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Measuring the Short-Term Effects of the ECB's Unconventional Monetary Policy on Financial Markets: A Review

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Abstract

Following the financial crisis in 2008, the ECB implemented various unconventional policy measures to respond to the tensions on the market. These measures had a significant impact and short-term effects on financial markets. This literature review provides a extensive overview of the empirical literature dealing with the short-term effects of this unconventional monetary policy using event studies. Furthermore, a methodological analysis of conducted event studies is carried out. First, we review empirical event studies focusing on the effects on the bond market, the stock market, as well as on international spill-over effects. Secondly, we carry out a methodological analysis of event studies that estimate the announcement effects of the ECB's unconventional measures. In this context, the analysis provides insight into the process of determining relevant events, the categorization of those, measuring the surprise component, and determining control variables. By comparing the different approaches applied, we give a comprehensive overview of similarities as well as differences in the methodology used.

Keywords: Unconventional Monetary Policy, Event study, ECB

JEL Classification: E44, E50, E52

I. Introduction

As a result of the global financial crisis of 2008, the European Central Bank (ECB) has relied on unconventional measures in addition to its conventional monetary policy measures (i. e. main refinancing rate, standing facilities, minimum reserve) to respond to the tensions that have arisen. Before that, the Bank of Japan (BoJ), the Federal Reserve (Fed), and the Bank of England (BoE) had already used unconventional measures to stimulate the economy after the financial crisis or to avert the threat of deflation because of a decline in econom-

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ic activity (for a review, see *Fawley/Neely* 2013). These non-standard measures include liquidity measures like longer-term refinancing operations (LTROs) and asset purchase programs. The unconventional monetary policy measures should ease financing conditions, reduce long-term yields, and in consequence, stimulate the real economy. The European debt crisis, which was characterized by a widening of spreads on government bonds, led to the ECB's first purchase program. The Securities Markets Programme (SMP) should ease tensions in these markets (i. e. Greece, Italy, Ireland, Spain, and Portugal) by buying government bonds on the secondary market. The SMP was discontinued in 2012 with the announcement of Outright Monetary Transactions (OMTs). These OMTs allow the ECB to acquire short-term government bonds to an unlimited extent to secure or restore the monetary stability of selected countries. In 2016, the ECB announced a further purchase program. The Asset Purchase Programme (APP) should boost the economy and the inflation rate to maintain price stability throughout the euro area by continuously purchasing government, corporate, and covered bonds as well as asset-backed securities. Due to the current Covid-19 pandemic, the ECB implemented another purchase program (PEPP) in 2020.

As these unconventional measures led to a widening of the ECB's balance sheet and made the ECB one of the largest creditors, growing attention is given to the effectiveness and effects of these programs. A large part of the existing literature focuses on the evaluation or quantification of short-term effects, especially the announcement effects of these programs on (international) financial markets. Given that government bonds were bought within the framework of the SMP, OMTs, and APP, many studies focus on the effects on yields or spreads of government bonds. Spreads for different countries (crisis and non-crisis countries) are calculated using two proxies that serve as risk-free rates. The computation is based on the one hand on the yield of German government bonds and the other hand, on the maturity equivalent swap rate. In addition to the effects on the government bond market, empirical research also analyzes the effects on stock markets. The effects are quantified using either VAR models or event studies. Due to the popularity of event studies in this field of research this literature review focus on this econometric approach. In this context, we provide an overview of those empirical studies and their results that deal with the short-term effects of the ECB's unconventional monetary policy measures.

In detail, we focus on empirical studies that deal with the effects of the ECB's unconventional monetary policy measures since 2008 on bond and stock markets in the euro area. As pointed out by *Belke/Dubova* (2018), different economies are affected differently by unconventional measures. Therefore, we also look at international effects and summarize those spill-over effects. In contrast to *Fiedler* et al. (2017) that assess the effects and effectiveness of ECB's monetary measures, we also conduct a methodological analysis of event studies focusing

on the methods and process when determining relevant events and the categorization of those chosen events. Moreover, we give insights into the approaches to measure the surprise component and give an overview of different control variables used. The review contributes to the literature as it gives a comprehensive overview of empirical studies dealing with the short-term effects of the ECB's unconventional monetary policy since the 2008 financial crisis. Moreover, we are the first to carry out a methodological analysis focusing on the determination of events, the categorization of them and, the measurement of the surprise component to point out differences in the approaches used when applying event studies.

The remainder of this paper is structured as follows. Section II gives an overview of the ECB's unconventional monetary policy since the financial crisis in 2008. Section III summarizes the empirical research strands on the effects of unconventional monetary policy. In this context, we focus on the methodology of event studies as they are the main approach when assessing the short-term effects of unconventional monetary policy measures. Section IV gives an overview of the main short-term effects of studied unconventional measures on the bond market as well as on the stock market and global markets. Moreover, a methodological analysis of event studies dealing with the short-term effects of the ECB's non-standard policy measures is carried out in Section V focusing on the determination of events, categorization of them, the measurement of surprise and included control variables. Finally. Section VI concludes.

II. ECB's Unconventional Monetary Policy

Following the 2008 financial crisis, which had a negative impact on the real economy worldwide, the European Central Bank has taken various measures to respond to the decline in economic output and low inflation rates. Initially, the ECB relied on conventional measures. Within the range of conventional measures, the ECB's main refinancing rate plays an essential role. Additionally, the ECB sets the interest rates on the deposit and marginal lending facility, which serve as the upper and lower limits for the overnight rate in the euro area. After the financial crisis and in response to the turbulence on the financial markets and the real economy, the ECB lowered the key interest rate. It reached its lower limit of 0 % on March 10, 2016, which makes further cuts impossible. For a consequence, the ECB relied on unconventional measures, which we describe in this section.

Covered Bond Purchase Programme 1 and 2 (CBPP1 and CBPP2): In order to respond to the decline in bank lending following the financial crisis, the first covered bond purchase program was implemented on July 2, 2009. This program was designed to boost lending, ease financing conditions for credit insti-

tutions and companies, and improve market liquidity in the private debt securities market. Besides, the ECB announced a second Covered Bond Purchase Programme (CBPP2) on November 3, 2011. This program, like the previous one, was designed to increase lending and ease funding conditions for credit institutions and firms.

Longer-Term Refinancing Operations (LTROs): In the course of longer-term refinancing operations, liquidity can be provided to commercial banks over a maturity of three months from the ECB. These liquidity enhancing measures are intended to incentive commercial banks to increase lending to companies as well as private households to stimulate the real economy.

Targeted Longer-Term Refinancing Operations (TLTROs): The measures are intended to support the monetary policy transmission mechanism and to increase lending to firms and households. Eligible commercial banks will be able to obtain liquidity from the ECB up to a specific ratio of their total volume of outstanding loans to firms and households. The linkage to the volume of outstanding loans is intended to provide commercial banks with an incentive to increase lending to these two sectors in order to stimulate investment and consumption and, subsequently, inflation.

Securities Markets Programme (SMP): The Governing Council decided the Securities Markets Programme on May 9, 2010. The program was implemented in response to the Greek sovereign crisis and, subsequently, the Irish and Portuguese crisis and the tensions on those markets. These tensions led to a nearly dried up secondary market, unjustifiable high spreads, and disrupted the ECB's monetary policy transmission mechanism. As a result of the distorted monetary policy transmission, the monetary policy measures in the form of changes in key interest rates could no longer have an impact on interest rates in individual countries or could not do so to the extent intended. This bond purchase program was intended to contain the high spreads in the crisis countries (Greece, Italy, Ireland, Spain, and Portugal)[1] and restore the disturbed transmission mechanisms by purchasing government bonds at the secondary market and increasing liquidity.

In the scope of the SMP, government bonds of EUR 210 billion were purchased. These sovereign bonds were purchased exclusively on the secondary market to ensure that the transactions did not qualify as government financing.[2] The purchase of the bonds, like other unconventional measures taken previous-

[1] Hereinafter referred to as GIIPS.

[2] As of December 31, 2012, the outstanding nominal value of all purchases made under the SMP amounted to EUR 218.0 billion. For Ireland, the outstanding nominal value was EUR 14.2 billion, for Greece EUR 33.9 billion, for Spain EUR 44.3 billion, for Italy EUR 102.8 billion and for Portugal EUR 22.8 billion.

ly, increased the ECB's total assets. The SMP was discontinued with the announcement of the Outright Monetary Transactions.

