UNIVERSITÄT BONN

THE MACRO-ECONOMICS OF INEQUALITY GRK 2281

Title: Spillover Effects of Sovereign Debt-Based Quantitative Easing in the Euro Area

Authors: Matthias Gnewuch

Date: May 2020

RTG 2281 – Discussion Papers

No. 2020-3

Abstract

This paper proposes an identification strategy for news about sovereign debt-based as-set purchases. The idea is to measure sovereign yield changes unrelated to movements in risk-free interest rates or risk premiums. Around ECB announcements, these re-flect changes in bond scarcity. This paper documents that asset purchase news about government bonds have substantial spillovers to corporate bond and stock markets, within and beyond the euro area. Spillovers are unequal across euro-area countries, as corporate yields fall, and stock prices rise most in countries with initially low sovereign yields. In contrast, sovereign yields fall most where they are initially high.

Funded by DFG Deutsche Forschungsgemeinschaft German Research Foundation

Spillover Effects of Sovereign Debt-Based Quantitative Easing in the Euro Area*

Matthias Gnewuch†

May 6, 2020

Abstract

This paper proposes an identification strategy for news about sovereign debt-based asset purchases. The idea is to measure sovereign yield changes unrelated to movements in risk-free interest rates or risk premiums. Around ECB announcements, these reflect changes in bond scarcity. This paper documents that asset purchase news about government bonds have substantial spillovers to corporate bond and stock markets, within and beyond the euro area. Spillovers are unequal across euro-area countries, as corporate yields fall, and stock prices rise most in countries with initially low sovereign yields. In contrast, sovereign yields fall most where they are initially high.

Keywords: quantitative easing, portfolio balance channel, high-frequency identification, euro area heterogeneity, ECB, PSPP

JEL Codes: E58, E52, G12

*I would like to thank Keith Kuester, Donghai Zhang, Christian Bayer, Benjamin Born, Martin Dohmen, as well as seminar participants at the 7th Workshop on Empirical Monetary Economics, the 13th RGS Doctoral Conference in Economics, the 3rd Bonn-Mannheim PhD Workshop, the RTG 2281 Summer School 2019, the BGSE Brown Bag Seminar, and the Bonn Macro Reading Group for helpful comments and suggestions. I thank the DFG for supporting my research as part of the research training group RTG 2281 "The Macroeconomics of Inequality". Financial support from the Bonn Graduate School of Economics is gratefully acknowledged.

†University of Bonn, Bonn Graduate School of Economics, Adenauerallee 24 - 42, 53113 Bonn, Germany. E-mail address: matthias.gnewuch@uni-bonn.de

1 Introduction

Since the Great Recession, central banks around the world have introduced large-scale asset purchase programs to provide stimulus to economies at or near the Effective Lower Bound (ELB). Initially, these programs were considered to be exceptional and temporary, hence the name *unconventional* monetary policy. Yet, central bank balance sheets have remained at elevated levels and asset purchase programs may become a permanent instrument of central bank policy. In light of this, it is of first-order importance to understand the effects and transmission mechanisms of asset purchases.

In this paper, I examine whether central bank purchases of government debt, henceforth "asset purchases", have distributional effects. Towards this end, I first develop an identification strategy to provide accurate estimates of the effects of asset purchase news. Then, I evaluate the financial effects of news about asset purchases in the euro area. A particular focus is on heterogeneities across countries and spillovers to other asset classes. The evidence shows that asset purchases reduce sovereign yields most in countries with initially high sovereign yields. At the same time, they reduce corporate yields and raise stock prices; the effects being largest where sovereign yields are initially low. These contrasting heterogeneous effects may raise doubts about the prevalent view that asset purchases mostly benefit highly indebted countries.[1]

The identification strategy developed in this paper builds on high-frequency identification. To measure asset purchase news in the euro area, much of the related literature uses the change in a long-term bond yield in a tight window around hand-selected ECB announcements. Instead, I emphasize in this paper that the change in long-term bond yields may not only capture asset purchase news. Rather, it captures the sum of all news about monetary policy, including forward guidance. To identify asset purchase news, I therefore decompose long-term sovereign yields of several euro-area countries into the risk-free interest rate, a

[1]For example, *The Economist* wrote "QE, by lowering the financing costs of indebted southern governments, allows them to avoid painful reforms. It is true that loose money has benefited highly indebted countries the most." (The Economist, October 10, 2019, "What to make of the strife at the ECB")

country-specific risk premium, and a scarcity premium. The scarcity premium arises because financial institutions have a special demand for sovereign bonds. Thus, when supply is scarce, they are willing to hold sovereign bonds at a yield below the yield justified by risk-free rate and risk premium. The change in this scarcity premium around ECB announcements is used to measure asset purchase news. The idea is that bond scarcity is aggravated by asset purchases, but arguably not affected by other news about monetary policy. To create a single measure of asset purchase news, I take the first principal component of the changes in the scarcity premium of the ten largest euro-area countries around ECB announcements. This has the additional benefit of minimizing country-specific noise. Moreover, instead of hand-selecting events, I use *all* ECB Governing Council Meetings (GCMs) between October 2014 and December 2018. The resulting series of asset purchase news about government bonds correctly captures major announcements regarding the Public Sector Purchase Programme (PSPP).

With this identified series at hand, I estimate the effects of asset purchase news on financial markets in event-study regressions. I find that a large announcement of asset purchases, such as the initial PSPP announcement on January 22, 2015, reduces 10-year sovereign yields in the euro area by between 9 and 15 basis points. Purchases of sovereign bonds reduce not only the yields of euro-area sovereign bonds, but also the yields of corporate bonds and non-euro area sovereign bonds. Moreover, stock prices rise in the euro area and in other developed countries. These spillover effects are consistent with the portfolio balance channel of asset purchases, which holds that investors rebalance their portfolios from the sovereign bonds purchased by the ECB towards substitute assets. The estimated effects are larger among sovereign bonds with a higher yield, highly-rated corporate bonds, and stocks in countries with low risk premia, suggesting that investors search for yield, but mainly among relatively safe assets. In addition, asset purchases modestly reduce expected risk-free nominal interest rates in line with a signaling effect and strongly depreciate the euro against all major currencies.

I document heterogeneous effects across euro-area countries. While asset purchases reduce sovereign yields in all countries, the effect is largest in countries where sovereign yields were high initially (Italy, Spain, Portugal). Thus, asset purchases narrow sovereign spreads in the euro area. However, this pattern reverses in the corporate sector. Corporate yields themselves fall and stock prices rise in all countries, but the effects are largest where sovereign yields were low to start with (Finland, Germany, France, Netherlands). One reason is the distribution of firm ratings. In countries with a low sovereign rating, firms on average had low corporate ratings as well and thus benefited less from spillover effects among highly-rated debt.[2]

Institutional Background. The analysis focuses on asset purchases under the ECB's PSPP. Choosing the euro area as a setting strengthens the identification strategy that I propose for two reasons. First, I can exploit that the same monetary policy applies to a number of countries. Second, the identification strategy builds on bond scarcity, which allegedly was more severe in Europe than elsewhere, as Coeuré (2018) explains.

I focus on the PSPP because at the time of writing it is by far the largest of the ECB's asset purchase programs. The left panel of Figure 1 illustrates quarterly holdings under the four asset purchase programs, which comprise the ECB's Asset Purchase Programme (APP). By December 2018, the ECB held around €2100bn worth of euro-area government and agency debt under the PSPP, which amounts to roughly 20% of euro-area annual Gross Domestic Product (GDP). In comparison, the other programs were relatively small. The ECB held assets worth around €262bn under the Covered Bond Purchase Programme (CBPP), €178bn under the Corporate Sector Purchase Programme (CSPP), and €27bn under the Asset-Backed Securities Purchase Programme (ABSPP) by December 2018.

Throughout, the composition of PSPP purchases across countries was tied to the

[2]The corporate sector evidence connects to the theory proposed by Liu et al. (2019), according to which ultra-expansionary monetary policy benefits market leaders more than market followers. Whereas their mechanism relies on strategic behavior, my findings suggest that market leaders benefit most because financing conditions for highly-rated corporations improve more than for low-rated ones.

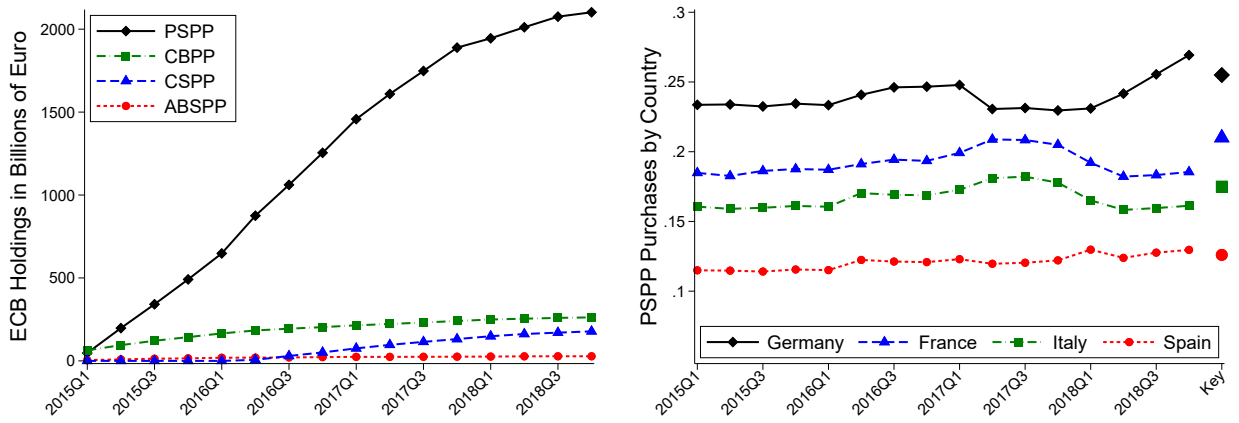


Figure 1: The European Central Bank's Asset Purchase Programme

Notes (left panel): ECB holdings under the Public Sector Purchase Programme (PSPP), the Covered Bond Purchase Programme (CBPP), the Corporate Sector Purchase Programme (CSPP), and the Asset-Backed Securities Purchase Programme (ABSPP) by quarter in billions of euro. Source: ECB.

Notes (right panel): ECB purchases under the Public Sector Purchase Programme (PSPP) by country as a share of total PSPP purchases, by quarter. Rightmost markers depict the Eurosystem key valid from 2015 to 2018. Source: ECB.

ECB's Eurosystem key.[3] Therefore, the composition was known in advance and stable over time.[4] The right panel of Figure 1 confirms that country shares of actual purchases under the PSPP fluctuated little over time. (Shown here for the four largest euro-area countries) These shares were also in line with the respective Eurosystem key. In contrast, both the duration of the program and monthly purchase amounts were adjusted several times.[5] Therefore, the final amount of ECB purchases was uncertain. In sum, any ECB communication possibly changed expectations about the final amount, but not about the distribution of ECB holdings across countries.

Related Literature. This paper relates to three strands of the literature. First and foremost, it relates to the literature investigating the information content of high-frequency monetary surprises. A seminal contribution is Gürkaynak et al. (2005), who show that more

[3]The ECB's Eurosystem key is closely linked to the better known *capital key*. However, the latter includes capital subscribed by non-euro area central banks, such as the Bank of England. Since these countries' government bonds were not purchased under the PSPP, the distribution of purchases follows the Eurosystem key.

[4]The Eurosystem key valid at the beginning of the PSPP remained unchanged until 2019.

[5]A detailed timeline of major events can be found in Hammermann et al. (2019).

than one factor is required to explain high-frequency monetary surprises. A number of recent papers, including Nakamura and Steinsson (2018), Zhang (2019), Kerssenfischer (2019), Cieslak and Schrimpf (2019), and Jarociński and Karadi (2019), emphasize that non-monetary news, such as the dissemination of central bank information, are an important aspect of central bank communication. Kroencke et al. (2018) identify shocks to investors' attitude towards risk during FOMC meetings. Andrade and Ferroni (2019) identify Delphic and Odyssean forward guidance shocks in the euro area. Swanson (2019) separates conventional monetary policy, forward guidance and asset purchase shocks for the U.S. by means of a factor rotation. Lewis (2019) identifies asset purchase shocks for the U.S. alongside other monetary policy shocks based on intraday time-varying volatility. I contribute to this literature by developing a new identification strategy for asset purchase news in the euro area, exploiting bond scarcity and the fact that ECB monetary policy applies to several countries.

Second, I relate to the literature on the portfolio balance channel and more broadly the financial market impact of large-scale asset purchases. Krishnamurthy and Vissing-Jorgensen (2011) provide an early assessment of the channels of the Federal Reserve's QE programs. D'Amico and King (2013) distinguish between stock and flow effects of asset purchases.[6] Krishnamurthy et al. (2018) consider the effects of the ECB's Securities Markets Programme (SMP) and Outright Monetary Transactions (OMT). Several recent papers, including Koijen et al. (2018), Bergant et al. (2018) and Albertazzi et al. (2018), analyze portfolio flows before and during the PSPP using quarterly transaction-level data. This paper complements their research on the portfolio balance channel by using data at a higher frequency and carefully identified asset purchase news.

Third, I add to the literature on heterogeneous effects of asset purchases across regions. Altavilla et al. (2015) and De Santis (2019), using different empirical approaches,

[6]By construction, asset purchase news only measure stock effects of asset purchases, i.e. the effect of the ECB holding (or announcing to hold) a certain stock of assets. Potential flow effects of asset purchases, i.e. the effect of the actual purchases of these assets, are not measured. D'Amico and King (2013) find stock effects to be quantitatively more important. See Schlepper et al. (2018) for an analysis of the flow effects of purchases under the PSPP in the market for German sovereign bonds.

find that asset purchases narrow sovereign spreads in the euro area. Wieladek and Pascual (2016), Burriel and Galesi (2018), and Hachula et al. (2019) provide VAR-based assessments of heterogeneous effects across countries of the ECB's unconventional monetary policies in general. Georgiadis and Gräb (2016) evaluate the financial effects of early PSPP announcements outside the euro area. To the best of my knowledge, this paper is the first to estimate and contrast heterogeneous financial effects of the ECB's asset purchases at the sovereign and corporate level.

Most closely related is Altavilla et al. (2019). In parallel work, they also identify asset purchase news, referred to as QE shocks, for the ECB by applying the factor rotation methodology of Swanson (2019) to the euro area. The advantage of my strategy is that it does not rely on orthogonality and exclusion restrictions among factors. In contrast, I use an economically motivated exclusion restriction and exploit the fact that the ECB's actions affect several countries. Reassuringly, using a different methodology and dataset, Altavilla et al. (2019) identify a similar shock series. Furthermore, they find similar results regarding the effect of asset purchases on sovereign spreads, risk-free interest rates, and euro exchange rates. New to my paper are the results regarding the corporate sector.

