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Abstract
As a response to the recent global financial crisis, the main central banks implemented several programs of unconventional monetary policies. This paper assesses the announcement effects of the policy measures taken by the European Central Bank, the Bank of England and the Federal Reserve on European securities markets. We measure the impact of these announcements on government bond and stock prices and trading volumes. Using the event study methodology, we evaluate the reaction of some of the major European market indices around the announcement dates of unconventional monetary policies, over the period between 2008 and 2016. Our results show that the overall impact of the announcements of unconventional monetary policy measures is significant for European stock markets. Further, results suggest that the impact was more significant with the announcement of "Forward Guidance" and "Asset Purchases" policy measures, respectively, on stock prices and trading volumes. If events are categorized using a narrow definition of "Forward Guidance", the effects for this category are positive but not always statistically significant.

JEL: E52, E58, G12, G14

Keywords: unconventional monetary policies, event study tests, bond markets, stock markets.

1. Introduction

The global financial crisis that started in 2007 was one of the most severe crises in the history of financial markets. It generated negative economic effects across the world, especially in the Euro Area, which faced an economic slowdown, a deflationary pressure and a sovereign debt crisis (see, *e.g.*, Mody and Sandri, 2012). The European Central Bank (ECB), the Bank of England (BoE) and the Federal Reserve System of the United States of America (Fed), had to find alternative tools to conventional monetary policies, whose effectiveness was sometimes limited, particularly when rates were close to zero (see, *e.g.*, Abbassi and Linzert, 2012; Frank and Hesse, 2009). Fawley and Neely (2013), for example, mention that the initial purpose of unconventional monetary policies was to relieve financial markets distress, but, later on, further monetary policy measures were implemented to boost the real economy. Particularly in the case of the ECB, the central purpose of these measures was increasing the degree of monetary policy accommodation and ensuring its effective transmission across euro area countries.

Understanding the impact of these policy measures on financial markets is of the utmost importance for central bankers, investors and researchers. The wide interest in this topic is expressed by the large number of news released around the announcement dates of monetary policy measures. We investigate the impact of central bank unconventional monetary policy measures on security prices and volumes. The results contribute to the debates on market efficiency and on the transmission channels of non-standard monetary policy.

Our paper is related to the growing literature on the impact of unconventional monetary policies on bond and stock markets (see, *e.g.*, Haitsma *et al.*, 2016; Hosono and Isobe, 2014; Joyce *et al.*, 2011; Rogers *et al.*, 2014). Yet, there is still a gap with regard to comparing the effects across central banks and for different categories of policy measures, as well as researching on the effect on trading volumes. Moreover, very few studies examine the international spillovers of Fed and BoE announcements to European securities markets (see, *e.g.*, Fratzscher *et al.*, 2013; Moessner, 2015).

Based on the efficient market hypothesis, we measure the impact of announcements on prices and on trading volumes, rather than the actual implementation of the programs. In this manner, we investigate the impact of new information conveyed in the non-standard policy measures on European stock and bond markets by measuring their effect on prices and on trading volumes around announcement dates. We consider not only ECB and BoE announcements but also those by the Fed, given the globalization of financial markets, which has greatly increased the linkages between financial markets in recent years (see, *e.g.*, Caporale *et al.*, 2016).

Our sample comprises all the relevant announcements from March 2008 to December 2016. We assess the impact of the announcements of these policies on European stock and government bonds by looking at the behavior of security market indices. We analyze the reaction of the most popular European security

market indices provided by FTSE Russell and STOXX, namely, the FTSE Gilts All-Stocks Index, the FTSE MTS Eurozone Government Bond Index, the FTSE 100, the Euro STOXX 50, the STOXX Europe 50, the STOXX Europe 600 and the STOXX Europe 600 Banks.

To measure the reaction of securities to announcements of unconventional monetary policy, we use the event study methodology (see, *e.g.*, Ajinkya and Jain, 1989; Mackinlay, 1997; Serra, 2004). We measure abnormal returns for two event windows ([0] and [-1; 1]) and use the mean-adjusted model to estimate abnormal returns and abnormal log-volumes. We test the individual significance of the effects on both variables for the entire sample of announcements and for several subsamples, by central bank (ECB, BoE and Fed) and by different broad categories of policy measures (Asset Purchases, Funding and Forward Guidance). We use parametric and non-parametric tests to assess the significance of abnormal returns and abnormal trading.

The evidence suggests a positive impact of ECB and Fed unconventional monetary policy announcements, particularly on European stock markets' prices. The findings suggest that the impact on prices was more significant for the announcements of "Forward Guidance". Yet, if we use a narrow definition of "Forward Guidance", the effects for the "Asset Purchases" announcements are stronger. Results also suggest that the impact on trading volumes was more significant for the announcements by the ECB and of "Asset Purchases".

2. Related studies

In recent years, research on the impact of non-standard monetary policies on securities markets has become very popular. Most of these studies look at the short-term price changes surrounding policy announcements and apply the event study methodology to measure and evaluate the impact. The papers that are most closely related to our work are: Haitsma *et al.* (2016), Hosono and Isobe (2014), Joyce *et al.* (2011), Moessner (2015), Rogers *et al.* (2014) and Neuhierl and Weber (2018). Based on different approaches, there are other studies that deal with some similar issues (see, *e.g.*, Georgiadis and Gräb, 2016; Neely, 2015; Smales, 2017).

Hosono and Isobe (2014) and Rogers *et al.* (2014) explore the impact of ECB, BoE and Fed unconventional monetary policies. After controlling for market expectations, Hosono and Isobe (2014) conclude that these policy measures have generally lowered domestic long-term government bond yields. They also claim that the ECB's announcements generated a positive impact on the prices of European equity indices, but that the BoE's announcements did not have a meaningful impact on the UK stock market. When policy announcements are accompanied by forward guidance, there is usually a more significant and greater effect on a wide range of assets. Rogers *et al.* (2014) demonstrate that unconventional monetary policies were effective in easing broad financial conditions by reducing intra-Euro Area sovereign spreads. For the ECB, announcements boosted the prices of the German

stock market, whereas, for the BoE, a much lower effect was registered on the UK stock market. At the same time, they show evidence of important cross-country spillovers from the Fed's unconventional monetary policy, including to Europe.

Haitsma *et al.* (2016) identify surprises in the announcements of the ECB's unconventional monetary policy by using futures market prices and evaluate the response of stock markets to these surprises. They show that the Euro STOXX 50 was broadly affected and that a remarkable impact was registered on stocks of the Euro Area banking sector. Neuhierl and Weber (2018) also examine the impact of "surprises" on stock prices with regard to Federal Open Market Committee announcements. They find that markets react significantly to announcements when the Fed does not act as expected. Fratzscher *et al.* (2016) argue that the ECB's announcements of non-standard policy measures affected positively the prices of the main stocks in the Euro Area, including those of the banking sector, and lowered bond yields in its *periphery*. Pereira (2016) estimates the effects associated with 22 ECB announcements of unconventional monetary policy measures and finds a significant negative impact on real and nominal long-term 10-year government yields but mixed results for corporate bond yields.

Andrade *et al.* (2016) examine the ECB's expanded Asset Purchase Programme (APP) and show that the main European equity indices experience positive price changes at the first two announcement dates. They show that APP has significantly and consistently reduced sovereign yields of long-term bonds and increased the stock prices of banks, particularly those that held more sovereign bonds in their portfolios. Altavilla *et al.* (2015) study the same program and reach a similar conclusion regarding bond yields, for a broad set of market segments. They note that the impact on bonds was stronger the longer the maturity and the higher the riskiness of the assets. They find that non-targeted assets, such as stocks, have also been affected. Georgiadis and Gräb (2016) point out that stock prices around the world, including Europe, responded positively to announcements of the APP, and that global sovereign bond yields have generally decreased.

Eser and Schwaab (2016), and Ghysels *et al.* (2016), investigate the ECB Securities Markets Programme. Eser and Schwaab (2016) assess the reaction of yields in five Euro Area sovereign bond markets (Greece, Ireland, Italy, Portugal and Spain) and report large significant announcement effects. In addition, interventions led to a reduction of government bond yields, implicit volatilities and tail risks for most of the targeted countries. Ghysels *et al.* (2016) present a distinct approach, based on intraday prices. Interventions of the Securities Markets Programme are shown to have succeeded in lowering government bond yields, and price volatility, for the countries targeted by the program, namely Ireland, Greece, Spain, Italy and Portugal.

Joyce *et al.* (2011), show that large-scale asset purchases by the BoE have considerably depressed medium to long-term gilt yields, particularly in the long-term. With regard to UK stock market prices, the impact was muted around announcement dates, though the long-term effect was positive and significant.

With regard to Fed's Large-Scale Asset Purchase Program, Fratzscher *et al.* (2017) indicate that its first phase generated cross-country spillovers to the government bonds of non-US countries, having reduced European yields. Non-standard policy measures since 2010 had a muted impact on long-term foreign government bond yields but they have increased equity prices worldwide, including European countries. Neely (2015) also reports a reduction of long-term foreign bond yields, including in Greece and in the UK, as a consequence of the announcements of the Fed's Large-Scale Asset Purchase Program. In Moessner (2015), the Fed's explicit forward guidance at the zero lower bound led to higher stock prices in a number of emerging markets and in several advanced markets, including the Euro Area. This impact was found to be higher in equity indices of economies with lower sovereign ratings, suggesting that market agents may have become more willing to bear risk thereafter. Bhattarai and Neely (2016) provide a review of the empirical literature on the impact of the Fed's unconventional monetary policy on financial markets. They conclude that unconventional monetary policy announcements have had considerable effects on international bond yields and asset prices, both in developed countries and in emerging markets.

Smales (2017) identifies a sharp increase in the market activity when the target rate decision results in lower than expected rates. This effect is observed following monetary policy announcements and targets more liquid large-cap stocks. Smales and Apergis (2017) evaluate the impact of the Fed's monetary policy announcements on the trading volumes of the US market for 10-year Treasury note futures. They claim that longer and more complex statements, potentially resulting in more differences of opinion, led to higher trading volumes. The influence of linguistic complexity was higher during the period of Quantitative Easing.

To sum up, most of the papers that analyze the effect of the ECB non-standard policy measures on European securities markets report both a significant reduction in government bond yields and a large increase in stock prices around the announcement of these policies. The impact is found to be felt majorly on riskier assets and in countries targeted by some specific programs. Yet, very few studies aggregate the impact of most of the ECB's programs (see, *e.g.*, Hosono and Isobe, 2014; Rogers *et al.* 2014) and some only look at one single program (see, *e.g.*, Andrade *et al.*, 2016; Eser and Schwaab, 2016). In this manner, we first contribute to the literature on this topic, in comparison to previous studies, by analyzing an extended sample to evaluate whether the impact is consistent over time and across programs. Furthermore, we are among the very few studies to investigate the impact on trading volumes.

Most of the existing studies on the impact of the BoE's non-standard policy measures focus on UK securities markets (see, *e.g.*, Joyce *et al.*, 2011) but not on other European securities markets. Similarly, little investigation has been done on the effect of the Fed's unconventional monetary policy measures on European stock and bond markets (there are few exceptions, such as Fratzscher *et al.*, 2013; Moessner, 2015). Therefore, we fill this gap by measuring and testing for

the significance of spillover effects of BoE and Fed announcements on European security markets.

In short, the contribution of this paper is to investigate the impact of the announcements of ECB, BoE and Fed unconventional monetary policies on European government bond and stock markets. We measure the effects of non-standard policy measures on prices and on trading volumes by analyzing bond and stock market indices around relevant announcement dates. For that, we apply the event study methodology. The impact of non-standard policy measures is expected to be positive and significant, on prices and on trading volumes.

Thus, we measure and evaluate the significance of abnormal returns and abnormal trading around announcement dates and compare the results across central banks and different types of policy measures. This enables us to assess the domestic impact as well as international spillovers of these measures. When possible, we also discuss the implications of the results regarding the transmission channels of unconventional monetary policy. Finally, the results of the abnormal trading tests provide insights on how the information and the language complexity conveyed in the announcements has affected investors and traders.

3. Data and Sample

3.1. Sample announcements

We constructed a sample of the most important ECB, BoE and Fed announcements of non-standard monetary policy measures.[1] We selected *relevant announcements*[2] as the subset of those made by high-level representatives of the three central banks, or that were turned into statements, press releases or conference minutes following the meetings of the Governing Council of the ECB, the Monetary Policy Committee of the BoE[3] or the Federal Open Market Committee.

