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Stock market effects of unconventional monetary policy in Europe and establishing a credit channel of monetary policy

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Abstract: In this paper I examine the effects of unconventional monetary policy announcements by the ECB on European stock markets. Comparing three different event study approaches, I develop an event study methodology robust to the heteroscedasticity and autocorrelation exhibited in daily stock returns. I find that most unconventional monetary policy announcements had significant and positive stock market effects in Europe, with peripheral (GIIPS) countries' stock markets reacting stronger than their northern counterparts. Using the cross-sectional difference in industry dependence on external finance, I also provide evidence for a credit channel of unconventional monetary policy through the stock market for the LTRO program, as financially constrained firms' stock prices reacted significantly more positive to these announcements than unconstrained firms. Using this methodology I find less strong evidence for a credit channel for the SMP and OMT program.

Keywords: *Unconventional Monetary Policy, Asset Prices, Event Study, Quantitative Easing, Credit Channel, External Finance Dependence*

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1 Introduction

During the European Sovereign Debt crisis, the ECB resorted to a number of temporary so-called unconventional monetary policy measures. These included the Securities Market Program (SMP), in which the ECB directly bought government debt from Eurozone countries in distress, Long Term Refinancing Operations (LTRO's) to recapitalize distressed Eurozone banks and eventually the Outright Monetary Transactions program in 2012. In 2015 the ECB introduced a new asset buying program similar to the Federal Reserve's Quantitative Easing program, called the Asset Purchasing Program (APP).

There is ample disagreement on whether these unconventional monetary policies were a success or not. Some have argued that the policies were successful since redenomination risk (risk of a breakup, exit of individual countries) was diminished, stress on bank funding conditions was eased and financial markets in general have calmed down as a result. Others have argued that for example the OMT has had adverse effects on the Eurozone as it could counter fiscal discipline, create all sorts of moral hazard problems and could potentially lead to inflation or another asset bubble. (Belke, 2013)

In light of the apparent success of the OMT program by bringing down yields of distressed sovereigns, some have argued that the OMT program in fact constitutes a violation of the prohibition on monetary public debt financing. Belke (2013) argues that OMT announcements could have had an impact on sovereign bond yields specifically by eliminating tail risk. This means market participants view the OMT announcements and specifically Draghi's ''whatever it takes'' announcement to have lowered the probability of say a three standard deviation move from mean returns. Such an event could occur for example due to a speculative attack by investors, in which case the ECB would use an unlimited amount of money within the OMT framework to counter such an attack. A lot of investors worry about such tail-end low probability risk and lowering this risk increases their demand for such debt, thereby suppressing yields.

Most research on unconventional monetary policy by the ECB during the sovereign debt crisis has focused on interbank rates or how these policies affected (perceived) riskiness of sovereign debt in the euro area. For example, De Pooter et al, (2015) develop an asset pricing model in which they examine how the ECB's SMP bond purchases affect liquidity premia on sovereign debt and find significant stock and flow effects on these liquidity premia in response to this bond market intervention.

Falagiarda & Reitz (2015) conduct a comprehensive event study to analyze patterns in yield spreads within the Eurozone with narrow time intervals around announcements of ECB unconventional monetary policies. They examine more than fifty events regarding unconventional monetary policy between 2008-2012, and controlling for other factors influencing yield spread movements they find announcements of unconventional monetary policy generally decreased perceived risk of peripheral Eurozone sovereign debt, except for Greece. Krishnamurthy et al (2014) use an event study approach to estimate the effects of the SMP, OMT and LTRO program on yields of distressed sovereign bonds in the Eurozone, and find dramatic decreases in yields for all countries around SMP and OMT announcement dates. For the LTRO program, they find no significant effect for GIIPS countries. Altavilla et al (2014) use high frequency data to examine the impact of OMT announcements on yields on government debt of France, Germany, Spain and Italy. They find decreases of 2-year government bond yields of Italy and Spain of around 2 percentage points, while they find no significant effects on the yields on similar German and French debt.

In the context of the discourse regarding what type of monetary policy should be applied in different macroeconomic circumstances (i.e. proactive vs. reactive, pro-cyclical vs. countercyclical), it is important to at least be able to show quantitatively that a relation exists between monetary policy and the stock market, and ideally what kind of relation and through which channels. Much research has already been done as to how certain monetary policy affects stock prices in general, by means of multivariate VAR models of stock returns and (federal funds) interest rates (see for example Rigobon & Sack, 2004, and Li, 2015). This paper adds to this research in that it examines the effects of unconventional monetary policy during the European sovereign debt crisis on stock markets.

While most research regarding the European sovereign debt crisis and subsequent unconventional monetary policy measures by the ECB has thus far focused on its effects on (sovereign) bond markets and credit default swap markets, no significant research has yet been done as to its effects on (European) stock markets. As monetary policy is transmitted to bond and CDS markets, it also has significant effects on stock markets, as expansionary policy changes the net present value of companies investment opportunities, alters its risk taking behavior and changes lending conditions. In this paper I examine in detail what the effects of ECB unconventional monetary policy announcements had on European stock markets by means of an up to date event study methodology.

In order to identify whether announcements by the ECB had statistically significant effects on European stock markets, I build on the methodology by Chodorow Reich (2014) and Krishnamurthy & Vissing Jorgensen (2011) who examine the effects of the Federal Reserve’s quantitative easing programs on financial institutions and interest rates. Chodorow-Reich uses a very basic event study methodology in which he takes the cross section of returns on event dates and regresses those on a constant. The resulting beta coefficient thus estimates the average stock price return of the sample of firms. This is the common component of all firms’ stock price reaction on the event date, while the idiosyncratic component is captured by the error term. Vissing Jorgenssen explains in her comments to the paper how this methodology is contingent on the fact that the common component of the regression actually measures the reaction to the announcement, and that no other significant events occurred on the event date, in such a way that that it is entirely attributable to the policy announcement. A more accurate approach which she proposes is a time-series dummy variable approach, since this would measure whether event returns are actually statistically different from returns on other days. Resulting t-statistics would thus more accurately infer whether an event day return is statistically significant from other days, rather than just assuming the entire return to be a result of the policy announcement.

Although using a simple cross sectional approach results in almost all program event dates to be positive and significant (and only negative for the LTRO), the more conservative time series dummy variable approach leads to wildly different results. A time series approach indicates only the SMP program announcement returns to be significantly different from other days, while its coefficients are roughly identical to the cross sectional regression.

While this approach seems reasonable, I argue that based on the well-known properties of daily stock returns, this time-series approach yields inaccurate standard errors and hence potentially type I and type II errors. As Brown & Warner (1985) argue, daily stock returns divert substantially more from normality than monthly stock returns, and in some cases exhibit forms of autocorrelation. While assuming normality will yield a well-specified procedure for event studies, statistical tests of my data indicate large divergence from normality. Analyzing the residuals of my regression also indicates that the OLS assumption of constant variance does not hold and a significant degree of autocorrelation exists, resulting in OLS not to be the best linear unbiased estimator (BLUE). Hence my resulting standard errors are incorrect and one cannot base reliable hypothesis tests on them.

Following Ioannidis & Kontonikas (2008) I consequently specify a regression using Newey-West standard errors taking into account heteroscedasticity and autocorrelation of my model. Resulting standard errors are lower OLS standard errors, and my resulting event date returns are shown to be significantly different from different days. Using two-day (anticipation) event windows, my results do not vary much between using OLS or Newey-West standard errors, as most two-day effects are still insignificant.

I consequently use this approach to conduct a country based event study of unconventional monetary policy announcements, and find that most countries' stock markets show significant stock price reactions to ECB announcements. Most countries' stock markets react in the same direction, with the exception of Greece, especially for the OMT. This confirms the notion that Greece's financial crisis developed relatively independently from the rest of Europe. Furthermore I find that large differences can be observed between northern and southern (peripheral) European countries, with peripheral countries generally exhibiting much larger and more significant event day returns than northern countries. This provides some evidence for a decrease in (perceived) default and redenomination risk of those countries as a result of these policies.

Lastly I try to establish a credit channel of unconventional monetary policy by using the cross sectional difference in industry dependence on external finance. As Acharya et al. (2014) find, the European sovereign debt crisis lead to a loan supply contraction especially in GIIPS countries, which in turn had significant negative macroeconomic effects. By restoring the credit channel of monetary policy, one of the goals of the ECB's resorting to unconventional monetary policy is to stimulate investment and alleviating credit and liquidity conditions for European (non-financial) firms.

Using the methodology pioneered by Rajan & Zingales (1998), I compile a database of US firms' external finance dependence. Using internally generated cash (funds from operations) and R&D

and investments over 15 years per company, I subsequently take the median external finance dependence per industry as a proxy for demand for external funds. As external finance dependence companies hypothetically experience larger positive effects from unconventional monetary policies' easing credit conditions, such an effect should be measurable in the stock price reactions of these companies vis-à-vis companies who can rely on internally generated cash to fund their operations and investments. I find that the percentile rank of firms' external financial dependence of GIIPS countries has a significant effect on announcement returns for the LTRO program, which explains about 35% of the variation in time series regression coefficients across industries. Less strong evidence is found for the SMP and OMT program, while no evidence is found for a credit channel for the APP program. This does not mean that no such channel is at work for these programs, but that I cannot find evidence contingent on my methodology by identifying such an effect through the stock market.

My addition to existing research is therefore threefold: first, I develop and compare an event study methodology for monetary policy event studies building on earlier studies, taking into account the characteristics of daily stock returns which would render statistical inference with normal OLS unattractive. Second, using this event study methodology I consequently show how the four relevant unconventional monetary policy measures by the ECB affected European stock markets in detail, and explain differences between them. Lastly, I use cross-sectional industry differences in external finance dependence to indirectly establish a credit channel of monetary policy through the stock market, rather than through bond or CDS markets or actual credit supply data.

I proceed with outlining relevant background literature on monetary policy transmission channels, monetary policy and stock prices and external finance dependence in the next chapter. After that I give a brief description of all 4 ECB programs in chapter 3. Then, in chapter 4 I outline my hypotheses and methodology in detail, and present some summary statistics. In chapter 5 I present my results, and I finish with some avenues for future research and my conclusion.