The remainder of this paper is structured as follows. Section 2 explains the identification of asset purchase news and presents the resulting series. Section 3 estimates the effects of asset purchases on financial markets and interprets the findings. Section 4 performs a number of robustness checks and section 5 concludes.

2 Identification Strategy

A large literature strives to identify exogenous variation, so called shocks, in monetary policy in order to better understand its effects and mechanisms. As Ramey (2016) discusses, it is essential that these shocks are not endogenous to the state of the economy due to foresight by policymakers, and not expected due to foresight by economic agents. A popular strategy to

deal with both of these foresight issues, which I build on, is high-frequency identification. The idea is to exploit that a considerable amount of news about monetary policy is communicated by central banks on particular occasions, the Governing Council Meetings in the case of the ECB. Given the availability of a high-frequency measure of monetary policy expectations, such as an interest rate future, the monetary surprise is captured by the change in this measure in a tight window around these events. The key assumption is about timing. That is, during the tight window there is news about monetary policy, which is fully reflected in the change of the high-frequency measure, while there are no other news that affect monetary policy expectations. Because monetary policy expectations are formed by economic agents, taking into account the state of the economy, the two foresight issues are taken care of.[7]

When a central bank only uses conventional monetary policy and is not constrained by the Zero Lower Bound (ZLB), it is straightforward to measure monetary policy expectations, using the expected short-term interest rate. However, in times of a binding ZLB and when unconventional monetary policies are employed, other measures of monetary policy expectations are needed. Namely, measures which capture unconventional policies while still being available at a high frequency. In the related literature, long-term bond yields are commonly used for this purpose.[8] However, while long-term bond yields can be used to capture expectations of unconventional policy measures in general, they themselves are ill-suited to measure the surprise due to a particular policy action. Specifically, the timing assumption is problematic, since changes in long-term yields capture the sum of *all* monetary surprises (conventional monetary policy, forward guidance, asset purchases, central bank information) during a particular event window. To deal with this multidimensionality of central bank communication, a growing literature proposes identification strategies to disentangle the information content of these high-frequency changes in long-term bond yields. My contribution

[7]This implicitly makes the assumption that economic agents and policymakers are equally well informed, which seems reasonable in recent contexts.

[8]For example, Andrade et al. (2016) use the German 5-year yield, Hachula et al. (2019) use a number of euro-area 2-year yields excluding German Bunds, and Gambetti and Musso (2017) use a GDP-weighted euro-area 10-year yield.

is to develop an identification strategy for asset purchase news in the euro area.

2.1 Measuring Asset Purchase News

For the purpose of identifying asset purchase news with regard to government bonds, I first of all use high-frequency identification around the ECB's Governing Council Meetings to deal with the two foresight issues. To measure changes in monetary policy expectations, I start out using long-term government bond yields, which capture asset purchase news, but also forward guidance and conventional monetary policy shocks, as explained above.

The basic idea of my identification strategy is not to use changes in the entire long-term government bond yield, but to decompose the yield and isolate a component, which around ECB Governing Council Meetings is affected only by asset purchase news. I draw on Krishnamurthy et al. (2018) and consider the following decomposition of the nominal yield of a sovereign bond of country c with remaining term to maturity T:

$$
\begin{aligned}
yield^{c,T} = & \underbrace{i^T}_{\substack{Overnight\ Index\ Swap\ (OIS)\ rate\ with\ maturity\ T}} \\
& + \underbrace{CountryRiskPremium^{c,T}}_{\substack{Credit\ Default\ Swap\ (CDS)\ rate\ of\ country\ c\ with\ maturity\ T}} \\
& + \underbrace{ScarcityPremium^{c,T}}_{Component\ of\ interest} + \epsilon^{c,T}
\end{aligned}
$$

The first component, i^T, is the risk-free nominal interest rate associated with the remaining maturity. It is straightforward to measure this rate from maturity-matched interest rate swaps using the Euro OverNight Index Average (EONIA) as the underlying floating rate.[9]

[9]These interest rate swap contracts are used to hedge interest rate exposure. The buyer periodically pays a fixed rate (the swap rate) to the seller and receives the current (floating) rate in return, thereby trading interest rate risk. Without uncertainty, the swap rate would equal the average expected interest rate. With uncertainty, the swap rate will also include a risk premium which compensates the seller for bearing the interest rate risk. Therefore, the overnight index swap (OIS) rate using the Euro OverNight Index Average (EONIA) as the underlying floating rate is a convenient measure of the Euro risk-free interest rate along with the interest rate risk premium. Lloyd (2018) explains that counterparty risk in OIS contracts is minor. EONIA OIS contracts are fairly liquid and available for a wide range of maturities ranging from two weeks to thirty years.

The second component, the country-specific risk premium, compensates the investor for bearing the risk of and loss in case of sovereign default and currency redenomination. For the time period of interest, it is also straightforward to measure this premium from maturity-matched credit default swap (CDS) rates traded under the 2014 ISDA Credit Derivatives Protocol.[10] The third component, which I refer to as the scarcity premium[11], is measured residually, along with idiosyncratic noise $\epsilon^{c,T}$. This premium should be negligible under no-arbitrage considerations. However, in the data it is quite large due to the particularities of sovereign bonds. These are commonly used to collateralize transactions, serve as a safe storage facility, and count as high-quality liquid assets towards banks' *liquidity coverage ratio*.[12] Therefore, they provide utility to banks and financial institutions. According to Krishnamurthy and Vissing-Jorgensen (2011), this gives rise to a *unique demand* for government bonds. The combination of this unique demand and a constrained supply, in particular in times of large-scale asset purchases by the central bank, gives rise to the scarcity premium. Moreover, the third component picks up any additional systematic drivers of the sovereign yield, such as potentially a liquidity premium[13], as well as idiosyncratic noise. I discuss the liquidity premium and show that it does not significantly affect the scarcity premium in Appendix A. Furthermore, I assert that the main results are unaffected by controlling for the presence of background noise in a robustness check in section 4.

I use the change in this scarcity premium around ECB Governing Council Meetings as a measure of asset purchase news. Doing so necessitates two key assumptions, which are

[10]CDS contracts based on the 2014 ISDA Credit Derivatives Protocol, which are traded since September 22, 2014, insure against sovereign default and currency redenomination risk. CDS contracts under the previous 2003 ISDA Credit Derivatives Protocol do not insure against currency redenomination for G-7 countries. Due to this, I restrict my analysis to the period after the introduction of the 2014 CDS protocol. Available maturities range from six months to thirty years. I use CDS contracts denominated in euro and impute missing values with the more liquid CDS contracts denominated in US dollars.

[11]I refer to this component as a premium, because, while it *decreases* the yield, it *increases* the price of the bond. This nomenclature follows the definition of the liquidity premium in Nagel (2016).

[12]Under the Basel III regulatory framework, banks are required to have a liquidity coverage ratio (LCR) of 100% or higher. The LCR is defined as high-quality liquid assets divided by total net liquidity outflows over 30 days. Sovereign bonds count as high-quality liquid assets without haircut.

[13]The liquidity premium can be negative if investors are willing to accept a lower yield for an extremely liquid asset, or positive if investors demand compensation for the risk of not being able to sell the asset immediately in the future, as was the case during the Euro crisis.

visualized in Figure 2. First, I assume that asset purchase news affect the scarcity premium (Relevance Assumption). This rests on a simple supply and demand logic, where asset purchases reduce the amount of sovereign bonds available to markets in the future and demand is sufficiently inelastic due to the special role of sovereign bonds for financial institutions.[14] Actual purchases do not need to happen during the event window, since financial markets are forward-looking and therefore incorporate the news into prices regardless. Secondly, I assume that other central bank communication does not affect the scarcity premium around ECB Governing Council Meetings (Exogeneity Assumption). News regarding conventional monetary policy and forward guidance affect bond yields through the risk-free rate. Central bank information or news affecting investors' perception of risk could in principle increase the demand for bonds and therefore the scarcity premium in safe haven countries, which is why I combine information from several countries at a later point. Moreover, the ECB did not directly affect bond scarcity on Governing Council Meeting days during the relevant time period through major changes to its collateral framework.[15] I provide empirical support for both assumptions in subsection 2.3.

In principle, the decomposition explained above can be applied to sovereign bonds of any maturity and any euro-area country, whose bonds were bought under the PSPP. I focus on long-term bonds and utilize 10-year sovereign yields. The reason is that in the relevant time period long-term bonds never traded at a yield below the Deposit Facility Rate (DFR), which would have made them ineligible for ECB purchases before December 2016. This matters in particular for the Netherlands, France, Germany, and Finland, whose short-term government bonds did periodically trade at a yield below the DFR. Furthermore, I focus on countries with a sufficiently large and liquid government bond market. Therefore, I select the

[14] Krishnamurthy et al. (2018) provide a short overview of studies discussing market segmentation in the form of limited substitution between sovereign and other bonds. In addition, most models which allow for asset purchases to have real effects rely on some form of market segmentation. Examples are Vayanos and Vila (2009) and Sims and Wu (2019).

[15] There are two potentially interfering regulatory changes. On December 8, 2016, the Eurosystem introduced cash collateral for PSPP securities lending facilities. On December 14, 2017, there were changes to collateral eligibility criteria for unsecured bank bonds. However, neither of these regulatory changes seems quantitatively important.

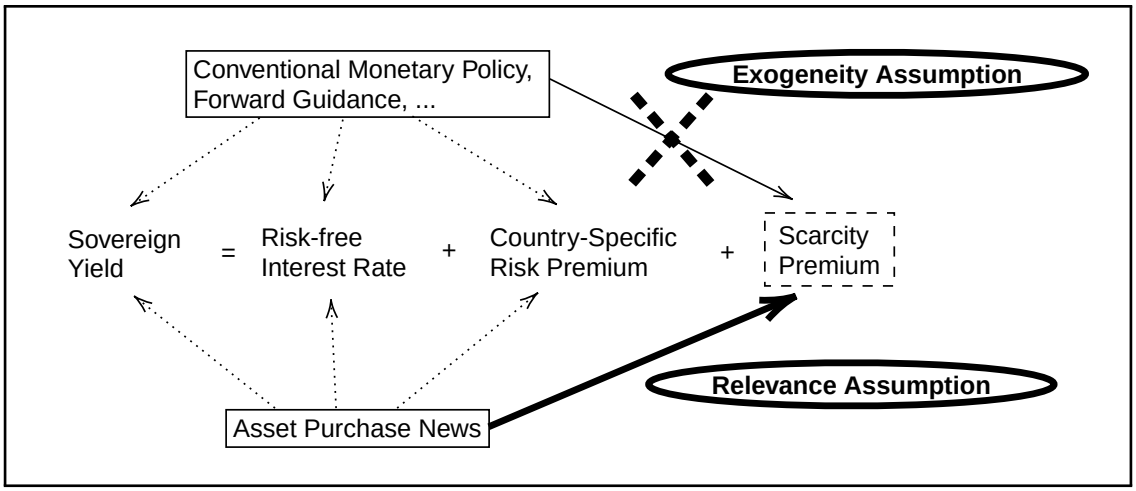


Figure 2: Visualization of Identifying Assumptions

ten biggest euro-area countries according to the ECB capital key. These are Belgium (BE), Germany (DE), Ireland (IE), Spain (ES), France (FR), Italy (IT), the Netherlands (NL), Austria (AT), Portugal (PT), and Finland (FI). In a robustness check in section 4, I assert that dropping any one country from the sample does not change any results. Note that Greece is excluded, because Greek bonds were not eligible for purchase under the PSPP. Following Hanson and Stein (2015), I use daily changes around ECB Governing Council Meetings. While not using data at a higher frequency certainly makes the measure more noisy, it ensures that the asset purchase news are completely reflected. The argument, also made in Gürkaynak et al. (2005), is that it can take financial markets longer to understand and react to complex news, such as asset purchase news, as opposed to simple news about policy rates.

In order to create a single measure of asset purchase news and minimize the influence of country-specific noise, I aggregate information from all ten countries. Therefore, I extract the first principal component of the changes in the scarcity premiums around ECB Governing Council Meetings.[16] This resembles Gürkaynak et al. (2005) and Nakamura and Steinsson (2018), who condense information from interest rates of various maturities using principal component analysis.

[16]In particular, I use uncentered principal component analysis to preserve the non-zero mean of the data.

2.2 Series of Asset Purchase News

Since the principal component decomposition only identifies the series up to sign and scale, I need to choose normalizations. For ease of interpretation, I choose the sign such that a positive (negative) realization denotes expansionary (contractionary) asset purchase news.[17] I normalize the scale such that the series has a standard deviation of one. Figure 3 shows the resulting series of asset purchase news with regard to government bonds. The sample contains a total of 35 ECB Governing Council Meetings between October 2014 and December 2018.

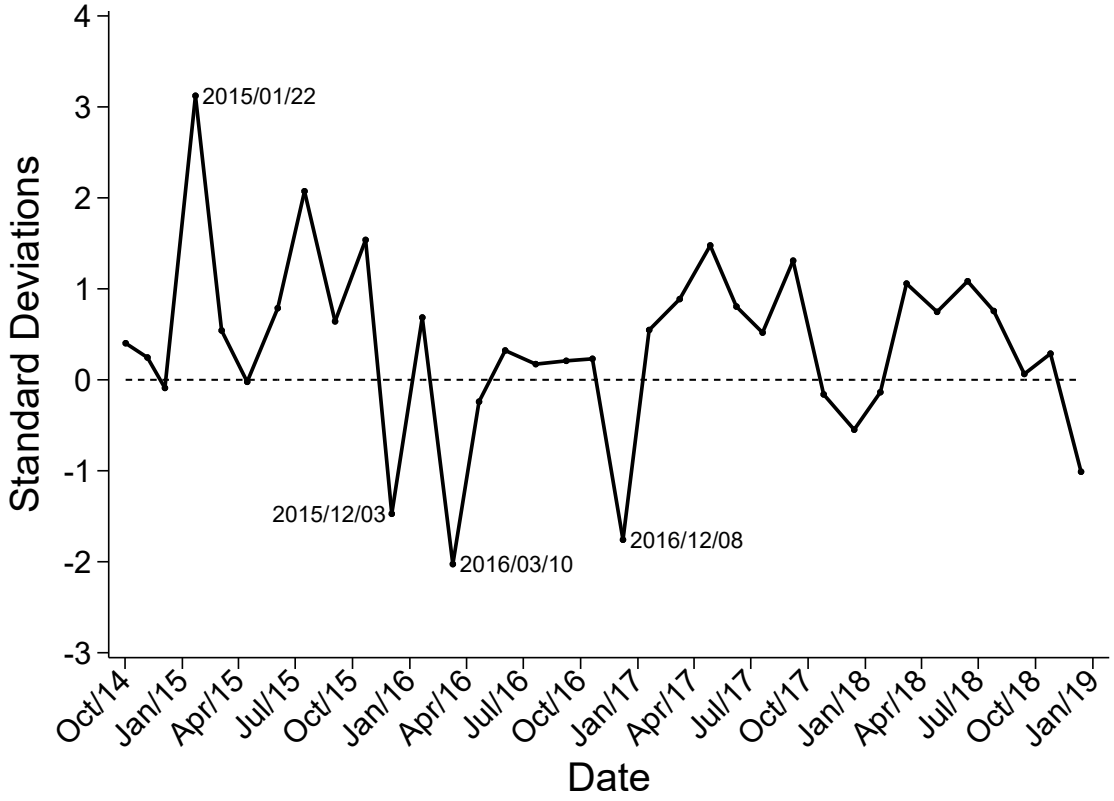


Figure 3: Series of Asset Purchase News

Notes: Observations refer to ECB Governing Council Meetings. Positive (negative) realizations denote expansionary (contractionary) asset purchase news. Sample: October 2014 - December 2018.