Another selection criterion was that the announcements of "Asset Purchases" or "Funding" had to reveal something new in comparison to previous announcements. This could be either the start, an expansion or a contraction of the size or length of a program, or an important announcement about its technical details.[4] Regarding "Forward Guidance", an announcement is included in our study, only when a new wording was introduced. We examined all announcements in detail to assess that.

1. For ten event dates, announcements included conventional and unconventional measures at the same time. Thus, the effects on market prices and volumes may reflect both (see, *e.g.*, Haitsma *et al.*, 2016).

2. It should be stressed that the announcements included in our sample are based on own choices. These are rather comprehensive but reflect some discretion with regard to which announcements were considered *relevant*.

3. In the case of the UK, two announcements were made by Her Majesty's Treasury.

4. The continuation of a programme exactly with the same features (size, length, etc.) is assumed as a non-event.

Our sample of non-standard monetary policy announcements is constituted of 69 announcements and 59 announcement days, within a period that ranges from March 2008 to December 2016. We also looked at subsamples of announcements by central bank (ECB, BoE and Fed; respectively, 29, 15 and 25 announcements) and by type of policy measure ("Asset Purchases", "Funding" and "Forward Guidance"; respectively, 42, 14 and 13 announcements).

For the same period, 75 other official press conferences were held by the ECB[5] and in 64 there were no announcements of *relevant* changes in monetary policy.

Detailed information about the announcements of non-standard policy measures by the ECB, the BoE and the Fed can be found on their respective websites, which constitute our source. Appendix I lists the subset of announcements that met the criteria described above.

3.2. Market data

We evaluate the impact of unconventional monetary policy announcements on European stocks and bonds by examining the effects on market indices changes. These were commonly used by previous studies that analyze the impact of non-standard policy measures on stock markets.

We selected some of the most popular European market indices provided by STOXX and FTSE Russell. With respect to general equity indices, we analyze the major UK stock index – FTSE 100 –, one regional index with stocks exclusively from the Euro Area – Euro STOXX 50 –, two regional European stock indices – STOXX Europe 50 and STOXX Europe 600 – and one European stock index composed of banks – STOXX Europe 600 Banks; for government bonds, we analyze the major index in the Euro Area – FTSE MTS Eurozone Government Bond Index – and the FTSE Gilts All-Stock Index for the UK, which are both composed of a diversified basket of maturities.

To address the endogeneity associated with the reverse causality between monetary policies and financial markets (Rigobon and Sack, 2003), we use daily market data, as in Fratzscher *et al.* (2016) and Haitsma *et al.* (2016).

The information relative to the indices was obtained from Thomson Reuters Eikon. From this platform, we extracted the price series, denominated in the respective currencies, of the market indices analyzed. The daily returns are calculated on the basis of total return indices, assuming dividends or coupons paid out on any share or bond as re-invested overnight in the index itself. These calculations ignore tax and re-investment charges.

5. These press conferences follow the monetary policy meetings of the ECB's Governing Council.

To perform the analysis on volumes, we use daily trading volumes of FTSE 100, Euro STOXX 50, STOXX Europe 50 and STOXX Europe 600.[6] These represent the sum of the daily number of common shares traded of their index constituents.

4. Methodology

In this paper, we use the event study methodology (see, *e.g.*, Ajinkya and Jain, 1989; Mackinlay, 1997; Serra, 2004).

The first decision to take is to define the event and the estimation windows. Two issues arise when choosing an event window: if its length is too wide, there is the possibility of being distorted by the release of other important information, such as macroeconomic data; on the other hand, when it is too narrow, it may not allow sufficient time for revised expectations to become fully incorporated in asset prices. Taking into account this trade-off, and for robustness, two event windows were chosen: [0] and [-1; 1], where [0] is the announcement day.[7]

A partial or entire overlap of event windows is observable in some cases, which could distort our results if not correctly handled. To capture the global impact of unconventional monetary policies, the first announcement is dropped out and only the latter announcement is considered.[8] This prevents us from double counting abnormal returns or abnormal volumes potentially associated to the same announcement.

When evaluating the impact of the non-standard policy measures of one central bank or of a particular category of policy measure, if the event windows corresponding to announcements of different central banks or categories coincide, in part or totally, both events are discarded. As such, event windows do not comprise two or more different announcements of different sources.

The estimation window contains T_1 trading days beginning 201 days and ending 2 days prior to the event date ($T_1 = 200$). This number is defined so as to match approximately the number of trading days in a calendar year excluding the days within the event windows of all the sample announcements. To estimate the expected trading volumes, we use a shorter estimation window of 100 days, considering that volumes exhibit higher volatility than returns. Event window days are not included to estimate normal trading volumes.

The model used in our study to measure abnormal returns and abnormal trading is the mean-adjusted model. The significance of the abnormal returns is then tested by applying parametric (t-test) and non-parametric tests (Generalized Sign

6. For the other indices analysed in this study, the trading volumes were not extracted as we were unable to obtain information about them.

7. In the event an announcement is made on a day when European securities markets are closed (*e.g.* at the weekend or bank holiday), the event day considered is the following trading day.

8. If two event windows exactly match each other, no exclusion is made, in other words, it is included once.

Test and May's U Test). For abnormal trading, only parametric tests (*t*-test) are performed on the assumption that trading volumes are approximately normally distributed after applying a logarithmic transformation.

Appendix II provides a detailed explanation of the methodology used in the paper.

5. Empirical results

5.1. Abnormal returns

In this section, we present the abnormal returns and the test statistics associated with the impact of the overall sample of unconventional monetary policy announcements. We also show the results obtained for the subsamples of announcements, for each central bank individually (European Central Bank, Bank of England and Federal Reserve) and for each type of policy measure (Asset Purchases, Funding and Forward Guidance).

The tables below show the average cumulative abnormal returns ($\overline{CAR}$) for the two event windows – [0] and [-1; 1] – given by the mean-adjusted model. The significance of the average cumulative abnormal returns is tested through the two-tailed *t*-test, the Generalized Sign test and the May's U test. The Generalized Sign test is a non-parametric test used to account for the possibility of non-normality of abnormal returns or volumes. The May's U test is used to test variance changes over the event window days.

The estimates of the standard deviation of the abnormal returns, to compute the *p*-values of the *t*-test, are obtained from the cross-sectional event window cumulative abnormal returns, since the variance of abnormal returns may have changed for the days around the announcement.[9] Results are robust to this choice. The significance levels used for the tests are: 1%, 5% and 10%.

5.1.1. Abnormal returns – full sample. The average cumulative abnormal returns for different windows around announcements of unconventional monetary policy and the *p*-values of the significance tests discussed before are shown in Table A.1, for the full sample, pooling all ECB, BoE and Fed policy measures announcements.

[Insert Table A.1 here]

The results suggest that unconventional monetary policies impacted positively mostly the prices of European stocks, if we take the results of the *t*-test, particularly for the [-1; 1] event window. By applying the Generalized Sign Test, the impact is even more significant, with a positive market reaction to the policy measures

9. Appendix III.1 shows the *t*-test statistics obtained using instead the standard deviation computed from the time series of the average abnormal returns over the estimation window.

announced. Yet, results are not supportive of a significant impact on the prices of European government bond markets.

We also observe a positive and significant effect on the prices of European bank equities, which is consistent with previous results (Fratzscher *et al.* 2016; Haitsma *et al.*, 2016). This result is in line with the *bank lending transmission channel*, as investors may interpret that unconventional monetary policies will reduce the banks' marginal cost of funding and increase credit supply, particularly for those that hold more debt securities purchased by central banks.

The more pronounced effect on stock than on government bond markets suggests that, following the announcement of the non-conventional monetary policy measures, there was a decrease in the risk aversion of market participants, as the *confidence channel* would imply. This is in accordance with Fratzscher *et al.* (2016). In other words, the *confidence channel* would be triggered by an improvement in the economic outlook, which would increase the willingness of economic agents to invest.

In addition, we observe that the results of these tests are usually more significant for the [-1; 1] event window. This means that the announcements were, at least partially, anticipated by market participants, which is substantiated by the results for the [-1; 0] and the [0; 1] event windows. However, additional tests using longer event windows suggest that the impact was mostly felt on the day prior but also on the day after the announcement.[10] [11] If there is partial anticipation, as conjectured, the positive abnormal returns we observe underestimate the total effects associated with the announcement of these effects.

Finally, the May's U test statistics are not significant. Thus, we cannot refuse the null of no increase in the variance of abnormal returns.

5.1.2. Abnormal returns per central bank. We split the overall sample into three subsamples of unconventional monetary policy announcements, each one including only the announcements of each central bank (the European Central Bank, the Bank of England and the Federal Reserve). The average cumulative abnormal returns and the *p*-values of the significance tests are presented in Table A.2.

[Insert Table A.2 here]

In general, the results suggest that ECB and Fed announcements generated a stronger impact on the prices of European stocks than the ones by the BoE.

10. We compute abnormal returns for four additional windows [-1; 0], [-2; 0], [-3; 0] and [0; 1]. These results are available in appendix III.3.

11. Most announcement dates are predetermined. Prior to the announcements, odds regarding the nature of the policy measure are usually available through market data providers and media. Therefore, market participants will take this information into account and trade upon, influencing market prices in advance of the official announcement. Given partial anticipation, the market reaction is reduced around the announcement date, when no surprises occur.

ECB announcements Taken together, our results for the ECB differ slightly from those of Fratzscher *et al.* (2016), Haitsma *et al.* (2016), Hosono and Isobe (2014) and Pereira (2016). They are in line with the results for European stock markets but not for government bond markets.

Considering the results of the *t*-test, the impact of the ECB's unconventional monetary policy on the prices of the Euro Area government bond market is not statistically significant. However, the results are significant, with a negative impact on prices, for the UK gilt market. When looking at the statistics of the Generalized Sign Test, particularly for the [-1; 1] event window, the impact is significant for the UK gilt market (with a negative impact on prices) and for most of the broad European stock markets (with a positive impact on prices), including the stock market of the banking sector.

A reasonable explanation for the lack of significance in the impact on the Euro Area government bond market may be the operational objectives of the ECB's non-standard policy measures (Rogers *et al.*, 2014). Further to increasing the degree of monetary policy accommodation in the euro area, they were aimed at ensuring its effective transmission across euro area countries. Given the composition of FTSE MTS Eurozone Government Bond Index[12], the negative or muted effect on the prices of the bonds of non-stressed countries (*e.g.* Germany) could have offset the positive impact on the prices of the bonds of distressed countries (*e.g.* Portugal). These findings may also be linked to the fact that the indices analyzed are baskets of maturities. Hence, the lower impact on short-term maturities could have offset the stronger effect on long-term maturities (see, *e.g.*, Hosono and Isobe, 2014).

Moreover, for the event-day, the results of the May's U Test reveal a strong impact of the ECB's announcements on the absolute value of the abnormal returns of European stocks, suggesting that variance is larger on the event days.

BoE announcements Hosono and Isobe (2014), Joyce *et al.* (2011), and Rogers *et al.* (2014), find that the BoE's announcements of unconventional monetary policy did not have a meaningful impact on the UK stock market prices, which is confirmed by our results. Yet, unlike them, we do not find a statistically significant impact on the prices of the UK gilt market, considering the results of the three tests.

All in all, the statistics of our tests suggest that the impact of the BoE's non-standard policy measures on the prices of European securities markets was not strong. However, the results should be analyzed with caution taking into account that the sample size is small.

Fed announcements With regard to the statistics of the *t*-test, the findings suggest that the impact of the Fed's unconventional monetary policy is significant

12. As of February 20, 2019, the composition of this index per country is as follows: Austria (4%), Belgium (6%), Finland (2%), France (25%), Germany (17%), Ireland (2%), Italy (22%), Netherlands (5%), Portugal (2%) and Spain (14%).

on the prices of European stock markets, particularly for the [-1; 1] event window. The results of the Generalized Sign Test validate that conclusion at a higher level of confidence. The statistics of the May's U Test, for the event-day, also reveal a significant impact on most of the broad European stock markets. However, we do not find a significant impact on European government bond markets.

