The Effects of Large Scale Asset Purchases on Corporate Bond Yields: Drivers & Channels

Rafael Schwalb[*]

July 20, 2017

Abstract

This work builds on the empirical literature using event studies to analyze the effects of the announcements of Large Scale Asset Purchase (LSAP) programs by the Federal Reserve and the European Central Bank with a special focus on their pass-through to corporate bond yields. Specifically, it attempts to answer the question raised by the existing literature which characteristics of the LSAP programs in terms of the composition of assets purchased and the financial market environment prevalent around the announcements drive their effects on corporate yields. For the Federal Reserve's LSAPs, I find that most of the pass-through from LSAPs to risky corporate debt takes place when the central bank purchases private assets in highly distressed financial markets while neither of these two factors can explain that pass-through by itself, whereas the purchases of assets with private default risk components by the ECB seem to have an effect independent of financial conditions, potentially due to the greater substitutability of the assets purchased by the ECB to corporate bonds. The pass-through of LSAPs to corporate bonds is further decomposed into its individual transmission channels. Most of the pass-through seems to be coming from a signaling and a credit default risk channel, which are affected by private asset purchases and financial conditions in opposite directions.

1   Introduction

In fighting the Great Recession beginning in 2008, central banks around the world quickly reached the limits of conventional policy that is presented by the zero lower bound (ZLB) on nominal interest rates. Due to the interchangeability of nominal bonds and cash at the ZLB, it should in theory be impossible to charge investors a negative nominal interest rate; thus central banks had to resort to unconventional policy tools to provide further stimulus to the economy. One of the most common of such tools are purchases of long-term securities. With short-term interest rates already at or close to zero, the objective of such large-scale asset purchases (LSAPs) is to put downward pressure on interest rates further out the yield curve. These long-term interest rates determine investment-, consumption- and savings-decisions of households and firms and thus lowering them should stimulate private demand.

Central banks face legal constraints about what type of assets they are allowed to purchase. For example, the Federal Reserve (Fed) is only allowed to purchase securities that are guaranteed by the federal government, i.e. Treasuries and the debt of the government-sponsored entities Fannie Mae and Freddie Mac and the Mortgage-Backed-Securities (MBS) they guarantee. In contrast, the European Central Bank (ECB) is restricted in their purchases of government debt, but is free to purchase assets with private default risk, such as Asset-Backed-Securities (ABS), covered bonds and corporate bonds.

A natural question to ask is whether purchases of different assets affects market interest rates differently, and which assets a central bank should ideally be purchasing given its legal constraints. Since the objective of LSAPs is to provide stimulus to private demand by lowering private borrowing costs and the opportunity cost of consumption and investment, their effectiveness is best measured in the extent to which they lower private sector interest

rates. For that reason this work investigates the effect of LSAPs on corporate bond yields, which constitute one of the main sources of financing costs for private businesses. Gilchrist, Yankov and Zakrajsek (2009) show that corporate bond spreads are a significant contributor to macroeconomic fluctuations, with unexpected increases in bond spreads lead to large and persistent contractions in economic activity. Similarly, lowering such spreads can significantly stimulate private demand and hence present a tool for monetary policy to provide further accommodation even after hitting the ZLB.

Investigating the effects of LSAPs on credit spreads is immediately related to the width of the transmission channels of such purchases: If a Central Bank's asset purchases affect all yields uniformly, spreads will be unaffected by such purchases. If however purchases of private sector securities have a larger effect on private than on public yields, such purchases will lower private credit spreads.

The transmission channel mostly cited by Fed officials and researchers is the portfolio rebalancing channel[1]. Under such a channel, the Central Bank's asset purchases induces investors to rebalance their portfolios from which the purchased assets were removed by replacing them with securities with similar risk characteristics. Hence portfolio rebalancing effects constitute a narrow transmission channel, as only assets similar to the ones purchased will be affected by the purchases.

In contrast to such a narrow transmission channel, Eggertson & Woodford (2003) provide the theoretical justification for a signaling channel. Under such a channel, purchases by the Central Bank do not directly affect specific asset yields through risk premia, but they serve as a signal for the Central Bank's intention to keep future short-term rates at the ZLB for longer, thereby shaping expectations for future short-term rates and thus broadly affecting all long-term rates through the expectation hypothesis[2].

---

[1]Bernanke (2012), Yellen (2011), Hancock & Passmore (2014)

Those two channels have direct implications for policy: Under only a signaling channel, the type of asset purchased should be irrelevant unless they provide different signals for the duration that short-term interest rates will remain at the ZLB. They further should affect all assets of a certain maturity equally, so corporate bond spreads should not be affected as Treasuries and corporate bonds of the same maturity move in parallel. In contrast, a portfolio rebalancing channel allows for effects to differ across assets, with the largest effects to be found in securities most similar to the ones purchased by the Central Bank. This implies that the choice of asset being purchased is of immediate importance for the effects of the purchase program: Purchases of assets with some private risk component might decrease corporate bond yields more so than Treasury yields due to the greater similarity of the former asset with corporate bonds. This would decrease credit spreads as opposed to the neutral effects on spreads under the broad signaling channel.

Besides focusing on the width of the channels of transmission from LSAPs to corporate bond spreads, this work is also concerned with what drives these channels to be active in the first place. Two contrasting potential drivers of the pass-through of unconventional monetary policy to corporate bond yields are investigated: The extent to which financial markets are under distress at the time of the announcement of a program, and the inclusion of private assets in the composition of asset purchases. They are discussed in more detail in the next section.

In evaluating the drivers and channels of the pass-through of LSAPs to corporate bond yields, I will be focusing on the programs implemented by the Federal Reserve and the European Central Bank in the wake of the financial crisis. Both had three major programs, which for the Fed are referred to LSAP 1, LSAP 2 and LSAP 3, while the ECB's programs were the Securities Market Program (SMP), the Outright Monetary Transactions (OMT),

---

[2]A more elaborate discussion of the different transmission channels and the expectation hypothesis can be found in Section 5

and the Asset Purchase Program (APP). The programs and their characteristics are discussed in more detail in Section 4.2. This analysis uses one unified framework for all different programs by each central bank, and exploits their variation in terms of the assets purchased and the financial environment the purchases were implemented in to investigate the effects of each of these dimensions on the pass-through of LSAPs to corporate bond yields and the channels through which this pass-through takes place.

2 Motivation

The focus on corporate bond yields chosen in this analysis is motivated by the importance of such yields for firms' investment decisions. Most studies about the effects of LSAPs focus largely or entirely on their effects on Treasury yields. However, for firms and households the Treasury yield is not of direct importance when making borrowing decisions because they borrow at a higher rates than the US government. Since increasing the ability and propensity of private economic agents to borrow is among the main objectives and channels through which monetary policy can stimulate private demand, its effectiveness should be measured in terms of how well it decreases private, not public interest rates.

The other reason that motivates the focus on the effects on corporate debt is the little existing knowledge about how they are affected by LSAPs, despite their relevance in propagating economic stimulus. In one of the first studies on the Fed's LSAPs, Krishnamurthy and Vissing-Jorgensen (2011) find that the first round of LSAPs by the Fed, corporate bond yields declined significantly while they were relatively unaffected in the second round. There were two major differences between the first and the second LSAP program that might drive this differential pass-through. First, LSAP 1 was implemented at the height of the financial crisis when asset markets were in extreme distress, while

4

the second round was implemented in much calmer financial markets. Second, during LSAP 1 the Fed purchased a large amount of Agency Debt and MBS, while the second round consisted solely of Treasury purchases. Hence one question at hand is whether the strong effect on corporate bond yields during LSAP 1 was driven by rebalancing effects stemming from the purchases of other private sector securities by the Fed, or whether the distressed financial market environment prevalent at the time of its implementation drove the stronger pass-through to corporate borrowing rates.

The inclusion of the policies of both the ECB and the Fed in this analysis is interesting given the question at hand for the reason that their programs differed significantly along those dimensions of interest. While the Fed reacted aggressively at the height of the financial crisis, the ECB started purchasing assets much later and much more cautiously as a reaction to the European sovereign debt crisis. And in contrast to the Fed, which purchased large amounts of MBS in course of its first purchase program, only in its most recent program has the ECB extended the composition of assets purchased to a wide range of private sector securities. The different structures of the economies and financial markets of the US and the Eurozone make direct comparisons between the impact of ECB's and Fed's policies impossible, but similarities in the patterns of how the pass-through of policy takes place and what drives it can confirm the relevance of such drivers and channels.

Lastly, the subject of this analysis is of not just academic interest, but also of immediate importance for policy and its implementation. Better knowledge about the drivers and channels of policy pass-through to the private economy can allow central banks to design future LSAP programs that stimulate the economy more effectively and at a lower cost. Furthermore it can also be useful in the current discussion about unraveling their large balance sheets that resulted from the purchases in response to the Great Recession, an issue that is at the forefront of current policy discssion in the US.

3 Literature Review

3.1 Event Studies about LSAP announcements

In the first event study on the Fed's LSAP 1, Gagnon et al. (2010) find that the announcements were successful in lowering long term interest rates. The authors find a decline in yields on corporate bond indices, which they explain by the existence of a rebalancing effect giving rise to duration risk channels. This is confirmed by the finding that 10-year Treasuries respond stronger than 2-year Treasuries, which is shown to be coming from a decline in the Kim & Wright (2005) term premium. The decline in the term premium is nearly as large as the total decline in the 10-year Treasury yield, which leads the authors to the conclusion that changes in expected short-term rates did not play a major role in the declining long-term yields.[3]

Krishnamurthy and Vissing-Jorgensen (KVJ 2011) extend Gagnon et al.'s (2010) investigation to LSAP 2. They find that in LSAP 2 there is much less evidence of an effect on corporate bond yields. This finding's contrasting potential explanations - the lack of private assets purchased in LSAP 2, or the less distressed financial market environment at the implementation of the second program - is at the core of the analysis of this paper. Furthermore, Krishnamurthy and Vissing-Jorgensen also decompose the asset price responses into different transmission channels. Those channels and their identification are discussed in section 5. In general, Krishnamurthy and Vissing-Jorgensen compare the response of different securities around the announcements, with the securities chosen such that they are comparable along all but one dimension of risk. This risk dimension is then assumed to be responsible for the assets' differential responses, which allows the effect of

---

[3]However, as Woodford (2012) notes, Bauser and Rudebusch (2011) argue that the DTSM of Kim and Wright (2005) leads to estimates of the term premium include a bias term due to the exaggeration of mean-reversion in short-term rates, which lead it to overstate the effect on the term premium

the purchases on this risk premium to be quantified. The authors find the presence of a default risk channel that decreases the yields on corporate bonds during LSAP 1 but no evidence for such a channel during LSAP 2, which they hypothesize to be stemming from the lack of private asset purchases during LSAP 2.

Woodford (2012) criticizes that event studies are unable to distinguish between the effects of forward guidance and LSAPs. Since the announcements about LSAPs arguably also contain explicit or implicit information that affects the public's stance about expected future policy, it seems to be an exaggeration to attribute the entire effect during the announcement to the effect of asset purchases.

Importantly for the identification strategy chosen in this paper, Swanson (2016) presents evidence that shows that corporate bond yields are not affected by forward guidance. This would imply that all effects on corporate bond yields found around the announcements do in fact arise from the expectation of asset purchases, which would make the event study a more appropriate and accurate methodology for analyzing corporate bonds. Swanson decomposes a monetary policy shock measured as the asset price responses of certain fixed income assets in the event window into an LSAP- and a forward guidance component. However, his identifying assumption is the similarity of the forward guidance shock before and after the Fed reached the ZLB in 2008. This is at least questionable due to the fact that forward guidance at the ZLB was concerned with much longer horizons than in the pre-ZLB period.

Woodford (2012) also criticizes the fact that event studies assume some degree of market efficiency in assuming a direct stock effect of the announcement being priced relatively immediate, while attempting to measure an effect that should not arise under efficient markets. Purchases of assets by the central bank should not affect yields at all in efficient markets as such purchases have no impact on the distribution of future

returns of these assets, which is what should determine their prices and hence yields. Furthermore, he criticizes the validity of such studies in stating that the portfolio rebalance effects that give rise to some of the observed effects might only arise under extremely distressed markets when arbitrageurs are too risk-averse or capital-constraint to arbitrage between different assets. While these criticisms are hard to overcome when employing event studies, the focus of this study on the impact of the financial market environment on the effects of LSAPs should illuminate how different financial market environments affect the pass-through of asset purchases.

While by far not as common, similar event studies have also been used to study the ECB's LSAP programs. Altavilla et al. (2014) look at the OMT announcements and find a large effect of these announcements on the sovereign debt yields of the countries targeted in the purchases, but less so on sovereign debt yields of non-targeted countries, indicating narrow policy transmission channels. The authors do not investigate effects on corporate bonds.

Altavilla et al. (2015) perform a similar study of the APP announcements, this time also including corporate bonds in the analysis and decomposing the effects into different transmission channels. The authors find sizeable effects despite the fact that the APP was announced in times of relatively low financial distress. They explain those findings with the fact that although local supply channels might be weaker under less distressed financial markets, spill-overs to other asset classes than the one targeted should be stronger. The authors find some evidence of a duration channel and a credit risk channel for the APP announcements. However, they include a very wide set of event dates, many of which contain no explicit information about future asset purchases. Since any yield changes on such dates are more likely to arise from other information contained in the announcements that not directly related to LSAPs, I exclude such dates in my analysis and find much

weaker results than the authors report.

Related to this issue, Thornton (2017) criticizes the existing event study evidence on the basis that most event dates don't satisfy the criteria for identification, namely that the effects within the window are statistically significant and are coming only from news about LSAPs. To mitigate such concerns, I only use the most narrow set of event dates identified in the literature, and show the relevance of LSAP-news on such dates using an index of news articles related to LSAPs I construct from Factiva (discussed in more detail in Section 4.2). Furthermore I only interpret effects that are statistically significantly different from zero, assuming all other point estimates are simply noise.

The idea behind event studies is that the window can be chosen to be narrow enough to not capture any other, unrelated news that affect the variable of interest but are not caused by the LSAP announcement. The novelty of the programs considered and the relative illiquidity of corporate bonds make an intraday identification challenging, so researchers resort to using 1-day or 2-day windows. However, these windows are so large that there are obvious problems with the assumption that monetary policy announcements are the only factor driving the interest rate reactions. This is particularly relevant in the Eurozone, where the ECB's press conferences take place on Thursday afternoon, while the US Employment Report is published on Friday morning. Altavilla et al. (2014) show that the US's Employment Report numbers are significantly drive yields in the Eurozone so that omitting them as a control can lead to biased results. Fratzscher et al. (2015) propose a framework that controls for the publication of other macroeconomic news that becomes public information within the event window. Specifically, the authors use Bloomberg's consensus estimates as the market's expectation, and deviations from this expectations as the news component they control for. I adopt their design to use in my event study, which should be particularly interesting for the US results where such controls have not

usually been included[4].

This highlights another problem with event studies, namely the use of simple event dummies unconditional of the public's expectation of the announcement. Foerster and Cao (2012) construct indices of news mentionings and Google searches related to key words associated with asset purchases. They show that not only do these indices spike well before the LSAP announcements take place, they also show an inverse relationship of yields and term premia with those indices, implying that expectations are formed in anticipation of the announcements and already affect interest rates in advance. Simple event studies are unable to capture such effects.

3.2 Theoretical Results

Eggertsson and Woodford (2003) show that in efficient financial markets, asset purchases by the central bank do not have a direct effect on asset prices or monetary outcomes. They can however have an impact by affecting the public's expectations of future policy rates. This result gives rise to a "signaling channel", where LSAPs affect long-term yields through the expectation of future short-term interest rates.

In contrast to that, Vayanos and Vila (2009) and Vayanos and Greenwood (2014) build models around preferred-habitat investors with a clientele-demand for certain maturities that gives rise to a duration risk channel. Their models imply that LSAPs work best when financial distress is high and liquidity is low, allowing for inefficiencies in asset prices due to capital-constrained arbitrageurs.

In efficient markets in which assets are priced at the present value of the risk-adjusted expected returns they provide, LSAPs do not affect asset prices and hence yields because

---

[4]Nakamura and Steinsson (2015) show that even for 1-day event windows in the US, background noise is significant implying benefits from including controls for US event studies as well

an asset's expected returns do not directly depend on who holds these assets. Hence the cental bank's purchases of certain securities should not affect asset prices directly. However, such direct effects can arise under certain inefficiencies. Most notable here are funding constraints of arbitrageurs in preferred-habitat models á la Vayanos and Vila (2009): In their model there exist preferred habitat investors that have a specific preference for certain maturities, and arbitrageurs that take advantage of relative mispricings across the entire term structure and make it arbitrage-free. However, arbitrageurs' risk aversion and funding constraints can lead to local shocks having an impact on the term structure - this is how LSAPs can have an effect in such models. When financial markets are in distress, specifically when the arbitrageurs' funding liquidity is low and risk aversion is high, such effects are expected to be stronger as there is less arbitrage between the different habitats.

In line with that, Altavilla et al. (2015) show that under financial distress, narrow supply channels in the propagation of asset purchases are stronger. However, their model also produces the result that asset purchases are expected to have wider spill-over effects under less distressed markets. This is due to the fact that arbitrageurs are better capitalized to exploit arbitrage opportunities between different habitats in such an environment. This causes more rebalancing from the purchased securities to other assets, which weakens the local supply channel but allows for wider transmission channels of asset purchases.