It is reassuring that the largest expansionary realization of asset purchase news oc-

[17] In the nomenclature of the literature, asset purchase news could also be called asset purchase news *shocks*. I remain by *asset purchase news* for the sake of brevity. In addition, I frequently omit the supplement *expansionary* when referring to (positive) asset purchase news.

curs on January 22, 2015, the day the PSPP was initially announced. Although market participants were expecting the ECB to introduce a large-scale asset purchase program, they did not anticipate its size.[18] The largest contractionary realization is March 10, 2016. On this day, the ECB announced an increase in the monthly amount of purchases, but also expanded its asset purchase programme to corporate bonds. Thus, while the total amount of expected purchases likely increased, the amount of expected government bond purchases likely decreased.[19] This explains the contractionary realization, as the asset purchase news series only measures news about government bond purchases under the PSPP. The second largest contractionary realization occurs on December 8th, 2016, when the ECB reduced the amount of monthly purchases from €80bn to €60bn, while also extending the duration of the program. This contractionary news is in line with market commentary.[20] Another large contractionary realization occurs on December 3rd, 2015. On this day, the ECB extended the program for only 6 months, while markets had expected a longer extension or even an increase in the monthly amount of purchases.[21] The second largest expansionary realization is July 16, 2015. During this meeting's press conference, there were several questions regarding the conduct of asset purchases which may have been interpreted as expansionary asset purchase news. However, during that week there was also turmoil due to negotiations about a bailout for Greece, which certainly influenced bond yields. Section 4 presents robustness checks, which account for background noise and the dissemination of central bank information unrelated to asset purchases. The third largest expansionary realization is October 22,

[18] The *Financial Times* wrote "Mario Draghi's bond-buying plan outstripped expectations". (Financial Times, January 22, 2015, "Mario Draghi's bond-buying plan outstrips expectations" by Claire Jones)

[19] The *Financial Times* wrote "The ECB raised the amount of bonds the eurozone's central bankers buy each month under QE from €60bn to €80bn — a greater sum than many analysts had expected. It also expanded the range of assets it will buy to include high-quality corporate bonds". (Financial Times, March 10, 2016, "ECB cuts rates to new low and expands QE" by Claire Jones)

[20] *The Guardian* wrote "The European Central Bank has vowed to continue with its programme of electronic money printing to shore up the eurozone recovery but surprised financial markets by reducing the amount of stimulus it expects to provide each month". (The Guardian, December 8, 2016, "ECB surprises markets by scaling back QE programme" by Katie Allen)

[21] *The Guardian* wrote "Mario Draghi dashes expectations that the European Central Bank would pump more new money into the eurozone economy each month". (The Guardian, December 3, 2015, "ECB Day: markets tumble as Draghi disappoints investors - as it happened" by Graeme Wearden)

2015, when President Draghi hinted at an expansion of asset purchases at the next Governing Council Meeting.[22]

2.3 The Exogeneity Assumption

Figure 3 and the earlier discussion show that the series of asset purchase news picks up important news about the PSPP, thereby supporting the relevance assumption. Empirically supporting the exogeneity assumption, which states that the scarcity premium is not systematically affected by other monetary policy news, is less straightforward. Ideally, I would assert that the series of asset purchase news is uncorrelated with identified conventional monetary policy, central bank information, and forward guidance shocks. However, to the best of my knowledge, there exist no identification strategies, which identify such shocks and at the same time account for asset purchase news. To nevertheless provide some empirical support for the exogeneity assumption, I conduct two indirect tests of it.

First, I compare identified monetary policy shocks to a series of asset purchase news in the period before the PSPP. During this period, there were of course no euro-area wide asset purchase news. Thus, this series should only pick up noise and is therefore referred to as *non-asset purchase news*. I construct the series of non-asset purchase news from January 2010 to July 2014[23] by applying the identification strategy for asset purchase news to a subset of four countries, namely Austria, Belgium, Finland, and the Netherlands. Italy, Ireland, Spain, and Portugal are excluded because their government bonds were then already bought by the ECB under the Securities Markets Programme (2010-2012). Further, Germany and France need to be dropped, because their scarcity premiums would include a redenomination risk premium.[24]

[22] *The Guardian* wrote "Mario Draghi, the president of the European Central Bank, has stunned markets by signalling that he is prepared to cut interest rates and step up quantitative easing to stave off the risk of a renewed economic slump in the eurozone". (The Guardian, October 22, 2015, "Mario Draghi: ECB prepared to cut interest rates and expand QE" by Heather Stewart)

[23] The speech by Mario Draghi at the annual central bank symposium in Jackson Hole on August 22, 2014 is often mentioned as the first signal toward large-scale asset purchases in the euro area. Therefore, I end the pre-PSPP sample in July 2014.

[24] Before September 2014, CDS contracts were traded only under the 2003 protocol, which does not insure against currency redenomination. Bayer et al. (2018) discuss redenomination risk in the euro area between

However, including them leads to similar results. Under the exogeneity assumption, the series of non-asset purchase news only picks up noise and is therefore uncorrelated with monetary policy shocks. I test this prediction resorting to several identified monetary policy shocks from the literature. I use the (monetary) policy and central bank information shocks identified in Kerssenfischer (2019) using the co-movement of bond yields and stock prices.[25] Moreover, I use the Delphic and Odyssean forward guidance shocks identified in Andrade and Ferroni (2019) using the co-movement of 1-year OIS and 5-year inflation-linked swap (ILS) rates.[26] Table 1 displays the correlation coefficients of these four monetary shocks with the series of non-asset purchase news. All correlations are small and not significantly different from zero, thereby lending support to the exogeneity assumption.

Monetary Policy Shock	**Correlation with Non-AP News**
Kerssenfischer (2019)	
→ Central Bank Information Shocks	-0.06 *(.66)*
→ Pure Policy Shocks	-0.16 *(.24)*
Andrade & Ferroni (2019)	
→ Delphic Forward Guidance Shocks	-0.03 *(.84)*
→ Odyssean Forward Guidance Shocks	0.09 *(.50)*

Table 1: Correlation of Monetary Policy Shocks with Non-Asset Purchase News

Notes: Sample includes all ECB GCMs from January 2010 to July 2014 (N=55). p-values are reported in parentheses.

Second, I compare pure interest rate surprises to a subset of asset purchase news. Here, I exploit the fact that in the early part of the sample, the ECB communicated its interest rate decision separately from other decisions. After a Governing Council meeting, the ECB publishes a press release at 13:45 CET, before holding a press conference at 14:30 CET. Before March 2016, with two exceptions[27], the press release only contained the interest

January 2010 and October 2014 and argue that even for these two countries, it was sizable.

[25]The shock series were downloaded from Mark Kerssenfischer's website in March 2019.

[26]I thank Filippo Ferroni for sharing the series of Delphic and Odyssean forward guidance shocks.

[27]On two occasions (January 22, 2015 and December 3, 2015), the press release contained the statement "Further monetary policy measures will be communicated by the President of the ECB at a press conference starting at 14:30 CET today.", clearly hinting at a major unconventional monetary policy decision. Therefore,

rate decision, while all other decisions were communicated during the press conference. Since March 2016, the press release also contains information on unconventional monetary policy decisions. Under the exogeneity assumption, press release surprises before March 2016 should be uncorrelated with asset purchase news, since the former only reflect conventional monetary policy. Using intraday data from the Euro Area Monetary Policy Event-Study Database (EA-MPD) constructed by Altavilla et al. (2019), I can test this prediction. I compute the correlation of conventional monetary policy surprises, measured by the change in interest rate swap rates around the press release, with asset purchase news. Table 2 displays the correlation coefficients along with p-values. All correlations are small and not significantly different from zero, lending support to the assumption that conventional monetary policy does not affect the scarcity premium.

Press Release Interest Rate Surprise	**Correlation with Asset Purchase News**
Δ 1-Month OIS rate	-0.15 *(.68)*
Δ 3-Month OIS rate	-0.16 *(.66)*
Δ 1-Year OIS rate	-0.04 *(.92)*

Table 2: Correlation of Press Release Interest Rate Surprises with Asset Purchase News

Notes: Sample includes all ECB GCMs between October 2014 and February 2016, excluding the GCMs in January 2015 and December 2015 (N=10). p-values are reported in parentheses.

3 Results

With this series of asset purchase news at hand, I explore the effects of central bank purchases of government debt on financial markets. In particular, I examine the so called portfolio balance channel. The basic idea is that by buying large amounts of government bonds, the central bank not only influences their prices, but also the prices of similar assets, because

I exclude these two dates from this empirical test.

private investors turn from government bonds to close substitutes. Due to this rebalancing of portfolios towards substitute assets, asset purchases can very broadly increase prices and reduce yields. In the following, I trace out the portfolio balance channel and investigate which assets beyond the directly purchased government bonds are affected by asset purchases. Throughout, particular attention is paid to heterogeneous effects across euro-area countries.

3.1 Estimation Framework

To estimate the effects of asset purchase news, I use the following regression specification commonly used in the event-study literature:

$$y_t = \alpha + \beta s_t + \epsilon_t \tag{1}$$

where y_t is the one-day change in some financial variable of interest, s_t is the identified asset purchase news, and ϵ_t is the error term. The parameter of interest is β, which captures the effect of asset purchase news on the dependent variable. Throughout, I use standard errors robust to heteroskedasticity and autocorrelation.[28]

Using ordinary least squares (OLS) to estimate the effects of asset purchases assumes that the shock is measured without error and that there is no background noise.[29] Neither assumption is innocuous in a setup with daily financial data. Measurement error would introduce an attenuation bias, distorting the estimate $\hat{\beta}$ towards zero. In that case, $\hat{\beta}$ would provide a lower bound on the true effect of asset purchases. How background noise affects the estimate is ex ante ambiguous. I discuss this issue in a robustness check in section 4

[28]Since the regressor, i.e. the asset purchase news, is generated, standard errors should reflect the additional uncertainty arising from its construction. However, confidence intervals constructed using a wild bootstrap in the spirit of Swanson (2019) are barely distinguishable from those constructed with asymptotic standard errors robust to heteroskedasticity and autocorrelation. Therefore, I remain with asymptotic standard errors. Gürkaynak et al. (2005) similarly observe that bootstrapping standard errors leads to almost identical results.

[29]Building on the framework of Rigobon and Sack (2004), background noise describes any omitted variables, which are unrelated to monetary policy, but nevertheless influence the dependent (outcome) and independent (asset purchase news) variable, thereby violating the OLS assumptions. In contrast, measurement error describes noise which only influences the independent variable.

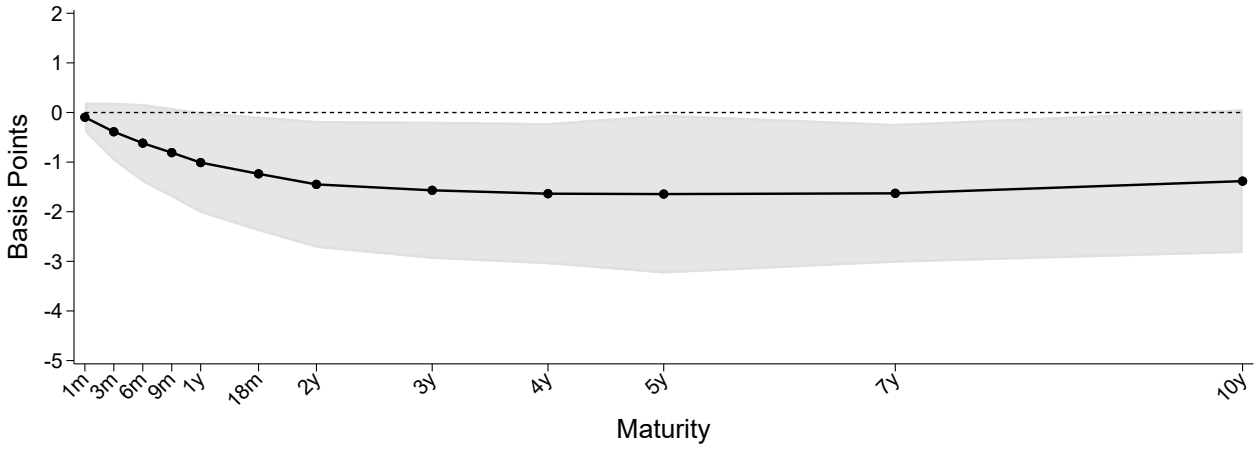
and show that controlling for background noise leads to comparable results. Maintaining both assumptions as well as the identifying assumptions made in section 2, the subsequent estimates can be given a causal interpretation.

3.2 Risk-Free Interest Rates

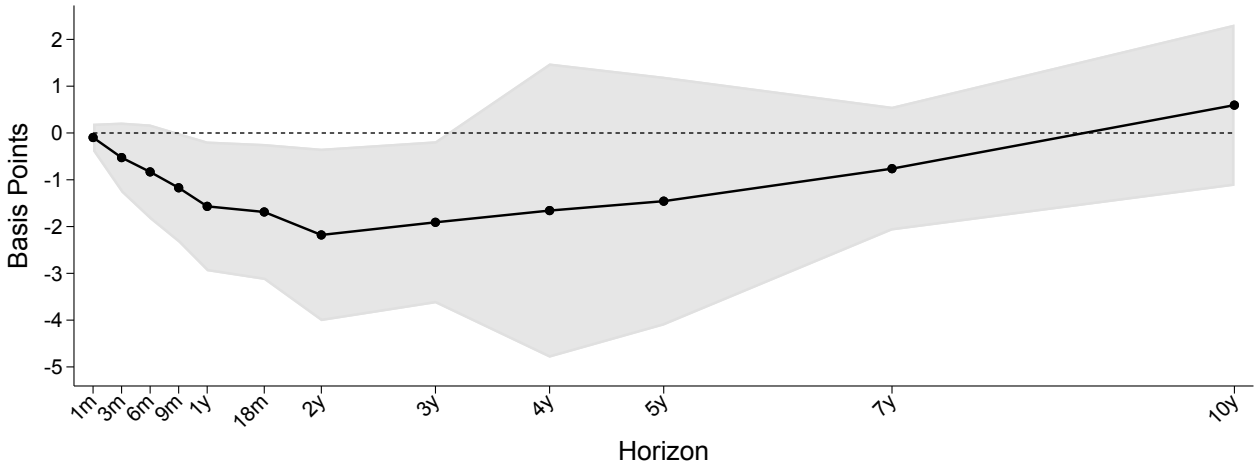
To understand how asset purchases affect financial markets, it is crucial to know how these affect risk-free interest rates. Usually, and also in the case of the PSPP, large-scale asset purchase programs are employed to provide additional monetary stimulus to an economy at or near the ZLB. Therefore, short-term risk-free interest rates cannot be reduced much more. Nevertheless, asset purchases can still reduce long-term risk-free interest rates by reducing expected future short-term interest rates. This is referred to as the signaling channel of asset purchases.[30] One rationale is that asset purchases can be seen as a commitment to keep rates low, because the central bank would make losses on its purchased assets if it raised interest rates. However, this rationale has lost credibility as the Federal Reserve raised short-term interest rates between 2015 and 2018 despite still holding large amounts of long-term bonds. Yet, asset purchase news may still signal the central bank's willingness to maintain an accommodative policy stance in the future.

