The Asset Purchase Programme in Europe: Financial market impact and European bond market fragmentation.

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Abstract

Since March 2015, the ECB adopted unconventional policy measures aiming to increase inflation at its target level. There is much discussion on the effectiveness of the Asset Purchase Program of the ECB, since real outcomes are hard to observe. This paper analyzes the effect of the unconventional policy measures of the ECB on the European bond market, using a time series panel data regression comprising observation for 10 EMU countries participating in the Private Sector Purchase Program for the period of January 2014 till March 2018. Furthermore, 4 countries are added as a control group to make the outcomes more robust. As many papers focus on the announcement effect and show a temporary relation between QE and bond yields, this paper shows that the PSPP program is able to lower bond yields on a permanent level. During the PSPP, purchases were not equally divided across European countries due to imposed regulations of the ECB, causing discussion across participating countries. This paper illustrates that the unfair monthly division of monthly purchases did not contribute to a divergence of the intra-European bond market.

Key words: Quantitative Easing, Bond yield, ECB, PSPP

JEL Classifications: E52, E44, G12

Contents

Introduction

In a response to the financial crisis of 2007, the European Central Bank (ECB) reached the Zero-Lower bound (ZLB) of short-term interest rates. Since the ECB did not succeed in satisfying the 2%, or just below 2% target level of inflation, they were forced to introduce more unconventional policy measures. Starting on 9 March 2015, the European Quantitative Easing program (QE), was introduced, intended to break the trend of low inflation. This unconventional monetary expansion is intended to increase the level of money supply by expanding the central bank's balance sheet (Bernanke and Reinhart, 2004). The stated objective of QE is to lower long-term interest rate encouraging economic activity (Krishnamurthy & Vissing-Jorgensen, 2011). Increasing the amount of money in an economy alters an increase in nominal spending and thereby boosting the CPI inflation to its target levels (Joyce et al., 2011). In this case of Quantitative Easing, the central bank purchases long-term government bonds from the secondary market[1]. In return for this, the private sector holds reserves at the ECB. Holding money at the ECB is costly, altering expected higher purchases of risky assets, to cover the longer-term borrowing costs. Overall, the QE program is purposed to increase the amount of lending to the private sector, stimulating consumption and investment, resulting in higher inflation levels.

However, many economists doubt the effectiveness of unconventional measures such as Quantitative Easing. I contribute to the existing literature on the effects of Quantitative Easing by focusing on the overall effect of the implementation of the Private Sector Purchase Program (PSPP) to the European government bond yields. The ECB imposed regulation and limitations to the PSPP, resulting in disproportional changes of purchases per month per country. This paper examines whether deviations from the fair monthly purchases can affect the intra-European bond market. The research question of this paper is: Does the PSPP executed by the ECB lower bond yields of participating countries and does the deviation of the 'fair' capital share result in a divergence in the intra-European bond market?

It might not be completely obvious why I specifically research the effect on government bonds when the general purpose of QE is to increase nominal spending resulting in higher inflation levels. However, it is extremely difficult to judge the effects of QE on real macroeconomic variables. In example, Van Marle & De Vries (2015) mention that the European recovery is due to the low oil price, instead of the expansionary policy of the ECB. Furthermore, the transmissions mechanisms are expected to be subject to long lags and economic spillover effects from other regions are challenging to exclude. The reaction of the financial markets on QE is expected to demonstrate the clearest direct impact. This response will serve as a clear indicator on how the ECB program feeds through the real economy (Joyce et al., 2012). Surprisingly, in empirical work, much more attention is paid to equity markets than to bond markets. This is somewhat odd, given the overall importance of bond markets for a proper performance of the overall economy (Brandner et al., 2007).

This paper will assess the effectiveness of QE by examining whether the total purchases of the ECB did lower yields of government bonds. In this paper, data on 14 countries are assessed, 10 participating countries (Austria, Belgium, Finland, France, Germany, Italy, Ireland, Spain, The Netherlands and Portugal) and 4 control countries not receiving any expansionary treatment (Greece, Norway, Switzerland,

[1] Secondary market is the indirect buying from the private sector. Instead of purchasing the bonds directly from the government in place, the bonds are acquired from commercial banks and national agencies. Simply because European legacy does not approve to buy it directly from the governments. Furthermore, it provides direct stimulus in the private sector.

the U.K.). Much literature studied the announcement effect, the stock effect, of central bank asset purchases and bond yields and find that the announcement and time of purchase indeed increased the bond yield (De Santis, 2016; Joyce et al, 2011; Andersson et al, 2006). Even though those results are highly significant, announcement effects may only be temporarily and do not give a meaningful argument for the overall effect of QE, since the die out rate is often large (Martin and Milas, 2012). Having more recent data on purchases and bond yields, this paper is one of the first to assess the overall effect, the flow effect, on bond yields for the ECB Program by looking at the entire period of the program. Since bond yields and prices respond relatively quickly to a changing environment, 51 months of information for 13 countries on total purchases is expected to give interesting insights in how QE feeds through the bond market. Next to studying whether the QE program of the ECB did influence European bond yields, this study examines whether the deviation from the 'fair' monthly purchases lead to a divergence in the intra-European bond market.

The remainder of this paper is structured as follows. In section 2.1, the Asset Purchase Program of the ECB is explained in detail. Section 2.2 illustrates how the monthly purchases could not adhere to the fair capital keys and lead to a discrimination across participating countries. In section 3, the literature review is split into two parts, 3.1 relates to the relation between QE and bond yields, section 3.2 relates to the literature on determinants of intra-euro government bonds spreads. Section 4 will present the dataset used and show the methodology and the results from the regressions. In section 5, the discussion, a critical assessment of the results will be provided. Section 6 will conclude.

Asset Purchase Program ECB

Under the Asset Purchase Program, the ECB buys euro-area government securities and bonds from European Institutions and agencies (Claeys et al, 2015). The purchases were intended to last at least until September 2016. With no clear end date, the ECB emphasized that it would conduct purchases until: "a sustained adjustment in the path of inflation which is consistent with the aim of achieving inflation rates below, but close to, 2 percent over the medium term"[2].

The central bank adjusted the amount of implied total monthly purchases and the form of purchases several times. A detailed explanation of this asset purchases can be found in Appendix A. At the start of the program in 2015, the ECB announced to purchase an amount of 60 billion securities every month. Figure 1 depicts how the total monthly amount of 60 million purchases is allocated (Claeys et al, 2015). 10 bln euros per month will be continued to be spend on covered bonds.[3] The additional 50 mln spend on the PSPP is divided between governments bonds (44mln) and supranational bonds (6mln). Since data on PSPP is available on country level, we can run a panel data for PSPP. Supranational debt refers to bonds which are issued by international organizations, such as quasi-government organizations[4]. These supranational bonds held by National Central Banks (such as the Bundesbank, Banco de Espana, De Nederlandsche Bank) will be purchased by the ECB as a part of the total purchase program.

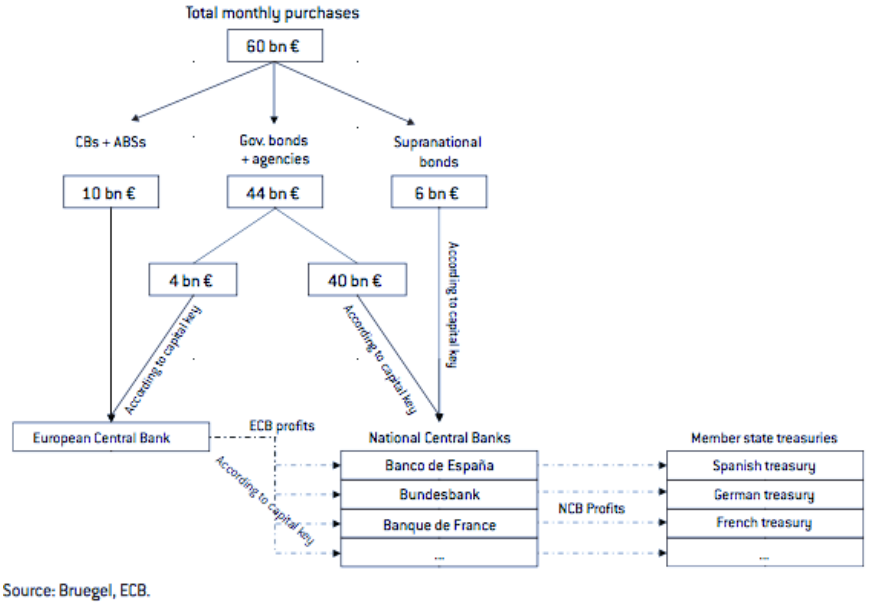


Figure 1: Allocation of monthly asset purchases by the Eurosystem (Claeys et al. 2015)

Limitations of the Asset Purchase Program

With the introduction of the QE program, the ECB announced subsequent regulations. Those rules ensure that the Eurosystem is not in a position that it is receives voting power in a country, and that the purchases are equally spread across countries.

[2] Mario Draghi, President of the ECB, Frankfurt am Main, 22 January 2015
[3] Those purchases already started in October 2014.
[4] Eligible supranational issuers in the Euro Area are in example: European Financial Stability Facility, European Investment Bank and the European Union.

In terms of allocation per country of the government bonds, the ECB intended to fairly split the total amount of purchases between all euro-area countries via the ECB capital keys. This capital key indicates the share of the National Central Bank respective a country's share in the total population and gross domestic product of the EU. The capital keys of Europe are shown in figure 2.
Next to the capital key division, strict eligibility criteria and issue share limits are imposed on Eurosystem holdings and on supranational holdings and.