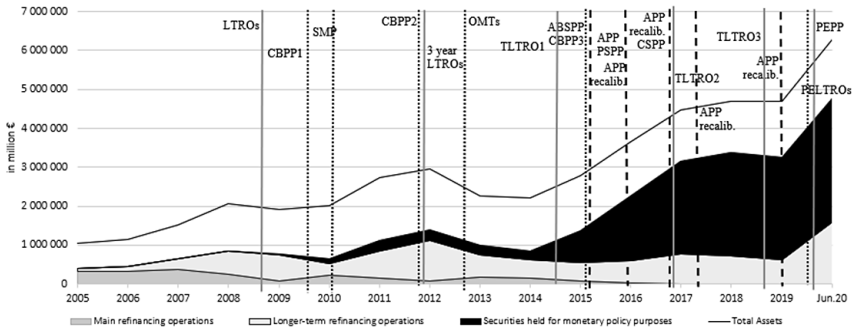
Outright Monetary Transactions (OMTs): On September 6, 2012, the Outright Monetary Transactions were decided. The objective of this program was to restore transmission channels in disrupted market segments. This program thus replaced the SMP. Under this program, government bonds were to be purchased on the secondary market in order to ensure or restore the ECB's monetary policy transmission. Similar to the SMP, no upper limits were set ex-ante concerning the planned purchase volumes. Unlike the SMP, the OMTs were not limited in time. Since the announcement of the program in 2012, however, no bond purchases have been made under the OMTs.

Asset Purchase Programme (APP): On January 22, 2015, the ECB announced an extension of its pre-existing bond purchase programs. Under the Asset Purchase Programme (APP), bonds of EUR 60 billion were to be purchased each month. The APP consists of four subprograms – the Asset-Backed Securities Programme (ABSPP) and Covered Bond Purchase Programme (CBPP2), Public Sector Purchase Programme (PSPP), Corporate Sector Purchase Programme (CSPP). In contrast to other programs, such as the SMP, this program is meant to fulfill the ECB's mandate of achieving price stability. Price stability corresponds to an inflation rate of 2 % per annum, as measured by the Harmonised Index of Consumer Price Index (HICP) for the euro area. The extension of the bond purchases should counteract the risks of low inflation, which has prevailed since the financial crisis in 2008. As both the historical inflation rate and the expected inflation rate were at an all-time low, this program was implemented in order to stimulate the economy in the euro area.

On December 13, 2018, the ECB announced that net purchases under the APP would be terminated at the end of December 2018. The ECB Council reinvested redemption payments of maturing bonds between January 2019 and October 2019. In November 2019, the APP was restarted and extended in March 2020 in response to the COVID-19 outbreak. Under the APP, the ECB set monthly average purchase volumes.[3]

Pandemic Emergency Purchase Programme (PEPP): In the wake of the COVID-19 crisis the ECB implemented in March 2020 the PEPP to prevent a disruption of the monetary transmission mechanism and a slowdown of the real economy. Under this temporary asset purchase programme bonds of 1,350 billion EUR can be bought.

[3] These were 60 billion (March 2015 to March 2016), 80 billion (April 2016 to March 2017), 60 billion (April 2017 to December 2017), 30 billion (January 2018 to September 2018), 15 billion monthly (October 2018 to December 2018), 20 billion monthly (November 2019 onwards) and additional 120 billion (between March and December 2020) respectively.



Source: European Central Bank

Note: Vertical lines refer to liquidity supporting measures implemented by the ECB. Vertical dotted lines refer to the announcement of unconventional policy measures. Vertical dashed lines refer to the announcement of the APP and subsequent re-calibrations and adjustments as well as the announcement of the PEPP.

Figure 1: ECB's Unconventional Monetary Policy Measures and Development of Total Assets (in Million EUR)

Pandemic Longer-Term Refinancing Operations (PELTROs): In April 2020 the ECB implemented additional longer-term refinancing operations in reaction to the COVID-19 crisis. These operations provide liquidity to support the financial system in the euro area.

Figure 1 shows the development of the ECB's total asset in million EUR and highlights the introduced unconventional monetary policy measures since 2008. The enormous expansion of the ECB's balance sheet due to the unconventional measures led to a growing interest in the effects of these measures. Therefore, we discuss this research area and its strands in the following.

III. Empirical Research Strands on the Effects of Unconventional Monetary Policy

Empirical studies dealing with the effects of unconventional monetary policies of central banks are numerous. The first empirical studies were on the effects of unconventional monetary policy in Japan as the Bank of Japan was the first central bank to rely on non-standard measures. As other central banks (Fed, BoE, and finally, the ECB) adopted the non-standard measures after the financial crisis, this research area received increasing attention. We divide literature evaluating the effects of the unconventional measures roughly into two strands: short-term and long-term effects, focusing on the short-term effects in this review.

1. Long-Term Effects

Given that the aim of the ECB's unconventional monetary policy, especially of the APP, was to stimulate the economy and maintain price stability in the euro area, much of the research is devoted to the long-term impact on macroeconomic variables (e. g. real GDP growth and inflation in the euro area). Unlike the effects on financial markets, the effects on the real economy are not quantified using event studies since macroeconomic variables do not show an immediate adjustment due to an announcement or the implementation of unconventional monetary policy measures, but instead, occur with a time lag. Effects on the real GDP growth and the inflation rate of the eurozone or individual countries are quantified and modelled in the literature using mainly two different econometric approaches. First, Equilibrium models are used. Several papers used dynamic stochastic general-equilibrium (DSGE) models to evaluate the impact of unconventional policy measures in the euro area (see *Priftis/Vogel* 2016; *Cahn/Matheron/Sahuc* 2017; *Sahuc* 2016). *Cagler* et al. (2011) give an overview of different modelling approaches when using a DSGE model. Second, vector autoregressive models are used in empirical studies to assess the effects on real GDP growth and inflation rate in the euro area. *Gambetti/Musso* (2017), *Boeckx/Dossche/Peersman* (2017), *Gambacorta/Hofmann/Peersman* (2014), *Lewis/Roth* (2019), *Wieladek/Garcia Pascual* (2016) and *Zabala/Prats* (2020) assess the effects of unconventional policy shocks on macroeconomic variables on an aggregated level using the inflation rate (HICP) and real GDP growth of the euro area as a whole. As the examination of effectiveness based on aggregated data is problematic due to the heterogeneity of the individual countries and their real GDP growth and inflation rates, many studies deal with these differentiated effects. *Burriel/Galesi* (2018), *Georgiadis* (2015), *Georgiadis* (2014), *Potjagailo* (2017), *Horvath/Voslarova* (2017), *Hajek/Horvath* (2016), *Serati/Venegoni* (2019) and *Bluwstein/Canova* (2016) evaluate the long-term effects of non-standard policy measures for different economies in and outside of the euro area. For a recent overview, see *Papadamou/Kyriazis/Tzeremes* (2019).

When assessing the long-term effects of unconventional monetary policy, literature also evaluates the effects on lending rates and volumes. Conventional monetary policy measures in the form of changes in the key interest rate of the euro area have an impact on lending rates, deposit rates, and lending and deposit volumes (*Bernanke/Blinder* (1992)). In the aftermath of the financial crisis, empirical studies focus on the impact of both conventional and unconventional measures on lending rates and volumes. Attention is given to possible heterogeneous effects between corporate and household lending rates. The long-term effects of these measures are estimated using mainly vector autoregressive models (see *Hristov/Hülsewig/Wollmershäuser* 2014; *Altavilla/Canova/Ciccarelli* 2020;

Creel/Hubert/Viennot 2016; *Von Borstel/Eickmeier/Krippner* 2016). Some literature relies on event-based linear regressions or panel regression to investigate both the effects on lending volume and lending rates (see *Horvath/Kotlebova/Siranova* 2018; *Kanga/Levieuge* 2017; *Martins/Batista/Ferreira-Lopes* 2019). However, in this review, we neglect this strand of interesting research to focus on event studies for evaluating the short-term effects of unconventional policy measures in the following.

2. Short-Term Effects

The second strand of the literature deals with the short-term effects of unconventional monetary policy. It focuses on the announcement effects of the various measures as well as the actual purchases. We find empirical studies dealing with the short-term effects of unconventional monetary policy measures use different econometric approaches. We divide the methods into two main methods (1) macro-econometric models and (2) financial econometric models. Figure 2 illustrates our distinction. We also look at what effects being studied. First, the effects of the announcements of the unconventional measures and, secondly, the effects of actual asset purchases made on the market are being evaluated. Depending on which effects are examined, empirical literature applies a different econometric method.