Figure 4 illustrates the impact effect of asset purchases on risk-free nominal interest rates of various maturities (upper panel) and implied forward rates at various horizons (lower panel). I use interest rate swaps to measure risk-free interest rates and implied forward rates, as in section 2. Asset purchases do significantly reduce long-term interest rates as can be seen from the upper panel. The lower panel provides support for the signaling channel, as asset purchases reduce implied forward rates, while the effect is largest and most significant between 1- and 3-years ahead, roughly in line with the expected remaining duration of the ZLB. The peak effect around the 2-year horizon is later than observed for conventional

[30] Bauer and Rudebusch (2014) discuss the importance of the signaling channel for the Fed's QE programs and argue that it contributed 40-50 % to the decline of long-term Treasuries.



(a) Risk-Free Interest Rates



(b) OIS-implied Forward Rates

Figure 4: Response of Risk-Free Interest Rates to Asset Purchase News

Notes: The dots represent the estimated $\hat{\beta}$ from separate regressions: $y_t = \alpha + \beta s_t + \epsilon_t$, where y_t is the daily change, measured in basis points. Shocks are scaled to have a standard deviation of 1. Shaded areas depict the 90% confidence interval using standard errors robust to heteroskedasticity.

monetary policy shocks.[31]

The magnitude of the signaling channel, however, appears to be quite small. One standard deviation asset purchase news reduce the expected short-term interest rate 2-years

[31]For example, Brand et al. (2010) estimate a downward-sloping maturity response pattern to ECB policy decisions.

ahead by only two basis points. Thus, a large shock, such as the initial PSPP announcement on January 22, 2015, would reduce the expected short-term rate by a mere 6 basis points. Moreover, a simple back-of-the-envelope calculation suggests that asset purchase news on ECB Governing Council Meeting days between October 2014 and December 2018 cumulatively reduced expected short-term interest rates by only 25 basis points.[32]

In addition, the estimated impact effects might have little relevance, if they are not persistent. For example, financial markets could overreact to the announcements initially. Several studies, including Wright (2012), Rogers et al. (2014), and Greenlaw et al. (2018), argue that this was the case for the Federal Reserve's Quantitative Easing programs. In contrast to the U.S. evidence and in line with Altavilla et al. (2019), I find the impact effects of asset purchase news in the euro area to be very persistent, as shown in Appendix B. These disparate findings in euro area and U.S. can be explained by market participants learning about the effects of asset purchases over time, or the fact that the Federal Reserve's programs were implemented in times of higher financial distress.

3.3 Bond Markets

To understand how asset purchases affect bond markets, I reuse the bond yield decomposition introduced in section 2 for the identification of asset purchase news. Thus, I consider bond yields to be the sum of the risk-free interest rate, a risk premium, and a scarcity premium. The previous subsection presented evidence that asset purchases reduce risk-free interest rates and thus bond yields through a signaling effect. Moreover, asset purchases can influence bond yields through the risk premium by affecting solvency considerations, and the scarcity premium by changing bond prices beyond their value implied by no-arbitrage considerations.

[32]This back-of-the-envelope calculation is obtained by adding up the 35 observations of asset purchase news and multiplying that number with the impact effect. Note that by construction, I measure the effect of news, i.e. unexpected information, regarding asset purchases, but not the effect of anticipated announcements. Of course, in perfectly forward-looking financial markets, anticipated announcements should not have an effect anyways.

3.3.1 Sovereign Bonds

It is largely undisputed that the ECB was successful in reducing government bond yields in the euro area. Figure 5 confirms that asset purchases significantly reduce government bond yields across maturities, using the example of French bonds.[33] The magnitude of the effect exceeds the effect on risk-free interest rates, implying that either the risk premium or the scarcity premium, or both, were affected as well. This comes as no surprise, since I use changes in scarcity premiums to identify asset purchase news. A concern might therefore be that this effect is partly mechanical, since I use the French 10-year yield as a dependent variable and also for the construction of asset purchase news. The robustness exercise in subsection 4.3 shows, however, that estimates barely change if the country used as dependent variable is left out of the construction of asset purchase news.

Figure 5 also offers first insights into the working of the portfolio balance channel. Recalling that the ECB only purchased bonds with a remaining maturity between 1- and 30-years[34], it is noteworthy that the 50-year yield falls strongly and in line with other long-term bond yields. Yields of bonds with maturities of less than 1-year fall less strongly, which could be caused by a lack of rebalancing towards short-term bonds or lower bound constraints. These findings suggest that investors rebalanced their portfolios towards sovereign bonds not purchased by the ECB, in particular those with a longer maturity. Among the maturities purchased by the ECB, long-term bond yields fall more strongly than short-term yields. This is consistent with a portfolio rebalancing in search for yield, but could also be due to a less elastic supply of long-term bonds, if their holders are less willing to sell to the ECB.

A recurring question with respect to asset purchases in the euro area is whether some countries are affected more than others. Altavilla et al. (2015) find that asset purchase announcements narrowed sovereign spreads in the euro area. The left panel of Figure 6

[33] I use French bonds here, because France issues bonds with a maturity of 50-years. I display the effect on the other countries' government bond yields in Figure A.2.

[34] The ECB initially announced to purchase bonds with a remaining maturity of 2- to 30-years. On December 8, 2016, it decreased the minimum remaining maturity to one year.

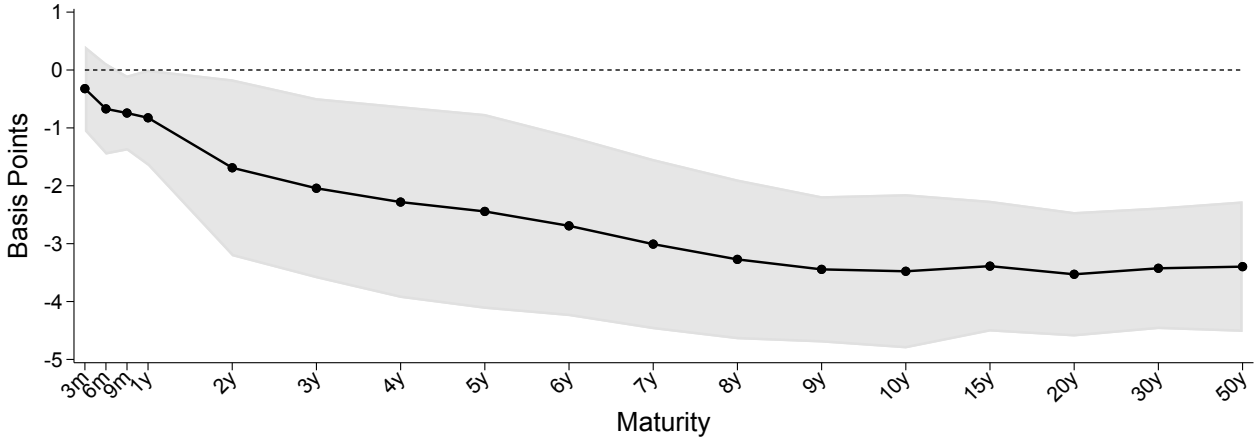


Figure 5: Response of French Sovereign Yields to Asset Purchase News

Notes: The dots represent the estimated $\hat{\beta}$ from separate regressions: $y_t = \alpha + \beta s_t + \epsilon_t$, where y_t is the daily change, measured in basis points. Shocks are scaled to have a standard deviation of 1. Shaded areas depict the 90% confidence interval using standard errors robust to heteroskedasticity.

confirms this heterogeneous effect on 10-year sovereign yields. Whereas the German yield falls by roughly 3 basis points in response to one standard deviation asset purchase news, the Spanish, Italian, and Portuguese yields fall by 4.5 to 5 basis points.

The same panel decomposes the effect on 10-year yields into the effect on the three yield components. This reveals that only for Portugal the country-specific risk premium (light gray bars) falls by a relevant magnitude. Thus, I find little evidence for the so called credit risk channel of asset purchases, which holds that asset purchases reduce bond yields by reducing the risk of sovereign default. The heterogeneity in responses across countries is mostly driven by the scarcity premium (medium gray bars). Similar to the effect of asset purchases across maturities, this heterogeneity is consistent with a portfolio rebalancing in search for yield, but could also be due to holders of Spanish, Italian, and Portuguese bonds being less willing to sell their bonds to the ECB. Nevertheless, the right panel of Figure 6 supports the interpretation of a search for yield, as it shows that the magnitude of the effect on sovereign bonds is strongly correlated with the level of the same yield before the start of the PSPP.[35]

[35]I use the average 10-year government bond yield between January 1, 2014 and December 31, 2014.

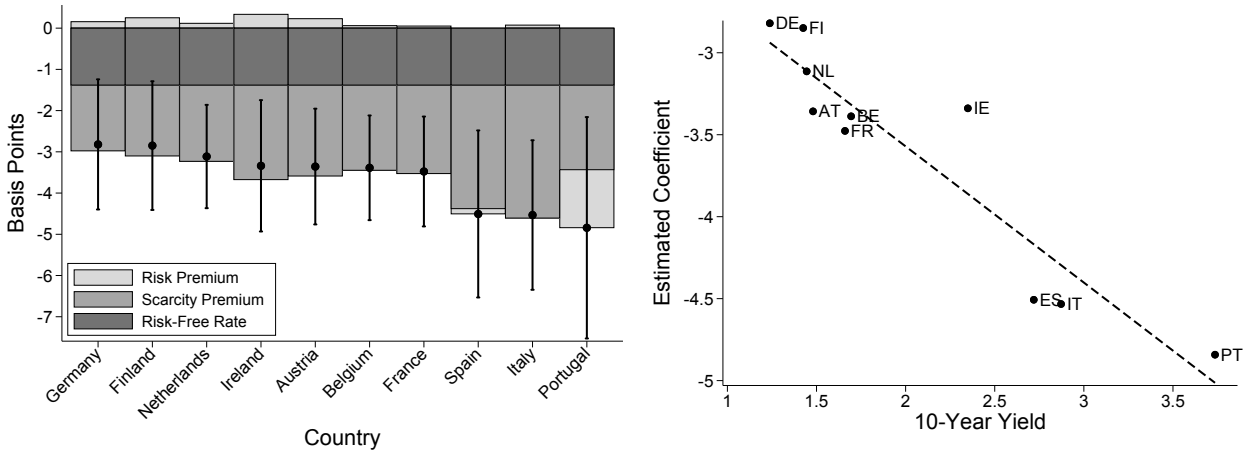


Figure 6: Response of 10-Year Sovereign Yields to Asset Purchase News

Notes (left panel): The dots represent the estimated $\hat{\beta}$ from separate regressions: $y_t = \alpha + \beta s_t + \epsilon_t$, where y_t is the daily change, measured in basis points. Shocks are scaled to have a standard deviation of 1. Whiskers depict the 90% confidence interval using standard errors robust to heteroskedasticity. Dark gray bars depict the effect on risk-free interest rates, medium gray bars the effect on scarcity premiums, and light gray bars the effect on country-risk premiums.

Notes (right panel): Each hollow circle represents one country. The estimated coefficient (y-axis) is the estimate from the left panel. The average 10-year yield before the PSPP (x-axis) is the average yield throughout 2014. The dashed line depicts the best linear fit.

In sum, the evidence shows that asset purchases reduce sovereign yields across countries and maturities. In line with a portfolio rebalancing in search for yield, the effect is larger in countries with a higher yield and for longer maturities, and spills over to bonds not purchased by the ECB. However, the overall magnitude of the effect is rather small. Doing a simple back-of-the-envelope calculation, asset purchase news on ECB Governing Council Meeting days between October 2014 and December 2018 cumulatively reduced sovereign yields by between 36 (Germany) and 62 (Portugal) basis points. This accounts to only a third of the estimates of the yield reduction due to the APP provided in Hammermann et al. (2019). Of course, these two estimates do not necessarily contradict each other, since I only measure asset purchase news released on ECB Governing Council Meeting days. Thus, the above estimates should be considered a lower bound on the total effect of the PSPP. To nevertheless give a rough calculation of the magnitudes involved here, I estimate the countries in the sample to annually save between €522m (Finland) and €18.7bn (Italy) due to the

PSPP. Relative to GDP, estimates range from 0.2% (Finland) to 1.02% (Portugal).[36]

3.3.2 Corporate Bonds

Given the previous results, one would expect asset purchases to affect corporate bond markets, as well. On the one hand, lower risk-free interest rates all else equal imply lower corporate bond yields. On the other hand, if there is a portfolio rebalancing within the sovereign bond market, there might also be a rebalancing towards corporate bonds. Importantly, there is no direct effect on corporate bond markets, as under the PSPP, the ECB only purchased government and supranational bonds. I do not measure asset purchase news with regard to the Corporate Sector Purchase Programme (CSPP), under which the ECB directly purchased corporate bonds.[37] This section focuses on the response of a number of euro-area corporate bond indices.[38]

Figure 7a displays the effect of asset purchases on euro-area corporate bond indices of various maturities and credit ratings. It shows that asset purchases reduce investment-grade corporate bond yields across the board. Similar to the effect on sovereign bonds, the effect of asset purchases increases with the remaining maturity and therefore the yield level, suggesting that a portfolio rebalancing in search for yield also took place in the corporate bond market. However, and very much in contrast to the sovereign bond market, yields fall less, not more, for riskier corporate bonds. This may not necessarily be surprising since highly-rated corporate bonds are closer substitutes for sovereign bonds. Still, it suggests that investors were reluctant to search for yield among rather risky corporate bonds. Moreover, it leaves little scope for a credit risk channel of asset purchases, which would imply that yields

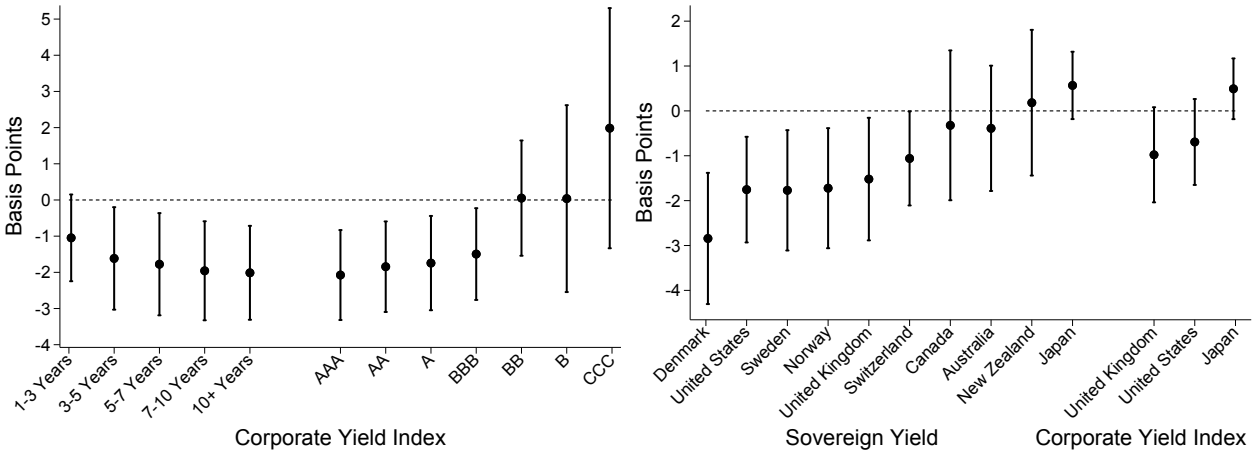
[36]These coarse estimates are obtained by first estimating the amount of debt rolled over each year as outstanding debt divided by the weighted average maturity (WAM) of outstanding debt. This amount is multiplied with the effect on 10-year bond prices, which is obtained from the effect on 10-year yields reported above and the price of 10-year bonds.