Therefore, cross-country spillovers from the Fed's unconventional monetary policy to European government bond markets were not so significant than those reported by Fratzscher *et al.* (2017), Neely (2015), Neuhierl and Weber (2018) and Rogers *et al.* (2014). Nevertheless, our findings seem to be in accordance with the literature regarding international spillovers to European stock markets (Fratzscher *et al.*, 2013; Moessner, 2015; Rogers *et al.*, 2014; Neuhierl and Weber, 2018). These results suggest that the international transmission channels of unconventional monetary policy are not always triggered, and the impact is more positive for large stocks, in particular, bank stocks.

We also measure the price effects around the dates of ECB's press conferences with no *relevant* changes in monetary policy, either conventional or non-conventional. Table A.3 compares the results for the two different samples of announcements.

[Insert Table A.3 here]

Overall, results suggest that only press conferences with announcements of ECB's unconventional policy measures, unlike other ECB monetary policy conferences, produced positive and significant price effects on European stocks. The price effects are smaller and not statistically significant in ECB monetary policy conferences when no unconventional measures are announced. Exception is the positive effect for the Euro Area government bonds over the [-1; 1] event window, but only when we use the Generalized Sign Test.

5.1.3. Abnormal returns per type of policy measure. We also split the overall sample of unconventional monetary policy announcements into three different categories of policy measures: Asset Purchases, Funding, and Forward Guidance. Asset Purchases include all programs under which private and public securities are purchased by the central bank (*e.g.*, expanded Asset Purchase Programme); Funding comprises all the policy measures aimed at incentivizing lending from credit institutions by providing them funding conditions (*e.g.*, Funding for Lending Scheme); and Forward Guidance is defined in broad terms and refers to the communication of the likely course of monetary policy, signaling tightening or loosening of monetary conditions, regarding interest rates or large-scale asset purchases.[13] Despite no explicit reference, some announcements may signal, in

13. In the case of large-scale asset purchases, only announcements for which a programme is not explicitly mentioned are classified as "Forward Guidance". See appendix I for the categorization of the announcements included in our sample.

anticipation, other types of measures, so results in Table A.4 have to be interpreted with caution.[14]

[Insert Table A.4 here]

The *t*-test statistics suggest that announcements of Asset Purchases affected significantly the prices of European stock markets, for the [-1; 1] event window, except for the stock market of the banking sector. In contrast, the statistics of the Generalized Sign Test indicate that the impact is also significant (and positive) for European bank equities, but not for the UK stock market, for the [-1; 1] event window. These statistics do not reveal a significant impact for European government bond markets. Hence, our results for European government bond markets are not so significant as in Fratzscher *et al.* (2017), Fratzscher *et al.* (2016), Joyce *et al.* (2011), and Rogers *et al.* (2014). However, with regard to the findings for European stock markets, these are similar.

The *t*-test statistics suggest that announcements with regard to Funding did not have a significant impact on European securities. Nevertheless, when looking at the results of the Generalized Sign Test, we report a significant, but negative, impact on the European blue-chip stock market, for the [-1; 1] event window. Our results are in line with the literature (Fratzscher *et al.*, 2016; Rogers *et al.*, 2014).

The results for the subsample of Forward Guidance suggest that these announcements positively affected the prices of European stocks, but not of bonds, and the effects are statistically significant taking into consideration the results both for the *t*-test and the Generalized Sign Test. These findings corroborate those presented by Moessner (2015), and further support the importance of the signaling channel. These results should be interpreted with caution, due to the small size of this subsample.

On the whole, we find that Forward Guidance was the type of policy measure that most affected the prices of European stocks. This suggests that European stock markets are forward looking and that market participants value more (and new) information in advance. The results also show positive significant effects for Asset Purchases. On the contrary, the impact of Funding announcements was not significant.

If we use a narrower definition of Forward Guidance, referring only to interest rates policy, the announcements of July, 26 2012 ("whatever it takes") and November 6, 2014 (information suggesting the start of a new asset purchases program) would be categorized as Asset Purchases instead of Forward Guidance announcements. The results of the alternative categorization are shown in the Appendix. Overall, the results are similar, but the effects of Forward Guidance are only statistically significant for FTSE100.

14. For example, the announcement of November 6, 2014 suggests but does not explicitly mention the start of the APP program.

5.2. Abnormal trading

We measure abnormal trading for the components of four equity indices – FTSE 100, Euro STOXX 50, STOXX Europe 50, STOXX Europe 600.[15] We analyze the impact for the full sample and for the subsamples by central bank and type of policy measure. This consisted of calculating average cumulative abnormal log-volumes ($\overline{CAV}$) for two event windows – [0] and [-1; 1] – and testing their individual significance through the two-tailed *t*-test. As in the previous sections, for abnormal returns, we use the standard deviation computed on the basis of the cross-sectional event window cumulative abnormal log-volumes to estimate the *p*-values. [16] In this way, we account for possible changes in the variance of abnormal log-volumes for the days around the events. The significance levels used are: 1%, 5% and 10%.

5.2.1. Abnormal trading – full sample. Table A.5 shows the results for the full sample.

[Insert Table A.5 here]

There is strong evidence that announcements of unconventional monetary policy induced positive abnormal trading in the UK and Euro Area stock markets. This may be explained by the complexity and the length that is inherent to unconventional monetary policy statements, which may have contributed to more differences of opinion in these markets, thereby leading to more trading (Smales and Apergis, 2017). In line with this study and with Smales (2017), the effect occurs on the announcement day, which is observable by a more significant impact for the event-day than for the [-1; 1] event window. As in Smales (2017), large cap-stocks were more affected, which is observed by the higher significance for STOXX Europe 50 in comparison to STOXX Europe 600.

5.2.2. Abnormal trading per central bank. The average cumulative abnormal log-volumes and the *p*-values of the *t*-test are shown in Table A.6, for different windows around the announcements and subsets of central banks.

[Insert Table A.6 here]

We can conclude that the ECB's unconventional monetary policy measures had a strong positive impact on the trading activity of European stock markets, particularly on the announcement days. Abnormal trading is significantly higher for the Euro Area than for the other stock markets analyzed. The BoE's announcements of non-standard policy measures do not appear to have significantly affected the trading volumes of European stock markets, not even of the UK

15. This is due to the fact that we were unable to obtain data regarding the other indices covered by this study.

16. Nevertheless, we present the *p*-values of the *t*-test calculated by using the standard deviation of the abnormal log-volumes in the estimation window, in appendix III.2.

stock market, but the results may be affected by the sample size. The Fed's announcements do not seem to have significantly affected the trading volumes of European stock markets as well.

Table A.7 compares, over the same period, abnormal trading registered around ECB's unconventional monetary policy announcements with abnormal trading around other ECB's announcements with no *relevant* changes in monetary policy.

[Insert Table A.7 here]

These results suggest that the trading activity of most of the broad European stock markets increased around the dates of both types of announcements.

5.2.3. Abnormal trading per type of policy measure. The results are displayed in Table A.8, for the different categories of policy measures.[17]

[Insert Table A.8 here]

The statistics reveal that announcements of Asset Purchases had a significant positive effect on the trading activity of the UK and Euro Area stock markets, in particular on the event-day. In contrast, the impact of this type of policy measure on the trading volumes of other broad European stock markets was not meaningful. As far as the announcements of Funding and Forward Guidance are concerned, abnormal trading in European stock markets is not significant. Yet, the sample size in these tests is very small, potentially leading to unreliable test statistics.[18]

6. Conclusions

In this paper, we examine the impact of ECB, BoE and Fed unconventional monetary policies on European securities markets. For that, we analyze the behavior of the stock and government bond index returns over different event windows. We also investigate the behavior of the trading volumes for four equity indices. First, we estimate the overall impact of the announcements of non-standard policy measures. Second, we evaluate and compare the impact across central banks (European Central Bank, Bank of England and Federal Reserve) and by policy measures types (Asset Purchases, Funding and Forward Guidance).

The empirical analysis was performed by using the event study methodology, in order to measure short-term market effects. In most cases, our findings are in line with those from earlier studies (see, *e.g.*, Hosono and Isobe, 2014; Rogers *et al.*, 2014).

17. As defined in section 5.1.3

18. Classifying the announcements of 26.07.2012 and 06.11.2014 as Asset Purchases instead of Forward Guidance does not impact these results. Appendix III.5 shows the alternative results.

Overall, the evidence from this study suggests that unconventional monetary policy announcements affected significantly European stocks, but this is not the case for UK gilts or Euro Area government bonds.

When we focus on the impact per central bank, the impact of the ECB's announcements was positive and significant for the European stock markets. There is also some evidence of international spillovers from Fed's non-standard policy announcements to European stock markets, particularly in the case of large stocks and bank stocks, but not to government bond markets. As far as the abnormal returns per type of policy measure are considered, Forward Guidance produced a stronger impact than Asset Purchases and Funding, but this conclusion relies on the categorization of events using a broad definition of Forward Guidance. When we categorize events using a narrower definition of Forward Guidance, the results are less significant for this subsample and more significant for Asset Purchases.

Turning to the impact on abnormal trading, unconventional monetary policy announcements generated a significant positive impact on European stock markets. When looking at the subsamples of central banks and types of policy measures, we find that the ECB's announcements, along with the ones referring to Asset Purchases, were the ones that mostly affected the trading volumes of these markets.

When we look at the impact of other ECB's announcements, there are no significant effects on prices but there are positive and significant effects on trading volumes even if these are of smaller magnitude.

This study has enabled to gain additional insight with regard to the impact of ECB, BoE and Fed unconventional monetary policies on European securities markets. Taken together, our findings are in line with previous studies, suggesting that stock market investors react positively to announcements of unconventional monetary policy. Furthermore, we provide some evidence of international spillovers and of a significant positive effect on the trading activity around the announcement days.

A number of limitations could have influenced the results presented hereby. First, given the small number of observations on unconventional monetary policy announcements, estimating their impact with a high level of accuracy is a difficult process (Bhattarai and Neely, 2016). Therefore, the results, particularly of parametric tests, could have been distorted by other relevant information, whose impact our models did not control. This is the case of the release of macroeconomic data around the announcement dates, which could also have an impact on financial markets. Second, event studies assume that the entire announcement effect is registered within the event window. This makes it hard to choose an appropriate event window, since the persistence of the unconventional monetary policy effects is difficult to determine with any precision (Neely, 2014). On the other hand, if the policies were anticipated, abnormal returns around the announcement would underestimate, in absolute terms, the true effects of the announced policies, given that market reaction, would occur prior to the event window. Finally, endogeneity is also a subject of concern, because the expectations of market participants influence

the state of financial markets and therefore may condition monetary policy (Hung and Ma, 2017; Rigobon and Sack, 2003).

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Appendix A: Tables

	Event window	[0]	[-1; 1]
FTSE Gilts All-Stocks Index		-0.02%	-0.11%
	t-test	(0.757)	(0.441)
	GS Test	(0.747)	(0.056)*
	May's U Test	(0.638)	(0.653)
FTSE MTS Eurozone Government Bond Index		-0.01%	0.03%
	t-test	(0.908)	(0.705)
	GS Test	(0.427)	(0.597)
	May's U Test	(0.934)	(0.618)
FTSE 100		0.12%	0.80%
	t-test	(0.562)	(0.036)**
	GS Test	(0.093)*	(0.013)**
	May's U Test	(0.842)	(0.881)
Euro STOXX 50		0.22%	1.02%
	t-test	(0.479)	(0.041)**
	GS Test	(0.037)**	(0.001)***
	May's U Test	(0.840)	(0.584)
STOXX Europe 50		0.10%	0.67%
	t-test	(0.693)	(0.112)
	GS Test	(0.170)	(0.000)***
	May's U Test	(0.993)	(0.621)
STOXX Europe 600		0.12%	0.73%
	t-test	(0.628)	(0.075)*
	GS Test	(0.691)	(0.012)**
	May's U Test	(0.895)	(0.660)
STOXX Europe 600 Banks		0.41%	1.25%
	t-test	(0.322)	(0.071)*
	GS Test	(0.052)*	(0.006)***
	May's U Test	(0.879)	(0.551)
	Observations	57	57

Table A.1. Announcement effects of unconventional monetary policies: abnormal returns, full sample

This table shows the average cumulative abnormal returns ($\overline{CAR}$) of European market indices, for two event windows around the announcements of unconventional monetary policy measures: [0] and [-1; 1], where [0] is the announcement day. The abnormal returns were estimated using the mean-adjusted model. The p-values of the two-tailed t-test, the Generalized Sign test (GS Test) and the May's U test are presented in parentheses. ***, ** and * denote significance of ($\overline{CAR}$) at the 1%, 5% and 10% levels, respectively.

