The Transatlantic Transmission of Monetary Policy Shocks

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May 2016

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52 Pages (excl. Appendices), approx. 115'000 Characters

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ABSTRACT

This paper examines how U.S. and European equity markets react to unanticipated changes in monetary policy initiated by the Federal Reserve System and the European Central Bank. We find that, on average, both U.S. and European equity markets rise in response to negative Fed shocks. However, for ECB shocks, the coefficients are of the opposite sign, as both U.S. and European equity markets fall. Standard logic indicates that transatlantic heterogeneity in the response of equity markets to shocks is due to heterogeneity in the wealth-substitution effect trade-off. The wealth effect dominates the substitution effect for the ECB shocks, while the opposite holds for Fed shocks. Furthermore, the study finds that the reaction to the different shocks varies in terms of timing. Around Fed meetings, stock markets start to react already the day before the announcement of the new monetary policy, while the reaction of markets to ECB shocks occurs solely after the publication of the central bank's decision. Finally, for all shocks and equity markets, we present evidence of sticky price responses to surprises.

Keywords: Monetary Policy, Asset Pricing, International Financial Markets
First version: May 17, 2016

We thank Paul Whelan for the supervision of our thesis and the guidance and ideas he provided.

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I. Introduction

Central banks are among the most influential institutions in the world. Their monetary policy decisions have far-reaching consequences and not only affect banks and other participants of the financial industry but entire economies and, eventually, almost every person's financial situation. Central banks have several tools at their disposal: open market operations, discount rate decisions, minimum reserve requirements, and several non-standard monetary policies. The open market operations are the most important one. Through them, central banks try to influence the short-term interest rates. By doing so, the prices of different financial assets will be affected directly or indirectly.

In this paper, we examine how equity markets in the U.S. and in Europe are affected by the monetary policies of the world's two most influential central banks: the Federal Reserve System (Fed) and the European Central Bank (ECB). Our contribution to existing research is twofold: Firstly, we consider the so-far overlooked ECB as a source of monetary policy shocks. Secondly, we extend the knowledge about the well-understood U.S. equity market and also analyze European stock markets. We follow the prevalent approach of considering only unanticipated changes in monetary policy since past research has found strong evidence that only that part of the target rate changes results in significant price reactions (e.g. Bernanke and Kuttner (2005)).

The links between monetary policy and asset prices are the subject of a large body of research due to their relevance to academia as well as to the financial industry. Especially interest rate and equity price reactions to monetary policy changes have been scrutinized by a vast number of studies. However, most studies focused on equity market responses are limited to the U.S. A majority of them finds that a (unanticipated) cut in the interest rate by the Fed is followed by a rise in the U.S. stock markets. There are only a few studies that extend this research and investigate how international stock markets are affected by Fed monetary policy. Even less research focuses on the impact of monetary policy changes by other central banks, especially the European Central Bank. This is surprising since the ECB is arguably the second most influential central bank in the world and can be expected to exert some influence on equity markets. This limited coverage of the ECB monetary policy might be due to the relative newness of the ECB which, in the past, has limited the availability of observations for analyses.

Our results confirm the well-documented negative relationship between FOMC shocks and U.S. equity markets. We also find evidence that the same shocks have a similar impact on European markets. Furthermore, the stock market reaction in Europe appears to be stronger in countries that have experienced higher GDP growth and inflation during our sample period. Contrary to the results for FOMC shocks, we find that a cut in the target rate by the ECB is not followed by a rise in the stock markets. Equity markets in most European countries and in the U.S. fall in response to an unexpected target rate cut. Even though we try to develop some explanations on why that might be the case, the exact transmission mechanism remains a puzzle.

The remainder of this paper is structured as follows: Chapter II reviews existing literature on the link between the monetary policy and asset prices. Chapter III describes the two central banks analyzed in our study and their monetary policy tools. Chapter IV explains the money market instruments that are used to proxy monetary policy shocks. Chapter V describes the data and the methodology we use, followed by a presentation of our results. The discussion thereof follows in chapter VI. Finally, in chapter VII we draw the conclusion.

II. Literature Review

A. How to measure monetary policy changes?

One of the main challenges in the analysis of equity market reaction to monetary policy changes lies in finding an appropriate measure for these changes. Using an inadequate measure may lead to biases or distorted results. In the past, researchers have used different methods of measuring monetary policy changes (specifically the unanticipated part of it). Most approaches fall in one of the following two categories: (1) vector autoregressions (VARs) models, as for example used by Christiano et al. (1996b), or (2) shock identification using high-frequency data on interest rate sensitive assets around central bank announcements (Cook and Hahn (1989); Kuttner (2001)). Other identification methods have been developed, such as using changes in interest rates not included in Fed Greenbook forecasts (Romer and Romer (2004)), but none of them has become as prevalent in research as the aforementioned two.

Existing research differs with regard to how sophisticated the changes in target rates are taken into account. Some studies, especially older ones, look at the raw changes in target rate and investigate how asset prices react to these. Cook and Hahn (1989), for example, use such an approach in one of the first studies on the impact of changes in target rates on market interest rates. They use a simple regression on high-frequency data to estimate how a raw change in the target rate translates into a change in yields of different maturities. They do not distinguish between the anticipated and the unanticipated constituents of the target rate change. The findings of more recent studies, however, support the notion that the distinction between the two parts is relevant because anticipated and unanticipated changes are highly likely to affect asset prices to different extents. More specifically, the anticipated change in interest rate should not have any effect on asset prices at all, at least not if the semi-strong market efficiency holds. Under that assumption, expectations about changes of the target rate are already priced in at the moment of the official announcement. Only deviations from the market's expectation should then result in fluctuations of asset prices. Indeed, more recent studies found that changes in interest rates on days of target rate change announcements are mainly driven by surprises (or shocks) in the changes (e.g. Kuttner (2001)).

Over the last decades, researchers have used different methods to approximate the unexpected part of the target rate changes. A prevalent approach in academia is the use of high-frequency Fed fund future data to derive the shocks. The future rate is the weighted average of current fed fund rates realized up to a date (d) and the expectations about the rates for the remaining time up to the maturity. [1] The difference between the spot future rate right after and before the FOMC announcement - scaled up for the moment within the month the event is at - can then be considered a proxy for the target rate shock.

$$shock = \frac{D}{D-d}(f_d^0 - f_{d-1}^0) \tag{1}$$

Krueger and Kuttner (1996), Rudebusch (1998), Söderström et al. (2001), and Buraschi and Whelan (2015) use such a methodology to separate the anticipated and unanticipated parts of the target rate change. Using these two components of the target rate change in the analysis leads to significantly different results compared to considering simply a raw target rate change. Kuttner (2001), for example, finds that when the target rate changes are split up, the anticipated part has only little effect on the asset prices. The shocks, however, are highly significant. Hamilton (2008) uses a similar, slightly more general approach and comes to the same conclusion. This emphasizes the importance of extracting the shocks from the raw changes.

B. How do monetary policy changes affect interest rates?

Even though the main focus of this thesis is on the link between equity prices and monetary policy changes, it makes sense to have a look at some of the main findings regarding interest

[1] In mathematical terms :

$$f_{t-1}^0 = \frac{d}{D} r_{t-1}^0 + \frac{D-d}{D} E_{t-1}[r_t^0]$$

rates since they are related to stock prices (they are substitutes). Therefore, some of the main findings of previous studies will be reviewed hereafter.

Cook and Hahn (1989) were among the first to investigate the link between monetary policy and the bill/bond market. In their research, they find statistically and economically significant reactions over the 1974-1979 period, especially for the short-term end of the yield curve (3-month t-bill), with a 55 basis points increase for a 1% increase in the target rate. Kuttner (2001) uses different methods to investigate the interest rate reaction to monetary policy changes. Firstly, he applies the same regression model used by Cook and Hahn. Interestingly, for the period between 1989 and 2000, the results are much weaker (statistically and economically) compared to Cook and Hahn's. He suggests that this might be due to a more accurate anticipation of target rate changes by the markets in the more recent years. Secondly, he uses the Fed fund future approach to differentiate between raw target rate changes and shocks. He finds that the bond market reaction to the anticipated target rate change is small, while it is large and significant for the unanticipated part of the change. Cochrane and Piazzesi (2005) and Gürkaynak et al. (2005) use Eurodollar instead of Fed fund futures as an expectation proxy. They also find a frequent and persistent response around FOMC announcements, especially for long-term bond rates. Gürkaynak et al. (2005) expand the previous analyses by including a second factor (path shock) based on FOMC statements. This path shock contains information on changes of expectations about future monetary policies. They find that it has a significant impact on long-term Treasury rates because of changes of investors expectations on future inflation and output levels (see also Romer and Romer (2000)). A similar distinction between a target and path shock is made by Buraschi and Whelan (2015). They found that both are relevant in transmitting Fed monetary policy changes to (long-term) bond prices. Cochrane and Piazzesi (2005) and Boyarchenko et al. (2016) found similar results for long-term rates but argue the main reason is that monetary policy announcements affect the risk premia required by investors (see also Hanson and Stein (2015)). Ellingsen and Söderström (2001) gave another interpretation, setting up a model that accounts for endogenous and exogenous policies. It predicts that, when the monetary

policy is endogenous (based on economic fundamentals), all the interest rates move in the same direction because a period of tight/loose monetary policy is expected; on the other hand, if the monetary policy is exogenous (based on central bank's preferences), short and long rates move in different directions because the market realizes that the policy will not be persistent.
With regard to the timing of the interest rates reactions, Fleming and Piazzesi (2005) computed 30-minutes, 60-minute and daily interval windows in their event study analysis and find that bond markets react sluggishly to monetary policy changes because it takes more time to price in all the information (see also Cook and Hahn (1989) and Boyarchenko et al. (2016)).

C. How do monetary policy changes affect stock prices?

Besides the research on the effect of monetary policy shocks on interest rates, there is also a great academic interest in how stock markets react to (unanticipated) changes in the target rate. There are different theories on whether monetary policy should have an effect on stock prices or not. According to the neutrality of money concept, monetary policy only affects nominal variables (e.g. wages, prices) but not real ones (e.g. output, consumption). Since share prices represent a claim on real future output, they should then not be affected by changes in monetary policy. Indeed, there are some studies that fail to find such a relationship (e.g. Durham (2005)) but they are heavily outnumbered by the ones that find a reaction of stock prices on monetary policy shocks. This implies that money is - at least in the short term - not neutral, but affects real economy (and thus share prices). This is evidenced by several papers (e.g. Bernanke and Blinder (1992); Christiano et al. (1996a), to name just a few).

Despite the fact that there are numerous studies that find that equity prices react to some degree to monetary policy changes, most of them do not analyze in what ways these changes translate into stock prices. Instead, a majority of the research focuses on the resulting effect only. However, it is important to understand the different channels through which monetary policy can exert influence on stock markets.

Theory suggests two main channels through which monetary policy potentially affects stock prices: the interest rate channel and the credit channel. Assuming that equity prices are the result of discounted cash-flows, there are two ways that prices can be affected by monetary policy shocks: either by a change in expected future cash-flows and/or a changed discount rate.

The first channel is the interest rate channel through which monetary policy directly affects the real economy and the cash-flows of companies. The mechanism behind that channel works as follows: a central bank analyzes the economic situation, defines its goals, and then sets the target rate in order to reach these goals. The bank tries to ensure that the short-term (overnight) rates at which banks can borrow from each other stays close to the target. It does so by actively using its monetary policy tools (see next chapter). These short-term nominal interest rates then affect long-term nominal interest rates. Due to stickiness of prices in the short term, not only nominal but also real interest rates are affected. In case of an expansionary monetary policy, the real interest rates would fall. This has a profound impact on the economy. On the one hand, companies are facing lower cost-of-capital. This means that they are able to raise new external capital at a lower cost and are, thus, able to finance additional investments. On the other hand, consumers will earn lower interest on their bank deposits, making consuming more attractive relative to saving. Taken together this two effects will result in a supply-demand equilibrium that is higher than before and, thus, in a higher production. This should make equity prices rise.

The second transmission mechanism of monetary policy is the credit channel. Bernanke and Gertler (1995) consider it could be a complement and amplify the interest rate channel. The credit channel refers to the external finance premium (cost difference between raising external capital and internal financing) that is affected by monetary policy. It can be divided in two sub-channels: the balance sheet channel and the bank lending channel. As the name suggests, the balance sheet channel refers to the fact that changes in interest rates affect

positions in the financial statements of companies. For instance, if a company has floating rate debt outstanding, the cash flows that have to be allocated to debt payments vary with the market interest rates. Furthermore, company assets that could be posted as collateral will be affected as well. This affects the net-worth and the creditworthiness of companies and can make it easier/harder for them to raise debt. This, in turn, affects the investment decisions of companies. The lending channel refers to the supply of money that is available to banks for lending to companies seeking loans. A contractionary monetary policy, for example, decreases that supply, making it harder for companies to borrow money.
Apart from these channels, academia also discusses additional ways of how equity prices can be affected by monetary policy shocks. Bernanke and Kuttner (2005), for example, suggest that monetary policy shocks will affect the expected equity premium, either by changing equity risk or by altering investors' risk tolerance. They argue that changes in monetary policy make investors update their expectations about future dividends, excess returns, and real interest rates. They find evidence that especially the updated expected excess returns seem to drive stock price reaction. Expectations about future real interest rates seem to contribute surprisingly little, however. This is in line with a finding by Campbell (1991) that suggests that unexpected equity returns are mainly driven by changed expectations about future dividends and returns. Ammer et al. (2010) define another monetary policy transmission channel that is relevant for the analysis of the impacts of policy shock on other countries. They refer to this channel as foreign interest rate channel. According to this channel, a monetary policy shock in the U.S. affects short-term interest rates in other countries and thereby translates into movements in stock markets in those countries. Having an understanding of how monetary policy shocks potentially affect stock prices, some empirical findings of existing studies will be summarized in the following paragraphs.

Bernanke and Kuttner (2005) - using the fed fund future rate identification approach - find that for the sample period between 1989 and 2002, the U.S. stock market would, on average, rise (fall) by 100 basis point per 25 basis points negative (positive) monetary policy shock. They use an event-study approach and only consider FOMC meeting days where the target rate has been changed. They find a statistically and economically significant reaction of U.S. stock prices to Fed policy shocks. Additionally, they also try to identify the sources of it. They use an approach developed by Campbell (1991) which is based on decomposing excess returns into revisions of expected future excess returns, dividends, and real interest rates. The expectations are proxied by a VAR analysis. They conclude that stock price reactions are mainly driven by changes in expected future excess returns and expected future dividends but only to a neglectable part by changes in expected future real interest rates.