1. A 25% issue limit on a countries debt is applied to prevent the ECB from being in a position in which it can block a potential vote on the restructuring of ECB-held debt of the different euro-area countries (Claeys et al, 2015). This means that the share of a countries debt in all the portfolios of the Eurosystem central banks cannot be larger than 25% of the total outstanding debt of a country. Next the purchases during PSPP, this also includes bonds purchases during the Securities Market Program[5].
2. The securities that are purchased have to meet certain eligibility criteria. Next to the issue limits, the securities must have a residual maturity between 2 and 30 years. Furthermore, the yield on eligible securities must exceed the deposit facility rate (currently -0.4) (BNP Paribas). Only a limited number of institutions in Europe are providing securities that satisfy the eligibility criteria (ecb.europe.eu) of the PSPP program.
3. The issue limit for EU supranational bonds is 33%. This means that per NCB (National Central Bank) the Eurosystem holdings on supranational bonds may not exceed 33% of the total 100% holdings of supranationals.[6]

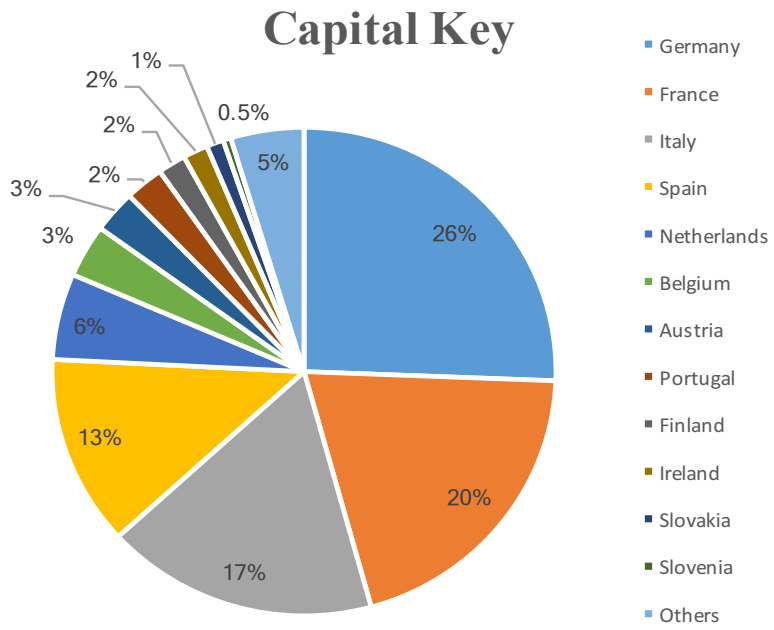


Figure 2: Fair ECB Capital Key Source: ecb.europe.eu

[5] The "Securities Markets Programme" (SMP) was intended to ensure depth and liquidity in debt security markets to five euro area countries: Greece, Ireland, Portugal, Spain, and Italy ranging from 2010-2012 (ecb.europe.eu)
[6] The 33% issuer holding limit of total Eurosystem holdings will not be discussed as this limit was solely intended for Greece. The ECB decided not to purchase bonds from Greece, which makes this limitation redundant.

Discrimination across European countries

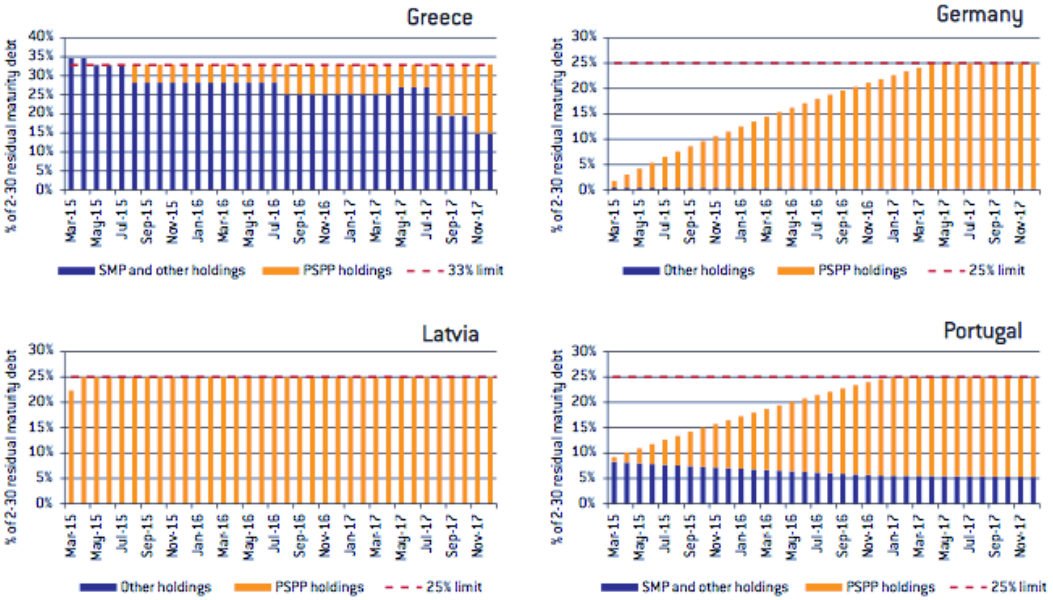
The ECB clearly announced to leave the possibility open to continue the purchases even after September 2016 and they proved to do so. At the time of writing (June 2018) the program is still in place. The ECB just announced that the program will be reduced to €15bn monthly purchases after September and will be completely ended at the end of this year (2018) (ecb.europe.eu[7]). This paragraph shows how the prolonged purchases led to an unfair division of monthly purchases across countries.

Any deviation from a fair capital division can results in discussion across countries. An example of such a discussion one of last March: Luigi Di Maio (leader of the Italian Five Star party) declared that the sudden increase in Italian government bonds spread (relative to Germany) was completely due to the decrease in total purchases of Italian government bonds by the ECB (Bloomberg, May 2018). ECB replied that they had to compensate for the maturing bonds of Germany of the month before (April 2018). When monthly deviations of the fair capital keys could indeed result in large fluctuation in bond yield spreads across European countries, the ECB should be more careful in choosing the right allocation of securities every month. Instead of stimulating European countries with the QE program, this programme could diverge the European countries as stimulus is not proportionally executed across countries.

In the beginning of the QE program, many economists already defined the consequences the imposed regulation should have for the amount of purchases per country. Observing the imposed limitations, Claeys et al. (2015) made a figure showing the expected discrimination across countries. In the case of Greece, the prediction showed that the ECB would only be able to purchase Greece bonds from August 2016 onwards, when other ECB holdings would be expired. The forgone purchases of Greece bonds under SMP already exceed the first rule: not exceeding 25% issue limit of total Eurosystem holdings. This limitation is also noticeable in the case of Portugal. Portuguese bonds purchases are expected to decrease significantly after January 2017. The Eurosystem would only be able to buy Portuguese bonds from new issuance as the Eurosystem is expected hold 25% of total Portuguese debt in November 2016. However, the Portuguese government is under strict surveillance since they own a rich history in exceeding the European target levels of 60% total debt to GDP and 2% deficit per year (Andrade & Duarte, 2011). Therefore, simply increasing the level of government bonds (and thereby the total government debt) is not considered as a solution for this possible difficulty. The Latvian case pictures how countries with very small debts cannot be included in the purchase program as the 25% issue limit is attained immediately. The case of Germany shows that even for major countries, the PSPP program is not able to continue forever and will exceed its proposed limits. As the capital keys suggets, monthly purchases of German bonds should equal 25,6% of the total purchases. Those enourmous monthly purchases would also lead to scarcity of German bonds, providing a difficult job for the ECB to find bonds every month that meet the imposed eligibility criterea.

As the ECB decided to extend the QE program after December 2016, they noticed that for some countries, the imposed limits provided serious concerns. On 8 December 2016, the ECB made the following adjustments in their regulation:

[7] ECB Press Conference 14 June, Riga



Source: Bruegel based on ECB, NCBs, national treasuries.

Figure 3: Evolution of Eurosystem sovereign holdings for Greece, Germany, Latvia and Portugal

1. Purchases below the ECB's deposit rate will be allowed (-0.4).
2. The maturity criteria of 2-30 years will be extended to 1-30 years maturity.
3. The terms and conditions attached to the securities lending facilities will be eased, allowing for cash collateral, thereby supporting to smooth implementation of the PSPP (ecb.europe.eu).
4. The issue limit of supranational bonds increase from 33% issue limit to a 50% issue limit. This means that of all the supranational bonds held by a specific NBC, 50% could be purchased by the Eurosystem, instead of 33%.

Those adjustments enlarged the total amount of available government bonds per countries (point 1,2 & 3) that could be purchased by the ECB, to overcome the problem of bond scarcity. Deviations from the capital keys could be compensated by purchasing larger amounts of supranational bonds (point 4).

However, even with the newly announced QE rules, the ECB could not completely adhere to the fair ECB capital division. Figure 4 shows how the actual monthly purchase executed by the ECB does differ from the fair division across countries. The picture shows that the actual purchases made by the ECB from March 2015-March 2018 (connected line), compared to the 'fair imposed purchases' (dotted line) are most notable for Portugal, Finland and Ireland. The implied purchases are calculated by multiplying the countries capital key times the realized total purchases, thereby adjusting for the periods where the ECB could not realize the total purposed amounts of total PSPP. The ECB did not purchase Greece government bonds, since serious concerns persist regarding the sustainability of Greece's public debt.

When researching the fluctuations in monthly purchases, it is important to understand why the ECB could not adhere to a fair deviation. Why is the ECB not able to purchase more Portuguese debt from the secondary market? As the Bank of Portugal stated: "The availability of Portuguese public debt for purchases

is far from reaching its limit." (Reuters, 2016). The vice-president of the ECB, Vítor Constâncio, explained that the purchases are limited due to previous acquisitions made within a similar program in 2010-2012. New public debt issuance allows to increase the bond issuance, but since Portugal's total debt is already exceeding the allowed levels (stated in the introduction), this cannot be a proper solution. The ECB warned Portugal for the Snowball Effect, since the Portuguese growth will not suffice to absorb the high financing costs (ECO news: Portuguese Economy, 2017), thereby giving indirect restrictions for new issuance of government debt.

For Ireland, the 25% issue holding limit was also attained relatively soon. The official Euro system holdings of Irish bonds were bloated by previous interventions of the ECB in 2010-2014 (Guardian, 2010). Therefore, a deviation from its capital key is visible starting at XX 2017.

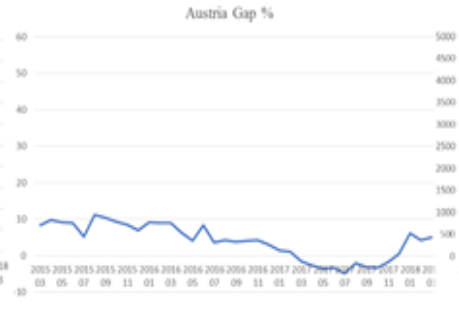
For Finland it is less obvious why there is a sudden deviation from its capital key. Danske Bank (Lumholtz, 2017) reports that this is due to the 'redemption effect', meaning that the actual purchases (and reinvestments) of the previous months did exceed the allowed amount of Finnish purchases and have to be compromised by the coming months.