	Central bank	ECB		BoE		Fed	
	Event window	[0]	[-1; 1]	[0]	[-1; 1]	[0]	[-1; 1]
FTSE Gilts All-Stocks Index		-0.19%	-0.44%	0.20%	0.29%	0.09%	0.12%
	t-test	(0.091)*	(0.002)***	(0.525)	(0.590)	(0.198)	(0.536)
	GS Test	(0.185)	(0.002)***	(0.835)	(0.693)	(0.106)	(0.470)
	May's U Test	(0.813)	(0.459)	(0.268)	(0.411)	(0.253)	(0.473)
FTSE MTS Eurozone Government Bond Index		-0.04%	-0.02%	0.02%	0.05%	0.05%	0.08%
	t-test	(0.712)	(0.854)	(0.828)	(0.791)	(0.269)	(0.316)
	GS Test	(0.265)	(0.265)	(0.673)	(0.433)	(0.532)	(0.860)
	May's U Test	(0.139)	(0.341)	(0.368)	(0.560)	(0.339)	(0.410)
FTSE 100		-0.09%	0.11%	0.02%	1.14%	0.13%	1.12%
	t-test	(0.852)	(0.845)	(0.958)	(0.115)	(0.442)	(0.086)*
	GS Test	(0.986)	(0.207)	(0.150)	(0.404)	(0.370)	(0.073)*
	May's U Test	(0.156)	(0.732)	(0.437)	(0.723)	(0.138)	(0.657)
Euro STOXX 50		0.37%	0.71%	-0.04%	1.21%	0.06%	1.22%
	t-test	(0.622)	(0.371)	(0.938)	(0.315)	(0.755)	(0.076)*
	GS Test	(0.343)	(0.072)*	(0.132)	(0.366)	(0.341)	(0.006)***
	May's U Test	(0.007)***	(0.505)	(0.388)	(0.957)	(0.083)*	(0.555)
STOXX Europe 50		0.06%	0.18%	0.04%	1.14%	0.02%	0.90%
	t-test	(0.918)	(0.790)	(0.925)	(0.198)	(0.873)	(0.174)
	GS Test	(0.689)	(0.011)**	(0.132)	(0.367)	(0.712)	(0.031)**
	May's U Test	(0.019)**	(0.496)	(0.378)	(0.973)	(0.072)*	(0.494)
STOXX Europe 600		0.07%	0.25%	0.00%	1.19%	0.06%	0.91%
	t-test	(0.907)	(0.709)	(0.995)	(0.206)	(0.680)	(0.147)
	GS Test	(0.890)	(0.117)	(0.414)	(0.830)	(0.865)	(0.039)**
	May's U Test	(0.012)**	(0.486)	(0.374)	(0.968)	(0.067)*	(0.455)
STOXX Europe 600 Banks		0.74%	1.29%	-0.69%	0.07%	0.53%	1.67%
	t-test	(0.417)	(0.199)	(0.508)	(0.975)	(0.096)*	(0.088)*
	GS Test	(0.301)	(0.059)*	(0.111)	(0.697)	(0.610)	(0.064)*
	May's U Test	(0.017)**	(0.549)	(0.523)	(0.665)	(0.105)	(0.548)
	Observations	22	22	11	11	20	20

Table A.2. Announcement effects of unconventional monetary policies: abnormal returns, by central bank

This table lists the average cumulative abnormal returns ($\overline{CAR}$) of European market indices, for two event windows around the announcements of unconventional monetary policy measures: [0] and [-1; 1], where [0] is the announcement day. The results are shown for three subsamples of announcements: European Central Bank, Bank of England and Federal Reserve announcements. The abnormal returns were estimated using the mean-adjusted model. The p-values of the two-tailed t-test, the Generalized Sign Test (GS Test) and the May's U Test are presented in parentheses. ***, ** and * denote significance of ($\overline{CAR}$) at the 1%, 5% and 10% levels, respectively.

		ECB			
	Category	Unconventional		Other announcements	
	Event window	[0]	[-1; 1]	[0]	[-1; 1]
FTSE Gilts All-Stocks Index		-0.19%	-0.44%	-0.07%	-0.01%
	t-test	(0.091)*	(0.002)***	(0.180)	(0.906)
	GS Test	(0.185)	(0.002)***	(0.251)	(0.525)
	May's U Test	(0.813)	(0.459)	(0.123)	(0.142)
FTSE MTS Eurozone Government Bond Index		-0.04%	-0.02%	0.02%	0.11%
	t-test	(0.712)	(0.854)	(0.657)	(0.134)
	GS Test	(0.265)	(0.265)	(0.991)	(0.010)**
	May's U Test	(0.139)	(0.341)	(0.982)	(0.894)
FTSE 100		-0.09%	0.11%	0.03%	0.01%
	t-test	(0.852)	(0.845)	(0.835)	(0.967)
	GS Test	(0.986)	(0.207)	(0.673)	(0.498)
	May's U Test	(0.153)	(0.726)	(0.130)	(0.187)
Euro STOXX 50		0.37%	0.71%	0.10%	0.26%
	t-test	(0.622)	(0.371)	(0.556)	(0.457)
	GS Test	(0.343)	(0.072)*	(0.359)	(0.914)
	May's U Test	(0.007)***	(0.500)	(0.125)	(0.413)
STOXX Europe 50		0.06%	0.18%	0.05%	0.15%
	t-test	(0.918)	(0.790)	(0.741)	(0.589)
	GS Test	(0.689)	(0.011)**	(0.634)	(0.770)
	May's U Test	(0.018)**	(0.491)	(0.126)	(0.491)
STOXX Europe 600		0.07%	0.25%	0.09%	0.20%
	t-test	(0.907)	(0.709)	(0.515)	(0.485)
	GS Test	(0.890)	(0.117)	(0.991)	(0.600)
	May's U Test	(0.012)**	(0.480)	(0.131)	(0.429)
STOXX Europe 600 Banks		0.74%	1.29%	0.19%	0.66%
	t-test	(0.417)	(0.199)	(0.372)	(0.160)
	GS Test	(0.301)	(0.059)*	(0.213)	(0.213)
	May's U Test	(0.016)**	(0.543)	(0.130)	(0.578)
	Observations	22	22	61	61

Table A.3. ECB announcement effects of monetary policy measures: abnormal returns

This table shows the average cumulative abnormal returns ($\overline{CAR}$) of European market indices, for two event windows around the announcements of ECB's monetary policy measures: [0] and [-1; 1], where [0] is the announcement day. The results are shown for two samples of ECB press conference announcements: announcements of unconventional policy measures and other announcements. These latter exclude announcements of changes in the official interest rates. The abnormal returns were estimated using the mean-adjusted model. The p-values of the two-tailed t-test, the Generalized Sign Test (GS Test) and the May's U Test are presented in parentheses. ***, ** and * denote significance of ($\overline{CAR}$) at the 1%, 5% and 10% levels, respectively.

	Category	Asset Purchases		Funding		Forward Guidance	
	Event window	[0]	[-1; 1]	[0]	[-1; 1]	[0]	[-1; 1]
FTSE Gilts All-Stocks Index		-0.11%	-0.10%	0.05%	-0.35%	0.06%	0.27%
	t-test	(0.381)	(0.579)	(0.628)	(0.156)	(0.618)	(0.503)
	GS Test	(0.478)	(0.285)	(0.871)	(0.114)	(0.322)	(0.731)
	May's U Test	(0.790)	(0.462)	(0.333)	(0.564)	(0.407)	(0.968)
FTSE MTS Eurozone Government Bond Index		-0.05%	0.00%	-0.09%	-0.17%	0.19%	0.16%
	t-test	(0.466)	(0.965)	(0.228)	(0.380)	(0.117)	(0.368)
	GS Test	(0.114)	(0.616)	(0.106)	(0.843)	(0.110)	(0.687)
	May's U Test	(0.561)	(0.790)	(0.585)	(0.925)	(0.756)	(0.696)
FTSE 100		0.09%	1.01%	-0.59%	-0.20%	0.71%	1.48%
	t-test	(0.709)	(0.041)**	(0.409)	(0.819)	(0.124)	(0.019)**
	GS Test	(0.219)	(0.219)	(0.471)	(0.488)	(0.115)	(0.025)**
	May's U Test	(0.361)	(0.713)	(0.790)	(0.547)	(0.670)	(0.849)
Euro STOXX 50		0.25%	1.18%	-0.51%	0.01%	1.11%	1.88%
	t-test	(0.583)	(0.069)*	(0.604)	(0.991)	(0.070)*	(0.064)*
	GS Test	(0.092)*	(0.041)**	(0.938)	(0.136)	(0.092)*	(0.092)*
	May's U Test	(0.673)	(0.789)	(0.737)	(0.754)	(0.701)	(0.761)
STOXX Europe 50		0.16%	0.98%	-0.63%	-0.28%	0.76%	1.28%
	t-test	(0.625)	(0.076)*	(0.495)	(0.836)	(0.059)*	(0.058)*
	GS Test	(0.416)	(0.024)**	(0.961)	(0.038)**	(0.096)*	(0.096)*
	May's U Test	(0.950)	(0.826)	(0.861)	(0.864)	(0.903)	(0.662)
STOXX Europe 600		0.19%	0.95%	-0.59%	-0.04%	0.75%	1.34%
	t-test	(0.570)	(0.082)*	(0.491)	(0.977)	(0.059)*	(0.042)**
	GS Test	(0.957)	(0.166)	(0.932)	(0.184)	(0.113)	(0.113)
	May's U Test	(0.926)	(0.909)	(0.861)	(0.982)	(0.742)	(0.588)
STOXX Europe 600 Banks		0.56%	1.35%	-0.80%	-0.53%	1.15%	1.54%
	t-test	(0.412)	(0.174)	(0.393)	(0.741)	(0.078)*	(0.214)
	GS Test	(0.172)	(0.085)*	(0.408)	(0.408)	(0.306)	(0.306)
	May's U Test	(0.414)	(0.683)	(0.627)	(0.680)	(0.620)	(0.637)
	Observations	31	31	8	8	9	9

Table A.4. Announcement effects of unconventional monetary policy measures: abnormal returns, by policy measure

This table presents the average cumulative abnormal returns ($\overline{CAR}$) of European market indices, for two event windows around the announcements of unconventional monetary policy measures: [0] and [-1; 1], where [0] is the announcement day. The results are shown for three subsamples of the categories of policy measures: Asset Purchases, Funding and Forward Guidance announcements. The abnormal returns were estimated using the mean-adjusted model. The p-values of the two-tailed t-test, the Generalized Sign Test (GS Test) and the May's U Test are presented in parentheses. ***, ** and * denote significance of ($\overline{CAR}$) at the 1%, 5% and 10% levels, respectively.

	Event window	[0]	[-1; 1]
FTSE 100		0.045	0.094
	t-test	(0.006)***	(0.035)**
Euro STOXX 50		0.063	0.133
	t-test	(0.003)***	(0.004)***
STOXX Europe 50		0.031	0.067
	t-test	(0.131)	(0.217)
STOXX Europe 600		-0.010	-0.024
	t-test	(0.576)	(0.601)
	Observations	57	57

Table A.5. Announcement effects of unconventional monetary policy measures: abnormal trading volumes, full sample

This table exhibits the overall average cumulative abnormal log-volumes ($\overline{CAV}$) of European equity indices, for two event windows around the announcements of unconventional monetary policy measures: [0] and [-1; 1], where [0] is the announcement day. The abnormal log-volumes were estimated using the mean-adjusted model. The p-values of the two-tailed t-test are presented in parentheses. ***, ** and * denote significance of ($\overline{CAV}$) at the 1%, 5% and 10% levels, respectively.