Rigobon and Sack (2003) examine in a series of studies the effect of stock markets on the Fed's monetary policy and the reverse. In their 2003 paper, they investigate the former by applying a model that uses heteroscedasticity of stock returns to identify to what extent stock price fluctuations affect monetary policy. This model is necessary in order to distinguish between the part of the stock price movement that is exogenous and causes the monetary policy change and the other part that is following the monetary policy shock. They find that the Fed's policy decisions are related to the behavior of the U.S. stock market. Their findings suggest that a 5% fall of the S&P 500 on a single day results in an increase of likelihood of a target rate increase by 25 basis points of 50%. For a 5% decrease in one week, they find an even stronger reaction. In a later study, the authors examine how asset prices are affected by monetary policy (Rigobon and Sack (2004)). Since the problem of exogenous stock price movements is still present, they apply a similar heteroscedasticity based approach to extract the stock market reaction caused by monetary policy and exclude stock market behavior that motivated the change in policy in the first place. Besides concluding that target rate changes by the Fed translate into changes in market rates (especially for shorter maturities), they also find evidence that equity prices are affected. For a 25 basis point drop in the 3 month interest rate, they find a 1.7% increase in the S&P 500 and a 2.4% increase for the NASDAQ.

Several studies refine the analysis of stock price reaction on monetary policy shocks by looking at industry portfolios. Indeed, monetary policy seems to affect industries to different extents. Bernanke and Kuttner (2005) find some evidence that high-tech and telecommunications stocks are more sensitive to unanticipated monetary policy changes, while energy and utilities react only weakly.

Kontonikas and Kostakis (2013) find that stock price sensitivity towards monetary policy shocks does not only differ across industries but also across portfolios based on several other company characteristics. More specifically, they look at portfolios based on value versus growth stocks, size, and momentum. They find that small companies, value stocks, and such with a recently negative performance are more affected by monetary policy shocks. Furthermore, they find that these relationships are not stable over time. They analyze data from 1967 to 2007. The higher sensitivity of momentum portfolios to monetary policy shocks is only found evidence for for the period before 1983. Similarly, the sensitivity of small company and value stocks to shocks decreases over time. This indicates that the sample period for the analysis is highly relevant with regard to the results. Another study that finds that sensitivity to monetary policy shocks is linked to specific company characteristics was conducted by Ehrmann and Fratzscher (2004). The authors ascertain that stocks of companies with certain attributes are more affected by monetary policy shocks. The factors that they identify as making companies more sensitive to policy shocks are small size, low debt (relative to total capital), bad credit rating, low cash flows, high Tobin's Q, and high price-earnings ratio. They argue that these factors cause companies to be financially more constrained and, therefore, more exposed to monetary policy shocks.

All the previously mentioned studies focus on the effect of U.S. monetary policy on U.S. equity markets. This is due to the fact that a large majority of research is U.S.-centric. Only a few studies examine how U.S. monetary policy affects international equity markets. This is surprising since it would be highly relevant to have a sound understanding of how monetary policy shocks are transmitted internationally. Especially, Europe, with some of the world's largest and most significant equity markets, should be the focus of more research.

One of the few studies to examine the transmission of U.S. monetary policy shocks to equity markets outside the U.S. was conducted by Ammer et al. (2010). They investigate how the reaction of U.S. and international stock markets to Fed monetary policy shocks compare.

The international equity index they use is the MSCI EAFE, representing the global, developed markets apart from the U.S. and Canada. They find that the reactions of the U.S. and international indices between 1994 and 2006 are both positive and comparable in size. The reaction found for international equity markets is slightly stronger. The authors conclude in their paper that these strong cross-country effects are attributable to the demand and the foreign interest rate channel but not to the credit channel. Their conclusion is based on the observation that the companies included in the MSCI EAFE are, on average, financially healthier than their counterparts in the S&P 500. This means that these companies are less affected by the mechanisms implied by the credit channel, e.g problems receiving new credit. However, in the sample of international companies, cyclical industries are more prevalent than in the U.S. sample. This supports the hypothesis that international transmission of U.S. policy shocks works via the demand channel. The authors also argue that due to the inclusion of many countries which have their interest rate pegged to the U.S. interest rate, the foreign interest rate channel plays an important part.

Wongswan (2005) examines how U.S. monetary policy shocks (computed as in Kuttner (2001)) translate to 16 different countries. He includes developing and emerging countries and considers two different types of shocks: unanticipated changes to the current target rate and changes to the future path of monetary policy. He comes to the conclusion that for most countries only the former type of shock has an effect on equity markets. Equity market reactions differ widely among the countries in the sample. The stock markets rise between 0.5% and 2.5% for a U.S. monetary policy shock of 25 basis points. The author analyzes several country characteristics, such as trading activities with the U.S., financial integration, and exchange rate flexibility to identify the reasons for these differences. He comes to the conclusion that it is mainly proxies for financial integration, for example foreign equity holdings, that can explain the variation in countries' reactions to U.S. monetary policy shocks. Proxies for trading activity and exchange rate flexibility lack significant explanatory power. In a later study by Hausman and Wongswan (2006), a similar analysis is conducted for 50 countries and for multiple asset prices (short-term interest rates, bond yields, stock prices).

In line with the previous study, they find that countries with a significant portion of their securities hold by U.S. investors exhibit a stronger reaction to Fed policy shocks. Additionally, they also find that the exchange rate flexibility of a country affects the sensitivity of its equity market to monetary policy shocks. The sensitivity of interest rates, on the other hand, depends mainly on a country's level of exports to the U.S.

III. Central Banks And Monetary Policy

The Eurozone and United States central banks (ECB and Fed) are characterized by cultural and technical differences but their key mandates are similar. As defined by the Maastricht Treaty (Article 105.1), the ECB's only official mandate is to maintain price stability. On the other hand, the Federal Reserve has been tasked with a dual mandate by the Congress: keep prices stable and achieve maximum employment.

Even though the Fed has not explicitly stated the main pillar of its monetary policies, it is plausible to assume that maintaining price stability is the main goal for the two central banks. There are several reasons why it is important to have long-term price stability for the economy and the financial markets. Firstly, price stability improves the transparency of relative prices, helping investors and consumers to clearly understand price movements and allocate resources in an efficient way. Secondly, it enhances the incentives to invest and increases capital markets' efficiency. Investors require a lower risk premium and are facing a lower necessity to use hedging strategies for their long term assets. Furthermore, a stable price regime is necessary to avoid distortions in the tax and social systems since indexation and changes for high inflation or deflation are not always contemplated. With unpredictable price movements, distortions can also occur in the redistribution of income and wealth between creditors and debtors and it would create social and financial problems. Lastly, price stability directly affects financial and banking stability. With an unpredictable price regime, banks' and financial institutions' balance sheets and assets would have to be continuously reevaluated, undermining the stability of the financial sector and the allocation of peoples' wealth.

Central Banks can directly affect the price stability since they have the monopoly of money supply in a country/region. In the short-term, changing the money supply and therefore also the (short-term) interest rates allows asserting influence on prices and outputs. This is possible because of several transmission channels which build a complex nexus of actions and mechanisms, through which the different economic and financial agents affect the main economic variables. In the long-term, after all the internal and external adjustments have taken place, a change in the monetary supply will affect the level of prices but not the real variables, such as the employment rate or the level of output. This is due to the "neutrality of money": this theory by Von Hayek (1931) states that real economic variables are unaffected by changes in the monetary base but only nominal variables are (wages, prices).These adapt proportionally to the monetary supply's changes. In other words, the long-term price level can be controlled by the central banks without having significant impact on the real variables. In the short term, money neutrality does not always hold, however.

We now describe how the ECB and the Fed conduct their monetary policy and which are the main standard and non-standard instruments.

A. European Central Bank

The Eurosystem set price stability as its main objective in the medium term and, specifically, it defines it as "year-on-year increase in the Harmonised Index of Consumer Prices (HICP) for the euro area of below, but close to, 2% over the medium term". The transmission channels, as mentioned above, are a nexus of mechanisms through which the monetary policy decision affects the whole economic system and, in particular, the level of prices. We will now describe the 5 main transmission channels present in the Eurosystem.

1. Interest rate channel : the ECB has the monopoly of the money supply and can affect the funding costs for banks, thereby steering the short-term interest rate. This also affects the long-term end of the yield curve since expectations about future change in short-term interest rates are priced in (expectation theory). Interest rate changes affect both the investment and spending decisions of firms and households, as will be explained in more detail later on.

2. Bank lending channel : a change in the interest rate also affects the credit and banking sector and the effect is amplified by the information asymmetries. For instance, an

interest rate hike increases the possibility of bankrupt borrowers on loans or similar lending products and therefore banks will be more reluctant to lend money. This result directly affects households and firms investment and spending decisions.

3. Risk-taking channel : a lower interest rate regime might create wrong incentives for borrowers and banks to take excessive risk. A lower interest rate usually leads credit institutions and banks to lower their credit standards and increase the credit supply. Borrowers are thereupon willing to exploit this favorable situation to invest in risky asset, whose value is enhanced by the low interest rates as well.

4. Exchange rate channel : the exchange rate has a direct effect on the price levels. Through the exchange rate it is possible to control the inflationary force. The exchange rate affects the price of imported goods, the competitiveness, and the aggregate demand of these goods.

5. Expectations channel : the ECB has to maintain high-credibility in order to maximize the transmission mechanism and the magnitude of its decisions. Households, firms and economics agents will have expectations and believe the ECB can meet its goals only if it is credible and transparent in its communications.

The ECB has three main tools that it can use in order to achieve its goals: open market operations (OMO), standing facilities and required reserves.

1. Open market operations (OMOs) refers to the purchase and sale of securities in the open market. Main refinancing operations (MROs) are the main OMO used by the ECB. They have a maturity of 1 week and are the key monetary policy instruments of the Eurosystem. A MRO is a collateralized loan: ownership of a collateral is transferred for a cash loan and the parties agree to reverse the transaction at a given date. The ECB defines these operations in this way: "The difference between the purchase price and the repurchase price in a repurchase agreement corresponds to the interest due on the amount of money borrowed or lent over the maturity of the operation, i.e. the

repurchase price includes the respective interest to be paid". A short example will clarify this concept. When the ECB intends, for instance, to lower interest rates, it will lower the rate on MROs. Due to that, current reserves for banks become cheaper, and the rate banks ask to lend reserves to other banks goes down. In turn, this will lead banks to increase the credit supply to households and firms. To lend out the excess reserves banks have to lower the interest rate they charge to their customers.

2. Standing Facilities are expensive alternatives to weekly and non-weekly refinancing operations. These are always available overnight and on the counterparties' initiatives : marginal lending facility (from which the banks can borrow for a rate 1% higher than MROs rate) and deposit facility (that pays an interest rate 1% lower than the MROs rate). These two rates create the so-called corridor for the overnight rates on the money market (EONIA).

3. Required Reserve refers to the compulsory deposit account that banks have to hold at the respective National Central Banks (NCBs) and it is calculated as 1% of the reserve base. This standard instrument is used to stabilise the money market and to increase the demand for CB credit, making it easier and more effective for the ECB to control interest rate.

In addition to these standard monetary policy instruments, the ECB has also adopted the so-called non-standard monetary policy strategies, especially during 2008 and 2011 crises. For instance through the Asset Purchase Program (or Quantitative Easing) the ECB creates new money to purchase financial assets from private investors to stimulate the economy and signal its commitment to keep low interest rates also in the future. Another unconventional measure is the fixed-rate full allotment policy that guarantees Euro area financial institutions, during crisis period, to have an unlimited and continuous access to ECB liquidity at the main refinancing rate.

Communication strategy and transparency are also pivotal components in the ECB monetary policy. It facilitates the market participants' understanding of the monetary policy and therefore renders the central bank's policy more credible and effective. The ECB Governing Council meets twice a month in Frankfurt and, immediately after the first meeting of the month, the ECB President holds a press conference where monetary policy decisions are explained in detail together with future development and a Q&A session. Furthermore, a monthly bulletin is published usually one week after the meeting of the Governing Council which contains a detailed analysis of the economic and financial environment of the Eurozone. Lastly, four times a year the ECB President appears in front of the European Parliament's Committee on Economic and Monetary Affairs to discuss ECB's policy decisions and answer questions from the Committee members.

B. Federal Reserve System

The Fed implements its mandate primarily by setting a target for the federal funds rate, which is what financial institutions charge each other when lending money in the overnight market. The federal funds rate is a yardstick for many other short-term interest rates and, therefore, strongly influences credit conditions in the U.S. The Fed cannot directly fix long-term interest rate nor steer key economic variables such as output, inflation or employment. It impacts these economic variables indirectly, mainly through influencing the federal funds rate. All depository institutions are required to hold minimum reserve balances in accounts at Fed Banks. In order to meet these requirements banks that do not meet the minimum balance on a certain day need to borrow money borrow money. On the other hand, bank whose balances exceed the minimum requirements will have an incentive to lend it to these other banks. The interest rate that results from this demand and supply is the federal fund rate. If the banks have no problems meeting the reserve requirements, the federal fund rate decreases because of an excess of supply compared to the demand. Taking advantage of this mechanism, the Fed can use its tools to exert influence on the federal fund rate. Changes in the federal funds rate are then expected to change other short-term interest rates. Indirectly, the federal funds rate also affects long-term interest rates because of expectations over future Fed decisions, the total amount of money and credit in the economy, and also employment, output, and inflation.

The Fed has three main tools available to influence the federal fund rate: open market operations, the discount rate, and the reserve requirements. Additionally, it can support their monetary policy goals by setting the interest rates on the required balances as well as on excess balances, using the Overnight Reverse Repurchase Agreement Facility, and the Term Deposit Facility. The latter two tools were introduced in the course of the policy normalization process that was initiated in December 2015. Since they are of secondary importance, new, and not widely used yet, these tools will not be focused on in the following. The three main tools will shortly be explained hereafter:

1. Open market operations (OMOs) refers to the purchase and sale of securities in the open market. Those assets are often Treasury securities but are not limited to them. When the Fed decides to increase liquidity in the banking system, it enters into repos. When it decides to reduce liquidity, the Fed enters into reverse repos. OMOs are a widely used tool and flexible in the implementation. By engaging in these trading activities, the supply of reserves in the banking system can be increased/decreased which will in turn affect (short-term) interest rates.

2. Discount rate is the interest rate at which Fed lend money (usually overnight) to commercial banks and depository institutions, given certain collaterals. It is divided in primary credit rate (to banks with a sound financial situation), secondary credit rate (to banks that do not meet the requirements for a primary credit rate) and seasonal credit rate (to banks that occasionally have long-term liquidity problems). The two main purposes of this instrument are to be an accessory measure to OMOs in order to implement the decided policy and to be a liquidity reserve for depositary institutions, in case they are not able to meet their daily obligations.