2 Theoretical background

2.1 Monetary policy transmission channels

Several risk factors have been identified which resulted in rising bond spreads and Credit Default Swap (CDS) spreads during the European Sovereign debt crisis. These factors include macroeconomic fundamentals and fiscal positions of Eurozone countries, default risk, redenomination risk (risk of breakout of Eurozone and returning to national currency) and contagion effects, liquidity risks, risk aversion and general market sentiment. (Falagiarda & Reitz, 2015)

Monetary policy can affect asset prices through the so-called signaling or expectations channel, which focusses on the role of expectations of market participants. It influences the way market agents perceive future (macro) economic conditions and ECB policy, thereby affecting their asset allocation decisions (Falagiarda & Reitz, 2015). Policies such as asset purchases by central banks changes the public's perception of future policy rates and through the expectation hypothesis of the term structure long-term nominal interest rates consequently fall. This together with forward guidance lowering interest rate expectations leads to a consumption boom and increased spending through the Euler equation. (Chodorow-Reich, 2014)

Another well-established channel of unconventional monetary policy is the portfolio rebalancing channel, which entails the direct effects of these policies on the portfolio composition that investors hold in equilibrium. For example, when a central bank executes transactions in financial markets, such as the purchasing of government debt, this raised demand for sovereign debt increases the price of existing bonds while lowering the interest paid (Falagiarda & Reitz, 2015). Increased asset prices solidify the balance sheets of financial institutions by raising the values of their legacy assets, which in turn increases their distance to default (Chodorow-Reich, 2014). Related to this is the credit channel or bank lending channel. As unconventional monetary policy, such as asset purchases, is financed in large part by creating new central bank reserves, this increased balance at central banks by financial institutions (banks) promotes expansion of bank lending to the private sector and households (Falagiarda & Reitz, 2015). For example, Acharya et al (2014) find that losses on GIIPS sovereign debt during the crisis lead to severe undercapitalization of both GIIPS and non-GIIPS Eurozone banks, leading to contraction in loan supply to European firms. This contributed significantly to a contraction in the Eurozone economy. Unconventional monetary policy, by relieving undercapitalized banks through improvement of their balance sheet by increasing the value of legacy assets, could potentially counter such loan supply disruptions.

Chodorow-Reich (2014) conducts an extensive study of the effects of unconventional monetary policy in the US during the financial crisis on financial institutions. These policies included open market operations by purchasing distressed assets (quantitative easing). In this paper he discusses four main channels through which such unconventional monetary policy might affect financial institutions. First, these measures reduce risk free rates within the economy and thereby hurdle rates (minimum rates of return) for investment projects. This consequently leads to new investment in projects with lower returns and higher variances in which no investments would be made if interest rates were higher. The second channel is the so-called ''reaching for yield'' channel in which financial institutions increase risk taking to compensate for low yields. While he describes this channel as a potential adverse effect of unconventional monetary policy (more risk taking than what holders of this risk would like), reaching for yield might as well be an intended consequence of these policies. This is because eliminating credit supply contraction through the bank lending channel might be the intended purpose of the central bank, and increasing the optimal risk taking propensity of the financial sector might counter this contraction. The third channel is by accelerating recovery of the overall economy, thereby reducing default rates, increasing profits and lowering risk aversion. All this increases the value of legacy assets, improving solvency of financial institutions. The last channel he describes is lowering the opportunity cost of holding reserves and collateral by lowering interest rates. This might increase balance sheets and leverage of banks with binding reserve requirements.

By using high frequency event studies on CDS, bond yields and equity price data Chodorow-Reich (2014) consequently examines the announcement effects of these policies on for example banks and life insurers. He finds that the introduction of unconventional monetary policy measures had a significant stabilizing impact on financial institutions in the US, especially on life insurers. His results generally suggest that recapitalization of financial institution by asset relief and strengthening balance sheets is one of the main channels through which these unconventional policy measures affect the stability of financial institutions and their activity in the real economy.

Krishnamurthy et al. (2014) provide an extensive quantitative analysis of the channels through which unconventional ECB policies affected interest rates by disentangling these rates into different components. They differentiate between two different components of bond rates of Eurozone sovereigns. First are the components which are common to all countries within the Eurozone, namely an expectations hypothesis and euro-rate term premium which should be equal across all countries using the Euro. Second are country-specific components, such as redenomination risk, default risk and bond market segmentation. After constructing a model consisting of the components of interest rates, they use a Kalman filtering approach to identify the size of each of these components. They find that default risk and bond market segmentation are the dominant channels through which the SMP and OMT programs affected the yields of Italy and Spain. Also redenomination risk might have played a role in the case of Spain and Portugal. Surprisingly, they do not find the expectations hypothesis of the yield curve or the euro-rate term premium to be important channels. To assess the broader macroeconomic impact, they also conduct a small event study around OMT announcements on stock markets, and find large reactions to the SMP and OMT program announcements. Altavilla et al. (2014) construct a multi-country vector autoregressive model with six macroeconomic variables together with a measure of the ECB's policy rate and expected Eurozone bond market volatility. They simulate the effects of different interest rate paths due to the OMT over the course of three years on these macroeconomic variables and find that OMT announcement have statistically and economically significant effects on credit and economic growth in Italy and Spain, with minor spillovers in France and Germany.

The effects of the OMT policy can also be viewed in the context of the ongoing discussion among economists who adhere to a more *fundamentalist* approach to sovereign bond markets and those who hold a *multiple-equilibria* view. The fundamentalists view the increase in yield spreads in the Eurozone as something reflecting just deteriorating underlying macroeconomic fundamentals of periphery sovereigns, while multiple-equilibria proponents argue that behavioral considerations such as panic driven herd behavior of investors might lead to a liquidity crisis and therefore a worse equilibrium than would otherwise occur. The arguments underlying the so-called ‘’fragility hypothesis’’ of multiple equilibria proponents have to do with the fact that Eurozone member states individually lack the authority to conduct monetary policy, and are therefore susceptible to self-fulfilling feedback loops. As countries lack a monetary authority which can intervene in times of panic, this panic could send sovereign yields sky-high, resulting in a liquidity crisis as the sovereign struggles to meet its debt obligations, leading to a further increase in yields. (Saka, Fuertes, & Kalotychou, 2015)

Countries who would retain control over their monetary policy would not be susceptible to such self-fulfilling dynamics, as there would always be a ‘’lender of last resort’’. Theoretically, such dynamics would not be present when the ECB assumes this role of lender of last resort, injecting liquidity in sovereign debt markets when a speculative attack occurs. Saka et al (2015) find overwhelming support for this fragility hypothesis. They conduct a principal component analysis of Eurozone CDS spreads and first of all find a structural break in the markets assessment of sovereign risk on the first event date (the ‘’whatever it takes’’ pledge by Draghi). The principal components point to increased commonality in risk of periphery and core sovereign debt after the announcement. Second, they indicate a shift to a more fundamental-based approach as to how sovereign risk is perceived. As a preliminary analysis, they regress CDS spreads of Eurozone countries on several macroeconomic indicators, and find several outliers which have higher CDS spreads than their macroeconomic fundamentals would warrant. These are all periphery countries in the pre-OMT period, providing evidence for the multiple-equilibria point of view. Their news transmission and herding contagion analysis additionally provide evidence that significant self-fulfilling dynamics caused CDS spreads to diverge, and that the OMT program has diminished these effects and channeled European debt-markets towards a more fundamentals based valuation of sovereign risk. All this points toward a multiple equilibria point of view in which self-fulfilling dynamics after an exogenous shock can push solvent countries toward default. These results strongly suggest the OMT program has in fact done what it was supposed to do, and does not contain a unwarranted sovereign subsidy as some have argued.

2.2 Monetary policy and stock prices

Since this study aims to quantify how unconventional monetary policy affects the stock market, it relates to previous work on the monetary transmission and signaling channel through the stock market. Conventional monetary policy objectives normally cover a number of macroeconomic variables such as output, inflation and employment. However, as these variables are only indirectly influenced by monetary policy and with large lags, one cannot directly observe the effectiveness of monetary policy. Financial asset prices such as stock market data are thus used as proxies since financial markets according to the semi-strong form of the efficient market hypothesis are quick to incorporate new information, and asset prices adjust according to how the market expects a shift in monetary policy to affect these asset prices in the long-run. The stock market not only serves as a signal for the efficacy of monetary policy, but also has a direct influence on the broader macro economy through the wealth effect channel leading to increased spending and a balance sheet channel leading to increased investment. Some researchers even see the stock market as a separate macroeconomic variable to which monetary authorities want to respond. (Ioannidis & Kontonikas, 2008)

Using the discounted cash flow model, which states that stock prices are simply the present value of expected cash flows, we observe that monetary policy can affect stock prices by either altering the discount rate used or by changing the market's expectation of firms' earnings. Monetary tightening (i.e. higher interest rates) then leads to lower stock returns as the discount rate increases and economic activity slows down. The reverse should be true for expansionary monetary policy, namely higher stock returns due to increased earnings and lower discount rates. (Ioannidis & Kontonikas, 2008)

2.3 External finance dependence and monetary policy

Previous research indicates that there are cross-sectional differences in reactions to monetary policy shifts across companies and industries. A lot of emphasis has been placed on how the credit channel of monetary policy differs across companies. For example, through the balance sheet channel firms are affected by monetary policy in different ways, since a company's balance sheet may signal to external finance providers the riskiness and indebtedness of the company. Altering the composition of the balance sheet is consequently a way monetary policy may affect the degree of external finance provided to a firm. Another way is through a bank lending channel, as a monetary tightening (expansion) may decrease (increase) the amount of loans given to firms. Since alternative sources of financing are oftentimes imperfect substitutes, credit supply tightening or expansion should therefore affect companies differently as they differ in their means and capabilities of financing. For example, smaller and younger firms have less access to some capital markets, making them especially exposed to bank lending conditions and internally generated cash for their operations and investments. Any shift in monetary policy that affects the propensity to lend to firms would therefore have a bigger effect on the performance and ability to finance operations of firms which are especially dependent on these loans. (Bougheas, Mizen, & Yalcin, 2005)

Kasyap, Stein, & Wilcox (1993) investigated the effect of monetary tightening on financially constraint firms by creating a variable measuring external finance dependence and differentiating between bank loans and other external funds, to consequently measure the relative changes in bank financing to other external sources of finance. They provide evidence for a credit channel and bank lending channel by showing how both sources of external funds (bank and other market based) declined due to monetary tightening.

Bougheas et al. (2005) perform an extensive study as to the effects of firm-specific characteristics on the response of corporate financial decisions and capital structure to monetary policy. Their main proposition states that credit supply varies across time as monetary policy stances adjust to business cycle dynamics. Their theoretical framework states that external finance can be obtained either from the market or from financial intermediaries where verification as to creditworthiness is costly and thus can only be done by financial intermediaries such as banks. They conduct an extensive panel data analysis where they examine the effects of firm specific characteristics on firms access to different sources to external finance. They find that smaller, riskier and younger firms are disproportionately affected by monetary policy tightening than other firms. Their results also emphasize the role that collateral plays in access to external finance. They confirm a general broadbased credit channel effect and specifically a bank lending channel effect through which monetary policy affects lending conditions to different kinds of firms.