	Central bank	ECB		BoE		Fed	
	Event window	[0]	[-1; 1]	[0]	[-1; 1]	[0]	[-1; 1]
FTSE 100		0.069	0.135	0.028	0.076	0.001	0.006
	t-test	(0.012)**	(0.088)*	(0.382)	(0.496)	(0.955)	(0.914)
Euro STOXX 50		0.160	0.279	-0.007	-0.017	-0.021	0.024
	t-test	(0.000)***	(0.004)***	(0.761)	(0.775)	(0.260)	(0.541)
STOXX Europe 50		0.092	0.159	-0.005	0.041	-0.025	-0.028
	t-test	(0.013)**	(0.115)	(0.881)	(0.641)	(0.432)	(0.726)
STOXX Europe 600		-0.027	-0.064	-0.026	-0.105	0.019	0.068
	t-test	(0.407)	(0.428)	(0.613)	(0.386)	(0.470)	(0.351)
	Observations	22	22	11	11	20	20

Table A.6. Announcement effects of unconventional monetary policy measures: abnormal trading volumes, by central bank

This table presents the average cumulative abnormal log-volumes ($\overline{CAV}$) of European equity indices, for two event windows around the announcements of unconventional monetary policy measures: [0] and [-1; 1], where [0] is the announcement day. The results are shown for three subsamples: European Central Bank, Bank of England and Federal Reserve announcements. The abnormal log-volumes were estimated using the mean-adjusted model. The p-values of the two-tailed t-test are presented in parentheses. ***, ** and * denote significance of ($\overline{CAV}$) at the 1%, 5% and 10% levels, respectively.

		ECB			
	Category	Unconventional		Other announcements	
	Event window	[0]	[-1; 1]	[0]	[-1; 1]
FTSE 100		0.069	0.135	0.032	0.068
	t-test	(0.012)**	(0.088)*	(0.004)***	(0.012)**
Euro STOXX 50		0.160	0.279	0.055	0.089
	t-test	(0.000)***	(0.004)***	(0.001)***	(0.021)**
STOXX Europe 50		0.092	0.159	0.043	0.096
	t-test	(0.013)**	(0.115)	(0.003)***	(0.004)***
STOXX Europe 600		-0.027	-0.064	-0.003	0.013
	t-test	(0.407)	(0.428)	(0.837)	(0.680)
	Observations	22	22	61	61

Table A.7. ECB's announcement effects of monetary policy measures: abnormal trading volumes

This table shows the average cumulative abnormal log-volumes ($\overline{CAV}$) of European equity indices, for two event windows around announcements of ECB's monetary policy measures: [0] and [-1; 1], where [0] is the announcement day. The results are shown for two samples of announcements: announcements of unconventional policy measures and other announcements. These latter exclude announcements of changes in the official interest rates. The abnormal log-volumes were estimated using the mean-adjusted model. The p-values of the two-tailed t-test are presented in parentheses. ***, ** and * denote significance of ($\overline{CAV}$) at the 1%, 5% and 10% levels, respectively.

	Category	Asset Purchases		Funding		Forward Guidance	
	Event window	[0]	[-1; 1]	[0]	[-1; 1]	[0]	[-1; 1]
FTSE 100		0.044	0.082	-0.008	-0.030	0.010	0.025
	t-test	(0.029)**	(0.114)	(0.868)	(0.843)	(0.736)	(0.817)
Euro STOXX 50		0.068	0.148	0.036	-0.003	0.009	0.002
	t-test	(0.022)**	(0.016)**	(0.545)	(0.982)	(0.787)	(0.978)
STOXX Europe 50		0.034	0.069	-0.027	-0.118	0.003	0.030
	t-test	(0.280)	(0.346)	(0.593)	(0.415)	(0.931)	(0.800)
STOXX Europe 600		-0.017	-0.046	-0.054	-0.139	0.001	0.004
	t-test	(0.489)	(0.476)	(0.418)	(0.398)	(0.977)	(0.951)
	Observations	31	31	8	8	9	9

Table A.8. Announcement effects of unconventional monetary policy measures: abnormal trading volumes, by policy measure

This table lists the average cumulative abnormal log-volumes ($\overline{CAV}$) of European equity indices, for two event windows around announcements of unconventional monetary policy: [0] and [-1; 1], where [0] is the announcement day. The results are shown for three subsamples of the categories of policy measures: Asset Purchases, Funding and Forward Guidance announcements. The abnormal log-volumes were estimated using the mean-adjusted model. The p-values of the two-tailed t-test are presented in parentheses. ***, ** and * denote significance of ($\overline{CAV}$) at the 1%, 5% and 10% levels, respectively

Appendix B: List of the sample of announcements

This appendix details the sample of announcements included in our sample and gives a brief description of the selected announcements of unconventional monetary policy by the European Central Bank, the Bank of England and the Federal Reserve.

Event date	Programs	Brief description
28.03.2008	LTRO	ECB press release: "The Governing Council decided to conduct supplementary Longer-Term Refinancing Operations with a maturity of six months."
08.10.2008	FRFA	ECB press release: "[...] the weekly main refinancing operations will be carried out through a fixed rate tender procedure with full allotment [...]."
07.05.2009	CBPP1	ECB press conference: "The Eurosystem will purchase euro-denominated covered bonds issued in the Euro Area."
07.05.2009	LTRO	ECB press release: "The ECB has decided to conduct liquidity-providing Longer-Term Refinancing Operations with a maturity of one year."
04.06.2009	CBPP1	ECB press release: "Following-up on its decision to purchase euro-denominated covered bonds issued in the Euro Area, the Governing Council decided upon the technical modalities today. [...] The purchases, for an amount of €60 billion [...]."
03.12.2009	LTRO	ECB press release: "The Governing Council has decided to carry out the last six-month Longer-Term Refinancing Operations on 31 March 2010."
10.05.2010	SMP	ECB press release: "The Governing Council decided to conduct interventions in the Euro Area public and private debt securities markets (Securities Markets Programme)."
04.08.2011	LTRO	ECB press release: "The Governing Council has today decided to conduct a liquidity-providing supplementary Longer-Term Refinancing Operations with a maturity of approximately six months."
07.08.2011	SMP	Statement by the President of the ECB: " [...] It is on the basis of the above assessments that the ECB will actively implement its Securities Markets Programme."
06.10.2011	CBPP2	ECB press release: "The Governing Council has today decided to launch a new Covered Bond Purchase Programme (CBPP2). Purchases will be for an intended amount of €40 billion."
06.10.2011	LTRO	ECB press release: "The Governing Council [...] has today decided to conduct two longer-term refinancing operations, one with a maturity of approximately 12 months, to be conducted in October 2011, and the other with a maturity of approximately 13 months, to be conducted in December 2011."
03.11.2011	CBPP2	ECB press release: "Further to its decision to launch Covered Bond Purchase Programme 2, the Governing Council decided today upon the technical modalities of the programme."
08.12.2011	LTRO	ECB press release: "The Governing Council has decided to conduct two Longer-Term Refinancing Operations with a maturity of 36 months."
26.07.2012	FG	Speech by Mario Draghi, President of the ECB, at the Global Investment Conference: "Within our mandate, the ECB is ready to do whatever it takes to preserve the euro. And believe me, it will be enough."
02.08.2012	OMT	ECB press conference: "The Governing Council may undertake outright open market operations. This effort will be focused on the shorter part of the yield curve."

Table B.1. Panel A - European Central Bank - Part 1

Source: European Central Bank.
Notes: APP - Expanded Asset Purchase Programme; CBPP - Covered Bond Purchase Programme; ECB - European Central Bank; FG - Forward Guidance; FRFA - Fixed Rate Full Allotment; LTRO - Longer-Term Refinancing Operations; NDFIR - Negative Deposit Facility Interest Rate; OMT - Outright Monetary Transactions; SMP - Securities Markets Programme; TLTRO - Targeted Longer-Term Refinancing Operations.

Event date	Programs	Brief description
06.09.2012	OMT	ECB press release: "The Governing Council has today taken decisions on a number of technical features regarding the Eurosystem's outright transactions in secondary sovereign bond markets. [...] These will be known as Outright Monetary Transactions."
04.07.2013	FG	ECB press conference: "The Governing Council expects the key ECB interest rates to remain at present or lower levels for an extended period of time. [...] The Governing Council has taken the unprecedented step of giving Forward Guidance in a rather more specific way [...]."
05.06.2014	TLTRO	ECB press release: "The Governing Council has decided to conduct a series of Targeted Longer-Term Refinancing Operations [...] over a window of two years."
05.06.2014	NDFIR	ECB press release: "ECB introduces a negative Deposit Facility Interest Rate."
03.07.2014	TLTRO	ECB press release: "The Governing Council decided today on further technical details of a series of Targeted Longer-Term Refinancing Operations."
04.09.2014	APP	ECB press conference: "The Eurosystem will purchase a broad portfolio of simple and transparent asset-backed securities with underlying assets consisting of claims against the Euro Area non-financial private sector under an Asset-Backed Securities Purchase Programme. [...] will also purchase a broad portfolio of euro-denominated covered bonds issued by Monetary Financial Institutions domiciled in the Euro Area under a new Covered Bond Purchase Programme (CBPP3)."
02.10.2014	APP	ECB press release: "ECB announces operational details of Asset-Backed Securities Purchase Programme and Covered Bond Purchase Programme 3. Programmes will last at least two years."
06.11.2014	FG	ECB press conference: "In response to the request of the Governing Council, ECB staff and the relevant Eurosystem committees have stepped up the technical preparations for further measures."
22.01.2015	APP	ECB press conference: "The Governing Council decided that asset purchases should be expanded to include a secondary markets Public Sector Purchase Programme [...]. The combined monthly purchases of public and private sector securities will amount to €60 billion. They are intended to be carried out until end-September 2016 [...]."
03.12.2015	APP	ECB press conference: "We decided to extend the expanded Asset Purchase Programme. The monthly purchases of €60 billion under the expanded Asset Purchase Programme are now intended to run until the end of March 2017, or beyond, if necessary."
10.03.2016	APP	ECB press release: "ECB adds Corporate Sector Purchase Programme to the expanded Asset Purchase Programme [?]. Investment-grade euro-denominated bonds issued by non-bank corporations established in the Euro Area will be included in the list of assets eligible for regular purchases under a new Corporate Sector Purchase Programme [...]. Combined monthly purchases under the expanded Asset Purchase Programme are to increase to €80 billion from €60 billion."
10.03.2016	TLTRO	ECB press release: "Four new Targeted Longer-Term Refinancing Operations [...] will be conducted from June 2016 to March 2017 [...] will have a four-year maturity."
21.04.2016	APP	ECB press release: "ECB announces details of the Corporate Sector Purchase Programme."
08.12.2016	APP	ECB press release: "The Governing Council decided to continue its purchases under the APP at the current monthly pace of €80 billion until the end of March 2017. From April 2017, the net asset purchases are intended to continue at a monthly pace of €60 billion until the end of December 2017 [...]."

Table B.2. Panel A - European Central Bank - Part 2

Source: European Central Bank.
Notes: APP - Expanded Asset Purchase Programme; CBPP - Covered Bond Purchase Programme; ECB - European Central Bank; FG - Forward Guidance; FRFA - Fixed Rate Full Allotment; LTRO - Longer-Term Refinancing Operations; NDFIR - Negative Deposit Facility Interest Rate; OMT - Outright Monetary Transactions; SMP - Securities Markets Programme; TLTRO - Targeted Longer-Term Refinancing Operations.