Gertler and Karadi (2013) incorporate LSAPs into a macroeconomic model as a form of central bank intermediation. In that model, LSAPs can be effective due to borrowing frictions that produce limits to arbitrage in the private sector. Since those limits to arbitrage are greater in markets for private assets, their model produces stronger policy effects if the assets purchased have some private risk components. Greater limits to arbitrage also imply a greater direct impact on the asset purchased by the central bank,

11

so purchases of private sector securities are expected to affect these private securities stronger than purchases of Treasuries.

Lastly, preferred habitat models can also predict a larger impact of private asset purchases on other private assets such as corporate bonds, if the clienteles are not determined by their maturity- or duration preference, but by other risk characteristics. If investors are characterized by their preference for taking on specific amounts of private sector risks, for example credit default risks in the case of corporate bonds or prepayment risks[5] in the case of MBS, then purchases of some of these assets by the central bank will lead to a rebalancing towards other assets with similar risk characteristics, and hence could explain a larger pass-through to private assets from purchases of assets with such private risk components than purchases of solely Treasuries. Of course, the fundamental inefficiency giving rise to such effects would still be the arbitrageurs' risk aversion and their funding constraints, so one might again expect to find a larger effect from such purchases in distressed rather than calm markets.

4   Methodology

4.1   Event Study

When analyzing the effects of unconventional monetary policy, many researchers have chosen an event study design. It is a suitable approach in such cases as a direct measure of the policy shock is not available and can furthermore overcome the endogeneity issue that is present in measuring the effects of monetary policy on the economy. This endogeneity issue arises because the same shocks to macroeconomic conditions that affect policy also

---

[5]Since the MBS purchased by the Fed were guaranteed by Fannie Mae and Freddie Mac who were under government conservatorship, they are free from any default risks. The only private risk component the agency MBS carry is a prepayment risk coming from the optionality to pay back the principal ahead of time (for example for refinancing purposes) and hence foregoing future interest payments.

drive corporate bond yields.

Event studies attempt to circumvent this issue by looking at changes of the variable of interest over a short event window in which one can safely assume that no other shocks to the variable of interest arise. In the LSAP case, the researchers focus on short periods around the Central Bank announcements of LSAPs and measures changes in assets' yields within that window. It is then assumed that only the monetary policy announcement, not any other macroeconomic news, affects the yields and that even if such other news arise, they will not anymore affect the central bank's decision about the announcement to be made later in the day, resolving the endogeneity issue.

Implicit in using event studies to analyze LSAP announcements is the assumption that LSAPs work through a stock effect as opposed to a flow effect: Already at the announcement of the purchases, markets should fully adjust to the anticipated shortage of those assets in the aggregate portfolio and the actual implementation of the purchases should have no further financial market impact.

While researchers have chosen windows as narrow as 30 minutes for event studies of regular FOMC announcements, for unconventional policy such as LSAPs, windows of one or two days are more common. This choice is driven by the trade-off to on the one hand use as narrow a window as possible in order to exclude background noise, but it also has to be wide enough for the full effect to be priced in. It is usually argued[6] that due to the novelty of LSAPs, particularly the earlier programs, and due to the illiquidity of financial markets during their implementation, the actual pricing of the effects takes longer than the pricing of conventional policy announcements. For that reason most researchers use one or two days as the event windows. Specifically for the purpose of this analysis this approach is not only appropriate, but also the only implementable one as corporate bonds

---

[6]for example by Gagnon et al. (2010) in the first of such event studies

are relatively illiquid and therefore usually are not quoted on an intraday frequency.

In my analysis, I will use two different regression specifications. For the baseline event study that captures the yield changes of corporate bond yields on LSAP announcement dates while controlling for other macroeconomic news arriving within the event window, I use the following specification

$$\Delta r_t = \sum_{j=1}^{J} \alpha_j D_{j,t} + \sum_{j=1}^{J} \beta_j D_{j,t-1} + \sum_{l=1}^{L} \gamma_l News_{l,t} + \epsilon_t \tag{1}$$

where Δr_t is the daily change in yield of the security or index to be investigated (usually, these are corporate bond yield indices or sovereign debt yields as a benchmark, but for the identification of specific transmission channels, other securities are considered as well). $D_{j,t}$ is a dummy for an announcement taking place on date t, while $D_{j,t-1}$ indicates an announcement having taken place on the preceding day (more on the announcement dates in subsection 4.2), so that α_j measures the 1-day effect announcement j had on yields, while $\alpha_j + \beta_j$ measure its two-day effect. In most cases, I report the cumulative affects aggregated for all announcements pertaining to one individual LSAP programs.

To investigate the impact that asset purchase composition, specifically the purchases of private assets, and the financial market environment had, I use specification (2)

$$\Delta r_t = \sum_{j=1}^{J} \alpha_j D_{j,t} + \sum_{j=1}^{J} \beta_j D_{j,t-1} + \delta Private_t + \eta Stress_t \text{x} Event_t + \phi Stress_t + \sum_{l=1}^{L} \gamma_l News_{l,t} + \epsilon_t \tag{2}$$

where $Private_t$ is a dummy variable, indicating whether an announcement was concerning the purchase of private assets, while $Stress_t$ is the studentized value of the respective index measuring distress in the financial system and $Event_t$ is the sum of all event dummies. I also include the interaction of private asset purchases and financial distress

(not pictured here due to space constraints). Lastly, $News_{l,t}$ is the studentized surprise element in the announcement of important macroeconomic indicators (Section 4.3 discusses the financial distress indices and Table 1 in the Appendix lists the macroeconomic indicators used). Note that the coefficients δ, η as well as the coefficient on the interaction term are the average *additional* effects of an announcement from either including private asset purchases, from being announced when financial market distress was one standard deviation above its mean, or from the combination of both.

4.2   LSAP programs and Announcement Dates

The programs considered are the Federal Reserve's LSAP 1, LSAP 2 and LSAP 3 as well as the ECB's Securities Market Program (SMP), Outright Market Transactions (OMT) and Asset Purchase Program (APP). Of special interest is the heterogeneity of these programs in terms of what assets were purchased and what financial conditions they were implemented in.

For the Fed's LSAP programs, the first round was announced and initiated at the height of the financial crisis in late 2008. Besides Treasuries, it included purchases of Agency MBS and Agency Debt. The second LSAP program was initiated in financially calmer times in late 2010 and only included purchases of Treasuries, while the third round was started when distress in markets had further dissipated in later 2012, but it again included Agency MBS to about the same extent as Treasuries.

In the Eurozone, the purchases started in 2010 with the Securities Market Programme (SMP). While it authorized the ECB to purchase public and private securities, it effectively was a program of purchases of sovereign debt. It shared this aspect with its successor program, the Outright Market Transactions (OMT), in which the ECB continued its purchases of sovereign debt. Both differ significantly from the Asset Purchase

Program (APP), which widened the scope of assets purchased to private sector securities such as corporate bonds, Asset Backed Securities (ABS) and covered bonds. Further, the APP was initiated when financial market disruption that had been present around the SMP and OMT announcements had dissipated significantly.

My analysis exploits the variation in the combination of financial market regimes and asset purchase composition to study their implications for the effects of policy on corporate bond yields. In the following tables, I list the event dates and announcements used for each of the different programs.

Table A1: Announcement Dates for LSAP 1 (from KVJ (2010))

Date	Announcement
11/25/2008	The Federal Reserve announced it would purchase up to $100 billion in agency debt, and up to $500 billion in agency MBS
12/01/2009	Speech by Chairman Bernanke where he stated the Fed could purchase longer-term Treasury securitiesin substantial quantities
12/16/2008	December 2008 FOMC statement: The FOMC anticipates...exceptionally low levels of the federal funds rate for some time. It also stands ready to expand its purchases of agency debt and mortgage-backed securities...[and] is also evaluating the potential benefits of purchasing longer-term Treasury securities.
01/28/2009	January 2009 FOMC Statement: The FOMC is prepared to purchase longer-term Treasury securities.
03/18/2009	March 2013 FOMC Statement: The FOMC anticipates...exceptionally low levels of the federal funds rate for an extended period. It also announced purchases of up to an additional $750 billion of agency mortgage-backed securities, up to $100 billion in agency debt, and up to $300 billion of longer-term Treasury securities over the next six months.

Table A2: Announcement Dates for LSAP 2 (from KVJ (2011))

Date	Announcement
08/10/2010	August 2010 FOMC statement: "the Committee will keep constant the Federal Reserve's holdings of securities at their current level by reinvesting principal payments from agency debt and agency mortgage-backed securities in longer-term Treasury securities."
09/21/2010	September 2010 FOMC statement: "The Committee also will maintain its existing policy of reinvesting principal payments from its securities holdings[]The Committee will continue to monitor the economic outlook and financial developments and is prepared to provide additional accommodation if needed to support the economic recovery"
11/03/2010	November 2010 FOMC statement: The Committee will maintain its existing policy of reinvesting principal payments from its securities holdings. In addition, the Committee intends to purchase a further $600 billion of longer-term Treasury securities by the end of the second quarter of 2011.

Table A3: Announcement Dates for LSAP 3 (from Altavilla and Giannone (2016))

Date	Announcement
08/22/2012	July 2012 FOMC minutes: "Many members judged that additional monetary accommodation would likely be warranted fairly soon"
09/13/2012	September 2012 FOMC statement: The FOMC decided "to increase policy accommodation by purchasing additional agency mortgage-backed securities at a pace of $40 billion per month"

Table B1: Announcement Dates for SMP (from Fratzscher et al. (2014))

Date	Announcement
05/10/2010	ECB press release: "The Governing Council decided to conduct interventions in the euro area public and private debt securities markets (Securities Markets Programme) to ensure depth and liquidity in those market segments which are dysfunctional"
08/08/2011	SMP reactivated and extended to Spanish and Italian government bonds: "It is on the basis of the above assessments [about the policies implemented by the governments of Spain and Italy] that the ECB will actively implement its Securities Markets Programme." (The announcement took place on Sunday 08/07/2010, so the event dummy was moved to the subsequent Monday)

Table B2: Announcement Dates for OMT (from Altavilla et al. (2014))

Date	Announcement
07/26/2012	Speech by Mario Draghi: "Within our mandate, the ECB is ready to do whatever it takes to preserve the euro. And believe me, it will be enough."
09/06/2012	ECB press release about technical features of OMT program: "Outright Monetary Transactions will be considered for future cases of EFSF/ESM macroeconomic adjustment programmes or precautionary programmes as specified above. They may also be considered for Member States currently under a macroeconomic adjustment programme [...]. Transactions will be focused on the shorter part of the yield curve, and in particular on sovereign bonds with a maturity of between one and three years. No ex ante quantitative limits are set on the size of Outright Monetary Transactions."

Table B3: Announcement Dates for APP (from Altavilla et al. (2015))

Date	Announcement
09/04/2014	ECB Press Statement: ABS purchase program announced
10/02/2014	ECB Press Statement: Details on the ABS and covered bond purchases announced
11/06/2014	ECB Press Conference: Draghi points out that ABS and covered bond purchases are likely to increase
12/04/2014	ECB Press Conference : Draghi points out that ABS purchases are likely to increase, are very efficient, and hints at expansion to other assets such as corporate bonds
01/22/2015	ECB Press Statement: Launch of the Public Sector Purchase Program (PSPP)
03/05/2015	ECB Press Statement: Timing of the PSPP announced

In order to demonstrate that the event dates listed above in fact are dominated by the LSAP announcements, I construct a news intensity index from the news database Factiva. This index identifies the number of articles on a given day that where concerned with asset purchases by the Fed or ECB, respectively [7]. These indices are shown below for the time surrounding the different programs by the Fed and ECB:

Figures 1 and 2 show that all identified announcement dates correspond with spikes in the news intensity index. Especially for the US, it also appears that the announcement dates capture most of the major spikes in the index. However, there also exist a number of spikes in the news index that are not identified as announcement dates. However, many of these spikes correspond with heightened reporting before or after FOMC or Governing Council meetings where the public speculated about announcements to be made but no such news were actually communicated. Other dates corresponding with spikes in the index are associated with negative surprises about LSAPs, such as statement

---

[7]For example, for LSAP 1, I search for articles containing the one of the keywords "QE" "LSAP" or "asset purchases", and one of the keywords "Bernanke", "FOMC", "Fed" or "Federal Reserve" , and none of "ECB" "European Central Bank", "BoE", "Bank of England", "BoJ" or "Bank of Japan" to not contaminate my index with other central banks' LSAP announcements

(a) LSAP 1

(b) LSAP 2

(c) LSAP 3
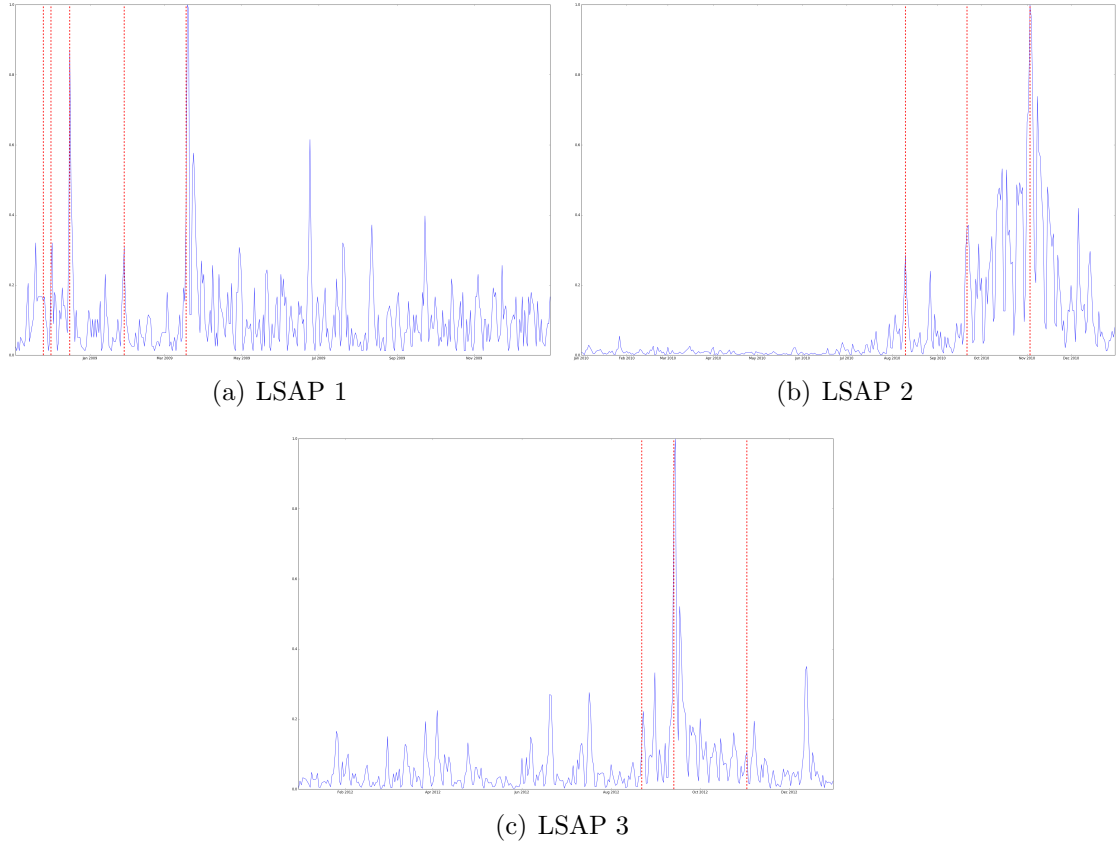
Figure 1: News Intensity Index around Fed Programs and Event Dates

by central bank officials questioning their efficiacy or vouching to end the programs. However, some of the spikes actually do seem to contain LSAP news that have not been identified in the literature thus far. In response to Thornton's (2017) criticism of the lack of identification in the event dates used in the literature I chose to exclude those dates from my baseline analysis to keep it as narrow, well-identified and in line with the existing literature as possible, but I re-ran the analysis with an expanded set of event dates which gave qualitatively and quantitatively similar results.