So, not all countries receive the same treatment from the ECB. The reason that the countries do not receive fair treatment is due to external regulation, and not because the economies in those countries perform better or worse. Since the European countries do have their own government bonds and related yields, the relation between central bank purchases and bond yield can be examined on country level. The deviation from its fair capital key rule provides the opportunity to run an experiment in the path of country specific bond yields, thereby receiving more information on how QE feeds through an economy in Europe.

An important side note should be made according to the provided number in figure 4. As the ECB also purchases supranational bonds and corporate bonds from countries, the provided division per country as illustrated in figure 4 cannot be completely accurate. Since the ECB does not publish a detailed breakdown of supranational bonds and CSPP (Corporate Sector Purchase Programme), it is not clear what share of supranationals or corporate bonds is purchased from which countries. However, the share of CSPP is limited compared to the total purchases via PSPP (see Appendix A), it is not expected to cause a major concern. The supranational bonds, as explained in the introduction, are not purchased via the secondary markets, but from countries central bank directly. As this paper assesses the yield (spread) on government bonds, expecting to be affected mostly through purchases in government bonds[8] and not through supranational bond yields.

[8]Some researchers (Gagnon et al., 2011) emphasize that also excessive purchases in other assets, such as corporate bonds, can indirectly influence government bond yields. However, since this effect is expected to be minor, this effect is out of the scope of this paper.


Austria
Implied
Actual


Austria Gap %


Belgium
Implied
Actual


Belgium Gap %


Finland
Implied
Actual


Finland Gap %


Ireland
Implied
Actual


Ireland Gap %


The Netherlands
Implied
Actual


The Netherlands Gap %


Portugal
Implied
Actual


Portugal Gap %

Figure 4: Implied (via capital key) versus actual government bond purchases in millions per country. Source: own calculations, Bloomberg, ecb.europe.eu.

Literature review

My study is related to two separate segments in literature. Firstly, literature on the transition channels of QE on bond yields will be summarized. Thereafter, I will continue by summarizing the literature on intra-European bond market and focus on their differences and determinants.

Transition channels Quantitative Easing

When investigating the relation between QE and bond yields, it is important to understand via which channels the purchases can affect bond yields. In this chapter, I will summarize the literature on the three main channels: Portfolio Rebalancing Channel, Liquidity Premia Channel and the Signaling Channel.

Portfolio Rebalancing Channel

If assets are not perfect substitutes, a change in the supplied quantity will most definitely lead to a change in its relative expected rate of return (Tobin 1963, 1969; Brunner and Meltzer, 1973; Joyce et al, 2012; Christensen & Rudebusch, 2012). Since bonds with different maturities are assumed to be imperfect substitutes, this mechanism qualifies QE in affecting asset prices when central banks purchase large amounts of specific assets. When the central bank purchases long-term, relatively safe assets, yields on safe assets decrease, while liquidity is created on the private investors' side. Investors will respond to the relative changes in yields balancing their portfolio towards more risky assets (Albertazzi et al., 2018; Arslanalp & Botman, 2015). This affect is called the flight-to-quality effect (Beber et al. 2008). Gagnon et al. (2011) shows that due to the imperfect substitution between maturities, spillover effects to other yields reflects lower yields in a wide range of bonds. QE can directly influence the decisions of investors through this so-called portfolio rebalancing channel.

Liquidity Premia Channel

Additionally to the portfolio rebalancing channel, the purchases of the central bank improve market functioning by reducing premium for illiquidity (Joyce et al., 2012). Liquidity is defined as the ability to sell or buy specific amounts of security in a short time notice, without having impact on the price (Campbell, Lo and MacKinlay, 1997; Bernoth et al, 2004). When a financial market is illiquid, there are not sufficient volume of buy and sell orders (market depth), often referred as a stressed financial market. The Private Sector Purchases Programme makes it less costly for investors to sell their assets when required. The liquidity risk premium compensated the investor the probability that he or she cannot buy or sell the bonds at a preferred time and captures the possibility of capital losses due to early liquidation or significant price reductions. When the liquidity is increased via the Asset Purchase Program, the investors are not required to be compensated via a liquidity premia. Furthermore, the government bonds are exchanged for reserves, which are more easily traded in secondary markets (Lim et al, 2014). This means that previously liquidity-constrained banks are enabled to extend credit to investors. However, it is expected that the QE program of the ECB reveals a lower liquidity premia effect than earlier QE program (in example those of the FED, UK or Japan) since those QE programs were all executed in times of high financial stress. Since the European market is currently relatively liquid (Appendix B), the effect is expected to be minimal.

Signaling Channel

The third transmission channel is the signaling channel (Meaning & Zhu, 2011; Christensen & Rudebusch, 2012; Bauer & Rudebusch, 2013; Joyce et al., 2012). When purchasing serious amounts of long duration assets, the balance sheet of the ECB will be sensitive to changes in short-term interest rate. Increasing those rates would imply losses for the central bank. The ECB thereby signals that this serves as a credible

commitment of keeping those rates low (Clouse et al., 2003). This could lower the expected future short-term interest rates as well as longer-term yields. Furthermore, commitment of a central bank reduces uncertainty, increase consumer and business confidence and drive down risk premia (Meaning & Zhu, 2011). Christensen and Rudebusch (2012) find that the signaling channel is stronger when the central bank is more transparent in its communication. Bauer and Rudebusch (2013) illustrate this with an example of an announcement of the Federal Reserve. In 2009 and 2010, investors were uncertain about how long the fed rate would remain at its ZLB. The FOMC provided some guidance by stating that it was "…likely to warrant exceptionally low levels of the federal funds rate for an extended period." The statement contributed to a direct fall in bond yields.

To conclude, the portfolio rebalancing channel is expected to negatively influence the bond yields as a lower available supply of government bonds increase the prices, yet lowers the yields. Since the liquidity in government bond markets increases as a result of the excessive purchases from the ECB, liquidity premia decreases, yet lowers the bond yields. Lastly, by signaling that future interest rates will remain low, expected long term interest rates will also remain relatively low. This paper examines the combined effect of those channels, however, since there exists an accurate monthly liquidity variable for all countries, an interaction term can separately illustrate the importance of the liquidity effect.

Determinants of intra-euro area government bond spread

As illustrated in figure 4, for many countries the implied total purchases differed significantly from its actual purchases. In some countries, the private investors will benefit more from the government bond purchases than other countries.

Since 1999, the euro area bond market is far from homogeneous (Brandner et al., 2007). Since the beginning of the financial crisis, a clear divergence of euro-area government bond yields is observed (Barrios et al., 2009; Brandner et al., 2007, Schuknecht et al, 2010). To study whether the level of QE per country is partly responsible for the different levels of bond yield spreads, the determinants of the intra-euro government bond spread will be summarized. Determinants of government bond yield (spreads) are often grouped into three factors: Liquidity risk, credit risk, international risk and risk aversion.

Liquidity, as discussed in the previous paragraph, is defined as the ability to sell or buy specific amounts of security in a short time notice, without having impact on the price (Campbell, Lo and MacKinlay, 1997; Bernoth et al, 2004). The liquidity risk premium compensated the investor the probability that he or she cannot buy or sell the bonds at a preferred time. In Europe, this premium is reduced by the introduction of the EMU membership, expected to increase the financial market integration (Bernoth et al., 2004). However, Pagano et al. (2004) shows that even after EMU membership, liquidity fluctuates on daily basis and differs across European countries. German bonds are relatively more liquid than other EU countries, since most of the trading occurs on the future markets. Future markets are often far deeper and extremely liquid. Pagano et al. (2004) suggest that the relatively lower yield on German government bond is partly due to this higher liquidity. Codogno et al. (2003) show that the introduction of EMU decreased the liquidity risk factor, even though it is still present. Even after the EMU membership, the level of liquidity is still expected to have a negative effect on government bond prices in Europe.

The second risk, credit risk, measures the probability that the issuer of the bond fails to meet the obligation to repay at maturity, or to pay the coupon payments (Barrios et al., 2009). This risk is typically approximated using values of past or projected fiscal performances or Credit Default Swaps (CDS). Examples of fiscal

performance are current (future) budget deficit, debt levels or abilities to raise tax rates. Those variables can easily influence public finance and can therefore affect the risk of a country defaulting on government debt. Several papers researching the bond market in the United States (Bayoumi et al.,1995; Goldstein and Woglom, 1991; Poterba and Rueben, 1997) provide evidence that bonds yields on 39 US states (relative to New Jersey) are positively related to public levels of debt. Alesina et al. (1992) investigate whether this credit risk is priced in the European bond market and show that the spread between private and public bonds yields depends positively on the level of public debt. Building on the work of Alesina et al. (1992), Lemmen and Goodhart (1999) also show that the European bond yield differentials are well explained by their different debt levels.

As those studies compare debt levels of European countries before the introduction of the Euro, it's even more interesting to compare the debt levels and government bonds in the same currency (Bernoth et al., 2012). Bernoth et al (2012) do argue that the EMU membership could have increased the credit risk, as governments choose to surrender their monetary sovereignty and the possibility to monetize their debts. However, the perceived credit risk could have decreased as member governments in financial stress will be bailed out by other governments or the ECB. Klepsch and Wollmershäuser (2011) state that investors did suppress the importance of credit risk after the introduction of the Euro. Only the financial crisis led to the rediscovery of credit risk in European countries. The relation between financial projections and bond yields changed significantly after the financial crisis in 2007. The high cost of bail out packages and the aggressive fiscal stimulus policies during the crisis lead to a deterioration of the fiscal positions (Barrios et al., 2009). High current account deficits depreciated the markets' perception of default on rose questions about the sustainability of public finances. Moreover, during the financial crisis, credit rating agencies downgraded the rating of debt on various euro-area government bond issuers. Zoli and Sgherri (2009) find that the relation between government debts and government bond yield spread increased significantly after September 2008. Barrios et al (2009) also points out that after the financial crisis, investors started to discriminate more between countries, putting more weight to its domestic factors on financial public health.