[37]I discuss the CSPP in more detail and verify that it does not drive the results regarding the private sector in section 4.4.

[38]I use the Bank of America Merrill Lynch EMU Corporates Non-Financial AAA, AA, A, and BBB indices, the Merrill Lynch Euro High Yield BB, B, and CCC and Lower indices, as well as the Bank of America Merrill Lynch EMU Corporates Non-Financial 1-3Yr, 3-5Yr, 5-7Yr, 7-10Yr, and 10+Yr indices.

of riskier bonds fall more strongly.

These findings likely imply that asset purchases affect corporations across euro-area countries in a heterogeneous manner. The reason is that corporate bond ratings are tied to and only in exceptional cases exceed the respective sovereign bond rating. Therefore, corporate bond yields in highly-rated countries likely fell more than corporate yields in countries with a lower sovereign rating. The latter group includes Spain, Italy, and Portugal, whose sovereign ratings did not exceed BBB at the start of the PSPP, while all other countries had at least an A rating. An inspection of corporate ratings before the start of the PSPP of firms listed on the STOXX Europe 600 confirms that with only one exception[39], Spanish, Italian, and Portuguese firms were rated BBB and lower, while a sizeable fraction of firms in Germany, France, Finland, and the Netherlands were rated A and higher. Figure A.3 in Appendix C plots the distribution of firm ratings.



(a) Corporate Bond Indices (b) Non-Euro Area Bonds

Figure 7: Spillovers to Euro-Area Corporate and Non-Euro Area Bonds

Notes: The dots represent the estimated $\hat{\beta}$ from separate regressions: $y_t = \alpha + \beta s_t + \epsilon_t$, where y_t is the daily change, measured in basis points. Shocks are scaled to have a standard deviation of 1. Whiskers depict the 90% confidence interval using standard errors robust to heteroskedasticity.

[39]The only exception is the Italian firm Eni.

3.3.3 Non-Euro Area Bonds

Figure 7b shows that asset purchases by the ECB not only have effects on euro-area sovereign and corporate bond markets, but also on bond markets beyond it. 10-year sovereign yields of several advanced economies with tight financial linkages to the euro area (Denmark, United Kingdom, Switzerland, United States, Sweden, Norway) fall significantly in response to asset purchase news. Sovereign yields of other advanced, but more distant economies (Canada, Australia, New Zealand, Japan) do not react significantly and neither do the yields of most emerging market economies. Corporate yields in the U.S. and U.K. also fall, but insignificantly. While the ECB's actions could in principle also reduce expected risk-free interest rates in other economies, the magnitude of the effects suggests a portfolio rebalancing towards non-euro area bonds. This contrasts Fratzscher et al. (2016), who argue that the ECB's earlier unconventional monetary policy announcements had mixed effects on global bond markets.

3.4 Exchange Rates

Before turning to stock markets, it is useful to estimate how asset purchases affect exchange rates. Figures 6 and 7b have shown that euro-area bond yields fall to a larger extent than bond yields outside the euro area. According to the uncovered interest rate parity, this should go hand in hand with a depreciation of the euro. Indeed, Figure 8 shows that asset purchase news significantly depreciate the euro against all major currencies. The only exception is the Swiss Franc, against which the euro depreciated insignificantly. This could be due to the abolishment of the Franc's cap with the euro around the same time the ECB announced the PSPP.

The magnitude of the depreciation is quite large. One standard deviation asset purchase news depreciate the euro vis-à-vis the U.S. dollar by roughly 0.5%. This implies that a large shock (3 standard deviations), such as the initial PSPP announcement on January 22, 2015, may have depreciated the euro by around 1.5% against the U.S. dollar. This magnitude

exceeds most estimates of the effect of ECB conventional monetary policy on the exchange rate.[40] These findings echo Glick and Leduc (2018), who find that the Fed's unconventional monetary policy announcements had a much larger effect on the dollar exchange rates than previous conventional monetary policy announcements.

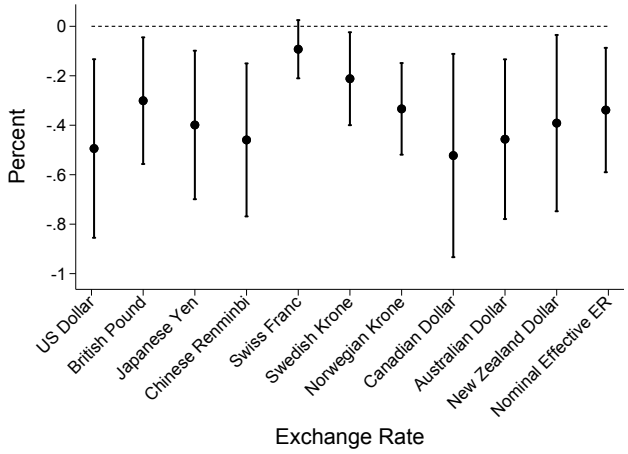


Figure 8: Response of the Euro Exchange Rates to Asset Purchase News

Notes : The dots represent the estimated $\hat{\beta}$ from separate regressions: $y_t = \alpha + \beta s_t + \epsilon_t$, where y_t is the daily change, measured in percent. Shocks are scaled to have a standard deviation of 1. Whiskers depict the 90% confidence interval using standard errors robust to heteroskedasticity. Exchange rates are denoted in foreign currency per euro.

3.5 Stock Markets

Given the spillovers from central bank purchases of government bonds to corporate bonds and sovereign bonds outside the euro area, it seems plausible that there are spillovers to other asset classes as well, in particular to stocks. To understand the response of stock prices to asset purchases, it is important to note that three previous findings suggest that stock prices increase even without any portfolio rebalancing towards stocks. First, asset purchases reduce risk-free interest rates, which all else equal implies that stock prices increase through the discount factor. Second, asset purchases reduce corporate bond yields, which improves financing conditions for firms, increasing stock prices all else equal through higher

[40]For example, scaling the pure (monetary) policy and information shocks from Kerssenfischer (2019) to a standard deviation of 1 yields a much smaller effect on exchange rates.

expected dividends. Third, asset purchases depreciate the euro, which is associated with higher stock prices of euro-area firms through higher expected dividends, since these firms gain a competitive advantage. Firms outside the euro area, in contrast, lose competitiveness and should all else equal see lower stock prices. However, whether or which of these effects matter quantitatively so far remains unclear.

3.5.1 Euro-Area Stocks

While it is hard to gauge the effect of asset purchases on stock prices via the exchange rate or corporate bond yields, it is possible to get a rough estimate of the effect via risk-free rates using a simple framework in which stock prices reflect discounted future dividends.[41] This exercise, using the effect on risk-free interest rates displayed in Figure 4a, suggests that stock prices in the euro area should increase by roughly 0.25% in response to a one standard deviation asset purchase news shock.

The left panel of Figure 9 shows that the stock indices of some euro-area countries increase very much in line with this estimate, while other stock indices increase by much more. The right panel of Figure 9 shows that the magnitude of the effect is negatively correlated with the level of the respective sovereign yield before the PSPP, indicating that stock prices increase more in safe countries. This could be due to the heterogeneous effect on corporate bond yields, but is also consistent with a portfolio rebalancing towards relatively safe stocks.[42] Either way, the evidence from stock markets aligns well with the evidence from corporate bond markets. Corporations in euro-area countries with low sovereign yields experience stronger effects of asset purchases than corporations in other countries.

[41] For the purpose of this back-of-the-envelope calculation, I assume that stock prices reflect constant future dividends, which are discounted by the risk-free rate and an equity risk premium, which is set to 4%, in line with Mehra and Prescott (2003):

$$P_t = \sum_{s=t}^{\infty} \frac{1}{1 + RiskFreeRate_s + EquityPremium} \times Dividend$$

[42] As discussed in subsection 3.3.2, corporations in countries with a high sovereign rating had on average a higher corporate rating.

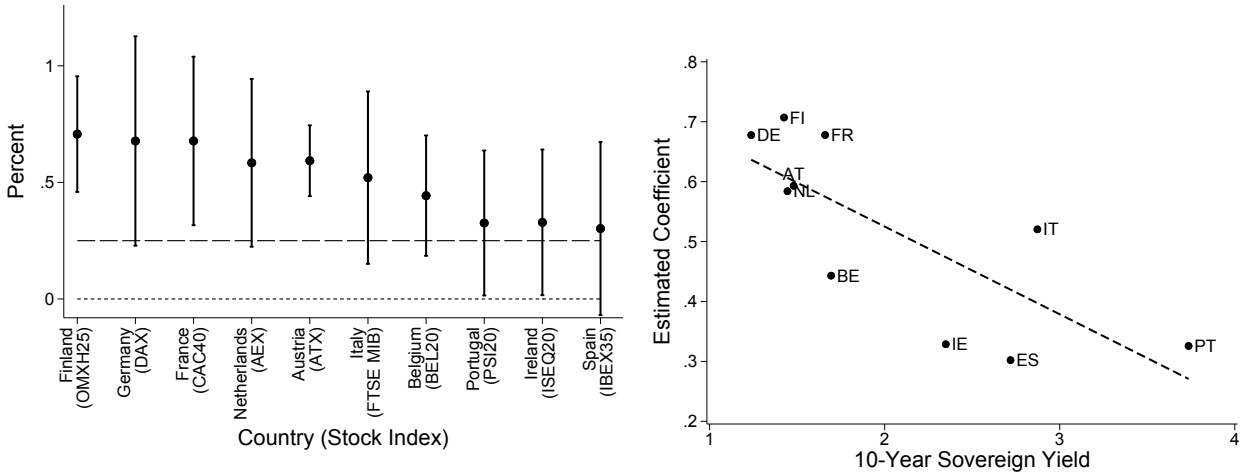


Figure 9: Response of National Stock Indices to Asset Purchase News

Notes (left panel): The dots represent the estimated $\hat{\beta}$ from separate regressions: $y_t = \alpha + \beta s_t + \epsilon_t$, where y_t is the daily change, measured in percent. Shocks are scaled to have a standard deviation of 1. Whiskers depict the 90% confidence interval using standard errors robust to heteroskedasticity. The long-dashed horizontal line depicts the back-of-the-envelope calculation of the effect.

Notes (right panel): Each hollow circle represents one country. The estimated coefficient (y-axis) is the estimate from the left panel. The average 10-year yield before the PSPP (x-axis) is the average yield throughout 2014. The dashed line depicts the best linear fit.

3.5.2 Non-Euro Area Stocks

Figure 10 shows that asset purchases not only increase stock prices in the euro area, but also beyond it. Stock indices in a number of advanced economies with tight financial linkages to the euro area (Denmark, United Kingdom, Switzerland, United States, Sweden, Norway, Canada) rise significantly. The effect is insignificant in other advanced, but more distant economies (Australia, New Zealand, Japan). While the ECB's actions could in principle reduce expected risk-free interest rates in other economies, this is unlikely to drive the effect on non-euro area stock prices.[43] Moreover, these findings suggest that the exchange rate is only of minor importance. Firms outside the euro area lose competitiveness due to the appreciation of their own currencies against the euro, but nevertheless see rising stock prices. In particular the Norway, Sweden, and Switzerland should be hit hard by this, since a large

[43] A back-of-the-envelope calculation for stock prices in the United States and the United Kingdom reveals that one standard deviation ECB asset purchase news increase stock prices by roughly 0.05%. Moreover, the effect on U.S. and British OIS rates is insignificant at most horizons.

share of their exports go to the euro area. Thus, the large increase in non-euro area stock prices could be driven by higher expected dividends through easier financing conditions, but is also consistent with a portfolio rebalancing towards stocks in relatively safe countries. This contrasts with Koijen et al. (2018), who find little evidence for a portfolio rebalancing from sovereign bonds to other asset classes.

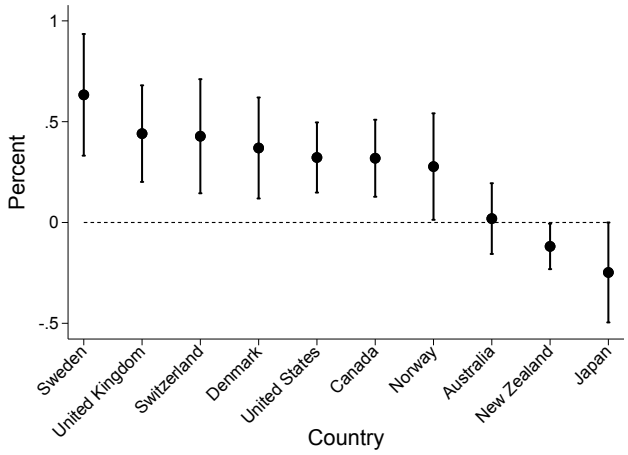


Figure 10: Response of Stock Indices Beyond the Euro Area

Notes: The dots represent the estimated $\hat{\beta}$ from separate regressions: $y_t = \alpha + \beta s_t + \epsilon_t$, where y_t is the daily change, measured in percent. Shocks are scaled to have a standard deviation of 1. Whiskers depict the 90% confidence interval using standard errors robust to heteroskedasticity.