3. Reserve requirements are set as a percentage of depositary institutions' customers deposits and must be kept as vault cash or deposit at the Fed. The amount of required reserves is calculated applying the reserve ratio to the dollar amount of the net trans-

action account. Effective 21.01.2016, depository institutions are required to hold a reserve requirement of 0% for the first \$15.2 millions in net transaction accounts, 3% from \$15.2 to \$110.2 millions and 10% above \$110.2 millions.[2] To better understand how exactly this tool works, it is essential to look at the structure of commercial banks' balance sheets: liabilities are composed mainly by deposits, whilst assets by loans and reserves. A share of the deposits is held at FED as reserves (R= θ D), loans are therefore a fraction of deposits [L=D(1-θ)]. Increasing the θ coefficient FED can decrease the share of deposits used for loans and vice versa. This instrument is rarely used (last in 1992).

After the subprime crisis, with the fed fund rate at the zero bound, Fed was forced to implement some unconventional measure to stimulate the economy: Quantitative Easing (QE) and Term Asset-Backed Securities Loan Facility (TALF). On one side through the QE, which is a planned repurchase of long-term Treasury securities and Mortgage Backed Securities (MBS), Fed tries to lower the long-term interest rates on these securities, stimulating the consumption and investments. On the other side, the TALF is an monetary operation aimed at increasing credit and stimulating economy boosting the issuance of ABS.

Responsible for the Fed decisions is the Federal Open Market Committee (FOMC). It consists of twelve members: the seven members of the Board of Governors of the Federal Reserve System; the president of the Federal Reserve Bank of New York; and four of the remaining eleven Reserve Bank presidents, who serve one-year terms on a rotating basis. The rotating seats are filled from the following four groups of Banks, one Bank president from each group: Boston, Philadelphia, and Richmond; Cleveland and Chicago; Atlanta, St. Louis, and Dallas; and Minneapolis, Kansas City, and San Francisco. Reserve Bank presidents without the voting rights also attend the meetings, participate in the discussions, and contribute to the Committee's assessment of the economy and policy options. The FOMC holds eight regularly scheduled meetings every year. The week before the meeting, the Greenbook

[2] source:https://www.federalreserve.gov/monetarypolicy/reservereq.htm)

(report on the economic environment and economy forecasts) and Bluebook (report on current financial situation and potential policy options) are drafted by the Board of Governors and considered for the final policy decision. During the scheduled meetings, the Committee reviews the financial and economic current situation, determines the appropriate monetary policy strategies, and assesses the risks to its long-run goals of price stability and long-term economic growth.

IV. Money Market Instruments

For the analysis of the impact of monetary policy shocks on equity returns, we analyze the rates of different money market assets in order to identify which one can be used to most accurately derive the market's expectation about the change of a target rate. Money market assets have the characteristic that they are highly sensitive to target rate changes. We can use this quality for our analysis.

Based on the expectation theory, yields of assets with a maturity overlapping a possible change in target rate (a monetary policy meeting) should reflect the expectations about the rate after that change. When the market expects the target rate to increased in the near future, the rate of the money market asset should reflect that in its price and, therefore, offer a higher interest rate as well. The opposite holds when a central bank is expected to lower the target rate. If the asset did not price that (expected) future interest rate development in, arbitrage would be possible. Understanding this pricing mechanism allows to back out the anticipated and, more importantly, the unanticipated parts of the rate changes. In the following chapter, the money market instruments that we consider in our analysis will be shortly explained and their relation to the target rates will be pointed out.

A. Commercial Paper

Commercial papers are an asset class that exists in the U.S. as well as in Europe. It is an unsecured, promissory note that is usually issued by large companies with excellent credit ratings. Unsecured implies that the company does not provide any collateral that could be used for liquidation in order to mitigate the loss at a default. Characteristics of commercial papers are that they are of short-term nature (maturity of less than 270 days), with an average maturity of approximately 30 days. Companies often roll commercial papers over at maturity, thereby ensuring a constant availability of the funds. Since the nominal values of commercial papers are usually in \$ 1'000'000s, direct investing is mainly limited to institutions. Retail investors participate via money market funds. The short maturity of these commercial papers exempts them from SEC registration which makes them a quick and inexpensive alternative to bank debt for the issuing companies. For the investors, commercial papers provide a relatively safe investment (in normal times) and the yields are comparable to those of riskless Treasury bills. However, during the financial crisis commercial paper yields were significantly higher than Treasury bill yields due to decreased liquidity and uncertainty about the date of repayment. The U.S. Federal Reserve Board started the Commercial Paper Funding Facility Program (CPFF) in 2008 in order to improve short-term liquidity in the short-term funding market. A special purpose vehicle (SPV), backed by the Federal Reserve of New York, was created with the purpose of buying short-term unsecured commercial papers from eligible issuers. The program ended in 2010 and all the commercial paper notes were repaid in full, without any loss for the Fed.

The rates of 30 days non-financial corporate paper generally match the movement of the target rate relatively accurately (see table 3). For the U.S., the commercial paper rate appears to move with a slight lead before the target rate, which is an indication that it could predict target rate changes well. The European commercial paper rate moves generally close to the ECB's refinancing rate as well. However, the leading movement is less distinct than for the U.S. counterpart. A purely graphic analysis suggests that movements in these rates could be used as a predictor of target rate changes. A statistical analysis of the appropriateness of the commercial papers as a proxy will be conducted in the next chapter.

B. Euribor and EONIA

The Euro Interbank Offered Rate (Euribor) is the average interest rate at which a panel of European banks lend and borrow funds (in Euros) from each other. The maturities for the different Euribors are 1 and 2 weeks and 1, 2, 3, 6, 9, and 12 months. There is also a rate for a 1 day maturity, the Euro Overnight Index Average (Eonia). The Euribor and Eonia are both unsecured. They are the basis for various other interest rate bearing assets, such as interest rate futures, swaps etc.

A look at how the Euribors for different maturities move relatively compared to the ECB's

refinancing rate suggests a close matching pattern, especially for the one week and the one month maturity (see Figure 4). The Eonia exhibits more volatility and therefore deviates more often from the target rate. At the other end of the maturity spectrum, the one-year-Euribor is usually above or below the target rate but generally follows the same direction as the target rate changes. In line with the expectation theory, the Euribor with one year maturity lies above the target rate in periods where the target rate is raised and below when the ECB implements a expansionary monetary policy. Since the one year maturity overlaps several possible target rate changes, the Euribor has to price all of them (or the expectations about them) in. This explains why the Euribor rates with longer maturities are less closely matching the target rates.
With regard to whether the Euribor predicts the target rate changes or just follows them, there is no obvious conclusion possible from just looking at the graphs. A statistical analysis is necessary to determine that.

C. Relation of money market instrument rates and target rates

As mentioned in the previous chapter, the Federal Reserve System and the European Central Bank are implementing their monetary policies by influencing the rate at which banks borrow from each other by varying the money supply. These interbank rates will then in turn affect other short-term interest rates throughout the economy. The relationship between the interbank rates and other rates is based on substitutability. For example, if a bank in the U.S. needs to provide additional reserves to meet the requirement of the Fed, it can either borrow from other banks at the federal fund rate or it can finance itself through other channels. One option is to enter into a repurchase agreement. A bank will only do so, however, if the repo rate is attractive relative to the federal fund rate. The counterparties of such repos will then be forced to set their rates at a level such that banks have an incentive to participate. This mechanism transmits changes in the interbank rates to the repo rates. The same concept underlies also other asset yields in the market. Assets that have a maturity overlapping the date of a potential target rate change should not only depend on the current interbank rates but also on the ones expected after that date. Assuming, for instance, that the market expects the central bank to raise their target rate at their next meeting date which would also raise the interbank rate, this expectation will be priced in the current yields. Such an asset will only be attractive to investors if it reflects that expectation in its yield.

V. Empirical Analysis

A. Data

The data used in this study is mainly based on Datastream and Bloomberg as well as on the official websites of the European Central Bank and the different Federal Reserve Banks. Additionally, other sources, such as Eurostat and the World Bank database, have been used. The base case sample period of this study spans the time period from June 1999 to December 2008 for Fed meetings and April 1999 to December 2008 for ECB meetings. The reason underlying the choice of this sample period is straightforward: the ECB did not exist before June 1998. Since we only look at central bank meetings where the target rate was changed (as opposed to all monetary policy meetings), the first data point falls into the beginning of 1999. For the Fed, data availability would allow going further back. However, in order to ensure comparability of the results for Europe and U.S, the same time period is used in the analysis. The upper limit of the sample period is set at the end of 2008 because no federal fund target rate changes occurred after that for several years. This does not apply to the ECB, which continued changing the refinancing rate after 2008. However, for the aforementioned reason of comparability, we impose this upper time limit on both regions. For the extended sample period of the robustness test, we use data going back to 1994.

We only consider monetary policy meetings where the target rate is actually changed instead of all monetary policy meetings. The reason for looking at this subset of monetary policy meetings is that target rate changes were only agreed upon at a relative low number of these meetings. 50% of Fed meetings (40 of 80) and 83% of the ECB meetings (126 of 152) during our period of interest did not result in a change of the target rate. Dates without a change fall in one of two categories. First, there are the ones where no change is implemented even though the market expects one to occur. This would represent a conventional shock and could have been included in the analysis without any concerns. Second, there are the meetings where no change is implemented and the market does not expect one. In that case, there is no shock. If too many of those non-shocks events are included in the analysis, a bias could be introduced.

The dates considered are also limited to regular meeting days only. Extraordinary meetings with target rate changes (e.g. September 17, 2001 as a response to the 9/11 attacks) were left out since they usually occur in times of increased volatility and significant stock market swings might then not be attributable to monetary policy announcements only (risk of endogeneity). This leaves 40 event days for the analysis of Fed shocks and 26 for ECB shocks. A list of all the dates with the according target rate changes can be found in the appendix (see table XIII).

For the analysis of the U.S. stock market's reaction, four indices are analyzed: the S&P 500, the NYSE Index, the NASDAQ, and the Dow Jones. For Europe, indices of 17 individual countries are included: Greece, Austria, Belgium, Germany, France, Italy, Switzerland, Spain, Sweden, Netherlands, Finland, Denmark, Ireland, Norway, Portugal, Poland, United Kingdom. There are two reasons for drilling down to individual countries instead of using pan-European indices. Firstly, there is significant heterogeneity among the different countries. It is likely that stock market reactions may differ in terms of significance, strength, and even in direction among the different countries. Looking at a pan-European index, reactions might cancel out. Secondly, the composition of aggregate indices is relatively hard to see through and track over time. It is unknown which countries have what weights in an index. Furthermore, if certain countries have stronger weights, they would dominate the results and cloud how less considered countries are affected.

B. Empirical Model

It is straightforward to assume that market participants' expectations about target rate changes do not always turn out to be exact. The actual target rate change can therefore be split up in an anticipated and an unanticipated part (shock):

$$TAR_t - TAR_{t-1} = E_{t-1}(TAR_t - TAR_{t-1}) + \mu_t \tag{2}$$

where μ_t represents the deviation from expectation. As seen in the chapter II, it is essential to differentiate between the two components since market reaction is mainly driven by the unanticipated target rate changes. Most of the existing research that explicitly focuses on the effect of unanticipated monetary policy changes on asset prices uses Fed fund future prices to isolate the unanticipated part from the raw target rate change. This method proved to be relatively accurate and is easy in its implementation. Furthermore, data for Fed fund futures is available back until 1988, making it an attractive asset for research. In this paper, however, another method is applied. The reason is simple. While such a future exists for the U.S., no equivalent can be found for Europe. Most existing studies were not affected by that problem since their focus is exclusively on U.S. monetary policy. In our study, however, an important part is the investigation of how the European central bank's monetary policy decisions affect asset prices. In order to allow a sensible comparison of the effects of the monetary policies of the two central banks, it is essential to use the same (or at least a similar) asset for isolating the unanticipated target rate changes.

In a first step, we try to find assets whose prices contain a sensible amount of information about the expected changes in the target rates. As a mean of identification, we use a regression of the following form:

$$TAR_t - TAR_{t-1} = \alpha + \beta(Y_{t-1} - TAR_{t-1}) + \epsilon_t \tag{3}$$

Assets that we look at include commercial papers, and Treasury bills and bonds with different maturities (3 months, 6 months, 1 year, 5 years, and 10 years) for the U.S. and commercial papers and Euribor (overnight, 1 week, 1 month, 3 months, 1 year) for Europe [3]. The results are summarized in table III for the U.S. and table II for Europe. Looking at the R^2 for the U.S. regressions, the commercial papers have a very high explanatory power (91%) as well as bills/bonds with shorter maturities (up to 1 year). For Europe, the regressions have lower

[3] The analysis is also run for Repos with different maturities (overnight, 1 week, 1 month, 3 months, 1 year). Despite relatively high R^2s, we decide to use the 1 month Euribor due to higher correlation with the European commercial paper rate. A robustness test based on Repo rates instead of the Euribor has resulted in comparable coefficients.

R^2 for all assets. European commercial paper rates do not seem to hold much information about target rate changes. This could, however, be due to the fact that there are only 14 observations available. The reason for this low number is that commercial papers were not introduced in Europe before 2003, leaving only 5 years of data. In order to avoid using a very limited time period with almost no observations, we analyze which of the other assets (that hold significant information on target rate changes) has the highest correlation with the commercial paper rate changes. The rate changes of the Euribor with a 1 month maturity exhibits a correlation of 0.63 (IV), making it the most suitable alternative. Its R^2 is 24% and, thus, contains a reasonable amount of information. Data on Euribor is available until far back in time, allowing us to analyze the same time period for Europe as for the U.S.

Having identified the assets that can be used to predict target rate changes, we compute the residuals from the regression. Under the assumption, that the aforementioned assets contain an adequate amount of information, fitted values of the regression represent the market expectation about the change in the target rate. The residuals, or the difference between the realized and the fitted value, are then the unanticipated part of the target rate change (shock). A graphical representation of the shocks for both ECB and FOMC announcement days can be found in figure 2. It appears that the shocks are, on average, smaller for target rate changes by the FOMC than for changes by the ECB. This could be an indication that the investors have more accurate expectations on Fed policy than they have on ECB policy. However, it could also be a consequence of the fact that the asset we use for deriving the FOMC shocks (U.S. commercial paper rates) is better at predicting target rate changes than the Euribor is.