In more recent studies, risk of default is often measured as the Credit Default Swap (Albu et al., 2014; Barrios et al 2009; Krishnamurthy & Vissing-Jorgensen, 2011). This swap is particularly used to transfer the credit exposure of fixed income products between two or more parties. This Swap is used to hedge against default of the receiver, in this case, the government. The higher the risk of default, the higher the price on this CDS. CDS is thus expected to have a positive relation towards bond yields

Favero et al. (2007) conclude that liquidity risk and credit risk interact with each other. An increase in liquidity risk also increases credit risk effects. Barrios et al. (2009) also point out that when financial markets turn to become illiquid, the relation between deteriorated public finances and bond yields differentials increase significantly.

After the financial crisis, a new government bond determinant was introduced, called the international (banking) risk (Afonso et al., 2012; Gerlach et al., 2010; Schuknecht et al, 2010). In Europe, the national banking sectors have different levels of exposure to international financial conditions, increasing the heterogeneity between the degree of risk and associated yields. After the financial crisis, volatility on foreign markets is considered as an increasingly important factor of risk, therefore affecting the bond yield spread. Higher volatility levels lead to more uncertainty. The international risk factor predicts that in times of high foreign volatility, European bond spreads will increase, since governments have different exposure to the foreign stock market.

The last risk factor is the general risk aversion. Risk aversion is associated with the willingness of agents to take risk. In times of financial stress, investors will have a higher general risk aversion, rebalancing their portfolios more toward less risky assets (Barrios et al., 2009). In principle, high risk aversion should benefit government bond yields, as those bonds are regarded as saver assets than equities or corporate bonds. The risk of default is for companies much larger than for entire companies. Haugh et al. (2009) argue that the reaction of investors to financial markets could become increasingly important, referring to the financial crisis. They argue that even though general risk aversion is an important factor on its own, its importance is magnified by fiscal performances. Since data on risk aversion is scarce, confidence and sentiment indicators are often utilized to measure risk aversion of investors (Goldberg and Leonhard, 2003; Andersson et al., 2006). When general confidence increases, sentiments increases (risk aversion decreases) resulting into lower bond yields.

Data and Empirical Approach

To determine whether the level of bond purchases executed by the ECB did affect the bond yields of European countries, I analyze a time series panel data regression comprising observations for 14 EMU countries for the period of January 2014 till March 2018. The countries which are included are Austria, Belgium, Finland, France, Germany, Greece, Italy, Ireland, Spain, The Netherlands, Portugal and as stated in the introduction, data of Switzerland, Norway and the UK is used as a control group.

As the dependent variable I use monthly 10-year government bond yields and monthly government bond yield spreads relative to Germany. The spread of the government bonds is calculated as follows:

$$Spread = spr_{it} = spread_{it} - spread_{germany,t}$$

When looking at the bond spreads relative to Germany as a dependent variable, the flight-to-quality effect on European level is examined. This variable is commonly used in literature (for example: Afonso et al, 2012; Barrios et al, 2009) to study determinants of the intra-European bond market. As European bonds are no perfect substitutes, an investor can choose to rebalance their portfolio towards a government bond of a 'in their eyes' saver government bond from a different country. German bonds are perceived as the flight-to-quality asset during periods of high uncertainty as probability of default of the German government is lowest (Afonso et al., 2012). By researching bond spreads as a dependent variable, the differences between European bond yields is examined. This assists in answering the question whether the unfair division of monthly purchases did contribute to a divergence in the European bond market.

The variable of interest is measured in three different ways: PSPP, Gap and PSPP_total. The PSPP is the logarithm of executed monthly purchases of government bonds per country. This variable is considered to show how the level of Asset Purchases executed by the ECB did influence bond yield and yield spreads. As explained in the 'discrimination across countries' paragraph, the ECB could not adhere to a fair division of monthly purchases across countries. The Gap variable represents the difference between the actual purchases, and the purchases that would be executed without any regulations. This variable is illustrated in figure 4 and proxies the relatively unfair division of the purchases. The PSPP_total variable measures the total accumulated purchases of governments bonds for country i as a share of the total issued government debt in country i. To illustrate, in January 2016 this variable equals 9.89 for Portugal, meaning that the accumulated PSPP for Portugal is in total 9.89 percent of the total issued debt of the Portuguese government.

It would be far more interesting to see how large the share of total securities, including previous purchases (during other programs) and other debt securities held by the ECB is, per country per month. However, this information is not available per country per month.

To account for credit risk, I follow the approach of Krishnamurthy & Vissing-Jorgensen (2011) in using CDS 5-year rating. This 5-year CDS refers to an insurance contract that expires within 5 years, being the most standard and liquid maturity (Barrios et al., 2009). In addition to this measure of credit risk, data on government debt to gdp is linearly extrapolated[9], creating monthly data on fiscal performance. This variable is used as an alternative to the CDS variable.

To account for liquidity risk, I computed the bid-ask spreads for country specific 10-year government bonds by taking the difference between the bid and ask price. I converted the daily data into monthly, being able to include the bid-ask spreads in the panel data. This procedure is widely used in measuring liquidity (Afonso et al., 2012; Barrios et al., 2009; Favero et al., 2010; Gerlach et al., 2010) since the bid ask spread is influenced by the debt in the market. A deep market is often considered to have low bid-ask spreads with higher levels of trading efficiency. Furthermore, bid-ask spreads are considered to be a better indicator than volumes traded (Barrios et al., 2009) since those volumes can be affected by inter-banking trading to meet balance sheet requirements.

To consider international risk, I used the volatility on foreign markets, measured as VIX. It represents the S&P 500 implied stock market volatility index varying by month. The VIX is often called the 'investors fear gauge' (Afonso et al., 2012) since it is highly correlated to market turmoil periods (Whaley, 2000). To illustrate, the index increased nearly eightfold from February 2007 to October 2008, presenting high levels of international risk during the financial crisis (Chen et al., 2011; Ericsson & Renault, 2006; Klepsch et al., 2011). Due to heterogeneous exposure to foreign stock markets, bond spread are expected to increase with higher VIX levels. Furthermore, as some authors (Klepsch et al., 2011) do also use this proxy to measure risk aversion on bond yields, as a robustness check, VIX is also utilized on bond yield (complementary to the spread level) as an alternative for sentiment.

As a proxy for risk aversion I follow the approach of Martelli & Aristei (2011) in using sentiment indicators. This sentiment indicator is calculated from the European Commissions business and consumer surveys and varies per month per country. It is constructed from the following indicators: Industrial confidence indicator (40%), the service confidence indicator (30%), the consumer confidence indicator (20 %), the construction confidence indicator (5%) and the retail trade confidence indicator (5%). A higher sentiment indicator refers to more overall confidence. When consumers and investors have positive market expectations, they are prone to take more risk. This implies that portfolios are rebalanced towards riskier assets. It would be more informative to only include data on investor sentiment, as they do invest in bonds, and consumers do not buy assets. However, those indicators are not available on country level (only on European level).

The data sources and complete definition of all the variables can be found in Appendix C. In Appendix D, the descriptive statistics can be found.

Taking all the above-mentioned together, my empirical model of bond yields takes the following form:

[9] Assuming that a countries debt is monthly equally generated over a quarters time.

$$by_{it} = c + \beta_1 by_{it-1} + \beta_2 creditrisk_{it} + \beta_3 ba_{it} + \beta_4 PSPP_{it} + \beta_5 (ba_{it} * \text{PSPP}_{\text{it}}) + \beta_6 sent_{it} + annoucement_t + \delta_i + \varepsilon_{it} \quad (1)$$

with i= 1,…,10 denoting the ten European countries and t = 1,…, 36 denoting monthly time dimension. by_{it}, is the bond yield of country i in month t. $by_{it-1}$is the lagged bond yield. Following standard practice on empirical literature on EMU, equation (1) includes a lag of the bond yield to account for yield persistence (Gerlach et al., 2010). An exclusion of this lag would generate omitted variable bias. Credit risk variables are captured in $creditrisk$, denoting the CDS 5-year price and the debt-to-GDP varying per country per month. Liquidity conditions are proxied by the variable ba_{it} denoting the bid-ask spreads of the 10-year bond prices varying monthly per country. The PSPP variable captures the effect of bond purchases by the ECB. Next to the PSPP, the PSPP_total measure is regressed to examine whether higher levels of total share of debt held by the ECB is able to lower the bond yield. Since the liquidity channel is expected to be slightly strengthened by bond purchases, an interaction term is added. $sent_{it}$ indicates the sentiment indicator, measuring the risk aversion per country per month. The announcement variable equals 1 in months where a crucial announcement regarding the start or the expansion of the PSPP program is made, zero otherwise.

To assess whether the unequal monthly purchases had led to a divergence in the intra-Euro bond market, a second regression is examined

$$spr_{it} = c + \beta_1 spr_{it-1} + \beta_2 creditrisk_{it} + \beta_3 ba_{it} + \beta_4 ECB_{it} + \beta_6 vix_t + \beta_7 relsent_{it} + announcement_t + \delta_i + \varepsilon_{it} \quad (2)$$

with i= 1,…,9 denoting the ten European countries and t = 1,…, 36 denoting monthly time dimension. spr_{it}, is the bond yield spread of country i relative to Germany in month t. Since the 10-year government bond yield from Germany is used as a benchmark to the rest of the countries one country less is used in this panel estimation. Credit risk variables are captured in $creditrisk$, denoting the CDS 5-year spread (relative to Germany) and the debt-to-GDP (relative to Germany) varying per country per month. The bid-ask spreads of the 10-year bond prices varying monthly per country are relative to the bid-ask spreads of Germany. The effect of the bond purchases executed by the ECB is assessed with three different variables: 'PSPP','PSPP_total' and 'Gap'. The *PSPP* proxy tells us how the actual monthly purchases in month t did increase or decrease the spread of country i relative to Germany. When this variable is nonzero, it would mean that the purchases increased the difference between country i's bond yield and that of Germany. This would be the case when the effect PSPP has on bond yield varies across participating countries. The *PSPP_total* variable tells us whether the share of debt held by the ECB does influence the bond yield of country i, respectively to Germany. When this variable would be negative it implies that countries with larger shares of their total issued debt securities held by the ECB would have lower bond yield, relative to Germany. The *Gap* proxy tells us how the relative unequal monthly purchases did result in a relatively higher/lower bond yield, relative to Germany. vix_t denotes the implied volatility being a proxy for international risk, varying per month. $relsent_{it}$ is the sentiment indicator varying per month per country, relative to Germany. To control for time invariant country specific characteristics, regression (1) and (2) use country fixed effects. As mentioned in the introduction, many papers on QE programs show that bond yields move significantly with QE announcements and news (De Santis, 2016; Joyce et al, 201; Andersson et al, 2006). The communication of the ECB is very important for how a market responds to certain decisions (Kenourgios et al., 2015). An announcement dummy is added in months where the ECB

announced the start or the expansion of the Asset Purchase Program. This data is collected from the ECB press release website. By not controlling for the announcement effect, the relation of the outcome of the program could be underestimated, since most of the reaction would already have been absorbed by the market before the actual implementation has taken place. Next to the announcement dummy, I use quarterly fixed effects to absorb any variation between quarters.