3.6 Summary of the Evidence

Summing up, I find that central bank purchases of sovereign debt have wide effects on financial markets. Not only the yields of sovereign bonds purchased by the ECB fall strongly, but also yields of not-purchased sovereign bonds, corporate bonds, and non-euro area sovereign and corporate bonds. Moreover, stock prices rise in the euro area and in other advanced economies. All these findings are consistent with a portfolio balance channel of asset purchases, which holds that investors rebalance their portfolios frrom the sovereign bonds purchased by the ECB towards towards substitute assets. The effects are particularly strong among sovereign bonds with a higher yield, highly-rated corporate bonds, and stocks in safe countries, suggesting that investors search for yield, but primarily among relatively safe as-

sets. Moreover, asset purchases modestly reduce expected risk-free interest rates in line with a signaling effect and strongly depreciate the euro against all major currencies.

Several effects are heterogeneous across countries. Sovereign yields fall most in Italy, Spain, and Portugal, confirming the view that asset purchases have narrowed sovereign spreads. However, this pattern reverses in the corporate sector. Corporate bond yields fall and stock prices rise in all euro-area countries, but most strongly so in Finland, Germany, France, and the Netherlands. One reason is the distribution of firm ratings. In countries with a low sovereign rating, firms on average had low corporate ratings as well and thus benefited less from spillover effects among highly-rated bonds.

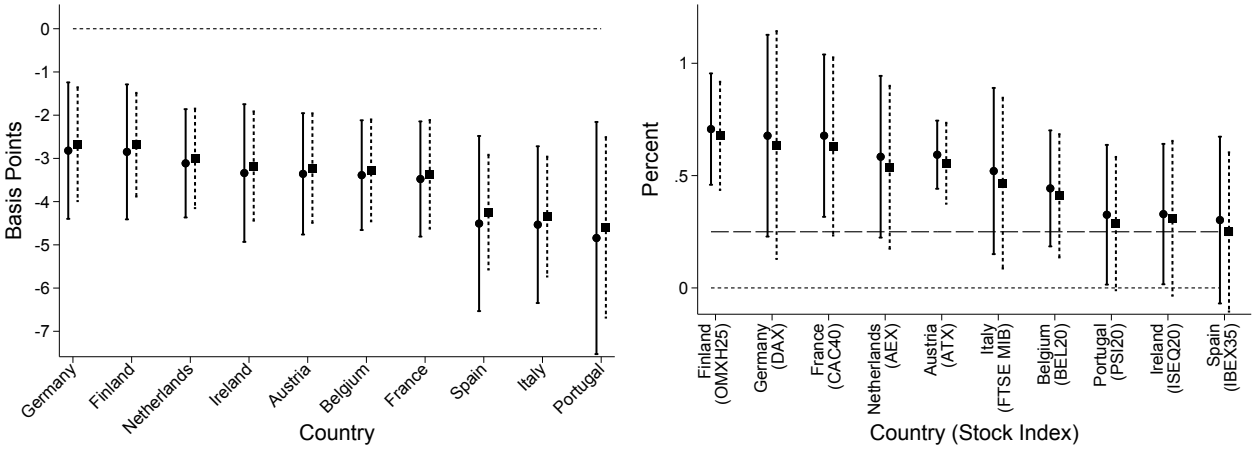
While the effects of asset purchases on financial outcomes can be given a causal interpretation under the maintained assumptions, their association with certain channels and mechanisms remains suggestive due to the nature of the data. I only observe prices, but no actual transactions, and therefore cannot accurately separate valuation effects and flow effects, as do for example Bubeck et al. (2018) or Bergant et al. (2018). Nevertheless, my findings complement the research on the portfolio balance channel using transaction-level data. In contrast to these contributions, which mostly rely on data from the Securities Holding Statistics (SHS), my analysis is not limited to euro-area investors, but includes the effects of transactions made outside the euro area. In addition, the low-frequency nature of the SHS data does not allow to separate the effects of the ECB's asset purchases from other drivers of portfolio flows.

4 Robustness Checks

I now discuss a number of robustness exercises. These are meant to rule out alternative explanations for the findings presented in the previous section. In the interest of space, I focus on Figures 6 and 9 to show that the key finding of opposing cross-country heterogeneities in bond and stock markets is robust. Nevertheless, the other findings are similarly robust.

4.1 Information Shocks

First, to ensure that my findings are not diluted by information shocks, I replicate Figures 6 and 9, while controlling for information shocks. I use the series of information shocks from Kerssenfischer (2019). Figure 11 shows that the new estimates of the effect of asset purchases on 10-year sovereign yields and stock prices (squares) are very close to the previous estimates, which did not control for information shocks (dots).



(a) Sovereign Yields (b) National Stock Indices

Figure 11: Robustness Exercise - Controlling for Information Shocks

Notes (left panel): The dots represent the estimated $\hat{\beta}$ from separate regressions: $y_t = \alpha + \beta s_t + \epsilon_t$, where y_t is the daily change, measured in basis points. The squares represent the estimated $\hat{\beta}$ from separate regressions: $y_t = \alpha + \beta s_t + \gamma\ InfoShock_t + \epsilon_t$. Shocks are scaled to have a standard deviation of 1. Whiskers depict the 90% confidence interval using standard errors robust to heteroskedasticity.

Notes (right panel): The dots represent the estimated $\hat{\beta}$ from separate regressions: $y_t = \alpha + \beta s_t + \epsilon_t$, where y_t is the daily change, measured in percent. The squares represent the estimated $\hat{\beta}$ from separate regressions: $y_t = \alpha + \beta s_t + \gamma\ InfoShock_t + \epsilon_t$. Shocks are scaled to have a standard deviation of 1. Whiskers depict the 90% confidence interval using standard errors robust to heteroskedasticity. The long-dashed horizontal line depicts the back-of-the-envelope calculation of the effect.

4.2 Background Noise

The event-study regression used throughout section 3 assumes that there is no background noise, i.e. no contemporaneous shocks, which affect the series of asset purchase news and the outcome variable. The identification strategy outlined in section 2 ensures that no contem-

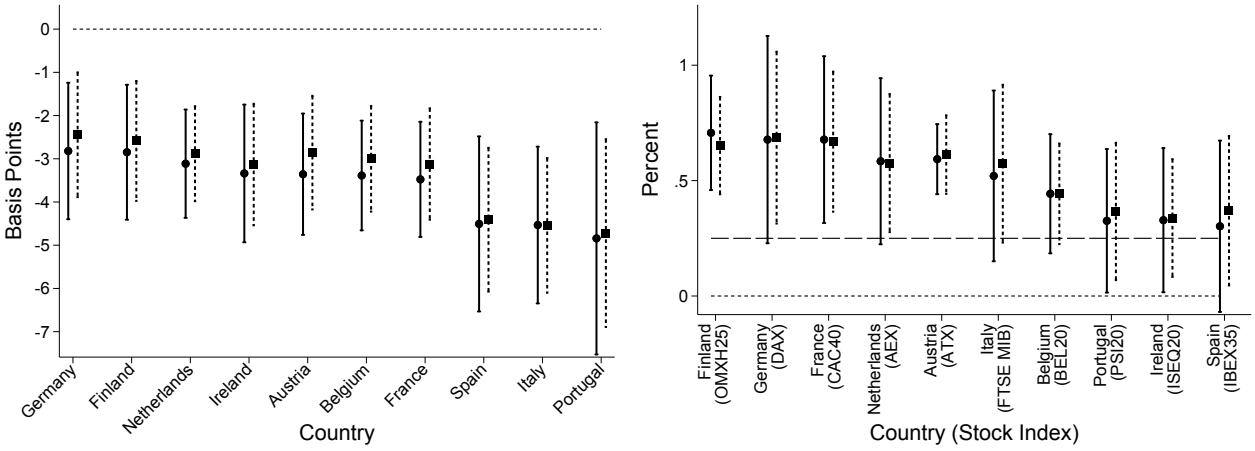
poraneous monetary shocks affect the measure of asset purchase news, but does not address non-monetary shocks. Arguably, these are less problematic, but since I use daily financial data, there is no way to rule out the existence of background noise ex ante. To investigate this issue, I once again construct placebo asset purchase news using exactly the same identification strategy, but on the three days before each Governing Council Meeting day. This series captures background noise, which is most likely also present on ECB Governing Council Meeting days. To see whether it affects the results, I run the following regression, pooling actual and placebo asset purchase news under s_t^*:

$$y_t = \alpha + \gamma \times s_t^* + \beta \times s_t^* \times \mathbb{1}(GCM\ Day) + \epsilon_t \tag{2}$$

In this specification, β still captures the effect of asset purchase news on the outcome variable, while γ captures the effect of background noise on it. Figure 12 plots the newly estimated β (squares) in comparison to the baseline estimates (dots) from Figures 6 and 9. Evidently, accounting for background noise has minor effects on the estimated effect of asset purchases, while leaving the heterogeneous patterns unchanged.

4.3 Leave-One-Out Asset Purchase News

Given that I use some financial variables, such as 10-year sovereign yields, for the identification of asset purchase news and as outcome variables, another concern could be that some results arise mechanically. To test this concern, I construct leave-one-out asset purchase news series, which are computed by leaving out one country at a time and otherwise constructing the series as usual with the remaining nine countries. I then replicate Figures 6 and 9, using the respective leave-one-out series for each country. As shown in Figure 13, the estimated coefficients (squares) barely differ from the baseline estimates (dots). Moreover, correlations among the ten leave-one-out asset purchase news series and with the baseline series exceed



(a) Sovereign Yields (b) National Stock Indices

Figure 12: Robustness Exercise - Controlling for Background Noise

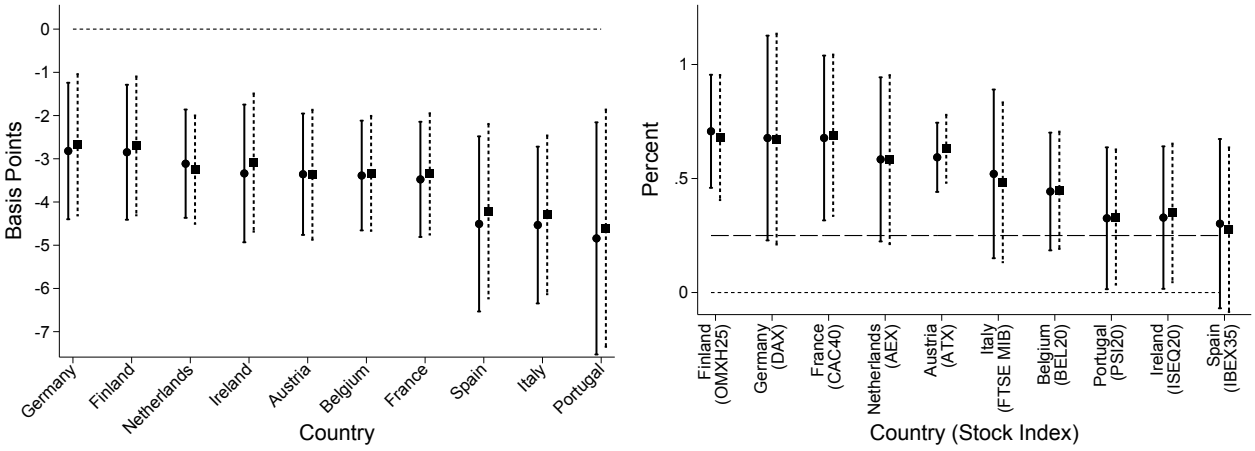
Notes (left panel): The dots represent the estimated $\hat{\beta}$ from separate regressions: $y_t = \alpha + \beta s_t + \epsilon_t$, where y_t is the daily change, measured in basis points. The squares represent the estimated $\hat{\beta}$ from separate regressions: $y_t = \alpha + \gamma \times s_t^* + \beta \times s_t^* \times \mathbb{1}(GCM\ Day) + \epsilon_t$. Shocks are scaled to have a standard deviation of 1. Whiskers depict the 90% confidence interval using standard errors robust to heteroskedasticity.

Notes (right panel): The dots represent the estimated $\hat{\beta}$ from separate regressions: $y_t = \alpha + \beta s_t + \epsilon_t$, where y_t is the daily change, measured in percent. The squares represent the estimated $\hat{\beta}$ from separate regressions: $y_t = \alpha + \gamma \times s_t^* + \beta \times s_t^* \times \mathbb{1}(GCM\ Day) + \epsilon_t$. Shocks are scaled to have a standard deviation of 1. Whiskers depict the 90% confidence interval using standard errors robust to heteroskedasticity. The long-dashed horizontal line depicts the back-of-the-envelope calculation of the effect.

0.98 throughout, confirming that no single country dominates the series of asset purchase news.

4.4 Corporate Sector Purchase Programme

As discussed and demonstrated in section 2, the identified series of asset purchase news successfully captures important PSPP announcements and is unrelated to conventional monetary policy, forward guidance, and central bank information shocks. However, the series of asset purchase news might be correlated with news about *other* asset purchase programs, in particular the Corporate Sector Purchase Programme (CSPP), for two reasons. First, announcements of corporate bond purchases might have spillover effects to the sovereign bond market, therefore affecting the bond scarcity premium in sovereign bonds and, thereby, my measure of asset purchase news. Second, in the later part of my sample, the ECB often-



(a) Sovereign Yields (b) National Stock Indices

Figure 13: Robustness Exercise - Leave-One-Out Asset Purchase News

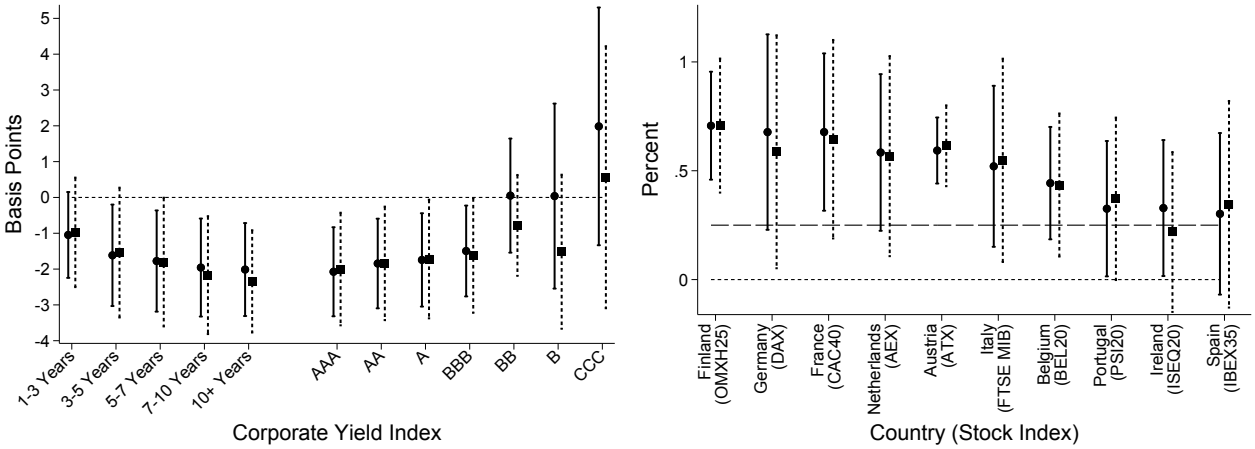
Notes (left panel): The dots represent the estimated $\hat{\beta}$ from separate regressions: $y_t = \alpha + \beta s_t + \epsilon_t$, where y_t is the daily change, measured in basis points. The squares represent the estimated $\hat{\beta}$ from separate regressions: $y_t = \alpha + \beta s_t + \epsilon_t$, which use the respective leave-one-out shocks. Shocks are scaled to have a standard deviation of 1. Whiskers depict the 90% confidence interval using standard errors robust to heteroskedasticity.