Event date	Programs	Brief description
19.01.2009	APF	HMT statement: "The BoE will set up an asset purchase programme [?]. The Bank will be authorised by the Treasury to purchase high quality private sector assets, including paper issued under the Credit Guarantee Scheme, corporate bonds, commercial paper, syndicated loans and a limited range of asset backed securities created in viable securitisation structures. The Treasury will authorise initial purchases of up to £50bn."
05.03.2009	APF	MPC statement: "The BoE should finance £75 billion of asset purchases by the creation of central bank reserves."
07.05.2009	APF	MPC statement: "The BoE should finance a further £50 billion of asset purchases by the creation of central bank reserves, implying a total quantity of £125 billion of such asset purchases."
06.08.2009	APF	MPC statement: "The BoE should finance a further £50 billion of asset purchases by the creation of central bank reserves, implying a total quantity of £125 billion of such asset purchases."
05.11.2009	APF	MPC statement: "The BoE should finance a further £25 billion of asset purchases by the creation of central bank reserves, implying a total quantity of £200 billion of such asset purchases."
06.10.2011	APF	MPC statement: "The BoE should finance a further £75 billion of asset purchases by the issuance of central bank reserves, implying a total quantity of £275 billion of such asset purchases."
29.11.2011	APF	HMT statement: "Maximum private asset purchases reduced: HMT lowered the ceiling on Asset Purchase Facility private asset holdings from £50 billion to £10 billion."
09.02.2012	APF	MPC statement: "The BoE should finance a further £50 billion of asset purchases by the issuance of central bank reserves, implying a total quantity of £325 billion of such asset purchases."
05.07.2012	APF	MPC statement: "The BoE should finance a further £50 billion of asset purchases by the issuance of central bank reserves, implying a total quantity of £375 billion of such purchases."
13.07.2012	FLS	MPC statement: "The Funding for Lending Scheme is designed to incentivise banks and building societies to boost their lending to UK households and non-financial companies. The Funding for Lending Scheme will do this by providing funding to banks and building societies for an extended period [...]."
24.04.2013	FLS	MPC statement: "Extension to the Funding for Lending Scheme [...] an extension to the FLS by one year to allow drawdowns up to the end of January 2015."
07.08.2013	FG	MPC statement: "The MPC intends not to raise Bank Rate from its current level of 0.5% at least until [...] the unemployment rate has fallen to a threshold of 7% [...]. The MPC stands ready to undertake further asset purchases while the unemployment rate remains above 7% if it judges that additional monetary stimulus is warranted."
12.02.2014	FG	MPC statement: "The MPC sets policy to achieve the 2% inflation target [...] there remains scope to absorb spare capacity further before raising Bank Rate [...]. The MPC intends to maintain the stock of purchased assets at least until the first rise in Bank Rate."
04.08.2016	APF (CBPS)	MPC statement: "The BoE will purchase sterling corporate bonds [...] of up to £10 billion. [...] as expansion of the asset purchase scheme for UK government bonds of £60 billion, taking the total stock of these asset purchases to £435 billion.
04.08.2016	APF (TFS)	MPC statement: [...] the MPC is launching a Term Funding Scheme that will provide funding for banks at interest rates close to Bank Rate.

Table B.3. Panel B - Bank of England

Source: Bank of England.
Notes: APF - Asset Purchase Facility; BoE - Bank of England; CBPS - Corporate Bond Purchase Scheme; FG - Forward Guidance; FLS - Funding for Lending Scheme; HMT - Her Majesty's Treasury; MPC - Monetary Policy Committee; TFS - Term Funding Scheme.

Event date	Programs	Brief description
25.11.2008	LSAP1	FOMC statement: "The Fed announced that it will initiate a program to purchase the direct obligations of housing-related government-sponsored enterprises [...] and mortgage-backed securities [...]. Purchases of up to $100 billion in government-sponsored enterprises direct obligations will be conducted [...]. Purchases of up to $500 billion in mortgage-backed securities will be conducted [...]."
16.12.2008	FG	FOMC statement: "The Committee anticipates that weak economic conditions are likely to warrant exceptionally low levels of the federal funds rate for some time."
18.03.2009	LSAP1	FOMC statement: "[...] the Committee decided today [...] purchasing up to an additional $750 billion of agency mortgage-backed securities, bringing its total purchases of these securities to up to $1.25 trillion this year, and to increase its purchases of agency debt this year by up to $100 billion to a total of up to $200 billion. [...] decided to purchase up to $300 billion of longer-term Treasury securities over the next six months."
18.03.2009	FG	FOMC statement: "The Committee [...] anticipates that weak economic conditions are likely to warrant exceptionally low levels of the federal funds rate for an extended period."
12.08.2009	LSAP1	FOMC statement: "[...] the Committee has decided to gradually slow the pace of these transactions and anticipates that the full amount will be purchased by the end of October."
23.09.2009	LSAP1	FOMC statement: "[...] agency mortgage-backed securities [...] agency debt. The Committee will gradually slow the pace of these purchases [...] and anticipates that they will be executed by the end of the first quarter of 2010."
04.11.2009	LSAP1	FOMC statement: "[...] the Fed will purchase about $175 billion of agency debt. The amount of agency debt purchases, while somewhat less than the previously announced maximum of $200 billion [...]"
03.11.2010	LSAP2	FOMC statement: "[...] the Committee intends to purchase a further $600 billion of longer-term Treasury securities by the end of the second quarter of 2011."
09.08.2011	FG	FOMC statement: "The Committee currently anticipates that economic conditions [...] are likely to warrant exceptionally low levels for the federal funds rate at least through mid-2013."
21.09.2011	MEP	FOMC statement: "The Committee intends to purchase, by the end of June 2012, $400 billion of Treasury securities with remaining maturities of 6 years to 30 years and to sell an equal amount of Treasury securities with remaining maturities of 3 years or less."
25.01.2012	FG	FOMC statement: "The Committee [...] currently anticipates that economic conditions [...] are likely to warrant exceptionally low levels for the federal funds rate at least through late 2014.
20.06.2012	MEP	FOMC statement: "The Committee decided to continue through the end of the year its program to extend the average maturity of its holdings of securities."
13.09.2012	LSAP3	FOMC statement: "The Committee agreed today [...] purchasing additional agency mortgage-backed securities at a pace of $40 billion per month."
13.09.2012	FG	FOMC statement: "The Committee [...] currently anticipates that exceptionally low levels for the federal funds rate are likely to be warranted at least through mid-2015. [...] If the outlook for the labor market does not improve substantially, the Committee will continue its purchases of agency mortgage-backed securities, undertake additional asset purchases, and employ its other policy tools as appropriate until such improvement is achieved in a context of price stability."
12.12.2012	LSAP3	FOMC statement: "The Committee also will purchase longer-term Treasury securities after its program to extend the average maturity of its holdings of Treasury securities is completed at the end of the year, initially at a pace of $45 billion per month."

Table B.4. Panel C - Federal Reserve - Part 1

Source: Federal Reserve.
Notes: Fed - Federal Reserve; FG - Forward Guidance; FOMC - Federal Open Market Committee; LSAP - Large-Scale Asset Purchase Program; MEP - Maturity Extension Program.

Event date	Programs	Brief description
12.12.2012	FG	FOMC statement: "The Committee [...] currently anticipates that this exceptionally low range for the federal funds rate will be appropriate at least as long as the unemployment rate remains above 6.5 percent, inflation between one and two years ahead is projected to be no more than a half percentage point above the Committee...s 2 percent longer-run goal, and longer-term inflation expectations continue to be well anchored."
18.12.2013	LSAP3	FOMC statement: "Beginning in January, the Committee will add to its holdings of agency mortgage-backed securities at a pace of $35 billion per month rather than $40 billion per month, and will add to its holdings of longer-term Treasury securities at a pace of $40 billion per month rather than $45 billion per month."
29.01.2014	LSAP3	FOMC statement: "Beginning in February, the Committee will add to its holdings of agency mortgage-backed securities at a pace of $30 billion per month rather than $35 billion per month, and will add to its holdings of longer-term Treasury securities at a pace of $35 billion per month rather than $40 billion per month."
19.03.2014	LSAP3	FOMC statement: "Beginning in April, the Committee will add to its holdings of agency mortgage-backed securities at a pace of $25 billion per month rather than $30 billion per month, and will add to its holdings of longer-term Treasury securities at a pace of $30 billion per month rather than $35 billion per month."
30.04.2014	LSAP3	FOMC statement: "Beginning in May, the Committee will add to its holdings of agency mortgage-backed securities at a pace of $20 billion per month rather than $25 billion per month, and will add to its holdings of longer-term Treasury securities at a pace of $25 billion per month rather than $30 billion per month."
18.06.2014	LSAP3	FOMC statement: "Beginning in July, the Committee will add to its holdings of agency mortgage-backed securities at a pace of $15 billion per month rather than $20 billion per month, and will add to its holdings of longer-term Treasury securities at a pace of $20 billion per month rather than $25 billion per month."
30.07.2014	LSAP3	FOMC statement: "Beginning in August, the Committee will add to its holdings of agency mortgage-backed securities at a pace of $10 billion per month rather than $15 billion per month, and will add to its holdings of longer-term Treasury securities at a pace of $15 billion per month rather than $20 billion per month."
17.09.2014	LSAP3	FOMC statement: "Beginning in October, the Committee will add to its holdings of agency mortgage-backed securities at a pace of $5 billion per month rather than $10 billion per month, and will add to its holdings of longer-term Treasury securities at a pace of $10 billion per month rather than $15 billion per month."
18.03.2015	FG	FOMC statement: "The Committee judges that an increase in the target range for the federal funds rate remains unlikely at the April FOMC meeting. [...] this change in forward guidance [...]."
16.12.2015	FG	FOMC statement: "The Committee expects that economic conditions will evolve in a manner that will warrant only gradual increases in the federal funds rate; The federal funds rate is likely to remain, for some time, below levels that are expected to prevail in the longer run."

Table B.5. Panel C - Federal Reserve - Part 2

Source: Federal Reserve.
Notes: Fed - Federal Reserve; FG - Forward Guidance; FOMC - Federal Open Market Committee; LSAP - Large-Scale Asset Purchase Program; MEP - Maturity Extension Program.

10.04.2008;	08.05.2008;	05.06.2008;	07.08.2008;	04.09.2008;	02.10.2008;	05.02.2009;
02.07.2009;	03.09.2009;	08.10.2009;	05.11.2009;	14.01.2010;	04.02.2010;	04.03.2010;
08.04.2010;	10.06.2010;	08.07.2010;	05.08.2010;	02.09.2010;	07.10.2010;	04.11.2010;
02.12.2010;	13.01.2011;	03.02.2011;	03.03.2011;	05.05.2011;	09.06.2011;	08.09.2011;
12.01.2012;	09.02.2012;	08.03.2012;	04.04.2012;	03.05.2012;	06.06.2012;	04.10.2012;
08.11.2012;	06.12.2012;	10.01.2013;	07.02.2013;	07.03.2013;	04.04.2013;	06.06.2013;
01.08.2013;	05.09.2013;	02.10.2013;	05.12.2013;	09.01.2014;	06.02.2014;	06.03.2014;
03.04.2014;	08.05.2014;	07.08.2014;	04.12.2014;	05.03.2015;	15.04.2015;	03.06.2015;
16.07.2015;	03.09.2015;	22.10.2015;	21.01.2016;	02.06.2016;	21.07.2016;	08.09.2016;
20.10.2016						

Table B.6. Panel D – Other ECB announcements of monetary policy

Appendix C: Methodological note

C.1. Abnormal returns: measurement and significance tests

The model used in our study for measuring abnormal returns is the mean-adjusted model. Notwithstanding its simplicity, Brown and Warner (1980, 1985) find that the mean-adjusted model frequently leads to similar results to those of more complex models. The mean-adjusted model can be formulated as:

$$R_t = E(R_t) + AR_t \tag{C.1}$$

where R_t is the period-t return of a particular index, $E(R_t)$ is the expected return of that index, calculated from the estimation window, and AR_t is the time period t disturbance term, with an expected value of zero and variance equal to ${\sigma_{AR}}^2$. $E(R_t)$ is calculated as follows, with $T_1 = 200$:

$$E(R_t) = \frac{1}{T_1} \sum_{t=1}^{T_1} R_t \tag{C.2}$$

By aggregating the periodic residuals over an event window (T_2 days around the announcement date), we obtain the cumulative abnormal return of a particular index, with regard to announcement i, CAR_i:

$$CAR_i = \sum_{t=1}^{T_2} AR_t \tag{C.3}$$

To calculate the average cumulative abnormal return of a particular index, originated by a set of similar announcements n, $\overline{CAR_n}$, we can aggregate the cumulative abnormal returns over announcements through time:

$$\overline{CAR_n} = \frac{1}{N} \sum_{i=1}^{N} CAR_i \tag{C.4}$$

where CAR_i is defined as above and N is the number of announcements. We can test the significance of the average cumulative abnormal return, generated by a set of announcements *n*, $\overline{CAR_n}$, through the t-test. This parametric test relies on the assumption that abnormal returns are normally distributed. In this context, the null hypothesis is that the average cumulative abnormal return is equal to zero, while the alternative hypothesis establishes that it is different from zero. The standard statistic for this test follows a Student's t-distribution:

$$t = \frac{\overline{CAR_n}}{S(\overline{CAR_n})} \tag{C.5}$$

where $(\overline{CAR_n})$ is an estimate of the standard deviation of the average cumulative abnormal return, $\sigma(\overline{CAR_n})$. The standard deviation of the cumulative abnormal

returns, *S(CAR)*, is estimated on the basis of the cross-sectional event window cumulative abnormal returns. We test the robustness of the results using instead the estimate of *S(CAR)*, given by the time series of the average abnormal returns over the estimation window. To account for the possibility of non-normality of the abnormal returns, we also use a non-parametric test. The test performed is the Generalized Sign Test, whose null hypothesis establishes that the proportion of positive (cumulative) abnormal returns computed across event periods equals the fraction of positive abnormal returns on the estimation period. The alternative hypothesis is that the proportion is different from that prior. The statistic GS has an approximate unit normal distribution:

$$GS = \frac{|p_0 - p|}{\sqrt{\frac{p(1-p)}{N}}} \tag{C.6}$$

where p_0 is the observed proportion of positive (cumulative) abnormal returns computed over multiple event windows, p is the average proportion of days with positive abnormal returns on the estimation window and N is the number of announcements. Given that we do not control for surprises and some of these policy measures may lead to positive or negative market reactions (above, below or even against expectations), we test whether, on average, the effect is significant regardless of the sign of the (cumulative) abnormal returns. For that, we propose to apply the May's U Test. This enables us to assess changes in the variance of abnormal returns following the events. The test statistic of this non-parametric test is:

$$U_i = \left| \frac{CAR_i}{S(CAR_i)} \right| \tag{C.7}$$

and, if abnormal returns are normally distributed, the absolute value of the standardized residual (U_i) is asymptotically distributed as $F(1, T_1 - d)$. The normal approximation applies for sums of random variables, so the test statistic

$$Z = \frac{\sum_{i=1}^{N} U_i - N\frac{T_1-d}{T_1-d-2}}{\sqrt{N\frac{2(T_1-d)^2(T_1-d-1)}{(T_1-d-2)^2(T_1-d-4)}}} \tag{C.8}$$

is distributed unit normal. As before, N is the number of announcements, T_1 is the number of days in the estimation period (200) and d is equal to 1. The null hypothesis is that the variance of abnormal returns does not change, whereas the alternative hypothesis establishes that it changes (increases or decreases).