(a) SMP

(b) OMT

(c) APP
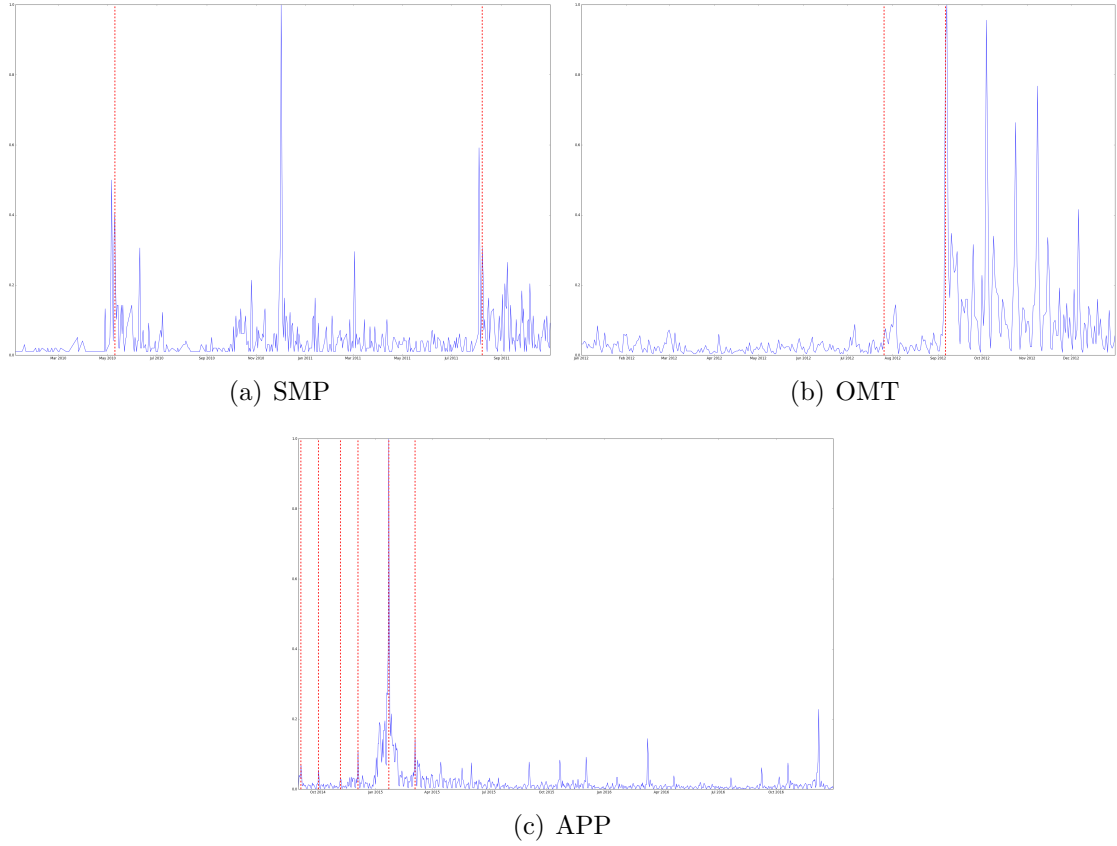
Figure 2: News Intensity Index around ECB Programs and Event Dates

4.3 Data

To study the effects on corporate bond yields, I use different yield indices on corporate bonds that range across different maturities and credit ratings. Specifically, for the United States I use Bank of America Merrill Lynch Corporate Bond indexes, which are available for credit ratings ranging from AAA to BB. For the Eurozone, I use iBoxx indices of Corporate Bond Yields that span the investment grade spectrum (AAA to BBB). All these are obtained from Datastream. For sub-investment grade Eurozone bonds, I use Bloomberg's European Corporate High Yield Index. From Bloomberg, I further obtain the European Covered Bond Index, which allows for the investigation of narrow transmission channels from the purchases of covered bonds by the ECB. Treasury yields are

obtained from FRED and yields on German and Italian Government bond yields come from Bloomberg.

To obtain the surprise element in the announcement of macroeconomic news I use Bloomberg's Economic Calendar, which lists the announcement dates of macroeconomic indicators with their realized value as well as a consensus estimate which is the median value of a survey of economists' expectations about the indicator. I construct the surprise element for the most important indicators for the US, the Eurozone and Germany, France, Italy and Spain as the difference of the realized and the expected value, which I studentize to give them better interpretation. Table 1 in the Appendix lists the indicators used.

To measure expectations about future short term interest rates, I use Federal Funds Futures (obtained from Bloomberg). Federal Funds Futures are liquid up to a horizon of approximately 2 years. Since they present a direct measure of the expected policy rate they are the preferred measure in those maturities where reliable data is available. Gurkaynak et al. (2007) show that for such horizons, Federal Funds Futures are the best available measure of policy expectations.

Overnight Interest-Rate Swaps (OIS) provide another instrument that can be used to measure changes in policy expectations as it lets investors swap a fixed rate against the variable overnight rate, giving an average expected overnight rate at different horizons. However, OIS have risk characteristics very close to Treasuries, so they might serve as substitutes for Treasuries. This makes them less suitable as an independent measure of policy expectations at longer horizons, as at such horizons OIS rate include risk premia that are arguably closely connected to the Treasury term premium and that hence could be similarly affected under LSAPs. In that case OIS rates do not solely reflect expectations about future policy but as substitutes they could also be directly affected by purchases of Treasuries by the Fed. Bauer and Rudebusch (2013) argue that under
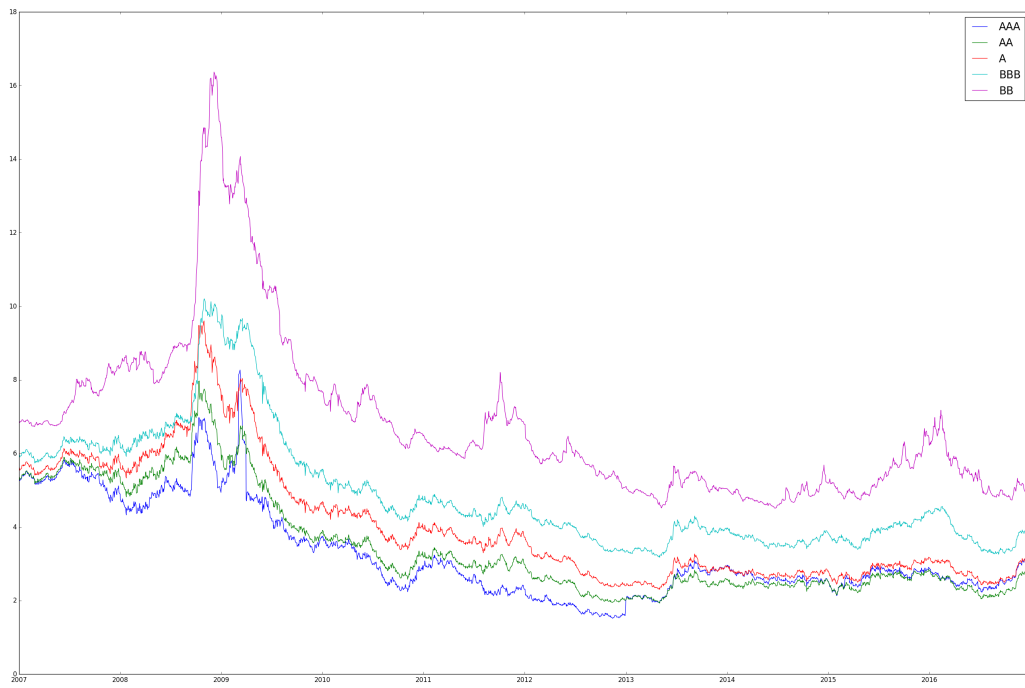
(a) United States

(b) Eurozone

Figure 3: Corporate Bond Yields used in the Event Study for US and Eurozone

23

a narrow transmission channel where no such rebalancing from Treasuries to OIS takes place, OIS rates do serve as a measure of only policy expectations.

In absence of a financial market instrument directly measuring expectations about the ECB's future policy rate, I use OIS rates (obtained from Bloomberg) as an indirect measure of such expectations, but restricting the horizons to 3 years to get a measure that is largely free of term premia effects on longer-maturity bonds that might serve as substitutes for OIS.

To measure financial distress, I use the most commonly used distress measure for the US and the Eurozone, the St. Louis Fed Financial Stress Index (STLFSI, obtained from FRED) and the ECB's Composite Indicator of Systemic Stress (CISS, obtained from the ECB). Both indices aggregate different measures of financial distress, among them public and private interest rates of various maturities, yield spreads capturing term premia as well as liquidity- and default-risks in money- and bond markets as well as other risk measures such as volatility indices and breakeven inflation rates[8]. One weakness about these measures is that they are broad measures of financial distress and do not directly address the specific sort of financial distress that might be expected to have an impact on the propagation of policy, specifically the funding liquidity of market participants that would be expected to arbitrage away any local supply effects arising from LSAPs. However, such measures are components of these indices and are highly correlated with systemic distress, hence they still provide a suitable measure. Furthermore, although they might not directly measure the sort of distress giving rise to inefficiencies that in theory allow for LSAPs to be effective, they are still relevant to policy in the sense that these indices are high at times when central banks are most likely to act due to the systemic stress the measures indicate.

---

[8]CISS: Holló et al. (2012); STLFSI: https://www.stlouisfed.org/news-releases/st-louis-fed-financial-stress-index/stlfsi-key

5 Channels and Identification Method

LSAPs are hypothesized to work through numerous different channels that affect long-term yields differently. These channels are best understood in the light of the expectations hypothesis, which describes how long term yields are formed in financial markets.

5.1 Expectation Hypothesis

According to the Expectation Hypothesis, the first component of long term rates are the short-term rates that are expected to arise over the maturity of the longer-term asset. An investor who invests in a 10-year bond has the alternative to invest in the overnight money market every day for the next 10 years, so in the absence of any additional risk in the 10-year bond, that bond should pay an interest rate that equals the investor's expectation of the average overnight rate over the next 10 years.

Of course a 10-year corporate bond is much riskier than a sequence of overnight money market investments. Additionally to a higher default probability over the longer horizon, differences in duration, liquidity and other properties of the assets give rise to further risks that an investor of a long-term asset is exposed to. In financial theory, any such risks borne by investors have to be compensated for by the existence of risk premia that pay a higher return to the holder of the more risky asset. Hence there exist significant term premia on longer bonds that compensate for their higher risk, which can be decomposed into their individual risk components.

5.2 LSAP Channels

If LSAPs affect long-term assets, the question is through which component of long-term yields this effect takes place. In describing the channels through which these effects arise,

a lot of Fed researchers and officials focus on rebalancing channels in which the decrease in supply of an asset caused by the Feds purchases causes the investors who previously owned these assets to rebalance them by purchasing other assets with similar characteristics, thus spreading the affects to such similar assets (Yellen (2011); Bernanke (2012); Hancock & Passmore (2014)). This effect takes place through a specific risk premium channel. For example if investors have a demand for a specific maturity or duration and assets of that duration are purchased by the central bank, then the decreased supply of assets of that duration lead to a decline in the associated duration risk premium, and hence a decrease in the yield of all assets that carry duration risk. In the identification of the different transmission channels, I use the methods used by Krishnamurthy and Vissing-Jorgensen (2011), adjusting their methods to be applicable to the Eurozone.

5.2.1 Signaling Channel

In contrast to working through risk premia, LSAPs can affect long term yields through the expectations of future short-term interest rates. If asset purchases by the central bank are interpreted by the markets as an implicit commitment to keep interest rates lower for longer, it will lower expectations of future short term rates and through that channel lower long term yields. In a sense this channel (often called the signaling channel) works like forward guidance in that the public interprets the purchases as a credible commitment to also keep future short-term lower.

Since such a channel is characterized by a shift in the expectations of future levels of the policy rate, futures contracts can be used to elicit such expectations and their reactions. Specifically, for the U.S., Federal Funds Futures can be used to directly measure market expectations of future rates. The signaling channel implies that the yield curve of federal funds futures contracts of different maturities shifts out around the LSAP announcement

as investors expect a lower federal funds rate in the future. It can hence be proxied for by the magnitude of the shift of the yield curve of federal funds futures around policy announcements.

For the Eurozone, where no such direct measure of policy expectations is available, I use OIS spreads to measure expectations of future overnight rates which are closely related to the ECB's policy rate and a frequently used instrument to measure such policy expectations (Ferrero & Nobili, 2008).

5.2.2 Inflation Expectations Channel

Since borrowing and investment decisions should be driven by real rates, but the considered corporate bond yields are in nominal terms, inflation expectations play a role in the transmission of policy to the real economy. Specifically, if LSAPs have an expansionary effect on the economy, they should increase inflation expectations and hence depress real rates even if nominal rates are unchanged.

Expected inflation in the US is usually measured as the difference in yield between nominal Treasuries and Treasury Inflation Protected Securities (TIPS) of the same maturity, the so-called break-even rate of inflation. However, since Treasuries and TIPS are subject to different risk premia[9] that can distort this analysis because these risk premia might change around the policy announcements and since there exist no Eurozone-wide inflation protected bonds , I use inflation swap rates (obtained from Datastream) to measure expected average inflation over the maturity of the swap. Specifically, I use 5-year and 10-year maturities as well as the 5-year 5-year forward rate, which measures expectations

---

[9]TIPS are less liquid and hence carry a liquidity premium, while Treasuries not only compensate for expected inflation, but also deviations from expectations and hence carry an inflation volatility premium. Furthermore, TIPS have a built-in deflation floor, that can overstate break-even rates if there is a significant probability of deflation. Lastly, TIPS break-evens can be distorted in flight-to-safety episodes when investors flood into save and liquid Treasuries more so than into TIPS

six to ten years into the future.

5.2.3 Duration Risk Channel

The theoretical work on preferred habitat models of investment by Vayanos and Vila (2009) where investors have a specific clientele-demand for certain maturities give rise to the existence of a duration risk channel, where purchases of assets of a certain duration lead to a decline in the amount and the price of duration risk in the aggregate private investors' portfolio. If such a duration risk channel is active and functional during LSAP announcements, one should see long-maturity (and hence long-duration) assets decline more in their yields than assets of shorter duration.[10]

5.2.4 Liquidity Channel

Corporate bonds not only have a higher default probability than Treasuries, they are also far less liquid. In purchasing long-term assets by issuing highly liquid reserves, the Fed provides liquidity to private portfolios and hence should decrease the price of illiquidity risk borne by the public. This implies that more illiquid assets such as corporate bonds should move more strongly than liquid Treasuries, and further imply an *increase* rather than a decline in Treasury yields, as Krishnamurthy and Vissing-Jorgensen (2011) point out. However, the difference between corporate bonds and Treasuries goes far beyond their different liquidity profiles. For the US, I therefore also look at the spread between duration-matched Agency debt[11] and Treasuries, whose only differential risk dimension is the lower liquidity of Agency debt. This is because the federal government took Fannie

---

[10]It has to be noted that there is a possibility of this channel being not applicable to the same extent across the entire fixed income market, but only narrowly, e.g. only to Treasuries. In this case it can work differently for different assets of the same duration, but the general result that *ceteris parisbus* longer-duration assets should be affected more still holds.

[11]Specifically, bonds by Fannie Mae (yields obtained from Bloomberg)

Mae and Freddie Mac into conservatorship in 2008, guaranteeing for their liabilities and hence equating their default risk properties with those of Treasuries. Thus their spread is reflective of only liquidity differentials and can be used to proxy for the liquidity channel.

In lieu of such a measure for the Eurozone, I measure the liquidity channel by the spread between AAA-rated corporate bond yields and the duration-matched German Bund yield, since both assets have similar risk properties in all dimensions of risk except for the AAA-rated corporate bonds being much less liquid.

5.2.5   Default Risk Channel

Another channel through which LSAPs can affect corporate bond yields is the perception and valuation of default risk in an economy. If following the announcement of an LSAP program, market participants expect the program to significantly improve macroeconomic conditions, this should manifest itself in a decrease in the compensation required to take on default risk[12].

Hence one can proxy for this channel by looking at how an index of credit-default-swaps (CDS) performs on the event dates, as the only driver of those CDSs should be the perceived probability of default of the underlying assets. Interestingly, Krishnamurthy and Vissing-Jorgensen (2011) find that LSAP 1 worked through this channel, while LSAP 2 did not. It seems natural to explain the presence of this channel with the inclusion of private sector securities in the mix of assets purchased during LSAP 1 and that the channel disappeared once such assets were not purchased anymore in LSAP 2, which would give evidence for a narrow transmission of policy. However, it alternatively could have been the case that the effect on the evaluation of private credit risk comes from a

---

[12]Besides directly decreasing the probability of default due to improved economic conditions, "Standard Asset Pricing Models imply that investor risk aversion falls as the economy recovers, implying a lower default risk premium" (Krishnamurthy & Vissing-Jorgensen, 2011)

fall in risk aversion that was caused by an improved economic outlook rather than direct effects of asset purchases, or that such effects could only take place in the highly disrupted financial markets of late 2008 and early 2009, and should not be expected to arise under more normal conditions. The evidence on such a channel during LSAP 3 will help resolving this question, as LSAP 3 was arguably less effective in improving the general economic outlook than LSAP 1 and was implemented in much more liquid financial markets, but it still included purchases of private MBS.

5.2.6 Safety Channel

Similar to a specific habitat for assets of a certain duration, there could be habitats for specific safe assets. Krishnamurthy and Vissing-Jorgensen (2010) provide evidence for the existence of such a habitat by regressing the spread between Baa and Aaa (or alternatively, Agency) bond yields on the supply of Treasuries. They show that this spread is high in times of a shortage of Treasuries and interpret this finding as evidence that in such times of a shortage of Treasuries, investors instead satisfy their clientele-driven demand for safe assets with their closest private substitute, highly rated corporate and agency bonds. Those habitats could exist due to the importance of such assets for banks, insurance companies, and other financial institutions who are subject to risk-weighted capital ratios and other regulatory guidelines inducing them to hold safe assets. Furthermore, such assets serve a special purpose in being used as collateral, which could lead them to be priced out of line with what their state-contingent payoffs should imply.

KVJ (2011) also find the presence of such a channel in both LSAP 1 and LSAP 2. Besides evidence from Treasury and Agency bonds, relevant for this study, KVJ's (2011) evidence for the safety channel also comes from looking at the yield changes on CDS-adjusted corporate bond yields. Their differential response across the rating-spectrum

cannot be driven by default risk[13], so a stronger response of safe assets would have to come from a special clientele demand for their higher safety.

However, AAA bonds only constitute a very small portion of the corporate bond market, so KVJ's safety channel is not relevant for the vast majority of private borrowers. Furthermore, I only have data on an investment grade and an high yield index of CDS spreads, not on individual credit ratings. Thus I will investigate a slightly different safety channel in measuring whether the CDS-adjusted yield on investment grade bonds declines more than the CDS-adjusted high yield index. This is asking the question whether the price of safety (after controlling for default risk probabilities) is affected by LSAP announcements, where safety is defined as being in the investment grade- as opposed to the high yield-spectrum. A clientele-demand for investment grade assets is plausible as many money managers are restricted to investing in the investment grade space. The cut-off to the high yield spectrum is further relevant as many of those managers tend to prefer the lower-rated assets at the bottom of the investment grade in order to generate higher returns.