3 Program description

3.1 Securities Market Program (SMP)

The Securities Market Program (SMP) was introduced on May 10, 2010. It entailed the purchasing of government bonds (sovereign debt) of distressed Eurozone countries in order to decrease the default risk of these governments by lowering yields on their sovereign bonds. There was no limit on the amount of securities to be purchased, but up to July 2011 the ECB held around €75 billion in these securities. In the first round, the ECB only focused on buying securities by Greece, Ireland and Portugal, but on August 7, 2011 the ECB decided to expand the program to include Italian and Spanish debt. About three years after the introduction of the SMP, holdings amounted to about €220 billion, of which the majority consisted of Spanish and Italian debt. The official statements by the ECB state the objective of the SMP program is to ‘’address the malfunction’’ of these specific securities markets and to ensure ‘’depth and liquidity in those market segments which are dysfunctional’’. (Krishnamurthy et al., 2014)

3.2 Long Term Refinancing Operations (LTRO)

The Long Term Refinancing Operations (LTRO) program was announced on December 8, 2011 by the ECB. It was meant as an extension of the ECB’s Main Refinancing Operation (MRO) program to three years. The program entailed the provision of loans to banks under certain conditions and collateral requirements, and interest on these loans were determined by the ECB’s policy rate. The ECB stipulated that there would be no limit on the amount of loans provided under the program. In its statement, the ECB made clear that the goal of the program was to provide credit support to banks and to ease liquidity and lending conditions in the Eurozone. The program was thus primarily focused on easing pressures on financial institutions and money markets, and one of the mechanisms through which it would work was a bank lending channel to ease lending conditions throughout the Eurozone. The additional measures in the LTRO to the MRO were arguably minor though, like the provision indicating the possible quantity of loan supplies would now be unlimited and its maturity extended. The LTRO take-up was large though, indicating banks perceived there to be much value in the program relative to the MRO. (Krishnamurthy et al, 2014)

3.3 Outright Monetary Transactions program (OMT)

The Outright Monetary Transactions program entailed outright transactions in the secondary bond market and was ‘’aimed at safeguarding an appropriate monetary policy transmission and the singleness of the monetary policy’’ (ECB, 2012). This policy was aimed at lowering sovereign bond yields by creating extra demand, thereby reducing refinancing difficulties by distressed sovereigns. It was announced on August 2, 2012 and its details were published on September 6, 2012. The program covered government bonds on the secondary market with remaining maturities between 1 and 3 years and without any ex ante quantitative limits. Importantly, this policy differs significantly from so called ‘’Quantitative Easing’’ policies since the injected liquidity is sterilized by some liquidity absorption measures. Money supply (M3) is thus not supposed to increase as a result of the policy. These transactions could be executed under some conditionality, which mainly focused on target countries’ fiscal and macroeconomic policies. The announcement of the OMT program practically terminated and replaced the aforementioned SMP program. (ECB, 2012)

3.4 Asset Purchasing Program (APP)

The expanded Asset Purchase Program (APP) was announced on January 22, 2015. Under this Quantitative Easing program the ECB would purchase as much as €60 billion a month in sovereign bonds until at least September 2016 (Georgiadis & Grab, 2015)**.** The Governing Council of the ECB indicates in its announcement of the program that it is aimed at maintaining price stability in the Eurozone against the backdrop of sustained low inflation. Furthermore it is aimed at easing financial and monetary conditions in order to expand credit supply within the Eurozone thereby accelerating investment and consumption (credit supply channel), until inflation rates return towards the target rate of 2%. Under the program bonds of euro area institutions will be bought in the secondary market against central bank money, which can then be used by these institutions to extend credit to firms and households. (ECB, 2015)

4 Data and methodology

4.1 Hypothesis and research question

In this paper I identify the stock market reaction of European countries and provide evidence for a credit channel of unconventional monetary policy by the ECB during the European sovereign debt crisis, using a robust time series event methodology. The covered programs are the SMP, LTRO, OMT and APP programs. Through a balance sheet channel and bank lending channel, unconventional policy measures are supposed to increase credit supply in the economy generally, and to firms specifically in order to accelerate investment, growth and risk-taking. Previous research on this topic has primarily focused on effects of announcements on (sovereign) yield curves and bank balance sheets, and inferred from these effects that unconventional monetary policy is indeed working through a credit channel. This paper builds on this previous research by providing further evidence of a credit channel of monetary policy. My first aim is to provide evidence for a general stock market effect by conducting an event study of policy announcements on the European stock market. Using the property of cross sectional differences in external finance dependence of non-financial public companies, I then aim to provide evidence of a specific credit channel by analyzing the cross sectional differences in stock price reactions across more and less financially dependent firms and industries. Since monetary easing theoretically should expand credit supply in the economy, one would expect financially constraint firms to be more sensitive to unconventional expansionary measures.

4.2 External finance dependence

My underlying assumption is that some companies or industries inherently are in need of more external funds due to the nature of their business models, capital intensity and cash harvesting period. Companies and industries which are more external finance dependent should therefore theoretically be more exposed to monetary policy shocks.

In order to distinguish effects on companies which are more dependent on external finance and those that are less so, I need some kind of measure of external finance dependence of companies. Specific data on this is not widely available and also not necessarily useful since the use of external finance simply reflects the equilibrium between supply and demand for external finance. Several previous studies have allready been done on external finance dependence and monetary policy decisions, although these have all been from a credit supply perspective. Notable studies which take a credit supply approach are Bougheas et al (2005) and Kasyap et al. (1993).

In contrast to these studies, I will take a different approach to identify external finance dependence and use of external finance, by creating a proxy for the demand that companies have for external funds, by comparing their investent needs and internally generated funds.

I need company information in order to construct a variable which would measure to what degree a company needs to be financed with outside funds. Following the methodology used by Rajan & Zingales (1998) I collect information on US listed companies to create a proxy for external finance dependence. Specifically, what is meant by external finance dependence is the demand for investment activity which cannot be financed by means of internally generated cash. I need to note that this methodology is contingent on the fact that capital markets in the United States are relatively frictionless, and that actual use of external finance reflects the equilibrium between supply and demand for outside funds. This is a strong assumption, given the nature of the financial crisis in European debt markets and its worldwide spillovers. However, by averaging over several years one might smooth out imperfections that existed (probably in opposite directions) before and after the crisis. Another necessary assumption is that external finance dependence, or technological demand for outside funds, carries over from the US to Europe, so that those industries most dependent on external finance in the US are also most dependent in Europe.

The data are retrieved from the Compustat database of annual reports of listed companies for all US companies listed on the NYSE, AMEX or NASDAQ over the period of 2000 until 2014.

Following Rajan & Zingales (1998) I construct the proxy for external finance dependence as:

$$external\ dependence = \frac{(capital\ expenditures + R\&D) - funds\ from\ operations}{(capital\ expenditures + R\&D)} \quad (1)$$

Cash flow from operations here is cash flow from operations plus changes in the nonfinancial components in net working capital (Δ inventories, Δ receivables and Δ payables), which can be considered as funds from operations. These are added since these items can in fact be used to avoid using external finance. I also download industry SIC codes for each company in order to compile a database of external finance dependence per industry. To aggregate across companies and industries, I first calculate the average external finance dependence and investment intensity per company. Consequently, to compare external finance dependence across industries I take the median of the average external finance dependence across firms within an industry. This is done to take into account extreme values and outliers, and to smooth across large and small companies, since larger companies presumably have a lower external finance dependence and could therefore create an upward bias in the average within an industry. Taking the median thus creates a reasonable proxy for how much a specific industry might be dependent on external finance. Following Acharya & Xu (2013), I consequently make a percentile distribution of this external financial dependence variable, and assign each industry a percentile rank and use those in my final analysis. The resulting database can eventually be used to test my hypothesis that industries that are more dependent on external finance react more heavily to unconventional monetary policy shocks, and is presented in table 1. As expected and in concurrence with previous studies, industries such as mining and chemical products (like pharmaceuticals) are the most external finance dependent while the tobacco industry's demand for external finance is the lowest of all industries.

Table 1: Industry external finance dependence

SIC Code:	Sub industry	External Finance Dependence - median	Percentile rank
1500	Building Construction General Contractors and Operative Builders	2.284	0.983
2800	Chemicals and Allied Products	1.745	0.966
1000	Metal Mining	0.728	0.95
3800	Measuring, Analyzing and Controlling Instruments	0.607	0.933
4400	Water Transportation	0.492	0.916
3600	Electronic and other Electrical Equipment and Components except Computer Equipment	0.391	0.9
1300	Oil and Gas Extraction	0.340	0.883
7500	Automotive Repair, Services, and Parking	0.280	0.866
100-999	Agriculture, Forestry, Fishing	0.251	0.85
3900	Miscellaneous Manufacturing Industries	0.108	0.833
4900	Electric, Gas and Sanitary Services	0.057	0.816
7300	Business Services	0.031	0.8
4200	Motor Freight Transportation and Warehousing	0.017	0.783

3500	Industrial and Commercial Machinery and Computer Equipment	0.001	0.766
4500	Transportation by Air	-0.037	0.75
3700	Transportation Equipment	-0.203	0.733
7000	Hotels, Rooming Houses, Camps, and other lodging places	-0.232	0.716
3200	Stone, Clay, Glass and Concrete Products	-0.265	0.7
3300	Primary Metal Industries	-0.294	0.683
4000	Railroad Transportation	-0.315	0.666
1200	Bituminous Coal and Lignite Mining	-0.338	0.65
5800	Eating and Drinking Places	-0.339	0.633
1400	Mining and Quarrying of Nonmetallic Minerals Except Fuels	-0.345	0.616
2900	Petroleum Refining and Related Industries	-0.349	0.6
7900	Amusement and Recreation Services	-0.358	0.583
5400	Food Stores	-0.413	0.566
5500	Automotive Dealers and Gasoline Service Stations	-0.471	0.55
4600	Pipelines except Natural Gas	-0.480	0.533
3000	Rubber and Miscellaneous Plastics Products	-0.485	0.516
4800	Communications	-0.489	0.5
1600	Heavy Construction other than Building Construction Contractors	-0.492	0.483
2500	Furniture and fixtures	-0.549	0.466
7800	Motion Pictures	-0.563	0.45
5700	Home Furniture, Furnishings and Equipment Stores	-0.607	0.433
2400	Lumber and Wood Products except furniture	-0.609	0.416
5300	General Merchandise Stores	-0.690	0.4
4700	Transportation Services	-0.706	0.383
2000	Food and Kindred Products	-0.805	0.366
5600	Apparel and Accessory Stores	-0.824	0.35
5900	Miscellaneous Retail	-0.833	0.333
8000	Health Services	-0.859	0.316
9900	Nonclassifiable Establishments	-0.867	0.3
5100	Wholesale Trade-Nondurable Goods	-0.914	0.283
2600	Paper and Allied Products	-0.924	0.266
5200	Building Materials, Hardware, Garden Supply, and Mobile Home Dealers	-0.958	0.25
3400	Fabricated Metal Products, Except Machinery and Transportation Equipment	-1.035	0.233
8300	Social Services	-1.119	0.216
8200	Educational Services	-1.379	0.2
2300	Apparel and other Finished Products Made from Fabrics and Similar Materials	-1.567	0.183
2200	Textile Mill Products	-1.598	0.166
4100	Local and Suburbarn Transit and Interurban Highway Passenger Transportation	-1.652	0.15
1700	Construction Special Trade Contractors	-1.695	0.133
3100	Leather products	-2.011	0.116
7200	Personal Services	-2.096	0.1

