation from Bid and Ask price
	UK	Bloomberg	M	Author calculation from Bid and Ask price
	US	Bloomberg	M	Author calculation from Bid and Ask price
Financial Stress	SWE	ECB	M	CLIF
	UK	ECB	M	CLIF
	US	FED	M	VIX Index/100