---

[13]Subtracting the spread on a CDS-contract from a corporate bond yield of the respective credit risk gives a measure of the compensation on that bond that is not driven by different default risk probabilities

5.2.7 Summary

In summary, we can decompose the real return on a illiquid, risky long-term asset such as a corporate bond in the following way, where each line corresponds to one of the channels discussed above and each risk premium is formed by the product of the quantity and the price of that risk. Using the identification methods described above, I will test each of the different LSAP programs with respect to which of these channels contributed to the programs' effect on corporate bond yields.

$$
\begin{aligned}
r_{long-term,illiquid,risky} = {} & E\big[i_{short-term,liquid,safe}\big] \\
& - E[inflation] \\
& + InflationVolatility * P_{InflationVolatility} \\
& + Duration * P_{Duration} \\
& + Illiquidity * P_{Illiquidity} \\
& + DefaultRisk * P_{DefaultRisk} \\
& + LackofSafety * P_{LackofSafety}
\end{aligned}
$$

6 Results

6.1 Overall Effects

6.1.1 United States

Table 1: Cumulative Effects - US

Program	Window	AAA	AA	A	BBB	BB	Treas.
LSAP 1	1-day	-69.3***	-58.7***	-42.3**	-56.7***	-77.2***	-85.8***
	2-day	-107.6***	-80.4***	-51.8**	-64.8***	-115.8***	-98.3***
LSAP 2	1-day	-10.7	-12.7	-10.8	-11.3	-3.8	-17.6*
	2-day	-24.4	-25.8**	-25.5**	-27.5**	-5.9	-42.9***
LSAP 3	1-day	-5.2	-8.3	-10	-8.2	-1.8	-9.6
	2-day	-8.8	-9.5	-12.6	-11.4	-14.2	-1.3

This table reports the cumulative coefficients of the regression of the daily basis point shift of the corporate bond yield indices and the duration-matched Treasury yield on the Fed's LSAP announcement dummies aggregated by program while controlling for the arrival of other macroeconomic news. The sample is January 2008 - December 2016. Standard errors are computed using HAC errors with Newey-West lags. Wald tests are used to determine statistical significance of the cumulative dummies.
Statistical significance levels are denoted by: * - 10%, ** - 5%, *** - 1%.

Table 1 shows the cumulative effects of the announcements of the Fed's three different LSAP programs on corporate bond yields and the duration-matched Treasury yield. It shows that LSAP 1 significantly decreased yields of corporate bonds of all credit ratings by approximately 50 to 100 basis points, with the largest effects occurring at the ends of the spectrum for the AAA- and the BB-rated bonds. Those effects might hint at the importance of a safety- and a credit default-channel respectively, which will be investigated separately later. What is striking is that yields for all other ratings decreased by less than the decrease in the duration-matched Treasury yield. This implies that the spreads for these bonds in fact *increased*.

For the LSAP 2-announcements, Treasury yields fell more than corporate bond yields

for all credit ratings, implying a further increase in spreads. The large effect LSAP 2 had on Treasuries, especially relative to corporate bonds, might be caused by the fact that LSAP 2 consisted of purchases of Treasuries only. Under narrow transmission mechanisms, such purchases would affect Treasury yields exclusively, or at least more so than yields of other assets. Hence the evidence from LSAP 2 appears to provide some evidence for rather narrow transmission channels with limited spill-overs from Treasury purchases to corporate bond yields.

Further noteworthy is that corporate bond yields fall much less than during LSAP 1 and that the strongest and only statistically significant effect takes place in the medium credit ratings, in direct contrast to LSAP 1. This could indicate the absence or weaker presence of a safety- and a default risk-channel for LSAP 2. The former might be amiss since markets had largely recovered from the immediate crisis during which LSAP 1 was implemented, while the latter could be missing either for the same reason of less disrupted financial markets, or due to the absence of private sector purchases in LSAP 2 [14].

The effects of LSAP 3 provide some evidence to resolve that question. LSAP 3 included purchases of agency MBS to nearly the same extent as Treasuries. However, for the LSAP 3 announcements we observe no statistically significant effect on corporate bond yields at all. This finding supports the hypothesis that private asset purchases are not sufficient to generate effects on corporate bonds, and that disruptions in financial markets are a necessary condition for a strong pass-through to corporate yields.

---

[14]Krishnamurthy and Vissing-Jorgensen (2011) argue that the default risk channel seems to only be affected when private assets are purchased. I will investigate this issue more when discussing the specific risk channels in section 6.3, and test it directly in section 6.4.

6.1.2 Eurozone

Table 2: Cumulative Effects - Eurozone

Program	Window	AAA	AA	A	BBB	HY	COV	Bund
SMP	1-day	1.2	-3.6	-1.7	-3.1	-6	-18.8***	8.1
	2-day	10.2	14.1*	19.6**	20.4**	69.3***	-10.8**	16.3*
OMT	1-day	7.8	8.6	6.9	-2.1	-4.3	2.7	9.3
	2-day	11	10.1	5.7	-16.2*	-34.2**	2.3	14.2
APP	1-day	-3	-3.9	-4.2	-6	-21.4	-3.7	-5.8
	2-day	-11.4	-11.3	-12.9	-17.7	-42.6	-11	-12.6

This table reports the cumulative coefficients of the regression of the daily basis point changes of the US corporate bond yield indices and the duration-matched Bund yield on the ECB's LSAP announcement dummies aggregated by program while controlling for the arrival of other macroeconomic news. The sample is January 2010 - December 2016. Standard errors are computed using HAC errors with Newey-West lags. Wald tests are used to determine statistical significance of the cumulative dummies. Statistical significance levels are denoted by: * - 10%, ** - 5%, *** - 1%.

Table 2 presents the cumulative effects of the ECB's programs on corporate bond yields and the duration-matched German Bund yield. It shows that the SMP announcements in fact increased all corporate bond yields except for covered bonds. This is a striking finding as it implies that the ECB's actions deteriorated the borrowing conditions for private companies. The yield increases are economically highly significant, increasing borrowing costs for high risk firms by nearly 70 basis points. Three possible explanations exist for the increase in risky corporate bond yields. First, the ECB's announcements might have been interpreted by the markets as implying that the macroeconomic environment was worse than previously anticipated, and that adjustments to those greater risks lead to yield increases for securities most exposed to default risk. This explanation would explain why the increases are the largest for the bonds with the largest amount of default risk, while the

effect on very safe AAA-rated bonds is non-significant and secure covered bonds exhibit a decrease in yields. Alternatively, due to the fact that the SMP was a program of purchases of distressed sovereign bonds, investors might have abandoned other comparable securities such as corporate bonds and purchased such distressed sovereign bonds instead, now that there existed the possibility of the ECB buying these assets. Lastly, market participants might have formed expectations about a larger or more comprehensive LSAP program, so that the announcement was a negative shock to their expectations, leading to the adverse effects on corporate bond yields.

For the OMT program the effect on risky corporate bond yields is the exact opposite compared with the SMP. Now the private bond yields that increased the most during the SMP show the largest and only statistically significant decline over the 2-day window. It is also interesting to note that this decline is not driven by Mario Draghi's "Whatever it takes"-speech, but by the announcement of the details of the OMT program, which only included public securities[15]. Since this announcement came at a point of heightened financial distress due to the European sovereign debt crisis, this again might hint at the fact that for the pass-through of asset purchases to public sector yields, the overall financial environment might be more relevant than the composition of assets purchased.

The evidence from the APP can be taken as providing further evidence to this claim. The APP was a program of mostly private asset purchases, but was implemented in financially much calmer times than either of its predecessors. Hence the finding that it did not affect yields in a statistically significant way could be taken as confirmation of the view that the effects of LSAPs are determined more by the financial market environment they are implemented in than by the composition of assets purchased.

---

[15]The results for individual announcement dates can be found in Tables 2 and 3 of the Appendix

6.2 Private Asset Purchases and Financial Market Distress

This section specifically investigates this question of whether the effects on corporate bond yields are primarily driven by purchases of other private assets, or whether the financial market environment surrounding the announcements is responsible for the majority of the yield responses. For that purpose, I here report the point estimates of the coefficients from regression specification (2). Specifically, the rows labeled "Private Assets" list the point estimate for δ that captures the effect of the announcement of private asset purchases. Rows labeled "Financial Distress" report estimates of η for the effects that financial distress had on the announcement date beyond how it normally affect yields, which is captured by the coefficient ϕ (not reported). I also report the results of a regression that additionally includes the interaction of the two variable of interest to investigate whether the combination of private asset purchases in a distressed financial environment has effects on corporate yields that goes beyond the individual effects by those two explanatory variables.

Interestingly, Table 7.a seems to imply that private asset purchases have a highly significant negative effect on corporate bond yields. This is especially true for lower credit ratings, while AAA-rated bonds and Treasuries are unaffected in a statistical sense. Similarly interestingly, the effects of financial distress point the exact opposite way: A higher degree of financial disruption on an announcement date leads to a decline of the yields on very safe bonds (AAA-rated corporates and Treasuries), while leaving unaffected or even increasing lower-rated corporate bond yields. This finding is somewhat in contrast to the evidence of the previous section, which seemed to imply that financial distress, not private asset purchases, were the main driver of the pass-through of LSAPs to corporate yields.

Table 3.a: Private Asset Purchases and Financial Distress: US

Driver	Window	AAA	AA	A	BBB	BB	Treas.
Private Assets	1-day	-2.2	-7.3***	-16.0***	-9.5***	-15.3***	-1.8
	2-day	-3.2	-4.4**	-10.1***	-6.8***	-11.6***	2.2
Financial Stress	1-day	-2.4**	-0.8	1.8**	-0.4	0	-3.8***
	2-day	-1.7**	-0.7	1.3**	0.1	0.1	-3.1***

Table 3.b: Interaction included

Driver	Window	AAA	AA	A	BBB	BB	Treas.
Private Assets	1-day	-3.1	-3.4	-4.6*	-3	-1	-2.5
	2-day	-2.6	-0.8	-1.4	-1.1	-2.6	3.8
Financial Stress	1-day	-2.8**	0.9	6.9***	2.5**	6.2***	-4.1***
	2-day	-1.5	0.6	4.4***	2.2***	3.3***	-2.5***
Interaction	1-day	0.8	-3.3**	-9.6***	-5.5***	-12.0***	0.5
	2-day	-0.4	-2.6***	-6.3***	-4.2***	-6.5***	-1.1

This table reports the coefficients of the regression (2) of the daily basis point changes in the US corporate bond yield indices and the duration-matched Treasury yield on the $PrivAssets_t$, $Stress_t \mathrm{x} Event_t$ and their interaction. The sample is January 2008 - December 2016. Standard errors are computed using HAC errors with Newey-West lags. Wald tests are used to determine statistical significance of the cumulative dummies. Statistical significance levels are denoted by: * - 10%, ** - 5%, *** - 1%.

Including the interaction of Financial Distress and Private Asset Purchases shown in Table 7.b resolves some of that conflict. The table shows that most of the effect coming from private asset purchases arises when financial market disruption is also high. This is evidenced by the fact that now nearly all of the coefficients on Private Assets are insignificant, while the interaction term has a sizeable[16] and highly significant negative effect on corporate bond yields, especially for the lower credit ratings.

It however does not fully resolve the puzzling results of the Financial Stress regressor.

---

[16]The reported point estimates are the additional effects coming from the presence of private asset purchases and financial distress *per announcement*

Financial distress without private asset purchases still significantly decreases Treasury- and AAA-rated bond yields, but also seem to have a highly significant positive effect on lower-rated corporate bond yields. LSAP announcements in financially disruptive times could have communicated a worse economic outlook than market participants previously anticipated, leading them to increase the compensation they require for taking on default risk. This hypothesis will be further investigated in section 6.4. However, the effect might have to do with the measure of financial distress, which is more an indication of systemic stress in the entire financial system, than the measure of funding (il-)liquidity that theory predicts to be the main driver of stronger effects of LSAPs in disrupted markets.

6.2.1 Eurozone

In the Eurozone, we also see a 10bp decrease in the yield on high yield bonds and a weaker, 2.6bp effects on covered bonds coming from private asset purchases. The negative effect on covered bonds, which were targeted in some of the purchase programs could be assumed to be stemming from very narrow supply channels, especially since other safe assets are unaffected or increase in yields. Table 8.b shows that even after including the interaction term, the negative effect on covered bonds doesn't vanish, and the one on high yield bonds even increases. The interaction also explains none of the effect on covered bond yields, providing further evidence that it arises due to direct narrow supply channels, and that those channels do not require the financial market disruption that seems to generate the spillover effects on non-targeted private assets.

Table 4.a: Private Asset Purchases and Financial Distress: Eurozone

Driver	Window	AAA	AA	A	BBB	HY	COV	Bund
Private Assets	1-day	1.9	-0.4	-0.5	-1.6	-9.9***	-2.6**	3.9**
	2-day	1.5	0.9	1	0.3	-1.7	-1.4	2.5*
Financial Stress	1-day	1.4	0.3	0.5	-0.1	-1	-2.9***	3.0*
	2-day	2.5	2.6**	3.0**	2.5**	6.1**	-0.6	3.3**

Table 4.b: Interaction Included

Driver	Window	AAA	AA	A	BBB	HY	COV	Bund
Private Assets	1-day	2.5	-0.4	-0.7	-2.2	-13.2***	-2.5**	5.1***
	2-day	1.8	0.5	0.4	-0.5	-4.4	-1.5*	2.7*
Financial Stress	1-day	0.3	0.2	0.8	0.8	4.2	-3.0***	1.2
	2-day	2.1	3.2**	4.0***	3.7***	10.0***	-0.4	2.9*
Interaction	1-day	2.6	0.1	-0.8	-2.2	-12.7***	0.3	4.4**
	2-day	1.1	-1.6	-2.4	-3.0*	-9.9***	-0.4	0.9

This table reports the coefficients of the regression (2) of the daily basis point changes in the European corporate bond yield indices and the duration-matched Bund yield on the $PrivAssets_t$, $Stress_t \text{x} Event_t$ and their interaction. The sample is January 2010 - December 2016. Standard errors are computed using HAC errors with Newey-West lags. Wald tests are used to determine statistical significance of the cumulative dummies. Statistical significance levels are denoted by: * - 10%, ** - 5%, *** - 1%.

For the 2-day window, I find relatively strong positive effects from financial market distress on announcement dates on high risk assets, similar as in the US. This pattern is somewhat puzzling: Not only do I not find a stronger negative effects of purchases of public assets on more distressed announcement dates, it seems like such an environment actually mitigates the effects of LSAPs by working in the opposite direction. In absence of significant spill-overs from public to private assets and without the direct purchases of such private assets, announcements of public asset purchases in distressed times could significantly increase the valuation of default risk in the economy, which would explain

the strong effects on the risky segments of the market. Alternatively, it might be that under such illiquid market conditions the public expected the ECB to restore liquidity in the distressed private market segments, and a lack of private asset purchases led to a negative change in the valuation of risky private assets. The specific effects of financial market distress and private asset purchases on the activity of the different transmission channels will be investigated in Section 6.4.

6.3 Evidence on Transmission Channels

After investigating the overall effects of the different LSAP programs on corporate bond yields in Section 6.1 and analyzing which characteristics of those programs make for the strongest effects on those yields in Section 6.2, I now decompose the total effects into the different transmission channels using the identification strategies described in Section 5.

6.3.1 Signaling Channel

	Table 5: Signaling Channel: US				
Program	Window	3 months	6 months	12 months	24 months
LSAP 1	1-day	-28.9	-35.8	-58.6***	-85.1***
	2-day	-15.3	-19.3	-36.5	-45.8
LSAP 2	1-day	-0.5	-0.3	-6.7	-10.9
	2-day	1.4	1.2	-6.7	-18.7**
LSAP 3	1-day	0.3	0	-1.1	-7.2
	2-day	-0.2	0.3	-1.9	-14.0**

This table reports the cumulative coefficients of the regression of the daily basis point shift of Federal Funds Futures at different maturities on the Fed's LSAP announcement dummies aggregated by program while controlling for the arrival of other macroeconomic news. The sample is January 2008 - December 2016. Standard errors are computed using HAC errors with Newey-West lags. Wald tests are used to determine statistical significance of the cumulative dummies.
Statistical significance levels are denoted by: * - 10%, ** - 5%, *** - 1%.