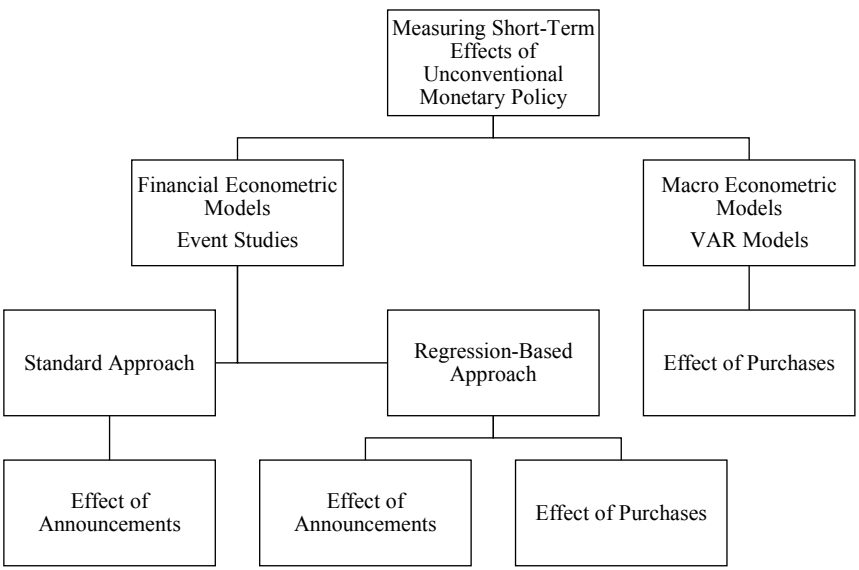


Figure 2: Approaches on Assessing Short Term Effects on Financial Markets

First, macro-econometric models, mainly vector autoregressive models, are used to assess the short-term effects and persistence of actual asset purchases made on financial markets. VAR models are mainly used to measure the long-term effects but also to evaluate short-term effects using high-frequency data.

a) VAR Models

Vector autoregressive (VAR) models offer an advantage over event studies as this econometric method accounts for the endogeneity problem of monetary policy measures in the model. As stressed by *Ghysels* et al. (2017), this approach addresses the problems that can arise from a simple regression of purchase volumes. In their model, they consider the endogeneity between changes in yields of sovereign bonds and the purchases made under the SMP of the ECB. Furthermore, the persistence of the implemented measures can be evaluated by impulse-answer functions. This approach can show the persistence and fading effects of the implemented measures.

If the announcement effects of unconventional measures are measured using VAR models, problems arise since policy rates have reached the lower limit of 0 %. As described by *Aßhoff/Belke/Osowski* (2020), policy rates cannot be included as endogenous variables in the model, as VAR models cannot be constructed using constant variables or variables corresponding to zero. This problem is solved in event studies by introducing dummy variables that represent the announcement of monetary policy measures (*Altavilla* et al. 2015). To measure the effects of the announcement of monetary policy measures using VAR models, the Qual VAR method is used in literature (*Dueker* 2005; *El-Shagi/von Schweinitz* 2016; *Tillmann* 2016). This method allows measuring announcement effects by constructing latent variables. *Galariotis/Makrichoriti/Spyrou* (2018) employ different VAR models as well as an event study to measure the effects of ECB's conventional and unconventional monetary policy. *Caraiani/Calin* (2020) assess the impact of monetary policy shocks on the stock market in OECD countries, focusing on possible stock bubbles due to interventions of central bank. *Gertler/Karadi* (2015) use an event study approach to determine high-frequency surprises for the following VAR analysis to assess the effects of monetary policy announcements. Few studies also apply a combined approach of event studies and VAR analysis (*Aßhoff/Belke/Osowski* 2020). *Andrade* et al. (2016) use a VAR model to present the dynamic effects of the APP on sovereign yields and to show their persistence. They find that the announcement of the APP had effects on yields and furthermore these effects persist for several months and can be compared to standard monetary policy shocks. However, the purchases itself do not have an impact on asset prices.

Secondly, financial econometric models, in particular event studies, are used as the primary approach to analyze short-term effects. This method allows measuring both announcement effects as well as the effect of purchases made. When measuring the effect of announcements, academic research uses the standard approach or the regression-based approach. Empirical literature also applies the regression-based approach when measuring the short-term effects of actual purchases under the various asset purchase programs. Due to the popularity of event studies when measuring the short-term effects of the ECB's unconventional monetary policy measures, we focus on this econometric model in the following.

b) Event Studies

Event studies established as the main method to measure the short-term effects of conventional as well as unconventional monetary policy announcements for different economies. The use of event studies makes it possible to measure the effect of such new information, assuming that markets are information efficient. The use of these econometric method allows a quantification of the immediate effects on pre-defined events.

Event studies were initially used in accounting and corporate finance research to evaluate the effects of mergers and acquisitions, dividend announcements, earnings announcements, or financing decisions on the value of a company. Financial research uses the share price as a proxy for the value of the company. The application of such studies has become widely established in the accounting and finance sector due to its broad applicability. In general, event studies test whether the changes in a time series in a given event window follow a normal-return generating model, or abnormal changes occur following the pre-defined event. In other words, event studies measure the effect of new (unanticipated) information.

The methodology of the event studies relies on three main assumptions – markets are efficient, events are unpredictable, and no confounding events exist. Since event studies examine how prices react to new information, the assumption of market efficiency forms the basis of this methodology (*Fama* 1970). Financial markets are information-efficient if new information is immediately reflected in the prices of securities. Thus, the new information that represents the event in the method leads to an immediate adjustment of prices. This assumption is necessary because event studies quantify these adjustments and to check whether the new information has resulted in abnormal returns. Event studies further assume that the information is new, i. e., the event was not anticipated by the market. Possible knowledge before the event on which the information was officially announced creates problems with this empirical method, as it is no longer possible to determine precisely when the information reached the mar-

ket. The third assumption concerns confounding events. In this context, it is assumed that the selected events examined by the method have been isolated from possible effects of other events to ensure price changes were caused only by the event under investigation.

In principle, the objective of event studies is to examine the significance of possible abnormal returns in the event window. The abnormal return $AR_{i,t}$ is the difference between the actual return $R_{i,t}$ and the normal or expected return $E[R_{i,t} \mid X_t]$ on a specific day in the set event window.

$$AR_{i,t} = R_{i,t} - E[R_{i,t} \mid X_t] \tag{1}$$

Here, X_t corresponds to the available information on the market at time t. In general, event studies assume that the returns of a security follow a normal-generating process. Whenever an event takes place where new information is made available, it is assumed that the returns of the variable of interest will change.

Empirical research uses two methodological approaches to estimate abnormal returns. The first approach is the standard event study, where the abnormal returns are computed as forecast errors of a normal return-generating model. The second approach is an event-based regression.

Standard Approach

The standard approach assesses the effects of monetary policy measures by calculating abnormal returns, which correspond to the estimation error of a specific normal return-generating model. Theses normal return-generating models estimate the normal return that would have been expected if the investigated event had not taken place. The normal return is estimated using a pre-event sample (estimation window) to exclude possible bias that could result from the event itself. After the estimation of normal return, the abnormal returns can be obtained (see equation (1)). They correspond to the difference between the actual return and the normal return on a specific day in the event window. In literature various normal-generating models are discussed (*MacKinlay* 1997). Possible models are the Constant Mean Return Model, the Market Model, and the Capital Asset Pricing Model (CAPM).

The simplest way to estimate normal returns is to use the Constant Return Model. Following this model, the normal (expected) return corresponds to the average return in the estimation window (*Pacicco/Vena/Venegoni* 2019, *Fiordelisi/Galloppo/Ricci* 2014). However, different lengths of the estimation window are used. In detail, *Pacicco* et al. (2019) use an estimation window of 252 days before the event, whereas *Fiordelisi* et al. (2014) use a window of 20 days to calculate the expected daily return. The Constant Return Model assumes that the

return of a security does not change in the absence of the event under investigation (*Cable/Holland* 1999). However, as the development of the market is not considered, this can lead to distortions, as possible trends of the market are not represented.

Another approach to estimate normal returns is to use the *market model* as proposed by *Fama* et al. (1969) in their paper. The two coefficients α and β for the market model are estimated using the estimation window with the standard OLS (ordinary least squares) method. The choice of benchmark plays an essential role in the market model, as it is employed to estimate the normal returns of the company under consideration. If an incorrect benchmark is chosen for the calculation, this can lead to distortions in the estimate. We find that studies using the market model apply different estimation windows as well as proxies for the market. In detail, *Ricci* (2015) uses the market model to estimate abnormal returns. The estimation window is 252 days and ends 20 days before the selected monetary policy announcements. The authors use three different indices as a proxy for the market – MSCI Europe, MSCI European Union, and MSCI Monetary Union to test the robustness of the results. *Fiordelisi* et al. (2014) also use the market model to estimate abnormal returns in their empirical study. *Ricci* (2015) uses different indices as a proxy for the stock market to ensure the robustness of the results. *Henseler/Rapp* (2018) use a risk-adjusted market model to calculate the normal returns using an estimation window of 100 days.

However, using the market model to calculate the normal return has a drawback compared to the constant mean return model. If the reactions of broad stock indices are measured according to unconventional measures, endogeneity problems with the selected market index may arise, since the indices examined usually cover almost the entire market. If broad indices are used as market indices, the estimates of the normal return can be distorted by currency or country-specific effects (*Pacicco* et al. 2019). Furthermore, event studies that span a short period, the results obtained using the constant mean return model are very similar to those obtained using more sophisticated models to calculate normal returns (*Brown/Warner* 1980). However, significant differences arise in relation to the choice of the event window or the frequency of the data. These differences show that the choice of the event window and the exact determination and definition of the event are more crucial than the chosen method for determining normal returns.