2700	Printing, Publishing and Allied Industries	-2.223	0.083
5000	Wholesale Trade-Durable Goods	-2.338	0.066
8700	Engineering, Accounting, Research, Management, and Related Services	-2.535	0.05
8100	Legal Services	-2.841	0.033
2100	Tobacco Products	-4.624	0.016

Notes: This table presents external finance dependence per (sub) industry. Industries are represented by SIC codes and short description. Data comes from Compustat and are from all NYSE, AMEX and NASDAQ companies from 2000 until 2014. External finance dependence is calculated as the part of Capex and R&D which cannot be financed with internally generated cash (cash flow from operations). I take the mean of each companies' external finance dependence each year and subsequently take the median of this per SIC industry to create the variable. Lastly I compute a percentile rank distribution to represent each industries' dependence.

4.3 Event study approach and stock market data

I set the event dates in accordance with previous event studies which deal with the effects of ECB unconventional monetary policy announcements on bond and CDS markets. The majority of event studies (see for example Falagiarda & Reitz, 2015 and Saka et al., 2015) set the dates and times as described in table 2. For identifying through what channels these unconventional monetary policy measures work, omitting potentially relevant other event dates reduces the power of the test but does not introduce any biases. For the overall direct effects this is a potential problem since omitting relevant event dates can result in an upward or downward bias in my estimates. Based on the significance of my chosen event dates regarding for example the OMT and APP in these earlier studies, I can be fairly confident these are the most important dates. (Krishnamurthy & Vissing Jorgensen, 2011)

Table 2: Event dates and description of ECB unconventional monetary policy announcements

Date	Type	Description
10/5/2010	SMP	ECB announces SMP programme
8/8/2011	SMP	ECB announces expansion of SMP programme
1/12/2011	LTRO	Draghi European Parliament speech indicating upcoming measures to restore credit channel of monetary policy
8/12/2011	LTRO	ECB announces LTRO
26/07/2012	OMT	Mario Draghi announces the OMT program and says the ECB will do ''whatever it takes to preserve the euro''
02/08/2012	OMT	Additional info regarding OMT programme
27/08/2012	OMT	Asmussen's speech regarding OMT
06/09/2012	OMT	Announcement by Governing Council of OMT details
22/01/2015	APP	Announcement of expanded asset purchase program

The stock price data are retrieved from datastream, and consist of daily closing prices for all Eurozone stock markets. Next to this I download all corresponding SIC codes with every company in order to later aggregate the data at the industry level. Since this research focuses on financial dependence of companies on external funds, I exclude all financial companies (SIC 60-67) from my sample.

Table 3 shows descriptive statistics for my stock market time series data from January 3 2005 until December 31 2015. All indexes are computed excluding financial companies and are weighted according to each companies' total market capitalization, as done in previous studies. To obtain returns I compute differences of the logarithm of all stock prices. As can be seen, the mean daily stock return over this period is the largest in Spain and Germany, while it is by far the smallest (even negative) for Greece. The standard deviation is the largest for the Irish stock market, providing evidence for a relative volatile Irish stock market during this period. A skewness kurtosis test for normality indicates a strong degree of non-normality in daily stock returns, which is a well-known property of (daily) stock returns.

There are several options available as to how to conduct such an event-study. Chodorow-Reich (2014) takes a very simple approach conducting an event study of QE announcement effects on asset prices in the US. In his cross-sectional approach he regresses the event window (in his case 20 minutes) return of companies on a constant according to

$$\Delta y_i = \beta_0 + \varepsilon_i \tag{2}$$

The common component among all companies will thus be estimated as the constant β_0 and its OLS t-statistic indicates whether it is significantly different from zero and thus whether there is a significant price reaction to the event. The error term in this simple regression ε_i is the non-common component of returns, since firms do not react identically to the event.

Table 3: Descriptive statistics daily stock market data[1]

	Netherlands	Germany	France	Spain	Portugal	Ireland	Greece
Mean	0.00024	0.00035	0.00018	0.00039	0.00022	0.0001	-0.00011
Min	-0.0868	-0.0842	-0.089	-0.086	-0.121	-0.162	-0.089
Max	0.10	0.117	0.126	0.113	0.104	0.121	0.115
SD	0.012	0.013	0.013	0.016	0.012	0.021	0.016
Normality (S/K)[2]	0.000	0.000	0.000	0.000	0.000	0.000	0.000

	Belgium	Austria	Finland	Luxembourg	Slovenia	Italy	GB
Mean	0.00035	0.00019	0.00013	0.00001	0.00007	0.0001	0.00029
Min	-0.0941	-0.095	-0.07	-0.16	-0.101	-0.094	-0.083
Max	0.126	0.119	0.089	0.152	0.096	0.119	0.105
SD	0.012	0.014	0.013	0.02	0.012	0.013	0.010
Normality (S/K)	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Notes: 1: Measured as the first difference in log stock price. 2: Skewness Kurtosis test for normality similar to a Jarque Bera test of normality. Shows probability>chi^2.

In her comments to the paper by Chodorow-Reich, Vissing-Jorgensen criticizes this methodology since it rests on the strong assumption that the common component is entirely due to the event (policy announcement) and that no other events took place that could have caused the common price reaction. It is normal in event studies that to ensure the price reaction is due to the event one investigates, to take into account periods outside the event window and compare those with each other. It is common to calculate a normal return and abnormal return to identify any event specific price movements of assets.

However, when the event is the same across securities one has total clustering of observations. In this case, according to MacKinlay (1997) in his seminal paper regarding financial event studies, it might be better to use a multivariate regression model and use dummy variables for each event. This is exactly what Vissing-Jorgensen proposes should be the standard in monetary policy event studies. In the context of unconventional monetary policy in the US, Vissing Jorgensen shows how her time-series dummy variable approach leads to drastically lower t-statistics than Chodorow-Reich's more basic approach, and argues for her methodology to become standard practice in monetary policy event studies such as this one.

To compare between the two approaches, I will start out by using both approaches in my event study to identify effects of ECB unconventional monetary policy on stock prices in the Eurozone in general. The first regression will be according to the equation above, namely simply regressing stock returns on event dates on a constant. As is common in analyzing stock returns I will consider the change in log prices instead of real returns. The coefficient on the constant will simply reflect the mean change in log prices on the specific event dates. The event window is from the previous trading day closing to the event day closing. Since some events took place relatively late in the trading day, and there might potentially be a delayed reaction in asset prices to events, I also consider a delayed (anticipation) effect by increasing my event window to two days. While this could potentially aid identification of stock price reactions to events, it also increases the possibility of contaminating the event by other events as the event window has increased. Also, stock prices usually are among the most liquid assets, hence increasing the chances of immediate stock price adjustments as market participants respond to the event.

Secondly, I specify a model which relaxes the strong assumption that no other common shocks occur during the event window except for the monetary policy announcement. I do this since the more basic approach only takes into account firm specific idiosyncratic shocks in the error term. This is wrong however since there could actually be other common shocks as well during the event window, leading to useless t-statistics. Thus a more accurate approach would be to construct a dummy variable model which takes into account the returns on non-event dates in order to identify whether the common component in returns can actually be attributed to the monetary policy announcement. I therefore specify a time series regression with 7 dummy variables representing the event dates as follows

$$\Delta y_t = \beta_0 + \beta_i X_t + \varepsilon_t \qquad (3)$$

In which Δy_t is the time series of return in log stock prices and X_t is a vector of event dummies representing the 7 event dates, equaling 1 on the event date and zero otherwise. I also specify a regression in which the dummies represent 2 day anticipation effect and check whether this significantly changes the event study results. While this proposed approach by Vissing Jorgensen might seem more reasonable, it fails (as she alludes to herself) to take into account the inherent non-normality, heteroscedasticity and autocorrelation exhibited in daily stock returns. As Brown & Warner (1985) point to, daily stock returns characteristics would render normal OLS standard errors to be inefficient and leads OLS to no longer be the best linear unbiased estimator (BLUE). Following Ioannidis & Kontonikas (2008) I develop a model taking into account daily stock return characteristics and calculate robust standard errors.

In order to answer the question whether external finance dependence explains stock returns during unconventional monetary policy announcements I first run the above regression on all individual industry returns. Consequently I use these regression coefficients as dependent variable in a second regression in which my main independent variable is my external finance dependence proxy. This is a basic cross sectional regression of the following form

$$y_i = \beta_0 + \beta_i X_i + \varepsilon_i \qquad (4)$$

In which y_i is the time series regression coefficient of industry i and X_i is the external finance dependence in industry i. I also use this approach using dummies representing external finance dependence versus independence across different percentiles of the external finance dependence distribution of industries.

5 Results

5.1 Comparing event study methodologies for the entire European market

My data consists of stock prices of 365 European companies, retrieved from datastream and are from 14 European stock markets. I transform my price data to its logarithm and then take first differences in order to get my stock return data for all companies and consequently weigh all returns to its market capitalization to get market capitalization weighted returns. The first regression I specify is according to the approach used by Chodorow-Reich, which is basically a cross sectional regression of returns within an event window on a constant (specified above). The resulting regression coefficient gives the mean return of the entire sample on the specific event date. Since previous literature and theory indicates the presence of a possible anticipation effect (i.e. Falagiarda & Reitz, 2015), I also include a regression in which I increase my event window by one day (event day +1). This is because there might be a delayed reaction by different kinds of market participants to these monetary policy announcements, as they examine the possible effects of these policies and adjust their positions. The results of this regression are shown in table 4.