Notes (right panel): The dots represent the estimated $\hat{\beta}$ from separate regressions: $y_t = \alpha + \beta s_t + \epsilon_t$, where y_t is the daily change, measured in percent. The squares represent the estimated $\hat{\beta}$ from separate regressions: $y_t = \alpha + \beta s_t + \epsilon_t$, which use the respective leave-one-out shocks. Shocks are scaled to have a standard deviation of 1. Whiskers depict the 90% confidence interval using standard errors robust to heteroskedasticity. The long-dashed horizontal line depicts the back-of-the-envelope calculation of the effect.

times made announcements about total purchase amounts under the APP without specifying amounts under each single program. On the contrary, the left panel of Figure 1 showed that the PSPP sizewise clearly dominates the other asset purchase programs. By December 2018, the ECB had spent more than 10 times as much under the PSPP than under the CSPP (€2100bn vs. €178bn). Relative to the amount of eligible bonds, the amount purchased under the PSPP also clearly exceeds the amount purchased under the CSPP.[44]

To verify empirically that my results regarding the corporate sector are not driven by the CSPP, I replicate Figures 7a and 9 while leaving out major CSPP announcements. According to Dedola et al. (2018), such major announcements were made after the Governing Council Meetings on March 10, April 21, and June 2 in 2016. Figure 14 shows that excluding

[44]Relative to the respective eligible bond universe, the size of the PSPP exceeds the size of the CSPP almost by a factor of 2.



(a) Corporate Yields (b) National Stock Indices

Figure 14: Robustness Exercise - Corporate Sector Purchase Programme

Notes (left panel): The dots represent the estimated $\hat{\beta}$ from separate regressions: $y_t = \alpha + \beta s_t + \epsilon_t$, where y_t is the daily change, measured in basis points. The squares represent the estimated $\hat{\beta}$ from separate regressions: $y_t = \alpha + \beta s_t + \epsilon_t$, where the three CSPP dates have been excluded. Shocks are scaled to have a standard deviation of 1 (before excluding dates). Whiskers depict the 90% confidence interval using standard errors robust to heteroskedasticity.

Notes (right panel): The dots represent the estimated $\hat{\beta}$ from separate regressions: $y_t = \alpha + \beta s_t + \epsilon_t$, where y_t is the daily change, measured in percent. The squares represent the estimated $\hat{\beta}$ from separate regressions: $y_t = \alpha + \beta s_t + \epsilon_t$, where the three CSPP dates have been excluded. Shocks are scaled to have a standard deviation of 1 (before excluding dates). Whiskers depict the 90% confidence interval using standard errors robust to heteroskedasticity. The long-dashed horizontal line depicts the back-of-the-envelope calculation of the effect.

these three dates leaves the effect of asset purchase news on high-quality corporate bonds and stocks almost unchanged. The heterogeneity across countries weakens slightly. One difference is that I now find a negative but still insignificant effect on corporate bonds rated BB and B. In total, I conclude that the results regarding the corporate sector are robust to excluding dates with major CSPP announcements.

5 Conclusion

I develop an identification strategy for asset purchase news and apply it to the ECB's Public Sector Purchase Programme. I implement high-frequency identification around official ECB communication, use a government bond yield decomposition, and combine information

from ten euro-area countries. I discuss and demonstrate that the identified asset purchase news successfully capture important PSPP announcements and are unrelated to conventional monetary policy, forward guidance, and other central bank communication.

Employing the identified series, I estimate the effects of central bank purchases of sovereign debt on financial markets. I find them to reduce not only the yields of euro-area sovereign bonds, but also the yields of corporate bonds, and non-euro area sovereign bonds. Moreover, stock prices rise in the euro area and other developed countries. These spillover effects are consistent with a portfolio balance channel of asset purchases, which holds that investors rebalance their portfolios from the sovereign bonds purchased by the ECB towards substitute assets. The effects are particularly strong among sovereign bonds with a higher yield, highly-rated corporate bonds, and stocks in safe countries, suggesting that investors search for yield, but mainly among relatively safe assets. Moreover, asset purchases modestly reduce expected risk-free interest rates in line with a signaling effect and strongly depreciate the euro against all major currencies.

There are heterogeneous effects across countries. Sovereign yields fall most in Italy, Spain, and Portugal, confirming the view that asset purchases have narrowed sovereign spreads. However, this pattern reverses in the corporate sector. Corporate yields themselves fall and stock prices rise in all countries, but the effects are largest where sovereign yields were low to start with (Finland, Germany, France, Netherlands). One reason is the distribution of firm ratings. In countries with a low sovereign rating, firms on average had low corporate ratings as well and thus benefited less from spillover effects among highly-rated bonds. These two contrasting heterogeneous effects may raise doubts about the prevalent view that asset purchases mostly benefit highly indebted countries.

Directly investigating the real effects of asset purchases, for example by means of a structural VAR with an external instrument, is challenging due to data limitations, but constitutes an interesting avenue for future research. The identification strategy and series of asset purchase news developed in this paper may provide a helpful starting point.

References

Albertazzi, Ugo, Miguel Boucinha, and Bo Becker (2018). "Portfolio rebalancing and the transmission of large-scale asset programmes: evidence from the euro area". *ECB Working Paper No. 2125, European Central Bank*.

Altavilla, Carlo, Giacomo Carboni, and Roberto Motto (2015). "Asset purchase programmes and financial markets: lessons from the euro area". *ECB Working Paper No. 1864, European Central Bank*.

Altavilla, Carlo, Luca Brugnolini, Refet Gürkaynak, Roberto Motto, and Giuseppe Ragusa (2019). "Measuring euro area monetary policy". *Journal of Monetary Economics (forthcoming)*.

Andrade, Philippe and Filippo Ferroni (2019). "Delphic and Odyssean monetary policy shocks: Evidence from the euro-area". *Working Paper, University of Surrey*.

Andrade, Philippe, Johannes Breckenfelder, Fiorella De Fiore, Peter Karadi, and Oreste Tristani (2016). "The Reanchoring Channel of QE - The ECB's Asset Purchase Programme and Long-Term Inflation Expectations". *ECB Working Paper No. 1956, European Central Bank*.

Bauer, Michael and Glenn Rudebusch (2014). "The signaling channel for Federal Reserve bond purchases". *International Journal of Central Banking 10* (3), 233–289.

Bayer, Christian, Chi Kim, and Alexander Kriwoluzky (2018). "The Term Structure of Redenomination Risk". *DIW Discussion Paper No. 1740, Deutsches Institut für Wirtschaftsforschung*.

Bergant, Katharina, Michael Fidora, and Martin Schmitz (2018). "International capital flows at the security level-evidence from the ECB's asset purchase programme". *ECMI Working Paper No. 7 October 2018, European Capital Markets Institute*.

Brand, Claus, Daniel Buncic, and Jarkko Turunen (2010). "The impact of ECB monetary policy decisons and communication on the yield curve". *Journal of the European Economic Association 8* (6), 1266–1298.

Bubeck, Johannes, Maurizio Michael Habib, and Simone Manganelli (2018). "The portfolio of euro area fund investors and ECB monetary policy announcements". *Journal of International Money and Finance 89*, 103–126.

Burriel, Pablo and Alessandro Galesi (2018). "Uncovering the heterogeneous effects of ECB unconventional monetary policies across euro area countries". *European Economic Review 101*, 210–229.

Cieslak, Anna and Andreas Schrimpf (2019). "Non-monetary news in central bank communication". *Journal of International Economics 118*, 293–315.

Coeuré, Benoit (2018). "The persistence and signalling power of central bank asset purchase programmes". *Speech at the 2018 US Monetary Policy Forum, New York City.*

D'Amico, Stefania and Thomas King (2013). "Flow and stock effects of large-scale treasury purchases: Evidence on the importance of local supply". *Journal of Financial Economics 108* (2), 425–448.

De Santis, Roberto A. (2019). "Impact of the Asset Purchase Programme on euro area government bond yields using market news". *Economic Modelling (forthcoming).*

Dedola, Luca, Georgios Georgiadis, Johannes Gräb, and Arnaud Mehl (2018). "Does a Big Bazooka Matter? Central Bank Balance-Sheet Policies and Exchange Rates". *ECB Working Paper No. 2197, European Central Bank.*

Drechsler, Itamar, Alexi Savov, and Philipp Schnabl (2017). "The deposits channel of monetary policy". *Quarterly Journal of Economics 132* (4), 1819–1876.

European Central Bank (2017). "The ECB's corporate sector purchase programme: its implementation and impact". *ECB Economic Bulletin* (4), 40–45.

Fratzscher, Marcel, Marco Lo Duca, and Roland Straub (2016). "ECB Unconventional Monetary Policy Actions: Market Impact, international Spillovers and Transmission Channels". *IMF Economic Review 64* (1), 36–74.

Gambetti, Luca and Alberto Musso (2017). "The Macroeconomic Impact of the ECB's Expanded Asset Purchase Programme (APP)". *ECB Working Paper No. 2075, European Central Bank*.

Georgiadis, Georgios and Johannes Gräb (2016). "Global financial market impact of the announcement of the ECB's asset purchase programme". *Journal of Financial Stability 26*, 257–265.

Glick, Reuven and Sylvain Leduc (2018). "Unconventional monetary policy and the dollar: conventional signs, unconventional magnitudes". *International Journal of Central Banking 14*, 103–152.

Greenlaw, David, James D Hamilton, Ethan Harris, and Kenneth West (2018). "A Skeptical View of the Impact of the Fed's Balance Sheet". *NBER Working Paper No. 24687, National Bureau of Economic Research*.

Gürkaynak, Refet S, Brian Sack, and Eric T. Swanson (2005). "Do Actions Speak Louder Than Words? The Response of Asset Prices to Monetary Policy Actions and Statements". *International Journal of Central Banking 1*, 55–93.

Hachula, Michael, Michele Piffer, and Malte Rieth (2019). "Unconventional Monetary Policy, Fiscal Side Effects and Euro Area (Im)balances". *Journal of the European Economic Association (forthcoming)*.

Hammermann, Felix, Kieran Leonard, Stefano Nardelli, and Julian von Landesberger (2019). "Taking stock of the Eurosystem's asset purchase programme after the end of net asset purchases". *ECB Economic Bulletin Articles, European Central Bank*.

Hanson, Samuel and Jeremy Stein (2015). "Monetary policy and long-term real rates". *Journal of Financial Economics 115* (3), 429–448.

Jarociński, Marek and Peter Karadi (2019). "Deconstructing monetary policy surprises: the role of information shocks". *American Economic Journal : Macroeconomics (forthcoming)*.

Jordà, Òscar (2005). "Estimation and Inference of Impulse Responses by Local Projections". *American Economic Review 95* (1), 161–182.

Kerssenfischer, Mark (2019). "Euro Area Monetary Policy Effects : New Evidence from High-Frequency Futures Data". *Deutsche Bundesbank Discussion Paper No 07/2019, Bundesbank*.

Koijen, Ralph S J, Francois Koulischer, Benoît Nguyen, and Motohiro Yogo (2018). "Inspecting the Mechanism of Quantitative Easing in the Euro Area". *NBER Working Paper No. 26152, National Bureau of Economic Research*.

Krishnamurthy, Arvind and Annette Vissing-Jorgensen (2011). "The Effects of Quantitative Easing on Interest Rates: Channels and Implications for Policy". *Brookings Papers on Economic Activity 2011* (2), 215–287.

Krishnamurthy, Arvind, Stefan Nagel, and Annette Vissing-Jorgensen (2018). "ECB Policies Involving Government Bond Purchases: Impact and Channels". *Review of Finance 22* (1), 1–44.

Kroencke, Tim, Maik Schmeling, and Andreas Schrimpf (2018). "The FOMC Risk Shift". *Working Paper, University of Zurich*.

Lewis, Daniel (2019). "Announcement-Specific Decompositions of Unconventional Monetary Policy Shocks and Their Macroeconomic Effects". *Working Paper, Federal Reserve Bank of New York*.

Liu, Ernest, Atif R. Mian, and Amir Sufi (2019). "Low Interest Rates, Market Power, and Productivity Growth". *NBER Working Paper No. 25505, National Bureau of Economic Research*.

Lloyd, Simon (2018). "Overnight Index Swap Market-Based Measures of Monetary Policy Expectations". *Bank of England Staff Working Paper No. 709, Bank of England*.

Mehra, Rajnish and Edward C. Prescott (2003). "The equity premium in retrospect". *Handbook of the Economics of Finance 1*, 889–938.

Monfort, Alain and Jean Paul Renne (2014). "Decomposing Euro-area sovereign spreads: Credit and liquidity risks". *Review of Finance 18* (6), 2103–2115.

Nagel, Stefan (2016). "The liquidity premium of near-money assets". *Quarterly Journal of Economics 131* (4), 1927–1971.

Nakamura, Emi and Jon Steinsson (2018). "High Frequency Identification of Monetary Non-Neutrality: The Information Effect". *Quarterly Journal of Economics 133* (3), 1283–1330.

Ramey, Valerie (2016). "Macroeconomic Shocks and Their Propagation". *Handbook of Macroeconomics 2*, 71–162.

Rigobon, Roberto and Brian Sack (2004). "The impact of monetary policy on asset prices". *Journal of Monetary Economics 51* (8), 1553–1575.

Rogers, John H, Chiara Scotti, and Jonathan H Wright (2014). "Evaluating asset-market effects of unconventional monetary policy: a multi-country review". *Economic Policy 29* (80), 749–799.