The estimated abnormal returns can then be cumulated over the event window or on a cross-sectional basis. Aggregation is usually carried out symmetrically around the event day itself or to measure anticipation effects or delayed effects. These cumulative average abnormal returns are then tested on its significance (One-Step Methodology). In a second step, in literature, the significance of possible drivers of abnormal returns is estimated (Two-Step Methodology).

Following the Two-Step Methodology, abnormal returns or cumulative abnormal returns are regressed on to possible influencing parameters. Both company-specific (*Henseler/Rapp* 2018) and macroeconomic (*Pacicco* et al. 2019) factors are used in this context.

Regression-Based Approach

A more general approach of event studies estimates a multivariate regression with dummy variables to represent pre-defined events. As the standard approach, event-based regressions also assume efficient markets. Therefore, it is assumed that price movements follow a random walk in the absence of new information. Unlike the standard approach, the regression-based approach estimates the effects of an event directly in a multivariate regression using standard OLS techniques. In the context of the unconventional monetary policy of the ECB, literature evaluates two different effects.

On the one hand, empirical studies measure the effects of the announcement of these programs (as the standard approach) and, on the other hand, the effects of the actual bond purchases. In both cases, academic research applies a regression-based approach:

$$R_t = \gamma UMP_t + \alpha z_t + \varepsilon_t \tag{2}$$

Here R_t is the variable of interest, UMP_t represents the surprising, unconventional monetary policy news (either an announcement or a purchase of assets), z_t is a vector of control variables if needed and ε_t is an error term. The parameter of interest (abnormal return) γ is estimated directly in the multivariate regression using standard OLS techniques.

If the *effects of announcements* are being assessed, studies define dummy variables that takes a value of 1 on the event day (or during the event window) and zero otherwise. This dummy variable replaces the variable UMP_t in equation (2). The coefficient of interest γ which measures the effect of the event, can then be estimated directly from the regression. If several events are examined within a time window, a dummy variable can be introduced, which takes the value 1 for each event examined. The coefficient γ can then be interpreted as the average abnormal return overall event windows (*Binder* 1998).

Another strand of empirical studies deals with the *effect of purchases* under the various programmes. In contrast to the assessment of the announcement effects of unconventional or conventional measures, this field of research uses actual or approximate purchase volumes to measure the impact of these on financial markets. The use of actual purchase volumes allows quantifying the effects of actual purchases rather than the simple announcement. The use of actual

purchases is important as the volumes varied greatly from country to country and fluctuated strongly over time. As a result, the different countries in the samples were affected differently by the purchase programs, and therefore a single 0/1 dummy cannot reflect them properly. The exact methodology for evaluating the effects of the purchases carried out is very diverse. The approaches range from standard linear regression estimated for each country or a group of countries in the sample (*Jäger/Grigoriadis* 2017; *Gerlach-Kristen* 2015) to panel regression models (*De Pooter/Martin/Pruitt* 2018; *Eser/Schwaab* 2016). Much of the literature estimates effects on individual countries (*Ghysels* et al. 2016; *Eser/Schwaab* 2016; *Gibson/Hall/Tavlas* 2016) while others estimate effects for a group of countries. *Jäger/Grigoriadis* (2017) evaluate the effects on the crisis (GIIPS) as well as non-crisis countries (Austria, Germany, France, Belgium, Finland, Netherlands) to highlight the different impacts between these two groups of countries. For this purpose, the estimates are carried out for three different samples (all countries, crisis countries, non-crisis countries). Furthermore, the frequency of the data also differs in the models. Here, intraday (*Ghysels* et al. 2016), daily (*Eser/Schwaab* 2016) and weekly (*De Pooter* et al. 2018) data are used, while in the case of the assessment of announcement effects, mostly daily data are used.

The challenge of measuring the effects of actual purchases arises from the fact that, as in the case of the SMP, bond purchases were only published weekly as a part of the ECB's assets. A precise breakdown of purchases on a country-by-country basis was not made until after the end of the program. Bond purchases under the APP were published weekly. This lack of data poses a problem in estimation using daily or high-frequency data, as these data on actual bond purchases on a country and issuer basis are confidential. In comparison, the exact dates of the announcements of the non-standard measures were available to the public immediately.

Eser/Schwaab (2016) use actual purchase volumes at nominal values of the SMP to assess the effect of the SMP on the 5-year yields of government bonds. The authors use confidential daily data from the ECB to evaluate bond purchases under the SMP on the bond yields of the crisis countries (GIIPS) and the changes in the spreads compared to Germany. The use of actual volumes allows a quantification of the effects on yields following a bond purchase of one billion euros. If the actual purchases are not available, empirical literature uses the average purchases of the programs published by the ECB. *Gibson* et al. (2016) employ average purchases (monthly) at the country level to evaluate the effects of the SMP, CBPP1 and CBPP2 on the bond yield spreads of crisis countries (GIIPS).

In addition to the use of published ECB data, datasets from different data providers are also used in academic literature. *Jäger/Grigoriadis* (2017) conduct a

standard event-based regression using actual purchase volumes to quantify the effects of the SMP on bond yields spreads. The authors employ a dataset from Barclays containing the weekly approximated purchase volume at the country level. This dataset can be used to distribute the bond purchases on a country basis at any point in time. *De Pooter* et al. (2018) use this dataset to evaluate the effects of bond purchases of the SMP. The authors use weekly data in their regression as a distribution on a daily basis would be too ambiguous.

However, estimating the effects of actual purchase volumes using daily data or data with a lower frequency may lead to distortions due to the endogeneity of the measures. This bias arises as the measures are driven by market changes such as, in the case of SMP, an extreme increase in bond yield spreads. A simple regression of yields on daily purchases leads to an underestimation of the correlation between the yields and the bond purchases. This procedure can result in regressions with insignificant or even positive coefficients when the effects are evaluated. An estimation using high-frequency data or intraday data can solve this endogeneity problem. For an overview of high-frequency studies, see *Menkhoff* (2010). If data with sufficient frequency are used, it is possible to measure the effect of interventions in the form of bond purchases on yields. As argued by *Ghysels* et al. (2017) a correlation between purchases and yields can be zero based on daily data; it can be negative when using higher frequency data. There is empirical evidence that regressing yield changes on SMP purchases leads to insignificant coefficients and, in some cases, even positive coefficients. However, if the same regression is performed using high-frequency data, negative coefficients can be found. We remark that event studies only measure the short-term effect of unconventional policy. No conclusion can be drawn regarding the persistence of these observed effects. To evaluate the persistence of these effects, VAR models can be applied (*Andrade* et al. 2016). However, empirical studies rely mostly on event studies due to their broad applicability to measure the short-term effects of monetary policy measures on financial markets. We therefor discuss and summarize the results of these event studies in the following.[4]

IV. Effects on Financial Markets

Empirical literature suggests that the unconventional monetary policy measures had short-term effects on several markets. Typically, literature evaluates the effects of monetary policy on (1) the bond market, (2) the stock market, and (3) on international markets. In the following the results of empirical studies using event studies to evaluate the effects are summarized.

[4] It should be noted that the results of VAR models are largely consistent with the results of the event studies. (*Andrade* et al. 2016)

Gagnon et al. (2011), *Swanson* (2011), *Krishnamurthy* et al. (2011), *Thornton* (2017) employ this econometric method to evaluate the effects of unconventional measures of the Fed, especially their announcement on financial markets. *Gagnon* et al. (2011) examine the effects of the announcement of the Fed's purchase programs between 2008 and 2009, finding that these announcements reduced long-term bond yields. *Krishnamurthy* et al. (2011) draw similar conclusions. In contrast, *Neely* (2015), and *Rogers/Scotti/Wright* (2014) examine the effects of the Fed's announcement of unconventional measures on international financial markets. They find that the announcements have an impact on asset markets, and thus international spill-over effects prevail. In particular, *Neely* (2015) finds that the announcement leads to a reduction in global government bond yields and leads to a depreciation of the US dollar in the currency markets. For a recent overview, see *Bhattarai/Neely* (2016).

For the UK, *Joyce* et al. (2011), *Joyce/Tong* (2012), *Gagnon* et al. (2011), and *Glick/Leduc* (2012) assess the effects of the asset purchase program of the BoE. The announcements of the BoE's asset purchase programs led to declining yields similar to the announcements of the Fed (*Joyce* et al. 2011; *Gagnon* et al. 2011).