Results

Table 1
Impact of PSPP on the 10-year government bond yield

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
by$_{t-1}$	0.852***	0.852***	0.693***	0.693***	0.681***	0.867***	0.677***	0.711***
	(0.020)	(0.020)	(0.017)	(0.017)	(0.017)	(0.019)	(0.017)	(0.016)
cds	0.001***	0.001***	0.001***	0.001***	0.001***		0.001***	0.001***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)		(0.001)	(0.001)
ba	-1.809	-2.005	0.246***	0.252***	0.267***	0.255***	0.279***	0.259***
	(1.296)	(1.281)	(0.039)	(0.039)	(0.039)	(0.050)	(0.038)	(0.039)
pspp	0.002	0.001	-0.047***	-0.047***	-0.057***	0.004	-0.050***	
	(0.010)	(0.009)	(0.011)	(0.011)	(0.011)	(0.014)	(0.010)	
*ba*pspp*	0.695*	0.649**	0.081	0.077	0.08	0.072	0.055	
	(0.345)	(0.342)	(0.066)	(0.066)	(0.066)	(0.084)	(0.066)	
sent	0.003	0.002	0.005*	0.005*	0.004*	0.002		0.005*
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)		(0.002)
announce					-0.168***	-0.075*	-0.181***	-0.138***
						(0.056)	(0.044)	(0.044)
debt						0.080		
						(0.003)		
vix							0.055	
							(0.048)	
pspp_total								-0.016***
								(0.005)
Constant	-0.059	-0.136	-0.106	-0.102	0.075	-0.371	0.347*	-0.092
	(0.205)	(0.205)	(0.213)	(0.216)	(0.220)	(0.423)	(0.140)	(0.240)
Country FE	YES	YES	YES	YES	YES	YES	YES	YES
Quarterly FE	NO	YES	NO	YES	YES	YES	YES	YES
with Control group	NO	NO	YES	YES	YES	YES	YES	YES
Obs.	459	459	662	662	662	662	662	662
countries	10	10	14	14	14	14	14	14
R-squared	0.9623	0.9641	0.9758	0.976	9.9755	0.9673	0.9746	0.9768

*Note: The regression models are estimated over the time period 2014.1-2018.3 (T=51). The panel members include Austria, Belgium, Finland, France, Germany, Greece Italy, Ireland, Spain, The Netherlands, Portugal, Switzerland, UK and Norway (the last three only as control). The dummy variable for announcement equals one in 2014.10, 2015.1, 2015.2 and in 2016.3, and zero otherwise. The asterisks ***, **, * indicate significance at the 1, 5, 10% level respectively. Standard errors between brackets.*

Bond yields

Table 1 shows the estimation results for the regression on bond yields. Column (1) to (5) represent the estimates for the regression without any alternative controls. Column (2) adds to the specification the quarterly fixed effects. Column (3) includes the control group and column (4) includes both quarterly fixed effects and the control group. Column (5) adds the announcement dummies to the specification, being our key specification. Column (6)-(8) are variations on the key estimation, using alternative controls including the control group and fixed effects.

Column (1) and (2) show that the PSPP variable has no predictive power in explaining bond yields, regardless of the quarterly fixed effects. Bond yields are well explained by their lags and their credit risk variable. Column (3) and (4) show that when including the control group, the estimates differ significantly. The PSPP variable is now significantly negative, as we expected. Furthermore, the variable measuring liquidity shows also a significant positive sign, as theory predicts.

In column (5) the announcement dummy is added. This paper attempts to study the permanent effect of the QE program of the ECB, its flow effect. However, announcements towards investors are absorbed by markets incredibly quickly. Financial markets will thus respond to treatment announcements, biasing the effect on the real treatment. Since much research on QE effectiveness is committed to show that the stock effect, the announcement effect, is strongly present, it is crucial to see how this announcement effects could bias the flow effect. I tried to control for the announcement effect by using quarterly fixed effects and dummy variables. However, as announcement effects occur within days, or even within hours, the monthly dummies are only able to cover part of the problem. The estimations in Table 1 show that for months, prior to the start or regarding the expansion of the program, communication concerning the QE program did lower bond yields. This means that in months were the ECB communicates or publishes news regarding the start or expansion of the program, investors already adjust their demand for the bonds, lowering the yield on the 10-year government bonds. Column (5) shows that when including the announcement dummy, the PSPP estimate has the correct sign and is slightly increasing in comparison to column (4). Without controlling for the announcement effect, the variable of interest would thus be underestimated. Column (5) demonstrates that the PSPP is able to lower bond yields with -0.057 meaning that when the ECB increases the purchases in government bonds with 1 percent, the bond yield will go down with approximately 0.00057 ($\beta_4/100$). Those outcomes could serve as evidence to justify the impact the QE program on the financial markets for European countries. Since the purpose of QE is to nudge investors towards more risky assets to stimulate lending facilities, the estimations reflect the desired outcome for the ECB.

The liquidity variable, measured as the bid-ask spread in 10-year government bonds (ba), reveals a significant positive influence when control groups are added. When markets are more efficient and possess more depth, bond yield are lowered. The relation seems pretty stable, fluctuating between 0.246 and 0.279, meaning bond yields go up by approximately 0.25 when bid ask spread increase with 1. The interaction term ba*PSPP measures whether the PSPP does strengthen the liquidity premia channel. This variable is able to show whether this liquidity channel is present in the current situation. In all estimation results one cannot observe a significant negative sign. This means that even though the liquidity variable is a good proxy in explaining the bond yields, the PSPP program did not strengthen this relation. As discussed in the literature review, the liquidity channel is mainly present in times of financial stress. Currently, even in the absence of PSPP, markets are already very liquid. Therefore, the PSPP does not serve as a measure to increase liquidity in the market, thereby lowering bond yields. This outcome implies that the significant negative sign for PSPP is most probably due to the portfolio rebalancing channel and the signaling channel.

The variable for the credit risk is highly significant in all estimations. The results imply an additional bond yield increase of 0.001 if the CDS 5 year prices would increase with 1. Since the prices of the CDS 5-year in this estimation have a mean of 308.66 and bond yields have a mean of 3.16, this relation is meaningful (see Appendix D for descriptive statistics). Column (6) shows that the alternative for the credit risk factor, debt-to-GDP, is not significant. The estimates show that the total debt-to-GDP in a country does not reflect the credit risk for an investor and is not a good proxy in explaining the country specific bond yield. As Afonso et al. (2012) and Klepsch and Wollmershäuser (2011) find, the role of fiscal fundamentals appears very limited in years that are not crisis year. Since 2014-2018 are not perceived as crisis years, the relation seems to be absent.

Table 1 shows that the model is not able to explain the risk aversion effect. The sentiment indicator was expected to show a negative sign, since better sentiment would encourage investors to rebalance their portfolios towards more risky securities. This could be due to the difference in cultures and the associated opinion towards risk. Weber and Hsee (1998) give evidence of how different cultures respond differently to indicators of risk. The sentiment variable used in this paper does not purely reflect the sentiment of professional investors, but is made up of a mix of consumers and private opinions. It could be hard to compare the different levels of sentiment and the associated demand for saver assets. Column (7) uses an alternative proxy for risk aversion, the market volatility VIX. This variable is also not able to show how higher risk translates into lower bond yields.

As an alternative for the PSPP variable, column (8) shows the results for the PSPP_total variable. The outcome illustrates that the larger the share of total accumulated PSPP of government bonds as a percentage of total debt securities issued, the lower bond yields will be. This output shows that when the share of PSPP of the total debt issued for a country increases with 1 percent, the bond yield will decrease with 0.016. This outcome implies that the longer (or the larger the monthly volume) the ECB purchases the government bonds from a specific country the lower the bond yields will be. Since this gives evidence that the effect of PSPP does not die out with larger total accumulated volumes, this could serve as a credible argument in extending the current QE program even further.

Bond yield spreads

Table 2 shows the estimations output for the intra-European bond market. Column (1) to (3) show the regressions for the three variables of interest, PSPP, Gap and PSPP_total respectively. Regressions (4) to (6) include, next to the country fixed effects, the control group. Column (7) till (9) add the quarterly fixed effects to the estimation.

The variables of interest, PSPP, Gap and PSPP_total show that the PSPP does not change the intra-European bond market, regardless of the specification details. The PSPP variable is not significant, implying that the level of purchases per country does not influence country i's bond yield relative to Germany. This implies that the European countries respond in the same way to the same treatment. The Gap variable, showing the relative unfair or 'missed' treatment, does not lead to a divergence in bond yields. When this variable would have been significantly positive, this would imply that countries that receive less monthly purchases due to the imposed regulations would suffer from this relating to higher bond yields relative to Germany. The higher the gap would be, the more monthly purchases they miss, the higher the bond yield spread. The

regressions show that this is not the case as all parameters for Gap equal zero. This outcome shows that monthly deviations from the 'fair' capital key cannot result in increasing bond yield spreads, or any fragmentation in the intra-European bond market. As the goal of the ECB is to treat all the European countries the same, this is the desired outcome. In measuring the share of the ECB in the total debt securities issued (PSPP_total) only a slightly significant sign is visible in regression 3. This does not give strong evidence that the ECB's share of the total debt securities issued by a country could lead to a change in the bond yield spread relative to Germany.