The shocks are used in the following regression:

$$R_t = \alpha + \beta shock_t + \mu_t \tag{4}$$

At this point it is important to mention the issue of endogeneity. It is one of the main problems in studies that examine the effect of monetary policy on asset prices. An important component of monetary policy decisions is endogenous to the current economical environment, while we are interested in the exogenous shocks and the related equity market reaction. This condition does not hold, for example, if monetary policy decisions are the result of stock market development or stock markets and monetary policy change simultaneously after the release of new information. An example could be a weaker-than-expected report on key economic variables such as employment, consumption or manufacturing production: markets would react and also monetary policy setters would include this new information in their assessment on whether to change the current monetary policy. This is also the reason why we decide to exclude the 17.09.2001 from our dataset to avoid biased results. Since our analysis is based on a relative narrow event window around the target rate changes, the issue of endogeneity is minimized. Still, a bias cannot be completely ruled out.

There is some research examining to what degree monetary policy decisions are based on stock market developments. Bernanke and Gertler (1999) and Fuhrer and Tootell (2008) build a model to test if FOMC decisions are affected by equity prices movements. Both studies find that the Fed's monetary policy does not respond to equity prices changes. These findings are in line with the Fed's (and also ECB's) long term inflation targeting commitments.

C. Results

In this chapter, the empirical results are analyzed and discussed. We look at the four possible combinations of monetary policy shocks and equity markets individually and then compare the results. For aforementioned reasons, the base case sample period is from 1999 to 2008 for all four cases. In order to capture the entire effect of a monetary policy decision on stock markets, we analyzed different event windows to account for possible prior-to-announcement movements and lagged reactions due to gradual information processing. Indeed, there appear to be some differences in the timing of stock market reaction, depending on the market and the source of the shock.

After a preliminary analysis of the reaction pattern, we define the event window for U.S. monetary shocks with one lag day and 2 full trading days after the target rate change. For European shocks, a lag day proved to be irrelevant, therefore only two full trading days are considered. A graphical depiction of the event windows can be found in figure 1.

Additionally, also for shocks from the same source there are some minor differences in the event windows. The reasons for this is that the number of hours of active trading on the same day after a central bank announcement differs among European countries. Additionally, different time zones and different opening hours of the stock exchanges increase the issue. To illustrate the complexity of timing, a short scenario is presented. On a given day, the ECB announces a change in monetary policy at 13:45 CET. In most European countries, there are 3:45 hours of trading left at that point (since most stock exchanges close at 17:30 in CET zone and 16:30 in GMT). However, a few stock exchanges have shorter opening hours (Norway until 16:30 CET, Denmark until 17:00 CET) which leaves market participants less time to price the news in on the same day. Since we are looking at relatively widely defined event windows, the impact of such small inconsistencies should not be very pronounced.

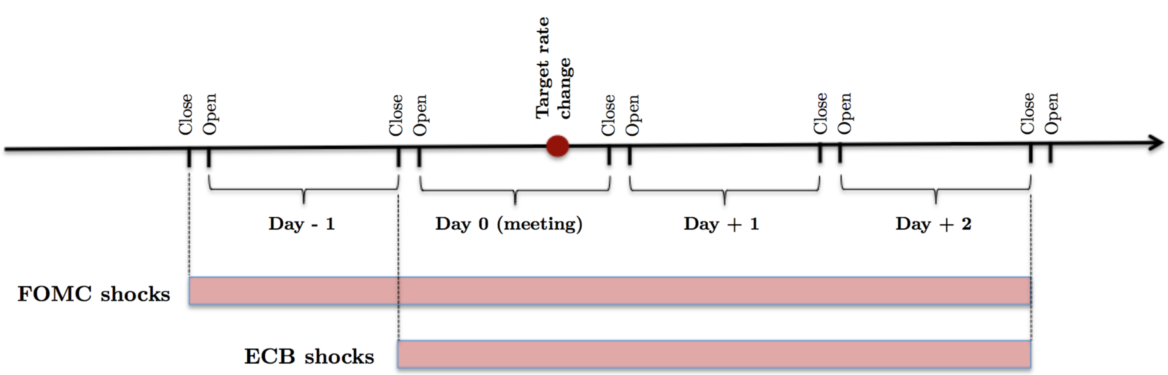

Figure 1. Event Window Definition

C.1. Case I: FOMC Shocks on U.S. Stock Market

The effect of Fed monetary policy shocks on U.S. equity is the relationship that has been most extensively investigated in past research. The reason for this in-depth coverage lies in the importance of the U.S. central bank for the global economy and the size of the U.S. equity markets. Furthermore, it is easier to conduct an analysis for the U.S region than for Europe for several reasons. The Fed has existed for many decades, which provides enough event days (days where target rate has been changed) to enable a meaningful analysis. Furthermore, there exists time series data reaching far back on several money market instruments that can be used to price in the market's expectations regarding future monetary policy. The most popular ones are the Fed fund futures and the Eurodollars. The existence of such assets (and good data availability for them) makes the U.S. a convenient target for research.

An analysis of the days surrounding the announcement of a target rate change by the FOMC shows that the U.S. equity markets start reacting already the day before the announcement. Furthermore, during the two days after the announcement there is still significant market movement observable. For this reason, we look at the period from one trading day before the announcement to two full trading days after the announcement. Past research almost exclusively finds a negative relationship between U.S. monetary policy shocks and U.S. stock markets. Not surprisingly, our results are in line with these earlier findings. Over the full event window, a hypothetical negative monetary policy shock of 25 basis points results in an increase of 3.32% for the S&P 500 and 3.50% for the NASDAQ (table V). When looking at the days surrounding the announcement individually, there are some surprising insights. In fact, the coefficients for the day of the announcement itself are not statistically significant. However, the coefficient for the day before the announcement is both economically and statistically highly significant. The S&P 500 rises on average by 2.17% for each 25 basis points shock (1.73% for NASDAQ). This could be due to the issue that already the day before the monetary policy announcements the FOMC sometimes releases other important economic information that could either influence stock markets itself and/or lead to revising the expectations regarding the upcoming monetary policy change. For the day after the announcement the S&P 500 rises by 1.11% and the NASDAQ by 1.70%. On the second trading day after the announcement, the coefficient is still negative but significantly lower in size. After that, there is no more reaction observable. This lag in reaction stock market suggests that the participants in the U.S. equity market require some time to price in the

shocks. It is likely that this lagged response is also caused by additional information that is released after the announcement of the new target rate (e.g. interviews, statements etc.).
The monetary policy shocks can explain a significant part of the stock price variance. The R^2 for the regression of S&P 500 returns is 32%. For the NASDAQ it is lower but still relatively high at 23.4%. Since data availability allows going further back for the U.S. market, the same analysis is conducted for an extended sample period of 1994 to 2008. The general relationship that is found for the 1999-2008 period still holds. However, the size of the effect is significantly smaller in this robustness test (table VI). For the full event window a hypothetical negative shock of 25 basis points leads to a 1.60% increase in the S&P 500 and a 1.91% increase in the NASDAQ. Compared to the coefficients of the base case sample period, these are only approximately half as large. This is implies that the effect of U.S. monetary policy shocks on U.S. equity has increased over the years. This instability of the coefficients over time is also found evidence for in other studies (e.g. Wong (2000), Chen (2007)).
The coefficients that we found are significantly higher than the ones found by Bernanke and Kuttner (2005) even though a similar issue is examined. This difference may be due to several methodical differences between the our approach and theirs. These are of statistical and economical nature. The former includes the variation in the sample period (1999 - 2008 vs. 1989 - 2002) and the use of another asset to identify the unanticipated part of the monetary policy change (commercial paper vs. fed fund future). On the economical side, one difference lies in the definition of the event window. Our event window is wider (includes more days) in order to measure the entire reaction, including any lagged and preceding responses. Most of these differences amplify the size of coefficients and explain why the impact evidenced in this study exceed the ones found by Bernanke and Kuttner.

C.2. Case II: FOMC Shocks on European Stock Markets

The event window that is looked at it is the same as in case I. The sample of European stock markets includes 17 different country specific indices. For 14 out of the 17 countries, a significant stock price reaction to FOMC shocks can be observed for the entire 3 day event window (see table VII). The only three countries that do not show any statistical significance are Germany, Sweden, and Finland. The coefficients are negative for all countries. This is in line with findings of previous research that has found evidence that international stock markets tend to be react negatively to FOMC shocks. Of the countries for which the coefficients are significant, Poland exhibits the lowest stock price reaction. For a negative FOMC shock of 25 basis points, the Warsaw Stock Exchange Index only increases by 2.14% over the event window. The other end of the range is represented by the Irish Stock Exchange Index which under the same conditions increases by 4.66% on average. Overall, there is a wide variance observable between the different European countries. Other countries that show a very strong reaction to FOMC shocks are Greece, Spain (both 4.01%), Austria (3.89%), Denmark (3.16%), UK (3.11%), Italy (3.22%). Switzerland (2.89%) and France (2.73%) exhibit a moderate reaction and the stock markets in the Netherlands (2.50%), Portugal (2.44%), Belgium (2.42%), and Norway (2.32%) are relatively less (but still significantly) affected. There is no obvious pattern in how the different countries are affected. Countries that are economically relatively weak (e.g. Greece, Spain) are among the most affected as are some economically sounder countries (Switzerland, Denmark). Some explanatory approaches that could explain some of the country specific reactions will be looked at in the next chapter. The explanatory power of U.S. monetary policy shocks for European stock returns is relatively high. The R^2 lies in the range between 15% and 30% for most countries that show significant coefficients. R^2s lower than that are found for France (13%), the Netherlands (10.6%), Norway (13.7%), and Poland (13.4%). Overall, these numbers are reasonably high. The processing of the FOMC shocks by market participants follows a similar pattern as in the U.S. equity markets. As for the U.S. stock returns on FOMC shocks, a robustness test with an extended sample period is conducted. The coefficients are consistently smaller for the 94-08 period than for the 99-08 period for all countries (table VIII). The difference in size is striking, especially since the extended period contains only 13 more observation than the base case scenario. Also, there appears to be a loss in statistical significance for many countries. Denmark, the Netherlands, Norway, and Poland do not have statistically significant coefficients anymore. However, Finland and Sweden (that show no significance on the 0.1 level for the base case sample period) are now (slightly) significant. The R^2s are also lower in the robustness test.

C.3. Case III: ECB Shocks on U.S. Stock Market

For the analysis of the ECB monetary policy, we use a different event window than for FOMC shocks. Since no pre-announcement stock market reaction is observed for ECB shocks, we only look at the 2 (full) trading days following the target rate changes. Table IX summarizes the results. We find a positive correlation between stock prices and monetary policy shocks. Over the 2-day event window, the S&P 500 goes up on average by 0.83% (0.81% for NASDAQ) for each hypothetical negative 25 basis point ECB shock. These findings are statistically significant at the 0.05 level and the R^2 is 23% (and 15%), indicating that the shocks can explain a significant part of the stock price variance. Looking at the days individually, we find that on the first full trading day after the announcement the S&P 500 gains on average 0.71% (0.75% for NASDAQ) for each 25 basis points negative shock. On the second full trading day after the announcement, however, the results lose both economically and statistically significance. After that, there is no significant reaction at all. A robustness test for an extended sample period, like we conducted for the FOMC shock cases, cannot be done due to the unavailability of data before 1999 (since the ECB did not exist before that).

C.4. Case IV: ECB Shocks on European Stock Markets

European stock markets show consistently positive reactions for positive ECB shocks, as it is displayed in Table X. Looking at the first 2 (full) trading days after the announcement, the coefficients are significant on the 0.05 level for all but two countries. Denmark's coefficient is only significant on the 0.01 level and Poland shows no significance at all. For a positive ECB shock of 25 basis points, the main stock price indices in Europe rise between 0.89% (Denmark) and 1.82% (Spain) over the two (trading) day event window. Besides Spain, other countries whose stock markets react strongly to ECB shocks are Austria (1.76%) and the Netherlands (1.71%). The other countries' coefficients lie all within a relatively narrow range between 1.18% and 1.43%. Compared to the reaction to U.S. monetary policy shocks, European stock markets react in more homogenous way. The R^2s range from 14.8% to 36.1%. The processing of the shocks occurs to a large extent on the first trading day after the announcement. On the second day, there is only little shock-related stock movement observable. This movement is still in the same direction as the overall tendency but not significant on its own. This indicates that the European markets are quick at pricing new information in. The markets appear to be accurate as well since there is no subsequent erosion observable.

VI. Discussion

The direction of the coefficients for the four cases is summarized again in the following table:

Table I. Direction of Stock Market Reaction for Various Shocks

	European Equity Markets	U.S. Equity Market
Fed Shocks	−	−
ECB Shocks	+	+

Since the event windows differ slightly for the four cases, caution is required when comparing the coefficients of the different cases with each other. In fact, it is advisable not to compare the results on a quantitatively too detailed level. Nevertheless, the results of this study offer a number of highly interesting findings and interpretations.

A. Timing of Stock Market Reactions

The first significant finding of our study regards the timing of the stock market reactions. We find that the reaction patterns differ between the cases. They appear to depend on the source of the shocks (FOMC vs. ECB). Across the different stock markets (U.S. and individual European countries), the patterns are relatively consistent.

For U.S. monetary policy shocks, a first reaction of stock markets can be observed on the day before the actual target rate change, while on the day of the change itself, there is no statistically significant reaction. On the day after the announcement and the one after that, another economically and statistically significant reaction is observed. For ECB shocks, the stock market reactions (in the U.S. and Europe) take place on the two trading days following the announcement but no pre-announcement reaction is observed. This pattern is more intuitive. A reaction on the day of the announcement itself is straightforward, while some lagged stock market movements in the days following the announcement indicate that the markets require some time to fully process unexpected changes in the target rates. Additionally, investors might revise their expectations further after additional interviews, statements etc. are published. This is in line with studies that found evidence that markets still react to the publication of the FOMC meeting minutes some weeks after the actual meeting (Boukus and Rosenberg (2006) and Rosa (2013)).

Less intuitive are the abnormal stock market movements preceding the announcement of the target rate change. There are several possible explanations why that might be. The first explanatory approach is based on the observation that the time window around the target rate changes sometimes coincides with the releases of news regarding other macroeconomic key variables. During the economic year, agencies, departments, and other economic agents release reports, information, and data regarding key economic and financial variables such as GDP, inflation, unemployment, production etc. When these releases coincide with central banks' monetary policy announcements, they can affect stock market volatility and potentially influence expectation formation about the upcoming central bank decision. In fact, Taylor (2010) finds that releases of announcements about key macroeconomic variables act as determinants of future monetary policy. According to that study, the most influential news are those regarding non-farm payrolls and unemployment updates. The sensitivity of stock markets to macroeconomic news is also found evidence for in other studies (e.g. Flannery and Protopapadakis (2002), Boyd et al. (2001a), Savor and Wilson (2013)).