C.2. Abnormal trading: measurement and significance tests

The study of abnormal trading around announcement dates of unconventional monetary policy will be only applied to FTSE 100, Euro STOXX 50, STOXX Europe 50 and STOXX Europe 600. This is due to the fact that we did not find data for the trading volumes of the other indices analyzed in this study. Ajinkya and Jain (1989) report that the distributions of the prediction errors for the untransformed trading volume measure often indicate departure from normality. Because standard parametric statistical tests rely on the assumption that the variable to be tested follows a normal distribution, we apply a natural logarithmic transformation to the daily number of common shares traded. To determine abnormal trading, we use the mean-adjusted model, which is analogous to the model we use to measure abnormal returns, and is formulated as:

$$V_t = E(V_t) + AV_t \tag{C.9}$$

where V_t is the period-t log-volume of a particular index, $E(V_t)$ is the expected log-volume of that index, calculated from the estimation period, and AV_t is the time period *t* disturbance term, with an expected value of zero and variance equal to ${\sigma_{\text{AV}}}^2$ is determined as follows, with $T_1 = 100$:

$$E(V_t) = \frac{1}{T_1} \sum_{t=1}^{T_1} V_t \tag{C.10}$$

The cumulative abnormal log-volume of a particular index, over the event window of a given announcement *i*, CAV_i, is obtained by summing the periodic residuals over an event window (T_2 days around the announcement date):

$$CAV_i = \sum_{t=1}^{T_2} AV_t \tag{C.11}$$

The average cumulative abnormal log-volume of a particular index, generated by a set of similar announcements *n*, $\overline{CAV_n}$, is given by:

$$\overline{CAV_n} = \frac{1}{N} \sum_{i=1}^{N} CAV_i \tag{C.12}$$

where CAV_i is defined as above and *N* is the number of announcements. The parametric test is the *t*-test, which assesses if the average cumulative abnormal log-volume, for a set of announcements *n*, (CAV_n), is significantly different from zero. The null hypothesis is that the average cumulative abnormal log-volume is equal to zero, whereas the alternative hypothesis establishes that this parameter is different from zero. The standard statistic for this test follows a Student's *t*-distribution:

$$t = \frac{\overline{CAV_n}}{S(\overline{CAV_n})} \tag{C.13}$$

where $S(CAV_n)$ is an estimate of the standard deviation of the average cumulative abnormal log-volume, $\sigma(\overline{CAV_n})$. The standard deviation of the cumulative abnormal log-volumes, $S(CAV)$ is estimated on the basis of the cross-sectional cumulative abnormal log-volumes. We look at the robustness of the results using estimating $S(CAV)$ from the time series of the average abnormal log-volumes over the estimation period.

Appendix D: Appendix III – Additional tables

D.1. t-test statistics using the standard deviation of the abnormal returns in the estimation window

The tables below show the results if the t-test statistics are obtained using the estimate of standard deviation computed from the time series of the average abnormal returns over the estimation window. The average cumulative abnormal returns ($\overline{CAR}$) of European market indices are listed, for two event windows around announcements of unconventional monetary policy measures: [0] and [-1; 1], where [0] is the announcement day. The results are shown for the overall sample, three subsamples of central banks (European Central Bank, Bank of England and Federal Reserve announcements) and three subsamples of policy measures (Asset Purchases, Funding and Forward Guidance announcements). The abnormal returns were estimated using the mean-adjusted model. The p-values of the two-tailed t-test are presented in parentheses. ***, ** and * denote significance of $\overline{CAR}$ at the 1%, 5% and 10% levels, respectively.

	Event window	[0]	[-1; 1]
FTSE Gilts All-Stocks Index		-0.02%	-0.11%
	t-test	(0.678)	(0.301)
FTSE MTS Eurozone Government Bond Index		-0.01%	0.03%
	t-test	(0.873)	(0.588)
FTSE 100		0.12%	0.80%
	t-test	(0.518)	(0.017)**
Euro STOXX 50		0.22%	1.02%
	t-test	(0.324)	(0.010)**
STOXX Europe 50		0.10%	0.67%
	t-test	(0.626)	(0.051)*
STOXX Europe 600		0.12%	0.73%
	t-test	(0.544)	(0.030)**
STOXX Europe 600 Banks		0.41%	1.25%
	t-test	(0.177)	(0.020)**
	Observations	57	57

Table D.1. Abnormal returns – full sample

	Central bank	ECB		BoE		Fed	
	Event window	[0]	[-1; 1]	[0]	[-1; 1]	[0]	[-1; 1]
FTSE Gilts All-Stocks Index		-0.19%	-0.44%	0.20%	0.29%	0.09%	0.12%
	t-test	(0.044)**	(0.010)**	(0.186)	(0.272)	(0.368)	(0.473)
FTSE MTS Eurozone Government Bond Index		-0.04%	-0.02%	0.02%	0.05%	0.05%	0.08%
	t-test	(0.456)	(0.782)	(0.859)	(0.733)	(0.386)	(0.408)
FTSE 100		-0.09%	0.11%	0.02%	1.14%	0.13%	1.12%
	t-test	(0.743)	(0.799)	(0.966)	(0.196)	(0.693)	(0.061)*
Euro STOXX 50		0.37%	0.71%	-0.04%	1.21%	0.06%	1.22%
	t-test	(0.263)	(0.210)	(0.944)	(0.241)	(0.869)	(0.076)*
STOXX Europe 50		0.06%	0.18%	0.04%	1.14%	0.02%	0.90%
	t-test	(0.828)	(0.698)	(0.942)	(0.212)	(0.943)	(0.143)
STOXX Europe 600		0.07%	0.25%	0.00%	1.19%	0.06%	0.91%
	t-test	(0.807)	(0.600)	(0.996)	(0.185)	(0.853)	(0.126)
STOXX Europe 600 Banks		0.74%	1.29%	-0.69%	0.07%	0.53%	1.67%
	t-test	(0.100)*	(0.096)*	(0.393)	(0.961)	(0.307)	(0.073)*
	Observations	22	22	11	11	20	20

Table D.2. Abnormal returns, by central bank

		ECB			
	Category	Unconventional		Other announcements	
	Event window	[0]	[-1; 1]	[0]	[-1; 1]
FTSE Gilts All-Stocks Index		-0.19%	-0.44%	-0.07%	-0.01%
	t-test	(0.044)**	(0.010)**	(0.205)	(0.909)
FTSE MTS Eurozone Government Bond Index		-0.04%	-0.02%	0.02%	0.11%
	t-test	(0.456)	(0.782)	(0.549)	(0.040)**
FTSE 100		-0.09%	0.11%	0.03%	0.01%
	t-test	(0.743)	(0.799)	(0.852)	(0.968)
Euro STOXX 50		0.37%	0.71%	0.10%	0.26%
	t-test	(0.263)	(0.210)	(0.590)	(0.431)
STOXX Europe 50		0.06%	0.18%	0.05%	0.15%
	t-test	(0.828)	(0.698)	(0.768)	(0.581)
STOXX Europe 600		0.07%	0.25%	0.09%	0.20%
	t-test	(0.807)	(0.600)	(0.555)	(0.469)
STOXX Europe 600 Banks		0.74%	1.29%	0.19%	0.66%
	t-test	(0.100)*	(0.096)*	(0.453)	(0.129)
	Observations	22	22	61	61

Table D.3. Abnormal returns – ECB's monetary policy measures

	Category	Asset Purchases		Funding		Forward Guidance	
	Event window	[0]	[-1; 1]	[0]	[-1; 1]	[0]	[-1; 1]
FTSE Gilts All-Stocks Index		-0.11%	-0.10%	0.05%	-0.35%	0.06%	0.27%
	t-test	(0.188)	(0.458)	(0.727)	(0.213)	(0.671)	(0.292)
FTSE MTS Eurozone Government Bond Index		-0.05%	0.00%	-0.09%	-0.17%	0.19%	0.16%
	t-test	(0.261)	(0.953)	(0.306)	(0.293)	(0.051)*	(0.296)
FTSE 100		0.09%	1.01%	-0.59%	-0.20%	0.71%	1.48%
	t-test	(0.727)	(0.036)**	(0.217)	(0.801)	(0.110)	(0.063)*
Euro STOXX 50		0.25%	1.18%	-0.51%	0.01%	1.11%	1.88%
	t-test	(0.421)	(0.036)**	(0.364)	(0.987)	(0.054)*	(0.059)*
STOXX Europe 50		0.16%	0.98%	-0.63%	-0.28%	0.76%	1.28%
	t-test	(0.557)	(0.050)*	(0.193)	(0.725)	(0.106)	(0.115)
STOXX Europe 600		0.19%	0.95%	-0.59%	-0.04%	0.75%	1.34%
	t-test	(0.484)	(0.052)*	(0.224)	(0.964)	(0.106)	(0.097)*
STOXX Europe 600 Banks		0.56%	1.35%	-0.80%	-0.53%	1.15%	1.54%
	t-test	(0.203)	(0.078)*	(0.309)	(0.687)	(0.104)	(0.192)
	Observations	31	31	8	8	9	9

Table D.4. Abnormal returns, by policy measure

D.2. t-test statistics using the standard deviation of the abnormal trading volumes in the estimation window

The tables below show the results if the t-test statistics are obtained using the estimate of standard deviation computed from the time series of the average abnormal log-volumes over the estimation window. The average cumulative abnormal log-volumes ($\overline{CAV}$) of European equity indices are listed, for two event windows around announcements of unconventional monetary policy measures: [0] and [-1; 1], where [0] is the announcement day. The results are shown for the overall sample, three subsamples of central banks (European Central Bank, Bank of England and Federal Reserve announcements) and three subsamples of policy measures (Asset Purchases, Funding and Forward Guidance announcements). The abnormal log-volumes were estimated using the mean-adjusted model. The p-values of the two-tailed t-test are presented in parentheses. ***, ** and * denote significance of $\overline{CAV}$ at the 1%, 5% and 10% levels, respectively

	Event window	[0]	[-1; 1]
FTSE 100		0.045	0.094
	t-test	(0.005)***	(0.001)***
Euro STOXX 50		0.063	0.133
	t-test	(0.000)***	(0.000)***
STOXX Europe 50		0.031	0.067
	t-test	(0.087)*	(0.036)**
STOXX Europe 600		-0.010	-0.024
	t-test	(0.514)	(0.371)
	Observations	57	57