The persistence in the bond market is significantly present in all the estimations. The credit risk relative to Germany, shows that when the CDS spread increases with one, bond yield spread increase with 0.001. The ba_spread variable fluctuates between 0.189 and 0.197 meaning that higher liquidity in a market lowers bond yield spreads. The interaction term in table 2 shows that the PSPP did not strengthen this relation. As I find no evidence that PSPP is able to influence the bond yield spread, it is logical that the table provides no evidence for the liquidity channel.

It's interesting to observe that the indicator for risk aversion has only a significant correct sign for estimations excluding the control group. This could be due to Greece, a country that suffered significantly after the crisis and almost went bankrupt. As bond yields do demonstrate this severe time of the Greek debt crisis, the sentiment indicator does not move accordingly. Comparing the Greek 'crisis' sentiment with the sentiment of Ireland during their debt crisis (see Appendix E) proves that different cultures respond differently towards levels of risk. The international risk factor, proxied by VIX, shows that higher levels of foreign volatility indeed result in higher levels of bond yield spread, relative to Germany. The sign is statistically significant for 7 out of 9 regressions with the theoretically expected sign.

Furthermore, the announcement dummy has the expected, negative sign in all estimation, being only significant for the one without the control group. I added the dummy also for the control group countries, to see if there's any spillover effects. As the announcement dummy turns insignificant when including those countries, this gives evidence that investors in countries that do not receive the treatment do not respond to the announcement effect. The announcement effects is not exposed to spillover effects to non-treated countries.

As mentioned before, to make the outcomes more robust, I added a control group including UK, Greece, Norway and Switzerland in Table 1 and 2. Norway, UK and Switzerland are not members of the European Union and do therefore not receive any help in increasing their inflation levels from the ECB. Greece is a member of the European Union, but since the ECB just rescued Greece from its crisis, the Greece bond are considered too risky to invest in. In this setting, it is challenging to select a control group that does not create a selection bias since selection and treatment is not random. First, it could be possible that unconventional policy programs such as QE could lead to international spillovers, creating a serious selection bias. Fratzscher et al. (2016) show that the effects of ECB policies on bonds markets are negligible outside the Euro area. They find that credit risk channel could be slightly affected among banks, but that there exists limited evidence for any portfolio rebalancing in untreated countries. Falagiarda et al. (2015) find evidence for spillover effects for selected non-euro area EU countries (Czech Republic, Hungary, Poland and Romania) from general ECB announcements regarding the bond market. However, those of this relation for the PSPP program appeared to be very limited. Furthermore, table 2 shows that the

announcement dummy is only significant without the control group, giving evidence of a limited spillover effect. Secondly, the control group should be exposed to the same economic or political shocks as the treated countries as these shocks are not included in the regression. Changes in European jurisdiction for financial markets[10] or political implications such as Brexit should affect the countries proportionally. Therefore, this study does not include countries located in other continents (such as Canada or Japan). By including the selected control group, I assume that the central banks of those countries do not implement any unconventional policies purchasing securities within the selected time span.

To conclude the results, in line with theory, this paper finds that the PSPP program is able to lower bond yields. When controlling for the announcement effect, this paper finds that a 1 percent increase in PSPP results in a decrease in bond yields of 0.00057. Since this paper finds evidence that the liquidity premia channel was not accountable for this effect, the other two transmission channels, portfolio rebalancing and the signaling channel, will be responsible. Any deviations from the fair capital key did not result in a fragmentation of European bond markets, as bond yield spread are not affected. Furthermore, European countries respond in the same way to the unconventional measures of the ECB. The outcomes show that the total accumulated PSPP as a share of total securitized debt has no influence on the bond yield spreads. As the ECB requires to give all EMU countries the same treatment, this is the desired outcome for the ECB. The bond yields for the selected countries are well explained through the credit risk channel and the liquidity channel. This paper finds no evidence for the risk aversion channel. The output in table 2 shows that the intra-European bond market is also well explained through the credit risk channel and liquidity channel, in the absence of any evidence for the risk aversion channel.

[10] A current example are the new European Union rules that force fund issuers to provide a Key Information Document. This new regulation blocks European investors to invest in certain foreign funds, such as the SPY ETF's (the very popular $270 billion S&P 500 ETF Trust listed on the NSYE area) (Bloomberg, 23-02-2018).

Table 2
Impact of PSPP on the bond yield spread (relative to Germany)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
spr t-1	0.624***	0.624***	0.624***	0.640***	0.641***	0.641***	0.641***	0.642***	0.642***
	(0.025)	(0.024)	(0.024)	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)
cds_spread	0.004***	0.004***	0.004***	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***
	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ba_spread	-0.505	0.058	0.073	0.189***	0.192***	0.192***	0.196***	0.197***	0.197***
	(0.742)	(0.088)	(0.088)	(0.036)	(0.036)	(0.036)	(0.036)	(0.036)	(0.036)
rel.sent	-0.003**	-0.003**	-0.004***	0.007***	0.006***	0.006***	0.007***	0.006**	0.006**
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
vix	0.029	0.029	0.045*	0.086**	0.086**	0.088**	0.083**	0.083**	0.084*
	(0.021)	(0.021)	(0.022)	(0.043)	(0.043)	(0.044)	(0.044)	(0.044)	(0.047)
*ba*pspp*	0.151			-0.017			-0.011		
	(0.198)			(0.060)			(0.060)		
pspp	-0.002			-0.009			-0.008		
	(0.004)			(0.009)			(0.009)		
gap		0.000			0.000			0.000	
		(0.000)			(0.000)			(0.000)	
pspp_total			-0.003*			0.000			0.0002
			(0.002)			(0.004)			(0.004)
Announce	-0.075***	-0.074***	-0.065***	-0.036	-0.025	-0.024	-0.048	-0.038	-0.038
	(0.019)	(0.018)	(0.018)	(0.038)	(0.037)	(0.037)	(0.039)	(0.038)	(0.039)
Constant	-0.019	-0.026	0.084	0.107	0.086	0.078	0.121	0.105	0.099
	(0.062)	(0.058)	(0.065)	(0.117)	(0.115)	(0.124)	(0.127)	(0.125)	(0.137)
Country FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Quarterly FE	NO	NO	NO	NO	NO	NO	YES	YES	YES
incl. control group	NO	NO	NO	YES	YES	YES	YES	YES	YES
Obs.	459	459	459	662	662	662	662	662	662
#countries	9	9	9	13	13	13	13	13	13
R-squared	0.982	0.9819	0.9821	0.9772	0.9771	0.9771	0.9773	0.9772	0.9772

*Note: The regression models are estimated over the time period 2014.1-2018.3 (T=51). The panel members include Austria, Belgium, Finland, France, Greece Italy, Ireland, Spain, The Netherlands, Portugal, Switzerland, UK and Norway. The variables cds_spread, ba_spread and rel.sent are relative to the variables of Germany. The dummy variable for announcement equals one in 2014.10, 2015.1, 2015.2 and in 2016.3, and zero otherwise. The asterisks ***, **, * indicate significance at the 1, 5, 10% level respectively. Standard errors between brackets.*

Discussion

The estimated results of the regression warrant further discussion. To start, it is very difficult to assess the impact of QE, since those unconventional policy programs are only undertaken in times of severe economic difficulty when the short-term interest hits its ZLB (Martin and Milas, 2012). Furthermore, before the implementation of QE, interest rates and bond yields are already quite low. This could lead to insignificant results.

In studying the real effect of QE, it is most interesting to investigate daily or intra-daily data (De Santis, 2016; Altavilla et al., 2015) as bond yield fluctuate on intra-day basis. However, in explaining fluctuation in the bond markets, we use variables that are not available on daily basis, such as country specific sentiment indicators or fiscal fundamentals. It is extremely difficult to compare high frequency data with quarterly data such as debt levels. Since PSPP executed by the ECB is only available on monthly basis, high frequency data is converted into monthly data and quarterly data is linearly extrapolated into monthly data. When the ECB has information on daily purchases of the PSPP per country, credit risk would be proxied by CDS (available on daily basis) instead of using *debt-to-GDP* and there would exist a variable for risk aversion that is available on daily basis, a more accurate estimation could be studied.[11]

When studying the intra-European bond market and the influence QE has on this market, it would be very interesting to make country specific regressions, to see how different countries respond differently on the treatment and to observe which transition channels functions best for which countries. However, since the ECB purchases per country are only available on monthly basis, the total observation per country would be (2014.1-2018.3) 51 months. Including even more data from before the program could be misleading, since enlarging the dataset by including data from before the introduction of QE could lead to biased outcomes since it is assumed not to be biased by the extraordinary event that led to the introduction of QE (Martin and Milas, 2012). Furthermore, it is a pity that the ECB only publishes the purchases of country specific government bonds. They do not give information on the amounts of total monthly purchases of covered, corporate or supranational bond purchases per country. When the ECB would make this information available, the estimation in this paper should be redone.

For further research, it would be meaningful to collect the variable PSPP_total including all securities held by the ECB, including previous purchases during other programs instead of solely from the PSPP. When the ECB publishes this information, a more accurate picture of the relation between bond yields and total share of Eurosystem holdings of a country could be provided. This outcome could have serious policy implications in further decisions regarding extending the program, or discrimination across countries.

As a last comment, one should keep in mind that this study researches the effect QE has on the bond market, the financial market. The results of this paper do not give evidence on whether the unconventional policy measures of the ECB contributed in increasing the inflation and achieved its goal.