(a) LSAP 1
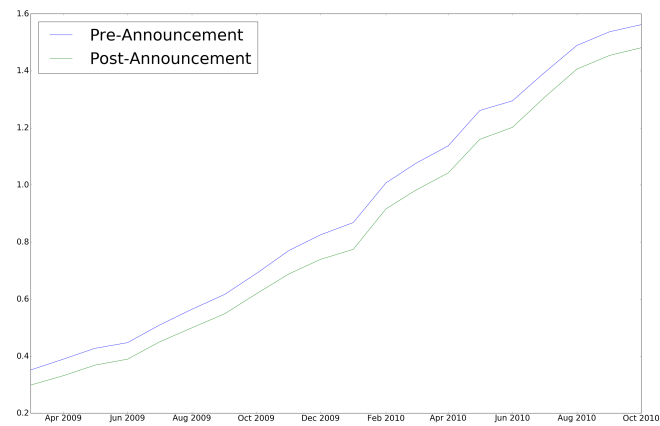
(b) LSAP 2
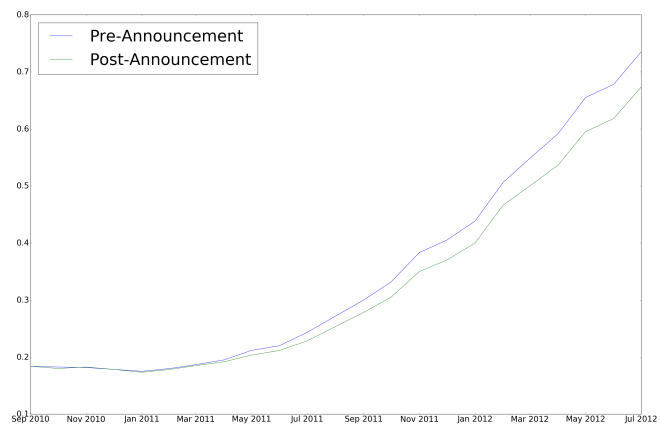
(c) LSAP 3

Figure 4: FFF Term Structure up to 24 months, pre- and post-announcements

42

Figure 4 shows the term structure of federal funds futures for horizons up to 2 years[17], averaged over all events on the day before and after the announcement. As the signaling channel implies, there is a clear shifting out of the yield curve at all horizons for LSAP 1, and at the longer horizons for LSAP 2 and LSAP 3 when markets were expecting to be stuck at the ZLB in the short-term fut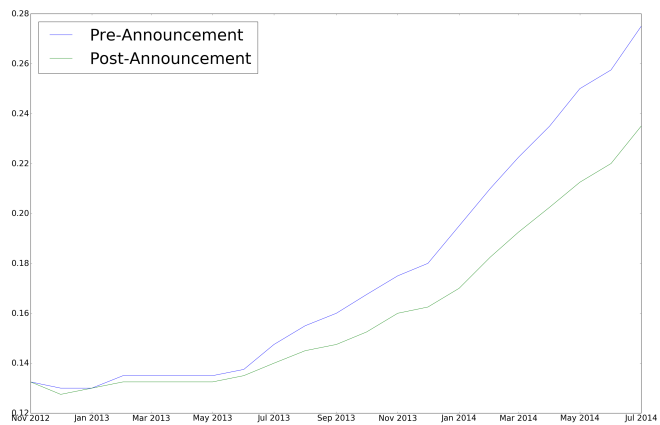ure anyways. Table 5 shows that this effect was by far the strongest under LSAP 1, where the announcements cumulatively decreased the expected federal funds rate 21 months ahead by 45-85 basis points. The effects of the later programs are weaker, but still decreased expected short-term rates two years ahead by 11-19 and 7-14 basis points, respectively. Those declines should affect corporate bond yields as they imply that *all* yields of those maturities fall by a similar amount. The extrapolation for longer maturities is more complicated, but Krishnamurthy & Vissing-Jorgensen (2011) argue that the 24-months-ahead changes can be seen as an upper bound on changes for over longer horizons as expected short-term rates should increase over the medium-long term again as the economy recovers. However, OIS rates seem to imply otherwise, at least for the US: Figure A1 in the appendix recreates Figure 4 with OIS rates for up to five years. The shift in rates increases with longer maturities for all three US programs, implying that the signaling effect is relevant and increasing for horizons much longer than two years. It however has to be noted that this could also be due to the potential substitutability of OIS and Treasuries at those longer horizons: Since Treasuries yields fall at all horizons around the program announcements, and increasingly so up to the 5-year maturity, it is possible that the shift in OIS rates is due to term premia effects on Treasuries as opposed to being reflective of expectations of short-term rates.

---

[17]Data on the 24-month contract was not available for the LSAP 1 period, so I use the 21-month as the longest available contract for that period instead

The magnitude of the shift in expectations seems to decline for later programs. The cumulative effects from LSAP 1 are very large in both an economic and statistical sense, implying that all 2-year bond yields should fall by at least half a percentage point. Compared to that, the declines around LSAP 2 and LSAP 3 announcements are still significant, but much smaller. This might indicate a decreasing signaling effect from additional programs, as market participants do not update their expectations about future policy as much from later programs as for the first one. However it could alternatively be the case that the later programs were as effective as the first one, but that market expectations had formed before the announcements took place in anticipation of further asset purchases and so the announcement dates do not capture the whole effect of the programs.

Program	Window	3 months	6 months	12 months	24 months
SMP	1-day	-9.4***	-17.7***	-19.9***	-17.4***
	2-day	-11.7***	-18.5***	-20.5***	-18.3***
OMT	1-day	-6.1**	-5.6**	-3.7	-2
	2-day	-8.3**	-8.2**	-9.3**	-11.0*
APP	1-day	-4	-4.3	-5.8	-4.9
	2-day	-0.4	-1.8	-4.9	-5.1

Table 6: Signaling Channel - Eurozone

This table reports the cumulative coefficients of the regression of the daily basis point shift of OIS rates at different maturities on the ECB's LSAP announcement dummies aggregated by program while controlling for the arrival of other macroeconomic news. The sample is January 2010 - December 2016. Standard errors are computed using HAC errors with Newey-West lags. Wald tests are used to determine statistical significance of the cumulative dummies.
Statistical significance levels are denoted by: * - 10%, ** - 5%, *** - 1%.

Figure 5 shows that like the Fed's announcements, the ECB's LSAP-related announcements caused a shift of policy expectations at all horizons up to two years. In Table 6

(a) SMP
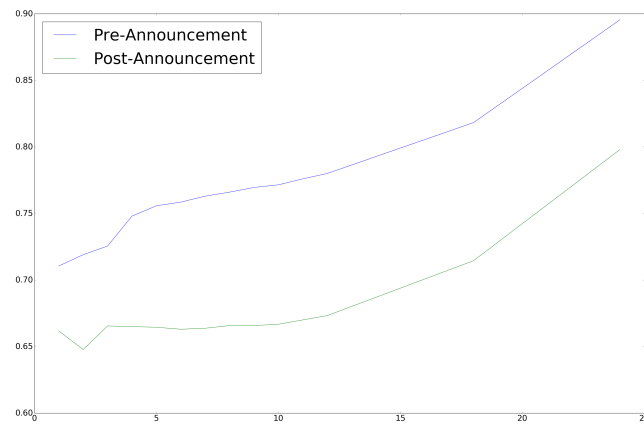
(b) OMT

(c) APP

Figure 5: Euro OIS Term Structure up to 24 months, pre- and post-announcements

it becomes apparent that again those shifts are the largest for the SMP. Interestingly, the effects of the SMP do not exhibit the same monotonic increase we saw for most of the Fed's programs. The largest shift in expectatio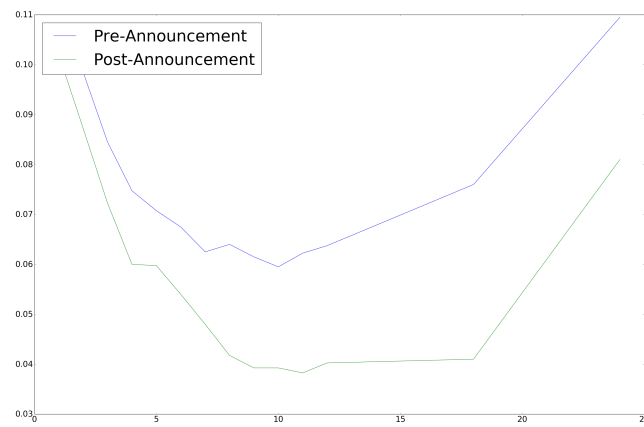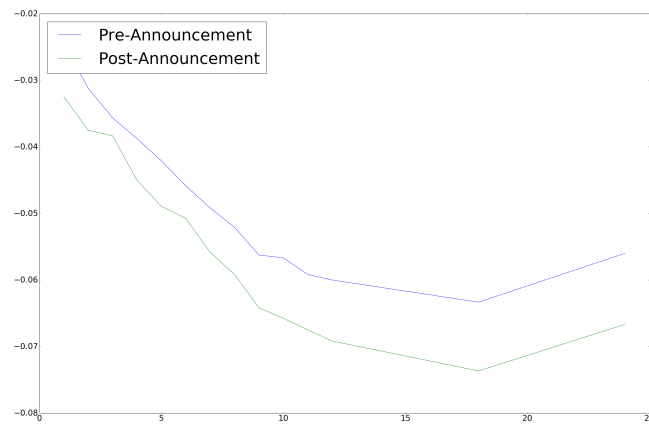ns is at the 12-months horizon, implying that at the time of the SMP announcements, markets anticipated economic conditions to normalize and money market yields to start rising again relatively soon. Further interesting is the convex shape of the anticipated path of future short-term rates for the OMT and the APP: As a results of the LSAP announcements, markets (correctly) anticipated the ECB to decrease the policy rate further in the future. Hence asset purchases do not only serve as a signal for a later lift-off from the ZLB, they can also signal an active lowering of rates if the Central Bank is not yet constrained by the ZLB. Figure A2 in the Appendix shows the shift of OIS rates up to a horizon of ten years. In opposite to the US, the magnitude of the shift tarts declining relatively fast, at approximately the 2-year horizon. For the OMT program, the implied post-announcement yields even move higher than pre-announcement one for horizons of more than 3 years. This shows that the ECB's announcements seem to have instilled a more positive medium-term outlook compared to the Fed's as market participants expected short-term rates to begin to rise much sooner as a response to the announcement than in the US, where the term structure of OIS permanently shifted out at all horizons up to 5 years. If one takes these shifts as exclusively indicative of market expectations of futures short-term rates this marks an important difference in the working of the signaling channel between the US and the Eurozone. In the US, such a signaling would have strong negative effects on the yields of longer maturity assets of horizons at least up to 5 years, whereas in the Eurozone the effects on 5-year bonds from the signaling channel should be close to zero (or, for the OMT, even positive).

6.3.2 Inflation Expectations Channel

Table 7: Inflation Expectations Channel - US

Program	Window	5Y	10Y	5Y5Y
LSAP 1	1-day	-3.4	9.6	5.2
	2-day	57.5*	52.7*	0.5
LSAP 2	1-day	15.3	10.3	-0.8
	2-day	6.3	-3.2	-0.7
LSAP 3	1-day	3.6	2.7	0.2
	2-day	1.4	1.7	1.4

This table reports the cumulative coefficients of the regression of the daily basis point change in inflation swap rates at different horizons on the Fed's LSAP announcement dummies aggregated by program while controlling for the arrival of other macroeconomic news. The sample is January 2008 - December 2016. Standard errors are computed using HAC errors with Newey-West lags. Wald tests are used to determine statistical significance of the cumulative dummies.
Statistical significance levels are denoted by: * - 10%, ** - 5%, *** - 1%.

Table 7 and 8 report the cumulative changes in inflation swap rates around the event dates for the US and the Eurozone, respectively. In the US, LSAP 1 appears to have increased inflation expectations at both the 5-year and 10-year horizon by approximately 50 basis points[18]. This is an economically significant effect because it implies that real yields at those horizons were lowered by an additional half percentage point on top of the decline in nominal yields. Interestingly, controlling for macroeconomic news makes the effect very uniform between the 10-year and the 5-year horizon, whereas the effect on the 10-year rate is much larger when not controlling for news[19]. The uniform reaction of both maturities is more in line with a view of LSAPs affecting medium-term expectations about the state of the economy.

---

[18]The activity in the market for US Inflation Swap is generally low and the market size was still relatively small during LSAP 1 (Fleming & Sporn, 2012), so the 1-day evidence should be discarded here

[19]Without such controls, KVJ (2011) find a much stronger effect on the 10-year than on the 5-year swap

There is no evidence that LSAP 2 or LSAP 3 had a noticeable effect on inflation expectations.

Program	Window	5Y	10Y	5Y5Y
SMP	1-day	19.4*	22.3**	0.2
	2-day	24.6*	26.8**	0.4
OMT	1-day	1.2	8.4	-0.7
	2-day	15.3	11.1	-1.3
APP	1-day	12.8	7.3	11.4
	2-day	15.4	7.7	0.9

Table 8: Inflation Expectations Channel - Eurozone

This table reports the cumulative coefficients of the regression of the daily basis point change in inflation swap rates at different horizons on the ECB's LSAP announcement dummies aggregated by program while controlling for the arrival of other macroeconomic news. The sample is January 2010 - December 2016. Standard errors are computed using HAC errors with Newey-West lags. Wald tests are used to determine statistical significance of the cumulative dummies. Statistical significance levels are denoted by: * - 10%, ** - 5%, *** - 1%.

In the Eurozone, the announcements of the SMP cumulatively increased inflation expectations by about a quarter of a percentage point, again uniformly over the 5-year and the 10-year horizon. Again, there is no statistically noticeable effect of the subsequent programs. This might imply that inflation expectations are, similar to the signaling channel, over-proportionally affected by novel programs or by the fact that the first round of LSAPs in both the Eurozone and the US were conducted in the most distressed market environment. However, it is also possible that the anticipation of later programs led to changes in inflation expectations having been incorporated before the announcements took place and hence show no noticeable response to the announcements.

6.3.3 Duration Risk Channel

Table 9: Duration Risk Channel - US

Program	Window	US 1Y	US 3Y	US 5Y	US 7Y	US 10Y	US 30Y
LSAP 1	1-day	-26.5**	-54.8***	-79.9***	-75.2***	-84.4***	-48.0***
	2-day	-26	-24.1	-47.7*	-53.4*	-72.9***	-48.3*
LSAP 2	1-day	-1.6	-12.7	-24.0**	-23.6**	-17.3	3.7
	2-day	-3.3	-15.2	-32.8**	-42.8***	-42.1***	-13.2
LSAP 3	1-day	-1.7	-4.8	-12.4	-12.4	-9.5	-3.8
	2-day	-1.3	-3.6	-6.7	-5.8	-0.8	5.9

This table reports the cumulative coefficients of the regression of the daily basis point change in US Treasury yields at different maturities on the Fed's LSAP announcement dummies aggregated by program while controlling for the arrival of other macroeconomic news. The sample is January 2008 - December 2016. Standard errors are computed using HAC errors with Newey-West lags. Wald tests are used to determine statistical significance of the cumulative dummies.
Statistical significance levels are denoted by: * - 10%, ** - 5%, *** - 1%.

Table 9 and 10 report the cumulative changes in safe sovereign yields (Treasuries for the US, Bunds for the Eurozone) across the term structure. The maturity-based preferred-habitat model of Vayanos and Vila (2009) implies that if a duration channel is active in the transmission of LSAPs, it should exhibit the largest effects on the assets with the largest amount of duration risk, i.e. the longest-maturity assets. In the US, there is no evidence of such a channel. The effects are generally non-monotonic and concave over the term structure, exhibiting the largest declines in the maturity range from 5 to 10 years.

Table 10: Duration Risk Channel - Eurozone

Program	Window	GER 1Y	GER 3Y	GER 5Y	GER 7Y	GER 10Y	GER 30Y
SMP	1-day	0.6	-4	-8.9	-8.2	-8.1	-12.3*
	2-day	3.4	-9.8	-17.0*	-16.4*	-15.8*	-28.4***
OMT	1-day	3	1.7	-0.7	-1.7	-1.1	-3.6
	2-day	8.1	0.5	-7.4	-10.3	-12.9	-17.3
APP	1-day	0.6	-1.2	1.4	2.2	5.3	10.2
	2-day	5.5	-0.5	6.9	7.3	10	14.2

This table reports the cumulative coefficients of the regression of the daily basis point change in Bund yields at different maturities on the ECB's LSAP announcement dummies aggregated by program while controlling for the arrival of other macroeconomic news. The sample is January 2010 - December 2016. Standard errors are computed using HAC errors with Newey-West lags. Wald tests are used to determine statistical significance of the cumulative dummies.
Statistical significance levels are denoted by: * - 10%, ** - 5%, *** - 1%.

In contrast to the US, there appears to be some evidence for a duration channel in the transmission of policy of the ECB, at least for the SMP. The announcement have the largest effect on the 30-year Bund yield, and the magnitude of the changes are generally increasing in maturity.

6.3.4 Liquidity Channel

Program	Window	3Y Spread	5Y Spread	7Y Spread	10Y Spread	30Y Spread
			Table 11: Liquidity Channel - US			
LSAP 1	1-day	19.2	31.2	4.2	30.2	19.2
	2-day	-60.1	-72.3*	-75.3*	-84.7*	-60.1
LSAP 2	1-day	0.7	1.8	-1.7	-9.7	-9.5
	2-day	-2.5	-3.7	3.7	-2.4	-9
LSAP 3	1-day	-1	0.8	-0.7	-3.9	-4.8
	2-day	-0.3	-0.1	-1.2	-7.3	-5.1

This table reports the cumulative coefficients of the regression of the daily basis point change in the spread between the yield on Fannie Mae's bond and the Treasury yield at different maturities on the Fed's LSAP announcement dummies aggregated by program while controlling for the arrival of other macroeconomic news. The sample is January 2008 - December 2016. Standard errors are computed using HAC errors with Newey-West lags. Wald tests are used to determine statistical significance of the cumulative dummies.
Statistical significance levels are denoted by: * - 10%, ** - 5%, *** - 1%.

Consistent with a liquidity channel, I find that Agency yields fall more than Treasury yields by around 75 basis points and significant in the 5- to 10-year maturities around the announcements of LSAP 1 (again focusing on 2-day changes). This effect is economically significant and relevant to corporate bonds, which are relatively illiquid and hence particularly affected by the existence of such a channel. For subsequent programs, I find no such differential effects on Treasuries versus Agencies, which is in line with a view of the liquidity channel being relevant in times of low market liquidity and correspondingly high risk premia on illiquidity.

Table 12: Liquidity Channel - Eurozone

Program	Window	AAA Yield	Bund Yield	Spread
SMP	1-day	1.3	8.2	-6.9
	2-day	9.5	16.4*	-6.9
OMT	1-day	7.6	8.6	-1
	2-day	5.2	10.3	-5.1
APP	1-day	-2.5	-5.2	2.6
	2-day	-5.8	-7.3	1.5

This table reports the cumulative coefficients of the regression of the daily basis point change in the AAA-index, the duration-matched Bund yield and their spread on the ECB's LSAP announcement dummies aggregated by program while controlling for the arrival of other macroeconomic news. The sample is January 2010 - December 2016. Standard errors are computed using HAC errors with Newey-West lags. Wald tests are used to determine statistical significance of the cumulative dummies.
Statistical significance levels are denoted by: * - 10%, ** - 5%, *** - 1%.