This emphasizes the importance of considering the timing of such announcements around central bank meetings. The release of such information might explain some of the observed stock market variation. For this reason, we compare Fed and ECB announcements days with the release of macroeconomic news during the 1999-2008 sample period. We use the Bloomberg Economic Calendar to identify the relevant dates. In line with the previous literature, we focus on the release of quarterly GDP, change in non-farm payroll, and monthly CPI. The dates of news releases are shown in table XVIII.

The FOMC event window comprises four days, including a one day lag and two full trading days after the announcement. For 8 out of 40 FOMC target rate changes (20%), there was a key economic release one or two days before the monetary policy announcement, possibly causing the markets to react to the information (at least if it is to some part unexpected). For 5 out of 40 events (12.5%), economic releases (mainly quarterly GDP) and FOMC announcement days coincide. Lastly, releases about CPI and GDP were released the day following the FOMC meetings in 7 out of 40 cases.

For the ECB target rate changes, we look at GDP, inflation, and unemployment reports in France, Germany, Italy, and Spain, mainly because these are the largest economies in our sample. For the analysis of the ECB shocks, we look at a two day event window around the interest rate changes. For 8 out of 26 events (31%), the ECB meetings line up with unemployment reports from Germany or Spain and Italian GDP. Furthermore, the trading day after the monetary announcements often coincides with the release of data on French inflation (11.5%), Italian GDP and inflation (11.5%), and Spanish unemployment and inflation (11.5%). On the second day after the announcement, there are rarely any economic releases (7.7%). This analysis offers insights and a possible explanation for the strong significance of these countries on certain days that are difficult to explain with target rate changes only. France, Italy, Germany, and Spain (but not limited to these countries) show on average both economical and statistical significance for days around ECB meetings if many other economic news are released. Furthermore, Spain, a country with many economic releases around the announcement day, exhibits the strongest reaction to ECB shocks of all the European countries in the sample. This is in line with Caporale et al. (2016) who demonstrate that peripheral European countries (i.e. Spain) react more than core countries (i.e. Germany and France) to macroeconomic news.

Another explanation for the pre-announcement stock market reaction is offered by Lucca and Moench (2015). They find that U.S. equities generate significant excess returns before FOMC announcements. This phenomenon can be observed in the data since the 1980's and it has become stronger over the years. Furthermore, the pre-FOMC-announcement drift also holds for international equity markets (France, Germany, Japan, Spain, Switzerland and UK). However, they fail to find a similar stock market pattern for the days before other central banks' monetary policy announcements, suggesting that it is a FOMC-specific occurrence. This is in line with our results. We only find a significant pre-announcement reaction before FOMC target rate changes but not before ECB announcements. The authors discuss several theories that might explain the pre-announcement drift for FOMC meetings, some of which are based on informational frictions. However, due to the lack of an empirically-backed explanation for this anomaly, Lucca et al. refer to it as a puzzle.

A further explanation is based on the findings of Savor and Wilson (2013) and Brusa et al. (2015). The studies find that for U.S. as well as for international stock markets higher returns and Sharpe ratios are observable on FOMC meetings days. This is due to a higher equity premium that investors require on these days for the risk associated with the FOMC decisions. While the authors find evidence for these higher equity returns on the days of the announcements, it is thinkable that this uncertainty among investors already starts being priced in the day(s) before the actual announcement. The studies only observe higher returns for FOMC meeting days but not for any of the other influential central banks (ECB, Bank of England, Bank of Japan).

B. Standard Logic: Wealth vs. Substitution Effect

The insight that U.S. stock markets are negatively related to FOMC shocks does not surprise. This relationship has been documented by numerous studies and there is no disagreement among researchers about the direction of the relationship. Almost all of them come to the conclusion that an unexpected cut (hike) in the interest rate leads to a rise (fall) in the U.S. stock markets. This is also in line with the standard macroeconomic theory. We find that a relationship of the same direction holds for most European markets as well. For 14 out of 17 countries that we look at, there are economically and statistically significant, negative coefficients. The less intuitive finding is that the ECB's monetary policy shocks affect stock markets in the opposite direction. An unanticipated, negative target rate change by the ECB leads to a negative reaction of stock markets. For the base case sample period, this holds for U.S. and European stock markets. Such a relationship between monetary policy

and stock markets has not been documented before. Furthermore, most standard macroeconomic models fail to explain how stock markets can react negatively to negative monetary policy shocks. Nevertheless, we will develop some explanatory approaches that try to shed some light on this - at first glance - surprising result.
The first explanation is based on the analysis of the opposing wealth and substitution effects. On the one hand, a change in (real) interest rate will affect the relative attractiveness of consuming/spending compared to saving (substitution effect). On the other hand, it will also have an impact on the wealth of the investors (wealth effect). A short example will illustrate this. Assuming that a central bank decides to lower the target rate (and this also decreases the market rates), investors will have fewer incentives to save their incomes because the rewards are lower (lower interest rate paid on savings). It is now more attractive to consume or invest today. On the other hand, the lower interest rate will also decrease the overall wealth available. As a result, investors will be forced to spend less. This affects current consumption in the opposite direction. The dominating of the two effects determines which overall impact is observable. If the substitution effect dominates, a decrease in the interest rate results in a higher consumption today. If the income effect dominates, consumption is shifted from today to the future. A formal derivation of these effects will elude the theory behind the idea and show how the distribution of consumption between the point in time affects stock prices.

We assume a constant relative risk aversion utility function of the following form:

$$u(C_t) = \frac{C_t^{1-\gamma}}{1-\gamma} \tag{5}$$

The Euler equation

$$u'(C_t) = \beta(1+r)u'(C_{t+1}) \tag{6}$$

for such a utility function would then become

$$C_t^{-\gamma} = \beta(1+r)C_{t+1}^{-\gamma} \tag{7}$$

or

$$C_t = [\beta(1+r)]^{-1/\gamma} C_{t+1} \tag{8}$$

The intertemporal budget constraint is

$$C_t + \frac{C_{t+1}}{1+r} = Y_t + \frac{Y_{t+1}}{1+r} \tag{9}$$

or

$$C_{t+1} = (1+r)(Y_t - C_t) + Y_{t+1} \tag{10}$$

Substitute the BC into the Euler equation

$$C_t = [\beta(1+r)]^{-\gamma}[(1+r)(Y_t - C_t) + Y_{t+1}] \tag{11}$$

In order to see how current consumption is affected by changes in the interest rate, we apply total differentiation:

$$\frac{dC_t}{dr} = \frac{(Y_t - C_t) - \gamma C_{t+1}/(1+r)}{[\beta(1+r)]^{\gamma} + 1 + r} \tag{12}$$

While the denominator is positive, the sign of the numerator (and thus the total impact of the interest rate change on the current consumption) can be positive or negative. The sign of the total derivative depends on whether the wealth or substitution effect is dominating. The relative level of future consumption to current consumption (in other words the consumption growth) defines the prices of a stock (and other assets). The basic asset pricing formula of an asset is

$$P_t = E_t[M_{t+1} X_{t+1}] \tag{13}$$

which is the future cash-flows X_{t+1} discounted via the stochastic discount factor (SDF) $M_{t+1} = \beta \frac{u'(C_{t+1})}{u'(C_t)}$. The SDF, also known as the marginal rate of substitution, describes the ratio at which consumption between the different points in time can be substituted without changing the utility of the consumer. It depends on the level of patience (or discounting of time, β), the level of current and future consumption, and γ (factor determining the sensitivity of the SDF to differences in consumption between the periods). The distribution of consumption over time affects the stochastic discount factor through the marginal utility in each point in time. If the future consumption rises, the marginal utility of C_{t+1} decreases and the SDF becomes smaller. This results in a higher discounting of future cash-flows and, thus, a lower asset price. The opposite is true if current consumption C_t rises. A shift towards current consumption increases the SDF and leads to higher prices.

Following that rationale, the different signs of the coefficients for FED and ECB shocks implies that different effects are dominating in the two situations. Our results suggest that for the Fed the substitution effect dominates the wealth effect and a cut in the target rate leads to higher equity prices. For the ECB, however, it appears that the wealth effect dominates the substitution effect and a target rate cut leads to lower stock prices.

C. Impact of Crisis

A vast majority of the studies document a negative relationship between target rate changes and equity prices. The only study - at least to our knowledge - to find a equity market response of the other direction is by Kang et al. (2015). They find evidence for a positive relationship between ECB negative monetary shocks and equity market reaction during the U.S. subprime crisis. They argue that this is due to inappropriate crisis handling by the ECB. Kang et al. develop the theory that investors perceived the effectiveness of the Fed and the ECB at countering the crisis in highly different ways. According to the authors, the Fed took monetary policy decisions proactively and aggressively and thereby convinced investors that it is willing and able to fight the negative impacts of the crisis. On the other hand, ECB's monetary policy changes were often only implemented when there was no way to avoid them anymore. Furthermore, investors had some concerns about the adequacy of the ECB's decisions and were not sure if they would not do more harm than good. As a consequence, so Kang et al. argue, ECB's target rate decreases were not cherished by the markets and led to lower equity prices.

Our sample period (1999-2008) includes some recessions and crises periods such as the 1998

Russian default, the 2001 Argentine financial crisis, the early '00s dotcom bubble, and, most importantly, the 2007-2008 U.S. subprime crisis. In order to check whether the inclusion of the 2007/2008 crisis could have caused the positive relationship between ECB target rate shocks and stock markets, we repeat our analysis for a sample period without the crisis. Excluding the years 2007 and 2008 reduces the number of observations by 6, leaving 20 observations in the sample. The 6 observations, that are dropped, represent some of the largest target rate shocks in our sample (see figure 2).

The coefficients for the U.S. equity market reaction to ECB monetary policy shocks lose their significance when the crisis years are dropped (table XII). This is in support of Kang's theory and indicates that the positive coefficient for U.S. stock market reaction on ECB shocks might be solely due to the crisis. For the European stock markets, excluding the crisis does not result in a complete disappearance of a significant reaction for most countries (table XI). While some countries that exhibited a statistically significant coefficient in the base case sample period do not continue to do so (e.g. Austria, Belgium, Switzerland), 9 out the 17 countries still have positive coefficients that are significant on at least the 0.1 level. The coefficients are in all cases smaller than for the base case scenario.

The analysis of the crisis allows us to gain two insights. First, the years 2007 and 2008 do have a major influence on the results. Without the observations from the crisis, there is no statistically significant impact of ECB shocks on U.S. stock markets and only weaker results for the European markets. Second, despite its undeniable impact on the results, the crisis alone is not able to explain the positive coefficients we find for European stock market reaction after ECB shocks. They are robust for the exclusion of the crisis years.

D. Factors affecting Sensitivity to Monetary Policy Shocks

When we compare how specific countries are affected by U.S. and ECB shocks, not only the direction, but also the size of the coefficients varies significantly (table XIV). As mentioned before, an exact comparison between the two coefficients cannot be drawn due to several restrictions. However, the difference in size between the coefficients is pronounced for most countries that it can most likely not be explained by simple calculations differences only. The observable pattern, that holds true for the U.S., as well as for most European countries, is that equity markets react significantly more to monetary policy shocks initiated by the Fed than those from the ECB. It comes as no surprise that the difference between the reaction to FOMC and ECB shocks is strongest for the U.S. since its economy is directly targeted by Fed monetary policy.

The fact that most European countries react stronger to Fed shocks than to ECB shocks is more surprising. It would be intuitive to assume that for European countries the ECB is the most influential central bank since it is supposed to structure its policy along the Eurozone member's interests. Our results suggest, however, that it is the Fed that exerts most influence on Europe's stock markets via its monetary policy. This is in line with findings by other studies, for example Conover et al. (1999) or Brusa et al. (2015). However, these studies are not able to provide an unambiguous explanation for the Fed's dominance.

We also document that the degree to which the individual countries are affected by monetary policy shocks from a specific central bank differs significantly. Furthermore, there seems to be only little overlapping between countries that are strongly affected by U.S. monetary policy shocks and those that react most to ECB shocks. An analysis of which countries' equity markets react how to monetary policy would optimally be based on a detailed inspection of the characteristics of the individual companies comprising the equity indices. As mentioned in the literature review, characteristics such as size, debt-to-capital ratio, Tobin's Q, export ratio etc. may affect the degree to which companies are affected by monetary policy changes. It is thinkable, for example, that companies that are strongly depending on exports to the U.S. are likely to be more affected by U.S. monetary policy, than countries that generate their revenues mainly domestically. However, the gathering and analysis of such detailed company-level data would be an enormous task and is limited by data availability. In this study, we will have to keep the analysis more general and therefore base it on country-level variables.

Among the countries that react the strongest to Fed shocks are many that lack a stable and healthy economy. Four out of the five countries that exhibit the highest negative coefficients are struggling economies (Ireland, Greece, Spain, and Italy (Table XIV)). They are among the most highly indebted countries in Europe and had serious economic problems in the past (and still have). The only exception in the group of the most affected countries is Austria, which has a stable economy. On the other end of the ranking, Sweden, Finland, and Germany show no statistically significant reaction to Fed shocks. These countries are characterized by healthy economies and low debt exposure. In the range between the two extremes, there is no obvious pattern. Strong economies (e.g. Switzerland, Denmark) are similarly affected as weaker ones (e.g. Portugal, France). It appears that mainly at the extremes, a country's economic health and stability seems to determine the extent to which it is affected by U.S. monetary policy shocks. Looking at the ranking of countries for ECB shocks, the pattern is less apparent (table XIV). A weak economy exhibits the strongest reaction (Spain) but there are some countries with relatively sound economies that have large coefficients (Austria, Netherlands, Finland). On the other hand, Ireland with a specifically weak economy only shows the 13th strongest reaction. However, it is noteworthy that the differences in coefficients are significantly lower for ECB shocks than for Fed shocks. The exact position of the countries in the ranking may therefore be less informative.

A characteristic that we consider to be a potential factor influencing the effect of U.S. monetary policy on European stock markets is the real integration between the U.S. and the European countries. More specifically, the trading activity between the U.S. and the European countries could affect the degree to which monetary policy changes in one region spill over to the stock markets in the other region. It is, for example, possible that a country which has an intensive trading relationship with the U.S. is more exposed to demand changes in the U.S. following a Fed policy change. Hausman and Wongswan (2006) finds that interest rates in countries with high exports to the U.S. are more affected by U.S. monetary policy, than countries that exhibit a low real integration. Table XIX provides an overview over the trading activities that the various countries were involved in with the U.S.. Hausman and Wong use exports and total trade volume (among other variables) as proxies for the real integration of a country. We look at the same two variables and one additional one the imports. We use the average exports, imports, and total trade volume over the sample period. We rank the countries according to their factor loading and their trading variables and apply a rank correlation method to identify possible links. For each of the three proxies, we fail to find a significant correlation. In each case, the spearman's ρ is close to 0 (table XV). This is in line with Kim (2001) who concludes that changes in the trade balance play only a small part in the transmission of U.S. monetary policy to the output in European countries.