Most literature on the effects of ECB's unconventional monetary policy is focusing on the effects on the *bond market* using event-based regressions. It covers both bond markets of individual countries and as well as of groups (S*zczerbowicz* 2015, *Jäger/Grigoriadis* 2017). When evaluating the effects on bond markets of individual countries, two different methods are applied in the literature. On the one hand, individual regressions are conducted for each country. On the other hand, panel regressions (*Eser/Schwaab* 2016, *Urbschat/Watzka* 2017) are used. The main focus is on yields of euro area government bonds, which were primarily the target of the bond purchase programs (SMP or OMT), and represented the most substantial part of the APP (PSPP). The purchase of the previously specified bonds should lower long-term interest rates to stimulate the real economy through easing financing conditions. For this purpose, the yields of government bonds with a maturity of 10 years are usually considered (*Altavilla* et al. 2016, 2015; *Fendel/Neugebauer* 2019). Another approach is to consider a maturity of 5 years (*Eser/Schwaab* 2016) or two years (*Altavilla* et al. 2015). In addition to the examination of individual maturities, effects depending on the maturity of government bonds are examined (*Fendel/Neugebauer/Kilinc* 2020). This approach is crucial as pointed out by *Andrade* et al. (2016), *Hausken/Ncube* (2013), as the effects increased with the maturity (duration) of the respective bonds.

However, not the bond yields are entered into the model as a dependent variable. Nevertheless, instead, regression is estimated in first differences as unit-root tests suggest that yields are non-stationary for most countries. Usually, studies that evaluate the effects on yields compare the reactions of crisis and non-crisis countries. This comparison is made as individual purchase programs

pursued different objectives. For example, the SMP was intended to reduce the spreads of crisis countries, while the APP should ease general financing conditions (reduction of long-term yields in both crisis and non-crisis countries). Particularly in the case of Greece, there are considerable differences concerning the effects on the yield. The most significant effect results after the announcement of the SMP, the smallest after the announcement of the APP. The programs were able to lower the yields of the crisis countries, which speaks for the effectiveness of these bond purchase programs.

In comparison, however, the 10-year yield on German government bonds remained virtually unchanged as these bonds were not the focus of the SMP or OMTs. In Italy, Greece, and Spain, the most substantial changes occurred in the course of the SMP, while this purchase program left the yields of the German (French) government bonds nearly unchanged (*Szczerbowicz* 2015; *Altavilla* et al. 2016; *Falagiarda/Reitz* 2015). The announcement of the OMTs had similar effects across all crisis countries. The announcement of the APP or the implementation of the APP only had marginal effects on the yields of crisis countries. In contrast, in Germany, the APP led to a reduction in 10-year yields. A distinction between crisis and non-crisis countries makes it possible to evaluate the effects of the various measures on the spreads of the countries in question. In crisis countries, the SMP and OMT had more potent effects; LTROs for non-crisis countries show more substantial effects compared to the crisis countries (*Jäger/Grigoriadis* 2017).

In addition to using sovereign bond yields, spreads are also used in empirical research. Spreads are considered as the variable of interest, as unconventional measures, especially the SMP and OMTs, were intended to reduce the high spreads of the crisis countries (GIIPS). Spreads are calculated using two proxies that serve as risk-free rates. The computation is based on the one hand on the yield of German government bonds (*Szczerbowicz* 2015; *Jäger/Grigoriadis* 2017; *Falagiarda/Reitz* 2015) and on the other hand, on the maturity equivalent swap rate (*Kilponen* et al. 2015). The use of swap spreads offers an advantage over the use of the spread over German government bonds. First, Germany can be included in the analysis. Second, the swap rate is often used by market participants as a risk-free interest rate (*Beber/Brandt/Kavajecz* 2009). Similar to yields, unit-root tests also suggest non-stationary in spreads, and therefore the regression is estimated in first differences. Studies again compare the effects of individual programs between crisis and non-crisis countries. *Kilponen* et al. (2015). find that SMP, OMTs, and LTROs had significant effects on the spreads of almost all countries. However, the CBPPs have no significant effects on the yield spread between the 10-year yield on government bonds (GIIPS countries) and the German government bond. *Szczerbowicz* (2015) finds effects on crisis-countries such as Spain and Italy are significantly more potent than in non-crisis countries such as France.

In the course of the SMP, most literature examines the effects on government bond yields of GIIPS countries and spreads compared to Germany. *Eser/Schwaab* (2016) examine the effects on 5-year government bond yields (GIIPS) using actual purchase volumes. The results show heterogeneous effects in the countries considered raging between –0.01 % (IT) and –0.19 % (GR) for a purchase of EUR one billion. In contrast, the announcement effect of the SMP amounts to –0.94 %. *Gibson/Hall/Tavlas* (2016) as well as *Szcerbowicz* (2015) find similar effects. Focusing on the OMTs *Altavilla* et al. (2016) find significant announcement effects for Italy and Spain while there are no statistically significant effects for Germany and France. *Jäger/Grigoriadis* (2017) also find heterogenous effects between crisis and non-crises countries as they distinguish between these two groups in their study when evaluating the effects of the announcement of the SMP as well as the OMTs.

Literature also evaluates the effects on the *stock market* using both standard event studies and event-based regressions. A large part of the literature deals with the effects on broad stock indices. If the European stock market is analyzed, the EURO STOXX 50 (*Haitsma* et al. (2016); *Altavilla* et al. 2015) and EURO STOXX 600 (*Hosono/Isobe* 2014) are primarily used in the evaluation. A small body of literature also focuses on individual countries and their key index (*Rogers* et al. 2014; *Fausch/Sigonius* 2018). Several empirical studies also examine different country indices simultaneously to show heterogeneity between euro area member states (*Pacicco* et al. 2019, *Fiordelisi* et al. 2014, *Chebbi* 2019). *Pacicco* et al. (2019) find that the impact of the programs was strongest on the German stock market, followed by the French, Belgian, and Italian equity markets. However, the impact on the Portuguese and Greek markets is minimal. *Chebbi* (2019) also concludes that the reaction in the German stock market is strongest, while monetary surprises do not affect the French stock market.

In addition to the examination of country indices, the use of self-constructed portfolios allows a differentiated examination of different stocks in respect of pre-defined characteristics. A distinction is crucial, as the response to monetary policy surprises varies between different industries or sectors. *Bernanke/Kuttner* (2005) find that high-tech and telecom react very strongly to unanticipated measures, while energy and utilities show a low response. Furthermore, differences between value and growth stocks are evident (*Kontonikas/Kostakis* 2013). Therefore, *Haitsma* et al. (2016) examine the impact of both conventional and unconventional ECB measures on 19 different sectors. Besides, they examine the effects on self-constructed portfolios based on firm characteristics such as size, financial leverage, debt-to-equity ratio. The construction of growth and value portfolios is based on market-to-book ratios and price-to-earnings ratios. Another approach is to analyze one sector merely. In the literature, the banking sector and the effects of unconventional monetary policy on this sector are of interest (*Fratzscher* et al. 2016; *Andrade* et al. 2016, *Fiordelisi* et al. 2014). In this

context, it can be assessed whether capitalization influences the exposure of banks to monetary policy. Ricci (2015) finds that banks with higher capitalization react less strongly to monetary policy measures. In contrast, less liquid banks are more dependent on the measures taken by the ECB.

A strand of empirical research deals with the effects at an individual company level. Similar to aggregated portfolios, this allows an investigation of possible cross-sectional heterogeneity on a firm-level basis. These cross-sectional heterogeneities could explain the contradictory results of those studies that examine the effects on broad indices. *Henseler/Rapp* (2018) examine the impact of the APP at a firm level using stock prices of companies in the euro area. They find heterogeneous effects at the corporate level after the announcement of the APP. The results show that the abnormal returns are negatively correlated with the size and negatively correlated with the leverage of companies. Furthermore, they find a negative correlation between abnormal returns and the market-to-book ratio. These results suggest that there are differences between value and growth stocks in respect of exposure to unconventional monetary policy measures (*Kontonikas/Kostakis* 2013). These differences cannot be detected when examining broad indices in contrast. In comparison, *Ricci* (2015) examines the reactions of the unconventional measures to stock prices of major European banks. He finds that banks with a higher capitalization ratio react less strongly to monetary policy measures. In contrast, banks with a lower capitalization are more dependent on the measures taken by the ECB.