The results of this regression indicate statistically significant returns at the 1 percent level for all regressions, except for the two-day window of the 27/8/2012 announcement. The table provides some evidence for some kind of anticipation effect, especially for the APP announcement, although for other events this anticipation effect is less pronounced.

Table 4: Cross sectional regression of event returns on constant

Event	1 day effect		2-day anticipation effect	
	Mean return in log stock price	t-statistic	Mean return in log stock price	t-statistic
10/5/2010 – SMP	0.063**	5.19	0.051**	5.23
8/8/2011 – SMP	-0.042**	-6.47	-0.029**	-4.68
1/12/2011 – LTRO	-0.007*	-2.33	-0.001	-0.15
8/12/2011 – LTRO	-0.017**	-6.02	-0.006**	-3.75
26/7/2012 – OMT	0.02**	4.13	0.033**	5.07
2/8/2012 – OMT	-0.015**	-6.80	0.006	1.81
27/8/2012 – OMT	0.006**	3.40	0.0002	0.13
6/9/2012 – OMT	0.022**	5.30	0.029**	5.22
22/1/2015 – APP	0.014**	4.50	0.029**	4.57

Note: this table shows the result of an OLS regression of event log stock returns on a constant. **, * indicates significance at the 1 and 5 percent level respectively (** $p<0.01$, * $p<0.05$).

As mentioned in the previous section, the way in which standard errors are calculated in this simple cross sectional approach might be misleading, since it simply assumes all returns are the result of the specific event. A fairer approach would be to compare returns within the event window to returns outside of the event window and infer whether the event day return differs significantly from nonevent-day returns. In this way we can make a credible inference as to whether a common shock occurring within the event window can indeed be attributed to the monetary policy announcement. To do this I specify a regression model according to the approach proposed by Vissing Jorgensen (2014), as presented in the previous section. This is a time series dummy variable approach, in which I obtain the time series from beginning 2005 until end 2015 of the difference in log stock price (value-weighted) of the entire market. Consequently I create dummy variables for each event, taking the value of 1 on the event day and 0 otherwise, and estimate this model with Ordinary Least Squares (OLS). I also include two-day anticipation effects by including dummies which also take the value of 1 one day after the event day. The results are shown in table 5 as model 1 and 3.

The results of this time series regression indicate that of the 9 event dates, only the SMP announcement returns and the fourth OMT returns can be regarded as being significantly different from other days, with some weak evidence for significance of the first OMT date. Also, anticipation effects seem completely absent using this method. What is remarkable is the large and significantly negative result for the event date for the second SMP announcement (8/8/2011). A quick search finds that on this date Standard & Poors downgraded US sovereign debt from its AAA credit rating to AA+, leading to the ‘’worst day on Wall Street since the 2008 financial crisis’’ (CNN Money, 2011). This event thus contaminated the effect of the ECB announcement to the extent that no accurate inference can be made. I will thus ignore this event date in my further analysis of individual countries and sectors.

While this approach proposed by Vissing Jorgensen (2014) makes more intuitive sense than a simple cross sectional regression of event returns on a constant, there is a potential problem with this OLS time series approach. This arises from the fact that hypothesis testing with OLS requires the variance of the error term of the model to be constant as in

$$V(\varepsilon_i) = \sigma^2 I_n. \qquad (5)$$

In which I_n is an identity matrix in dimension n and $\sigma^2$is the variance of each observation. Since stock returns generally do not follow a normal (Gaussian) distribution and potentially exhibit heteroscedasticity and autocorrelation, I perform some formal tests to see whether the estimated model has these characteristics. First I perform a Breusch Godfrey Lagrange Multiplier (LM) test for autocorrelation of the model which tests the null hypothesis of no autocorrelation versus the alternative that ε_i follows an AR(p) process. It is based on an auxiliary regression of ε_i on its lags and is computed as the NR^2 of the auxiliary regression, which follows a χ^2 distribution. As shown in the table, the null of no autocorrelation with 5 lags is clearly rejected. For brevity I do not report these tests on other time series and with different lags, however they follow similar patterns with differing AR(p) processes. Going forward I will assume the model to suffer from autocorrelation of about 5 lags and adjust my standard errors for this. I also compute a test for heteroscedasticity of the residuals of the model. This is an adjusted Breusch Pagan test which tests the null that t = 0 in

$$V(\varepsilon_i) = \sigma^2 \exp(zt) \qquad (6)$$

As reported in the table the null of homoscedasticity is clearly rejected for both models. In appendix 1 I report some residual diagnostics which further prove the residuals of my model not to be normally distributed and volatility to be clustered across time.

To take into account the non-constant variance of the model and its effects on standard errors, I follow the methodology used by Ioannidis & Kontonikas (2008) and estimate a different model in which standard errors are adjusted with a Newey West estimator which adjusts the covariance matrix for heteroscedasticity and autocorrelation. The results are given in table 5 as model 2 and 4. We observe the Newey West adjusted standard errors to be much lower than my OLS estimates. While this may sound counterintuitive, this is actually not surprising. The variance of the OLS estimator is estimated as

$$\hat{V}(\hat{\beta}) = \frac{\bar{\sigma}^2}{\sum_t (x_t - \bar{x})^2} \qquad (7)$$

In which x is the independent variable under consideration. This would be a correct estimate given the assumption of constant variance. If this condition is dropped however, we need a different way of estimating the variance of the OLS estimator. The correct sampling variance of the coefficient, of which the Newey & West (1987) estimator calculates a more complicated version[1], is

$$V(\hat{\beta}) = (\frac{1}{\sum_t (x_t - \bar{x})^2})^2 \sum_i \sigma_1^2 (x_i - \bar{x})^2 \tag{8}$$

Comparing these two expressions of the variance we can see that they are asymptotically similar in the case where σ_1^2 and $(x_i - \bar{x})$ are uncorrelated with each other. However, in the case of a positive correlation, OLS standard errors will be too small while when they are negatively correlated OLS standard errors will biased upwards. My results show in fact that a simple OLS time series regression yields significantly larger OLS standard errors than the one using heteroscedasticity and autocorrelation robust standard errors, meaning that OLS standard errors are probably biased upwards.

The results of my adjusted models confirm that monetary policy announcements did in fact have a significant effect on European stock markets (as can be seen in model 2), which is in accordance with earlier literature on the effects of ECB unconventional monetary policy on financial markets generally and stock markets specifically. My adjusted model's standard errors do not change significantly from normal OLS standard errors with anticipation effects, leaving several events, like both LTRO's, to have insignificant anticipation effects. Going forward I will use Newey West robust standard errors. Given my event study results I will use 10/5/2010 for the SMP program, 1/12/2011 and 8/12/2011 for the LTRO, 26/7/2012 (''whatever it takes'') and 6/9/2012 for the OMT program and 22/1/2015 for the APP program.

5.2 Country event study

In order to distinguish the effects of the different unconventional monetary policies, I now use my findings from the previous section to all value weighted time series returns for every individual European stock market. This time I adjust my standard error and scale the covariance matrix to take into account heteroscedasticity and autocorrelation by using Newey-West standard errors with 5 lags. I will use 5 lags throughout the remaining of this paper since autocorrelation tests indicate autocorrelation going back at least 5 lags in most of my time series. My results furthermore show that standard errors are lowered with 5 lags compared to 1 lag for most time series.

The results in table 6 show most of the European countries' stock markets reacted significantly (most even at 1% significance levels) to ECB unconventional policy announcements. What is remarkable is the fact that the LTRO event had a significantly negative effect on almost all countries' stock markets. Using two-day event windows leaves almost all stock market reactions for the LTRO to be insignificant though. This is in accordance with the finding of Krishnamurthy et al (2014) who find

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[1] In fact the Newey West estimator estimates variance as follows:
$X'\hat{\Omega}_0 X + \frac{n}{n-k} \sum_{l=1}^{m} (1 - \frac{l}{m+1} \sum_{t=l+1}^{n} \hat{e}_t \hat{e}_{t-l} \, (x'_t x_{t-l} + x'_{t-l} x_t)$
In which *m* is the number of lags included in the model, *X* is an *n x k* matrix of observations on the explanatory variables (which is a dummy vector in my case), $x_t$represents the row of matrix *X* and $\hat{e}_t$ are the estimated residuals at time *t*.

Table 5: Time series dummy variable event study

VARIABLES	(1) OLS	(2) Newey West 5 lags	(3) OLS anticipation	(4) Newey West 5 lags anticipation
SMP11	0.0629**	0.0629**		
	(0.0103)	(0.000199)		
SMP21	-0.0424**	-0.0424**		
	(0.0103)	(0.000199)		
LTRO11	-0.00718	-0.00718**		
	(0.0103)	(0.000199)		
LTRO21	-0.0170	-0.0170**		
	(0.0103)	(0.000199)		
OMT11	0.0200	0.0200**		
	(0.0103)	(0.000199)		
OMT21	-0.0148	-0.0148**		
	(0.0103)	(0.000199)		
OMT31	0.00599	0.00599**		
	(0.0103)	(0.000199)		
OMT41	0.0220*	0.0220**		
	(0.0103)	(0.000199)		
APP11	0.0140	0.0140**		
	(0.0103)	(0.000199)		
SMP12			0.0273**	0.0273**
			(0.00735)	(0.0103)
SMP22			-0.0154*	-0.0154*
			(0.00735)	(0.00780)
LTRO12			-0.000430	-0.000430
			(0.00735)	(0.00196)
LTRO22			-0.00347	-0.00347
			(0.00735)	(0.00390)
OMT12			0.0172*	0.0172**
			(0.00735)	(0.000848)
OMT22			0.00276	0.00276
			(0.00735)	(0.00509)
OMT32			-7.04e-05	-7.04e-05
			(0.00735)	(0.00177)
OMT42			0.0155*	0.0155**
			(0.00735)	(0.00189)
APP12			0.0145*	0.0145**
			(0.00735)	(0.000249)
Constant	0.000195	0.000195	0.000170	0.000170
	(0.000193)	(0.000199)	(0.000195)	(0.000199)
Observations	2,868	2,868	2,868	2,868
R-squared	0.024		0.011	
Breusch Godfrey LM test (5 lags) p>chi^2	0.0022		0.0048	
Breusch Pagan test p> chi^2	0.000		0.001	

Notes: table shows a time series regression of total market log stock returns on event dummies, with model 3 and 4 using 2-day event windows. Different dummies represent different event dates as presented in table 2. Model 1 and 3 use OLS to estimate standard errors, while model 2 and 4 use Newey-West standard errors with 5 lags. Breusch Godfrey test is LM multiplier test for autocorrelation, and Breusch Pagan is test for heteroscedasticity. *Standard errors* in parentheses, ** p<0.01, * p<0.05.

strong stock price reactions (using financial and non-financial stocks) for the OMT and SMP announcements and mixed and mostly insignificant reactions for the LTRO program. By excluding financial companies, my results present a fairer assessment of the broader macroeconomic impact of these policies, besides the relative yield changes and segmentation and redenomination risk channels. This is due to the fact that changes in yields resulting from policy announcements have a direct effect on financial company's stock prices through a balance sheet channel since it affects the value of sovereign debt on their balance sheets. This effect is not or less pronounced for non-financial companies.