Besides trading variables, we also analyze the average inflation and GDP growth for the European countries in order to identify a potential link (see table XX). Ireland, Greece, and Spain are among the countries with the highest GDP growth (on average 6.00%, 3.54%, and 3.65%) during the sample period. They are also countries that react strongly and significantly to FED monetary policy shocks. In economic terms, high economic growth influences the profitability of corporations through expected earnings, dividends, and stock price fluctuations Fama (1990). Economic growth can foster demand for financial services and credit, leading to an increase in investments and then returns of firms' stocks (Rousseau and Vuthipadadorn (2005)). Indeed, a study by Diebold and Yilmaz (2009) finds that GDP volatility causes stock markets volatility. This suggests that high growth countries react stronger than more mature economies. The rank correlation between factor loadings for FOMC shocks and GDP growth is relatively high. A spearman's ρ of 0.25 indicates that there is at least a medium-strong correlation between the GDP growth of a country and the degree to which is is affected by FOMC shocks. The sign of the correlation suggests that a higher growth is associated with a stronger equity market reaction. Doing the same rank correlation for the coefficients stemming from ECB shocks, we do not find any correlation (table XVI).

When we look at the inflation rates of different countries and compare them with their FOMC coefficients, there appears to be some overlapping at the bottom. Germany, Finland, and Sweden exhibited a low inflation during the 1998-2008 period (on average 1.56%, 1.83%, and

1.43%, respectively) and their stock market reactions to FED monetary policy shocks is the lowest and non significant (table XX). When we apply the rank correlation for coefficients from FOMC shock regression and average inflation rates over the sample period, the resulting spearman's ρ is 0.48 (table XVII). This indicates that countries with high inflation are also the ones that exhibit a stronger stock market reaction to FOCM shocks. This is in line with empirical evidence that suggests that inflation also affects stock market volatility (Geetha et al. (2011) and Saryal (2007)). For instance, during low inflation periods, firms do not have to change and post prices as frequently and this affects households' consumption and savings decisions if inflation is expected to last in the medium-run. Boyd et al. (2001b) investigate the link between inflation rate and financial market performances and find evidence of higher equity market variability when the inflation rate is higher. Similarly, Engle and Rangel (2008) study which macroeconomic factors affect stock volatility and discover that inflation rate is an important explanatory variable for volatility. The rank correlation for ECB coefficients results in a ρ of -0.10, indicating that there is only a low and negative correlation.

VII. Conclusion

This paper's aim has been to investigate how monetary policy changes initiated by the world's two most influential central banks (Fed and ECB) affect U.S. and European stock markets. We use commercial paper rates and the Euribor to extract the unanticipated part of the target rate changes and examine how these shocks are priced in by equity markets. For FOMC shocks, our results are in line with conventional macroeconomic theory and are supported by a large majority of existing research. Negative (positive) monetary policy shocks result in rising (falling) equity markets. We find that this holds for the U.S. stock markets, as well as for most European ones. Furthermore, we document that the size of the coefficients is linked to macroeconomic variables, such as the GDP growth and the inflation. A more surprising result is found for ECB shocks. Our findings suggest that an unexpected target rate cut results in a negative reaction of U.S. and European stock markets. This has not been documented before. We argue that this might be due to the wealth effect dominating the substitution effect for interest rate changes by the ECB. This would result in a higher discounting of future cash-flows and thus lead to lower equity prices. Another explanatory approach suggests that the crisis in 2007/2008 could be the cause of this unconventional finding. Investors might have perceived ECB's monetary policy during the crisis as harmful rather than being an adequate countermeasure to the economic problems, resulting in negative equity market reactions to monetary policy shocks. Robustness tests support this theory to some degree. If we exclude the crisis from the data sample, the U.S. stock market does not exhibit an economically and statistically significant reaction to ECB monetary policy shocks anymore. This indicates that the positive relationship found for the base case sample period is mainly driven by the crisis. For the European stock markets, however, the exclusion of the crisis does not result in a complete disappearance of a significant impact of ECB shocks. Various countries still exhibit positive coefficients, even though they are, on average, smaller in size. The crisis, though amplifying the impact, does not appear to be the only cause of the unintuitive sign of the coefficients. Complicating matters even more, we fail to find a link between macroeconomic variables and the sensitivity of individual countries to ECB shocks. The transmission of the ECB's monetary policy to equity markets will therefore remain a puzzle.

Furthermore, our study provides evidence that equity price reaction is not limited to the time window immediately after the announcement. We find that for both shocks there is a lagged equity market reaction observable during the two trading days following the announcement. This is either due to a slow information processing or due to further pieces of information (reports, opinions, analyses etc.) being released in the hours and days after the target rate change announcement. We also document a pre-announcement stock market reaction on days before FOMC shocks. While it might partially be caused by other macroeconomic announcements, it could also provide further evidence for the previously found pre-FOMC announcement drift Lucca and Moench (2015). We fail to find a comparable phenomenon for ECB shocks.

Our study provides some interesting insights and could provide a basis for further research. We have analyzed the monetary policies of only two central banks. Seeing that the impact of their monetary policies on stock markets is highly heterogenous, it would be important to examine how other (influential) central banks, such as the Bank of England or the Bank of Japan, have the ability to move stock markets across the globe with their decisions.

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VIII. Appendix

Table II. Assets for REFI Rate Change Prediction Europe

The regression: $REFI_t - REFI_{t-1} = \alpha + \beta(Y_{t-1} - REFI_{t-1}) + \epsilon_t$ is used to identify which assets (EU CP, EONIA, 1-week Euribor, 1-month Euribor, 3-month Euribor and 1-year Euribor) are able to predict REFI rate changes most accurately.

	Dependent variable:					
	Target Rate Change					
	(1)	(2)	(3)	(4)	(5)	(6)
CP	0.205					
	(0.384)					
EONIA		0.937***				
		(0.264)				
Euribor 1 Week			0.841***			
			(0.251)			
Euribor 1 Month				0.560***		
				(0.200)		
Euribor 3 Month					0.386**	
					(0.146)	
Euribor 1 Year						0.347***
						(0.092)
Constant	−0.001	−0.001	−0.001	−0.001	−0.001	−0.002**
	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Observations	14	26	26	26	26	26
R^2	0.023	0.344	0.319	0.247	0.225	0.371
F Statistic	0.286	12.588***	11.235***	7.867***	6.949**	14.143***
Note:				*p<0.1; **p<0.05; ***p<0.01		

Table III. Assets for Target Rate Change Prediction U.S.
The regression: $TAR_t - TAR_{t-1} = \alpha + \beta(Y_{t-1} - TAR_{t-1}) + \epsilon_t$ is used to identify which assets (U.S. CP, 3-month Bond, 6-month Bond, 1-year Bond, 5-year Bond, 10-year Bond) are able to predict target rate changes most accurately.

(a) Commercial Paper and Bonds 1999-2008

	Dependent variable:					
	Target Rate Change					
	(1)	(2)	(3)	(4)	(5)	(6)
CP	1.052***					
	(0.054)					
3 Month		0.559***				
		(0.042)				
6 Month			0.516***			
			(0.031)			
1 Year				0.424***		
				(0.032)		
5 Year					0.157***	
					(0.054)	
10 Year						0.052
						(0.051)
Constant	−0.0001	0.001***	−0.0001	−0.001***	−0.002**	−0.001
	(0.0002)	(0.0003)	(0.0002)	(0.0002)	(0.001)	(0.001)
Observations	40	40	40	40	40	40
R^2	0.910	0.825	0.878	0.818	0.182	0.027
F Statistic	384.756***	178.967***	273.401***	170.588***	8.464***	1.037
Note:	*p<0.1; **p<0.05; ***p<0.01					

(b) Commercial Paper and Bonds 1994-2008

	Dependent variable:					
	Target Rate Change					
	(1)	(2)	(3)	(4)	(5)	(6)
CP	1.023***					
	(0.058)					
3 Month		0.557***				
		(0.041)				
6 Month			0.517***			
			(0.030)			
1 Year				0.422***		
				(0.030)		
5 Year					0.164***	
					(0.047)	
10 Year						0.070
						(0.044)
Constant	−0.0004**	0.001***	−0.0002	−0.001***	−0.002***	−0.001*
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.001)	(0.001)
Observations	53	46	46	46	46	46
R^2	0.857	0.809	0.872	0.821	0.219	0.053
F Statistic	306.198***	186.236***	299.799***	201.923***	12.358***	2.472
Note:	*p<0.1; **p<0.05; ***p<0.01					

Table IV. Commercial paper vs MM instruments' rate changes correlation

This table lists the correlation coefficients between commercial paper change and money market instrument rate changes in order to select an appropriate proxy.

MM Instrument	Correlation
EONIA	0.019
1-week Euribor	0.220
1-month Euribor	0.625
3-month Euribor	0.397
1-year Euribor	0.234
TN Repo	0.085
1-week Repo	0.133
1-month Repo	0.220
3-month Repo	0.168
1-year Repo	0.089

Table V. US Equity Returns on FOMC Shocks 1999-2008

The coefficients for the 4 U.S. equity indices are computed over the full event window for the base case sample period (1999-2008) $(P_{t+2} - P_{t-1})/P_{t-1} = \alpha + \beta shock_t + \mu_t$

	Dependent variable:			
	S&P 500	NYSE	NASDAQ	Dow Jones
	(1)	(2)	(3)	(4)
Target Rate Shock	-13.266^{***}	-14.786^{***}	-13.982^{***}	-12.249^{***}
	(3.137)	(3.478)	(4.108)	(2.984)
Constant	0.010^{***}	0.010^{**}	0.014^{***}	0.010^{***}
	(0.003)	(0.004)	(0.004)	(0.003)
Observations	40	40	40	40
R^2	0.320	0.322	0.234	0.307
F Statistic	17.883^{***}	18.070^{***}	11.585^{***}	16.845^{***}
Note:				*p<0.1; **p<0.05; ***p<0.01

Table VI. US Equity Returns on FOMC Shocks 1994-2008

The coefficients for the 4 U.S. equity indices are computed over the full event window for the extended robustness test period (1994-2008) $(P_{t+2} - P_{t-1})/P_{t-1} = \alpha + \beta shock_t + \mu_t$

	Dependent variable:			
	S&P 500	NYSE	NASDAQ	Dow Jones
	(1)	(2)	(3)	(4)
Target Rate Shock	-6.390^{***}	-6.927^{***}	-7.655^{***}	-6.317^{***}
	(2.206)	(2.401)	(2.742)	(2.091)
Constant	0.008^{***}	0.008^{**}	0.011^{***}	0.008^{***}
	(0.003)	(0.003)	(0.004)	(0.003)
Observations	53	53	53	53
R^2	0.141	0.140	0.133	0.152
F Statistic	8.388^{***}	8.325^{***}	7.792^{***}	9.125^{***}
Note:				*p<0.1; **p<0.05; ***p<0.01

Table VII. European Equity Returns on FOMC Shocks 1999-2008

The coefficients for the 17 European countries are computed over the full event window for the base case sample period (1999-2008) $(P_{t+2} - P_{t-1})/P_{t-1} = \alpha + \beta shock_t + \mu_t$

	Dependent variable:								
	Greece	Austria	Belgium	Germany	France	Italy	Switzerland	Spain	Sweden
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Target Rate Shock	−16.047***	−15.554***	−9.667***	−3.769	−10.929**	−12.886***	−11.564***	−16.044***	−7.071
	(3.937)	(3.839)	(3.359)	(4.432)	(4.589)	(4.346)	(3.668)	(4.702)	(4.261)
Constant	0.009**	0.010**	0.009**	0.007	0.009*	0.006	0.007*	0.009*	0.012***
	(0.004)	(0.004)	(0.004)	(0.005)	(0.005)	(0.005)	(0.004)	(0.005)	(0.004)
Observations	40	40	40	40	40	40	40	40	40
R^2	0.304	0.302	0.179	0.019	0.130	0.188	0.207	0.235	0.068
F Statistic	16.609***	16.411***	8.284***	0.723	5.673**	8.792***	9.941***	11.643***	2.753

	Dependent variable:							
	Netherlands	Finland	Denmark	Ireland	Norway	Portugal	Poland	UK
	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
Target Rate Shock	−9.987**	−6.958	−12.656***	−18.647***	−9.279**	−9.774***	−8.554**	−12.457***
	(4.695)	(5.288)	(4.236)	(5.451)	(3.786)	(3.169)	(3.523)	(3.645)
Constant	0.010*	0.015**	0.011**	0.011*	0.011***	0.005	0.010***	0.006*
	(0.005)	(0.006)	(0.004)	(0.006)	(0.004)	(0.003)	(0.004)	(0.004)
Observations	40	40	40	40	40	40	40	40
R^2	0.106	0.044	0.190	0.235	0.137	0.200	0.134	0.235
F Statistic	4.524**	1.731	8.926***	11.702***	6.007**	9.510***	5.896**	11.682***

Note: *p<0.1; **p<0.05; ***p<0.01

Table VIII. European Equity Returns on FOMC Shocks 1994-2008

The coefficients for the 17 European countries are computed over the full event window for the extended robustness test period (1994-2008) $(P_{t+2} - P_{t-1})/P_{t-1} = \alpha + \beta shock_t + \mu_t$

	Dependent variable:								
	Greece	Austria	Belgium	Germany	France	Italy	Switzerland	Spain	Sweden
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Target Rate Shock	−9.375***	−6.796**	−4.823*	−3.326	−6.859**	−9.992**	−7.318**	−10.257***	−6.039**
	(2.846)	(3.027)	(2.404)	(3.045)	(3.175)	(4.178)	(2.829)	(3.436)	(2.896)
Constant	0.006	0.005	0.007**	0.005	0.006	0.006	0.005	0.005	0.010**
	(0.004)	(0.004)	(0.003)	(0.004)	(0.004)	(0.005)	(0.004)	(0.005)	(0.004)
Observations	53	53	53	53	53	42	53	53	53
R^2	0.175	0.090	0.073	0.023	0.084	0.125	0.116	0.149	0.079
F Statistic	10.848***	5.042**	4.024*	1.193	4.667**	5.720**	6.692**	8.911***	4.349**