Conclusion

This paper determines empirically the extent to which the PSPP program of the ECB did contribute to lower bond yields. Since the relation between QE and inflation and output growth is incredibly difficult to measure, the reaction of the financial markets on QE is expected to demonstrate the clearest direct impact. This response will serve as a clear indicator on how the ECB program feeds through the real economy

[11] The proxy for liquidity risk (bid-ask spread) is also available on daily basis

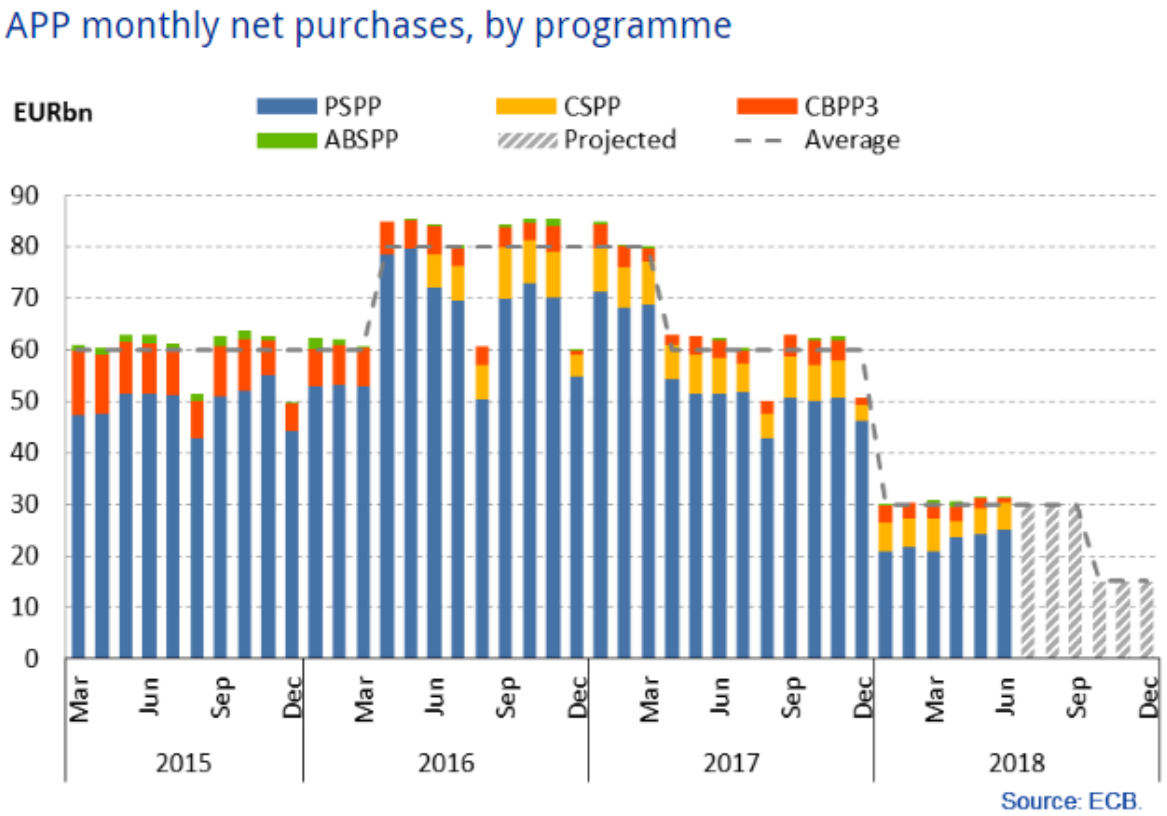
(Joyce et al., 2012). Furthermore, due to capital keys and imposed regulation by the ECB the monthly purchases differ significantly per month per country. This paper studies whether the deviation from this fair capital key could lead to changes in the intra-European bond market. To make the outcomes more robust, a control group of 4 non-participating countries is added. Previous literature focused on the announcement effect of the QE program, showing a temporarily effect on bond yields. Having more recent data, this paper is able to show the flow effect, giving more insight in the permanent effect of the QE program.

By using monthly data on bond yields and bond yield spread this paper finds evidence for a negative relation between the PSPP and bond yields, justifying the impact QE has on financial markets. As the output shows that the relation between liquidity and bond yields in not strengthened though the PSPP, the portfolio rebalancing channel and the signaling channel will most probably be accountable for this effect. The results show that the bond yields and bond yield spreads are well explained by the credit risk channel and the liquidity risk channel. This paper finds no evidence for the risk aversion channel being a prominent determinant for bond yields.

Output on bond yield spreads show that the participating countries did not respond to the treatment differently. Furthermore, the deviations from the fair capital key did not lead to a divergence in the intra-European bond market. This means that monthly deviations from its capital keys are not harmful for the European bond market in the way they are currently executed.

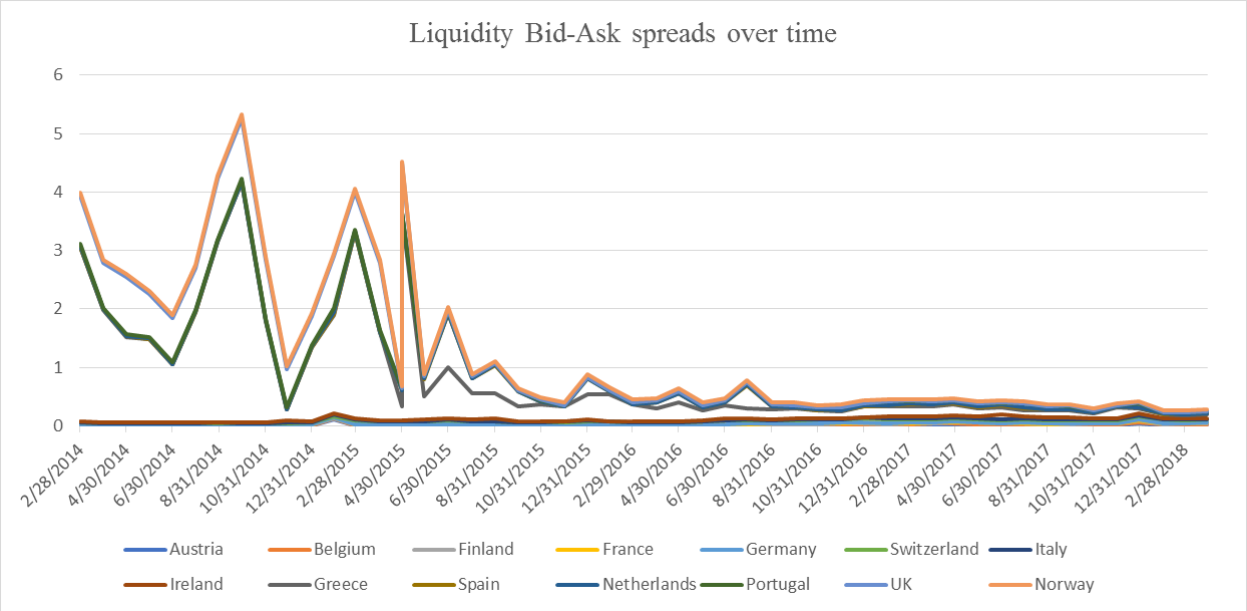
Appendix

Appendix A: Detailed explanation of Asset Purchases



Period	Amount	Securities
2015.3 – 2016.3	60 bln per month	Covered bond + PSPP
2016.4 – 2017.4	80 bln per month	Covered bonds + CSPP + PSPP
2017.5 – 2017.12	60 bln per month	Covered bonds + CSPP + PSPP
2018.1 – 2018.6	30 bln per month	Covered bonds + CSPP + PSPP

Appendix B: Liquid market



'The European market is already very liquid'

Picture illustrates that the bid-ask spread are already relatively low

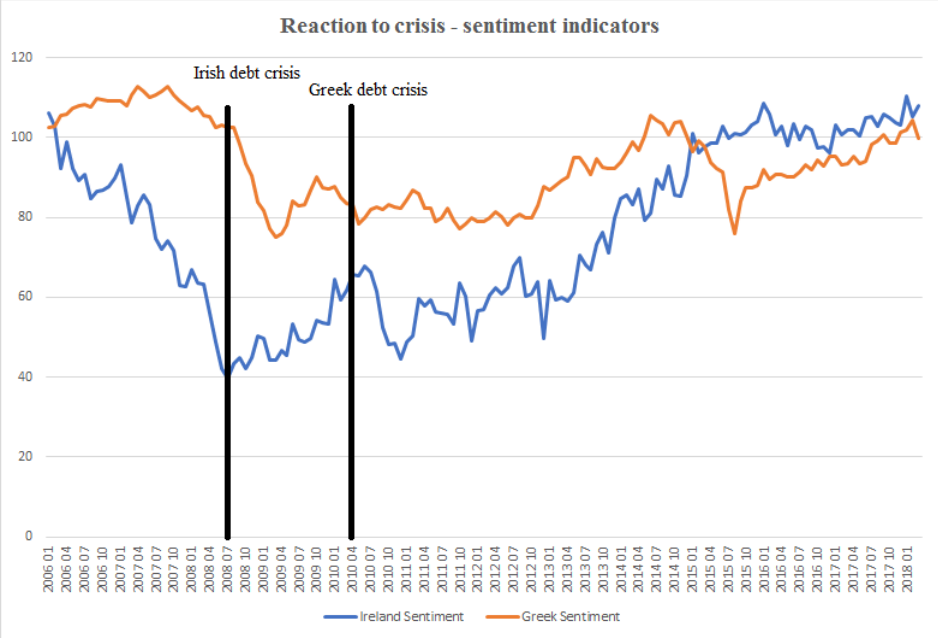
Appendix C: Sources of variables used

Variable	*Source*
Bond yield	Investing.com
CDS 5 Year	Bloomberg
VIX (Chicago Board Options Exchange SPX Volatility Index)	Bloomberg
European Commission Economic Sentiment Indicator	Bloomberg
Bid-ask spread 10 year government bonds	Bloomberg
Debt-to-GDP	Eurostat
Announcement dates	Ecb.Europe.eu, Press releases
PSPP	Ecb.Europe.eu, Bloomberg
Gap	Ecb.Europe.eu, Bloomberg, own calculations
Total securitized debt (PSPP_total)	Bloomberg

Appendix D: Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
by	1272	3.160457	3.729751	-.577	36.591
Bond yield spread	1272	1.866218	3.498272	-1.406	34.78
cds	1286	308.6648	1362.492	10.63	25422.81
cds spread	1287	274.3774	1357.28	-70.69	25349.15
Debt-to-gdp	1287	88.81904	36.21291	26.5	180.9
Rel. debt-to-gdp	1287	14.50793	36.69614	-51.6	115.4333
Implied PSPP	662	2051.972	3463.691	0	16014.27
Actual PSPP	662	1933.551	3355.193	-32	15398
Log(A.PSPP)	662	1.68129	1.712538	-1.105	4.187464
Gap	662	118.421	245.7938	-840.205	1096.05
PSPP_total	662	2.555643	3.529284	0	12.28308
Sentiment	1287	97.88772	11.82178	44.4	121.9
Rel. sent	1287	-7.406216	10.92144	-72.6	16.3
VIX	1287	17.34758	5.770664	9.51	42.96
ba	663	.0990407	.3672305	.001	4.109
ba_spread	663	.096178	.3673087	-.007	4.108

Appendix E: Sentiment Greek and Ireland crisis



The above figure shows that the Irish sentiment reacted much more drastically to their debt crisis than the Greek. As the sentiment indicator dropped from 100 towards 40 in Ireland, the Greek sentiment dropped from 100 to 80 during their crisis.