It becomes clear from this event study that the SMP and OMT program relatively had the largest effect on European stock markets. Given previous research on the sources of yield changes due to unconventional monetary policy measures this is unsurprising. Krishnamurthy et al (2014) find the SMP and OMT program to be working mainly through a reduction in default and redenomination risk, which would have generally large macroeconomic spillovers reflected in non-financial company's stock prices. In appendix 2 I present a graphical illustration of returns around announcements of the SMP, OMT and APP.

Besides analyzing the relative differences in reactions to different programs, it also becomes clear that the programs yielded different reactions in different countries/regions of the Eurozone. I present some graphical illustrations of this in appendix 3. As is unsurprising, the stock market reactions were generally much higher[2] in periphery (GIIPS) versus core European countries. For the SMP this differential is the largest with a coefficient of 0.103 for GIIPS and 0.048 for northern countries. This provides some evidence for unconventional monetary policy reducing default risk in peripheral countries, since default risk was an imminent threat at the height of the European sovereign debt crisis, especially for peripheral countries. It could also potentially point to a credit channel as lower interest rates as a result of the program vis-à-vis northern countries would alleviate some of the adverse credit and liquidity conditions of companies of those countries (see next section). Another potential reason for this large differential is that these policies work through a signaling channel, leading to market participant redenomination risk perception to be reduced due to anticipated capital flows from northern to southern European countries. (Krishnamurthy et al, 2014)

Another seemingly surprising result is the relative difference in reaction to announcements from the Greek stock market after the SMP, especially the negative reaction due to the OMT. This is however in line with the observation that the Greek financial crises developed relatively independently from the rest of the European sovereign debt crises (Gonzalez-Hermosillo & Johnson, 2014). This can also be said about the case of Ireland, which was dealing with several idiosyncratic stress factors such as a collapsing housing market. For this reason I also show the result for only IPS (Italy, Portugal & Spain)

[2] A formal test of equality of the coefficients by means of a Seemingly Unrelated Regression (SUR) is not possible in this case since this would estimate standard errors based on robust methods, using the covariance between the errors across the different models to estimate standard errors. The results of such a regression with many observations lead to extremely low standard errors resulting in formal tests of equal coefficients to reject any coefficient to be equal.

countries, and find its coefficient in general to be somewhere between the estimate for north and GIIPS, except for the APP program. This last fact is largely due to a relatively large stock reaction for Spain to the APP program.

The relatively high coefficients for Italy and Spain for the OMT program are in line with Falagiarda & Reitz (2015), who find the OMT program to have had the largest and most significant effect on Spanish and Italian sovereign yields. Since the OMT was mainly focussed on decreasing redenomination risk in peripheral countries such as Spain and Italy, this result is also unsurprising.

Table 6: Cross-country time series event study

COUNTRY/REGION	PROGRAM:							
	SMP	SMPa	LTRO	LTROa	OMT	OMTa	APP	APPa
All countries	0.063**	0.027	-0.017**	-0.019	0.021**	0.016**	0.014**	0.015**
North	0.048**	0.024*	-0.017**	-0.002	0.019**	0.014**	0.014**	0.015**
GIIPS	0.103**	0.044	-0.022**	0.001	0.028**	0.026**	0.026**	0.024**
IPS	0.087**	0.035	-0.018**	0.004	0.033**	0.024**	0.031**	0.028**
Netherlands	0.049**	0.023	-0.008**	0.001	0.013**	0.006*	0.012**	0.015**
Germany	0.034**	0.024**	-0.021**	-0.002	0.021**	0.017**	0.016**	0.017**
France	0.068**	0.032	-0.022**	-0.0004	0.031**	0.020**	0.014**	0.019**
Spain	0.097**	0.033	-0.014**	0.006	0.033**	0.024**	0.033**	0.030**
Portugal	0.087**	0.036	-0027**	-0.003	0.026**	0.021**	0.016**	0.009**
Ireland	0.109**	0.048	-0.025**	-0.0016	0.026**	0.027**	0.022	0.021**
Greece	0.061**	0.022	-0.011**	0.0015	-0.0036	0.008	0.016**	0.017**
Belgium	0.067**	0.032	-0.012**	0.001	0.023**	0.012	0.014**	0.020**
Austria	0.059**	0.026	-0.0001	-0.005	0.031**	0.017**	0.011**	0.008**
Finland	0.062**	0.025	-0.019**	-0.007	0.02**	0.016**	0.012**	0.015**
Luxembourg	0.07**	0.026	-0.023**	-0.0003	0.019**	0.021**	0.008**	0.0024
Slovenia	0.033**	0.014	-0.001**	0.0007	0.006	0.006	0.007**	0.005**
Italy	0.069**	0.036*	-0.027**	-0.0016	0.032**	0.026**	0.018**	0.014**
Great Britain	0.041**	0.017	-0.009**	0.0004	0.016**	0.01**	0.007**	0.007**

Notes: Table presents event study results per country/region. North includes Germany, Netherlands, Belgium, Luxembourg Austria and Finland. IPS are Italy, Portugal and Spain. Standard errors calculated using Newey-West heteroscedasticity and autocorrelation adjusted covariance matrices using 5 lags. SMP date: 10/5/2010 LTRO: 1/12/2011 and 8/12/2011. OMT: 26/7/2012 and 6/9/2012. APP: 22/1/2015. SMPa uses anticipation effects (two-day event windows). Statistical significance indicated at the 1% and 5% level (** $p<0.01$, * $p<0.05$).

5.3 Industry event study and establishing a credit channel

In order to make inferences regarding the cross sectional difference in stock price reactions across different industries I now apply the dummy variable time series regression model used in the previous section on all different industries on which I have balance sheet data. The event days considered are similar to those in the previous section, although I leave out potential anticipation effects. I cluster some industries on which there is little data together in larger groups (main industry), while I consider sub-industries where possible, especially with manufacturing companies. The regression results are presented in table 7. These are the regression results for SIC industries in GIIPS countries. I execute the same sector regression for all countries in my sample and for all industries in northern countries (Germany, Netherlands, Belgium, Austria, Finland and Luxembourg)[3].

Table 7: Industry time-series event study

SIC CODE	SMP	LTRO	OMT	APP
100-999	0.0330**	-0.0117	0.0056*	0.0103**
1000	0.0130**	0.0220	-0.0039	-
1300	0.0230**	-0.0063	-0.0024	0.0405**
1400	-0.0001	-0.0001	-0.0001	0.0470**
1500	0.0650**	-0.0180	0.0440	0.0018**
1600	0.0920**	-0.0170**	0.0369**	0.0097**
2000	0.0303**	-0.0176*	0.0152**	0.0097**
2400	0.1020**	-0.0229*	0.0136	0.0122**
2600	0.0598**	-0.0157**	0.0190**	0.0170**
2700	-0.0590**	-0.0590**	-0.0558**	0.0079**
2800	0.0408**	-0.0130	0.0250**	0.0116**
2900	0.1018**	-0.0145*	0.0547**	0.0141**
3100	-	-0.0244**	0.0230*	-0.0102**
3200	0.1140**	-0.0188**	0.0270**	0.0250**
3300	0.0750**	-0.0182	0.0271**	0.0168**
3500	0.0850**	-0.0159**	0.1080*	0.0220**
3600	0.0377**	-0.0145	0.0340**	0.0306**
3700	0.0730**	-0.0286	0.0315**	0.0298**
3800	0.0608**	0.0000	-0.0039	0.0185**
4200	0.0777**	-0.0163	0.0535**	0.0137**
4400	0.0580**	-0.0029	0.0045	-0.0078**
4500	0.0312**	0.0087	0.0248**	0.0231**
4700	0.0840**	-0.0264**	0.0456**	0.0224**
4800	0.1070**	-0.0145*	0.0391**	0.0183**
4900	0.0736**	-0.0122	0.0420**	0.0325**
5400	0.0906**	-0.0075	0.0061	0.0143**
5600	0.0861**	-0.0057	0.0364**	0.0049**
5900	0.1255**	-0.0140	0.0164*	0.0037**
7000	-	-	-	0.0052**
7300	0.0385**	-0.0056	0.0112**	-0.0022**
7900	0.0650**	-0.0183**	0.0087**	-
9900	0.1020**	-0.0390**	0.0388**	-

Notes: Table presents event study results per SIC industry. Dependent variable is the capitalization weighted log stock return time series of SIC industry. Standard errors calculated using Newey-West heteroscedasticity and autocorrelation adjusted covariance matrix using 5 lags. SMP date: 10/5/2010 LTRO: 1/12/2011 and 8/12/2011. OMT: 26/7/2012 and 6/9/2012. APP: 22/1/2015. Statistical significance indicated at the 1% and 5% level (** $p<0.01$, * $p<0.05$).

As becomes clear, in line with the country specific regression, most program announcements are significant for most sectors, with large positive stock market effects due to the SMP, OMT and APP

[3] These are omitted for brevity, but available upon request from the author.

announcements and slightly negative impacts from the LTRO announcements, although several of these last ones are insignificant at the sector level.

To empirically provide evidence for a credit channel of monetary policy to be at the heart of stock price reactions to unconventional policy announcements, I use the regression coefficients from the sector regressions as dependent variables in a cross sectional regression upon my external finance dependence variable. My external finance dependence variable is measured, as mentioned earlier, as the percentile rank of every industry, with 1 representing the most external finance dependent industry and 0 being the least external finance dependent. My regression equation now is

$$y_i = \beta_0 + \beta_i X_i + \varepsilon_i \quad (9)$$

In which y_i is the β coefficient of the sector time series regression of industry i and X_i is the external finance dependence in industry i.