Table 12 report the changes in the yields of AAA-rated corporate bonds and the duration-matched Bund yields as well as their spread. Since both yields should be largely free of default risk premia, their spread should again be reflective of the additional premium investors require to hold the less liquid corporate bonds. There is no evidence for an liquidity channel at work in the propagation of LSAPs in the Eurozone as the AAA-Bund spread does not change significantly for any of the ECB's programs.

The existence of such a channel for LSAP 1 but not in the Eurozone raises the question whether the price of liquidity generally is less affected by such purchases in the Eurozone, or whether there are certain characteristics of LSAP 1 that gave rise to such a channel. For example, it could be the case that market liquidity had recovered by the time that the ECB began purchasing assets, so that liquidity premia were low and showed no distinguishable effect. Alternatively, the purchases of illiquid assets by the Fed during LSAP 1, specifically the purchases of Agency debt and MBS could have

led to a greater effect on such assets, potentially in interaction with the low-liquidity environment.

To investigate whether local supply channels from the purchases of Agency debt led to their greater fall relative to Treasuries as opposed to a broader decline in the price of liquidity, I also analyze the AAA-Treasury spread in the US around the LSAP 1 announcement dates. I find that this spread *increases* by 15 basis points, albeit insignificantly. It hence at least cannot be ruled out that local supply effects in interaction with the low liquidity of Agency debt are responsible for their greater fall than Treasuries during LSAP 1, as opposed to a broader liquidity channel.

I further investigate this question by analyzing how the spread between the on-the-run and the off-the-run Treasury yield changes around the LSAP 1 announcements. The on-the-run Treasury is the most recently issued contract, while the off-the-run is the second most recently issued one. It is a well-documented fact that on-the-run Treasuries, which capture most of the volume of trades in that maturity, yield a lower return than the off-the-run Treasury, which contains a premium from being less liquid (Amihud & Mendelson, 1991). Under the assumption that the term premium effects stemming from the 3-months-difference in time to maturity between the two yields is negligible[20], this spread should only be determined by the price of liquidity in the market. The spread between the on-the-run and off-the-run increases over the 2-day windows around the LSAP 1 announcements by 6bp, significant at the 5% level. This implies that LSAP 1 in fact did decrease the price of liquidity risk in the economy broadly, and that the effects seen in in Table 11 are not just due to local supply effects on Agency bond yields.

---

[20]Note that the effect of the longer maturity should imply that the on-the-run contract carries a *higher* yield

6.3.5 Default Risk Channel

Table 13: Default Risk Channel - US

Program	Window	IG CDS Spread	HY CDS Spread
LSAP 1	1-day	-43.0***	-354.2***
	2-day	-80.0***	-305.0***
LSAP 2	1-day	4.4	7.8
	2-day	5.6	-14.3
LSAP 3	1-day	-5.1	-31.2
	2-day	-4.4	-20.6

This table reports the cumulative coefficients of the regression of the daily basis point change in the investment grade- and high yield- yield indices on the Fed's LSAP announcement dummies aggregated by program while controlling for the arrival of other macroeconomic news. The sample is January 2008 - December 2016. Standard errors are computed using HAC errors with Newey-West lags. Wald tests are used to determine statistical significance of the cumulative dummies. Statistical significance levels are denoted by: * - 10%, ** - 5%, *** - 1%.

Tables 13 and 14 report the changes in the spread on investment grade and high yield credit default swap indices for the US and the Eurozone, respectively. They provide a direct measure of changes in the price of default risk for those two market segments. For the US, we find that LSAP 1 had a large and significant effect on default risk premia, decreasing them by 80 basis point for investment grade bonds and 300 basis points for the high yield segment. These declines are economically highly significant, as they imply that the risk compensation required by investors to lend to high-risk companies decreased by 3 percentage points.

Again, there is no evidence for later programs having any effect on the default risk compensation on corporate bonds. Krishnamurthy & Vissing-Jorgensen (2011) hypothesize for LSAP 2 that this is due to the absence of private sector securities from the assets purchased. This hypothesis does not seem to capture the full story behind

the differential effect of LSAP 1 and 2, as LSAP 3 also has no statistically significant effect on CDS although the Fed purchased MBS, and is further analyzed in the next section.

Table 14: Default Risk Channel - Eurozone

Program	Window	IG CDS Spread	HY CDS Spread
SMP	1-day	-30.6***	-79.9***
	2-day	-30.5***	-64.5*
OMT	1-day	-15.6**	-42.9*
	2-day	-22.4**	-61.4*
APP	1-day	-6.0	-28.7
	2-day	-14.1	-66.3

This table reports the cumulative coefficients of the regression of the daily basis point change in the investment grade- and high yield- yield indices on the ECB's LSAP announcement dummies aggregated by program while controlling for the arrival of other macroeconomic news. The sample is January 2010 - December 2016. Standard errors are computed using HAC errors with Newey-West lags. Wald tests are used to determine statistical significance of the cumulative dummies. Statistical significance levels are denoted by: * - 10%, ** - 5%, *** - 1%.

In the Eurozone, there also is evidence of a credit default risk channel for the SMP and the OMT program. The SMP program decreased investment grade CDS spreads by 30 and high yield spreads by 70-80 basis points, while the OMT led to decreases of approximately 15-20 and 40-60 basis points, respectively. Although the APP also lead to economically large decreases in CDS spreads around the announcements, they are not statistically different from changes on non-announcement dates at the 10%-level, again implying that private sector asset purchases by themselves might not be sufficient in lowering default risk premia. The evidence from the Eurozone also appears to rule out that private asset purchases are necessary for effects on default risk compensation, as both the SMP and the OMT program lowered those risk premia despite consisting of only public sector asset purchases.

6.3.6 Safety Channel

Table 15: Safety Channel - US

Program	Window	CDS-adjusted IG	CDS-adjusted HY	Spread
LSAP 1	1-day	-39.5**	208.5*	-248.0**
	2-day	-24	-79.4	55.4
LSAP 2	1-day	-16.1	-16	-0.2
	2-day	-30.4**	4.1	-34.5
LSAP 3	1-day	-2	24.4	-26.4
	2-day	-6	-0.9	-5.1

This table reports the cumulative coefficients of the regression of the daily basis point change in the yield on investment grade- and high yield-bonds adjusted by their respective CDS spread as well as their spread on the Fed's LSAP announcement dummies aggregated by program while controlling for the arrival of other macroeconomic news. The sample is January 2008 - December 2016. Standard errors are computed using HAC errors with Newey-West lags. Wald tests are used to determine statistical significance of the cumulative dummies.
Statistical significance levels are denoted by: * - 10%, ** - 5%, *** - 1%.

Tables 15 and 16 report the changes in CDS-adjusted investment grade and high yield corporate bond yield indices as well as their spread. This spread is indicative of safety effects, since a decline of default risk-adjusted investment grade yields relative to risk-adjusted high yield bond yields implies that there is a special demand for such safer bonds that goes beyond the lower compensation for lower default risk[21]. Except for the 1-day effect of LSAP 1, there is no evidence that LSAPs affect the price of safety if safety is defined as spanning the entire investment grade spectrum[22], and one could argue that one-day changes were spurious as they do not persist over two days.

---

[21]Note that this is not the same safety effect on ultra-safe assets as in KVJ (2011), as I am here only broadly comparing the generally "safe" and generally "unsafe" segments of the market

[22]KVJ (2011) find the existence of a safety channel for ultra-safe assets such as AAA-rated bonds, but since these only constitute a very small portion of all investment grade bonds, my findings are not in contradiction to theirs

Table 16: Safety Channel - Eurozone

Program	Window	CDS-adjusted IG	CDS-adjusted HY	Spread
SMP	1-day	23.3***	74.3***	-51.0***
	2-day	42.5***	128.0***	-85.5***
OMT	1-day	21.3**	54.3***	-33.1**
	2-day	29.1**	53.6**	-24.5
APP	1-day	0	5.6	-5.6
	2-day	4.4	16.9	-12.5

This table reports the cumulative coefficients of the regression of the daily basis point change in the yield on investment grade- and high yield-bonds adjusted by their respective CDS spread as well as their spread on the ECB's LSAP announcement dummies aggregated by program while controlling for the arrival of other macroeconomic news. The sample is January 2010 - December 2016. Standard errors are computed using HAC errors with Newey-West lags. Wald tests are used to determine statistical significance of the cumulative dummies.
Statistical significance levels are denoted by: * - 10%, ** - 5%, *** - 1%.

In contrast to the US, there is a decline of risk-adjusted investment grade yields relative to high yield bond yields in the Eurozone. Specifically the SMP program had a statistically and economically significant effect on the spread between the yields of safer and riskier bond. This could be explained by the fact that the assets purchased by the ECB are generally riskier than the ones purchased by the Fed (even for the public debt they purchased under the SMP and OMT, as those was distressed peripheral European sovereign debt), but still part of the investment grade spectrum. Similarly to the Fed's purchases of very safe assets having only a safety effect on ultra-safe assets, the ECB's purchases of less safe investment grade bonds might have affected broader safety-habitats that also include bonds below the highest credit ratings.

6.3.7 Summary

In summary, in the US the effect of LSAPs on corporate bond yields seems to be largely propagated by a signaling channel for all programs, a default risk channel for LSAP 1 and, in weaker form, for LSAP 2, and a liquidity channel exclusively for LSAP 1. Safety effects do not seem to go far beyond the AAA-rated bonds, so they are largely irrelevant for most corporate bonds. Real corporate bond yields also declined the expansionary effect LSAP 1 had on inflation expectations.

In the Eurozone, the signaling channel appears to have been much weaker and only active during the SMP and to a limited extent during the OMT program. There is evidence for the SMP also working through a duration channel and a credit default risk channel, which in weaker form can also be found in the OMT. Lastly, in contrast to the US, the ECB's announcements of the SMP and the OMT appears to have had an impact on the relative demand for risk-adjusted investment grade bonds relative to their high yield counterparts, implying a pass-through from the generally riskier assets the ECB purchased to other lower-rated investment grade assets and the existence of a habitat for such investment grade assets.

6.4 The Drivers of Transmission Channels

Section 6.3 provided some evidence that seemed to imply that there might be a differential effect of the transmission channels under different market conditions. To further decompose the effects of different characteristic of LSAP-programs and -announcements on corporate bond yields, I investigate the impact those characteristics have on the individual transmission channels of policy. I use the different measures constructed as proxies for the transmission channels as the dependent variable in regression (2) to test

the implications of financial market distress and private asset purchases on the individual channels. After decomposing the total effects into their transmission channels, this investigates whether these risk channels are differentially active under different financial market conditions or when private asset purchases are involved.

Panel 1 below reports the specific measures used for the different transmission channels.

Panel 1: Channel Measures

Channel	United States	Eurozone
Signaling	2Y Federal Funds Future	3Y Euro OIS
Duration	10Y Treas. - 1Y Treas.	7Y Bund - 1Y Bund
Liquidity	10Y Agency - 10Y Treas.	n/a
Inflation	5y Inflation Swap Rate	
Credit	HY CDS Spread	
Safety	(CDS-adjusted IG-index) - (CDS-adjusted HY-index)	

I use slightly different measures for the Eurozone and the US for the first three channels. For the signaling channel, this is because Federal Funds Futures are only available up to horizons of 2 years, although most corporate bonds have longer maturities than that, so I use the longest horizon available. The choice of the 3-year contract for the Eurozone is motivated by the fact that a lot of the assets the ECB purchased were around that maturity, because according to Mario Draghi this is the "maximum most effective maturity to target" [23]. The reason for the different measures for the duration measure is to match the duration of the corporate bond yield indices used as closely as possible - the indices for the Eurozone have a duration comparable to 7-year Bunds, while the US indices are more comparable to 10-year Treasuries in their

[23]https://www.ecb.europa.eu/press/pressconf/2012/html/is120906.en.html

duration. Lastly, the measure for the Liquidity channel available for the Eurozone (the AAA-Bund Spread) is an imperfect measure of liquidity and did not appear to be of importance for the transmission of the effects of LSAPs anyways, so it is excluded here. First, to verify that the identified channel measures in fact explain a significant amount of the variation in corporate bond yields, I regress the daily changes of the bond yields of different maturities on the proxies identified for the individual channels described in Panel 1 above. This also allows to infer the importance of the channels for yields of different credit ratings. I report point estimates and adjusted R^2 of those regressions below.

6.4.1 United States

Table 17: Corporate Bond Yields and Channel Proxies - US

Channel	AAA	AA	A	BBB	BB
Signaling	21.61***	20.76***	20.55***	19.14***	18.35***
Inflation	1.12	-1.65	-2.11	-4.26	-6.52*
Duration	61.54***	56.55***	63.34***	66.28***	32.62***
Liquidity	0.73	1.18	1.63	0.81	3.62*
Credit	3.09	7.12***	1.3***	9.72***	44.56***
Safety	-2.27	-7.1***	-9.57***	-8.88***	-45.06***
Adj. R^2	0.32	0.56	0.48	0.56	0.48

This table reports the coefficients and adjusted R^2 of the regression of the daily basis point change in the US corporate bond yield indices on the channel measures described in Panel 1. The sample is January 2008 - December 2016. Standard errors are computed using HAC errors with Newey-West lags. Wald tests are used to determine statistical significance of the cumulative dummies.
Statistical significance levels are denoted by: * - 10%, ** - 5%, *** - 1%.

The transmission channels proxies I identified explain 32-56 % of the daily changes in corporate bond yields in the US. The lowest R^2 is found in the regression of the AAA-yield index, which is due to the fact that this index comprises by far the least number of firms and hence has the largest amount of idiosyncratic volatility that cannot be explained by risk premia reflective of general market conditions.

The signaling measure is positive and highly significant for all credit ratings, and is monotonically decreasing in magnitude across ratings, as risk premia gain relative importance over expected short-term rates with decreasing creditworthiness.

Changes in inflation expectations are only associated with yield changes at the lower end of the credit spectrum, where yields decrease with increasing inflation expectations that are generally corresponding with a more positive economic outlook, especially in

the sample period used. This means that real yields decline nearly one-to-one for declines in nominal yields as those nominal yields do not adjust for the higher inflation expectations, at least not instantaneously.

As to be expected, all bond yields are strongly positively affected by duration risk premia. The effect is relatively uniform across credit ratings, with the exception that BB-rated bond yields react less to changes in the price of duration risk, presumably again since default risk considerations are relatively much more important.

The measure of liquidity risk premia does not explain the variation in daily bond yield changes except for the least liquid BB-rated bonds, where it has a weak positive effect on yields.

Interestingly, changes in the spread on high yield CDS positively predict yields across the rating spectrum. However, as expected, this effect increases as creditworthiness falls, and is very large for BB-rated bonds. Table 17 shows that an increase in CDS spreads by one percentage point increases AAA-yields by 4 basis points, while the same change increases BB-yields by 44 basis points conditional on the other regressors being constant.

Lastly, the (negative) risk premium on safety does not affect AAA-rated bonds, but has strong negative effects on the lower rated bonds, with magnitude increasing as creditworthiness falls.

Table 18: Channel Proxies and Drivers - US

Driver	Window	Signaling	Inflation	Duration	Liquidity	Credit	Safety
Private Assets	1-day	-10.58	-9.7	-39.11	33.83	-32.94	-29.27
	2-day	25.98	43.29	70.98	-23.08	-1.68	2.65
Financial Stress	1-day	-63.14***	-11.14	-47.04**	48.83**	44.61**	11.8
	2-day	-32.2**	7.37	-32.96	-63.86***	31.66	6.03
Interaction	1-day	38.82**	19.94	-8.06	-52.78	-113.0***	-56.43**
	2-day	24.32*	38.68	-33.58	53.76	-89.5***	0.74

This table reports the coefficients of the regression (2) of the studentized daily basis point changes of the different channel measures scribed in Panel 1 on the $PrivAssets_t$, $Stress_t$x$Event_t$ and their interaction. The sample is January 2008 - December 2016. Standard errors are computed using HAC errors with Newey-West lags. Wald tests are used to determine statistical significance of the cumulative dummies.
Statistical significance levels are denoted by: * - 10%, ** - 5%, *** - 1%.

Table 18 reports the coefficients for regression (2) with the respective channel measure discuessed above as the dependent variable. Itshows that the Fed's purchases have a much larger effect on the expectation of future short-term yields when financial distress is high. If the financial distress measure is one standard deviation above its mean on an announcement date, the decrease in expected short-term rates at the 2-year horizon is 60 basis points higher than it otherwise would be. This decline is not just statistically large: Table 17 established a strong positive relationship of all corporate bond yields to the shift in federal funds futures, so this effect would be expected to affect all corporate bond yields significantly. Specifically, Table 17 shows that conditional on inflation expectations and risk premia remaining unchanged, a decrease of the signaling measure by 1 percentage point should decrease bond yields by approximately 20 basis points. Hence the additional decline in federal funds future coming from financial distress would be expected to lead to an additional decline in the corporate bond yields considered of approximately 12 basis points. However, as the event study is unable to

discriminate between the effects of forward guidance and LSAPs, it could alternatively be the case that there was simply more informative forward guidance on dates with high financial distress, or that markets are more receptive to forward guidance on such dates. The interaction of financial market distress and private asset purchases *increases* expectations for future short-term rates, even at the two-year horizon. It could be that announcements under this constellation are seen as particularly beneficial in improving macroeconomic conditions, so that market participants anticipate a sooner lift-off from the ZLB. This would explain the strong effect that the interaction term had on the risky segments of the corporate bond market. Of course, this would also imply that the effects from such announcement through signalling channel in fact work contractionary, as they broadly increase yields.