Effects of ECB's unconventional monetary policy on domestic variables are extensively studied in the literature. The literature on *spill-over effects* is relatively small but starts to get attention. Empirical studies that focus on spill-over effects of the Fed's monetary policy suggests that effects on international economies arise (*Gambacorta* et al. 2014, *Glick/Leduc* 2012; *Chen* et al. 2017; *Neely* 2015; *Rogers* et al. 2014). *Galloppo/Paimonova* (2017) and *Mukherjee/Bhaduri* (2015) examine the spill-over effects of the FED's unconventional measures on stock markets in the BRIC countries. The results show no significant responses. *Fratzscher* et al. (2016) address the effects of the ECB's unconventional measures between 2008 and 2012 on international bond, equity, and currency markets. The authors conclude that although the aim of the ECB's unconventional monetary policy measures was to improve the tense situation in the euro area, global capital markets are also influenced by these measures. In detail, *Fratzscher* et al. (2016) show that the announcement of the OMT and SMP lead to positive spill-over effects on international stock prices, while the impact of these two programs on global bond yields is negligible. However, *Falagiarda* et al. (2015) find that the announcement of the SMP led to significant spill-over effects in selected Eastern European countries (CZ, HU, PO and RO), while the announcement of the OMT and APP only had small effects in these countries. *Georigiadis/Gräb* (2016) examine the announcement effects of the APP in dif-

ferent economies (Eurozone, USA, Japan and emerging markets). They find that the APP had similar strong effects on global stock prices as the SMP and OMTs, respectively, the effects on bond yields are diverse.

When evaluating international spill-over effects, however, not only developed countries are examined, but also emerging markets and emerging economies. *Lubys/Panda* (2020) examine the effects of monetary policy announcements by the ECB and the FED on stock markets in the BRIC countries. Like *Galloppo/Paimanova* (2017), they find no apparent patterns or reactions after announcements of monetary policy measures. The significance of the abnormal returns depends on factors such as the specific country.

Since the announcement effects are measured using event studies, an explicit selection of relevant events is crucial, ensuring that only those events are included that were of high international priority. *Fratzscher* et al. (2016) include only these events that were mentioned on the title page of the Financial Times the next day (i. e. the day after the official announcement). As a result of this selection process, the announcement shock of these events is large enough to affect global markets.

An issue of importance in analyzing international spill-over effects after the announcement of monetary policy measures is the consideration of fixing dates of different stock exchanges. If the effects on exchange rates are analyzed, no problems occur as they are traded 24 hours a day. However, if the effects on bond or equity markets are examined, the respective country-specific fixings and trading hours must be considered (*Georgiadis/Gräb* 2016).[5]

V. Methodological Analysis of Event Studies

Event studies assessing the short-term effects of monetary policy measures show a wide range of variables, assumptions, and specifications. In this section, we review the following dimensions: (1) determination of relevant events, (2) categorization of events, (3) measurement of surprise, and (4) control variables.

1. Determination of Relevant Events

Since event studies measure the effects of monetary policy announcements, identifying the relevant events is a crucial step. First, possible events to be included must be identified. These can be official announcements, decisions, press conferences, and speeches of the ECB. A frequently used approach is to consid-

[5] For example, the closing prices of the day t + 1 are used for Asian stock markets, as the exchanges have already closed when the ECB announces measures.

er only official ECB announcements and publications of monetary policy decisions (*Szcerbowicz* 2015; *Gagnon* et al. 2011; *Ricci* 2015; *Falagiara/Reitz* 2015, *Fendel/Neugebauer* 2019; *Fendel/Neugebauer/Kilinc* 2020). *Andrade* et al. (2016), however, consider only those events in the sample if a new unconventional monetary policy measure has been announced or an existing program has been modified. A second approach to identify possible events is carried out based on a text-based search using a variety of databases (e. g. Lexis, Factiva, or Bloomberg News). This approach includes days in the survey that have the highest number of contributions to a specific search term. This approach is used by *Altavilla/Carboni/Motto* (2015) and *De Santis* (2016).

However, the two methods discussed above have some drawbacks. First, the events chosen (in this case, the announcement of monetary policy measures) ought not to have been anticipated by the market. If the market already anticipated the announcements, the effect is already priced into the market before the actual event. Consequently, only unanticipated announcements may be included in the analysis. These announcements not only have to be surprising but also relevant to the market in order to influence prices. Hence, in literature, only major monetary policy announcements are usually included in the analysis. Supporting announcements and decisions such as the extension of the maturity of longer-term refinancing operations are neglected. These are included in the analysis for robustness checks only.

To identify the unanticipated events, an additional step, besides, is carried out. First, potential events are identified using the two methods we discussed above, and in a second step, those events are determined, which are unexpected and relevant. The specific selection of the unanticipated events considered can be made based on a qualitative analysis of headlines in newspapers before and after an announcement. This approach is used by *Szcerbowicz* (2015) and *Fratzscher/Lo Duca/Straub* (2016). *Szcerbowicz* (2015), defines, based on the qualitative content in financial news, the unanticipated events that are included in the empirical study. *Fratzscher* et al. (2016) and *Urbschat/Watzka* (2019) conduct a qualitative analysis based on The Financial Times to filter those ECB monetary policy announcements that are of international importance. In their study, only those announcements are included in the sample that was reported on the front page (first three pages) of the Financial Times the day after the event. This procedure leads, however, to a strong reduction of events. However, the method ensures that only unexpected and relevant events that are of international importance are considered. The methods used to identify relevant events result in a different number of relevant events between studies.

Once the relevant events have been identified, it has to be ensured that no other market-relevant events have happened on these days. Confounding events would bias the results, as these events could have an impact on the variables un-

der consideration. Thus, the actual relevant event would not cause the observed reaction. The identification of a confounding event can, in turn, be carried out using a wide variety of databases (e. g. Bloomberg). Literature controls for announcements, e. g., monetary policy decisions of other central banks, as possible confounding events.

2. Categorization of Events

As individual monetary policy measures (conventional and unconventional) had different aims, the categorization of the relevant events identified is crucial. Classification ensures that the effectiveness of individual programs or their impact on the variables of interest can be quantified. In scientific literature, the classification is done in different ways. Much of the literature dealing with the monetary policy of the ECB divides events in a first step into conventional and unconventional measures. A distinction between these two measures is important as they operate through different transmission channels, and a joint consideration could distort the results. This approach is used by *Haitsma/Unalmis/de Haan* (2016), *Pacicco* et al. (2019), *Fiordelisi* et al. (2014) and *Ricci* (2015). When looking at conventional measures, a distinction is made into key interest rate cuts and raises. *Chebbi* (2019) divides conventional policy decisions into (1) increases of the key interest rate, (2) unchanged interest rates, and (3) interest rate cuts.

If unconventional measures are evaluated, they can be subdivided roughly into monetary easing and liquidity support measures (*Chebbi* 2019; *Fiordelisi* et al. 2014). However, a large body of literature categorizes the unconventional policy measures more granularly. A broadly applied approach is the differentiation into individual programs such as LTROs, SMP, OMTs, and the APP. This approach is followed by *Falagiarda/Reitz* (2015), *Falagiarda/McQuade/Tirpàk* (2015), and *Kilponen/Laakkonen/Vilmunen* (2015), whereby *Falagiarda* et al. (2015) make a granular distinction of the APP into the individual bond purchase programs (PSPP, CBPP, ABSPP). A small fraction of the literature considers each announcement on its own and does not merge the individual events. This method allows the reactions of individual events identified to be quantified (*Ambler/Rumler* 2019). In their study, the authors consider 14 single announcements of unconventional measures as well as liquidity-supporting measures.

Alongside quantifying the effects of the specified events, the effects of super events are also evaluated. In the context of the ECB's monetary policy, these events are the announcement of the SMP in 2011 and the "Whatever it takes" speech by Mario Draghi in July 2012 (*Falagiarda/Reitz* 2015). The identification of those super events is of particular importance when several programs are announced at a single press conference or within a single published monetary de-

cision. *Falagiarda/Reitz* (2015) show that after the elimination of super events such as the announcement of the SMP on May 10, 2010, the cumulative effect of other programs announced on that very day (LTROs) is no longer significant. This approach is relevant if the sample has not been corrected for confounding or overlapping events. If, however, two different announcements have been made by the same institution on a single day, literature treats them as a single event if they both belong to the same category of event. Otherwise, only one announcement (main announcement) is included in the study (*Fiordelisi* et al. 2014).

After identification and definition of the relevant events, it is necessary to specify the event window. The issue is to determine the most suitable event window. As discussed by *MacKinlay* (1997) and *Binder* (1998), if the event window is too short, there is a risk that the full market reaction will not be captured by the model. On the other hand, if the event window is too long, there is a risk that the effects found will be distorted by other confounding events. The literature on the effects of monetary policy measures and their announcements, most event-based regressions assume an event window of only one day (event day itself).[6] See for example *Haitsma* et al. (2016), *Georgiadis/Gräb* (2016) and *Fendel/Neugebauer* (2019).

Besides, event windows of two days are used with a rising frequency (*Altavilla* et al. 2015, *Szerbowicz* 2015). The motivation behind this two-day event window is that some announcements of new unconventional measures have reached the market after closing. Therefore, the reactions or effects of this new information can only be observed on the day after the actual event. Also, as argued by *Kilponen* et al. (2015), bond markets may be slower to respond to new relevant information because the effects of these measures on bond risk are more difficult to assess. These issues lead to a wide and growing use of an event window of two days (event day itself and the following day). Given that this research area includes only those announcements in the sample that were not anticipated, the mere extension of the event window to two days on the day before the event itself is not common. However, the event window is frequently extended to three days (the day before the event, event day, day after the event) in order to measure possible anticipation effects as well as delayed effects. See *Henseler/Rapp* (2018), *Jäger/Grigoriadis* (2017). This procedure is also frequently used in the context of robustness checks if shorter event windows were considered in the basic model. Event windows of up to five days are possible to check the robustness of the models (*Ricci* 2015; *Jäger/Grigoriadis* 2017).