	Dependent variable:							
	Netherlands	Finland	Denmark	Ireland	Norway	Portugal	Poland	UK
	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
Target Rate Shock	−6.548**	−6.671*	−3.221	−8.765**	−3.428	−6.085**	1.502	−7.147***
	(3.134)	(3.482)	(2.939)	(3.648)	(2.516)	(2.852)	(3.763)	(2.434)
Constant	0.007	0.012**	0.007*	0.008	0.008**	0.003	0.010*	0.005
	(0.004)	(0.005)	(0.004)	(0.005)	(0.003)	(0.004)	(0.005)	(0.003)
Observations	53	53	53	53	53	42	53	53
R^2	0.079	0.067	0.023	0.102	0.035	0.082	0.003	0.145
F Statistic	4.366**	3.671*	1.201	5.772**	1.857	4.553**	0.159	8.626***
Note:								*p<0.1; **p<0.05; ***p<0.01

Table IX. US Equity Returns on ECB Shocks 1999-2008

The coefficients for the 4 U.S. equity indices are computed over the full event window for the base case sample period (1999-2008) $(P_{t+1} - P_t)/P_t = \alpha + \beta shock_t + \mu_t$

	Dependent variable:			
	S&P 500	NYSE	NASDAQ	Dow Jones
	(1)	(2)	(3)	(4)
Target Rate Shock	3.300**	3.398**	3.229**	2.939**
	(1.230)	(1.224)	(1.562)	(1.114)
Constant	−0.003	−0.004	0.001	−0.005
	(0.004)	(0.004)	(0.005)	(0.004)
Observations	26	26	26	26
R^2	0.231	0.243	0.151	0.225
F Statistic	7.193**	7.705**	4.275**	6.965**
Note:				*p<0.1; **p<0.05; ***p<0.01

Table X. European Equity Returns on ECB Shocks 1999-2008

The coefficients for the 17 European countries are computed over the full event window for the base case sample period (1999-2008) $(P_{t+2} - P_t)/P_t = \alpha + \beta shock_t + \mu_t$

	Dependent variable:								
	Greece	Austria	Belgium	Germany	France	Italy	Switzerland	Spain	Sweden
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Target Rate Shock	5.496***	7.051***	5.048**	5.358**	5.702**	5.525***	4.700**	7.269***	5.024**
	(1.765)	(2.081)	(2.183)	(2.345)	(2.048)	(1.782)	(2.239)	(2.029)	(2.026)
Constant	0.007	−0.011	−0.006	−0.009	−0.008	−0.012*	−0.008	−0.010	−0.001
	(0.006)	(0.007)	(0.007)	(0.008)	(0.007)	(0.006)	(0.007)	(0.007)	(0.007)
Observations	26	26	26	26	26	26	26	26	26
R^2	0.288	0.324	0.182	0.179	0.244	0.286	0.155	0.348	0.204
F Statistic	9.700***	11.484***	5.349**	5.221**	7.750**	9.608***	4.405**	12.834***	6.149**

	Dependent variable:							
	Netherlands	Finland	Denmark	Ireland	Norway	Portugal	Poland	UK
	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
Target Rate Shock	6.853***	5.730**	3.545*	4.965**	5.307***	4.600***	1.658	5.320***
	(2.308)	(2.713)	(1.739)	(2.087)	(1.593)	(1.249)	(2.132)	(1.840)
Constant	−0.010	0.003	−0.003	−0.004	−0.009*	−0.003	0.003	−0.009
	(0.007)	(0.009)	(0.006)	(0.007)	(0.005)	(0.004)	(0.007)	(0.006)
Observations	26	26	26	26	26	26	26	26
R^2	0.269	0.157	0.148	0.191	0.316	0.361	0.025	0.258
F Statistic	8.814***	4.461**	4.157*	5.659**	11.101***	13.555***	0.605	8.358***

Note: *p<0.1; **p<0.05; ***p<0.01

Table XI. European Equity Returns on ECB Shocks 1999-2006 (without crisis)

The coefficients for the 17 European countries are computed over the full event window for the no-crisis case sample period (1999-2006) $(P_{t+2} - P_t)/P_t = \alpha + \beta shock_t + \mu_t$

	Dependent variable:								
	Greece	Austria	Belgium	Germany	France	Italy	Switzerland	Spain	Sweden
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Target Rate Shock	3.634**	0.267	2.294	3.588*	3.540**	3.222**	1.335	3.270**	3.709**
	(1.701)	(1.298)	(1.703)	(2.036)	(1.559)	(1.399)	(1.516)	(1.384)	(1.737)
Constant	0.012*	−0.003	−0.0005	−0.004	−0.002	−0.006	−0.002	−0.002	0.005
	(0.006)	(0.004)	(0.006)	(0.007)	(0.005)	(0.005)	(0.005)	(0.005)	(0.006)
Observations	20	20	20	20	20	20	20	20	20
R^2	0.202	0.002	0.092	0.147	0.223	0.228	0.041	0.237	0.202
F Statistic	4.565**	0.042	1.815	3.108*	5.158**	5.303**	0.776	5.584**	4.562**

	Dependent variable:							
	Netherlands	Finnland	Denmark	Ireland	Norway	Portugal	Poland	UK
	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
Target Rate Shock	4.021*	5.243	2.556*	1.562	1.411	2.065	−1.533	2.727**
	(1.944)	(3.073)	(1.432)	(1.408)	(1.467)	(1.269)	(1.945)	(1.186)
Constant	−0.004	0.010	0.003	0.003	−0.001	0.003	0.008	−0.005
	(0.007)	(0.010)	(0.005)	(0.005)	(0.005)	(0.004)	(0.007)	(0.004)
Observations	20	20	20	20	20	20	20	20
R^2	0.192	0.139	0.150	0.064	0.049	0.128	0.033	0.227
F Statistic	4.281*	2.912	3.187*	1.230	0.925	2.649	0.621	5.289**

Note: $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Table XII. US Equity Returns on ECB Shocks 1999-2006 (without crisis)

The coefficients for the 4 U.S equity indices are computed over the full event window for the no-crisis case sample period (1999-2006) $(P_{t+1} - P_t)/P_t = \alpha + \beta shock_t + \mu_t$

	Dependent variable:			
	S&P 500	NYSE	NASDAQ	Dow Jones
	(1)	(2)	(3)	(4)
Target Rate Shock	0.530	0.131	2.613	0.139
	(0.991)	(0.937)	(1.645)	(0.848)
Constant	0.003	0.002	0.007	0.0001
	(0.003)	(0.003)	(0.006)	(0.003)
Observations	20	20	20	20
R^2	0.016	0.001	0.123	0.001
F Statistic	0.287	0.020	2.523	0.027
Note:				*p<0.1; **p<0.05; ***p<0.01

Table XIII. Target Rate Changes

The tables list all the target rate changes and the dates they occurred between 1999-2008 for a) the FOMC and b) the ECB. * marks all the target rate changes that occurred on extra-ordinary central bank meetings and are therefore excluded in our analysis.

(a) FOMC Target Rate Changes

Date	Δ Target Rate	Date	Δ Target Rate
30.06.99	+0.25%	30.06.05	+0.25%
24.08.99	+0.25%	09.08.05	+0.25%
16.11.99	+0.25%	20.09.05	+0.25%
02.02.00	+0.25%	01.11.05	+0.25%
21.03.00	+0.25%	13.12.05	+0.25%
16.05.00	+0.50%	31.01.06	+0.25%
03.01.01*	-0.50%	28.03.06	+0.25%
31.01.01	-0.50%	10.05.06	+0.25%
20.03.01	-0.50%	29.06.06	+0.25%
18.04.01*	-0.50%	18.09.07	-0.50%
15.05.01	-0.50%	31.10.07	-0.25%
27.06.01	-0.25%	11.12.07	-0.25%
21.08.01	-0.25%	22.01.08*	-0.75%
17.09.01*	-0.50%	30.01.08	-0.50%
02.10.01	-0.50%	18.03.08	-0.75%
06.11.01	-0.50%	30.04.08	-0.25%
11.12.01	-0.25%	08.10.08*	-0.50%
06.11.02	-0.50%	29.10.08	-0.50%
25.06.03	-0.25%		
30.06.04	+0.25%		
10.08.04	+0.25%		
21.09.04	+0.25%		
10.11.04	+0.25%		
14.12.04	+0.25%		
02.02.05	+0.25%		
22.03.05	+0.25%		
03.05.05	+0.25%		

(b) ECB Target Rate Changes

Date	Δ Target Rate
08.04.99	-0.50%
04.11.99	+0.50%
03.02.00	+0.25%
16.03.00	+0.25%
27.04.00	+0.25%
08.06.00	+0.50%
31.08.00	+0.25%
05.10.00	+0.25%
10.05.01	-0.25%
30.08.01	-0.25%
17.09.01*	-0.50%
08.11.01	-0.50%
05.12.02	-0.50%
06.03.03	-0.25%
05.06.03	-0.50%
01.12.05	+0.25%
02.03.06	+0.25%
08.06.06	+0.25%
03.08.06	+0.25%
05.10.06	+0.25%
07.12.06	+0.25%
08.03.07	+0.25%
06.06.07	+0.25%
03.07.08	+0.25%
08.10.08	-0.50%
06.11.08	-0.50%
04.12.08	-0.75%

Table XIV. Coefficient Ranking

The coefficients of the main regression for ECB and FOMC shocks over the entire event window (see definition in paper). The coefficient reported for the U.S. is the one from the S&P 500.

(a)
Coefficients for ECB Shocks

Rank	Country	Coefficient
1	Spain	7.269***
2	Austria	7.051***
3	Netherlands	6.853***
4	Finland	5.730**
5	France	5.702**
6	Italy	5.525***
7	Greece	5.496***
8	Germany	5.358**
9	UK	5.320***
10	Norway	5.307 ***
11	Belgium	5.048**
12	Sweden	5.024**
13	Ireland	4.965**
14	Switzerland	4.700**
15	Portugal	4.600***
16	Denmark	3.545*
17	U.S.	3.300***
18	Poland	1.658

(b) Co-
efficients for FOMC Shocks

Rank	Country	Coefficient
1	Ireland	-18.647***
2	Greece	-16.047***
3	Spain	-16.044***
4	Austria	-15.554***
5	U.S.	-13.266***
6	Italy	-12.886**
7	Denmark	-12.656***
8	UK	-12.457***
9	Switzerland	-11.564***
10	France	-10.929**
11	Netherlands	-9.987 **
12	Portugal	-9.774***
13	Belgium	-9.667***
14	Norway	-9.279**
15	Poland	-8.554**
16	Sweden	-7.071
17	Finland	-6.958
18	Germany	-3.769

Table XV. Rank Correlation for FOMC Shocks: Trade Variables

The following tables rank the 17 European Countries for FOMC shock coefficients and (a) Exports (b) Imports and (c) Total Trade with U.S.and display the Spearman's test ρ coefficient to capture the respective rank correlation.

(a) Rank Correlation Coefficients vs. Exports

Country	Coefficients	Exports
Ireland	1st	5th
Greece	2nd	17th
Spain	3rd	10th
Austria	4th	12th
Italy	5th	4th
Denmark	6th	13th
UK	7th	2nd
Switzerland	8th	7th
France	9th	3rd
Netherlands	10th	6th
Portugal	11th	15th
Belgium	12th	8th
Norway	13th	11th
Poland	14th	16th
Sweden	15th	9th
Finland	16th	14th
Germany	17th	1st
Spearman's ρ	-0.003	

(b) Rank Correlation Coefficients vs. Imports

Country	Coefficients	Imports
Ireland	1st	7th
Greece	2nd	15th
Spain	3rd	8th
Austria	4th	11th
Italy	5th	6th
Denmark	6th	13th
UK	7th	2nd
Switzerland	8th	9th
France	9th	4th
Netherlands	10th	3rd
Portugal	11th	17th
Belgium	12th	5th
Norway	13th	12th
Poland	14th	14th
Sweden	15th	10th
Finland	16th	16th
Germany	17th	1st
Spearman's ρ	0.025	

(c) Rank Correlation Coefficients vs. Total Trade

Country	Coefficients	Total Trade
Ireland	1st	6th
Greece	2nd	17th
Spain	3rd	9th
Austria	4th	12th
Italy	5th	4th
Denmark	6th	13th
UK	7th	2nd
Switzerland	8th	8th
France	9th	3rd
Netherlands	10th	5th
Portugal	11th	16th
Belgium	12th	7th
Norway	13th	11th
Poland	14th	15th
Sweden	15th	10th
Finland	16th	14th
Germany	17th	1st
Spearman's ρ	-0.0123	

Table XVI. Rank Correlation for FOMC Shocks: Macroeconomic Variables

The following tables rank the 17 European Countries + U.S for FOMC shock coefficients and (a) GDP growth and (b) Inflation and display the Spearman's test ρ coefficient to capture the respective rank correlation.

(a) Rank Correlation Coefficients vs. GDP Growth

Country	Coefficients	GDP Growth
Ireland	1st	1st
Greece	2nd	4th
Spain	3rd	3rd
Austria	4th	10th
US	5th	7th
Italy	6th	18th
Denmark	7th	16th
UK	7th	8th
Switzerland	9th	11th
France	10th	14th
Netherlands	11th	8th
Portugal	12th	15th
Belgium	13th	12th
Norway	14th	13th
Poland	15th	2nd
Sweden	16th	6th
Finland	17th	5th
Germany	18th	17th
Spearman's ρ	0.2528	

(b) Rank Correlation Coefficients vs. Inflation

Country	Coefficients	Inflation
Ireland	1st	2nd
Greece	2nd	3rd
Spain	3rd	4th
Austria	4th	12th
US	5th	6th
Italy	6th	7th
Denmark	7th	9th
UK	7th	14th
Switzerland	9th	18th
France	10th	15th
Netherlands	11th	8th
Portugal	12th	5th
Belgium	13th	10th
Norway	14th	11th
Poland	15th	1st
Sweden	16th	17th
Finland	17th	13th
Germany	18th	16th
Spearman's ρ	0.4757	

Table XVII. Rank Correlation for ECB Shocks: Macroeconomic Variables
The following tables rank the 17 European Countries + U.S for ECB shock coefficients and (a) GDP growth and (b) Inflation and display the Spearman's test ρ coefficient to capture the respective rank correlation.