Schlepper, Kathi, Heiko Hofer, Ryan Riordan, and Andreas Schrimpf (2018). "The Market Microstructure of Central Bank Bond Purchases". *Journal of Financial and Quantitative Analysis*, 1–65.

Sims, Eric R. and Jing Cynthia Wu (2019). "The Four Equation New Keynesian Model". *NBER Working Paper No.26067, National Bureau of Economic Research.*

Swanson, Eric T. (2019). "Measuring the effects of federal reserve forward guidance and asset purchases on financial markets". *Working Paper, University of California Irvine.*

Vayanos, Dimitri and Jean-Luc Vila (2009). "A Preferred-Habitat Model of the Term Structure of Interest Rates". *NBER Working Paper No.15487, National Bureau of Economic Research.*

Wieladek, Tomasz and Antonio Garcia Pascual (2016). "The European Central Bank's QE: A New Hope". *CESifo Working Paper No. 5946, Center for Economic Studies and Ifo Institute (CESifo) Munich.*

Wright, Jonathan H. (2012). "What does monetary policy do to long-term interest rates at the zero lower bound?" *Economic Journal 122* (564), 447–466.

Zhang, Donghai (2019). "Term Structure, Forecast Revision and the Information Channel of Monetary Policy". *Working Paper, University of Bonn.*

Appendix A. Liquidity Premium

In times of financial distress, the scarcity premium measured as outlined in section 2 likely includes a liquidity premium. Drechsler et al. (2017) discuss how in the United States, conventional monetary policy can affect the demand for extremely safe short-term securities and in consequence the liquidity premium. This would invalidate the exogeneity assumption if this channel was operative in euro-area long-term bonds at a high-frequency.

However, liquidity was not an issue during the relevant time period due to low levels of financial distress. To rule out any concerns, I empirically show that liquidity is not a major driver of the scarcity premium on ECB Governing Council Meeting days. I employ two common proxies for the liquidity premium, namely the bid-ask spread of the respective government bonds and the KfW-Bund spread.[45] In general, a positive liquidity premium should be expected for smaller countries with less frequently traded government bonds, such as Portugal. This liquidity premium, a compensation for possibly not being able to resell at some point in the future, is proxied by the bid-ask spread. The liquidity premium in Drechsler et al. (2017) is negative in the sense that it is paid by the bond holder for having an extremely liquid asset. This kind of liquidity premium is plausible for countries like Germany. In this case, one cannot expect the bid-ask spread to capture changes in the liquidity premium, since it is already at a very low level. However, this liquidity premium can be proxied using the KfW-Bund spread. The idea is that bonds issued by the *Kreditanstalt für Wiederaufbau* (KFW) are guaranteed by the German government, thus face the same credit risk as Bunds, but are less frequently traded and therefore less liquid. In consequence, a higher KfW-Bund spread denotes a higher liquidity premium. To orthogonalize the asset purchase news to liquidity, I regress the change in each country's scarcity premium on the change in the same country's bid-ask spread on ECB Governing Council Meeting days, reconstruct the asset purchase news from the residuals, and finally regress this series on changes in the KfW-Bund spread. After all, this alternative series is very similar to the baseline asset purchase

[45] See Monfort and Renne (2014) for more details on the KfW-Bund spread.

news series with a correlation above 0.98, suggesting that changes in liquidity conditions do not affect the measure of asset purchase news in a relevant magnitude.

Appendix B. Persistence of Impact Effects

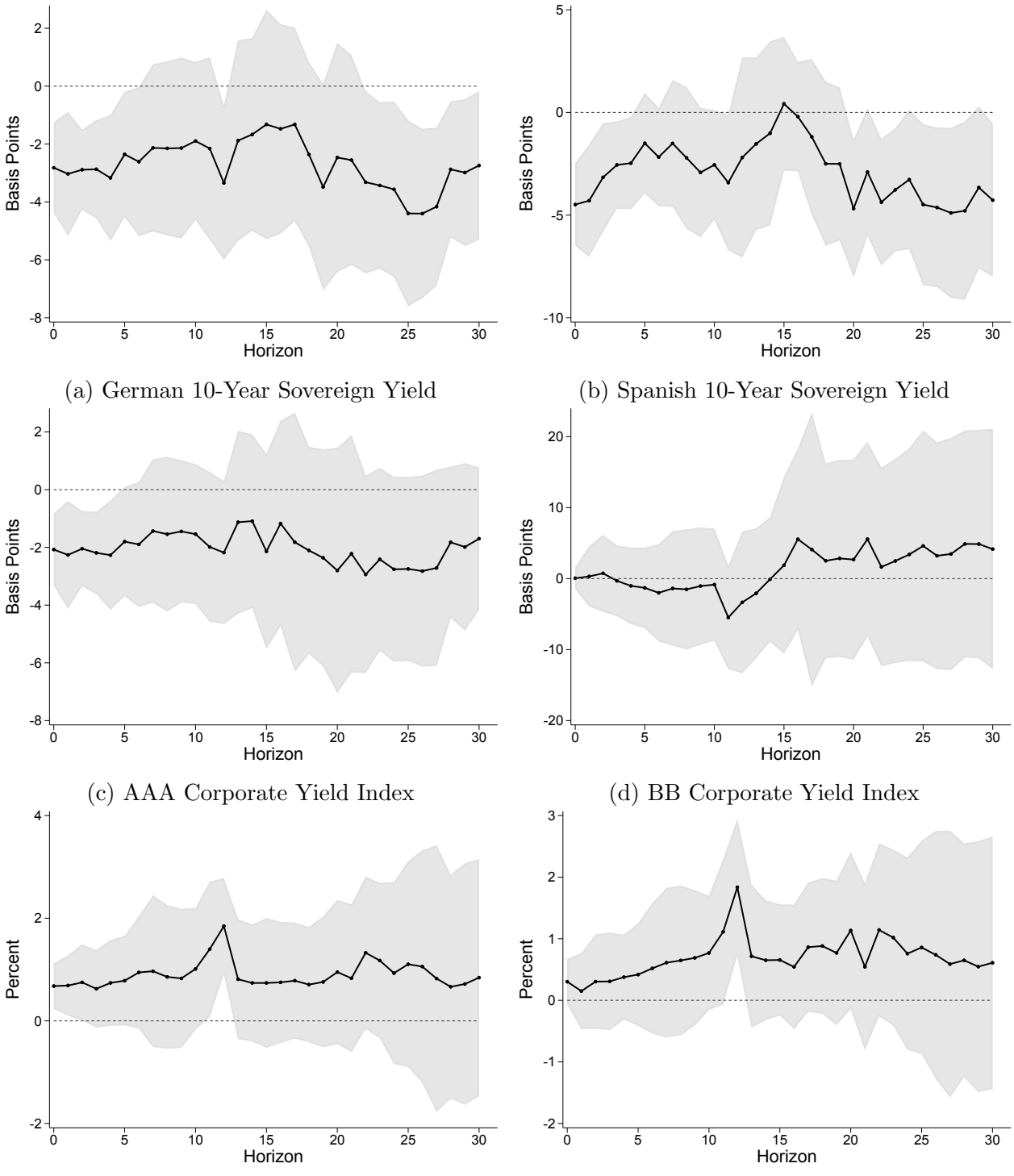
To evaluate the persistence of the impact effects of asset purchase news, I use the same event-study regression as before, but replace the one-day change as the outcome variable with the h-day change for horizons h between 0 and 30. These are essentially Jordà (2005) local projections:

$$y_{t+h} - y_{t-1} = \alpha_h + \beta_h s_t + \epsilon_{h,t}$$

The parameter of interest is β_h, which captures the cumulative effect of asset purchase news over h trading days[46]. Figure A.1 shows the persistence of the impact effect on German and Spanish 10-year sovereign yields, on AAA and BB corporate bond yield indices, and on the German and Spanish stock indices. Overall, the impact effects are fairly persistent, while confidence intervals naturally widen due to the amount of noise accumulating over 30 trading days.

Appendix C. Additional Figures

[46]Days without trading, such as weekends and public holidays are excluded.



(a) German 10-Year Sovereign Yield

(b) Spanish 10-Year Sovereign Yield

(c) AAA Corporate Yield Index

(d) BB Corporate Yield Index

(e) German Stock Index (DAX)

(f) Spanish Stock Index (IBEX)

Figure A.1: Persistence of Impact Effects

Notes: The dots represent the estimated $\hat{\beta}_h$ from separate regressions: $y_{t+h} - y_{t-1} = \alpha_h + \beta_h s_t + \epsilon_{h,t}$, where the left-hand side is the change over h days, measured in basis points or percent, respectively. Shocks are scaled to have a standard deviation of 1. Shaded areas depict the 90% confidence interval using standard errors robust to heteroskedasticity and autocorrelation.

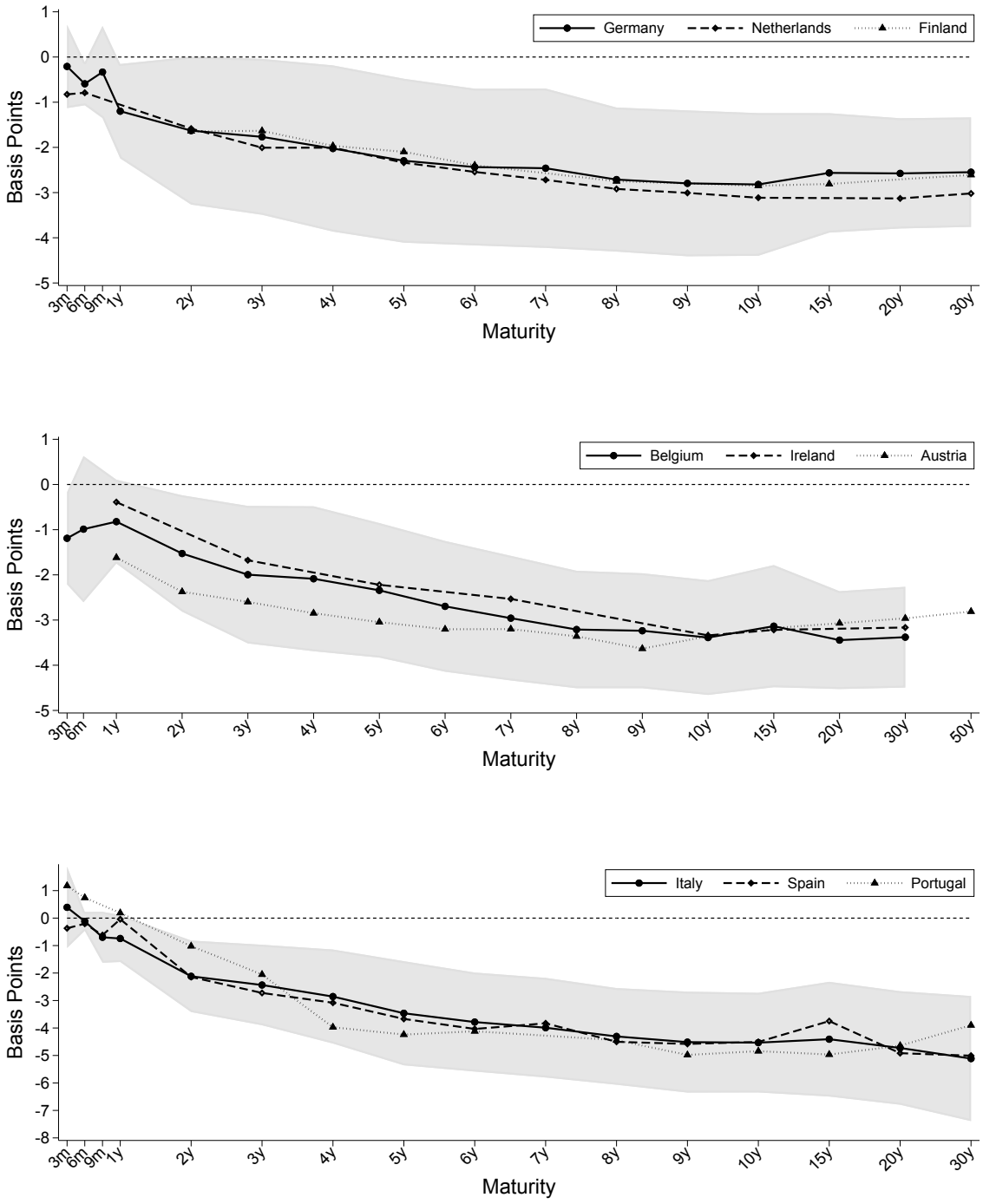


Figure A.2: Response of Euro-Area Sovereign Yields to Asset Purchase News

Notes: The dots represent the estimated $\hat{\beta}$ from separate regressions: $y_t = \alpha + \beta s_t + \epsilon_t$, where y_t is the daily change, measured in basis points. Shocks are scaled to have a standard deviation of 1. Shaded areas depict the 90% confidence interval using standard errors robust to heteroskedasticity for the first country in each panel. Missing dots due to missing or insufficient data.

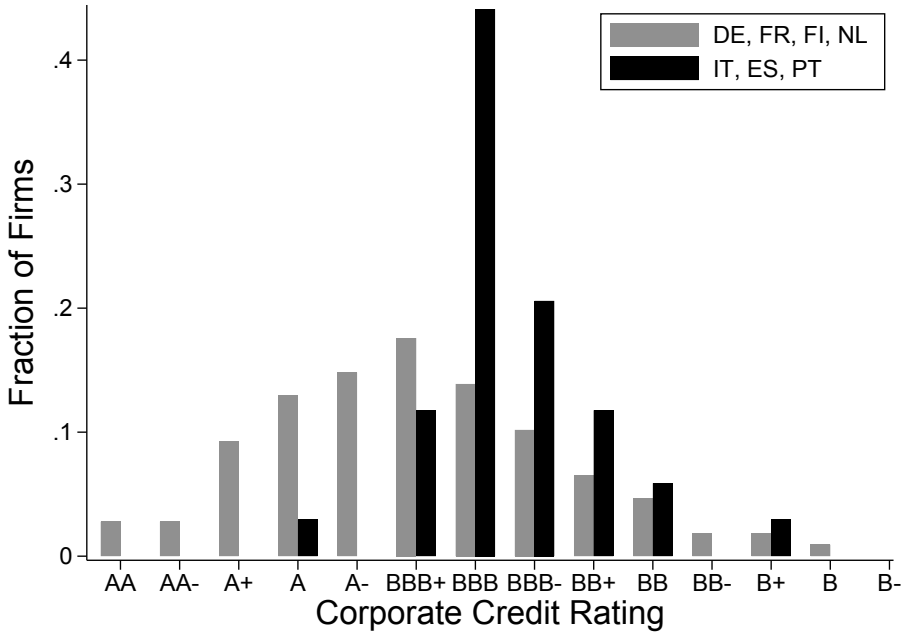


Figure A.3: Distribution of Corporate Credit Ratings

Notes: The sample consists of all firms listed on the STOXX Europe 600, which were rated as of January 2015.