[6] See *Falagiarda* et al. (2015), *Chebbi* (2019), *Georgiadis/Gräb* (2016), *Szczerbowicz* (2015), and *Fausch/Sigonius* (2018).

3. Measurement of Surprise

Event studies measure the effect of announcements or new information on the market. Recall, equation (2) where UMP_t represents the unconventional monetary policy measure. According to the theory of efficient markets (*Fama* 1970), however, R_t only reacts to unanticipated events. Therefore, it is crucial to quantify the degree of surprise of these monetary policy decisions. Therefore, in order to reduce possible bias, the unexpected (surprise) component should be separated from the expected component of a monetary policy announcement. The identification of the surprise component of conventional monetary policy measures is therefore crucial. Empirical research follows the approach of *Kuttner* (2001) to measure the monetary policy surprise. A monetary policy surprise is represented by the difference between future rates before the announcement and the actual announced key interest rate. *Kuttner* (2001), *Born/Ehrmann/Fratzscher* (2014), *Pacicco* et al. (2019), and *Bernanke/Kuttner* (2005) define the conventional surprise as the difference between the 3M Euribor Futures Rate on the day of the announcement and the previous day. This money market interest rate serves a good indicator of the future key interest rate (*Bernoth/Hagen* 2004). Thus, the expected change is the difference between the actual announced rate and the unexpected part.

However, if unconventional monetary policy measures and their effects are examined, monetary policy expectations cannot be determined using future interest rates. Therefore, various approaches to measure the unexpected component have emerged. One approach to measure market expectations is through surveys. *Joyce* et al. (2011) use survey data from Reuters by economists in their seminal paper to measure the volume of planned bond purchases by the BoE under its bond purchase program. However, this procedure does not apply to all economies, as the necessary data sources are not available.

A second approach is to carry out a qualitative analysis of newspaper articles before the announcement of monetary policy decisions. These articles can then be used to decide whether the measure was more restrictive or expansionary than expected. However, this approach is strongly biased by the researcher. Furthermore, this method can only measure the direction of the surprise but cannot determine a quantitative degree of the surprise component. Another approach when using newspaper articles is to divide the announcements according to their surprise. A distinction is made into events that were anticipated by the market, those that represent a positive surprise, and those that represent a negative surprise. This approach is followed by *Szcerbowicz* (2015) and *Ambler/Rumler* (2019).

Another approach to measure the unexpected component is to use market prices. As a measure of surprise, the change in the spread of ten-year German to government bonds of crisis countries on the day of the announcement com-

pared with the previous day is used. This approach is based on the aim of unconventional measures like the SMP or OMTs, reducing spreads in crisis countries. *Szcerbowicz* (2015), *Altavilla/Giannone/Lenza* (2016), *Krishnamurthy/Nagel/Vissing-Jorgensen* (2017) show that the SMP and OMTs lowered the spreads of crisis countries (especially Italy and Spain). The method follows that of *Rogers/Scotti/Wright* (2014). The authors identify surprises using the yield spread between ten-year German and Italian government bonds. This approach is also used by *Fausch/Sigonius* (2018), *Henseler/Rapp* (2018), and *Haitsma* et al. (2016) to measure the degree of surprise of unconventional monetary policy announcements. In addition to spreads, literature also uses the price change of risk-free bond. For the euro area, *Hosono/Isobe* (2014) use the price changes of 10-year German government bonds as a measurement of surprise.

Chebbi (2019) combines the approaches discussed to quantify the surprise component of unconventional monetary policy measures in his analysis in order to highlight possible diverging results due to them. Alongside the change in the 10-year yield of national bonds, the change in the spread between Italian (Spanish) and German government bonds is also used. Furthermore, the price changes in German Bunds are used. The surprise component is incorporated as a dummy variable. The dummy takes the value of the surprise on the announcement day and zero otherwise.

A crucial issue in the measurement of the unanticipated component is the frequency of measurement of it. This issue is like choosing the optimal event window. For example, *Wright* (2012), *Glick/Leduc* (2012), and *Rogers* et al. (2014) use intraday changes in the proxies for the unexpected component. This approach is designed to ensure that the variables respond only to monetary policy announcements and not to other external information (confounding events). However, long-term yields do not react instantly to new information.

On the contrary, a large body of literature does not explicitly measure the surprise component. The impact is then measured using a dummy variable that takes a value of one on the day of an announcement and zero otherwise. In other words, it is assumed that the surprise component can be measured by changes of variables of interest in a fixed window around the announcement. This method assumes that the monetary policy announcements is completely surprising. If this assumption cannot hold, the results are distorted. Empirical studies investigating the impact of unconventional measures of the ECB on bond yields solely use a 0/1 dummy variable in their event studies. Here it is implicitly assumed that by selecting the relevant events, only those events that were not anticipated by the market are included in the sample. See *Georgiadis/Gräb* (2016), *Andrade* et al. (2016), *Altavilla* et al. (2016), *Falagiarda* et al. (2015), *Falagiarda/Reitz* (2015), *Jäger/Grigoriadis* (2017), *Kilponen* et al. (2015), *Szczerbowicz* (2015), *Urbschat/Watzka* (2019).

4. Control Variables

When assessing the effects of unconventional monetary measures, a wide range of different control variables are included in the models used. Literature incorporates macroeconomic publications into the model as control variables that may have influenced the dependent variable in the model. Macroeconomic news for the euro area, specific publications for the largest economies in Europe as well as for the USA are considered (*Altavilla* et al. 2020, 2015). Publications of the inflation rate, real GDP, industrial production, unemployment data are some examples. Especially in the case of longer event windows, the inclusion of these control variables can be crucial (*Altavilla* et al. 2015). Since efficient markets are assumed, the dependent variable will only react to such macroeconomic announcements that were not anticipated by market participants. If the market fully anticipated an announcement, prices do not react to it. However, if an imperfectly predicted announcement is present, at least part of the announcement corresponds to a surprise, and prices are affected by it. Therefore, only the surprise component of macroeconomic releases is included as a control variable. The surprise component then corresponds to the difference between the actual published data and their corresponding expectations.[7] This procedure is common in the literature (*Altavilla* et al. 2016, 2015; *Ambler/Rumler* 2019; *Falagiarda* et al. 2015; *Fratzscher* et al. 2016; *Kilponen* et al. 2015; *Fausch/Sigonius* 2018). The Citigroup Economic Surprise Index is also used to represent the surprise component (*Georgiadis/Gräb* 2016; *Urbschat/Watzka* 2019). This index corresponds to the normalized deviation of the actual data release and the market consensus before the announcement. In addition to macroeconomic announcements, monetary policy announcements and meetings of other central banks are also monitored (*Ambler/Rumler* 2019; *Chebbi* 2019; *Falagiarda* et al. 2015; *Fratzscher* et al. 2016).

Since the unconventional monetary policy measures were announced in a volatile environment, empirical studies control for this turbulent environment. Thus, the sample can be divided into crisis and non-crisis years (*Haitsma* et al. 2016, *Fausch/Sigonius* 2018) and can be controlled for the debt crisis in Europe (*Szcerbowicz* 2015). The dummy variable for the debt crisis can absorb the effects of debt tensions in a eurozone country. Furthermore, the activation of the EFSF/ESM programs can be represented by 0/1 dummies (*Jäger/Grigoriadis* 2017; *Szczerbowicz* 2015).

[7] A dataset available in Bloomberg is usually used to display the expectations of market participants. This dataset contains the expectations of market participants (panel) for every economic announcement. The expectations correspond to the median forecasts collected up to one day before the official announcement. The unexpected part is then calculated using this dataset.

Furthermore, the overall risk on the market can also be controlled. This is accomplished by including a volatility index (*Falagiarda/Reitz* 2015; *Jäger/Grigoriadis* 2017; *Urbschat/Watzka* 2019). Different indexes such as the US VIX, VSTOXX are used. However, a problem arises when using the VIX index to measure the effects of unconventional monetary policy on bond yields. The problem arises because as the volatility index measures equity market risk rather than bond market risk appetite, and therefore this coefficient is usually insignificant (*Kilponen* et al. 2015). In the literature, variables are also included in the model that control for risk appetite in Europe (*Kilponen* et al. 2015) the conditions on stock markets (*Pattipeilohy* et al. 2013; *Falagiarda/Reitz* 2015) and the liquidity risk of individual countries (*Kilponen* et al. 2015; *Urbschat/Watzka* 2019). The iTraxx serves as a proxy for the risk appetite. Stock indices represent stock market conditions. The bid-ask spread observed on bond markets represents liquidity risk.