References

Afonso, A., Arghyrou, M., & Kontonikas, A. (2012). The determinants of sovereign bond yield spreads in the EMU. *ISEG Economics Working Paper No. 36/2012/DE/UECE*

Albertazzi, U., Becker, B., & Boucinha, M. (2018). Portfolio rebalancing and the transmission of large-scale asset programmes: evidence from the euro area.

Albu, L. L., Lupu, R., Călin, A. C., & Popovici, O. C. (2014). The Effect of ECB's Quantitative Easing on Credit Default Swap Instruments in Central and Eastern Europe. *Procedia Economics and Finance, 8, 122-128.*

Alesina, A., De Broeck, M., Prati, A., & Tabellini, G. (1992). Default risk on government debt in OECD countries. *Economic policy*, *7*(15), 427-463.

Altavilla, C., Carboni, G., & Motto, R. (2015). Asset purchase programmes and financial markets: lessons from the euro area.

Andersson, M., Hansen, L., & Sebestyén, S. (2006). *The effects of macroeconomic and monetary policy announcements on the euro area intraday bond market* (No. 631). ECB Working Paper.

Andrade, J. S., & Duarte, A. (2011). The fundamentals of the Portuguese crisis. *Panoeconomicus*, *58*(2), 195-218.

Aristei, D., & Martelli, D. (2014). Sovereign bond yield spreads and market sentiment and expectations: Empirical evidence from Euro area countries. *Journal of Economics and Business*, *76*, 55-84.

Arslanalp, M. S., & Botman, D. P. (2015). Portfolio Rebalancing in Japan: Constraints and Implications for Quantitative Easing. *(No. 15-186). International Monetary Fund.*

Bauer, M. D., & Rudebusch, G. D. (2013). The signaling channel for Federal Reserve bond purchases.

Barrios, S., Iversen, P., Lewandowska, M., & Setzer, R. (2009). Determinants of intra-euro area government bond spreads during the financial crisis *(No. 388). Directorate General Economic and Financial Affairs (DG ECFIN), European Commission.*

Bayoumi, T., Goldstein, M., & Woglom, G. (1995). Do credit markets discipline sovereign borrowers? Evidence from US states. *Journal of Money, Credit and Banking*, *27*(4), 1046-1059.

Beber, A., Brandt, M. W., & Kavajecz, K. A. (2008). Flight-to-quality or flight-to-liquidity? Evidence from the euro-area bond market. *The Review of Financial Studies, 22(3), 925-957.*

Bernanke, B., Reinhart, V., & Sack, B. (2004). Monetary policy alternatives at the zero bound: An empirical assessment. *Brookings papers on economic activity*, *2004*(2), 1-100.

Bernoth, K., Von Hagen, J., & Schuknecht, L. (2004). Sovereign risk premia in the European government bond market.

Bernoth, K., & Erdogan, B. (2012). Sovereign bond yield spreads: A time-varying coefficient approach. *Journal of International Money and Finance*, *31*(3), 639-656.

Brandner, P., Grech, H., & Kazemzadeh, K. (2007). Yield differences in Euro area government bond markets: a view from the market. *Federal Ministry of Finance.*

Brunner, K., & Meltzer, A. H. (1973). Mr. Hicks and the" Monetarists". *Economica, 40(157), 44-59.*

Campbell, J. Y., Lo, A. W., & MacKinlay, A. C. (1997). The econometrics of financial markets (Vol. 2, pp. 149-180). *Princeton, NJ: princeton University press.*

Chen, T. K., Liao, H. H., & Tsai, P. L. (2011). Internal liquidity risk in corporate bond yield spreads. *Journal of Banking & Finance*, *35*(4), 978-987.

Christensen, J. H., & Rudebusch, G. D. (2012). The response of interest rates to US and UK quantitative easing. *The Economic Journal*, *122*(564).

Claeys, G., Leandro, Á., & Mandra, A. (2015). European Central Bank quantitative easing: the detailed manual (No. 2015/02). Bruegel policy contribution.

Clouse, J., Henderson, D., Orphanides, A., Small, D. H., & Tinsley, P. A. (2003). Monetary policy when the nominal short-term interest rate is zero. *topics in Macroeconomics*, *3*(1).

Codogno, L., Favero, C., & Missale, A. (2003). Yield spreads on EMU government bonds. *Economic Policy*, *18*(37), 503-532.

De Santis, R. A. (2016). Impact of the asset purchase programme on euro area government bond yields using market news.

Dungey, M., Martin, V. L., & Pagan, A. R. (2000). A multivariate latent factor decomposition of international bond yield spreads. *Journal of Applied Econometrics*, *15*(6), 697-715.

Eser, F., & Schwaab, B. (2013). Assessing asset purchases within the ECB's securities markets programme

Ericsson, J., & Renault, O. (2006). Liquidity and credit risk. *The Journal of Finance*, *61*(5), 2219-2250.

Falagiarda, M., McQuade, P., & Tirpák, M. (2015). Spillovers from the ECB's non-standard monetary policies on non-euro area EU countries: evidence from an event-study analysis (*No. 1869). ECB Working Paper.*

Favero, C., Pagano, M., & Von Thadden, E. L. (2010). How does liquidity affect government bond yields?. *Journal of financial and quantitative analysis*, *45*(1), 107-134.

Fratzscher, M., Duca, M. L., & Straub, R. (2016). ECB unconventional monetary policy: Market impact and international spillovers. *IMF Economic Review*, *64*(1), 36-74.

Fratzscher, M., Lo Duca, M., & Straub, R. (2018). On the international spillovers of US quantitative easing. *The Economic Journal*, *128*(608), 330-377.

Gagnon, J., Raskin, M., Remache, J., & Sack, B. (2011). The financial market effects of the Federal Reserve's large-scale asset purchases. *international Journal of central Banking*, *7*(1), 3-43.

Gerlach, S., Schulz, A., & Wolff, G. B. (2010). Banking and sovereign risk in the euro area.

Goldberg, L. S., & Klein, M. W. (2005). Establishing credibility: evolving perceptions of the European Central Bank (No. w11792). *National Bureau of Economic Research.*

Goldstein, M. M., & Woglom, G. (1991). *Market-based fiscal discipline in monetary unions: Evidence from the US municipal bond market*. International Monetary Fund.

Haugh, D., Ollivaud, P., & Turner, D. (2009). What Drives Sovereign Risk Premiums?.

Joyce, M., Lasaosa, A., Stevens, I., & Tong, M. (2011). The financial market impact of quantitative easing in the United Kingdom. *International Journal of Central Banking*, *7*(3), 113-161.

Kenourgios, D., Papadamou, S., & Dimitriou, D. (2015). Intraday exchange rate volatility transmissions across QE announcements. *Finance Research Letters*, *14*, 128-134.

Krishnamurthy, A., & Vissing-Jorgensen, A. (2011). The effects of quantitative easing on interest rates: channels and implications for policy *(No. w17555). National Bureau of Economic Research.*

Klepsch, C. & Wollmershäuser, T. (2011). Yield spreads on EMU government bonds: How the financial crisis has helped investors to rediscover risk. *Intereconomics, ISSN 1613-964X, Springer, Heidelberg, Vol. 46, Iss. 3, pp. 169-176*

Langedijk, S., Monokroussos, G., & Papanagiotou, E. (2017). Benchmarking liquidity proxies: The case of EU sovereign bonds. *International Review of Economics & Finance*.

Lemmen, J. J., & Goodhart, C. A. (1999). Credit risks and european government bond markets: a panel data econometric analysis. *Eastern Economic Journal*, *25*(1), 77-107.

Lim, J., Minton, B. A., & Weisbach, M. S. (2014). Syndicated loan spreads and the composition of the syndicate. Journal of Financial Economics, 111(1), 45-69.

Lybek, M. T., & Sarr, M. A. (2002). Measuring liquidity in financial markets *(No. 2-232). International Monetary Fund.*

Martelli, D., & Aristei, D. Behavioral Factors Influencing Sovereign Bond Yield Spreads: Evidence from Euro Countries.

Martin, C., & Milas, C. (2012). Quantitative easing: a sceptical survey. *Oxford Review of Economic Policy, 28(4), 750-764.*

Meaning, J., & Zhu, F. (2011). The impact of recent central bank asset purchase programmes.

Nayak, S. (2010). Investor sentiment and corporate bond yield spreads. *Review of Behavioral Finance*, *2*(2), 59-80

Pagano, M., & Von Thadden, E. L. (2004). The European bond markets under EMU. Oxford review of economic policy, 20(4), 531-554.

Poterba, J. M., & Rueben, K. S. (1997). State fiscal institutions and the US municipal bond market *(No. w6237). National Bureau of Economic Research.*

Schuknecht, L., Hagen, J. V., & Wolswijk, G. (2010). Government bond risk premiums in the EU revisited: The Impact of the financial crisis.

Swanson, E. T. (2011). Let's twist again: a high-frequency event-study analysis of operation twist and its implications for QE2. *Brookings Papers on Economic Activity*, *2011*(1), 151-188.

Tobin, J. (1963). Commercial banks as creators of money. (No. 159). *Cowles Foundation for Research in Economics, Yale University.*

Tobin, J., & Buiter, W. (1976). Long-run effects of fiscal and monetary policy on aggregate demand. (*pp. 273-309). Cowles Foundation for Research in Economics at Yale University.*

Whaley, R. E. (2008). Understanding vix.

Van Marle. B.A.S., & De Vries, D. (2015). QE geen zichtbaar effect op economisch herstel in Europa.

Zoli, M. E., & Sgherri, M. S. (2009). Euro area sovereign risk during the crisis *(No. 9-222). International Monetary Fund.*