(a) Rank Correlation Coefficients vs. GDP Growth

Country	Coefficients	GDP Growth
Spain	1st	3rd
Austria	2nd	10th
Netherlands	3rd	8th
Finland	4th	5th
France	5th	14th
Italy	6th	18th
Greece	7th	4th
Germany	7th	17th
UK	9th	9th
Norway	10th	13th
Belgium	11th	12th
Sweden	12th	6th
Ireland	13th	1st
Switzerland	14th	11th
Portugal	15th	15th
Denmark	16th	16th
US	17th	7th
Poland	18th	2nd
Spearman's ρ	0.0052	

(b) Rank Correlation Coefficients vs. Inflation

Country	Coefficients	Inflation
Spain	1st	4th
Austria	2nd	12th
Netherlands	3rd	8th
Finland	4th	13th
France	5th	5th
Italy	6th	7th
Greece	7th	3rd
Germany	7th	16th
UK	9th	14th
Norway	10th	11th
Belgium	11th	10th
Sweden	12th	17th
Ireland	13th	2nd
Switzerland	14th	18th
Portugal	15th	5th
Denmark	16th	9th
US	17th	6th
Poland	18th	1st
Spearman's ρ	-0.1022	

Table XVIII. Economic Calendar

The tables list the main reports regarding key macroeconomic variables like unemployment, GDP, CPI etc. around the dates of target rate changes. The number indicates how many days before or after that dates the reports were released.

(a) Release of Reports regarding European Macro Variables

Date of Change	Spain CPI	Spain UNEMP	Italy CPI	Italy GDP	Germany CPI	Germany UNEMP	Germany GDP	France CPI
08.04.99						0		+1
04.11.99		-1						
03.02.00		+1						
16.03.00								
27.04.00			1		-1			+1
08.06.00						0		
31.08.00		+2					-2	
05.10.00		-1				0		
10.05.01	+1							+1
30.08.01		+2	-1					
08.11.01						-2		
05.12.02		0				-1		
06.03.03						0		
05.06.03						0		
01.12.05		+1				0		
02.03.06		0						
08.06.06				+1				
03.08.06		-1				-2		
05.10.06		-2						
07.12.06				0				
08.03.07				+1				
06.06.07				+2				
03.07.08		-1	-3			-2		
08.10.08								
06.11.08		-2						
04.12.08		-2						

(b)

Release of Reports regarding U.S Macro Variables

Date of Change	CPI MoM	GDP QoQ	Change Non-farm payroll
30.06.99			2
24.08.99		2	
16.11.99	1		
02.02.00			2
21.03.00	-2		
16.05.00	0		
31.01.01		0	2
20.03.01	1		
15.05.01	1		
27.06.01		3	
21.08.01	-3		
02.10.01			3
06.11.01			-2
11.12.01	3		
06.11.02			
25.06.03		1	
30.06.04		-3	2
10.08.04			-2
21.09.04			
10.11.04			-3
14.12.04	3		
02.02.05			2
22.03.05	1		
03.05.05	-3		3
30.06.05		-1	
09.08.05			-2
20.09.05	-3		
01.11.05		-2	3
13.12.05	2		
31.01.06			3
28.03.06		2	
10.05.06			
29.06.06		0	
18.09.07	1		
31.10.07		0	2
11.12.07	2		-2
30.01.08			2
18.03.08	-2		
30.04.08		0	2
29.10.08		1	

Table XIX. International Trade U.S. - Europe

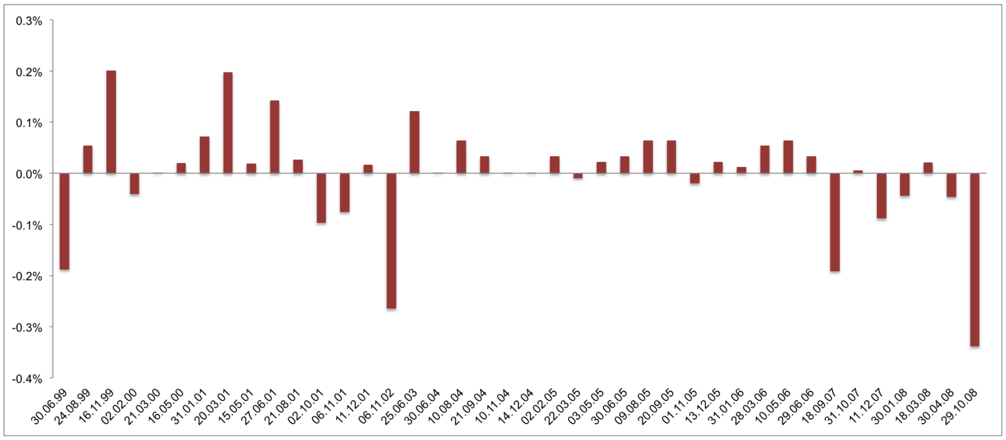
The table reports detailed trade data between U.S and the analyze European countries. In details, for each country: (a) export towards US as % of total exports, (b) U.S. rank in trade partners, (c) export in $ millions, (d) import in $ millions, (e) total trade amount in $ millions and (f) net export in $ millions

Country	% of Total Export	US Export Rank	Export	Import	Total Trade	Net Export
Greece	4%	5th	836	1'665	2'501	-829
Austria	4%	3rd	5'934	2'881	8'815	3'053
Belgium	6%	6th	12'478	16'437	28'915	-3'959
Germany	8%	2nd	76'298	43'399	119'697	32'899
France	7%	5th	33'954	24'886	58'840	9'068
Italy	7%	3rd	29'610	12'942	42'552	16'668
Switzerland	8%	2nd	12'539	7'183	19'722	5'356
Spain	4%	6th	8'037	8'077	16'114	-40
Sweden	7%	1st	11'587	4'086	15'673	7'500
Netherlands	6%	6th	13'824	26'808	40'632	-12'985
Finland	5%	3rd	4'267	1'636	5'903	2'630
Denmark	5%	4th	4'454	2'301	6'090	2'153
Ireland	19%	1st	24'123	8'494	32'617	15'629
Norway	7%	5th	6'340	2'833	9'173	3'507
Portugal	4%	5th	2'205	1'189	3'394	1'016
Poland	3%	9th	1'703	1'926	3'629	-222
UK	12%	1st	48'404	42'858	91'262	5'546

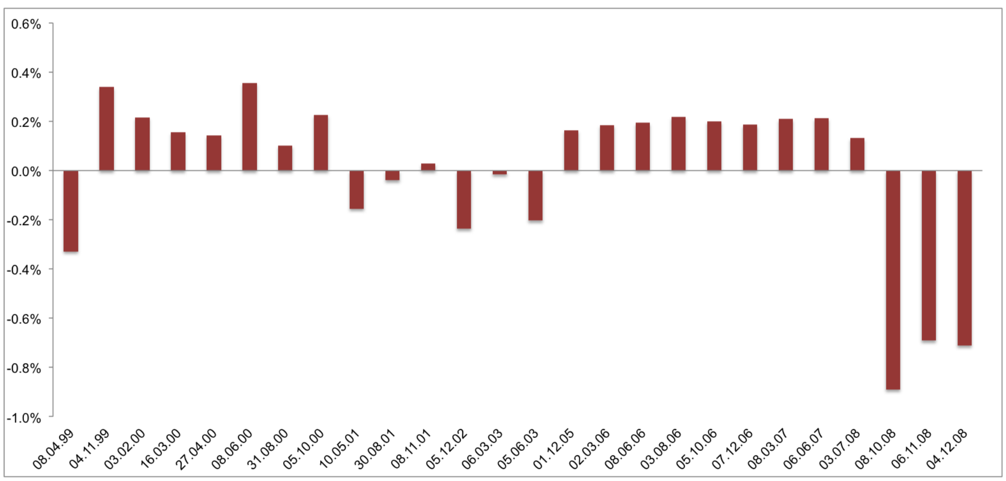
Table XX. Average GDP Growth and Inflation Over Sample Period

The table reports the average GDP growth and consumer prices inflation rate for the analyzed European countries between 1999 and 2008.

Country	GDP Growth	Inflation (CPI)
Greece	3.54%	3.44%
Austria	2.51%	1.90%
Belgium	2.26%	2.12%
Germany	1.62%	1.56%
France	2.19%	1.67%
Italy	1.28%	2.32%
Switzerland	2.41%	0.99%
Spain	3.65%	3.10%
Sweden	3.11%	1.43%
Netherlands	2.68%	2.20%
Finland	3.49%	1.83%
Denmark	1.78%	2.19%
Ireland	6.00%	3.65%
Norway	2.23%	2.12%
Portugal	1.92%	2.90%
Poland	4.18%	4.62%
UK	2.65%	1.75%



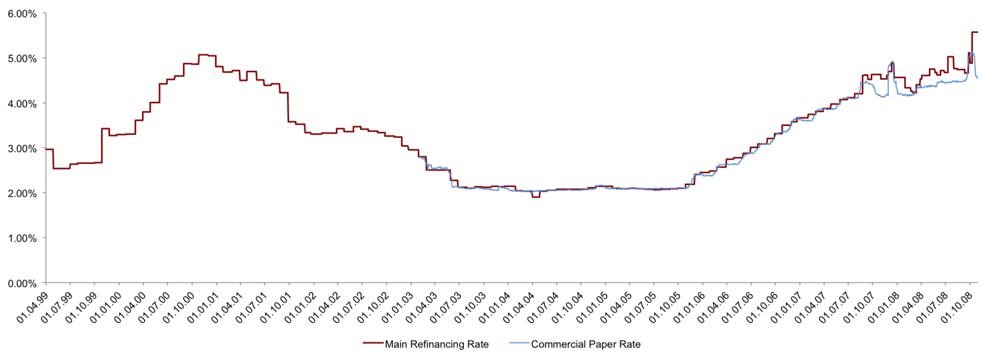
(a) US Monetary Policy Shocks



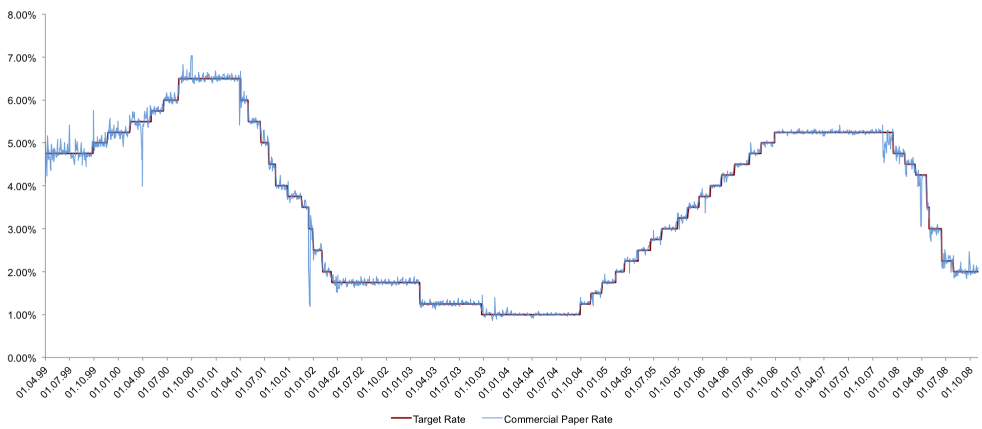
(b) ECB Monetary Policy Shocks

Figure 2. Monetary Policy Shocks

The bars represent the unanticipated part of the target rate changes that occurred between 1999 and 2008. They are chronologically ordered. a) displays the shocks for 40 FOMC target rate changes and b) the shocks for 26 ECB target rate changes.



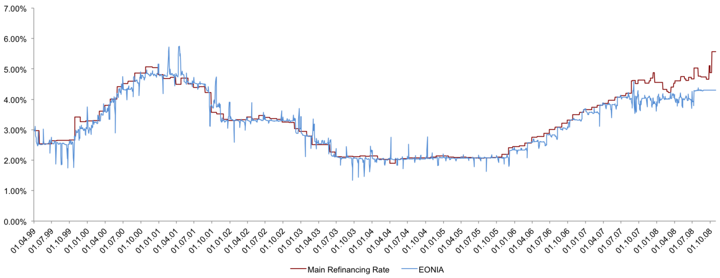
(a) Commercial Paper Europe



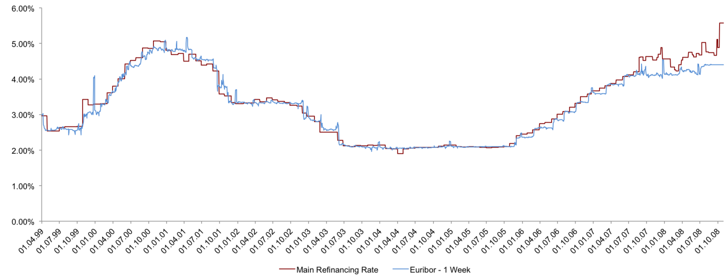
(b) Commercial Paper U.S.

Figure 3. Commercial Paper Rates

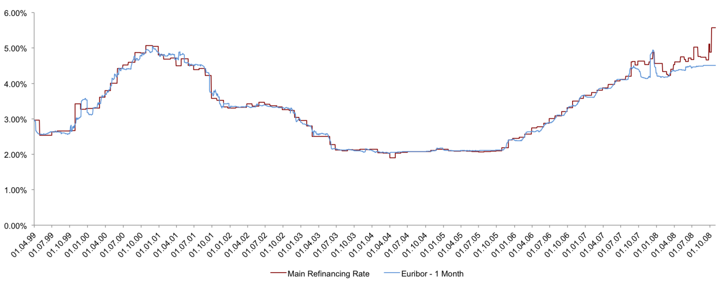
The figure plots how Commercial rates Paper in U.S. and Europe track the (a) Main Refinancing Opearations rate and (b) Target Fed Fund Rate. The sample period is 1999 to 2008.



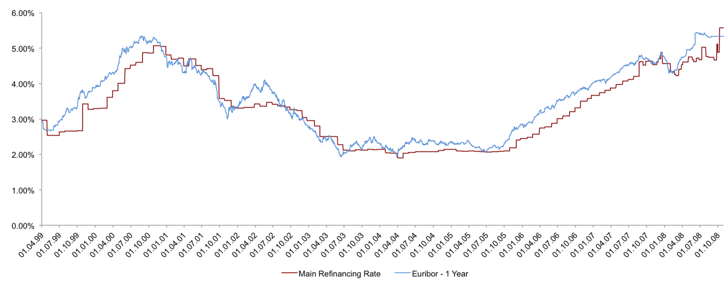
(a) Euribor rates - Overnight (EONIA)



(b) Euribor rates - 1 Week



(c) Euribor rates - 1 Month



(d) Euribor rates - 1 Year

Figure 4. Monetary Policy Shocks

The figure displays the time series of Main Refinancing Operations Rate with (a) Euribor Overnight - EONIA, (b) 1-week Euribor, (c) 1-month Euribor and (d) 1-year Euribor