Ideally I would want to check for all country fixed effects, however specifying my sector regression for each country individually will result in too few observations since in some countries only a few industries are represented. I therefore stick with a differentiation between north, GIIPS and all countries in my sample. I use north and south since presumably unconventional monetary policy would have different effects in core versus peripheral countries. For example, Falagiarda & Reitz (2015) find that interest rates of peripheral countries decreased significantly vis-à-vis German rates in response to SMP, LTRO and OMT announcements. Bank lending and credit conditions are thus arguably differently affected by expansionary monetary policy in northern versus southern European countries. As expansionary monetary policy in Europe generally lead to convergence of interest rates in Europe (i.e. see Altavilla et al., 2014), using all countries in my sample could arguably cancel out any stock market effect due to easing credit conditions. I perform my regressions on results of northern, GIIPS and all countries in my sample. The results of my cross sectional regression are presented in table 8.

The results in table 8, perhaps unsurprisingly, reject any significant evidence for a credit channel in the case of my entire sample or for core European countries. For peripheral countries, my results provide evidence that the LTRO worked through a credit channel, as external finance rank of an industry explains 35% of the variation in time series regression coefficients for industries in these countries, with a coefficient of 0.32 which is significant at the 1% level. For the other programs, no evidence is found for a credit channel of monetary policy using my external finance dependence proxy. To further test my hypothesis, I classify industries as external finance dependent and external finance independent with three dummy variables as can be seen in table 8 for my GIIPS results (results on northern and all countries yield insignificant results). This clearly provides evidence for my hypothesis for the LTRO program, with some less strong evidence for the SMP and OMT program. For the SMP programs, time series dummy coefficients are significantly higher at the 1% level for the upper 75% of external finance dependent firms versus the bottom 25%, while the OMT program is significant at the 5% level in this regard. My results do not find any evidence for a credit channel of unconventional monetary policy for the APP program. The relative significance of the LTRO program is not very surprising given that statements by the ECB regarding the LTRO indicate its main goal to be restoring the credit channel of monetary policy (see Krishnamurthy et al., 2014).

Table 8: Cross sectional regression of industry event study results on external finance dependence

GIIPS	SMP	LTRO	OMT	APP
β Dependence	-0.017	0.32**	0.154	0.01
	(-0.59)	(3.93)	(0.81)	(1.39)
Observations	30	31	31	29
R-squared	0.012	0.35	0.022	0.067

ALL	SMP	LTRO	OMT	APP
β Dependence	-0.008	0.008	-0.008	0.004
	(-0.54)	(1.06)	(-1.31)	(0.56)
Observations	48	49	49	47
R-squared	0.006	0.023	0.035	0.007

NORTH	SMP	LTRO	OMT	APP
β Dependence	0.0035	0.006	-0.006	0.004
	(0.24)	(0.96)	(-1.08)	(0.52)
Observations	37	37	37	39
R-squared	0.002	0.025	0.032	0.007

β GIIPS	SMP	LTRO	OMT	APP
>50th percentile	-0.015	0.013**	0.004	0.009
	(-1.00)	(2.92)	(0.40)	(1.75)
>25th percentile	0.13**	0.029**	0.042*	0.018
	(3.85)	(3.27)	(2.30)	(1.91)
>75th percentile	-0.02	0.011*	0.005	0.001
	(-1.44)	(2.21)	(0.49)	(0.11)

Notes: Table presents regression results of regression of time series event study regression coefficients on percentile rank of industries' external finance dependence. First only for GIIPS, second for ALL countries and thirdly for NORTH. 4th table presents regression on dummies representing higher than 50th, 25th and 75th percentile of external finance percentile distribution. T-statistics in parentheses (** p<0.01, * p<0.05).

I furthermore specify these same regressions, controlling for outliers and using robust standard errors[4]. This does not qualitatively alter my results of a significant credit channel for the LTRO program with minor evidence for a credit channel in the case of the SMP and OMT program. While these results do not provide strong evidence for a credit channel of monetary policy for the SMP, OMT and APP programs using the cross section of external finance dependence of industries and stock prices, this does not necessarily mean that no credit channel has been at work. It may just mean that contingent on my methodology of using stock returns, a credit channel cannot be established through the stock market, as other policy channels and market conditions influence the stock returns as well.

[4] These are omitted for brevity but available upon request from the author.

Implications and future research

These results show that the goal of the LTRO program of reestablishing a credit channel of monetary policy was probably positively received since externally financial dependent firms' stock prices reacted more positively than those of less dependent firms. Also, significantly more positive effects in peripheral countries versus core (northern) countries are observed, leading to the conclusion that market participants indeed perceived most of those policies to decrease default and redenomination risk of peripheral countries, which was one of the objectives of these policies. My results thus paint a relatively positive picture of the ECB's unconventional monetary policy measures.

A potential refinement for my methodology could arise from the fact that volatility usually increases in time series around event dates (i.e. volatility clustering, see appendix). One option would therefore be to use some variance modelling approach to take account of this characteristic. This is what Brown & Warner (1985) conclude in their seminal paper regarding event studies and stock prices. They find that since volatility increases around event dates, type I errors of rejecting the null of zero excess returns happen too often. Hence a potential avenue of future research could be testing whether other variance modeling approaches regarding stock returns lead to wildly different results of significance tests. Another avenue for refinement would be to see whether adding other explanatory variables will lead to different results for my last cross-sectional regression. One can use my event study methodology to check whether other country, industry or company specific characteristics affect event returns. One could for example use Bougheas et al' (2005) findings of younger, smaller and riskier firms showing more sensitivity to expansionary monetary policy to my stock return identification approach.

Conclusion

In this paper I identified the stock market effects in Eurozone stock markets to announcements of unconventional monetary policy by the European Central Bank during and after the European sovereign debt crisis. Using a refined methodology which built upon cross sectional event studies by Chodorow-Reich (2014) and time series event studies by Krishnamurthy & Vissing Jorgensen (2011), I provide evidence for significant stock market effects on announcement dates of the SMP, LTRO, OMT and APP programs. Using a simple cross sectional regression approach of event returns on a constant yields mostly positive and significant results, with LTRO announcements having a negative effect. The more reasonable time series approach used by Vissing Jorgensen (2011) results in only the SMP announcements to be significant. I argue that her time-series approach is not robust to the heteroscedasticity, autocorrelation and deviation from normality characteristic exhibited in daily stock returns, leading OLS to no longer be the best linear unbiased estimator. I specify a regression following Ioannidis & Kontonikas (2008) based on a Newey-West estimation of standard errors taking into account heteroscedasticity and autocorrelation. My subsequent results yield mostly significant event date effects, with little deviation from a non-robust approach with anticipation effects (few significant two day effects). Consequently, I use this approach to estimate announcement effects across eurozone countries and across industries. I find that most countries show significant stock price reactions to announcements, with the exception of Greece, who's financial markets reacted rather independently from other stock markets to monetary policy. Large differences in stock market returns can be observed across core and peripheral european stock markets, which mirrors the different effects across these countries on bond and CDS markets observed in earlier studies. Returns were generally higher in peripheral eurozone countries, providing some evidence for a decrease in (perceived) default and redenomination risk in the periphery as a result of these policies.

Using the methodology for measuring external finance dependence of industries developed by Rajan & Zingales (1998), I subsequently use the cross sectional difference in industry external finance dependence to establish a credit channel of monetary policy for all four programs. As external finance dependent companies hypothetically experience larger positive effects from expansionary monetary policy, one would expect such an effect to be measurable in the stock price reactions of these companies vis-à-vis companies who can fund all their operations and investments with internally generated funds. I find that the percentile rank of firms' external financial dependence of GIIPS countries has a significant effect on announcement returns for the LTRO program, explaining about 35% of the variation in time series regression coefficients across industries. This provides evidence for a credit channel of monetary policy for this program. I find less strong evidence for a credit channel of unconventional monetary policy for the SMP and OMT programs, and find no such evidence for the APP program. Importantly, this does not imply that no such channel was at work for these programs. It only indicates that no such channel can be established through the stockmarket using my methodology of the cross sectional difference in external financial dependence. An avenue for future research would therefore be to adjust my methodology in order to further disentangle different channels through which unconventional monetary policy affects stock prices, or to focus more on credit supply disruptions and use different measures of external finance dependence.

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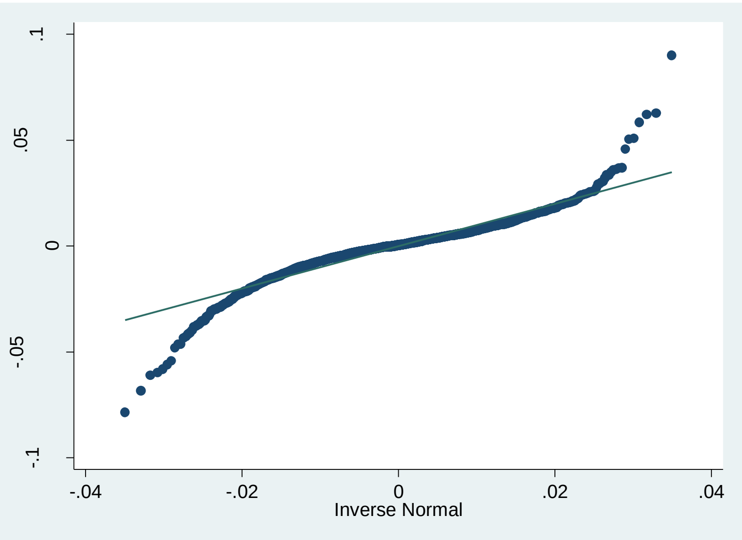
Appendix 1: Residual diagnostics

A well-known characteristic of stock market returns is that they are not normally distributed. Correct statistical inference with Ordinary Least Squares (OLS) requires the error term of the model to be constant ($V(\varepsilon_i) = \sigma^2 I_n$), and sometimes they are deemed to be normally distributed ($\varepsilon \sim N(0, \sigma^2 I_n)$), otherwise the OLS estimator will not be the best linear unbiased estimator (BLUE). To check whether the residual of the model of a regression of total daily market return on event dummies is in fact normal, I perform some residual diagnostics by creating some diagnostic plots comparing the model's residuals with the normal (Gaussian) distribution. Non-constant variance of the residual would lead to useless standard errors and therefore useless t-statistics, providing support for estimating standard errors in a different way.