VI. Conclusion

The growing interest in assessing the short-term effects of the ECB's unconventional monetary policy measures has led to a large body of empirical research. Due to the popularity of event studies when measuring the short-term effects, this paper focuses on those empirical studies that investigate the short-term effects of unconventional monetary policy on financial markets.

The paper reviews the literature and summarizes the studies dealing with the effects on bond markets, stock markets as well as international spill-over effects to give a comprehensive overview. Due to the popularity of event studies in this field of research, we further conduct a methodological analysis of this econometric approach to point out differences in the exact methodology applied in event studies. In detail, we focus on the determination of relevant events, the categorization of events, the measurement of the surprise component as well as included control variables. We find that mainly official ECB announcements are used. Another possibility is the use of text-based searches to identify relevant events. We further identify two different assumptions regarding the surprise effect of the selected events. Part of the empirical studies follow the standard approach and assume that the market did not anticipate the selected events. Secondly, a strand assumes that only part of the published information was surprising. This surprise component is measured using different market data. Although the methodology applied in event studies differs considerably large part of the studies finds a significant effect of ECB's unconventional measures on financial markets in the euro area as well as on other economies.

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Appendix

Table 1

Event Studies on the Short-Term Effects of ECB's Monetary Policy Measures

Author (Year)	*Data Frequency*	*Considered Programmes*	*Number of Events*
Altavilla et al. (2015)	Intraday-daily	APP	17
Altavilla et al. (2016)	Daily	OMT	3
Andrade et al. (2016)	Intraday-daily	APP	2
Chebbi (2019)	Daily	LTRO CBPP SMP OMT APP	34
De Santis (2016)	Monthly	APP	3
Eser and Schwaab (2016)	Daily	SMP	2
Falagiarda et al. (2015)	Daily	SMP OMT APP	93
Falagiarda and Reitz (2015)	Daily	CBPP SMP OMT LTROs	53

Event Window	*Dependent Variable*	*Control Variables*	*Main Results*
[0] [0,1]	Sovereign yield 5y and 10y (FR, IT, ES), Corporate yield 5y BBB, EURO STOXX 50	Surprise component macroeconomic announcements	APP lowered yields in different market segments, spill-over effects to non-targeted assets
[0]-[0,4]	Sovereign yield 2y and 10y (DE, IT; FR, ES)	Surprise component macroeconomic announcements	OMT decreased bond yields of IT and ES, no change in bond yields of DE and FR
[–1,1]	Stock prices European Banks (excl. FR and CY)	Capitalization	Well-capitalized banks benefit from APP.
[0]	CAC 40 CDAX FTSE MIB IBEX 35	VSTOXX, FOMC announcements	Increase in stock returns after monetary surprises.
[0]	10y euro area GDP-weighted yield	10y bid-ask spread. Public debt/GDP, 3M OIS-rate US VIX	
[0]	Sovereign yield 5y (GIIPS, AT, BE, DE, FR, NL)	Spread corporate bonds (BBB to AAA)	SMP lowered yields of crisis countries (GIIPS)
[0]	Exchange rate EUR, Stock indices (EU), Sovereign yield 5y and 10y, CDS spread 5y and 10y	Monetary decisions, VIX, MRO rate	Strong spill-over effects on bond yields in Central Eastern Europe. Stronger effects due to the SMP compared to OMTs and APP.
[0] [–1,0] [0,1]	Sovereign 10y spread (GIIPS to DE)	VSTOXX, Stock index euro area, TED spread	SMP significant effects on crisis countries. OMTs impacted only IT and ES.

Author (Year)	*Data Frequency*	*Considered Programmes*	*Number of Events*
Fiordelisi et al. (2014)	Daily	UMP CMP	454
Fratzscher et al. (2016)	Daily	SMP OMT LTROs TLTROs	13
Georgiadis and Gräb (2016)	Daily	APP	14
Haitsma et al. (2016)	Daily	SMP OMT LTROs TLTROs APP	22
Henseler and Rapp (2018)	Daily	APP	14
Hosono and Isobe (2014)	Daily	SMP OMT LTROs	9
Jäger and Grigoriadis (2017)	Daily-quarterly	SMP OMT LTROs CBPP	36

Event Window	*Dependent Variable*	*Control Variables*	*Main Results*
[0] [–1,0] [0,1]	3M LIBOR-OIS spread, Stock indices (EU), Stock prices G-SIFIs	Subprime crisis, Financial crisis, Debt crisis	Unconventional Measures have an impact on stock markets. CMP have a stronger effect on the interbank market.
[0]– [–3,0]	Sovereign 10y yield (global), Exchange rate EUR, Portfolio bond flows (global)	Surprise component macroeconomic data (EU, USA)	Measures lowered bond yields and boosted stock prices in the euro area. Effects outside the Euroarea on bond markets not significant. Spill-over effects on international equity markets.
[0]	Exchange rate EUR, Stock indices (39 countries), Sovereign 10y yield (global)	Surprise component macroeconomic data	APP causes depreciation of the Euro, boosted equity prices around the world.
[0]	EURO STOXX 50, Stock portfolios (sectors)	MSCI World (ex Europe), Debt crisis	Measures affected the EURO STOXX 50. Value and past loser stocks show a larger reaction.
[0] [–1,0] [0,1] [–1,1]	Stock prices companies (EU)	Leverage ratio, Market-to-book ratio	Effects on stock returns are positively correlated with leverage and negatively with size and market-to-book ratio.
[0]	STOXX Europe 600, EURO STOXX Banks, Sovereign 3M, 1y, 5y, and 10y yield (DE)	Surprise component monetary decisions	Measures lowered long-term bond yield and exchange rate. Positive effect of stock prices.
[0] [–1,0] [–1,1] [–2,2]	Spread sovereign 10y yield to 10y swap rate	ESM/EFSF Crisis/non-crisis countries	OMTs reduced bond spreads in the euro area. LTROs reduces spreads of non-crises countries. SMPT reduced mainly spreads of crisis countries.

Author (Year)	*Data Frequency*	*Considered Programmes*	*Number of Events*
Kilponen et al. (2015)	Intraday-daily	SMP OMT LTROs CBPP	57
Krishnamurthy et al. (2017)	Daily	SMP OMT LTROs	7
Pacicco et al. (2019)	Daily	SMP OMT LTROs TLTROs APP	16
Ricci (2015)	Daily	SMP OMT LTROs TLTROs APP	98
Rogers et al. (2014)	Intraday-daily	SMP OMT LTROs APP CMP	92
Szcerbowicz (2015)	Daily	SMP OMT CBPP LTROs	22

Event Window	*Dependent Variable*	*Control Variables*	*Main Results*
[0,1]	Spread sovereign 10y yield (DE, FR, GIIPS) to 10y swap rate	10y sovereign Bid-ask spread VIX, iTraxx, macroeconomic announcements, ESM/EFSF	Measures calmed the European sovereign market. Largest effects due to the SMP and OMTs.
[0,1]	Sovereign 2y and 10y yield (GIIPS), Stock indices Corporate yield		Bond yields of IT, ES and PT fell due to the SMP and OMTs announcements. Stock prices increased in core and crisis countries.
[0]	Stock indices (DE, GR, IT, NL, PT, ES)	Exchange rate EUR/USD, Debt crisis	Unconventional measures impacted broad country indices. The index in DE, BE, FR, ES and IT show most significant reactions.
[−1,3] [−1,1] [0]	Stock prices banks (Europe)	Financial/debt crisis	Stock prices of European banks show positive effects after unconventional measures. More capitalized banks are less sensitive to interventions than less liquid banks.
[0]	Corporate 5y yield (BBB and AA), Sovereign 10y yield (FR, DE, IT and ES), DAX	Surprise component monetary measures, Sovereign spread 10y yield IT to DE	Measures ease financial conditions and lower sovereign bonds yields. Pass through to other assets are the strongest in the USA.
[0]	Spread EURIBOR-OIS, Spread EURIPOR-DE treasury bill, Sovereign spread FR, IE, IT, PT, ES to DE	ESM/EFSF, Debt crisis	Asset purchases reduced refinancing costs, sovereign spreads, covered bond spreads and money market tensions.

Author (Year)	*Data Frequency*	*Considered Programmes*	*Number of Events*
Urbschat and Watzka (2019)	Daily	APP	10

Event Window	*Dependent Variable*	*Control Variables*	*Main Results*
[0]	Sovereign 2y and 10y yield (BE, FI, FR; DE, NL, GIIPS)	CDS premia, Sovereign Bid-ask spread, VSTOXX US Treasury Bill 10y yield	Reduction were most pronounced after the first announcement and declined with each additional announcement. Largest effects in GIIPS.