There is no evidence that the composition of the assets purchased or financial distress at the time of the announcements have an impact on how LSAPs affect inflation expectations.

Financial distress also appears to have an effect on the price of duration risk in the market. The spread between 10 year and 1 year Treasury yields declines statistically significantly by 50 basis points on the day of announcements with a high degree of financial market disruption. Although the evidence from section 6.3 showed that the duration channel as predicted by the model of Vayanos & Vila (2009) is not relevant for the propagation of LSAPs in the US, it still seems that policy announcements can decrease the price of duration risk in the economy when financial distress is high enough for different duration-habitats not being fully arbitraged instantaneously. The smaller magnitude and lack of significance over the two-day window seems to lend credence to this interpretation.

The results on the liquidity channel are somewhat puzzling. Remember that there was

some evidence for the price of liquidity risk declining in the two-day windows around LSAP 1 announcements, but not for other programs. Table 18 seems to imply that this decline was driven by the extraordinary high financial market distress around these announcements, which is associated with low liquidity and high premia on liquid assets. However, there is also a significant *increase* of the spread between agency bonds and Treasuries in the 1-day window around the announcements, which is hard to reconcile with such an interpretation and could be simply noise or mispricings in the 1-day window due to the low market liquidity.

The credit default risk premium is one of the primary drivers of riskier corporate bond yields - changes in CDS on high yield bonds have a 44% pass-through to BB-rated corporate bond yields, as Table 17 shows. Section 6.3 also implied the credit default risk channel to be one of the primary transmission channels of the effects of LSAPs. Section 6.2 established that the interaction of private asset purchases and financial distress drove most of the effects of policy on the risky segments of the market. The results of the regression of the changes of spreads on high yield CDS in Table 19 show that a large amount of the decline in risky corporate debt around announcements of private asset purchases in financially disruptive times comes from the effect of such announcements on the market's pricing of credit default risk in the economy. It also shows that announcements about solely public asset purchases on dates of high distress has the opposite effect, explaining the increases in risky yields I found on such dates in section 6.2. Hence Krishnamurthy & Vissing-Jorgensen (2011) appear to have been right that private asset purchases are necessary for the existence of a default risk transmission channel, however, such purchases are not sufficient unless announced in times when financial market distress is high.

Lastly, CDS-adjusted investment grade bond yields decline relative to risk-adjusted

high yield yields more on dates that combine private asset purchase announcements with a high degree of financial disruption. One interpretation for this is that safety considerations are particularly relevant to private investors in times of distress, and asset purchases by the Fed affect the relative supply of safe and unsafe corporate bonds due to the substitutability of the private assets purchased by the Fed and the investment grade corporate bonds. Although the assets the Fed purchased are all at the higher end of the investment grade range, high financial market distress might allow for spill-over effects across the entire investment grade spectrum. However, the effect does not persist for the two-day window in neither magnitude nor statistical significance, indicating a potentially spurious or very temporary safety effect.

6.4.2 Eurozone

Table 19: Corporate Bond Yields and Channel Proxies - Eurozone

Channel	AAA	AA	A	BBB	HY	COV
Signaling	53.41***	54.24***	55.18***	50.75***	49.63***	53.78***
Inflation	-1.26	-0.84	-0.67	-1.49	-1.57	0.15
Duration	53.94***	58.9***	58.06***	53.36***	44.1***	29.05***
Credit	-1.12	4.31***	1.03***	19.63***	78.73***	2.88**
Safety	1.15	-3.92**	-9.02***	-15.87***	-88.48***	-0.06
Adj. R^2	0.62	0.72	0.67	0.58	0.87	0.62

This table reports the coefficients and adjusted R^2 of the regression of the daily basis point change in the European corporate bond yield indices on the channel measures described in Panel 1. The sample is January 2010 - December 2016. Standard errors are computed using HAC errors with Newey-West lags. Wald tests are used to determine statistical significance of the cumulative dummies. Statistical significance levels are denoted by: * - 10%, ** - 5%, *** - 1%.

Despite the absence of a measure of liquidity premia in the Eurozone, the channel measures generally explain even more of the variation in daily yield changes than in

the US. Adjusted R^2s range from 58% to 87%, although it has to be noted that the high explanatory power on the high yield index is by construction since the measure of credit default risk is constructed from the CDS spreads on high yield bonds and the safety measure uses CDS-adjusted high-yield bond yields directly.

Again, changes in expected short-term rates are a highly significant positive predictor of yield changes of all credit ratings, with the magnitude of the effect again being relatively lower for firms with worse credit ratings.

Similar to the US, changes in inflation expectations changes have no noticeable effect on most yields besides a slight negative effect on BBB-rated bonds.

Duration effects are similarly strong in the Eurozone as in the US, and also have generally weaker effects on lowly rated bond yields.

Changes in the CDS spreads on high yield bonds are associated with a modest fall in AAA-rated yields, while all other yields increase, with the strongest effect at the low end of the credit rating spectrum. Table 19 shows that high yield bonds move closely in line with those CDS spreads, increasing by nearly 80 basis points for an increase in CDS spreads by one percentage point.

Lastly, while the lack-of-safety risk premium has no effects on AAA- and covered bonds, it increases yields significantly for all lower rated bonds, with magnitude increasing for lower credit ratings.

Table 20: Channel Proxies and Drivers - Eurozone

Driver	Window	Signaling	Inflation	Duration	Credit	Safety
Private Assets	1-day	44.94	66.39*	0.66	-236.06***	-79.77**
	2-day	20.9	59.78	-72.34*	-171.35***	-97.24**
Financial Stress	1-day	-162.27***	0.55	-74.89**	-5.23	-81.88**
	2-day	-129.04***	15.78	-77.87**	-0.02	-108.22***
Interaction	1-day	209.76***	70.64*	59.65	-219.53***	-79.66*
	2-day	142.01***	46.15	-4.01	-123.45***	-30.35

This table reports the coefficients of the regression of the daily basis point change in the European corporate bond yield indices on the studentized channel measures described in Panel 1. The sample is January 2010 - December 2016. Standard errors are computed using HAC errors with Newey-West lags. Wald tests are used to determine statistical significance of the cumulative dummies.
Statistical significance levels are denoted by: * - 10%, ** - 5%, *** - 1%.

Like in the US, financial disruption around the announcements increases the efficiacy of the signaling channel in the Eurozone. At 130-160 basis points, the magnitude of the shifts in expected short-term is even larger than in the US. In the Eurzone we also see an *positive* effect that the interaction of financial distress and private asset purchases have on OIS futures. It appears that markets take announcements under these conditions as implying a faster recovery of the economy and hence anticipate higher future short-term rates[24] in both the US and the Eurozone, albeit much stronger in the Eurozone.

There is some evidence for private asset purchases increasing inflation expectations, and effect that is further emphasized when private asset purchases are combined with financial market distress. This is in line with the interpretation of the effect of their interaction on the expectations for future short-term rates: Private asset purchases, especially when announced in distressed times, appear to create a more positive macroeconomic outlook. This finding is in contrast to the results in the US, where no effects on infla-

---

[24]The finding is robust to using the 6-month, 1-year or 2-year contract, and, for 1-day changes, for the 5-year contract as well

tion expectations were found. It could be that the assets purchased by the ECB are considered more effective in providing macroeconomic stimulus than the assets the Fed purchased, but it could also be driven by structural differences in the two economies and their financial markets.

The price of duration risk declines around the announcements pertaining to private asset purchases or surrounded by distressed financial markets, but there is no evidence for an additional effect from their interaction.

As in the US, it appears that a lot of the effects of the ECB's LSAPs on risky corporate bonds is transmitted through the default risk channel. This observation is supported by the previous findings that the proxy used for the default risk channel is highly relevant in explaining changes in risky corporate bond yields (see Table 18), and that this proxy is affected by LSAP announcements as shown in section 6.3. In contrast to the US though, there are credit default risk effects from the purchases of private sector assets even without financial market illiquidity. This both explains the fact that private asset purchases by themselves had an effect on risky corporate bond yields as shown in section 6.2, and is in line with the interpretation of the findings about the signaling- and inflation expectations-channel in the Eurozone discussed above, where private asset purchases seem to have contributed to a more beneficial effect on expectations about the macroeconomic outlook. It seems plausible that the greater similarity between the private assets purchased by the ECB and risky corporate bonds allow for such purchases to have an effect even without the presence of financial market disruptions.

Both private asset purchases and financial market distress contribute to a relative decrease of risk-adjusted investment grade bonds relative to the high yield segment. The interpretation is similar to the US: financial distress might induce a stronger preference for safer corporate bonds, while purchases of such bonds and other comparable assets by the

ECB made them relatively scarcer and hence decreased their yields. This substitutability-based explanation is also supported by the fact that the assets the ECB purchased - covered and corporate bonds as well as ABS - are arguably closer substitutes to corporate bonds than MBS or Agency debt, and there is a much stronger and significant effect on this safety channel from private assets alone in the Eurozone.

7   Conclusion

In line with the existing literature, the event study evidence presented in this analysis shows a strong effect of LSAP 1 on corporate bond yields, and a much more muted effect of LSAP 2. LSAP 3, whose effects on corporate bond yields had not yet been explicitly studied, had no noticeable effects on corporate bond yields.

In case of the ECB's programs, the evidence shows that the SMP program in fact *increased* corporate bond yields, especially in the risky segment of the market, while the OMT program lowered yields in those segments. Lastly, the APP program, which had previously been found to be effective in lowering a broad range of private and public sector interest rates, has no statistically significant effects on *any* yields.

In terms of the factors that drive the pass-through, in US there is no evidence that private asset purchases by themselves are sufficient to lower corporate bond yields significantly. The combination of private asset purchases and highly distressed financial markets is what drives the pass-through to such yields, while financial market distress during times of public sector purchases appears to in fact increase risky private bond yields.

In the Eurozone, there is a similar effect of high financial distress without private sector purchases, implying that this might be a systematic characteristic of such announcements. In contrast to the US however, it seems that not all of the effects of private asset purchases

come from their interaction with financial market distress. High yield bonds and covered bonds are affected by private assets purchases even without financial distress. However, the combination of private asset purchases with financial market distress still contributes an additional significant decrease in the bond yields of the riskier market segments.

In terms of the specific transmission channels of LSAPs, the effect on corporate bond yields appears to primarily be stemming from signaling and credit default risk channels, with the former affecting all yields relatively uniform and the latter having an effect that is stronger for assets with higher default risk.

Interestingly, the signaling and the credit risk channel react in opposite ways to the presence of financial distress and private asset purchases: While default risk premia fall the strongest in response to private asset purchases in combination with financial distress, this combination also leads to a positive shift in the expectations of future short-term yields. Likewise, while purchases during highly distressed market environments provide the strongest signal about lower future short-term rates, this constellation has no or if anything adverse effects on the price of default risk. It seems like the driving force behind these differential effects is their different exposure to an improved economic outlook: If, as hypothesized, the interaction of financial distress and private asset purchases in fact improves expectations about the macroeconomic outlook, it would imply a lowering of the price default risk and a quicker lift-off from the ZLB, generating the adverse effects from the signaling channel.

In the US there furthermore is some evidence of a liquidity effect on the least liquid corporate bonds during LSAP 1, however this effect only appears to arise in highly distressed markets. In the Eurozone, there seems to exist a safety effect that lowers the yields of investment grade bonds relative to high yield bonds after controlling for their different default risk probabilities.

There is generally a fundamental difference in the implications of private asset purchases between the Eurozone and the US. Private asset purchases in the US do not explain the pass-through to risky corporate debt or specifically to the price of credit risk in the economy without the presence of financial market disruption. None of the transmission channels is affected by private sector purchases alone. In the Eurozone such purchases make for a stronger effect on risky corporate debt by strengthening the effectiveness of the credit default risk channel and the safety channel. While other contrasting explanations could be at play here, it seems plausible to conclude that the greater similarity to corporate bonds of the private assets targeted by the ECB generated those differential effects. Specifically, in contrast to the Fed's purchases of Agency Debt and MBS, the risk profiles of the assets purchased by the ECB include private default risk components and hence are more substitutable with corporate bonds. If this is the reason for the differential effects of private asset purchases in the US and the Eurozone, this would imply the existence of narrow transmission channels that affect only assets with a similar risk profile as the ones targeted, as long as their similarity is great enough.

Those results raise several important implications for the implementation of policy. First and foremost, the effects of LSAPs are strongly state-contingent: The same purchases implemented under different financial conditions should not be expected to have the same effect. Second, purchases of only public-sector assets are not very efficient in lowering corporate bond yields and can even have the opposite effect when paired with high financial distress. Third, simply purchasing securities with some private risk component is not sufficient to generate a strong pass-through to corporate bond yields without simultaneous financial market disruption. Only purchases of assets with similar risk characteristics as corporate bonds seem to have an effect independent of financial market disruption.

Thus, if the objective of an LSAP program is to lower borrowing costs for the private sector, it seems like programs that directly address dislocations in disrupted private markets by purchasing the affected assets have the largest effects. In order to provide further stimulus when financial dislocations have abated, it seems that only purchases of assets that are very similar to the assets whose yields are to be lowered and hence constitute close substitutes give rise to effects on these assets, in line with narrow supply channels.

The opportunities for future extensions of this analysis are as manifold as the problems with the simple event study approach. First and foremost is the issue of event studies only identifying the presence of an announcement, but not taking into account how this announcement relates to previously formed expectations. The extraction of such expectations at a high enough frequency for such an analysis is complicated, but a promising approach to get better estimates for the effects of especially the later programs, where the formation of expectations about the programs arguably played a larger role.

Another approach would be to construct a policy shock measure from the responses of asset prices around the announcement. Since these asset prices incorporate expectations about the announcements, this shock measure will also address the issue of expectations raised in the preceding paragraph. This approach is the more conventional one and has been widely used in the literature, but primarily for conventional policy announcements and never with an explicit focus on explaining the channels of transmission of unconventional monetary policy.

8 References

Altavilla, C., Carboni, G., Motto, R. 2015. Asset Purchase Programmes and Financial Markets: Lessons from the Euro Area. *ECB Working Paper*

Altavilla, C., Giannone, D., 2016. The Effectiveness of non-standard Monetary Policy Measures: Evidence from Survey Data. *ECB Working Paper*

Altavilla, C., Giannone, D., Lenza, M. 2014. The Financial and Macroeconomic Effects of OMT Announcements. *ECB Working Paper*

Amihud, Y., Mendelson, H. 1991. Liquidity, Maturity, and the Yields on U.S. Treasury Securities. *Journal of Finance*

Bauer, M., Rudebusch, G. 2013. The Signaling Channel for Federal Reserve Bond Purchases. *Federal Reserve Bank of San Francisco Working Paper*

Bernanke, B. 2012. Monetary Policy since the Onset of the Crisis. *Federal Reserve Bank of Kansas City Jackson Hole Symposium 2012*

Eggertson, G. & Woodford, M. 2003. The Zero Bound on Interest Rates and Optimal Monetary Policy. *Brookings Paper on Economic Activity*

Ferrero, G., Nobili, A. 2008. Futures Contract Rates as Monetary Policy Forecasts *ECB Working Paper*

Fleming, M. & Sporn, J. 2012. An Analysis of OTC Interest Rate Derivatives Transactions: Implications for Public Reporting. Appendix: Trading Activity and Price Transparency in the Inlfation Swap Market *Federal Reserve Bank of New York Staff Reports*

Fratzscher, M., Lo Duca, M., Straub, R. 2014. ECB Unconventional Monetary Policy Actions: Market Impact, International Spillovers and Transmission Channels. *Iternational Monetary Fund 15th Jacques Polak Annual Research Conference*

Foerster, A. & Cao, G. 2012. Expectations of Large-Scale Asset Purchases. *Federal Reserve Bank of Kansas City Economic Review*

Gagnon, J., Raskin, M., Remache, J., Sack, B. 2010. Large-Scale Asset Purchases by the Federal Reserve: Did They Work? *Federal Reserve Bank of New York Staff Report*

Gertler, M.& Karadi, P. 2012. QE 1 vs. 2 vs. 3... A Framework for Analyzing Large Scale Asset Purchases as a Monetary Policy Tool *International Journal of Central Banking*

Gurkaynak, R., Sack, B., Swanson, E. 2005. Do Actions Speak Louder Than Words? The Response of Asset Prices to Monetary Policy Actions and Statements. *International Journal of Central Banking*

Gurkaynak, R., Sack, B., Swanson, E. 2007. Market-Based Measures of Monetary Policy Expectations. *Journal of Business and Economic Statistics*

Hancock, D. & Passmore, W. 2014. How the Federal Reserves Large-Scale Asset Purchases (LSAPs) Influence Mortgage-Backed Securities (MBS) Yields and U.S. Mortgage Rates. *Federal Reserve Board Finance and Economics Discussion Series Working Paper*

Holló, D., Kremeer, M., Do Luca, M. 2012. CISS A Composite Indicator of Systemic Stress in the Financial System. *ECB Working Paper*

Kim, D. & Wright, J. 2005. An Arbitrage-Free Three-Factor Term Structure Model and the Recent Behavior of Long-Term Yields and Distant-Horizon Forward Rates. *Federal Reserve Board Finance and Economics Discussion Series Working Paper*

Krishnamurthy, A. & Vissing-Jorgensen, A. 2010. The Aggregate Demand for Treasury Debt. *Journal of Political Economy*