Table D.5. Abnormal trading volumes – full sample

	Central bank	ECB		BoE		Fed	
	Event window	[0]	[-1; 1]	[0]	[-1; 1]	[0]	[-1; 1]
FTSE 100		0.069	0.135	0.028	0.076	0.001	0.006
	t-test	(0.014)**	(0.007)***	(0.451)	(0.240)	(0.962)	(0.903)
Euro STOXX 50		0.160	0.279	-0.007	-0.017	-0.021	0.024
	t-test	(0.000)***	(0.000)***	(0.861)	(0.813)	(0.466)	(0.639)
STOXX Europe 50		0.092	0.159	-0.005	0.041	-0.025	-0.028
	t-test	(0.006)***	(0.006)***	(0.908)	(0.586)	(0.402)	(0.594)
STOXX Europe 600		-0.027	-0.064	-0.026	-0.105	0.019	0.068
	t-test	(0.309)	(0.164)	(0.490)	(0.127)	(0.462)	(0.141)
	Observations	22	22	11	11	20	20

Table D.6. Abnormal trading volumes, by central bank

		ECB			
	Category	Unconventional		Other announcements	
	Event window	[0]	[-1; 1]	[0]	[-1; 1]
FTSE 100		0.069	0.135	0.032	0.068
	t-test	(0.014)**	(0.007)***	(0.049)**	(0.016)**
Euro STOXX 50		0.160	0.279	0.055	0.089
	t-test	(0.000)***	(0.000)***	(0.003)***	(0.005)***
STOXX Europe 50		0.092	0.159	0.043	0.096
	t-test	(0.006)***	(0.006)***	(0.017)**	(0.002)***
STOXX Europe 600		-0.027	-0.064	-0.003	0.013
	t-test	(0.309)	(0.164)	(0.850)	(0.578)
	Observations	22	22	61	61

Table D.7. Abnormal trading volumes – ECB's monetary policy measures

	Category	Asset Purchases		Funding		Forward Guidance	
	Event window	[0]	[-1; 1]	[0]	[-1; 1]	[0]	[-1; 1]
FTSE 100		0.044	0.082	-0.008	-0.030	0.010	0.025
	t-test	(0.043)**	(0.032)**	(0.854)	(0.699)	(0.801)	(0.730)
Euro STOXX 50		0.068	0.148	0.036	-0.003	0.009	0.002
	t-test	(0.006)***	(0.001)***	(0.445)	(0.970)	(0.834)	(0.978)
STOXX Europe 50		0.034	0.069	-0.027	-0.118	0.003	0.030
	t-test	(0.175)	(0.111)	(0.598)	(0.211)	(0.952)	(0.721)
STOXX Europe 600		-0.017	-0.046	-0.054	-0.139	0.001	0.004
	t-test	(0.433)	(0.220)	(0.231)	(0.093)*	(0.981)	(0.951)
	Observations	31	31	8	8	9	9

Table D.8. Abnormal trading volumes, by policy measure

D.3. Abnormal returns for other event windows

The table below shows the average cumulative abnormal returns ($\overline{CAR}$) of European market indices, for four event windows around all the sample announcements of unconventional monetary policy measures: [-1; 0], [-2; 0], [-3; 0] and [0; 1], where [0] is the announcement day. The abnormal returns were estimated using the mean-adjusted model. The p-values of the two-tailed t-test, the Generalized Sign test (GS Test) and the May's U test are presented in parentheses. ***, ** and * denote significance of $\overline{CAR}$ at the 1%, 5% and 10% levels, respectively.

	Event window	[-3; 0]	[-2; 0]	[-1; 0]	[0; 1]
FTSE Gilts All-Stocks Index		-0.06%	-0.12%	-0.18%	0.05%
	t-test	(0.634)	(0.254)	(0.052)*	(0.713)
	GS Test	(0.557)	(0.264)	(0.015)**	(0.167)
	May's U Test	(0.337)	(0.253)	(0.320)	(0.924)
FTSE MTS Eurozone Government Bond Index		0.00%	-0.06%	-0.05%	0.07%
	t-test	(0.988)	(0.314)	(0.407)	(0.380)
	GS Test	(0.427)	(0.064)*	(0.597)	(0.999)
	May's U Test	(0.328)	(0.200)	(0.499)	(0.089)*
FTSE 100		0.02%	0.23%	0.67%	0.27%
	t-test	(0.968)	(0.529)	(0.032)**	(0.334)
	GS Test	(0.375)	(0.093)*	(0.013)**	(0.156)
	May's U Test	(0.800)	(0.743)	(0.971)	(0.777)
Euro STOXX 50		0.20%	0.38%	0.84%	0.43%
	t-test	(0.669)	(0.391)	(0.034)**	(0.298)
	GS Test	(0.120)	(0.120)	(0.069)*	(0.002)***
	May's U Test	(0.655)	(0.596)	(0.881)	(0.642)
STOXX Europe 50		0.02%	0.17%	0.59%	0.20%
	t-test	(0.952)	(0.666)	(0.069)*	(0.555)
	GS Test	(0.269)	(0.269)	(0.102)	(0.030)*
	May's U Test	(0.702)	(0.712)	(0.897)	(0.772)
STOXX Europe 600		0.01%	0.16%	0.59%	0.29%
	t-test	(0.985)	(0.686)	(0.068)*	(0.379)
	GS Test	(0.354)	(0.508)	(0.012)**	(0.047)**
	May's U Test	(0.709)	(0.686)	(0.994)	(0.775)
STOXX Europe 600 Banks		0.20%	0.41%	1.03%	0.67%
	t-test	(0.790)	(0.526)	(0.054)*	(0.234)
	GS Test	(0.252)	(0.539)	(0.027)**	(0.014)**
	May's U Test	(0.772)	(0.823)	(0.775)	(0.622)
	Observations	57	57	57	57

D.4. Abnormal returns using a different categorization of policy measures

The table below presents the average cumulative abnormal returns ($\overline{CAR}$) of European market indices, for two event windows around announcements of unconventional monetary policy measures: [0] and [-1; 1], where [0] is the announcement day. The results are shown by three subsamples of policy measures: Asset Purchases, Funding and Forward Guidance announcements. The announcements of 26.07.2012 and 06.11.2014 are classified as Asset Purchases instead of Forward Guidance. The abnormal returns were estimated using the mean-adjusted model. The p-values of the two-tailed t-test, the Generalized Sign Test (GS Test) and the May's U Test are presented in parentheses. ***, ** and * denote significance of $\overline{CAR}$ at the 1%, 5% and 10% levels, respectively.

	Category	Asset Purchases		Funding		Forward Guidance	
	Event window	[0]	[-1; 1]	[0]	[-1; 1]	[0]	[-1; 1]
FTSE Gilts All-Stocks Index		-0.11%	-0.12%	0.05%	-0.35%	0.10%	0.43%
	t-test	(0.362)	(0.516)	(0.628)	(0.156)	(0.535)	(0.403)
	GS Test	(0.481)	(0.292)	(0.871)	(0.114)	(0.246)	(0.725)
	May's U Test	(0.952)	(0.408)	(0.333)	(0.564)	(0.609)	(0.769)
FTSE MTS Eurozone Government Bond Index		-0.02%	0.03%	-0.09%	-0.17%	0.12%	0.09%
	t-test	(0.760)	(0.779)	(0.228)	(0.380)	(0.239)	(0.589)
	GS Test	(0.228)	(0.612)	(0.106)	(0.843)	(0.271)	(0.680)
	May's U Test	(0.515)	(0.733)	(0.585)	(0.925)	(0.586)	(0.533)
FTSE 100		0.14%	1.08%	-0.59%	-0.20%	0.67%	1.29%
	t-test	(0.557)	(0.021)**	(0.409)	(0.819)	(0.253)	(0.089)*
	GS Test	(0.123)	(0.123)	(0.471)	(0.488)	(0.302)	(0.074)*
	May's U Test	(0.353)	(0.797)	(0.790)	(0.547)	(0.564)	(0.999)
Euro STOXX 50		0.38%	1.36%	-0.51%	0.01%	0.76%	1.26%
	t-test	(0.399)	(0.034)**	(0.604)	(0.991)	(0.150)	(0.160)
	GS Test	(0.046)**	(0.019)**	(0.938)	(0.136)	(0.262)	(0.262)
	May's U Test	(0.608)	(0.707)	(0.737)	(0.754)	(0.509)	(0.549)
STOXX Europe 50		0.23%	1.07%	-0.63%	-0.28%	0.61%	0.95%
	t-test	(0.472)	(0.043)**	(0.495)	(0.836)	(0.154)	(0.211)
	GS Test	(0.256)	(0.011)**	(0.961)	(0.038)**	(0.257)	(0.257)
	May's U Test	(0.975)	(0.763)	(0.861)	(0.864)	(0.839)	(0.493)
STOXX Europe 600		0.26%	1.04%	-0.59%	-0.04%	0.57%	1.00%
	t-test	(0.417)	(0.045)**	(0.491)	(0.977)	(0.149)	(0.155)
	GS Test	(0.770)	(0.092)*	(0.932)	(0.184)	(0.295)	(0.295)
	May's U Test	(0.908)	(0.854)	(0.861)	(0.982)	(0.668)	(0.439)
STOXX Europe 600 Banks		0.64%	1.49%	-0.80%	-0.53%	0.94%	0.94%
	t-test	(0.326)	(0.119)	(0.393)	(0.741)	(0.114)	(0.437)
	GS Test	(0.182)	(0.093)*	(0.408)	(0.408)	(0.255)	(0.255)
	May's U Test	(0.415)	(0.699)	(0.627)	(0.680)	(0.540)	(0.607)
	Observations	33	33	8	8	7	7

D.5. Abnormal trading volumes using a different categorization of policy measures

The table below lists the average cumulative abnormal log-volumes ($\overline{CAV}$) of European equity indices, for two event windows around announcements of unconventional monetary policy measures: [0] and [-1; 1], where [0] is the announcement day. The results are shown by three subsamples of policy measures: Asset Purchases, Funding and Forward Guidance. The announcements of 26.07.2012 and 06.11.2014 are classified as Asset Purchases instead of Forward Guidance. The abnormal log-volumes were estimated using the mean-adjusted model. The p-values of the two-tailed t-test are presented in parentheses. ***, ** and * denote significance of $\overline{CAV}$ at the 1%, 5% and 10% levels, respectively.

	Category	Asset Purchases		Funding		Forward Guidance	
	Event window	[0]	[-1; 1]	[0]	[-1; 1]	[0]	[-1; 1]
FTSE 100	$\overline{CAR}$	0.043	0.076	-0.008	-0.030	0.005	0.037
	t-test	(0.024)**	(0.130)	(0.868)	(0.843)	(0.886)	(0.772)
Euro STOXX 50	$\overline{CAR}$	0.072	0.149	0.036	-0.003	-0.027	-0.043
	t-test	(0.011)**	(0.011)**	(0.545)	(0.982)	(0.404)	(0.616)
STOXX Europe 50	$\overline{CAR}$	0.038	0.072	-0.027	-0.118	-0.025	0.002
	t-test	(0.201)	(0.296)	(0.593)	(0.415)	(0.489)	(0.989)
STOXX Europe 600	$\overline{CAR}$	-0.022	-0.050	-0.054	-0.139	0.029	0.036
	t-test	(0.350)	(0.413)	(0.418)	(0.398)	(0.396)	(0.653)
	Observations	33	33	8	8	7	7

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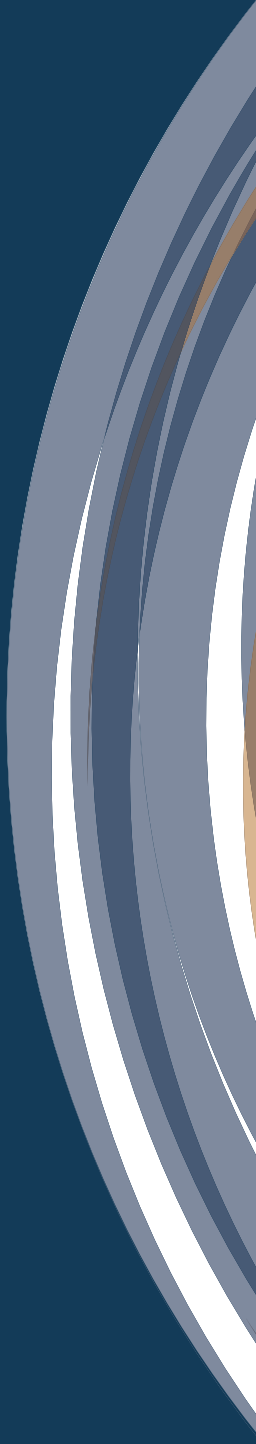

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