First I generate a normal quantile (Q-Q) plot which graphs the quantiles of the residual against the normal distribution. This diagnostic plot provides evidence for whether there exist non-normality in the tails of the distribution, and will show deviation from the straight line representing the normal distribution near the ends. The result is as follows:

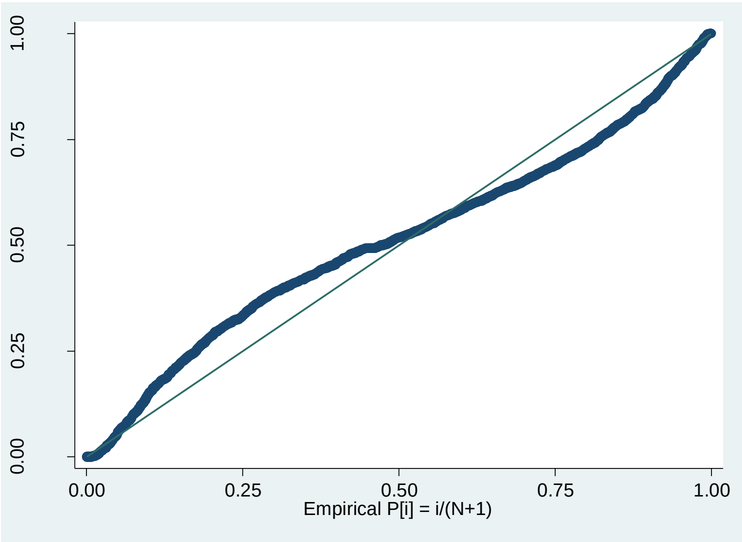
Figure 1: Q-Q plot of quantiles of residuals against normal distribution (straight line)



This plot indeed provides evidence for a relatively high degree of non-normality in the tails of the residual distribution as it deviates from the normal line at the ends.

Secondly I generate a normal probability (P-P) plot against the residual, which can provide evidence against normality at the center of the distribution. The result is as follows (*see next page*):

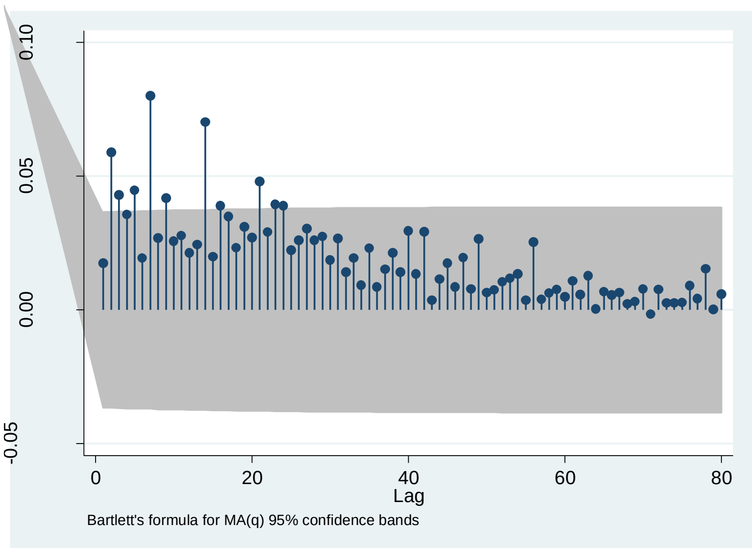
Figure 2: P-P plot of residuals against normality (straight line)



This plot also shows significant deviation from the normal line, leading to the conclusion that the residual distribution also significantly differs from a normal distribution at the center.

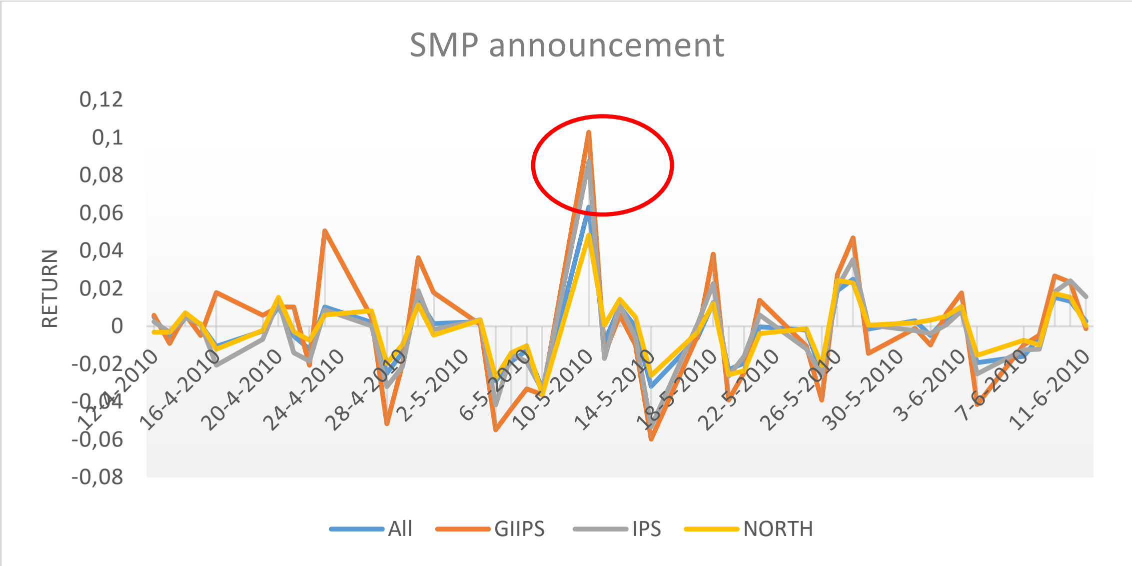
Figure 3 shows an autocorrelation plot of the squared residuals (e2) of a regression of the stock return time series of Germany on the explanatory variables. As the plot shows, there seems to be some significant autocorrelation at least in the squared residuals of my regression. This indicates that volatility clustering is present within my data and that my squared residuals are auto-correlated up to some large number of lags. This is not surprising given previous research indicating variance of stock returns to be non-constant over time. Volatility usually follows volatility and thus has a predictable component to it. More importantly it provides some more evidence against using simple OLS standard errors for my regression since the assumption of constant variance does not hold.

Figure 3: Autocorrelation plot of squared residuals (e2)



Appendix 2: Stock price movements around announcements

Figure 4: Stock price movements of different European stock markets around event dates. North is Germany, Netherlands, Belgium, Luxembourg, Austria and Finland. Red circle indicates peak due to policy announcement. SMP announcement is 10/5/2010, OMT announcement 26/7/2012 and APP announcement 22/1/2015.



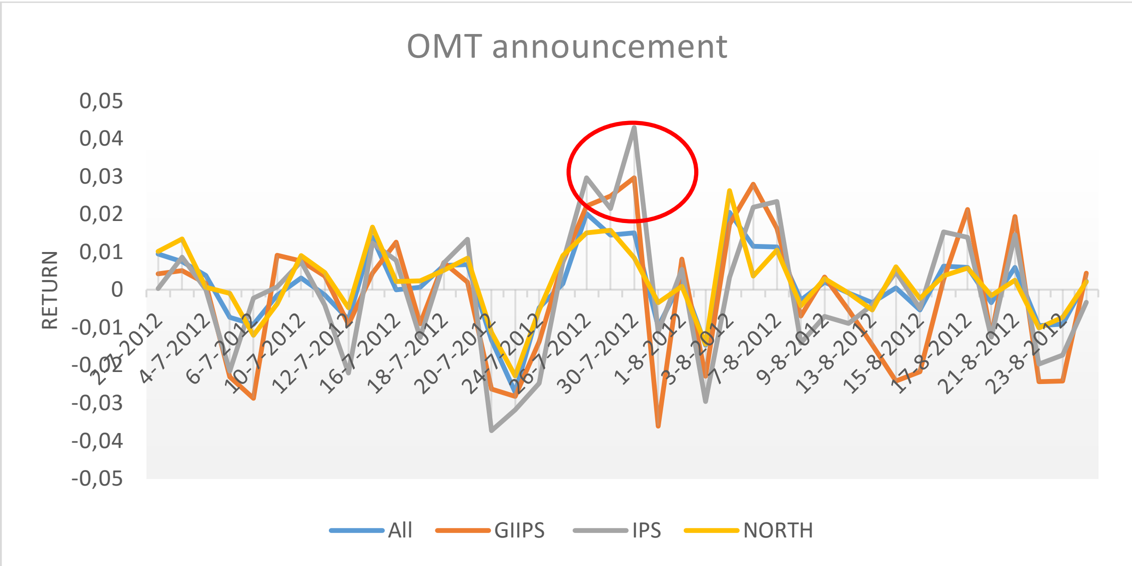
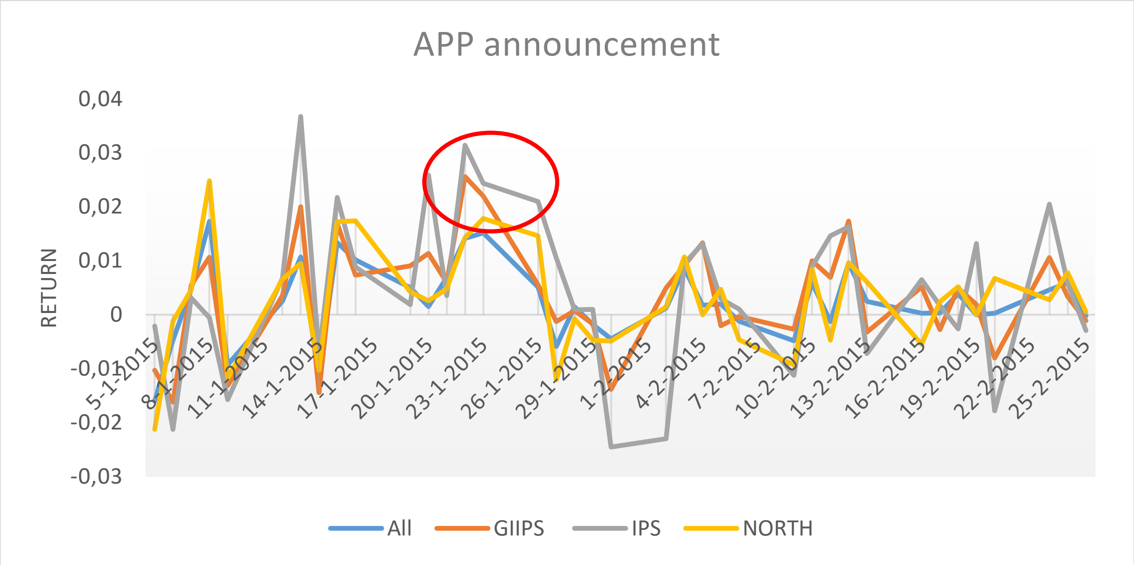


Figure 4 (continued):



Appendix 3: Comparing announcement returns across Europe

Figure 5: Time series regression coefficients for announcement dummies. SMP date is 10/5/2010, LTRO dates are 1/12/2011 and 8/12/2011, OMT dates are 26/7/2012 and 6/9/2012 and APP date is 22/1/2015. North is Germany, Netherlands, Belgium, Luxembourg, Austria and Finland.