Krishnamurthy, A. & Vissing-Jorgensen, A. 2011. The Effects of Quantitative Easing on Interest Rates: Channels and Implications for Policy. *Brookings Papers on Econonomic Activity*

Krishnamurthy, A. & Vissing-Jorgensen, A. 2012. The Ins and Outs of LSAPs. *Federal Reserve Bank of Kansas City Symposium on Unconventional Monetary Policy*

Nakamura, E. & Steinsson, J. 2015. High Frequency Identification of Monetary Non-Neutrality: The Information Effect. *Working Paper*

Rigobon, R. 2003. Identification Through Heteroskedasticity. *The Review of Economics and Statistics*

Swanson, E. 2016. - Measuring the Effects of Unconventional Monetary Policy on Asset Prices. *Working Paper*

Thornton D. 2017. Effectiveness of QE: An assessment of event-study evidence *Journal of Macroeconomics*

Vayanos, D. & Vila, J. 2009. A Preferred-Habitat Model of the Term Structure of Interest Rates. *NBER Working Paper*

Vayanos, D. & Greenwood, R. 2014. Bond Supply and Excess Bond Returns. *Review of Financial Studies*

Woodford, M. 2012. Methods of Policy Accommodation at the Interest-Rate Lower Bound *Federal Reserve Bank of Kansas City Jackson Hole Symposium 2012*

Yellen, J. 2011. Unconventional Monetary Policy and Central Bank Communications *University of Chicago Booth School of Business U.S. Monetary Policy Forum*

9 Appendix

US	Eurozone	Germany	France	Italy	Spain
Nonfarm Payrolls	Consumer Confidence	IFO Business Climate	Business Confidence	Consumer Confidence	CPI Harmonized YoY
Purchasing Manager	CPI Estimate YoY	CPI MoM	Consumer Confidence	CPI Harmonized MoM	CPI MoM
Consumer Confidence	CPI MoM	Factory Orders MoM	CPI Harmonized YoY	CPI Harmonized YoY	GDP QoQ
CPI MoM	CPI YoY	GDP NSA YoY	CPI YoY	CPI NIC MoM	GDP YoY
FOMC Rate Decision	ECB Interest Rate	GDP SA QoQ	GDP QoQ	GDP WDA QoQ	Manufacturing PMI
GDP Annualized QoQ	Economic Confidence	IFO Business Climate	GDP YoY	GDP WDA YoY	Retail Sales YoY
GDP Price Index	GDP SA QoQ	Current Assessment	Ind. Production MoM	Ind. Production MoM	Unemployment MoM
Housing Starts	GDP SA YoY	IFO Expectations	Ind. Production YoY	Manufact. Confidence	Unemployment Rate
Initial Jobless Claims	Ind. Production MoM	Unemployment Rate	Manufacturing PMI	PMI Manufacturing	
ISM Manufacturing	Composite PMI	Ind. Production MoM	Services PMI	PMI Services	
U. of Mich. Sentiment	Manufacturing PMI	Ind. Production MoM			
Unemployment Rate	Eurozone Services PMI	Composite PMI			
		Manufacturing PMI			
		Unemployment Change (000s)			
		ZEW Survey Expectations			

Table 1: List of Macroeconomic Variables used as Controls

Table 2.a: LSAP 1

Event Date	Window	AAA	AA	A	BBB	BB	Treas.
11/25/2008	1-day	-15.7**	-17.8***	-16.8***	-13.7***	-17.9***	-25.1***
	2-day	-24.1**	-27.1***	-25.7***	-21.6***	-24.3**	-38.9***
12/01/2008	1-day	-15.3**	3	32.4***	11.3**	29.2***	-20.1***
	2-day	-16.1*	2.1	37.4***	17.3**	25.7***	-23.9***
12/16/2008	1-day	5.5	-8.3	-19.3	-20.4	-64.0***	1.8
	2-day	-7.2	-21.3*	-33.4**	-32.5**	-83.4***	-14.6
01/28/2008	1-day	4.8	2.4	1.4	1.9	-21.4***	11.1*
	2-day	-13.2	-2	4	1.4	-18.4*	23.0***
03/18/2008	1-day	-48.6***	-38.0***	-40.1***	-35.8***	-3.2	-53.4***
	2-day	-47.0***	-32.1***	-34.0***	-29.5***	-15.4	-43.9***
Total	1-day	-69.3***	-58.7***	-42.3**	-56.7***	-77.2***	-85.8***
	2-day	-107.6***	-80.4***	-51.8**	-64.8***	-115.8***	-98.3***

Table 2.b: LSAP 2

Event Date	Window	AAA	AA	A	BBB	BB	Treas.
08/10/2010	1-day	-3.6	-3.6	-2.9	-3.4	-1.1	-9
	2-day	-7.5	-7.5	-7.2	-7.7	3.3	-15.9**
09/21/2010	1-day	-7.6	-9.8**	-9.5*	-9.3*	-2.3	-12.1**
	2-day	-8.9	-9.9	-10.7	-10.9	-2.2	-17.2**
11/03/2010	1-day	0.5	0.6	1.5	1.5	-0.3	3.5
	2-day	-8	-8.4	-7.6	-9	-7	-9.8
Total	1-day	-10.7	-12.7	-10.8	-11.3	-3.8	-17.6*
	2-day	-24.4	-25.8**	-25.5**	-27.5**	-5.9	-42.9***

Table 2.c: LSAP 3

Event Date	Window	AAA	AA	A	BBB	BB	Treas.
08/22/2010	1-day	-5	-6	-6.4	-6.3	-1.3	-9
	2-day	-8.6	-9.5	-9.6	-9.4	-5.4	-12.2
09/13/2012	1-day	-0.2	-2.3	-3.6	-1.9	-0.5	-0.6
	2-day	-0.1	0	-3	-2	-8.8	10.9
Total	1-day	-5.2	-8.3	-10	-8.2	-1.8	-9.6
	2-day	-8.8	-9.5	-12.6	-11.4	-14.2	-1.3

This table reports the individual and cumulative coefficients of the regression of the daily basis point changes of the US corporate bond yield indices and the duration-matched Treasury yield on the Fed's LSAP announcement dummies aggregated by program while controlling for the arrival of other macroeconomic news. The sample is January 2008 - December 2016. Standard errors are computed using HAC errors with Newey-West lags. Wald tests are used to determine statistical significance of the cumulative dummies.
Statistical significance levels are denoted by: * - 10%, ** - 5%, *** - 1%.

Table 3.a: SMP

Event Date	Window	AAA	AA	A	BBB	HY	COV	GER	ITA
05/10/2010	1-day	7.6	-0.7	-1.8	-6.2	-35.7***	-5.7**	15.6***	-44.6***
	2-day	9.2	1.7	1.1	-3	-18.4	-5	13.3**	-50.0***
08/08/2011	1-day	-6.4	-2.9	0.1	3.1	29.7***	-13.1***	-7.5	-89.5***
	2-day	1	12.4**	18.5***	23.3***	87.7***	-5.8	3	-96.8***
Total	1-day	1.2	-3.6	-1.7	-3.1	-6	-18.8***	8.1	-134.1***
	2-day	10.2	14.1*	19.6**	20.4**	69.3***	-10.8**	16.3*	-146.8***

Table 3.b: OMT

Event Date	Window	AAA	AA	A	BBB	HY	COV	GER	ITA
07/26/2012	1-day	2.1	1.8	0.9	-0.8	2.6	1.2	3	-49.5***
	2-day	7.7	6.5	4.5	-1.2	-10	3.9	10.2	-63.1***
09/06/2012	1-day	5.7	6.7	5.9	-1.3	-6.9	1.5	6.3	-31.2***
	2-day	3.3	3.6	1.2	-15.0**	-24.1**	-1.7	3.9	-46.1***
Total	1-day	7.8	8.6	6.9	-2.1	-4.3	2.7	9.3	-80.7***
	2-day	11	10.1	5.7	-16.2*	-34.2**	2.3	14.2	-109.2***

Table 3.c: APP

Event Date	Window	AAA	AA	A	BBB	HY	COV	GER	ITA
09/04/2014	1-day	0	-2.5	-1.5	-2.4	-18.8**	-4	-1.1	-9.6
	2-day	-1	-2.3	-1.8	-3.8	-19.3*	-8.8**	-1.1	-14.7
10/02/2014	1-day	0.7	0.5	0.8	1	4.3	-0.2	0.3	4.5
	2-day	2.6	1.7	1.9	2.3	3.1	-0.2	2.3	3.3
11/06/2014	1-day	0.4	0.1	-0.6	-0.7	-5	-0.3	-0.9	-4.7
	2-day	0.2	0.3	-0.8	-1	-8.3	-0.3	-0.9	-4.8
12/04/2014	1-day	-0.6	0	-0.1	-0.5	-1.5	2.2	1.7	5.8
	2-day	-5.1	-3.3	-2.7	-2.6	-4.8	1.9	-2	-2.5
01/22/2015	1-day	-4	-2.3	-2.3	-2.7	-3	-1.8	-4.4	-12.6
	2-day	-9.6	-7.4	-8.2	-10.7*	-14.4	-5.6	-10	-12
03/05/2015	1-day	0.5	0.2	-0.5	-0.6	2.6	0.5	-1.5	-9.5
	2-day	1.5	-0.3	-1.3	-1.8	1	1.9	-1	-9.9
Total	1-day	-3	-3.9	-4.2	-6	-21.4	-3.7	-5.8	-26.3
	2-day	-11.4	-11.3	-12.9	-17.7	-42.6	-11	-12.6	-40.7

This table reports the individual and cumulative coefficients of the regression of the daily basis point changes of the European corporate bond yield indices and the duration-matched Bund yield on the ECB's LSAP announcement dummies aggregated by program while controlling for the arrival of other macroeconomic news. The sample is January 2010 - December 2016. Standard errors are computed using HAC errors with Newey-West lags. Wald tests are used to determine statistical significance of the cumulative dummies.
Statistical significance levels are denoted by: * - 10%, ** - 5%, *** - 1%.

Table 4: Corporate Bond Yields and Channel Proxies - US

| Channel	AAA	AA	A	BBB	BB
Signaling	1.31***	1.26***	1.25***	1.16***	1.11***
Inflation	0.06	-0.08	-0.11	-0.21	-0.33*
Duration	3.47***	3.19***	3.57***	3.74***	1.84***
Liquidity	0.04	0.07	0.09	0.04	0.21*
Credit	1.02	2.76***	3.71***	3.38***	17.0***
Safety	-0.82	-2.59***	-3.49***	-3.24***	-16.57***
Adj. R^2	0.32	0.56	0.48	0.56	0.48

This table reports the coefficients of the regression of the daily basis point change in the US corporate bond yield indices on the studentized channel measures described in Panel 1. The sample is January 2008 - December 2016. Standard errors are computed using HAC errors with Newey-West lags. Wald tests are used to determine statistical significance of the cumulative dummies.
Statistical significance levels are denoted by: * - 10%, ** - 5%, *** - 1%.

Table 5: Corporate Bond Yields and Channel Proxies - Eurozone

Channel	AAA	AA	A	BBB	HY	COV
Signaling	1.68***	1.71***	1.73***	1.59***	1.56***	1.69***
Inflation	-0.09	-0.06	-0.05	-0.1	-0.11	0
Duration	2.26***	2.44***	2.41***	2.21***	1.85***	1.3***
Credit	-0.15	0.63***	1.38***	2.61***	10.75***	0.33**
Safety	0.11	-0.37**	-0.85***	-1.49***	-8.26***	0
Adj. R^2	0.62	0.72	0.67	0.58	0.87	0.62

This table reports the coefficients of the regression of the daily basis point change in the European corporate bond yield indices on the studentized channel measures described in Panel 1. The sample is January 2010 - December 2016. Standard errors are computed using HAC errors with Newey-West lags. Wald tests are used to determine statistical significance of the cumulative dummies.
Statistical significance levels are denoted by: * - 10%, ** - 5%, *** - 1%.
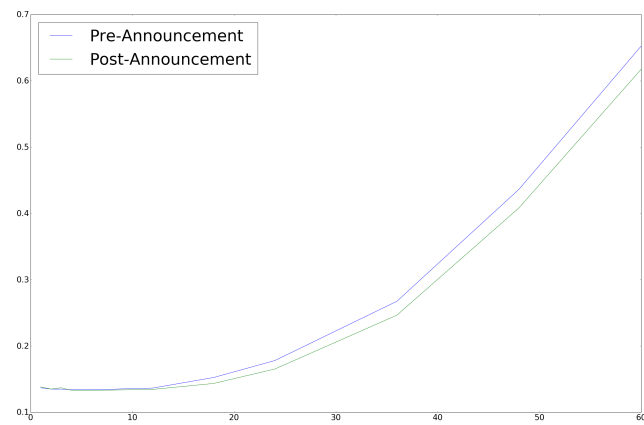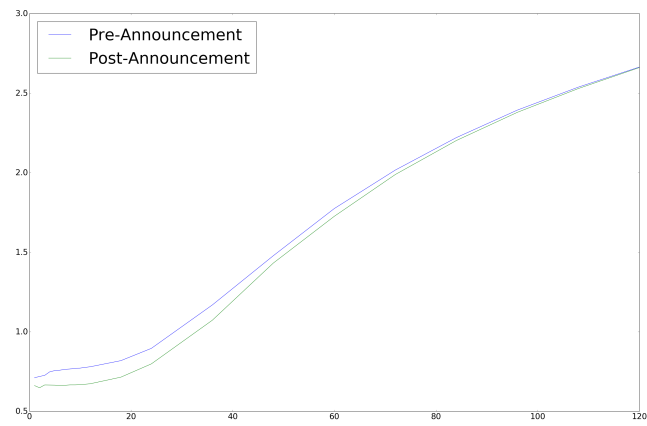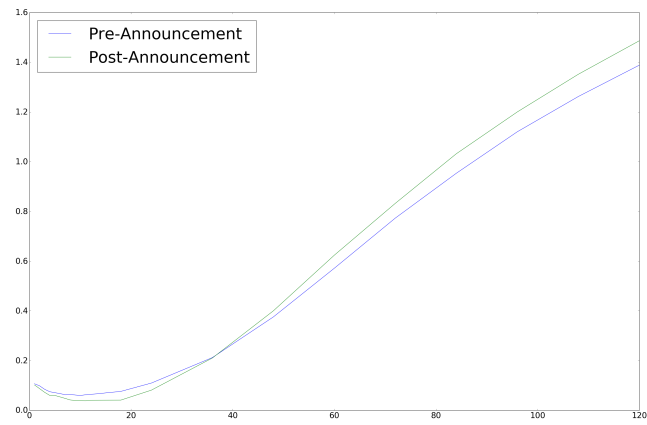
(a) LSAP 1
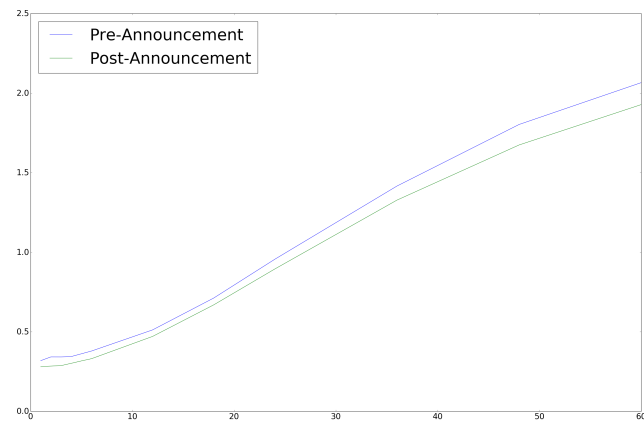
(b) LSAP 2
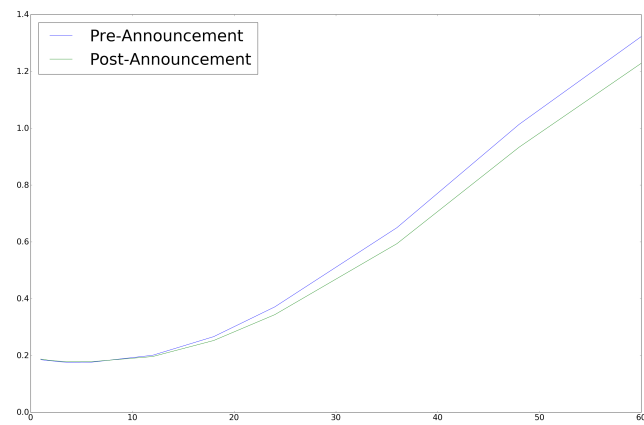
(c) LSAP 3

Figure A1: US OIS Term Structure up to 5 years , pre- and post-announcements
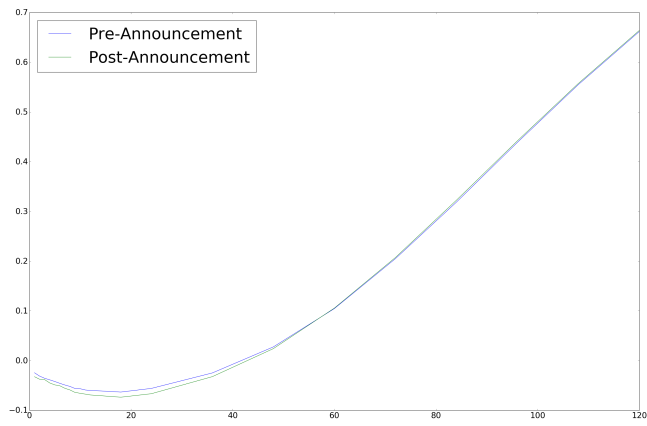
81

(a) SMP

(b) OMT

(c) APP

Figure A2: Euro OIS Term Structure up to 10 years, pre- and post-announcements